Computer Animation

Martin English

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by Martin English

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Ebook ISBN: 9781984664365

Published by:
Bibliotex
Canada
Website: www.bibliotex.com

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An Introduction to Computer Animation

Just what *is* computer animation? For decades, animation has been a trade that rested solely in the hands of the entertainment industry; the process required a great deal of time, manpower, and complex equipment to accomplish. However, with the ever-growing movement to computerize the industry, the animation process has become progressively simpler. What was once done with pencils, cels, and paint by a team of dozens of animators can now be accomplished by a single person with a powerful enough home computer and the right software.

The term "computer animation" itself broadly covers a wide variety of genres and applications, though the simplest way to break it down is into the categories of 2D and 3D animation. "2D", short for "two-dimensional", is sometimes also called "vector animation", and is typically done in programmes like

Macromedia Flash and Macromedia Director. The most familiar form of 2D animation can be found just by turning on your TV on a Saturday morning: traditional cartoons, which are progressing more and more into the digital realm. You probably see simpler animations every day just while surfing the web, in the form of advertisements, E-cards, and cartoon shorts. Vector animation is also useful in designing interactive interfaces for the web.

2D animation, true to its name, is rendered in a two-dimensional space. 3D animation, however, is rendered in a virtual three-dimensional space, using polygons captured by various virtual "cameras" to "film" the animation. 3D animation has a variety of applications, from video games to animated films; most commonly, 3D animation is used to render many of the special effects seen in live-action films, removing the need for scale model sets or staged stunts.

While both types of computer animation can be accomplished by either frame-by-frame animation or by mathematical interpolation between key frames, the initial steps prior to animating are drastically different; the two separate processes also require different software packages. With that in mind, the tutorials provided here have been grouped into the categories of 2D and 3D animation, before being subdivided by skill level to walk, step-by-step, through the basics of creating your own animations. The 2D animation tutorials cover animation in Flash and Director/Shockwave, while the 3D animation tutorials work in 3D Studio Max.

If you have any questions along the way, don't hesitate to check out the Glossary and FAQ in the Help section. Check back frequently, as these tutorials are always being updated with fresh information, tips, and tricks.

Graphical Animation

In computer graphics, the process of updating a graphical display so that it changes over time is called animation. Implementing animation typically involves displaying an initial version of the picture and then changing it slightly over time so that the individual changes appear continuous from one version of the picture to the next. This strategy is analogous to classical film animation in which cartoonists break up the motion of the scene into a series of separate frames. The difference in time between each frame is called a time step and is typically very short. Movies, for example, typically run at 30 frames a second, which makes the time step approximately 33 milliseconds. If you want to obtain smooth motion in Java, you need to use a time step around this scale or even faster.

A Simple Example of Animation

The easiest way to animate graphical programmes is to include a loop in your run method that updates the picture from one frame to the next and then pauses for the duration of the time step. An example of this style of animation appears, which moves a GLabel across the screen from right to left, just the way the headline displays in New York's Times Square do.

Code to Move Text Across the Screen

```
  /*
  * File: TimesSquare.java
  * ----------
  * This programme displays the text of the string HEADLINE
on the
  * screen in an animated way that moves it across the
```

```
display
  * from left to right.
  */
  import acm.graphics.*;
  import acm.programme.*;

  public class TimesSquare extends GraphicsProgram {

  /** Runs the programme */
    public void run() {
        GLabel label = new GLabel(HEADLINE);
        label.setFont("Serif-72");
            add(label, getWidth(), (getHeight() +
label.getAscent()) / 2);
        while (label.getX() + label.getWidth() > 0) {
            label.move(-DELTA_X, 0);
            pause(PAUSE_TIME);
        }
    }

  /* The number of pixels to shift the label on each cycle
*/
    private static final int DELTA_X = 2;

  /* The number of milliseconds to pause on each cycle */
    private static final int PAUSE_TIME = 20;

  /* The string to use as the value of the label */
    private static final String HEADLINE =
        "When in the course of human events it becomes
necessary " +
      "for one people to dissolve the political bands which
" +
       "connected them with another...";

  }
```

The TimesSquare programme begins by creating a GLabel object and positioning it so that it is centred vertically in the window. Its starting point in the horizontal dimension, however, is just at the right edge of the canvas, which means that the entire label is outside the visible area of the canvas. The animation is accomplished by the following lines:

```
  while (label.getX() + label.getWidth() > 0) {
    label.move(-DELTA_X, 0);
    pause(PAUSE_TIME);
  }
```

This code loops until the label has moved entirely past the left edge of the display, shifting it DELTA_X pixels to the left on every time step. The call to pause(PAUSE_TIME) inside the loop causes the programme to suspend operation for PAUSE_TIME milliseconds. This call is necessary to achieve the effect of animation, because computers run so quickly that the label would instantly zip off the left side of the window if you didn't slow things down.

Bouncing a Ball

A slightly more sophisticated application of animation appears. This programme bounces a ball around the walls of the graphics window and forms the foundation for such classic video games as Pong or Breakout. Because a static picture in this text would offer little insight into how such an animated programme works, it is useful to run this as an applet. If you are reading this tutorial on the JTF web site, you can bring up the applet in a separate window by clicking on the applet marker in the caption, but you can also run any of the applets from the demo site at http://jtf.acm.org/demos/index.html.

Programme to Bounce a Ball off the Boundaries of the Canvas

```
  /*
  * File: BouncingBall.java
  * ———————————
  * This file implements a simple bouncing ball using the
run method
  * to drive the animation.
```

```
  */

  import acm.graphics.*;
  import acm.programme.*;

  public class BouncingBall extends GraphicsProgram {
  /** Initialize the ball and its velocity components */
     public void init() {
      ball = new GBall(BALL_RADIUS);
      add(ball, getWidth() / 2, getHeight() / 2;
      dx = 2;
      dy = 1;
     }

  /** Run forever bouncing the ball */
      public void run() {
       waitForClick();
       while (true) {
          advanceOneTimeStep();
          pause(PAUSE_TIME);
       }
      }

  /* Check for bounces and advance the ball */
      private void advanceOneTimeStep() {
       double bx = ball.getX();
       double by = ball.getY();
      if (bx < BALL_RADIUS || bx > getWidth() - BALL_RADIUS)
dx = -dx;
      if (by < BALL_RADIUS || by > getHeight() - BALL_RADIUS)
dy = -dy;
       ball.move(dx, dy);
     }
  /* Private constants */
      private static final double BALL_RADIUS = 10;
      private static final int PAUSE_TIME = 20;

  /* Private instance variables */
      private GBall ball;   /* The ball object */
       private double dx;      /* Velocity delta in the x
direction */
       private double dy;     /* Velocity delta in the y
direction */
  }
```

The code uses the GBall class to create a ball whose reference point is at the centre. Doing so makes the geometric calculation simpler when checking whether a bounce occurs because all four edges can be treated symmetrically. The programme code is also divided between the init method, which creates the ball and adds it to the window, and the run method, which runs the animation. The code for the run method is

```
public void run() {
    waitForClick();
    while (true) {
        advanceOneTimeStep();
        pause(PAUSE_TIME);
    }
}
```

which is almost precisely the paradigmatic for an animation loop. The new statement is the call to the waitForClick method, which is implemented by GraphicsProgram and suspends the programme until a mouse click occurs in the graphics canvas. This call means that the programme does not start up immediately, but instead waits for a mouse click before proceeding. The code that implements the underlying physics of the animation appears in the private method advanceOneTimeStep. This method checks to see whether the ball has reached one of the edges of the canvas, in which case it changes the sign of the appropriate component of the ball's velocity, which is stored in the variables dx and dy. It then moves the ball by those displacements to update its position on the display.

Simulating Randomness in Animations

As written, the bouncing ball programme from the preceding section is altogether too predictable. The ball begins

with a constant velocity and then makes perfectly reflective bounces off the edges of the canvas, tracing the same trajectory each time. Many animated programmes will involve some kind of random behaviour, and students will quickly want to know how they can implement random processes in their own code.

Although it is certainly possible to use either the Math.random method or the Random class in java.util for this purpose, there are a couple of pedagogical advantages to using the RandomGenerator class in theacm.util package instead:

1. The name of the class emphasizes that a RandomGenerator object is a *generator* for random values and not a random value in itself. When students use the Random class, they are much more likely to create a newRandom instance for each value they wish to generate.
2. The RandomGenerator class offers several additional methods that are often much easier to use than those in the base class.

Useful Methods in the RandomGenerator Class

Factory Method

```
  static RandomGenerator getInstance()
    Returns a standard random generator.
   Methods inherited from the Random class in java.util

  int nextInt(int n)
     Returns a random integer chosen from the n values in
the range 0 to n - 1, inclusive.
  double nextDouble()
      Returns a random double d in the range
0 ¾ d < 1.
```

```
  void nextBoolean()
    Returns a random boolean that is true approximately 50%
of the time.
  void setSeed(long seed)
     Sets a "seed" to indicate a starting point for the
pseudorandom sequence.

   Additional methods defined by RandomGenerator

  int nextInt(int low, int high)
     Returns a random integer in the specified range
(inclusive).
  double nextDouble(double low, double high)
    Returns a random double in the specified range.
  boolean nextBoolean(double p)
    Returns a random boolean that is true with probability
p (0 = never, 1 = always).
  Colour nextColor()
    Returns a random opaque colour.
```

The conventional pattern for using the RandomGenerator class is to declare and initialize an instance variable to hold the generator using the line

```
private RandomGenerator rgen = RandomInteger.getInstance();
```

Once this declaration is made, every method in this class can then generate new random values by invoking the appropriate method on the rgen variable. For example, you could use this strategy in the BouncingBallprogram to initialize each velocity component of the ball to a random value between –3 and 3:

```
dx = rgen.nextDouble(-3, 3);
dy = rgen.nextDouble(-3, 3);
```

The RandomShapes programme makes more extensive use of the facilities of the RandomGenerator class. The programme generates ten shapes and positions them on the canvas using randomness in each of the following ways:

- The shapes are randomly chosen to be rectangles, ovals, or stars. The stars are represented internally using the GStar class define.

- The shapes are given a random size that ranges between MIN_SIZE and MAX_SIZE in each dimension.
- The shapes are positioned randomly on the canvas subject to the condition that the entire shape must fit inside the boundaries.
- The shape is filled in a random colour.

Most of RandomShapes programme is reasonably straightforward, but there are nonetheless a few aspects of the code that are easier to understand with some additional explanation:

- The code for the run method includes a while loop that allows the user to generate a new set of shapes by clicking the mouse. The waitForClick method was introduced earlier in the chapter in the discussion of the bouncing ball programmes and simply waits for a mouse click.
- The calculation of the random coordinate positions seems slightly more complex that necessary. At first glance, it would seem as if one could ensure that the entire figure was inside the canvas by writing

```
double x = rgen.nextDouble(0, getWidth() - gobj.getWidth());
double y = rgen.nextDouble(0, getHeight() - gobj.getHeight());
```

- While that code would be sufficient for the GRect and GOval objects that have their reference point in the upper left corner, it doesn't work for figures like GStar for which the reference point is inside the figure. ThegetBounds method returns the actual bounding box of the figure, which means that gobj.getBounds().getX() returns the actual *x*

coordinate of the left edge of the figure. You can make sure that the figure fits on the screen by adjusting the coordinates to compensate for the shift in origin.

The RandomGenerator class from the java.util class has applications in a wide variety of contexts beyond graphical animation.

In our experience it is far and away the most widely used class in the java.utilpackage.

Programme to Generate Random Shapes

```
/*
 * File: RandomShapes.java
 * ———————————
  * This file creates ten boxes, ovals, and stars at
random locations
 * on the screen, pausing for a suitable interval between
each one.
 */

import acm.graphics.*;
import acm.programme.*;
import acm.util.*;

public class RandomShapes extends GraphicsProgram {

/** Runs the programme */
    public void run() {
        while (true) {
            for (int i = 0; i < NOBJECTS; i++) {
                addOneRandomShape();
                pause(PAUSE_TIME);
            }
            waitForClick();
            removeAll();
        }
    }
/* Adds a random shape to the canvas */
    private void addOneRandomShape() {
        GObject gobj = createRandomShape();
        gobj.setColor(rgen.nextColor());
```

```
            if (gobj instanceof GFillable) ((GFillable)
gobj).setFilled(true);
            double x = rgen.nextDouble(0, getWidth() -
gobj.getWidth())
                  - gobj.getBounds().getX();
       double y = rgen.nextDouble(0, getHeight() -
gobj.getHeight())
                  - gobj.getBounds().getY();
         add(gobj, x, y);
     }

  /* Generates a random shape whose reference point is the
origin */
     private GObject createRandomShape() {
        double width = rgen.nextDouble(MIN_SIZE, MAX_SIZE);
        double height = rgen.nextDouble(MIN_SIZE, MAX_SIZE);
         switch (rgen.nextInt(3)) {
          case 0: return new GRect(width, height);
          case 1: return new GOval(width, height);
            case 2: return new GStar(width);
          default: throw new ErrorException("Illegal shape
index");
         }
     }

  /* Private constants */
     private static final int NOBJECTS = 10;
     private static final int PAUSE_TIME = 1000;
     private static final double MIN_SIZE = 25;
     private static final double MAX_SIZE = 150;
  /* Private instance variables */
            private RandomGenerator rgen =
RandomInteger.getInstance();
  }
```

Cyclic Animation

The Delight of Visual Rhythms

Human beings find aural and visual rhythms immensely satisfying. In fact we are pattern seekers and take great pleasure in notions of 'return' and the familiar. Animators have taken advantage of this human disposition.

Cycles - Cutting Down the Work

There are lots of tricks that animators constantly use to cut down the amount of work to be done. Cycles of repeating action are just one of these ways - and whenever animators find an opportunity to include a cycle in a sequence, you can bet they will seize upon it.

Some of the very early cartoons were almost entirely based on cyclic actions, especially when it was discovered that animation could echo the rhythmic patterns found in music. Walt Disney's 1928 'Steamboat Willie' was the first sound cartoon to amaze audiences of the day with its close synchronism between image and sound. This relationship was exploited to the hilt, (giving rise to the term 'Mickey Mousing' - a sound track which follows exactly what the image is doing) as was the use of cyclic animation which took its cues from the repeated phases and beats of the musical score.

Types of Cyclic Action

Cycles can be cyclic in nature, that is, the artwork is used in order 1,2,3,4 followed by exact repeats of that order again 1,2,3,4 etc. This type of cycle is useful for representing things like a wheel spinning. Cycles may also oscillate. That is the artwork is used in order 1,2,3,4 but then the artwork is used in reverse order 4,3,2,1 to return to the start position again etc. - like the motion of a clock pendulum. Or indeed cycles can be random, 1,4,3,1,2,4,3,1,2, etc. - to mimic a flag fluttering wildly in a stiff breeze. Using the technique of cycle animation, it is possible for the animator to reuse such a sequence of drawings over and over again to build up screen time without any additional effort. Some cycles may consist

of only two drawings, while others may be involve several tens of complex actions.

Animation and Visual Effects

The Animation & Visual Effects Programme offers students an understanding of the animation film-making process; from the story idea to the final film. Students will gain knowledge of the animation sector and build a strong portfolio which enables them to step out into the world confidently. The programme has been designed to meet the needs of the three stages of Design Pedagogy which are Design for Business, Design for Humanity and Design as Experimentation. Each sector of this programme feeds in to high-end skills, that helps students to work with the above stages effectively.

2D Animation Programme

The courses offered here begin with learning various concepts such as line of action, perspective, balance, weight & composition followed by different styles of drawings, gesture drawing, anatomy drawings, environment & props and from character design to Storyboarding & Animatics. This programme allows students to gain deeper understanding of the basic and advanced levels of animation and also takes them through the traditional methods followed, by learning software skills such as Flash, Adobe and After Effects.

3D Animation Programme

Courses begin with sculpture making and taking the student through an orientation programme to benefit students from traditional artistic backgrounds as also for those who are new to the 3D medium. Courses such as 3D

Modelling, Texturing, and Rigging (Character Setup), Animation, Lighting & Rendering, help students to explore a wide range of possibilities to apply their knowledge in animation film making or for design purposes.

Compositing & Visual Effects Programme

This programme helps the students to develop an eye for detail when it comes to 3D Film-making, Television Commercials or producing Vfx for films. Courses covered include Motion Graphics, Basic & Advanced levels of compositing, Post production techniques and Match Moving, which help students to produce stunning visual effects according to their requirements.

Internship

Internship practice provides students with real life challenges to meet the needs of the industry and professional standards; this experience allows them to test and practice their acquired creative & technical talents to the extreme. Internship offers students an opportunity to work with some leading professional Animation & VFX studios and Professional artists.

Limited Animation

Limited animation is a process of making animated cartoons that does not redraw entire frames but variably reuses common parts between frames. One of its major trademarks is the stylized design in all forms and shapes, which in the early days was referred to as modern design. The short cartoons and feature films of Walt Disney from the 1930s and 1940s are widely acclaimed for depicting

animated simulations of reality, with exquisite detail in every frame. However, this style of animation is very time-consuming and expensive. "Limited" animation creates an image that uses abstract art, symbolism, and fewer drawings to create the same effect, but at a much lower production cost. This style of animation depends upon animators' skill in emulating change without additional drawings; improper use of limited animation can be easily recognized as unnatural. It also encourages the animators to indulge in artistic styles that are not necessarily bound to the limits of the real world. The result is a new artistic style that could not have developed if animation was solely devoted to producing simulations of reality. Without limited animation, such ground-breaking films as *Yellow Submarine*, Chuck Jones' *The Dot and the Line*, and many others could never have been produced. The process of limited animation mainly aims at reducing the overall number of drawings. Film is projected at 24 frames per second. For movements in normal speed, most animation in general is done "on twos," meaning 12 drawings per second are recorded meaning that each drawing uses two frames of film. Faster movements may demand animation "on ones," while characters that do not move may be done with a single drawing (a "hold") for a certain amount of time. It is said that the Disney average was about 18 drawings per second, pretending that all characters of a scene share the same sheet of paper. Limited animation mainly reduces the number of inbetweens, the drawings between the keyframes which define a movement, and can cause stuttering if inbetweens are poorly setup. Overall, the use of limited animation does not necessarily

imply lower quality as it allows the use of many timesaving techniques that can improve the quality and flow of the keyframes and overall presentation of an animation.

History

The use of budget-cutting animation measures in animation dates at least to the 1930s; a handful of the Bosko cartoons in the early years of the *Looney Tunes* series used several visible tricks to give the shorts the comparable appearance of the Disney shorts of the same era, even though they were produced on a budget of just over half of their Disney counterparts. The 1942 *Merrie Melodies* short "The Dover Boys" was a particular early prototype of the use of limited animation, though pressure from Warner Bros. curtailed much further use of the technique. Limited animation was originally founded as an artistic device, though it was soon used widely as a cost-cutting measure rather than an aesthetic method. The UPA studio made the first serious effort to abandon the keyframe heavy approach perfected by Disney. Their first effort at limited animation, *Gerald McBoing-Boing*, won an Oscar, and it provided the impetus for this animation method to be accepted at the major Hollywood cartoon studios, including Warner Brothers and MGM. However, the real attraction of limited animation was the reduction in costs: because limited animation does not require as many drawings as fully keyframed animations, it is much less expensive to produce. The 1950s saw all of the major cartoon studios change their style to limited animation, to the point where painstaking detail in animation occurred only rarely. Limited animation techniques in

America were used during the 1960s and 1970s to produce a great number of inexpensive Saturday morning cartoons. Such TV series as *Clutch Cargo* are known for being produced on extremely low budgets, with camera tricks used in place of actual animation. Despite the low quality of the animation, the TV cartoon studios Hanna-Barbera, Jay Ward and Filmation thrived during this period. The desire of the time to emulate full animation with limited animation led to many highly apparent visual issues.

Techniques

These techniques used to produce cartoons on a reduced budget included:

- cels and sequences of cels were used repeatedly — animators only had to draw a character walking once.
- characters are split up into different levels: only portions of a character, such as the mouth or an arm, would be animated on top of a static cel.
- clever choice of camera angles and editing.
- use of camera techniques such as panning to suggest movement. A famous implementation of this is the "crash" technique, which involves the camera shaking rapidly back and forth to simulate a shock wave.
- "smear animation:" movement is rapid and portrayed in only three frames: the beginning state, the ending state, and a "blur" frame similar to that of a picture taken with a camera that had a low shutter speed.
- cel reversal (simply using a mirror image of the cell to represent the opposite angle). Many cartoon

characters are drawn symmetrically to expedite this technique.

- the visual elements were made subsidiary to audio elements, so that verbal humor and voice talent became more important factors for success ("talking heads").
- silhouette helped avoid having to keep track of shading on an animated character or object.
- sliding a cel across a background to suggest movement.
- Stock footage: sequences that are reused frequently. This is the case of the character transformations in the Magical girls subgenre of Japanese anime series. Filmation used this strategy for much of its productions.
- extensive recaps of previous episodes or segments, to cut down on the amount of new material necessary (used often in serials).
- The most egregious case of limited animation, known as Syncro-Vox, involved pasting a film of the moving lips of a real-life person over a still frame of an "animated" character to give the appearance that the character is doing the talking. Cambria Studios held a patent on the technology, and as such, it was primarily used on their productions, such as *Clutch Cargo*.

Examples

Animated cartoons which made use of limited animation include Gerald McBoing-Boing, Rooty Toot Toot, Mister Magoo, The Rocky and Bullwinkle Show, The Pink Panther, Clutch Cargo, and Kinnikuman. In recent years, nostalgia

for the 1970s, combined with technologies such as Adobe Flash, have led to a revival of the genre of limited animation. Also, some modern graphic styles naturally translate into limited animation. Much of Japanese animation (anime) makes use of techniques adapted from limited animation. Osamu Tezuka started to use this technique in *Astro Boy* in order to save money and time. However, the technique is now combined with manga styles and aesthetics, and is a very distinct style.

Limited animation in anime is frequently used in action scenes such as mecha battles or transformation scenes. Limited animation is seen most frequently in television serials, but the aesthetic is so grounded in the medium that even bigger-budget feature films make use of it. Most Japanese animation is significantly less expensive than its American counterparts as a result, with Hayao Miyazaki's *Ponyo* (the most expensive Japanese animated feature film yet produced) costing only $34,000,000.

Rotoscoping

Rotoscoping is an animation technique in which animators trace over live-action film movement, frame by frame, for use in animated films. Originally, recorded live-action film images were projected onto a frosted glass panel and re-drawn by an animator. This projection equipment is called a rotoscope, although this device has been replaced by computers in recent years. In the visual effects industry, the term rotoscoping refers to the technique of manually creating a matte for an element on a live-action plate so it may be composited over another background.

History

The technique was invented by Max Fleischer, who used it in his series *Out of the Inkwell* starting around 1915, with his brother Dave Fleischer dressed in a clown outfit as the live-film reference for the character Koko the Clown. Max patented the method in 1917. Fleischer used rotoscoping in a number of his later cartoons, most notably the Cab Calloway dance routines in three Betty Boop cartoons from the early 1930s, and the animation of Gulliver in *Gulliver's Travels* (1939). The Fleischer studio's most effective use of rotoscoping was in their series of action-oriented *Superman cartoons*, in which Superman and the other animated figures displayed very realistic movement. Leon Schlesinger Productions, which produced the *Looney Tunes* and *Merrie Melodies* for Warner Bros., producing cartoons geared more towards exaggerated comedy, used rotoscoping only occasionally. Walt Disney and his animators employed it in *Snow White and the Seven Dwarfs* in 1937. Rotoscoping was also used in many of Disney's subsequent animated feature films with human characters, such as *Cinderella* in 1950. From the latter film onwards, the rotoscope was used mainly for studying human and animal motion, rather than actual tracing. Rotoscoping was used extensively in China's first animated feature film, *Princess Iron Fan* (1941), which was released under very difficult conditions during the Second Sino-Japanese War and World War II. It was used extensively in the Soviet Union, where it was known as "Éclair", from the late 1930s to the 1950s; its historical use was enforced as a realization of Socialist Realism. Most of the films produced with it were adaptations of folk tales or poems -

for example, *The Night Before Christmas* or *The Tale of the Fisherman and the Fish*. Only in the early 1960s, after the Khrushchev Thaw, did animators start to explore very different aesthetics. The film crew on the Beatles animated film *Yellow Submarine* employed rotoscoping in numerous instances, most notably the sequence for "Lucy in the Sky with Diamonds." Ralph Bakshi used the technique quite extensively in his animated movies *Wizards* (1977), *The Lord of the Rings* (1978), *American Pop* (1981), and *Fire and Ice* (1983). Bakshi first turned to rotoscoping because he was refused by 20th Century Fox for a $50,000 budget increase to finish *Wizards*, and thus had to resort to the rotoscope technique to finish the battle sequences. Rotoscoping was also used in *Heavy Metal* (1981), three of a-ha's music videos, "Take on Me" (1985), "The Sun Always Shines on T.V." (1985), and "Train of Thought" (1986), and Don Bluth's *Titan A.E.* (2000). While rotoscoping is generally known to bring a sense of realism to larger budget animated films, the American animation company Filmation, known for its budget-cutting limited TV animation, was also notable for its heavy usage of rotoscope to good effect in series such as *Flash Gordon*, *Blackstar*, and *He-Man and the Masters of the Universe*. Smoking Car Productions invented a digital rotoscoping process in 1994 for the creation of its critically-acclaimed adventure video game, *The Last Express*. The process was awarded U.S. Patent 6,061,462, *Digital Cartoon and Animation Process*.

In the mid-1990s, Bob Sabiston, an animator and computer scientist veteran of the MIT Media Lab, developed a computer-assisted "interpolated rotoscoping" process

which he used to make his award-winning short film "Snack and Drink." Director Richard Linklater subsequently employed Sabiston's artistry and his proprietary Rotoshop software in the full-length feature films *Waking Life* (2001) and *A Scanner Darkly* (2006). Linklater licensed the same proprietary rotoscoping process for the look of both films. Linklater is the first director to use digital rotoscoping to create an entire feature film. Additionally, a 2005-08 advertising campaign by Charles Schwab uses Sabiston's rotoscoping work for a series of television spots, under the tagline "Talk to Chuck."

Technique

Rotoscope output can have slight deviations from the true line that differ from frame to frame, which when animated cause the animated line to shake unnaturally, or "boil". Avoiding boiling requires considerable skill in the person performing the tracing, though causing the "boil" intentionally is a stylistic technique sometimes used to emphasize the surreal quality of rotoscoping, as in the music video "Take on Me" and animated TV series *Delta State*. Rotoscoping (often abbreviated as "roto") has often been used as a tool for visual effects in live-action movies. By tracing an object, a silhouette (called a matte) is created that can be used to extract that object from a scene for use on a different background. While blue and green screen techniques have made the process of layering subjects in scenes easier, rotoscoping still plays a large role in the production of visual effects imagery.

Rotoscoping in the digital domain is often aided by motion tracking and onion-skinning software. Rotoscoping is often

used in the preparation of garbage mattes for other matte-pulling processes. Rotoscoping has also been used to allow a special visual effect (such as a glow, for example) to be guided by the matte or rotoscoped line. One classic use of traditional rotoscoping was in the original three *Star Wars* films, where it was used to create the glowing lightsaber effect, by creating a matte based on sticks held by the actors. To achieve this, editors traced a line over each frame with the prop, then enlarged each line and added the glow.

Examples

Animated Films

- *Peace on Earth* (1939)
- *Gulliver's Travels* (1939)
- *Princess Iron Fan* (1941)
- The 1940s Superman cartoons
- *Yellow Submarine* (1968) (most notably during the Lucy in the Sky with Diamonds sequence; other scenes)
- *Taekwon V* (1976)
- *Wizards* (1977)
- *The Lord of the Rings* (1978)
- *Heavy Metal* (1981)
- *Fire and Ice* (1983)
- *My Neighbors the Yamadas* (1999) (baseball game television footage; scene where Takashi Yamada confronts hooligans)
- *Year of the Fish* (2008)
- *Disney's Snow White* (1937)
- *Disney's Beauty and the Beast* (1991)

Live Action Films

- *The Birds* (1963)
- *Star Wars trilogy* (lightsaber effects)
- *Tron* (1982)
- *Ghostbusters* (1984)
- *Who Framed Roger Rabbit* (1988)
- *Forrest Gump* (1994) (Rotoscoping was used to integrate the title character into footage of famous events)
- *Waking Life* (2001)
- *Flags of Our Fathers* (2006) (Rotoscoping was used instead of blue screens i.e. to integrate the CGI naval backdrops)
- *Cicak Man* (2006)
- *Juno* (2007)
- *A Scanner Darkly* (2006)

Video Games

- *Karateka* (1984)
- *Prince of Persia* (1989)
- *Another World* (1991)
- *Flashback* (1992)
- *Commander Blood* (1994)
- *Lester the Unlikely* (1994)
- *The Last Express* (1997)
- *Hotel Dusk: Room 215* (2007)
- *Last Window: The Secret of Cape West* (2010)

Music Videos

- "The One That Got Away" by Tom Waits directed by John Lamb(1976)
- "Thumper" by Enter Shikari
- "Save Me" by Queen
- "Take on Me", "Train of Thought", and briefly in "The Sun Always Shines on T.V." by a-ha
- "Brothers in Arms" by Dire Straits
- "Money for Nothing" by Dire Straits
- "Shadrach" by Beastie Boys
- "The Kids Aren't Alright" by The Offspring
- "Get in Line" by Barenaked Ladies
- "Destiny" by Zero 7
- "Drive" by Incubus
- "Breaking the Habit" by Linkin Park
- "Rip It Up" by Jet
- "Shoot the Runner" by Kasabian
- "Heartless" by Kanye West
- "My Delirium" by Ladyhawke
- "Guilty Conscience" by Eminem
- "12:51" by The Strokes
- "11th Dimension" by Julian Casablancas
- "Frijolero" by Molotov
- "Baby I'm Yours" by Breakbot, animation by Irina Dakeva

Television Shows

- *Delta State*

- *The New Adventures of Flash Gordon* (Filmation 1979-1980)
- "Major Boobage" (South Park episode)
- *American Idol*

Miscellanea

- Skwisgaar Skwigelf lesson on the Dethklok season 1 DVD.
- Opening intros for "Michael Jackson's Vision"

Animatronics

Animatronics is the use of electronics and robotics in mechanised puppets to simulate life. Animatronics are mainly used in movie making, but also in theme parks and other forms of entertainment. Its main advantages to CGI and stop motion is that it is not a simulation of reality, but rather physical objects moving in real time in front of the camera.

The technology behind animatronics has become more advanced and sophisticated over the years, making the puppets even more realistic and lifelike. Animatronics for film and television productions are used to perform action on camera in situations where the action involves creatures that do not exist, the action is too risky or costly to use real actors or animals, or the action could never be obtained with a living person or animal. The application of animatronics today includes computer controlled as well as radio and manually controlled devices. The actuation of specific movements can be obtained with electric motors, pneumatic cylinders, hydraulic cylinders and cable driven

mechanisms. The type of mechanism employed is dictated by the character parameters, specific movement requirements and the project constraints.

Wire Frame Model

wire frame model is a visual presentation of a three dimensional or physical object used in 3D computer graphics. It is created by specifying each edge of the physical object where two mathematically continuous smooth surfaces meet, or by connecting an object's constituent vertices using straight lines or curves.

The object is projected onto the computer screen by drawing lines at the location of each edge. Using a wire frame model allows visualization of the underlying design structure of a 3D model. Traditional 2-dimensional views and drawings can be created by appropriate rotation of the object and selection of hidden line removal via cutting planes.

Since wireframe renderings are relatively simple and fast to calculate, they are often used in cases where a high screen frame rate is needed (for instance, when working with a particularly complex 3D model, or in real-time systems that model exterior phenomena). When greater graphical detail is desired, surface textures can be added automatically after completion of the initial rendering of the wireframe. This allows the designer to quickly review changes or rotate the object to new desired views without long delays associated with more realistic rendering. The wire frame format is also well suited and widely used in programming tool paths for DNC (Direct Numerical Control) machine tools.

Motion Graphic Design

Motion Design is a subset of graphic design in that it uses graphic design principles in a film or video context (or other temporally evolving visual medium) through the use of animation or filmic techniques. Examples include the typography and graphics you see as the titles for a film, or opening sequences for television or the spinning, web-based animations, three-dimensional logo for a television channel. About 12 minutes in every hour of broadcast television is the work of the motion graphics designer, yet it is known as the invisible art, as many viewers are unaware of this component of programming. Although this art form has been around for decades, it has taken quantum leaps forward in recent years, in terms of technical sophistication. If you watch much TV or see many films, you will have noticed that the graphics, the typography, and the visual effects within this medium have become much more elaborate and sophisticated.

Technology

The elevation of this art form is largely due to technology improvements. Computer programmes for the film and video industry have become vastly more powerful and more available. Probably the leading programme used by motion graphic designers is Adobe After Effects, which allows them to create and modify graphics over time. Adobe After Effects is sometimes referred to as “Photoshop for film.” A relatively recent product in the market is Apple Inc. Motion, now a part of Final Cut Studio. Adobe Flash is widely used to create motion design for the web. A typical motion designer

is a person trained in traditional graphic design who has learned to integrate the elements of time, sound and space into his/her existing skill-set of design knowledge. Motion designers can also come from filmmaking or animation backgrounds.

2

Focus on Architectural Animation

Architectural Animation

Architectural Animation is a short architectural movie created on a computer. A computer-generated building is created along with landscaping and sometimes moving people and vehicles. Unlike an architectural rendering, which is a single image from a single point of view, an architectural animation is a series of hundreds or even thousands of still images. When these images are assembled and played back they produce a movie effect much like a real movie camera except all images are artificially created by computer. It is possible to add a computer-created environment around the building to enhance reality and to better convey its relationship to the surrounding area; this can all be done before the project is built giving designers and stakeholders a realistic view of the completed project. Architectural renderings are often used along with architectural animation.

Uses

Commercial demand for computer-generated rendering is on the rise, but three-dimensional scale models are still popular. Typically members of the AIA (American Institute of Architects) and NAHB (National Association of Home Builders) prefer to use 3D animations and single renderings for their customers before starting on a construction project. These professionals often find their clients are unable to grasp the complexity and spacial qualities of large projects without the help of computer generated visual aids. The animations and renderings are usually supplied by small animation studios.

Future

Architectural animation is not considered to be the ambition of most small computer rendering firms because of the man hours and computer rendering time that is required to create so many single still images. Not all studios have the software to assemble and incorporate them into a moving sequence. Some smaller companies specialize in high quality single frame computer renderings. Architectural animations require a larger team of artists and animators than single renderings and a much longer time frame is required to complete an animation project. However, many architectural firms are now using architectural animation because it attracts investors and customers who may not know much about building designs. Architectural animation is considered to have a bright future ahead of it as more and more architects and real estate developers are including computer animations in their marketing programmes.

- Architectural visualization:
  3D rendering
  3D walk-through
  3D demo of city planning
  3D demo of landscape planning
  Restoration of ancient architecture
- Animation:
  Rendering
  Simulation of product and engineering design
- Virtual Reality:
  Digital sand-table system for city/community planning
  GIS (Geographic information system)
  Multifunctional educational system
  Simulation and restoration of cultural heritage and ancient architecture
  Virtual shopping mall.

Whole Building Design Guide

The Whole Building Design Guide or WBDG is the most used online resource for building information in the world, with over 500,000 distinct users per month and over 3 million document downloads according to data as of January 2011.

The online portal covers a wide range of topics, from performance and sustainability to security and resilience. WBDG is based on the premise that to create a successful high-performance building, one must apply an integrated design and team approach in all phases of a project, including

planning, design, construction, operations and maintenance. The WBDG is managed by the National Institute of Building Sciences.

History

The WBDG was initially designed to serve U.S. Department of Defense (DOD) construction programmes. A 2003 DOD memorandum named WBDG the "sole portal to design and construction criteria produced by the U.S. Army Corps of Engineers (USACE), Naval Facilities Engineering Command (NAVFAC), and U.S. Air Force." Since then, WBDG has expanded to give all building industry professionals free, wide access to federal and other design, construction and performance criteria. The WBDG is public and freely available to anyone. The majority of users are from the private sector. The WBDG draws information from the Construction Criteria Base and a privately-owned database run by Information Handling Services.

A significant amount of the Whole Building Design Guide content is organized by three categories: Design Guidance, Project Management, and Operations and Maintenance. It is structured to provide WBDG visitors first a broad understanding then increasingly specific information more targeted towards building industry professionals. WBDG is the resource that federal agencies look to for policy and technical guidance on Federal High Performance and Sustainable Buildings In addition, the WBDG contains online tools, the original Construction Criteria Base, Building Information Modeling guides and libraries, a database of select case studies, federal mandates and other resources.

The WBDG also provides online continuing education courses for architects and other building professionals, free of charge.

Development

Development of the WBDG is a collaborative effort among federal agencies, private sector companies, non-profit organizations and educational institutions. Its success depends on industry and government experts contributing their knowledge and experience to better serve the building community.

The WBDG web site is offered as an assistant to the building community by the National Institute of Building Sciences through funding support from the DOD, the NAVFAC Engineering Innovation and Criteria Office, U.S. Army Corps of Engineers, the U.S. Air Force, the U.S. General Services Administration (GSA), the U.S. Department of Veterans Affairs, the National Aeronautics and Space Administration (NASA), and the U.S. Department of Energy (DOE), and the assistance of the Sustainable Buildings Industry Council (SBIC). A Board of Direction and an Advisory Committee consisting of representatives from over 25 participating federal agencies guide the development of the WBDG.

Virtual Design and Construction

Virtual Design to Construction (VDC) is the management of integrated multi-disciplinary performance models of design-construction projects, including the Product (i.e., facilities), Work Processes and Organization of the design - construction - operation team in order to support explicit and public business objectives.

The theoretical basis of VDC includes:

- Engineering modeling methods: product, organization, process
- Analysis methods (model-based): including schedule, cost, 4D interactions and process risks, these are termed BIM tools
- Visualization methods
- Business metrics and focus on strategic management
- Economic Impact analysis (i.e., models of both the cost and value of capital investments)

VDC Project Manager

"The production of a Building Information Model (BIM) for the construction of a project involves the use of an integrated multi-disciplinary performance model to encompass the building geometry, spatial relationships, geographic information, along with quantities and properties of the building components. The Virtual Design to Construction Project Manager (VDC - also known as VDCPM) is a professional in the field of project management and delivery.

The VDC is retained by a design build team on the clients' behalf from the pre-design phase through certificate of occupancy in order to develop and to track the object oriented BIM against predicted and measured performance objectives. The VDC manages the project delivery through multi-disciplinary building information models that drive analysis, schedules, take-off, and logistics. The VDC is skilled in the use of BIM as a tool to manage and assess the technology, staff, and procedural needs of a project. In

short the VDC is a contemporary project managing architect who is equipped to deal with the current evolution of project delivery. The VDC acts as a conduit to bridge time tested construction knowledge to digital analysis and representation. VDC position avoids the well intentioned failures created by competent managers who lack the knowledge to implement the technology for which they are entrusted.

Recent economic conditions have placed a spot light on industry wide deficiency in the organization of architectural staff, the lack of interoperability of project generated information, and the amount of non-beneficial redundancy which eventually finds its way to the client through an inferior project with increased cost. The VDC fulfills a critical role in contemporary project delivery in part due to the single platform integration of sketch tools, massing, solid modeling, analysis, & rendering organized within a singular object change engine.

Available technology removes the need for digital redundancies and file conversions at each stage of design. Information can be tracked and managed from inception to project delivery with the use of a qualified VDC who secures the clients return on investment by tracking stated project performance objectives. The development of virtual design tools from 1957 to 2007 has created a digital landfill of applications, many whose continued use has hindered progress all the while accelerating Architect, Engineering, Contractor costs without increased accuracy, efficiency, or integration of disciplines."

VDC Managed BIM Project Model

"Virtual Design to Construction BIM models are virtual because they show computer-based descriptions of the project. The BIM project model emphasizes those aspects of the project that can be designed and managed, i.e., the *product* (typically a building or plant), the *organization* that will define, design, construct and operate it, and the *process* that the organization teams will follow, or POP. These models are logically integrated in the sense that they all can access shared data, and if a user highlights or changes an aspect of one, the integrated models can highlight or change the dependent aspects of related models. The models are multi-disciplinary in the sense that they represent the Architect, Engineering, contractor (AEC) and Owner of the project, as well as relevant sub disciplines. The models are performance models in the sense that they predict some aspects of project performance, track many that are relevant, and can show predicted and measured performance in relationship to stated project performance objectives. Some companies now practice the first steps of BIM modeling, and they consistently find that they improve business performance by doing so."

Construction Industry BIM Tools and Methodologies Utilized by VDC

BIM Software Tools

- ArchiCAD from Graphisoft
- Building Explorer
- Autodesk Navisworks JetStream 4D
- Autodesk Revit

- Autodesk AutoCAD Civil 3D
- Tekla Structures from Tekla Corporation
- Advance Concrete
- Advance Steel
- Microstation

VDC Related Methodologies

- Semantic integration
- Learning-by-doing
- Deductive-nomological model
- Scientific evidence
- Hypothesis
- Qualitative research
- Quantitative research
- Case-based reasoning
- Action research
- Power of a method
- Upper ontology within the Ontology domain
- Schema representation
- Work breakdown structure
- Object-oriented programming

3D Floor Plan

A 3D floor plan, or 3D floorplan, is a virtual model of a building floor plan, depicted from a birds eye view, utilized within the building industry to better convey archtitectural plans. Usually built to scale, a 3D floor plan must include walls and a floor and typically includes exterior wall fenestrations, windows, and doorways. It does not include

a ceiling so as not to obstruct the view. Other common attributes may be added, but are not required, such as cabinets, flooring, bathroom fixtures, paint color, wall tile, and other interior finishes. Furniture may be added to assist in communicating proper home staging and interior design.

Purpose

3D floor plans assist real estate marketers and architects in explaining floor plans to clients. Their simplicity allows individuals unfamiliar with conventional floor plans to understand difficult architectural concepts. This allows architects and homeowners to literally see design elements prior to construction and alter design elements during the design phase. 3D floorplans are often commissioned by architects, builders, hotels, universities, real estate agents, and property owners to assist in relating their floor plans to clients.

Construction

A 3d floor plan is built utilizing advanced 3d rendering software, the same type of software used to create major animated motion pictures. Through complex lighting, staging, camera, and rendering techniques 3D floorplans appear to be real photographs rather than digital representations of the buildings they are modeled after.

Architectural Rendering

Architectural rendering, or architectural illustration, is the art of creating two-dimensional images or animations showing the attributes of a proposed architectural design.

Computer-generated Renderings

Also known as photo-real renderings, but not restricted to that and may also be depicted in none photo-real methods. Complex 3d modeling and rendering software is used to create life-like images. These are normally done for presentation, marketing and design analysis purposes. Architectural 3D models are to the right proportion, scale and even use real life textures, materials, colour and finishes. Photoreal renderings come in various types specific to their particular use:

- Still renderings
- Walk through and fly by animations (movie)
- Virtual Tours
- Realtime 3D Renderings
- Panoramic Renderings
- Light and Shadow (sciography) study renderings
- Renovation Renderings (photomontage)
- and others

3D photoreal renderings play major role in real estate sales. It also makes possible to take design related decisions well before the building is actually built. Thus it helps experimenting with building design and its visual aspects.

Education

Traditionally rendering techniques were taught in a "master class" practice (such as the École des Beaux-Arts), where a student works creatively with a mentor in the study of fine arts. Contemporary architects use hand-drawn sketches, pen and ink drawings, and watercolor renderings

to represent their design with the vision of an artist. Computer generated graphics is the newest medium to be utilized by Architectural Illustrators.

Awards

The Hugh Ferriss Memorial Prize is awarded by the American Society of Architectural Illustrators in recognition of excellence in the graphic representation of architecture. It is the Society's highest award.

Building Information Modeling

Building Information Modeling (BIM) is the process of generating and managing building data during its life cycle. Typically it uses three-dimensional, real-time, dynamic building modeling software to increase productivity in building design and construction. The process produces the Building Information Model (also abbreviated BIM), which encompasses building geometry, spatial relationships, geographic information, and quantities and properties of building components.

Origins of BIM

Charles M. Eastman at Georgia Tech coined the term BIM,. This theory is based on a view that the term BIM "Building Information Model" is basically the same as "Building Product Model", which Eastman has used extensively in his book and papers since the late 1970s. ('Product model' means 'data model' or 'information model' in engineering.)

Architect and Autodesk building industry strategist Phil Bernstein, FAIA, first used the actual term BIM "building

information modeling." Jerry Laiserin then helped popularize and standardize it as a common name for the digital representation of the building process as then offered primarily by Graphisoft, Bentley Systems, and Autodesk to facilitate exchange and interoperability of information in digital format. According to him and others, the first implementation of BIM was under the Virtual Building concept by Graphisoft's ArchiCAD, in its debut in 1987.

Definition

Building information modeling covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components (for example manufacturers' details). BIM can be used to demonstrate the entire building life cycle, including the processes of construction and facility operation. Quantities and shared properties of materials can be extracted easily. Scopes of work can be isolated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities. Dynamic information of the building, such as sensor measurements and control signals from the building systems, can also be incorporated within BIM to support analysis of building operation and maintenance. Under the guidance of a Virtual Design to Construction Project Manager (VDC) BIM can be seen as a companion to PLM as in the Product Lifecycle Management, since it goes beyond geometry and addresses issues such as Cost Management, Project Management and provides a way to work concurrently on most aspects of building life cycle processes.

BIM goes far beyond switching to a new software. It requires changes to the definition of traditional architectural phases and more data sharing than most architects and engineers are used to. BIM is able to achieve such improvements by modeling representations of the actual parts and pieces being used to build a building. This is a substantial shift from the traditional computer aided drafting method of drawing with vector file-based lines that combine to represent objects.

The interoperability requirements of construction documents include the drawings, procurement details, environmental conditions, submittal processes and other specifications for building quality.

It is anticipated by proponents that VDC utilizing BIM can bridge the information loss associated with handing a project from design team, to construction team and to building owner/operator, by allowing each group to add to and reference back to all information they acquire during their period of contribution to the BIM model.

For example, a building owner may find evidence of a leak in his building. Rather than exploring the physical building, he may turn to his BIM and see that a water valve is located in the suspect location. He could also have in the model the specific valve size, manufacturer, part number, and any other information ever researched in the past, pending adequate computing power.

Such problems were initially addressed by Leite et al. when developing a vulnerability representation of facility contents and threats for supporting the identification of

vulnerabilities in building emergencies There have been attempts at creating a BIM for older, pre-existing facilities.

They generally reference key metrics such as the Facility Condition Index (FCI). The validity of these models will need to be monitored over time, because trying to model a building constructed in, say 1927, requires numerous assumptions about design standards, building codes, construction methods, materials, etc., and therefore is far more complex than building a BIM at time of initial design. The American Institute of Architects has further defined BIM as "a model-based technology linked with a database of project information", and this reflects the general reliance on database technology as the foundation. In the future, structured text documents such as specifications may be able to be searched and linked to regional, national, and international standards.

Managing the BIM Model Guidelines

"The production of a Building Information Model (BIM) for the construction of a project involves the use of an integrated multi-disciplinary performance model to encompass the building geometry, spatial relationships, geographic information, along with quantities and properties of the building components. The Virtual Design to Construction Project Manager (VDC - also known as VDCPM) is a professional in the field of project management and delivery. The VDC is retained by a design build team on the clients' behalf from the pre-design phase through certificate of occupancy in order to develop and to track the object oriented BIM against predicted and measured performance

objectives. The VDC manages the project delivery through multi-disciplinary building information models that drive analysis, schedules, take-off, and logistics. The VDC is skilled in the use of BIM as a tool to manage and assess the technology, staff, and procedural needs of a project. In short the VDC is a contemporary project managing architect who is equipped to deal with the current evolution of project delivery. The VDC acts as a conduit to bridge time tested construction knowledge to digital analysis and representation."

BIM in the UK

In the UK, CPIC, responsible for providing best practice guidance on construction production information and formed by representatives of the major UK industry institutions, has proposed a definition of Building Information Modelling for adoption throughout the UK construction industry and has invited all UK industry parties to discuss it in order to ensure an agreed starting point. The proliferation of interpretations of the term currently hampers the adoption of a working method that will drastically improve the construction industry and the quality and sustainability of the deliveries from the design and construction team to clients.

BIM in the USA

Contractors

The Associated General Contractors and contracting firms also have developed a variety of working definitions of BIM that describe it generally as "an object-oriented building development tool that utilizes 5-D modeling concepts,

information technology and software interoperability to design, construct and operate a building project, as well as communicate its details." 5-D modeling concepts involve modeling not only the 3 primary spatial dimensions of X, Y, and Z; but also time as the 4th dimension and cost as the 5th.

Although the concept of BIM and relevant processes are being explored by contractors, architects and developers alike, the term itself is under debate, and it is yet to be seen whether it will win over alternatives, which include:

- Virtual Building Environment (VBE)
- Virtual Design to Construction Project Manager (VDC)

BIM is seen to be closely related to Integrated Project Delivery (IPD) where the primary motive is to bring the teams together early on the project. A full implementation of BIM also requires the project teams to collaborate from the inception stage and formulate model sharing and ownership contract documents.

BIM is often associated with IFCs (Industry Foundation Classes) and aecXML, which are data structures for representing information used in BIM. IFCs is developed by buildingSMART (International Alliance for Interoperability).

Other data structures are proprietary, and many have been developed by CAD firms that are now incorporating BIM into their software. One of the earliest examples of a nationally approved BIM standard is the AISC (American Institute of Steel Construction)-approved CIS/2 standard, a non proprietary standard with its roots in the UK.

Proponents claim that BIM offers:

1. Improved visualization
2. Improved productivity due to easy retrieval of information
3. Increased coordination of construction documents
4. Embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering
5. Increased speed of delivery
6. Reduced costs

In August 2004 the US National Institute of Standards and Technology (NIST) issued a report entitled "Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry" (NIST GCR 04-867 (PDF), which came to the conclusion that, as a conservative estimate, $15.8 billion is lost annually by the U.S. capital facilities industry resulting from inadequate interoperability due to "the highly fragmented nature of the industry, the industry's continued paperbased business practices, a lack of standardization, and inconsistent technology adoption among stakeholders".

BIM in France

In France, several bodies are pushing for a more integrated adoption of BIM standards, in order to improve software interoperability and cooperation among actors of the building industry. Examples are the FFB (Fédération française du bâtiment), or the French arm of buildingSMART International who are supporting IFCs.

On the other hand, software editing companies such as Vizelia were early adopters of IFCs and can now benefit from the full potential of BIM in the Green Building fast-emerging business.

Additional Resources

Books

BIG BIM little bim
Published October 2007
Written by Finith Jernigan, AIA
ISBN 978-0-9795699-0-6

Building Information Modeling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers
Published April 2009
Written by Dana K. Smith and Michael Tardif
ISBN 978-0-470-250003-7

Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations
Published April 2008
Written by Willem Kymmell
ISBN 978-0-07-149453-3

BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers
Published March 2008
Written by Chuck Eastman, Paul Teicholz, Rafael Sacks, and Kathleen Liston
ISBN 978-0-470-18528-5

Interoperable Methodologies and Techniques in CAD. Chapter 4.
Written by Semiha Kiziltas, Fernanda Leite, Burcu Akinci, Robert Lipman
In: CAD and GIS Integration
Published December 2009
Edited by Hassan Karimi, Burcu Akinci
ISBN 978-1-4200-6805-4

Green BIM: Successful Sustainable Design with Building Information Modeling
Published April 2008
Written by Eddy Krygiel, Brad Nies; foreword by Steve McDowell, FAIA, BNIM
ISBN 978-0-470-23960-5

BIM and Construction Management: Proven Tools, Methods and Workflows
Published May 2009
Written by Brad Hardin; foreword by Eddy Krygiel
ISBN 978-0-470-40235-1

Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies
Published December 2009
Written by Jason Underwood, Umit Isikdag; foreword by Dana K. Smith
ISBN 978-1-60566-928-1

Research Reports

McGraw-Hill Construction SmartMarket Report on BIM.

Published December 2008
Written by Stephen A Jones
Research with hundreds of current BIM users on implementation and ROI. Includes 4-page special section "Introduction to BIM".

The Business Value of BIM - McGraw-Hill Construction SmartMarket Report
Published December 2009
Written by Stephen A Jones
Study of BIM adoption in North America and the ways in which users are experiencing business value and generating ROI

Green BIM: How BIM is Contributing to Green Design and Construction - McGraw-Hill Construction SmartMarket Report
Published August 2010
Written by Stephen A Jones
Study of how the tools and processes of BIM are contributing to higher performing buildings, more environmentally responsible construction practices and achievement of green objectives during operations and maintenance.

The Business Value of BIM in Europe - McGraw-Hill Construction SmartMarket Report
Published October 2010
Written by Stephen A Jones
Study of how BIM is being adopted and implemented in 3 major European economies: France, Germany and UK. Includes comparisons

to North American data collected as part of 2009 SmartMarket Report on Business value of BIM in North America.

Videos

Thoughts on BIM by John Stebbins, CEO, Digital Vision Automation http://www.digitalvis.com/bim/

Anticipated Future Potential

BIM is a relatively new technology in an industry typically slow to adopt change. Yet many early adopters are confident that BIM will grow to play an even more crucial role in building documentation. BIM provides the potential for a virtual information model to be handed from Design Team (architects, surveyors, consulting engineers, and others) to Contractor and Subcontractors and then to the Owner, each adding their own additional discipline-specific knowledge and tracking of changes to the single model.

The result greatly reduces the information loss that occurs when a new team takes "ownership" of the project as well as in delivering extensive information to owners of complex structures. It also prevents errors made by design team members as well as the construction team (Contractors and Subcontractors) by allowing the use of conflict detection where the computer actually informs team members about parts of the building in conflict or clashing, and through detailed computer visualization of each part in relation to the total building. As computers and software become more capable of handling more building information, this will become even more pronounced than it is in current design and construction projects. This error reduction is a great

part of cost savings realized by all members of a project. Reduction in time required to complete construction directly contributes to the cost savings numbers as well. It's important to realize that this decrease can only be accomplished if the models are sufficiently developed in the Design Development phase. The Industry Foundation Classes (IFC/ifcXML) are an open specification for Building Information Modeling and are used to share and exchange BIM in a neutral format among various software applications.

Green Building XML (gbXML) is an emerging schema, a subset of the Building Information Modeling efforts, focused on green building design and operation. gbXML is used as input in several energy simulation engines. But with the development of modern computer technology, a large number of building energy simulation tools are available on the market. When choosing which simulation tool to use in a project, the user must consider the tool's accuracy and reliability, considering the building information they have at hand, which will serve as input for the tool. Yezioro, Dong and Leite developed an artificial intelligence approach towards assessing building performance simulation results and found that more detailed simulation tools have the best simulation performance in terms of heating and cooling electricity consumption within 3% of mean absolute error.

Traditional Animation

Traditional animation, also referred to as classical animation, cel animation, or hand-drawn animation, is the oldest and historically the most popular form of animation. In a traditionally-animated cartoon, each frame is drawn by

hand. The term "traditional animation" is often used in contrast with the now more commonly used computer animation.

Process

Storyboards

Traditionally-animated productions, just like other forms of animation, usually begin life as a *storyboard,* which is a script of sorts written with images as well as words, similar to a giant comic strip. The images allow the animation team to plan the flow of the plot and the composition of the imagery. The *storyboard artists* will have regular meetings with the director, and may have to redraw or "re-board" a sequence many times before it meets final approval.

Voice Recording

Before true animation begins, a preliminary soundtrack or "scratch track" is recorded, so that the animation may be more precisely synchronized to the soundtrack. Given the slow, methodical manner in which traditional animation is produced, it is almost always easier to synchronize animation to a pre-existing soundtrack than it is to synchronize a soundtrack to pre-existing animation. A completed cartoon soundtrack will feature music, sound effects, and dialogue performed by voice actors. However, the scratch track used during animation typically contains just the voices, any vocal songs that the characters must sing along to, and temporary musical score tracks; the final score and sound effects are added in post-production. In the case of most pre-1930 sound animated cartoons, the sound was *post-synched;* that is, the sound track was

recorded after the film elements were finished by watching the film and performing the dialogue, music, and sound effects required. Some studios, most notably Fleischer Studios, continued to post-synch their cartoons through most of the 1930s, which allowed for the presence of the "muttered ad-libs" present in many *Popeye the Sailor* and *Betty Boop* cartoons.

Animatic

Often, an *animatic* or *story reel* is made after the soundtrack is created, but before full animation begins. An animatic typically consists of pictures of the storyboard synchronized with the soundtrack. This allows the animators and directors to work out any script and timing issues that may exist with the current storyboard. The storyboard and soundtrack are amended if necessary, and a new animatic may be created and reviewed with the director until the storyboard is perfected. Editing the film at the animatic stage prevents the animation of scenes that would be edited out of the film; as traditional animation is a very expensive and time-consuming process, creating scenes that will eventually be edited out of the completed cartoon is strictly avoided.

In the mid 1970s, these were known as videomatics and used primarily for test commercial projects. Advertising agencies today employ the use of animatics to test their commercials before they are made into full up spots. Animatics use drawn artwork, with moving pieces (for example, an arm that reaches for a product, or a head that turns). Video storyboards are similar to animatics, but do

not have moving pieces. Photomatics are another option when creating test spots, but instead of using drawn artwork, there is a shoot in which hundreds of digital photographs are taken. The large amount of images to choose from may make the process of creating a test commercial a bit easier, as opposed to creating an animatic, because changes to drawn art take time and money. Photomatics generally cost more than animatics, as they require a shoot and on-camera talent.

Design and Timing

Once the animatic has been approved, it and the storyboards are sent to the design departments. Character designers prepare model sheets for all important characters and props in the film. These model sheets will show how a character or object looks from a variety of angles with a variety of poses and expressions, so that all artists working on the project can deliver consistent work. Sometimes, small statues known as *maquettes* may be produced, so that an animator can see what a character looks like in three dimensions. At the same time, the *background stylists* will do similar work for the settings and locations in the project, and the art directors and *colour stylists* will determine the art style and colour schemes to be used. While design is going on, the *timing director* (who in many cases will be the main director) takes the animatic and analyzes exactly what poses, drawings, and lip movements will be needed on what frames. An *exposure sheet* (or *X-sheet* for short) is created; this is a printed table that breaks down the action, dialogue, and sound frame-by-frame as a guide for the animators. If a film is based more strongly in music, a *bar*

sheet may be prepared in addition to or instead of an X-sheet. Bar sheets show the relationship between the on-screen action, the dialogue, and the actual musical notation used in the score.

Layout

Layout begins after the designs are completed and approved by the director. The layout process is the same as the blocking out of shots by a cinematographer on a live-action film. It is here that the background layout artists determine the camera angles, camera paths, lighting, and shading of the scene. Character layout artists will determine the major poses for the characters in the scene, and will make a drawing to indicate each pose. For short films, character layouts are often the responsibility of the director. The layout drawings and storyboards are then spliced, along with the audio and an animatic is formed(not to be confused by its predecessor the leica reel).The term "animatic" was originally coined by Disney animation studios.

Animation

Once the Animatic is finally approved by the director, animation begins. In the traditional animation process, animators will begin by drawing sequences of animation on sheets of transparent paper perforated to fit the peg bars in their desks, often using coloured pencils, one picture or "frame" at a time. A *key animator* or *lead animator* will draw the key drawings in a scene, using the character layouts as a guide. The key animator draws enough of the frames to get across the major points of the action; in a sequence of a character jumping across a gap, the key animator may

draw a frame of the character as he is about to leap, two or more frames as the character is flying through the air, and the frame for the character landing on the other side of the gap. Timing is important for the animators drawing these frames; each frame must match exactly what is going on in the soundtrack at the moment the frame will appear, or else the discrepancy between sound and visual will be distracting to the audience. For example, in high-budget productions, extensive effort is given in making sure a speaking character's mouth matches in shape the sound that character's actor is producing as he or she speaks. While working on a scene, a key animator will usually prepare a *pencil test* of the scene. A pencil test is a preliminary version of the final animated scene; the pencil drawings are quickly photographed or scanned and synced with the necessary soundtracks. This allows the animation to be reviewed and improved upon before passing the work on to his *assistant animators,* who will go add details and some of the missing frames in the scene. The work of the assistant animators is reviewed, pencil-tested, and corrected until the lead animator is ready to meet with the director and have his scene *sweatboxed*, or reviewed by the director, producer, and other key creative team members. Similar to the storyboarding stage, an animator may be required to re-do a scene many times before the director will approve it. In high-budget animated productions, often each major character will have an animator or group of animators solely dedicated to drawing that character.

The group will be made up of one supervising animator, a small group of key animators, and a larger group of

assistant animators. For scenes where two characters interact, the key animators for both characters will decide which character is "leading" the scene, and that character will be drawn first. The second character will be animated to react to and support the actions of the "leading" character. Once the key animation is approved, the lead animator forwards the scene on to the *clean-up department,* made up of the *clean-up animators* and the *inbetweeners.*

The clean-up animators take the lead and assistant animators' drawings and trace them onto a new sheet of paper, taking care in including all of the details present on the original model sheets, so that it appears that one person animated the entire film. The *inbetweeners* will draw in whatever frames are still missing *in between* the other animators' drawings. This procedure is called tweening. The resulting drawings are again pencil-tested and sweatboxed until they meet approval. At each stage during pencil animation, approved artwork is spliced into the Leica reel. This process is the same for both *character animation* and *special effects animation*, which on most high-budget productions are done in separate departments. *Effects animators* animate anything that moves and is not a character, including props, vehicles, machinery and phenomena such as fire, rain, and explosions.

Sometimes, instead of drawings, a number of special processes are used to produce special effects in animated films; rain, for example, has been created in Disney animated films since the late-1930s by filming slow-motion footage of water in front of a black background, with the resulting film superimposed over the animation.

Pencil Test

After all the drawings are cleaned-up, they are then photographed on an animation camera, usually on black, and white film stock. Nowadays, pencil tests can be made using a video camera, and computer software.

Backgrounds

While the animation is being done, the *background artists* will paint the sets over which the action of each animated sequence will take place. These backgrounds are generally done in gouache or acrylic paint, although some animated productions have used backgrounds done in watercolour, oil paint, or even crayon. Background artists follow very closely the work of the background layout artists and colour stylists (which is usually compiled into a workbook for their use), so that the resulting backgrounds are harmonious in tone with the character designs.

Traditional Ink-and-paint and Camera

When an entire sequence has been transferred to cels, the photography process begins. Each cel involved in a frame of a sequence is laid on top of each other, with the background at the bottom of the stack. A piece of glass is lowered onto the artwork in order to flatten any irregularities, and the composite image is then photographed by a special animation camera, also called rostrum camera. The cels are removed, and the process repeats for the next frame until each frame in the sequence has been photographed. Each cel has *registration holes,* small holes along the top or bottom edge of the cel, which allow the cel to be placed on corresponding peg bars before the camera to ensure that

each cel aligns with the one before it; if the cels are not aligned in such a manner, the animation, when played at full speed, will appear "jittery." Sometimes, frames may need to be photographed more than once, in order to implement superimpositions and other camera effects. Pans are created by either moving the cels or backgrounds one step at a time over a succession of frames (the camera does not pan; it only zooms in and out). As the scenes come out of final photography, they are spliced into the Leica reel, taking the place of the pencil animation.

Once every sequence in the production has been photographed, the final film is sent for development and processing, while the final music and sound effects are added to the soundtrack. Again, editing in the traditional live-action sense is generally not done in animation, but if it is required it is done at this time, before the final print of the film is ready for duplication or broadcast. Among the most common types of animation rostrum cameras was the Oxberry.

Such cameras were always made of black anodized aluminum, and commonly had 2 pegbars, one at the top and one at the bottom of the lightbox. The Oxberry Master Series had four pegbars, two above and two below, and sometimes used a "floating pegbar" as well. The height of the column on which the camera was mounted determined the amount of zoom achievable on a piece of artwork. Such cameras were massive mechanical affairs which might weigh close to a ton and take hours to break down or set up. In the later years of the animation rostrum camera, stepper motors controlled by computers were attached to the various

axes of movement of the camera, thus saving many hours of hand cranking by human operators. A notable early use of computer cameras was in *Star Wars* (1977), using the Dykstra system at Lucas' Sun Valley facility. Gradually, motion control techniques were adopted throughout the industry. While several computer camera software packages became available in the early 1980s, the Tondreau System became one of the most widely adopted. Digital ink and paint processes gradually made these traditional animation techniques and equipment obsolete.

Digital Ink and Paint

The current process, termed "digital ink and paint," is the same as traditional ink and paint until after the animation drawings are completed; instead of being transferred to cels, the animators' drawings are scanned into a computer, where they are coloured and processed using one or more of a variety of software packages.

The resulting drawings are composited in the computer over their respective backgrounds, which have also been scanned into the computer (if not digitally painted), and the computer outputs the final film by either exporting a digital video file, using a video cassette recorder, or printing to film using a high-resolution output device.

Use of computers allows for easier exchange of artwork between departments, studios, and even countries and continents (in most low-budget animated productions, the bulk of the animation is actually done by animators working in other countries, including South Korea, Japan, Singapore, Mexico, and India). The last major feature film to use

traditional ink and paint was Studio Ghibli's *Princess Mononoke* (1997); the last major animation production to use the traditional process is Cartoon Network's series *Ed Edd n Eddy* (1999–2009), although it was forced to switch to digital paint in 2004. Minor productions such as Hair High (2004) by Bill Plympton have used traditional cels long after the introduction of digital techniques.

Digital ink and paint has been in use at Walt Disney Feature Animation since 1989, where it was used for the final rainbow shot in *The Little Mermaid.* All subsequent Disney animated features were digitally inked-and-painted, using Disney's proprietary CAPS (Computer Animation Production System) technology, developed primarily by Pixar (the last Disney feature using CAPS was *Home on the Range*). Most other studios use one of a number of other high-end software packages such as Toon Boom Harmony, Toonz, Animo, and even consumer-level applications such as Adobe Flash, Toon Boom Studio and TVPaint.

Computers and Digital Video Cameras

Computers and digital video cameras can also be used as tools in traditional cel animation without affecting the film directly, assisting the animators in their work and making the whole process faster and easier. Doing the layouts on a computer is much more effective than doing it by traditional methods. Additionally, video cameras give the opportunity to see a "preview" of the scenes and how they will look when finished, enabling the animators to correct and improve upon them without having to complete them first. This can be considered a digital form of *pencil testing*.

Techniques

The Cel & Limited Animation

The cel is an important innovation to traditional animation, as it allows some parts of each frame to be repeated from frame to frame, thus saving labor. A simple example would be a scene with two characters on screen, one of which is talking and the other standing silently. Since the latter character is not moving, it can be displayed in this scene using only one drawing, on one cel, while multiple drawings on multiple cels will be used to animate the speaking character.

For a more complex example, consider a sequence in which a girl sets a plate upon a table. The table will stay still for the entire sequence, so it can be drawn as part of the background. The plate can be drawn along with the character as the character places it on the table. However, after the plate is on the table, the plate will no longer move, although the girl will continue to move as she draws her arm away from the plate. In this example, after the girl puts the plate down, the plate can then be drawn on a separate cel from the girl.

Further frames will feature new cels of the girl, but the plate does not have to be redrawn as it is not moving; the same cel of the plate can be used in each remaining frame that it is still upon the table. The cel paints were actually manufactured in shaded versions of each colour to compensate for the extra layer of cel added between the image and the camera, in this example the still plate would be painted slightly brighter to compensate for being moved

one layer down. In very early cartoons made before the use of the cel, such as *Gertie the Dinosaur* (1914), the entire frame, including the background and all characters and items, were drawn on a single sheet of paper, then photographed. Everything had to be redrawn for each frame containing movements. This led to a "jittery" appearance; imagine seeing a sequence of drawings of a mountain, each one slightly different from the one preceding it.

The pre-cel animation was later improved by using techniques like the slash and tear system invented by Raoul Barre; the background and the animated objects were drawn on separate papers. A frame was made by removing all the blank parts of the papers where the objects were drawn before being placed on top of the backgrounds and finally photographed. The cel animation process was invented by Earl Hurd and John Bray in 1915. In lower-budget productions, this "shortcut" is used in a greater capacity. For example, in a scene in which a man is sitting in a chair and talking, the chair and the body of the man may be the same in every frame; only his head is redrawn, or perhaps even his head stays the same while only his mouth moves. This is known as *limited animation.* The process was popularized in theatrical cartoons by United Productions of America and used in most television animation, especially that of Hanna-Barbera. The end result does not look very lifelike, but is inexpensive to produce, and therefore allows cartoons to be made on small television budgets.

"Shooting on Twos"

Moving characters are often shot "on twos", that is to say, one drawing is shown for every two frames of film

(which usually runs at 24 frames per second), meaning there are only 12 drawings per second. Even though the image update rate is low, the fluidity is satisfactory for most subjects. However, when a character is required to perform a quick movement, it is usually necessary to revert to animating "on ones", as "twos" are too slow to convey the motion adequately. A blend of the two techniques keeps the eye fooled without unnecessary production cost. Animation for television is usually produced on tight budgets. In addition to the use of limited animation techniques, television animation may be shot on "threes", or even "fours", i.e. three or four frames per drawing. This translates to only eight or six drawings per second.

Animation Loops

Creating *animation loops* or *animation cycles* is a labor-saving technique for animating repetitive motions, such as a character walking or a breeze blowing through the trees. In the case of walking, the character is animated taking a step with his right foot, then a step with his left foot. The loop is created so that, when the sequence repeats, the motion is seamless. However, since an animation loop essentially uses the same bit of animation over and over again, it is easily detected and can in fact become distracting to an audience. In general, they are used only sparingly by productions with moderate or high budgets. Ryan Larkin's 1969 Academy Award nominated National Film Board of Canada short *Walking* makes creative use of loops. In addition, a promotional music video featuring the Soul Coughing song "Circles" poked fun at animation loops as they are often seen in *The Flintstones,* in which Fred and

Barney, supposedly walking in a house, wonder why they keep passing the same table and vase over and over again.

Multiplane Camera

The multiplane camera is a tool used to add depth to scenes in 2D animated movies, called the multiplane effect or the parallax process. The art is placed on different layers of glass plates, and as the camera moves vertically towards or away from the artwork levels, the camera's viewpoint appears to move through the various layers of artwork in 3D space. The panorama views in *Pinocchio* are examples of the effects a multiplane camera can achieve. Different versions of the camera have been made through time, but the most famous is the one developed by the Walt Disney studio beginning with their 1937 short *The Old Mill*. Another one, the "Tabletop", was developed by Fleischer Studios. The Tabletop, first used in 1934's *Poor Cinderella*, used miniature sets made of paper cutouts placed in front of the camera on a rotating platform, with the cels between them. By rotating the entire setup one frame at a time in accordance with the cel animation, realistic panoramas could be created. Ub Iwerks and Don Bluth also built multiplane cameras for their studios.

Xerography

Applied to animation by Ub Iwerks at the Walt Disney studio during the late 1950s, the electrostatic copying technique called xerography allowed the drawings to be copied directly onto the cels, eliminating much of the "inking" portion of the ink-and-paint process. This saved time and money, and it also made it possible to put in more details

and to control the size of the xeroxed objects and characters (this replaced the little known, and seldom used, photographic lines technique at Disney, used to reduce the size of animation when needed). At first it resulted in a more sketchy look, but the technique was improved upon over time. The xerographic method was first tested by Disney in a few scenes of *Sleeping Beauty*, and was first fully used in the short film *Goliath II*, while the first feature entirely using this process was *One Hundred and One Dalmatians* (1961). The graphic style of this film was strongly influenced by the process. Some hand inking was still used together with xerography in this and subsequent films when distinct coloured lines were needed. Later, coloured toners became available, and several distinct line colours could be used, even simultaneously. For instance, in *The Rescuers* the characters outlines are gray. White and blue toners were used for special effects, such as snow and water.

APT Process

Invented by Dave Spencer for the 1985 Disney film *The Black Cauldron*, the APT (Animation Photo Transfer) process was a technique for transferring the animators' art onto cels. Basically, the process was a modification of a repro-photographic process; the artists' work were photographed on high-contrast "litho" film, and the image on the resulting negative was then transferred to a cel covered with a layer of light sensitive dye. The cel was exposed through the negative. Chemicals were then used to remove the unexposed portion. Small and delicate details were still inked by hand if needed. Spencer received an Academy Award for Technical Achievement for developing this process.

Cel Overlay

A *cel overlay* is a cel with inanimate objects used to give the impression of a foreground when laid on top of a ready frame. This creates the illusion of depth, but not as much as a multiplane camera would. A special version of cel overlay is called *line overlay*, made to complete the background instead of making the foreground, and was invented to deal with the sketchy appearance of xeroxed drawings. The background was first painted as shapes and figures in flat colours, containing rather few details. Next, a cel with detailed black lines was laid directly over it, each line drawn to add more information to the underlying shape or figure and give the background the complexity it needed. In this way, the visual style of the background will match that of the xeroxed character cels. As the xerographic process evolved, line overlay was left behind.

Computers and Traditional Animation

The methods mentioned above describe the techniques of an animation process that originally depended on cels in its final stages, but painted cels are rare today as the computer moves into the animation studio, and the outline drawings are usually scanned into the computer and filled with digital paint instead of being transferred to cels and then coloured by hand. The drawings are composited in a computer programme on many transparent "layers" much the same way as they are with cels, and made into a sequence of images which may then be transferred onto film or converted to a digital video format. It is now also possible for animators to draw directly into a computer using a graphics tablet, Cintiq or a similar device, where the outline

drawings are done in a similar manner as they would be on paper. The Goofy short *How To Hook Up Your Home Theater* (2007) represented Disney's first project based on the paperless technology available today.

Some of the advantages are the possibility and potential of controlling the size of the drawings while working on them, drawing directly on a multiplane background and eliminating the need of photographing line tests and scanning. Though traditional animation is now commonly done with computers, it is important to differentiate computer-assisted traditional animation from 3D computer animation, such as *Toy Story* and *ReBoot.* However, often traditional animation and 3D computer animation will be used together, as in Don Bluth's *Titan A.E.* and Disney's *Tarzan* and *Treasure Planet.*

Most anime still use traditional animation today. DreamWorks executive Jeffrey Katzenberg coined the term "tradigital animation" to describe films produced by his studio which incorporated elements of traditional and computer animation equally, such as *Spirit: Stallion of the Cimarron* and *Sinbad: Legend of the Seven Seas*. Interestingly, many modern video games such as *Viewtiful Joe, The Legend of Zelda: The Wind Waker* and others use "cel-shading" animation filters to make their full 3D animation appear as though it were drawn in a traditional cel style. This technique was also used in the animated movie *Appleseed,* and cel-shaded 3D animation is typically integrated with cel animation in Disney films and in many television shows, such as the Fox animated series *Futurama*.

Rotoscoping

Rotoscoping is a method of traditional animation invented by Max Fleischer in 1915, in which animation is "traced" over actual film footage of actors and scenery. Traditionally, the live action will be printed out frame by frame and registered. Another piece of paper is then placed over the live action printouts and the action is traced frame by frame using a lightbox. The end result still looks hand drawn but the motion will be remarkably lifelike. *Waking Life* is a full-length, rotoscoped animated movie, as is *American Pop* by Ralph Bakshi.

The popular music video for A-ha's song "Take On Me" also featured rotoscoped animation, along with live action. In most cases, rotoscoping is mainly used to aid the animation of realistically rendered human beings, as in *Snow White and the Seven Dwarfs, Peter Pan,* and *Sleeping Beauty*. A method related to conventional rotoscoping was later invented for the animation of solid inanimate objects, such as cars, boats, or doors. A small live action model of the required object was built and painted white, while the edges of the model were painted with thin black lines. The object was then filmed as required for the animated scene by moving the model, the camera, or a combination of both, in real time or using stop-motion animation. The film frames were then printed on paper, showing a model made up of the painted black lines.

After the artists had added details to the object not present in the live-action photography of the model, it was xeroxed onto cels. A notable example is Cruella de Vil's car in Disney's *One Hundred and One Dalmatians*. The process

of transferring 3D objects to cels was greatly improved in the 1980s when computer graphics advanced enough to allow the creation of 3D computer generated objects that could be manipulated in any way the animators wanted, and then printed asoutlines on paper before being copied onto cels using Xerography or the APT process. This technique was used in Disney films such as *Oliver and Company* (1988) and *The Little Mermaid* (1989). This process has more or less been superseded by the use of cel-shading. Related to rotoscoping are the methods of vectorizing live-action footage, in order to achieve a very graphical look, like in Richard Linklater's film *A Scanner Darkly*; and motion-capturing actor's movements to use the data in 3D-animation, as in Robert Zemeckis's 2004 film *The Polar Express*.

Live-action Hybrids

Similar to the computer animation and traditional animation hybrids described above, occasionally a production will marry both live-action and animated footage. The live-action parts of these productions are usually filmed first, the actors pretending that they are interacting with the animated characters, props, or scenery; animation will then be added into the footage later to make it appear as if it has always been there. Like rotoscoping, this method is rarely used, but when it is, it can be done to terrific effect, immersing the audience in a fantasy world where humans and cartoons co-exist. Early examples include the silent *Out of the Inkwell* (begun in 1919) cartoons by Max Fleischer and Walt Disney's *Alice Comedies* (begun in 1923). Live-action and animation were later combined to successful

effect in features such as *The Three Caballeros* (1944), *Anchors Aweigh* (1945), *Song of the South* (1946), *Mary Poppins* (1964), *Bedknobs and Broomsticks* (1971), *Heavy Traffic* (1973), *Coonskin* (1975) *Pete's Dragon* (1977), *Who Framed Roger Rabbit* (1988), *Rock-a-Doodle* (1992), *Cool World* (1992), *The Pagemaster* (1994) *Space Jam* (1996), and *Looney Tunes: Back In Action* (2003). Other significant live-action hybrids include the music video for Paula Abdul's hit song "Opposites Attract" and numerous television commercials, including those for cereals such as Frosted Flakes, Honey Nut Cheerios, Trix, and Rice Krispies.

Special Effects Animation

Besides traditional animated characters, objects and backgrounds, many other techniques are used to create special elements such as smoke, lightning and "magic", and to give the animation in general a distinct visual appearance. Notable examples can be found in movies such as *Fantasia*, *Wizards*, *The Lord of the Rings*, *The Little Mermaid*, *The Secret of NIMH* and *The Thief and the Cobbler*. Today the special effects are mostly done with computers, but earlier they had to be done by hand. To produce these effects, the animators used different techniques, such as drybrush, airbrush, charcoal, grease pencil, backlit animation or, during shooting, the cameraman used multiple exposures with diffusing screens, filters or gels. For instance, the *Nutcracker Suite* segment in *Fantasia* has a fairy sequence where stippled cels are used, creating a soft pastel look.

3

Purpose of Dialogue and Animation

Dialogue can be the trickiest part of a script. Lucky for us, Jean Ann Wright continues her series of articles on writing for television animation and this month tells us how to tame the words of animated actors.

When Batman kicks butt, no words are needed. Justice League and all related characters are trademarks.

The Purpose of Dialogue

When Batman kicks butt, he doesn't need a lot of dialogue to dump the dumbdumbs. At its best animation is all about action and movement; it explores space and time. You want to show, not tell, your story. There are cartoons with no dialogue at all! But three dialogue blocks per page and no more than three short sentences per block are normal. Generally, in animation dialogue should be used only after you've tried all other methods of communication. Silence can accompany discoveries, revelations and deep emotions. Dialogue is used to reveal the characters. It provides direction, moving the story along and advancing the plot. It discloses information. It provides conflict. And it sets the spirit or mood of the story, whether it's a comedy or drama.

Revealing Character

Sometimes only dialogue can expose the real motivations and secrets of a character in all their complexity. It's especially effective when it exposes the character in an entirely new way from what we as an audience expect. We use dialogue to establish relationships. Dialogue reflects feelings and attitudes.

Be sure you know your characters. Each character has his own agenda, often hidden. What is really being said? Which character is driving each scene? Your characters can be driving the action directly or indirectly. Direct dialogue drives people apart. Indirect dialogue draws people together. Characters may talk around a problem as we often do in real life. There may be subtext. But because younger kids probably won't understand subtlety, writing targeted at

preschoolers should say what it means. Writing will also be more direct in shorter cartoons, as there simply is not time for many shadings.

A longer story digs deeper. To do this try using questions in order to get beneath the surface. Dialogue should never be interchangeable between characters. It should be dialogue that only that character would say. The words should be words that this character would use. Each character should have a different rhythm, perhaps a different sentence length. Dialogue reveals education, cultural and ethnic background, age. Use wording and colorful expressions that are individual to that one character. Unique phrases can serve as a character signature.

Moving the Story Along

A good animation story has to keep moving. Dialogue shouldn't slow it down. It should serve the plot. Dialogue is one way to tell the story, but the dialogue should always disclose tidbits that the characters must tell each other, not just information that you as a writer want the audience to know. Characters make discoveries about what's happening and discover secrets about each other.

Information and Conflict

All the exposition doesn't have to come right away. We want to know what happened before the story started that's motivating our characters now.

But information can come out throughout the story. Conflict in dialogue or tension between views is a good way to get information out and keep it interesting. Do be clear enough so that your young viewers understand, but don't

say everything. Leave enough unsaid that the audience becomes involved and wants to know more.

The Mood of the Story

Set the tone of the story right away. This is especially important in comedy, so that we know that it's OK to laugh. The type of dialogue must be appropriate for the genre of that specific series.

Characteristics of Dialogue

Good dialogue has a beat, a rhythm, a melody. It's affected by time, place, the weather, etc. It's intangible, like mist, and it depends upon your characters and who they are, their relationships, the situation, the genre, the world of that series, the target age of your audience, the length of the script, and who you are as you're writing the dialogue. Keep it simple; less is more.

For young children keep the words simple enough that they'll understand. Dialogue sounds like real talk, but it isn't. It's the essence of real talk with thematic content and an ongoing exchange of power. It must always be easily understandable and clear. You might want to repeat important story points, especially for preschoolers, but repeat with a twist.

Comedy Dialogue

The best comedy comes out of character. Be sure you have funny, exaggerated characters, reacting to a funny situation, and speaking in a funny way. Reactions are all-important to comedy. And so is timing! Try to avoid straight lines wherever you can. Use dialogue that plays off the situation.

If there's a fire, "Let's hot foot it out of here!" Then play the next line off of that. A straight man can serve as a foil for the one-liners. Insults can be funny. Comedy dialogue develops with a setup and then a surprise punch line. The punch line comes at the end of a speech. Comedy scenes usually go out on a laugh line (a button).

Fig. Homer Simpson's

Writing the Dialogue

If you can listen to tapes of your established characters in advance, do it. Your story should be set up in the first few words of dialogue. From the start, keep in mind your final end point, and build the dialogue towards the climax. Write less than you think you need. See and hear it as you write. Act it out in character. You'll want to add a new dimension with your dialogue, but don't make it so different that it doesn't sound like the established characters. Write the dialogue so that the actor can contribute something with his voice (a gulp, an excited squeal, a drawl). Think of Homer Simpson's "Doh!" Give your actors attitude, emotion, special

phrasing. Character sneezes, etc. should be written with the dialogue so they're not missed during the recording session. If you're writing only one line for an incidental character, make that one line a jewel…really memorable. Keep your language appropriate for that series. If you're writing an original script, decide ahead of time whether you want your language up-to-date and fresh or classic for a longer shelf life for that show. Dialogue for children can be whimsical and full of contradictions and non-sense. Be original and clever!

Animating a Believable and Appealing Dialogue Shot

Tackling a shot with facial animation involved can be challenging. To get great facial animation, you'll not only need to put a lot of time into it, but it helps if you approach the facial animation as if it's a completely separate shot. There is as much planning and care involved in animating the face as there is in the rest of the animation.

In this article, you will learn twelve important steps to ensuring the facial animation of your shot is rock solid and can hold up on its own.

When animating the face, head, and lip sync, the same techniques that you use to animate the entire body can also be applied. Thinking about the timing, lead and follow, drag, and exaggeration are all extremely vital to accomplishing a great facial animation.

The audience's attention is typically centered on the character's face and this is especially true during a shot with dialogue. Anytime that the audience notices something strange with the animation is the moment when they realize

your character isn't real. And that's exactly what you don't want to happen. Since you are trying to convey real-world movements into a 3D virtual world, knowing how human faces move is an extremely important step in creating strong facial animation in your virtual characters.

With this in mind, one of the first steps to creating believable well crafted facial animation is to study how your own face deforms and moves around.

The amount of planning that is involved can seem like overkill, but having this type of planning in place will speed up the process and help push the animation to the next level.

The character we'll animate will be saying, "Ahhhhh….Have you seen the rest of my body?" In total the shot is 77 frames long and you can find the project files for this shot on the disc for this issue. Although the character in this article will be an ogre, any character rig with good facial controls should suffice.

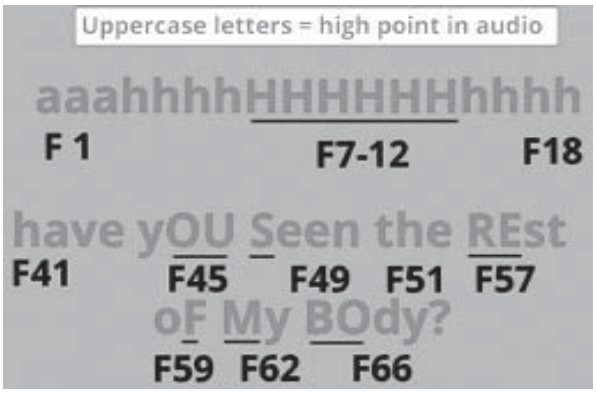
(Purchase the full 3D Artist Magazine with this 12 step masterclass included along with many other tutorials)

Create a Dialogue Chart

The planning out the audio is incredibly important when working on a shot with dialogue. Write down each word of dialogue and then break it up into syllables.

Track the timing for each word and study the high points, or the areas where the character speaks higher in the audio.

Most words should have one of these high points in them. Take notes on what syllable it's at and use them as guides on where to push the lip sync in your animation.



Act out the scene

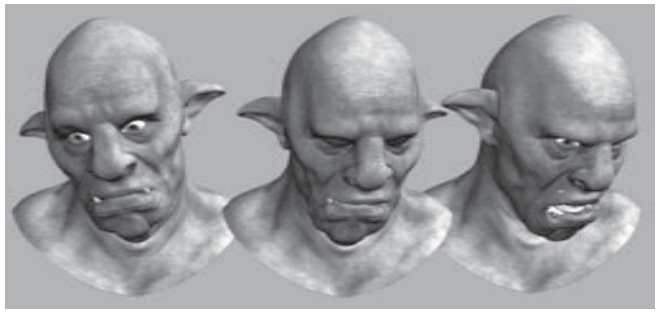
Animators are actors. The best way to get ideas for the scene is to get in front of a camera and act out the shot. Don't be shy, all animators do it. Try to become the character during the acting process. Play the audio in the background and act out the scene over and over. When you think you've got the shot, playback the video you've captured to double-check. Only stop when you're entirely happy with your performance. A good rule of thumb for this is to force yourself not to settle for anything less than fifteen to twenty minutes in front of the camera. This will help force you to really get into acting out the shot rather than accepting one of your first few takes.

Block in the key poses

Use the video you shot to get the proper story telling poses that describe the facial animation. For each story telling pose, you should make sure to pose each area of the face and not just the entire head. This will help you see the type of facial pose that you want to hit and at what word in the dialogue. Try to keep the poses to a minimum; you just want to get

the most important ones in at this point. For example, our blocking pass consisted of six main poses.

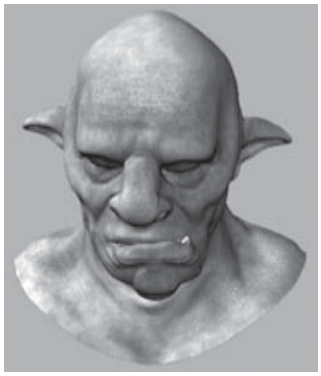
Breakdown Pass



The breakdowns are the poses inbetween the story telling poses that describe how the character is getting from one pose to the other. Study your reference and use that as a guide to help you create your breakdowns.

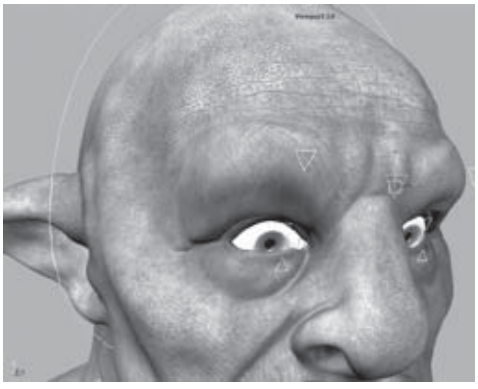
Look at the spacing between each pose that's in your reference and incorporate that into your animation. It's important for you to remember that breakdowns are not just inbetweens. You should be thinking about drag, exaggeration, and poses that can add more appeal to the action.

Exaggerate the movements



Once you have all the proper breakdowns in, the brunt work of the animation is almost done! Make sure the timing is exactly how you planned it and your holds are in the right spot. Once you're happy with the timing, go in and start pushing some of the poses to really exaggerate the facial movement. For example, when the character brings his head down, drag the eye brows and have them offset a few frames. You could even utilize the scale attributes for the head to add some squash and stretch. Exaggerating movement is just as important with facial animation as it is in the rest of the body.

Eye Brow Animation



It's important to have strong eye brow poses to sell the facial animation. Don't overdo it by having the eye brows moving during every single word. Instead, find a few important eye brow shapes that you want to hit during the dialogue. In the ogre animation there are really only two main eye brow poses: Frowned, and surprised. It's how you transition between the two that helps sell the animation.

Fine-Tune the Eye Lids

After the overall movements of the head are looking how you want them, it's time to go in and start fine-tuning some more of the smaller details. The eye lids may seem like the least important area on your character, but they can help sell to really the emotion of your character. For example, in our animation the eye lids have been opened very wide in the spots where the eye brows are raised. This makes our facial animation feel like its all one cohesive unit working together.

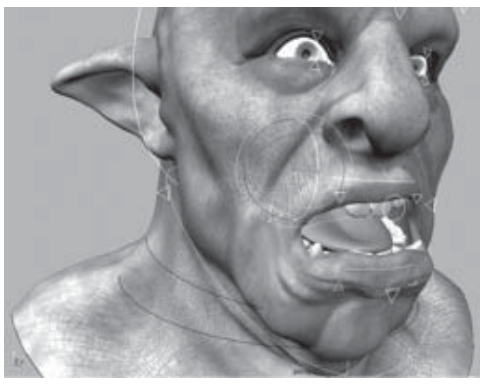
Add in Blinks

When adding blinks to your facial animation, make sure that you aren't adding them just because you the think the characters eyes must be getting dry. Instead, to add blinks

with the correct timing you need to think about the emotional state of the character.

Is he angry? Sad? In our animation, the dialogue has a concerned tone to it so the character's blinks can be minimal. In this shot there are a total of 3 blinks; the first is during the head turn at the beginning, the next is when the character looks up at camera, and the final one is when he bobs his head. Remember that you can also use the controls under the eye lids to be able to really make each blink feel very fleshy.

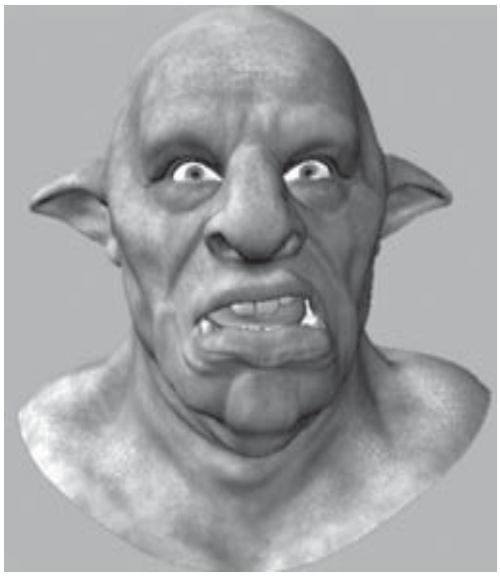
Animate Jaw Movement



Once the head movement and face is working properly now it's time to create the lip sync. This should be relatively simple since you created the dialogue chart beforehand. The

first step is to block in the jaw opening and closing. Typically this is done at the start and end of a word, but it can be very easy to open and close the jaw way more than is actually needed if you're not careful. Keep referring back to your reference video to see how much the jaw moves while the dialogue is being said and don't overdo it. Once this is completed you're already halfway done with the lip sync.

Add in the Mouth Shapes



When you've blocked in the jaw movement, now you can go in and start fine tuning the shape for the mouth. Add in some asymmetry to the mouth shapes to help add believability.

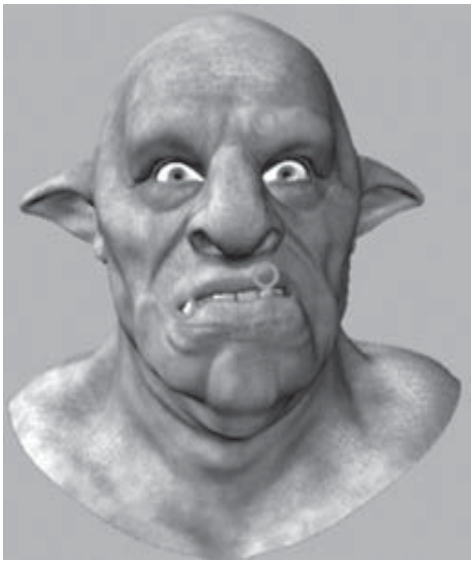
Animate each lip control to get a sort of peeling effect when the mouth opens. Think about the arcs that the jaw is taking during this stage. You can really add a very fleshy look to the lip sync by animating the entire rotation axes as well as the translate axes. Have fun with this and don't be afraid to exaggerate it!

Animate the Cheeks

A great place to be able to make the character's face feel fleshier is in the cheeks. When animating the face you don't want any area to feel dead, so you can utilize some of the facial controls to make the face feel like its all one unit working together to create the shapes.

For example, when the "B" shape is being said in our shot, try using the facial controls to puff out the cheeks. This adds a lot more appeal to the lip sync.

Polish the Animation



After you've animated the lip sync, now it's time to go in and add that final 10 per cent that will really push your facial animation to the next level!

Track the arcs of the corner of the mouth, the nose, and the eye brows. Tweak the eye lids to get a nice fleshy look during blinks. Once the polish pass is completed then your facial animation is done!

Be sure to use the techniques taught in this tutorial to help you create believable and appealing facial animation. Remember that often times, facial animation and lip sync need to be exaggerated beyond what you see in the real-world, so that it reads much easier in animation form.

4

3D Computer Animation

The **twelve principles of animation** were created in the early 1930s by animators at the Walt Disney Studios. These principles were used to guide production and creative discussions as well to train young animators better and faster. These twelve principles became one of the foundations of hand-drawn cartoon character animation. The twelve principles, as they are commonly referred to, also helped to transform animation from a novelty into an art form. By applying these principles to their work these pioneering animators produced many of the earliest animated feature films that became classics: Snow White (1937), Pinocchio and Fantasia (1940), Dumbo (1941), and Bambi (1942).

The twelve principles are mostly about five things: acting the performance, directing the performance, representing reality (through drawing, modeling, and rendering), interpreting real world physics, and editing a sequence of

actions. The original principles are still relevant today because they help us to create more believable characters and situations. They can be applied to almost any type of animation, even though they work best for comedy. But, some of these principles require updates, and a few new additional principles are also needed to address the new techniques and styles of three-dimensional computer animation.

Animation techniques and styles, and the scope of productions, have changed tremendously since the 1930s. The dominant, almost exclusive, style of animation then was hand-drawn pose-to-pose cartoon narrative animation. Today we have more styles including non-linear interactive videogames and non-narrative music videos. In the 1930s some animation techniques and capabilities were underdeveloped, camera moves and lighting for example, or misunderstood: rotoscoping or stop-motion. Consider too the new tools that have transformed our craft: hand-held cameras, television, non-linear editing, compositing, motion capture, computer graphics and procedural tools. Other artforms have greatly evolved since the 1930s, creating new languages and new principles. It is time to do the same with animation, it is time to reinterpret and expand the original principles. We also need to create new additional principles that address today's new animation styles and techniques. This is our collective challenge.

Squash and stretch, the first principle from the original twelve, is used to exaggerate the amount of non-rigid body deformations usually with the purpose of achieving a more comedic effect. Three-dimensional squash and stretch can

be implemented with a variety of techniques: skin and muscle, springs, direct mesh manipulation and morphing. It can also be implemented in more experimental ways with weighting, especially for dynamics simulations, and unusual IK systems.

The technique of **anticipation** helps to guide the audience's eyes to where the action is about to occur. Anticipation, including motion holds, is great for "announcing the surprise." In three-dimensional computer animation it can be fine-tuned using digital time-editing tools such as time sheets, timelines, and curves. More anticipation equals less suspense. Horror films, for example, switch back and forth from lots of anticipation to total surprise.

Staging, or mise-en-scène as it is also known, is about translating the mood and intention of a scene into specific character positions and actions. Staging the key character poses in the scene helps to define the nature of the action. Three-dimensional animatics are a great tool for previsualizing and blocking out the staging before the primary, secondary and facial animation. There are many staging techniques to tell the story visually: hiding or revealing the center of interest, and a chain reaction of actions-reactions are a couple of them. Staging can also be aided with contemporary cinematic techniques such as slow motion, frozen time, motion loops, and hand-held camera moves.

Straight-ahead action and pose-to-pose are two different animation techniques that yield fairly different results. In the early days of hand-drawn animation **pose-to-pose action** became the standard animation technique because it breaks

down structured motion into a series of clearly defined key poses. In **straight-ahead action** the character moves spontaneously through the action one step at a time until the action is finished. Motion capture and dynamics simulations, even three-dimensional rotoscoping, are clearly the straight-ahead techniques of three-dimensional computer animation. They can all be blended intelligently using channels.

Follow-through and overlapping action are two techniques that help make the action richer and fuller with detail and subtlety. **Follow-through action** consists of the reactions of the character after an action, and it usually lets audiences know how he or she feels about what has just happened or is about to happen. In **overlapping action** multiple motions influence, blend, and overlap the position of the character. In three-dimensional computer animation a lot of the common follow-through motions of clothing and hair, for example, can be animated with dynamics simulations. The layers and channels in three-dimensional computer animation software allow us to mix and blend different overlapping motions from different areas of the character.

Slow-in and **slow-out** consist of slowing down the beginning and the end of an action, while speeding up the middle of it. A snappy effect is achieved when motion is accelerated and retarded in this way. In three-dimensional computer animation slow-ins and slow-outs can be fine-tuned with digital time-editing tools. When using motion capture techniques for cartoon-style animated characters it is essential to remind performers to do slow-ins and slow-

outs. The inverse variation of this effect, a fast-in and fast-out, is often times seen in TV commercials and music videos where the beginning and end of the sequence are accelerated while the middle is slowed down giving it a surreal or dreamy feeling.

Using **arcs** to animate the movements of characters helps achieve a natural look because most living creatures move in curved paths, never in perfectly straight lines. Non-arc motion comes across as sinister, restricted or robotic. In three-dimensional computer animation we can use software constraints to force all or some of the motion within arcs. Even motion-captured performances can be fine-tuned with curve editors, as long as the motion is not flattened.

Secondary action consists of the smaller motions that complement the dominant action. In three-dimensional computer animation we can take advantage of layers and channels for building up different secondary motions, for example, a layer for hair, a layer for the character's hat, a layer for the cape, and so on.

Timing is the precise moment and the amount of time that a character spends on an action. Timing adds emotion and intention to the character's performance. Most three-dimensional computer animation tools allow us to fine tune the timing by shaving off or adding frames with non-linear time-editing. Timing can also be controlled and adjusted by placing each character on a separate track, and using sub-tracks for parts of the character such as head, torso, arms and legs.

Exaggeration usually helps cartoon characters to deliver the essence of an action. A lot of exaggeration can be achieved

with squash and stretch. In three-dimensional computer animation we can use procedural techniques, motion ranges and scripts to exaggerate motion. The intensity of a moment can be increased with cinematography and editing, not just with performance.

Solid modeling and rigging, or solid drawing as it was called in the 1930s, emphasizes the clear delineation of shape necessary to bring animated characters to life. Solid and precise modeling helps to convey the weight, depth and balance of the character, and it also simplifies potential production complications due to poorly modeled characters. Animation rigs are at their best when they are optimized for the specific personality and motion of the character. Pay attention to silhouettes when aligning characters to the camera.

Character personality, or appeal as it was originally called, facilitates the emotional connection between character and audience. Characters must be well developed, have an interesting personality, and have a clear set of desires or needs that drive their behaviour and actions.

Complexity and consistency of motion are two elements of character appeal that can be easily developed with three-dimensional computer animation.

Writing down the ways in which the character moves, how he/she reacts to different situations, and how he/she relates to other characters can help define the main characteristics of the character's personality. Fine-tune the personality with the key poses and the character turnarounds.

A Few New Principles for 3D Computer Animation

A few of the new issues that need to be addressed by new principles of three-dimensional computer animation include: visual styling, blending cartoon physics with real world physics, using cinematography, mastering facial animation, and optimizing user-controlled animation.

Visual styling in three-dimensional computer animation means more than just how things are supposed to look. Visual styling also has a significant impact on rendering, on animation techniques, and overall production complexity. As we develop a visual look we must keep in mind that it is feasible to produce within the boundaries of the project. A certain look for the skin of a beast, for example, might look cool but might also require too complex a rig, too detailed a model and too complex an animation process.

It is possible today to **blend motion** from different sources, and we need to develop a clear approach for blending cartoon with realistic motion. Before production starts it is necessary to define clear guidelines for a variety of motion/animation styles including cartoon physics, realistic cartoon, realistic human motion and rotoscoping. Above all, we must direct live performers when capturing their motion to add intention to their movements.

Since we have absolute control over camera positions and movement in three-dimensional computer animation, we should make the **cinematography** a crucial component of our animation, not just an afterthought. The composition, lighting, and sequencing of our moving images has a huge impact on storytelling. Most of this work can crystallize

during previsualization and the assembly of the three-dimensional animatics. The lighting style needs to be addressed separately, since it impacts both the look and the rendering pipeline.

Most of the thoughts and emotions of characters are expressed on their faces. Three-dimensional computer animation offers more **facial animation** control than ever before, including the subtle motion of eyelids and eyeballs. Establishing early in the process the level of facial control and techniques has a positive effect on the styling of the character and the design of the production flow. Building a catalogue of facial morph targets or blend shapes for production and reuse is today as essential as building walk cycles.

Computer and platform games put much of the animation control in the hands of gamers. This poses the challenge to create great animation that works regardless of what move the gamer decides to make. Games are a combination of **user-controlled animation** and preset/narrative animation. One of the creative animation challenges is to find a balance between the narrative and the improvisational aspect of the game. Look at the model of participatory street theater (different from traditional stage theater) for ideas on how to constraint the gamer-action to establish strong staging. User-controlled animation relies on strong animation cycles with built-in anticipation that are able to branch smoothly into reaction shots. Fortunately many of today's game engines have built-in intelligence that can smooth transitions between animation cycles. The combination of preset and dynamic user-controlled cameras is also unique to games

12 basic principles of animation

Disney's **Twelve Basic Principles of Animation** were introduced by the Disney animators Ollie Johnston and Frank Thomas in their 1981 book The Illusion of Life: Disney Animation. Johnston and Thomas in turn based their book on the work of the leading Disney animators from the 1930s onwards, and their effort to produce more realistic animations. The main purpose of the principles was to produce an illusion of characters adhering to the basic laws of physics, but they also dealt with more abstract issues, such as emotional timing and character appeal.

The book and some of its principles have been adopted by some traditional studios, and have been referred to by some as the "Bible of animation." In 1999 this book was voted number one of the "best animation books of all time" in an online poll. Though originally intended to apply to traditional, hand-drawn animation, the principles still have great relevance for today's more prevalent computer animation.

The 12 Principles of Animation

Squash and Stretch

Illustration of the "squash and stretch"-principle:

Example **A** shows a ball bouncing with a rigid, non-dynamic movement. In example **B** the ball is "squashed" at impact, and "stretched" during fall and rebound. The movement also accelerates during the fall, and slows down towards the apex.

The most important principle is "squash and stretch", the purpose of which is to give a sense of weight and flexibility

to drawn objects. It can be applied to simple objects, like a bouncing ball, or more complex constructions, like the musculature of a human face. Taken to an extreme point, a figure stretched or squashed to an exaggerated degree can have a comical effect. In realistic animation, however, the most important aspect of this principle is the fact that an object's volume does not change when squashed or stretched. If the length of a ball is stretched vertically, its width (in three dimensions, also its depth) needs to contract correspondingly horizontally.

Anticipation

Anticipation is used to prepare the audience for an action, and to make the action appear more realistic. A dancer jumping off the floor has to bend his knees first; a golfer making a swing has to swing the club back first. The technique can also be used for less physical actions, such as a character looking off-screen to anticipate someone's arrival, or attention focusing on an object that a character is about to pick up.

Staging

This principle is akin to staging in theatre, as it is known in theatre and film. Its purpose is to direct the audience's attention, and make it clear what is of greatest importance in a scene; Johnston and Thomas defined it as "the presentation of any idea so that it is completely and unmistakably clear", whether that idea is an action, a personality, an expression, or a mood. This can be done by various means, such as the placement of a character in the frame, the use of light and shadow, or the angle and position

of the camera. The essence of this principle is keeping focus on what is relevant, and avoiding unnecessary detail.

Straight Ahead Action and Pose to Pose

These are two different approaches to the actual drawing process. "Straight ahead action" means drawing out a scene frame by frame from beginning to end, while "pose to pose" involves starting with drawing a few key frames, and then filling in the intervals later. "Straight ahead action" creates a more fluid, dynamic illusion of movement, and is better for producing realistic action sequences.

On the other hand, it is hard to maintain proportions, and to create exact, convincing poses along the way. "Pose to pose" works better for dramatic or emotional scenes, where composition and relation to the surroundings are of greater importance. A combination of the two techniques is often used.

Computer animation removes the problems of proportion related to "straight ahead action" drawing; however, "pose to pose" is still used for computer animation, because of the advantages it brings in composition. The use of computers facilitates this method, and can fill in the missing sequences in between poses automatically. It is, however, still important to oversee this process and apply the other principles discussed.

Follow Through and Overlapping Action

Follow through and overlapping action is a general heading for two closely related techniques which help to render movement more realistically, and help to give the impression that characters follow the laws of physics,

including the principle of inertia. "Follow through" means that loosely tied parts of a body should continue moving after the character has stopped and the parts should keep moving beyond the point where the character stopped to be "pulled back" only subsequently towards the center of mass and/or exhibiting various degrees of oscillation damping. "Overlapping action" is the tendency for parts of the body to move at different rates (an arm will move on different timing of the head and so on).

A third, related technique is "drag", where a character starts to move and parts of him take a few frames to catch up. These parts can be inanimate objects like clothing or the antenna on a car, or parts of the body, such as arms or hair. On the human body, the torso is the core, with arms, legs, head and hair appendices that normally follow the torso's movement. Body parts with much tissue, such as large stomachs and breasts, or the loose skin on a dog, are more prone to independent movement than bonier body parts. Again, exaggerated use of the technique can produce a comical effect, while more realistic animation must time the actions exactly, to produce a convincing result.

The "moving hold" animates between similar key frames, even characters sitting still can display some sort of movement, such as the torso moving in and out with breathing.

Slow In and Slow Out

The movement of the human body, and most other objects, needs time to accelerate and slow down. For this reason, animation looks more realistic if it has more drawings near the beginning and end of an action, emphasizing the

extreme poses, and fewer in the middle. This principle goes for characters moving between two extreme poses, such as sitting down and standing up, but also for inanimate, moving objects, like the bouncing ball in the above illustration.

Arc

Most natural action tends to follow an arched trajectory, and animation should adhere to this principle by following implied "arcs" for greater realism. This technique can be applied to a moving limb by rotating a joint, or a thrown object moving along a parabolic trajectory. The exception is mechanical movement, which typically moves in straight lines.

As an object's speed or momentum increases, arcs tend to flatten out in moving ahead and broaden in turns. In baseball, a fastball would tend to move in a straighter line than other pitches; while a figure skater moving at top speed would be unable to turn as sharply as a slower skater, and would need to cover more ground to complete the turn.

An object in motion that moves out of its natural arc for no apparent reason will appear erratic rather than fluid. For example, when animating a pointing finger, the animator should be certain that in all drawings in between the two extreme poses, the fingertip follows a logical arc from one extreme to the next. Traditional animators tend to draw the arc in lightly on the paper for reference, to be erased later.

Secondary Action

Secondary Action: as the horse runs, its mane and tail follow the movement of the body.

Adding secondary actions to the main action gives a scene more life, and can help to support the main action. A person walking can simultaneously swing his arms or keep them in his pockets, speak or whistle, or express emotions through facial expressions. The important thing about secondary actions is that they emphasize, rather than take attention away from the main action. If the latter is the case, those actions are better left out. For example, during a dramatic movement, facial expressions will often go unnoticed. In these cases it is better to include them at the beginning and the end of the movement, rather than during.

Timing

Timing refers to the number of drawings or frames for a given action, which translates to the speed of the action on film. On a purely physical level, correct timing makes objects appear to obey the laws of physics; for instance, an object's weight determines how it reacts to an impetus, like a push. Timing is critical for establishing a character's mood, emotion, and reaction. It can also be a device to communicate aspects of a character's personality.

Exaggeration

Exaggeration is an effect especially useful for animation, as perfect imitation of reality can look static and dull in cartoons. The level of exaggeration depends on whether one seeks realism or a particular style, like a caricature or the style of a specific artist. The classical definition of exaggeration, employed by Disney, was to remain true to reality, just presenting it in a wilder, more extreme form. Other forms of exaggeration can involve the supernatural or surreal,

alterations in the physical features of a character; or elements in the storyline itself. It is important to employ a certain level of restraint when using exaggeration. If a scene contains several elements, there should be a balance in how those elements are exaggerated in relation to each other, to avoid confusing or overawing the viewer.

Solid Drawing

The principle of solid drawing means taking into account forms in three-dimensional space, or giving them volume and weight. The animator needs to be a skilled artist and has to understand the basics of three-dimensional shapes, anatomy, weight, balance, light and shadow, etc. For the classical animator, this involved taking art classes and doing sketches from life. One thing in particular that Johnston and Thomas warned against was creating "twins": characters whose left and right sides mirrored each other, and looked lifeless. Modern-day computer animators draw less because of the facilities computers give them, yet their work benefits greatly from a basic understanding of animation principles, and their additions to basic computer animation.

Appeal

Appeal in a cartoon character corresponds to what would be called charisma in an actor. A character who is appealing is not necessarily sympathetic – villains or monsters can also be appealing – the important thing is that the viewer feels the character is real and interesting. There are several tricks for making a character connect better with the audience; for likable characters a symmetrical or particularly baby-like face tends to be effective. A complicated or hard

to read face will lack appeal, it may more accurately be described as 'captivation' in the composition of the pose, or the character design.

Achieving an awesome animation performance

Published on August 20, 2015, by in Animation.

Animation is nothing more than a few drawings or models moving on screen. Then how do these lifeless objects give brilliant performances? From Timon and Pumbaa singing hakuna matata in The Lion King to Carl and Ellie in Up, what or, rather, who is it that makes them give their best performance? Of course, the simplest answer is the director of the film. But the director cannot play all the parts. This is where animators come in. They are not only responsible for bringing the characters alive, but also for their performance. In short, animators are the real actors behind the scene.

We bring you three factors that help animators achieve awesome performances that make you return to these films again and again.

Playfulness

Animation is a serious job. But being playful is part of the job. As we grow up, we tend to lose our sense of imagination and silliness that is usually responsible for some of the most amazing memories of our childhood. It is this elusive art that is the biggest tool for an animator. Some of the greatest animators of our time never forget to include a little playfulness into their work in order to work out dialogue accents, actions and expressions. Exaggeration is always welcome for that extra laugh. This gives them the opportunity

to work out different performances for the same scene, and then choose the most suitable one.

Metaphor

Using examples from what has been seen or known before can prove useful when creating something new. Animators often use real life references to come up with powerful performances. These references could be their own experiences or another acting performance that they have admired. The trick here is to combine the old and the new so that it gives way to something new. It is great if the audience can draw references but not so great if they feel that they have seen the performance before.

Verbs

Movies follow the age old rule 'show, don't tell'. This means that animators have to find action words/ verbs that define their characters, thoughts and emotions best. *E.g.* if a character is in love then let him/ her try 'to woo' the other character instead of saying, "I love you", or if the character is angry then give him/ her opportunities 'to explode' instead of giving dialogues. The saying, actions speak louder than words, are nowhere truer than for animation. Use this opportunity to its fullest.

If you are still stuck, go back to the basics. Observe people, record incidents or sketch them on a piece of paper for later reference. You can add to this by creating a sketchbook of ideas. This will ensure that you have a stockroom full of poses for days with less inspiration.

5

Acting and Animation

There is a common saying that, “An animator is an actor who uses a pencil and paper rather than their body to give a performance.” Animators, by-and-large are frustrated actors who can’t really perform physically in front of an audience for various reasons. Many of us tend to think of ourselves as “geeks” (well, that’s how I feel anyway). Our physical bodies are limited in what they can do or how they look. An actor such as Robert DeNero can portray boxing champion Rocky Marciano in one film, then a Taxi driver, a young Sicilian mob boss, or a father-in-law in others. He has versatility and great acting skills as well as a very good manager. The same can be said for many other well known actors and actresses.

Animators however, have far more versatility than could ever be imagined by any live action actor simply because the only limitation is their imagination. An animator can

become anything they want... anything. The only real limitation is their ability to a) draw, and b) animate. The two go hand-in-hand but are not completely bound. A person with limited drawing ability will not be able to portray a "realistic looking" human but if they know how to animate really well, they could give their drawings some truly exceptional character acting.

On the flip side, someone who knows how to draw incredibly well, (let's say like Michelangelo) but probably like Michelangelo, can't animate worth beans, you'd get some pretty ugly looking movements and hence bad acting. So what is it about acting that makes animation look so good?

Let's go back in time just for a bit to the mid 1800's. There was this guy in France named Francois Delsarte. He was born in 1811 and died in 1871. He taught acting and singing and ended up developing a theory on acting that relied on dramatic posing and physical signals. Rather than have the actor just stand in the middle of the stage without moving and deliver his lines such as, "My pain is too great for me to bear!", Francois thought it would look great if the actor threw his arm across his forehead while thrusting the other hand, claw-like, forward in front of him and then collapse back against a chair or something. Oh yeah!

In 1885, 14 years after he had passed away, (dramatically, I assume) his theories were published as the "Delsarte System of Expression". Many schools of acting in America adapted the system into their training during the late 19th century. In some early films from 1900 - 1925 you can still see some actors using his system (they're quite funny

to watch). In 1897, Konstantin Stanislavski, a Russian actor, set up his acting workshops at the Moscow Theatre. Rather than just having his actors pose to show their emotions he developed a system called "Method Acting" whereby the actor actually felt something because they had "become the character".

Stanislavski wrote several books on acting. The three which you will probably find most useful are: "An Actor Prepares", "Building A Character", and "Creating A Role". They are excellent books to study. However, as Stanislavski himself said, "You must not duplicate the Moscow Art Theatre (method acting). You must create something of your own. If you try to duplicate, that means that you merely follow tradition. You are not going forward."

He also said something which I feel applies equally as well to us as animators, "Artists must learn to think and feel for themselves and find new forms. They must never be content with what someone else has done." "If something excites you, use it, apply it to yourselves, but adapt it. Do not try to copy it. Let it make you think further."

This is basically the way I want you to view this book. There will be some analysis of existing scenes from animated films, examples of the assignments I will provide to you and suggestions of alternate ways to approach the given scenes. Follow Stanislavski's advice: "If something excites you, use it, apply it to yourselves, but adapt it. Do not try to copy it. Let it make you think further."

So, back to our main topic: Acting and Animation.

What is "acting"? By definition, acting or "to act" is a verb: to move to action: ACTUATE, ANIMATE, (interesting)

PERFORM, EXECUTE, to represent an incident or an emotion by action, to perform as an actor, to play the part of a character, assume the character of, to behave in a certain way as to convey an emotion, characterization, or certain actions.

So from this we know that acting is the physical performance which conveys:

- A character
- An incident
- An emotion
- Certain actions
- Certain behaviour

In his book, "Acting For Animators", Ed Hooks lists "Seven Essential Acting Concepts" as:

- Thinking leads to movement and emotion.
- Acting is reacting. Acting is doing.
- Your character needs to have an objective.
- Your character should play an action until something happens to make them play a different action.
- All action begins with movement.
- Empathy is the magic key. Audiences empathize with emotion.
- A scene is a negotiation.

Frank and Ollie felt there were three very special problems in the field of acting for animation which could not be ignored. These were found on page 502 of "Illusion of Life".

- The animator must know what the character should do in a particular circumstance.

- They must be skilled enough as a craftsman to capture in drawings what they know in their head.
- They must be able to retain the fleeting delicate thought of the moment over the several days it may take to animate the scene.

Again, in the book "Illusion of Life", on page 137, Frank and Ollie have a list of 12 components that are found in good animation:

- Inner feelings and emotions
- Acting with clear and definite action
- Character and personality
- Thought process through expression changes
- Ability to analyze
- Clear staging
- Good composition
- Timing
- Solidity in drawing
- Power in drawing
- Strength in movement
- Imagination

Trying to find the moment when the audience connects with the character on the screen. They are right there with the character, they understand them and are concerned about what happens to them. It is this moment when the character reaches out and touches the audience.

Getting the audience involved requires an understanding of the character and using feelings that are familiar with everyone. This doesn't necessarily mean using sympathetic emotions such as happiness or sadness. You can also create

feelings of anger, or fear, shock or revulsion. These are the six basic emotions.

In each of the lists above, the common thread is EMOTION. It's all about how you feel. How you feel about the character, how you feel about their circumstance, how you feel about the resolution. If you don't "FEEL" anything, what's the point?

Think about the last time you went to a movie. What kind of movie was it? Was it a comedy? Action/adventure? Horror, suspense, romance?

If it was a comedy, did you laugh at any point in the film? If it was action/adventure did you feel a certain thrill during a chase sequence? Was your heart beating faster? Were you excited? At the horror or suspense movie, were you scared or on edge? During the romance movie, did you feel the heartache or happiness of the united couple at the end?

If you answered "no" to any of the above questions, the movie was a failure and you probably should have asked for your money back. Our choice of movie genre is based on our emotional need at that point in time. You go to the film to feel that emotion, if you don't you were ripped off.

The only way you can feel an emotion is if you empathize with the character in their situation. To empathize, the actor needs to convey the proper actions that relay the appropriate emotion. This is where good acting comes into play. However, do not confuse action with acting. This goes back to our pal, Francois Delsarte back on page 5, remember him? You don't need to overly dramatize the action to make the emotion read. The character must be true to who they are.

Acting

Acting is really all about thought. If you have a character that doesn't think about what they are doing, you really have a puppet. Puppets are inanimate objects that only do what the person who is holding them, or controlling them, wants them to do.

I remember buying a stuffed doll which was also a hand puppet for my daughter when she was 2 years old. She saw it in a bin and fell in love with it. She named him "Charlie Dog" on the spot. When I pulled him out of the bin I noticed that it was also a puppet, so I stuck my hand in and started talking to Jenna in a "Goofy" voice. She didn't really like the idea that he could move and talk on his own so she grabbed him off my hand and hugged him. The moment he came off my hand he became inanimate and lifeless in her arms. The only time he became a "character" was when I did the puppet thing. I had to do all the thinking for him.

After a while, Charlie Dog became the bedtime routine for reading books and Jenna really enjoyed it.

Your animation needs to be treated in the exact same way. Without your concious thought flowing through the drawings and out of that character, the animation will appear lifeless. Many animators neglect this "thought process time" for the character on the screen.

One of the assignments I give my first year students is called "The Phone Call" In this assignment they are to have a character who receives a phone call from another character. The character receiving the phone call is to pick up the phone and answer it. The character on the other end is to say something which causes the first character

to change their emotion. Invariably, the student will animate the scene where the character picks up the phone with one visible emotion, then within half a second (literally) the character changes their emotion.

Twelve frames is not enough time for the first character to have registered who the other character is, get the message the other person is conveying, think about it and then change their emotion. The start of any phone call usually goes like this:

Ring, ring.

Character A picks up phone and holds it to their ear.

Character A: "Hello?"

Character B: "Hi, is this characterA?"

Character A: "Yes it is."

Character B: "Hi Character A, this is Character B. How are you?"

Character A: "Oh, hi Character B, I'm fine, how are you?"

This whole conversation takes about 10 seconds total. Of course the second and third lines could be eliminated but even then this conversation would still take about 6 or 7 seconds.

Character A's emotional change would take place on the last line after they recognize who it is on the other end of the phone. This would be about 5 seconds into the conversation.

5 seconds x 24 frames = 120 frames or 60 drawings (on two's) for the Character A to think about what Character B is saying and how they will repond to it. It is this "think time" that really allows your character to come alive to the audience.

This doesn't mean that your character needs to be doing some sort of action during those 120 frames. It could be a subtle as a moving hold with an eye blink. The idea is to make the character look as though they actually are thinking about something.

Don't Confuse "Action" With "Acting"

Your character needs to have a purpose for moving. Action, just for the sake of action is not a good thing. Of course on the flip side, you can't act something out without some form of action. Try playing charades without moving at all. What you're really trying to do is illustrate an idea or thought with the attitude or actions of your character.

Every action your character makes must have a purpose or reason. Any type of movement on screen will draw the audience's attention because they think something is going to happen and they follow the action. If it's distracting the audience may miss the focal point of the scene or become confused. You don't want the character to act like a magician who gestures with one hand while producing something in their other hand, seemingly out of thin air... unless of course, the character you're animating actually is a magician.

Here are 12 questions the animator must ask themselves before animating a scene:

- Is the character doing what the director wants in the sequence?
- Is the character doing only one thing at a time?
- Is the character putting over the story point in the scene you are doing?

- Is the character acting as if there is something going on in his mind?
- Does the character appear to be doing something on his own?
- Can the audience tell what the character is thinking?
- How does what the character is doing effect what the audience is thinking?
- Does the character have appeal?
- Is it passionate? Is passion going into the drawing and coming out of the character?
- Is it the simplest way to do it?
- Have you made small story sketches of one important character to be sure everything is working before you make a lot of drawings?
- Would any one else besides your mother like what you have done?

Animations

Clutter actors have a variety of properties (position, size, rotation in 3D space, scale, opacity) which govern their visual appearance in the UI. They may also have constraints on how they are aligned and/or positioned relative to each other.

The Clutter animation API provides a means of changing properties and constraints as a function of time: moving, scaling, rotating, changing opacity and colour, modifying postional constraints, etc.

Clutter also makes it possible to animate non-visual properties if desired.

High level overview

Here are the main concepts behind animation in Clutter:

- An animation changes one or more properties of one or more actors over time: their rotation in a particular dimension (x, y, z), scale, size, opacity etc.
- An animation has an associated timeline. Think of this as analogous to the "thing" you're controlling when you watch a video on the internet: it's what you control with the play/pause button and what is measured by the bar showing how far through the video you are. As with the controls on a video player, you can play/pause/skip a Clutter timeline; you can also rewind it, loop it, and play it backwards.

If a timeline is reversed, the progress along the timeline is still measured the same way as it is in the forward direction: so if you start from the end of the timeline and run it backwards for 75 per cent of its length, the progress is reported as 0.25 (*i.e.* 25 per cent of the way from the start of the timeline).

- The duration of a timeline (*e.g.* 500 milliseconds, 1 second, 10 seconds) specifies how long its animation will last. The timeline can be inspected to find out how much of it has elapsed, either as a value in milliseconds or as a fraction (between 0 and 1) of the total length of the timeline.
- An animation is divided into frames. The number of frames which make up the animation isn't constant: it depends on various factors, like how powerful your machine is, the state of the drivers for your hardware,

and the load on he system. So you won't always get the same number of frames in an animation of a particular duration.

- The change to a property in an animation occurs over the course of the timeline: the start value of the property heads towards some target value. When it reaches the end of the timeline, the property should have reached the target value.
- Exactly how the property changes over the course of the timeline is governed by an alpha.

Alphas

An alpha is generated for each frame of the animation. The alpha varies between -1.0 and 2.0, and changes during the course of the animation's timeline; ideally, the value should start at 0.0 and reach 1.0 by the end of the timeline.

The alpha for any given frame of the animation is determined by an alpha function. Usually, the alpha function will return a value based on progress along the timeline. However, the alpha function doesn't have to respect or pay attention to the timeline: it can be entirely random if desired.

To work out the value of a property at a given frame somewhere along the timeline for a given alpha:

- Determine the difference between the start value and the target end value for the property.
- Multiply the difference by the alpha for the current frame.
- Add the result to the start value.

The shape of the plot of the alpha function over time is called its easing mode. Clutter provides various modes

ranging from CLUTTER_LINEAR (the alpha value is equal to progress along the timeline), to modes based on various polynomial and exponential functions, to modes providing elastic and bounce shapes.

Most of the time, you can use the built-in Clutter easing modes to get the kind of animation effect you want. However, in some cases you may want to provide your own alpha function. Here's an example (based on the quintic ease in mode from clutter-alpha.c):

```
static gdouble
_alpha_ease_in_sextic (ClutterAlpha *alpha,
                       gpointer dummy G_GNUC_UNUSED)
{
ClutterTimeline *timeline = clutter_alpha_get_timeline
(alpha);
gdouble p = clutter_timeline_get_progress (timeline);
return p * p * p * p * p * p;
}
```

An alpha function just has to have a specified method signature and return a gdouble value when called. As stated above, you'd typically base the return value on the timeline progress; the function above shows how you get the timeline associated with the alpha, so you can apply the alpha function to it.

Clutter's animation API

All of the animation approaches in Clutter use the same basic underpinnings (as explained above), but the API provides varying levels of abstraction and/or ease of use on top of those underpinnings.

- Implicit animations (created using clutter_actor_animate() and related functions) are useful where you want to apply a simple or one-off animation to an actor. They enable you to animate

one or more properties using a single easing mode; however, you only specify the target values for the properties you're animating, not the start values.

- ClutterAnimator provides support for declarative animations (defined using ClutterScript). You can animate multiple actors with this approach, and have more control over the easing modes used during an animation: while implicit animations only allow a single easing mode for all properties, ClutterAnimator supports multiple easing modes for each property; key frames are used to indicate where in the animation each easing mode should be applied.
- ClutterState enables you to describe states: property values across one or more actors, plus the easing modes used to transition to those values. It can also be combined with ClutterAnimator for finer grained definition of transitions if desired.

States are particularly useful if you need actors to animate between a known set of positions/sizes/opacities etc. during their lifecycles (*e.g.* animating a list of items in a menu, or for animations in a picture viewer where you click on thumbnails to display a full view of a photograph).

Inverting Animations

Problem

You want to have an animation exactly mirroring another one that you just played.

Solution

Reverse the direction of the ClutterTimeline associated

with the animation. For example, here's how to invert an implicit animation which moves an actor along the x axis. The direction of the animation is inverted when the movement along the x axis is completed; it is also inverted if the mouse button is pressed on the actor.

First, set up the animation:

```
ClutterAnimation *animation;
/*
* animate actor to x = 300.0;
* the implicit animation functions return a ClutterAnimation
* which we can use to invert the timeline
*/
animation = clutter_actor_animate (actor,
CLUTTER_EASE_IN_OUT_CUBIC,
                                   2000,
                                   "x", 300.0,
                                   NULL);
/* callback for when the animation completes */
g_signal_connect (animation,
                  "completed",
                  G_CALLBACK (_animation_done_cb),
                  NULL);
/*
* callback for when the mouse button is pressed on the
actor;
* note the animation is passed as user data, so we can
* get at the timeline
*/
g_signal_connect (actor,
                  "button-press-event",
                  G_CALLBACK (_on_click_cb),
                  animation);
```

Next, add a function for inverting the timeline:

```
static void
_invert_timeline (ClutterTimeline *timeline)
{
ClutterTimelineDirection      direction      =
clutter_timeline_get_direction (timeline);
if (direction == CLUTTER_TIMELINE_FORWARD)
direction = CLUTTER_TIMELINE_BACKWARD;
else
direction = CLUTTER_TIMELINE_FORWARD;
clutter_timeline_set_direction (timeline, direction);
}
```

Then add a function which calls _invert_timeline when the animation completes. More importantly, the callback should stop emission of the "completed" signal by the animation. This prevents the ClutterAnimation underlying the implicit animation from being unreferenced; which in turn allows it to be inverted:

```
    static void
    _animation_done_cb (ClutterAnimation *animation,
    gpointer user_data)
    {
    /* stop the completed signal before the ClutterAnimation
is unreferenced */
    g_signal_stop_emission_by_name (animation, "completed");
    /* invert the timeline associated with the animation */
    ClutterTimeline *timeline = clutter_animation_get_timeline
(animation);
    _invert_timeline (timeline);
    }
```

Finally, the click callback function uses the same _invert_timeline function if the animation is playing; but if the animation is stopped, it will start it instead:

```
    static void
    _on_click_cb (ClutterActor *actor,
                        ClutterEvent *event,
                        gpointer user_data)
    {
    ClutterAnimation  *animation  =  (ClutterAnimation
*)user_data;
    ClutterTimeline *timeline = clutter_animation_get_timeline
(animation);
    if (clutter_timeline_is_playing (timeline))
                       {
    _invert_timeline (timeline);
                       }
    else
                       {
    clutter_timeline_start (timeline);
                       }
    }
```

Discussion

If you are using ClutterAnimator rather than implicit

animations, clutter_animator_get_timeline() enables you to get the underlying timeline; you could then use the techniques shown above to invert it.

ClutterState enables a different approach to "inverting" an animation: rather than having a single animation which you invert, you would define two or more keys for an actor (or set of actors) and transition between them. For the example above, you would define two keys: one for the actor's initial position; and a second for the actor at x = 300.0. You would also define the transition between them: 2000 milliseconds with a CLUTTER_EASE_IN_OUT_CUBIC easing mode.

With the states defined, you would then use clutter_state_set_state() inside callbacks to animate the actor between the two xpositions. Behind the scenes, ClutterState would handle the animations and timelines for you.

Fading an actor out of or into view

Problem

You want to animate an actor so that it fades out of or into view.

Solution

Animate the actor's opacity property.

You can do this using any of the approaches provided by the animation API. Here's how to fade out an actor (until it's completely transparent) using implicit animations:

```
/* fade out actor over 4000 milliseconds */
clutter_actor_animate (actor,
CLUTTER_EASE_OUT_CUBIC,
4000,
"opacity", 0,
```

```
NULL);
```

Here's an example of a rectangle fading out using this animation:

CLUTTER_EASE_OUT_CUBIC is one of the Clutter easing modes.

Here's an example of the transitions you could use to fade an actor in and out using ClutterState:

```
ClutterState *transitions = clutter_state_new ();
/* all transitions last for 2000 milliseconds */
clutter_state_set_duration (transitions, NULL, NULL, 2000);
/* transition from any state to "fade-out" state */
clutter_state_set (transitions,
NULL,/* from state (NULL means "any") */
"fade-out",/* to state */
actor, "opacity", CLUTTER_EASE_OUT_QUAD, 0,
NULL);
/* transition from any state to "fade-in" state */
clutter_state_set (transitions, NULL, "fade-in",
actor, "opacity", CLUTTER_EASE_OUT_QUAD, 255,
NULL);
/* put the actor into the "fade-out" state with no animation
*/
clutter_state_warp_to_state (transitions, "fade-out");
```

You would then trigger an animated state change as events occur in the application (*e.g.* mouse button clicks):

```
clutter_state_set_state (transitions, "fade-in");
```

Here's an example of this animation fading in then out again:

Note

ClutterState is most useful where you need to animate an actor backwards and forwards between multiple states (*e.g.* fade an actor in and out of view). Where you just want to fade an actor in or out once, clutter_actor_animate() is adequate.

Discussion

Reducing an actor's transparency to zero does not make it inactive: the actor will still be reactive even if it's not visible

(responding to key events, mouse clicks etc.). To make it really "disappear", you could use clutter_actor_hide() once you'd made the actor fully transparent.

Inside Out director talks 3 essential animation principles

The director of Pixar's UP, Pete Docter, was recently interviewed by CNN about the studio's newest feature, Inside Out, which examines the feelings inside the head of a an 11-year-old girl. In a strangely similar way, Docter's interview about the film also provides an interesting looking inside the mind of an accomplished and talented animator. Here are three valuable nuggets of wisdom Docter shared during the interview that can help any level of animator.

Use universal human experiences

"I think the secret sauce to animation, like anything, is truth, So even though [animators are] taking people to these far out places and showing them characters that you'd never believe are alive, we're seeing something of ourselves on the screen." The idea here is to emotionally connect your audience to your characters, no matter how different they are. One of the best ways to connect emotionally is to use universal themes and common experiences. Themes such as individuality, death, coming of age, innocence, loyalty, parent-child relationship are all common emotions and human experiences. You can think of universal themes as already-written, prepackaged narratives that provide background information and motivation for your characters. For example, Docter uses several of these themes in the opening sequence of UP to help the audience connect emotionally. During the

sequence, we watch Ellie and Carl's relationship–from adolescence to old age–within only a matter of 8 or 9 minutes! Yet the amount of characterization and emotional connection created is impressive.

One reason for the sequence's effectiveness is its reliance on universal human experiences to help"tell" Ellie and Carl's story. The short story is essentially the life cycle of a person, from birth to death (*i.e.* Ellie), something most of us already understand. In addition, there are also the themes of love, friendship, adventure, coming of age, innocence, and sacrifice. All are pre-known "stories" or meta-narratives that help flesh out the actual story while motivating the characters' actions.

Proof of the effectiveness of Docter's approach is evident within the fact that very little is actually said within the entire initial sequence, particularly after Ellie and Carl's wedding. The story is almost exclusively told through character actions (*i.e.* animation) and setting, while the universal themes help fill in the narrative gaps and prompt emotional responses within the audience.

Exercise projecting personalities

"People are funny — they are able to project personality onto anything. I remember as a kid I spent a $5 bill once and felt so bad because the other $5 bill was now going to be lonely without all the other bills I had in my wallet. You just invest these dead things with a sense of life. That is our tendency as people, so animation takes advantage of that, grabs on to it and runs with it."

The childhood tendency to imbue feelings and emotions onto inanimate objects is an essential part of telling animated

stories. The entire Toy Story franchise is based on this premise. However, as Docter suggests, good animators never really loose this ability/fascination with anthropomorphizing objects or understanding what their actions can "say" to an audience.

All objects usually have some type of social meaning connected to them.

Take for example a trashcan versus a teapot. What type of personality would you create for each?

What gender would you assign them? Probably most of us would have approximately the same answer: the trashcan would be male and vulgar while the teapot would be female and delicate. For most of us, these personality traits seem to correspond to our understanding of what a trashcan and teapot are. Of course, this goes for human characters as well. We usually think specific things about a garbage man versus a tea-serving maid.

During the interview, Docter actually demonstrates how the studio used these cultural values when creating the Inside Out characters: Anger and Fear (6:30-7:30).

"We try to start with simple shapes because we're after a sort of essence. So Anger is this square, he's like a brick. He's all about the brows because he's trying to hold it all in. I would keep his arms contained within the shape of the body because he's going to be angry. He's trying to hold it in and not explode."

The director's explanation shows how something as simple as a shape contains specific cultural values: a square is edgy, abrasive, aggressive, containing (anger), etc. Of course, Anger's foil is Fear who, not surprisingly, has a

completely opposite appearance–long, lanky, thin, bug-eyed with a bow tie.

It's essential for animators to foster an awareness of the types of social values placed upon things and people. Usually this means paying attention to the way objects and characters are used within other forms of art and entertainment. That's why watching other animators and animated films is one of the best ways to grow as an artist yourself. However, it's also important to listen to real people too, especially when it comes to new cultural artifacts like new occupations, generations of people, technological devices, etc. What type of personality would an iPhone have?

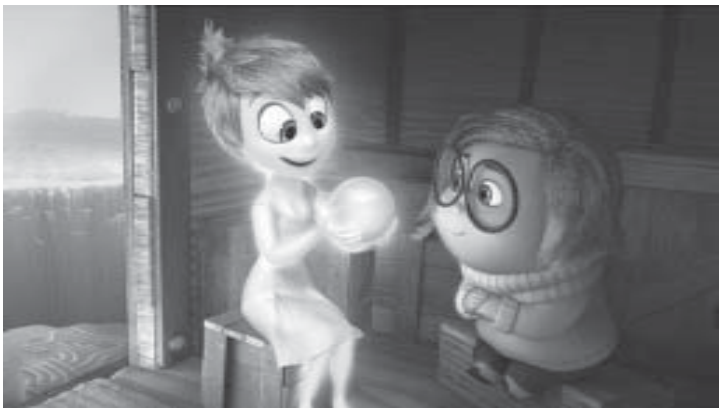
You'll notice in Docter's quote that he compares Anger's squarish shape to a "brick". That's because brick are often associated with aggression and danger, especially in the world of cartoons. Using brainstorming techniques like free writing or free association can help you make these types of connections and generate new ideas for animating characters.

Begin with motivation

"A great animator is basically a great actor. Yes, they have technical skills: they can draw, they can operate the computer, they can create beautiful movement. But fundamentally, they're thinking about what's going on inside the characters' heads. They're always thinking about what is causing that movement. So it's not movement for movement's sake."

What Docter is saying essentially is that character motivation should always precede animation. Often you will hear a real actor asking the director, "What's my character's

motivation in this scene?" That is, what does my character desire. Is it to escape? To fall in love? Maybe it's to fulfill a promise? Knowing what motivates a character first will help make many of the performance decisions for the actor. Since animation is simply vicarious acting in a way, the same motivations should be considered.



The idea of motivation before animation is similar to universal themes with respect to connecting with your audience. The audience should be able to see themselves reflected within the feelings and motivations of your characters.

"Seeing" themselves, of course, doesn't simply mean they recognize the character's physical movements as realistic. Rather what they are gauging is whether the character's feelings and reactions are realistically motivated ("That's exactly the way I would feel too!"). Of course, the way you convey these emotions and feelings is through what your character say and do (*i.e.* animation), but it's essential to begin with what they desire first if you want it to be more authentic.

Often its a good idea to act out your character's scene yourself and record video of your performance. Many times

you can catch subtleties that you may not have otherwise noticed, whether it's a certain way of blinking, hand movements, etc. Such subtleties can often speak louder than normal actions if they correctly convey motivation. Even overly-exaggerated, cartoony movements can benefit from such realistic touches.

6

Animation and Work

When considering issues such as this it is helpful to consider developments in socio-cultural animation and popular education practice in South America. The community arts movement in the UK (akin to creative-expressive animation in Italy and France) has looked to, for example, Nicuraguan arts and cultural practice. Animateurs have also looked to the discourse that has grown up around the Theatre of the Oppressed or Forum Theatre. Here the key figure is that of the Brazilian theatre director and writer, Augusto Boal (-2009).

In Augusto Boal's work around forum theatre, invisible theatre and the theatre of the oppressed we see some fascinating expressions of socio-cultural animation. He writes of theatre as the art of looking at ourselves:

The Theatre of the Oppressed is theatre in this most archaic application of the word. In this usage, all human

beings are Actors (they act!) and Spectators (they observe!). They are Spect-Actors.... Everything that actors do, we do throughout our lives, always and everywhere. Actors talk, move, dress to suit the setting, express ideas, reveal passions – just as we do in our everyday lives. The only difference is that actors are conscious that they are using the language of theatre, and are thus better able to turn it to their advantage, whereas the woman and man in the street do not know that they are speaking theatre. (Boal 1992: xxx).

In these words we can see some immediate connections to the activities of informal and community educators, and animateurs.

What Augusto Boal did was to work in workshops – perhaps with workers from a particular factory (Forum Theatre) or to take performance to the street (Invisible Theatre) where people are confronted with what at first sight appear to be events – but are revealed as theatre. He begins by seeking to integrate the group and to explore political and economic questions (2 days). In this there is an emphasis on exercise – 'actors must work on their bodies to get to know them better and to make them more expressive' (ibid.: 1). The group would then work for a couple of days on preparing 'scenes' (through exercises, games etc.). On the fifth day they may take the scenes to the street (Invisible Theatre) and then on sixth make a presentation to an audience (Forum Theatre).

What we can see in this is a fairly straightforward process that carries within in many of the concerns and a significant amount of the analysis that runs through Freire's work. For example on dialogue: 'I believe it is more important to achieve

a good debate than a good solution' (ibid. 230). However, two of the fascinating elements of this approach concern the animating force of performance; and the focus on emotion. In the case of the former, engaging in performance can bring forward questions, experiences and issues that are difficult to express in initially in words. It can reveal elements for the group to work on.

Second, Augusto Boal has picked up on the concerns of Stanislavski and the need to move beyond the mechanisation of the actor's body into allowing emotion to shape the final form of the actor's interpretation of a role. However, he is also at some concerns to explore that emotion. 'The important thing about emotion is what it signifies. We cannot talk about emotion without reason or, conversely, about reason without emotion; the former is chaos, the latter pure abstraction'. (ibid.: 48).

Animated Actors

"I'll be in my trailer...taking a nap!"

Haruko: Those slow motion scenes are really tough, huh?

Mamimi: Yeah, you have to hold your breath until they cut.

Haruko: You can get cramps from that, you know?

Naota: What? I thought it was a special effect! You're doing the slow motion?

— FLCL

An animated episode is in full swing. The action suddenly stops, the characters step out of character, and address an unseen figure. The view pulls back to reveal the action is taking place on an animated TV soundstage. Usually punctuated by a heated exchange between the animated director and the character.

This is a specific type of fourth wall joke.

Many times, the "actors" who play the characters are very different from the characters themselves. Often, the dumb, inarticulate comedy relief will turn out to be a posh Shakespearean ac-tor. A large, imposing character may take off his head, revealing himself to be a normal-looking guy wearing a costume. The Big Bad may turn out to be a total sweetheart when not in character.

Many times, the character's name will stay the same, but occasionally the crew will call them by the voice-actor's name.

Also used as a method of Lampshade Hanging, as the character will often complain about some trite or hackneyed element of the scene, and refuse to proceed. There's also the popular gag of having them mess up their lines or goof off, though obviously these Hilarious Outtakes took just as much work to write, voice, draw and animate as the rest of the show.

This can be a throw-away gag, or it can be the plot of an entire episode.

If the animated characters are interacting with live action humans/ people, it's the Roger Rabbit Effect.

If taken to a whole dimension, where characters in a writer's portfolio are reused across whole works (sometimes with different roles) like how a "real" actor/actress would, it becomes a Reused Character Design.

Make A Break Into Anime Voice Acting

As children we all watched cartoons and fell in love with characters who, in our innocence, we assumed to be real. Later we discovered, with the same disappointment that comes with shedding our belief in Santa Claus, that they were not.

Beyond childhood, many continue to enjoy the art and fantasy that can only be achieved through animation. As we enter adulthood, a growing number of us are discovering anime. With its more mature themes, intricate story lines and varied genres, anime provides us with a whole new level of animation and its popularity is growing strongly in our own culture.

As adults, though, we are more aware of things that escaped our attention as children. Foremost is an understanding of the creativity that comes to bear when creating anime. Additionally, we know that there are careers to be had in the North American anime industry.

In bringing anime titles to an audience that predominantly lacks mastery of the Japanese language, one career stands out as a dream-job to many — voice acting.

In this article you will discover the ins and outs of breaking into this career field as well as many insider tips

that you can use to make your move. You will also find other helpful information in preparing for success as an anime voice actor. But be advised: show business is a fickle thing. Theres no guarantee that you will be a success no matter how talented they are.

When considering the potential of a career as a voice actor, it perhaps does one well to understand that voice acting is far more than just talking.

To gain an insight into this line of work and the most important assets needed to succeed in getting that first audition, weve gone directly to the source. We surveyed six of the most influential directors and producers casting roles in anime today, including: Joel Baral of TOKYOPOP; Peter Bavaro of Skypilot Entertainment; Amanda Winn Lee of Gaijin Productions; Yutaka Maseba of ZRO Limit Productions; Jeff Thompson of The Right Stuf International, Inc.; and Tom Wayland of Central Park Media.

Prepare To Succeed

Preparing to pursue a career as a voice actor generally involves more than being able to mimic your favorite character. You need to be prepared to succeed.

Though most successful voice actors working in anime today began their careers as voice actors without any specific training in the field, almost all of them did begin their careers with certain things in common. Among these are acting experience, vocal range and the ability to assume and maintain a character. A voice actor is first and foremost an actor.

The vast majority of voice actors working today come from the theater. It is the acting skills possessed by these folks

that make them so desirable by anime studios. It is also those same skills that you should work to acquire if you want to be taken seriously and get that audition.

While few and far between, voice-acting courses are available, mostly in the form of workshops. Some of these are better than others with the most common criticism being that they teach only the intricacies of the equipment and techniques used in dubbing work, but do little in teaching one how to act, develop characters or even to read a script.

While there are valid pluses to taking voice-over courses, the best path to success is to first establish your skills as an actor, then take voice-acting courses and workshops. Remember: voice actors are first and foremost actors.

Assuming you are still in school, you can begin to shape your career by joining your school theater and/or glee club. These activities can give you a much-needed head start. Additionally, a history of acting or singing (or both) looks exceptionally good on a resume and, depending on the studio, may be key in getting an audition.

Should you attend college, your opportunities to develop your skills will increase greatly. Most schools offer courses in acting, script reading, character development, etc. that can be of great use. Most colleges today have full theater companies. There are few other opportunities where you will be able to gain professional-level experience and still have an educational institution right there to help you hone your skills even further.

Another opportunity that might be available to you at any age are theater groups that may be performing at local community theaters. Quite often these organizations also

conduct their own workshops and can help you develop your acting abilities. They can also give you much-needed experience in script reading and the various styles and methods of acting.

Trying your hand in full-fledged theater productions, be they at school or a local theater, can be an exceptional opportunity. The benefits come not only in terms of experience and education but in establishing connections and friendships that may in fact lead to an invitation to audition.

Another option that you may find attractive is taking a correspondence or on-line acting course. While it is difficult to state the value of such courses accurately, they will always beat no training but stand little to no chance of equaling actual experience acting in a group or company.

One additional use for these types of distance-learning programmes is to perform a self-evaluation. By taking these relatively-inexpensive courses, you might be able to determine if you really have the drive and desire to become a successful voice actor. Voice acting isnt all interviews and convention appearances before adoring fans. It takes a lot of hard work and self-discipline to succeed — or just to get an audition.

Though this may seem obvious, having some form of experience will set you apart from the hundreds of resumes and demos anime studios receive every week.

Local theater companies or singing clubs, choirs, extracurricular school activities, such as plays and musicals, college-level courses, acting workshops, voice training, even work at a college radio station, can all be used to create an impressive resume.

Every step you take in the acquisition, development and honing of your skills helps you prepare to succeed. They demonstrate that you are not only serious about voice acting but that you come with an arsenal of skills.

Plainly put, they show that you are ready to begin work as a productive member of a studios team. To a studio this translates to not only getting a good performance from you but to a savings in production time. It also greatly increases the chances that you will be called in for the all-important first audition.

Studios And Resumes And Demos — Oh My!

Once you feel youre ready, youll find yourself faced with what can appear to be an impossible task — getting noticed. The first thing you should realize about voice acting is that all — I mean all — voice actors, regardless of their popularity or resume, get rejected for roles. It is simply part of the job.

While not required by all studios, some will make their decision as to whether or not to grant an audition based on your resume. Of our six casting gurus, one, ZRO Limit Productions, reviews resumes prior to requesting a demo reel. (Actually, the term “demo reel” is a hold-over from the days of magnetic tape. Usually what is submitted, and expected, is a CD.)

Even though a resume is not the primary concern of most studios, it is a valuable tool for you to get noticed. The studio will most likely make their decisions based on the demo, but, depending on your experience and qualifications, your resume can call out to the person screening them, “Check out my demo!”

Virtually all of the studios we surveyed said they really like to see some sort of acting experience on a resume and that it does have an impact on their decisions to grant auditions. Given a good demo versus a good demo with a good resume, the resume addition will win every time.

You should take note that the studio will most likely not care to spend their time reading about every aspect of your life or even what you look like. Things like hair colour, eye colour, etc., are a definite no-no. In fact, not one studio said they require or even want to see head-shots.

About head-shots Peter Bavaro comments, “Hey, Im glad you spent $300 to get a professional head-shot; youre trying to do it right. And Im sure you have a nice smile and a killer body. But I want your voice — eat as many Cheetos as you want!”

By the way, sloppy, hand-written resumes will signal to the screener that you are a sloppy and unprofessional person and will greatly detract from your chances. Use good quality paper (no neon; use white, light gray or ivory), an easy-to-read font and keep it to one clear, concise page outlining your experience and talent.

Once you have your resume in order, the next task is your demo. A demo should be short (from one to three minutes long), of high quality and demonstrate your talent.

There are two ways to get a demo made. First, you could go to a professional recording studio, drop a few hundred dollars (or more), and record your bit. This will not guarantee a good demo, just one of a high quality without background sounds or breaks.

The second option is to record your demo yourself. If you choose to do this, dont use a hand-held portable tape recorder. Those days are gone forever. The medium of choice now is digital, as in CDs.

Many home computers today come equipped with high-quality sound cards and CD burners. When recording your own demo, dont use a cheesy little microphone that comes included with many computers. It would be a wise investment in your career to buy a higher quality mic that is compatible with your equipment.

A pitfall of recording your own demo is that there may be background noises. Little things that normally go unnoticed, like a squeaky desk chair, an air conditioner, the refrigerator, or even traffic outside, can ruin an otherwise good demo. Remember, the studio wants to hear you clearly so they can decide whether or not to spend hundreds of dollars by calling you in for an audition. As silly as it may seem, a roomy closet may be your best choice for sound isolation. Hanging blankets on the walls of the closet can even improve it by killing the slight echoes that can occur in a small space. Remember this when you get a microphone and make sure you have one with a long enough cord.

Another caution of home recording and burning your own demo CDs is to make sure you label them professionally. Another good investment might be to purchase a CD-labeling kit available at most department stores. Make sure your name, address, phone number and e-mail address are clearly presented on the CD.

Whether you record your own or go into a booth, you will have to decide what to record. Virtually all of the studios

said they want to hear as wide a range as possible so they can get a good idea of your skills and the roles to which you may be best suited.

Perhaps the best way to demonstrate what exactly screeners look for in a demo is to let a few of our experts speak for themselves. So lets hear what our six experts have to say.

Gerry Poulos: What would make a demo stand out?

Peter Bavaro: People without demos have asked what to do. I tell them get the New York Times and read a few different parts; a straight news item, a funny blurb, a sexy ad. Whatever. Just make it short and sweet. You dont have to blow $1000 at a studio adding music and sound effects. If your voice works for a role, youre in. No big deal.

Amanda Winn Lee: A good range and a great sense of humor.

Yutaka Maseba: A brief demo reel — 1 to 2 minutes — showcasing the actors range. What I mean by range is the ability to sound like several different characters were auditioning for.

Tom Wayland: A wide range with good coherent reads. I hate it when I get a demo where some kid rattles through 30 different voices in 60 seconds. I need to hear the person act with each character, not just spout some catch phrase or one-liner.

Gerry Poulos: What on a demo would guarantee that you would not give them an audition?

Peter Bavaro:

Dont try too hard. Short and sweet works wonders.

Amanda Winn Lee: If someone tries to do an impersonation on a demo reel and they sound nothing like the person theyre imitating, thats a huge red flag for me. You wouldnt believe how often that happens. This tells me that the person doesnt have a good ear, so they may be difficult to direct in the studio.

Yutaka Maseba: Unprofessionalism: sloppy hand-written resumes accompanied with poorly labeled demo reels.

Tom Wayland: I dont want to hear reading. I want to hear acting. Its not enough that you can do a silly little kid voice or an evil demon voice. I need to hear this character in a scene or conveying some sort of emotion. Nothing is worse than a flat demo.

Gerry Poulos: What are the most common mistakes people make?

Joel Baral: Including their height, weight and hair colour unnecessary. Less is more.

Peter Bavaro: Faxing head-shots. We tell them not to — we say it on the phone — we put it in the ads, "Please do not fax head-shots" — but they come; big black squares of barely discernible images that suck up all our toner.

Amanda Winn Lee: Doing impersonations of famous people, rather than just doing interesting character voices. If I wanted to use the voice of some one famous, Id contact them directly.

Yutaka Maseba: Sending the wrong type of demo reels. Know what type of product the person you are sending the demo creates. We're not looking for cartoony voices; in fact, natural voices are preferred.

Tom Wayland: Showing up in person is bad. Calling and e-mailing constantly is bad. Mail in your stuff and I will listen to it. I love to listen to new demos. Feel free to send a follow up to make sure that the package was received, but after that, let it go.

Playing The Waiting Game

So now you have your training. Youve gotten some experience. Youve done your resume. Youve cut your demo. Youve sent it all in to every studio in your geographical region. Now what?

You wait. Though this is extremely difficult, it is one of the things that virtually every single studio agrees on. The people at these studios have hundreds of resumes and demos coming in every week. If the person screening them has to talk to every person who sent in a demo in the last few months, he would be taking literally thousands of calls a week and not listening to demos.

Whats more, if you make a nuisance of yourself, they may simply say, “Im sorry. Were not interested,” even though they might have been. They might consider you very unprofessional and decide that the time you cost them on the phone is better spent somewhere else and cut their losses by cutting you. They do have other jobs, like actually producing anime.

Most studios will let you know from a few days to a few weeks if they want you to come in for an audition. You might be thinking that if they havent called you after a few weeks that youve got nothing to lose by constantly calling them. Youd be wrong.

They may not have a part suited for you at the moment but loved your demo. They may be considering you for something else theyre not ready to start auditions for yet. They may be planning on calling you in for audition in a few days. They may be willing to throw all of that out the window if you start calling and e-mailing them everyday too.

Most studios dont mind a brief letter or postcard from you to follow-up on if your demo has arrived. They also, for the most part, dont mind you contacting them every few months to let them know youre still out there. But remember, they do mind having to drop whatever theyre doing to take your call. Letters, postcards and patience are definitely the way to go.

Finally, A Phone Call

If a studio liked your demo, you may well receive a phone call asking if you can come in for an audition. Say yes. If you dont have time to come in, then theyll decide that you dont have time to be a voice actor. There are exceptions of course. If youre getting married that day or have a death in the family, they will most likely simply schedule another day. But short of those circumstances — and they had better be real — you have to always be ready to come in for an audition.

There are five things you have to "be" when the day of your audition arrives: Be early, fifteen to thirty minutes is good; Be ready, have your voice warmed-up and your acting underwear on; Be confident, directors hate having a shy person who cant get their "sides" (lines) out; Be prepared, they might ask you to be practically anything from an elf to a dragon; Be friendly, youre there to make friends and win a role. Attitude and posturing will get you nothing but gone.

I asked our friends, “What do you look for from an aspiring voice actor during an audition?”

Joel Baral: That they can receive direction and adjust immediately.

Peter Bavaro: Step oneshow up. Then try a clear voice, respond to direction and make an effort to please. If you want to try it once more, ask us. Auditions are hard, no question. You have very little to go on, so listen to what the director is asking you to do. If you need a little more info, ask for it.

Amanda Winn Lee: First of all, talent, of course. Other than that: range, enthusiasm, sense of humor. Basically, if I cast them, I will be spending 4-8 hours a day in a small room with them. I want to make sure theyre pleasant to work with.

Yutaka Maseba: A good performance by an actor who can lip synch to the picture.

Jeff Thompson: It is a potential actor’s job to convince a casting director/producer/director that they are perfect for a project.

Tom Wayland: Be on time. Be relaxed and cooperative. Take direction well. Have fun.

When asked, “What preparations would make an aspiring voice actors audition really shine?” our group of industry pros responded:

Joel Baral: Get to know the property the character [youre auditioning for. Theyll let you know beforehand what it is].

Peter Bavaro: Get warmed up outside the booth. Sign in and get your head together in the lobby. Focus on the roles that are listed and be confident in your natural voice. Ill ask you for any variations once were rolling.

Amanda Winn Lee: A wide range of character voices really helps. Also, warn the sound engineer if you are going to drastically change volume (i.e. go from speaking to screaming). This allows the engineer to adjust the input levels so the take doesnt get distorted. This also shows that you know what youre doing.

Yutaka Maseba: Find out what role you are auditioning for. Ask if the auditioning role requires a special accent or characteristic. Do your homework based on the information given to you. For example, if they ask for a Southern accent, find someone with an authentic accent and observe their speech. Come in early and ask the casting director for your side. Study it and get familiar with your lines.

Jeff Thompson: Arrive at any audition on time or even early and have completed your vocal warm-ups. Take a course — offered at most college acting programmes — on auditioning.

Tom Wayland: Take direction well. Be vocally warmed up just in case you have to read for a 10 year-old kid — and then we ask you to read for a tentacled beast 3 minutes later.

Finally, I asked, “What would definitely make an aspiring voice actors audition an utter failure?”

Joel Baral: If they cant hit the note.

Peter Bavaro: Any type of attitude or distracted nature wont help. Hey, we understand if youve got to be somewhere else in 20 minutes, but you came to audition so we like to feel youre interested.

Amanda Winn Lee: If they get “mike shy” — meaning they freeze up in front of the microphone. That doesnt help us or

them. I have seen veteran actors who have been on stage for years just clam up and get nervous once they set foot in the studio. If an actor is nervous or holding back, we can hear it in their voice. Also, if they act like a diva or are rude to the sound engineer. I fired an actor in the middle of a session once for being snippy with the sound guy. I dont care how many VO projects youve done — the world is crawling with voice actors, but its really hard to find a good sound tech.

Yutaka Maseba: Showing up late.

Jeff Thompson: Being late to an audition is typically fatal. Having a schedule that does not lend itself to the production environment means that many roles will not be available. Living far away from the studio is also difficult to overcome.

Tom Wayland: Lack of confidence. In this business you need to have confidence. It is just you and a microphone in there, so if you get all self-conscious emoting to this piece of machinery, you wont get the part.

Waiting – Again

Now that youve gotten your first audition, there are a few things you should know. First, be patient. All casting directors handle things a little differently. Some will pull you aside and say, "Yes," on the spot. Some will say nothing, and call the winners of the parts at home later. Still others will narrow their choices to a few actors and have them come in again. All the same rules for waiting on a response from your demo apply.

To give just a little more insight into what to expect following an audition, I asked our experts, "How soon does it usually take for you to let an aspiring voice actor know the results of an audition?"

Joel Baral: A week.

Peter Bavaro: Sometimes we give a basic response right away if someone is very good. Ill tell them they did a great job and even if they dont land something from us on this show they should keep in touch. We cant confirm anything until weve had time to really live with the reads and run them by our clients and/or associated producers. If someone does land a role, well be in touch over the next two weeks.

Amanda Winn Lee: Anywhere from one day to a week, depending on how long we are holding the auditions.

Yutaka Maseba: We tell the actors that we will call them within a week if they are cast for the role.

Jeff Thompson: Due to the sheer volume of people being auditioned, calls are made to the people who actually land the roles and not to the people who are not chosen for a project.

Tom Wayland: Around 2 days from the end of all auditions.

Gathering more info for you, I asked, “How long after an audition should an aspiring voice actor wait before contacting your studio regarding their audition?”

Joel Baral: Sorry, but we will call you, meaning we are generally in a rush to fill the roles, and finalizing actors is incredibly important. Calling us will not move the process forward. How about a quick follow-up postcard or note? Then, as you get other roles, keep the people you hit it off with updated on your career progress.

Peter Bavaro: Give us two weeks before you follow up.

Amanda Winn Lee: Actually, they shouldnt contact us at all. If Im going to cast them, I will call and let them know.

Our schedule is so crazy busy these days, I dont really have time to sit and chat with someone about why they didnt get a role, but someone else did. (Sorry.) Also, just because they dont hear from us then, that doesnt mean they wont still be considered for future projects.

Yutaka Maseba: We tell the actors that we will call them within a week if they are cast for the role.

Jeff Thompson: If the factors warrant a call to an actor, then someone will make this call; contacting the production staff more than a few times will not improve the odds of being cast.

Tom Wayland: If you dont get the call within a week or so, you didnt get it. If you really feel you had a great audition but maybe just werent right for the part and youd like to enquire about future auditions, give it a couple of weeks and then drop an e-mail.

Finally, I asked, "How often should aspiring voice actors contact your studio to keep in the running for future parts?"

Joel Baral: Every few months.

Peter Bavaro: The best time to contact us is when you have something to tell us — such as youre in a show, you read at some other audition, change of address, etc. Faxes are better than calls or e-mails. And ALWAYS put your contact information on any correspondence. We sometimes cant reach talent because their contact information has changed. This is frustrating for us and unfortunate for the talent.

Amanda Winn Lee: Different studios have different policies. Personally, I keep all auditions/demo reels that I find promising, even if they arent right for a role in the

current project were doing. As a result, I often request that actors not keep sending post cards, updates, etc. If Im interested, Ill definitely call you.

Yutaka Maseba: Generally, when there is a new "demo" reel created [by the aspiring voice actor]. Make sure the demo reel is updated not just a rehash of a previous reel.

Tom Wayland: Not too often. Pushy actors dont get work. We are on top of what were doing here. If we want to work with you, you will get called. Just so you know, we audition for shows about once a month, but certain shows have more roles than others. That being said there may be a few months where we dont need too many people, but there may be other times when were casting 20-30 people in a month.

In Parting

Aside from what Ive already offered by way of guidance, advice and giving you a peek at what happens from the inside to give you an edge on the competition, there are some final pieces of advice to offer.

Persevere!

Most successful voice actors working today didnt get the first role they sought or even auditioned for. Some didnt even get the first six.

Never Say No!

With rare exception you should never turn down a part, however small. The studio will interpret this as "prima donna syndrome," *i.e.* you think youre too good for the part and may be difficult to work with in other, more significant roles. Most successful voice actors first parts were small roles that

didnt show in the credits. Others just did background noises. Some have made a career of doing these small "bit" parts.

Continue to Improve Yourself!

If you felt that you lacked a certain something in your demo or audition, find it, fix it and try again. Besides, continuing to perform in other areas, such as theater or taking some extra acting classes, gives you a reason to submit a new "updated" resume and demo.

Well, we hope youve found some useful information for pursuing your dreams of becoming an anime voice actor. Good luck. We look forward to seeing you in the credits soon!

MacroMedia Director 4.0

Introduction to Director

On page one of the manual of Director, the package is described as an authoring tool for multimedia productions. A multimedia computer system is one that has the ability to provide interactive audio-visual effects. These are three very important points: Audio, Vision and Interaction. We will not concentrate on audio effects, as this is beyond the scope of this survey. However, Vision and Interaction are both provided by Director, and with a bit of work, the results can be amazing!

How it Works

Director is a widely used package for making animation and is examined since, it roughly represents the abilities of the animation software that exists at the present time. It is a flexible and versatile piece of software. This doesn't mean that there are no better animation systems currently available, as there are many more. The main reason that

makes Director distinguishable is that it can be used by different types of users and can create different types of results. The outcome may be from a simple presentation to a sophisticated *interactive cartoon movie*. However Director does not support three dimensional graphics and the design tools built into it are not very sophisticated so to produce real-time animation. Real-time graphics would be quite slow on Director, limiting its ability to produce only simple interactions.

In total there are eleven windows (!) which make up the Director Studio. The most essential windows though, are only four: paint, cast, stage and score.

Paint: is the window where the frames are designed or scanned from external sources. This is the window where the work starts since, the key-frames are modelled here.

Stage: is the window where the result animation is being displayed. This is the window which the users will view it and interact with.

Cast: it is a multimedia database of graphics, sounds and colours that frames are made up of. Once a member of the cast has been moved onto the stage it is called a *sprite*.

Score: keeps track of the position of each *sprite* in each frame and controls the timing of special effects like tempos, palettes, transitions and sounds. This window is very important for every approach to the package since, it gives the pattern of the animation in a special *grid* and every sprite can be traced independently.

An important drawback of the Director is that it supports only 48 layers on the stage (*i.e.*, There can be only 48 sprites at any moment). This sometimes found to be very limiting.

There are also only two channels for background sound which are very limiting as well. Basically the cast members are developed in the paint window then positioned in the cast window. Then we edit the score window where the duration of each frame and the soundtrack is declared. The simplest way to define the in-between frames is by using lerping (linear interpolation) which is very easy but does not produce very smooth results. Complex animation interpolation can be defined using a special window. The Programme takes care of anti-aliasing at the expense of animation speed. The anti-aliasing can also be disabled.

Simple animation can be achieved with the features. If something more advanced is required then we have to use the built-in script language Lingo, which provides a really powerful instruction set.

What is Lingo

As we said before Lingo is the programming language of Director. The key idea of Lingo is that, like Director as a whole, it can provide several layers of usability. One should not have to learn all Lingo features in order to create animation. Every layer gives more advanced tools but at the expense of the required experience of the user.

The main window where Lingo is written is the Script window. It is opened every time a new Lingo Script is needed. We can have as many script windows as we want running at the same time. The basic idea of using several script windows is that we want to attach each one to a certain frame and certain sprite. All scripts interact and can pass parameters to each other. They can also wait for an other script to start or finish in order to activate. Apart of each of these scripts a

frame script channel is provided in the Score. This channel can have general scripts which affect all the corresponding channels of a certain frame. Scripts are combination of words that convey information and instructions. Lingo and other script languages have certain elements that you use and rules that you follow to create statements. You use the statements in much the same way as when you speak.

A very simple example of Lingo is the following :

[Having a circle in the cast]

```
on mouseUp (* mouseUp is activated when a mouse button is
released *)
DoSomething (* DoSomething is a user-defined Handler - it
is called here *)
end
on DoSomething
puppetSprite 1, TRUE (* gives to sprite 1 a dynamic nature
*)
set the forecolour of sprite 1 to random(256) - 1 (*
randomly select a colour *)
updateStage
end
```

Using the above scripts we can create a circle which colour changes every time we click with the mouse pointer on it.

Functional Animation Languages No support in Director

There is an alternative, *functional* approach to animation systems which is developed the last years.

This type of programming approach is believed to provide an easier degree of control than the script-driven programming.

The basis of the functional approach is to build an animation system from a set of primitive operations which are used as blocks to construct more complex operations.

This gives a new era to *prototyping* of animation systems, by using little effort and having a very rapid development.

The greatest motive that caused this kind of approach is the skilled manpower involved. In the last years the progress in computer hardware design has decreased the costs of the required equipment. As a result the actual cost is the animator that is going to operate that equipment. Therefore, the smaller the needed skill and effort the less the system will cost.

Functional animation operates similarly to any other form of *functional programming*. We define *primitive* types such as Movie, Picture *etc.* which are *opaque*. Using a number of functions we can create, manipulate movies and combine them to make more complex ones.

A very simple example of functional animation is the following *(Note that this example is set only to give an idea of functional programming to the reader. Full understanding is not expected):*

(treepic is a picture of a tree bent over to the right)

```
osc ::[a]=>[a]
inbetween:: Int => Pic => Pic => [Pic]
tree::Movie
tree = osc treeframes where
treeframes = inbetween 5 treepic (flipx_pic 50 treepic)
```

Osc is a function that takes a sequence of finite length and returns an oscillated sequence of infinite length. Inbetween takes a number and two pictures as argument and returns the in-betweened sequence. In our example the one picture is the tree and the second is the tree flipped at x=50 axis. The frames in total will be 5 (argument) + 2 (pictures) = 7.

Performance Issues

As any other Programme, Director has a few problems. There are a few functions that are missing and should definitely included in such a Programme. There are other functions that don't give high quality results and others that run just too slow. Also there are some components that should be made a bit different so to make Director much easier to use:

Speed

One of the most notable problems, even on very fast machines, is the *flickering* of *sprites*, as they move across the screen. If the sprites have been *shrunk* or *enlarged*, the problem becomes more serious. This is mainly because the hardware is not fast enough to cope with the changes, and it is unlikely that the problem can be resolved by more efficient software.

Another problem appears, when trying to use functions such as *Dissolve* which require a lot of computations. *Dissolve*, is a function that makes every pixel of a frame to disappear, in a random fashion. Director slows down quite a lot when such a function is used, as the speeds of random number generators are not very good. Surprisingly enough, *Pattern Dissolve*, which makes the pixels disappear in a predetermined order (some geometric pattern) is much faster and does not slow down Director, even on the largest sprites. Hence, the speed of *Dissolve* could be increased substantially if the all the pixels disappeared in a random, but predetermined order. In other words, if the algorithm was changed, so that a random sequence was recorded once,

and the same sequence was used again and again. Finally, the last of the functions that are really slow, is *colour cycling* and *palette swapping*. It involves changing the colours of a sprite during the animation. This is extremely slow and makes the animation run on a third of the normal speed. Again, this is a hardware problem and little can be done about the implementation of the algorithm.

Note that Director supports animation speeds of up to 60 frames per second (fps) which should be enough for most applications, if the package could run at that speed on all applications.

Quality

In general, the quality of graphics on Director 4.0 is not very good. The paint window, used to design the members of the cast, does not provide enough functions to create good looking designs. The problems are realised when a design is *shrunk* or *expanded*, *rotated*, *distorted*, *etc.*. Then the results are not satisfactory at all. For this reason, Director 4.0 is usually used for the animation, whereas some other commercial package, such as PhotoShop, is used for the design of the graphics.

Reusability

Reusability can be defined as the ability of an animation system to use already existing resources in the production of animation. It is very important for an animation package to provide reusability as most of the animation work to be done is often the same and iterative. Undoubtedly the work of an animator can be reduced to a great extent if the system designer is provisional enough to provide a good degree of reusability.

In Lingo several elements define its reusability. We can define handlers which are procedure-like scripts and can have arguments and local variables as well. Global variables may also exist, and store information that can be accessed by different scripts.

Handlers can save a lot of work but they actually have a fixed nature so they do not offer very much reusability. The most important feature of Lingo in this issue are the Parent Scripts and Child Objects which are dynamic structures.

We might want to create a set of objects that share characteristics but can still behave independently of each other. For example we might want to create sprites which would look the same but move in different directions and at different speeds. If two sprites collide, each could respond differently to the collision. So if we want to create child objects, first we have to analyse how we want them to behave. Then write a parent script that declares any appropriate property variables, including the birth handler which sets up the child objects' initial values and parameters.

The following script is an example of a parent script. Two interactive buttons are displayed and when clicking on them the sprite goes either left or right.

```
property HorizPos
on birth me
set the horizPos of me to 256
set the locH of sprite 2 to the horizPos of me
set the locV of sprite 2 to 192
return me
end
on moveBall me, direction
set the horizPos of me to direction * 50 + the horizPos of
me
end
```

Important: We should note here that the above example is set only to give a vague idea about how the actual script looks like. Detailed understanding is not expected by the reader.

Proposed Features

Having talked to the people that use Director, we can say that there are a few new functions or modifications that could be made that would improve the performance of the package and make it more efficient and easy to use. First of all, it would be much appreciated if Director supported *three-dimensional animation*.

This is already supported by a few other products of MacroMedia and users would like to see it incorporated in Director. Secondly, it would be much better to be able to script (Programme in Lingo) functions of the paint window, such as rotate and distort. Currently this can only be done manually, so it is difficult to do for example interactive rotation, as the rotated sprites have to be calculated beforehand.

Also, an interesting feature would be some sort of *object orientation of the cast window* where all the different members of the cast are stored in such a fashion, so that the retrieval and generally the manipulation of them is easier. Finally, it is worth noting that Director provides an external interface for programmers using the C programming language.

This can be extremely useful as it increases the capabilities of Director, but it is generally accepted that this interface is difficult to use and again it would be appreciated if it was simplified as it would make Lingo much more powerful.

Future of Animation

Computer Animation is definitely the ultimate tool of the future. Its popularity is increasing in the area of entertainment, but scientific visualisation is the application that will utilise animation to all of its extent. In almost all areas of science, there is a vast amount of information available. Yet the most difficult part of it, is analysing the data and making sense out of it.

Animation by its nature, requires a lot of computer resources. As the speed of computers increases steadily and their prices decrease, animation is becoming available to everyone. Animation is a very good educational tool, and can be used for almost anything. It is the only way to see and understand things that cannot be seen otherwise. *Visualisation is the key to understanding and animation is going to be a huge part of it.*

7

Animation Techniques

Brief History of Animation

Picture animation was invented in 1831 by Joseph Antoine Plateau. He used a machine called *phenakistoscope* to create the illusion of movement. The device consisted of a spinning disc that held a series of drawings and windows that framed the user's perception of the drawings. Many other animating machines were invented since, then, but it was not until 1906 when the first complete animated film was produced by J.Steward Blackton.

It was called "Humorous Phases of a Funny Face". In 1915, Earl Hurd introduced the technique of *cell animation* which took its name from the transparent sheets of celluloid that was used. The father of animation, Walt Disney produced a huge cartoon world in less than ten years at 1928. The first commercial animated cartoon, "Snow White and the Seven Dwarfs", was then produced.

Many people followed, which contributed to this evolution. The results were good, but to a certain point. When very complex animation was required, everything turned out to be extremely difficult. Something was definitely missing and *technology* would give the answer in the following years.

Traditional Animation Techniques

Hand-drawn animation, with each frame individually crafted by an artist, requires a lot of skill, a lot of patience and very little equipment. The drawing is usually done on a *cell* which allows multiple frames to be drawn by the same cells. Each frame can be recorded on film or video, and the amount of work going into an animation is staggering. A feature film containing the production of 250,000 drawings would take fifty years of labour if all were to be drawn by a single artist. So usually it is coordinated by one person but the work is divided among a number of artists. Senior artists will draw the key frames and junior artists will draw in-between ones.

As we said before all the detail can be painted on to every frame; it is more likely that the frame will be compiled from several cells at the point of filming. The *background* may be on one cell, *static characters* on the other and the *moving character* on the top. In this way the bottom two cells can be used in a number of frames. It might also be that the cells are moved relative to one another, in successive frames, without being redrawn. Conventional animation is oriented mainly towards the production of two-dimensional cartoons. Every frame is a flat picture. In order to achieve the multiple frame design by using the same cells the *multiplane* technique is used. Several glass layers are placed beneath the camera

at varying distances. On the layers the cells are placed and the frame is filmed. A lot of camera effects can be added into the animation but they are usually difficult to produce and sometimes are very expensive. A few of them are: zooming, fade-in, fade-out, *etc.*

Computer Assisted Animation

It is very clear that *automation* of the whole animation or even part of it would be very productive. Computers were used for animation for the first time in early sixties but it was mainly for scientific reasons. Ten years later animators started to consider computers to be a very powerful and useful part of their animation systems.

Today, computers can be used in animation in two main ways: as tools to improve the application of traditional methods; and as a means of generating animation which is not possible using traditional methods. Computers can considerably improve the speed, accuracy and at the same time reduce the cost of traditional animation methods. Projects which were impossible to realise in the past could actually be attempted.

Computer animation systems are classified into several different levels. These levels define the depth of the assistance

that is provided by the computer. At the lowest level the animator can use software only to design the drawings. On the other hand at the highest level the whole work drawing, modelling and motion control is produced by the system.

The second more important advantage of modern animation systems apart of the fact that make everything easier is the *interactivity*. Animation can not only be a visual effect that one simply sees and waits until it is finished. The user becomes a participant of the whole story and can decide upon the development of the sequence. This has a large amount of applications which give to animation systems a very important existence in life.

There are several animation software packages currently available in the market. They all have a different approach to animation but tend to work on the same principle. There is an interactive graphics interface where the drawing, paint and modelling takes place. An *animation* language takes care of the *motion control* and of any advanced animation that is required. Every language currently available requires different programming skills. However the more advanced a language is, the more enhanced the produced motion will be. The problem that arises here is that computer animators usually don't have strong programming experience since, they mostly come from areas of traditional animation. There is not a single answer to this problem but the most satisfying one is that software should approach differently each user depending on the result that is required to produce.

Stop-Motion Animation

Some animators prefer to work with puppets, using clay, a plastic material, or foam. These projects are more like live-

action films. Characters must be made, sets built, and lighting rigged. Some people work with paper cutouts, sand, or pinscreens. For stop-motion animation, a digital video or film camera is placed on a tripod so the action can be filmed frame by frame, moving characters, objects, and camera after almost every frame. Computerized motion control equipment is available to make this process easier and more precise.

Game Production

Game production is quite different from TV or film production, and different kinds of games are obviously produced differently. The process is too complicated for the scope of this book, but remember that few games have budgets as large as feature films. Technical knowledge is essential for working in that industry.

Student Production

If you are making a student film or video, you'll abbreviate the traditional production process in a way that makes the best use of your expertise, crew, time, budget, and the equipment available to you. Ask your teacher for guidelines. There are many computer software Programmes that can help you make a film or video without a huge staff. Flash computer software makes it comparatively easy for you to make a film on a limited budget entirely by yourself. Attempt only what you can effectively produce. The longer the film, the better it should be to hold audience interest.

Other Production Considerations

The size of the budget is a consideration in all animation writing. Feature films made by large companies like Sony or

Dream Works have deep pockets, but their pockets aren't bottomless, especially in bad times. Smaller film companies work with tighter budgets. Some games have big budgets but not as big as those of a major film. Many game companies make low-budget games. The television industry can do a great deal on a very small budget.

In production, technology is a factor—what can be done and what can't. The larger companies have invested more in developing and buying high-end software. So it may be possible to produce animation with skin, fur, and water that looks real. It's conceivable to replicate actual people, but the cost is great, and there are legal issues. It is possible to make multiples of people, trees, or buildings for crowd scenes, forests, or cities. Again, the cost will probably be prohibitive for lower budgets. Software now makes it possible to animate those crowds without the digital actors running into or through each other as they did in earlier days. There have been great strides in computer character animation. Today, nuances in acting can be achieved that were impossible just a few years back, but, again, this comes with a high price tag.

Changes

Anyone who has ever worked at an animation company where at least some production is done on the premises has horror stories about changes to the script or characters after production has already started. If you knew the effect of casual changes on morale, meeting deadlines, and the budget, you would never, *ever* consider them after production has begun. Remember that even one scene may involve hundreds and hundreds of drawings or images. Because

animation is so labour-intensive, even in CGI, scenes in a single episode of a television series might be spread out over many departments and sometimes even over different companies. In a big-budget feature scenes may be spread out over several companies and several continents. Overseas contract companies might suddenly find that they have more work than they can handle at any given time and form out some of their work to a subcontractor.

Typically, scenes do not go through the pipeline in order. Instead, they go through as *fast* as possible. So if scene 108 is animated before scene 2 (because it is shorter, easier, or being animated by a faster artist), it moves on ahead to the assistant to clean up, and if that assistant works quickly, then the scene proceeds ahead to the checking department, and so on in the process. At any given time, scene 108 may be moving faster than scene 2, but scene 2 might catch up later and even pass it. CGI scenes are constantly being improved, but each minor improvement takes time. Of course, scenes are tracked. Changes can increase costs tremendously. There was a time in television animation where changes were simply not made once production started because of budget concerns.

If a change is made in scene 2, it's likely that changes must be made in other scenes to match the original change. Artists are interrupted. Some scenes are changed and others are forgotten. Suddenly the orderly production process is like a gourmet dish of Eggs Benedict morphing into scrambled eggs with broken shells and a chicken feather poking out the top. Be sure that the script, storyboard, and designs are in excellent shape before you begin production, even if that

means falling behind a week or two (or even a month or two). Allow yourself plenty of time for development before the clock starts ticking.

Preparing for Tomorrow

The world is changing ever more rapidly. Who knows what direction the world will take tomorrow? Animation is now created for all age groups and for many media. The more that you can learn, the better you'll be able to write and develop for this industry. And you'll need to continue learning all your life just to keep up. Read about trends, fads, and predictions for the future. Learn to assess what you need to know, and take the responsibility of finding a way to learn it on your own.

Creativity Versus Profit

We all crave a good story well told. Our souls long for something fresh and creative. In school it's okay to experiment and fail. But let's consider the animation industry for a moment. The industry wants and needs creative people, but it is first and foremost a business. Business executives don't like failure! If executives perceive that a choice must be made between creativity, freshness, and art or staying out of bankruptcy and making lots of money, money will win out pretty much every time.

If you want to work in the industry and be successful, you need to understand that basic fact. Keeping a job means producing what's practical and what will bring in money; unfortunately, sometimes creativity gets lost somewhere along the way. Don't lose your creativity or your love of animation! Try to be creative *and* remember the audience

and the budget for your project. This is a book about it all: learning to write creatively and well, and working successfully in the animation industry.

How to Make an Animated Movie

The production pipeline of a typical animated short or a movie can be divided into three stages : pre-production, production and post-production.

Pre-Production

The first process in the animation pipeline, and also one of the most important, is pre-production. It begins with the main concepts which are initially turned into a full story, and then, once the story has been finalized, other things such as the script, shot sequence and camera angles are worked on.

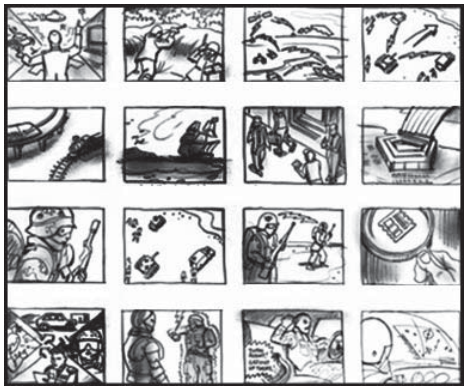
Some major components of pre production are Story Boarding, Layouts, Model Sheets and Animatics.

…they also provide a visual reminder of the original plan; something that can be referred back to throughout the production.

Story Boarding

The Storyboard helps to finalize the development of the storyline, and is an essential stage of the animation process. It is made up of drawings in the form of a comic strip, and is used to both help visualise the animation and to communicate ideas clearly. It details the scene and changes in the animation, often accompanied by text notes describing things occurring within the scene itself, such as camera movements.

Not only can storyboards be especially useful when working in group environments (something quite common in the animation industry,) but they also provide a visual reminder of the original plan; something that can be referred back to throughout the production.



Layouts

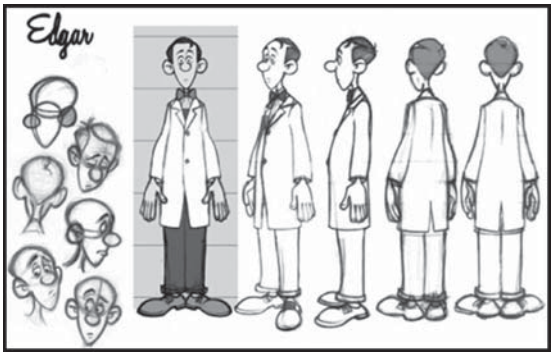
Once the storyboards have been approved, they are sent to the layout department which then works closely with the director to design the locations and costumes. With this done they begin to stage the scenes, showing the various characters' positions throughout the course of each shot.

Model Sheets

Model sheets are precisely drawn groups of pictures that show all of the possible expressions that a character can make, and all of the many different poses that they could adopt. These sheets are created in order to both accurately maintain character detail and to keep the designs of the characters uniform whilst different animators are working on them across several shots.

During this stage the character designs are finalized so that when production starts their blueprints can be sent to

the modelling department who are responsible for creating the final character models.



Animatics

In order to give a better idea of the motion and timing of complex animation sequences and VFX-heavy scenes, the pre-visualization department within the VFX studio creates simplified mock-ups called "Animatics" shortly after the storyboarding process. These help the Director plan how they will go about staging the above sequences, as well as how visual effects will be integrated into the final shot.

The Production Process

The production process is slightly different at different studios around the world. Even at a specific animation studio, each producer and director has his or her own preferences. Children's cartoons are produced differently from prime-time animation because of the huge variation in budget. Television shows are not produced the same way as feature films. Directto- videos are something of a hybrid of the two. Independent films are made differently from films made at a large corporation. Shorts for the Internet may be completed by one person on a home computer, and games are something else altogether; 2D animation is produced differently from

3D; each country has its own twist on the process. However, because of the demands of the medium, there *are* similarities, and we can generalize. It's important for writers to understand how animation is produced so they can write animation that is practical and actually works. Therefore, the production process follows in a general way.

The Script

Usually animation begins with a script. If there is no script, then there is at least some kind of idea in written form—an outline or treatment. In television a one-page written premise is usually submitted for each episode. When a premise is approved, it's expanded into an outline, and the outline is then expanded into a full script. Some feature films and some of the shorter television cartoons may have no detailed script. Instead, creation takes place primarily during the storyboard process. Writers in the United States receive pay for their outlines and scripts, but premises are submitted on spec in hopes of getting an assignment. Each television series has a story editor who is in charge of this process. The story editor and the writers he hires may be freelancers rather than staff members. The show's producers or directors in turn hire the story editor. Producers and directors have approval rights on the finished script. *Producer* and *director* are terms with no precise and standard meaning in the United States, and they can be interchangeable or slightly different from studio to studio. Independent producers may deal more with financing and budgets, but producers at the major animation studios may be more directly involved with production. Higher executives at the production company often have script approval rights. Programming executives also have approval

rights, as do network censors and any licensing or toy manufacturers that may be involved in the show. If this is a feature, financiers may have approval rights as well.

Recording

About the time the script is finalized, the project is cast. The actors may be given a separate actor's script for recording. Sometimes they get character designs or a storyboard if they are ready in time. A voice director will probably direct. If this is a prime-time television project, but usually there is no advanced rehearsal. At some studios the writer is welcome to attend the recording session. That is far from standard practice, however, and writers who do attend probably will have little or no input on the recording. Some studios still prefer to record all the actors at once for a television project, as if they were doing a radio play. However, each actor may be recorded separately. This is especially likely if the project is an animated feature. Individual recording sessions make it easier to schedule the actors, work with each actor, move the process along, and fine-tune the timing when it's edited. Recording the actors together allows for interaction that is impossible to get any other way. Executives with approval rights have to approve casting and the final voice recording.

The directors usually work with a composer, who may be brought in early for a feature. Hiring might not be done until later in the process if this is a television show, although some directors bring in a composer early for TV as well.

The Storyboard

Storyboard artists take the script and create the first visualization of the story. Often these boards are still a little

rough. In television and direct-to-video projects each major action and major pose is drawn within a frame representing the television screen. The dialogue and action are listed underneath each frame. Usually, an animatic or video of these frames is scanned or filmed from the board when it's complete. This animatic, which includes any recorded sound, helps the director see the episode in the rough and helps in timing the cartoon. Executives must approve the final storyboard or animatic. The storyboard process may take about a year for a feature. The script or treatment will undergo many changes as the visual development progresses. Artists sometimes work in groups on sequences, or a team of a writer and an artist may work together. The development team pitches sequences in meetings and receives feedback for changes. The director and other executives have final approval. Feature storyboard drawings are cleaned up and made into a flipbook. Finally the drawings are scanned or shot, the recorded and available sound is added, and the material is made into a story reel. Any necessary changes discovered during the making of the animatic or story reel are made on the storyboard. The building of the story reel is an ongoing process throughout production. Later breakdowns, then penciled animation, and finally completed animation will be substituted. This workbook of approved elements is usually scanned and available on staff computers and serves as an ongoing blueprint. For CGI features a 3D workbook shows characters in motion in space as well.

Slugging

The timing director sets the storyboard's final timing, and the board is slugged. This does not mean that somebody

gets violent and belts it with a left hook! Slugging is a stage when the overall production is timed out, and scenes are allotted a specific amount of time, measured in feet and frames. In television this information is added to the storyboard before it's photocopied and handed out. An editor conforms the audiotape.

Character and Prop Design

After the script has been approved, a copy goes to the production designer or art director. If the project is a television series, then the major and ongoing characters have already been designed and fine-tuned during development. The approved drawings, as seen from various angles, are compiled into the model sheets.

If the ongoing characters have a costume change in this TV episode or feature sequence, or new characters are needed, that must be considered. Each TV episode or feature sequence also requires props that have not been used before. Sometimes the same designers create new characters, costumes, and props; sometimes designers specialize and design either characters *or* props. New drawings are compiled into model sheets for each specific television episode. The drawings may be designed on paper or modelled in a computer. Approvals are required.

Background Design

The production designer or a background designer is responsible for all location designs.

In television or direct-to-video layout, artists will design these line drawings (layouts) from the roughs done by the storyboard artist. Then a background painter will paint a

few key backgrounds (especially those for establishing shots) and ship them overseas to be matched by other painters painting additional backgrounds.

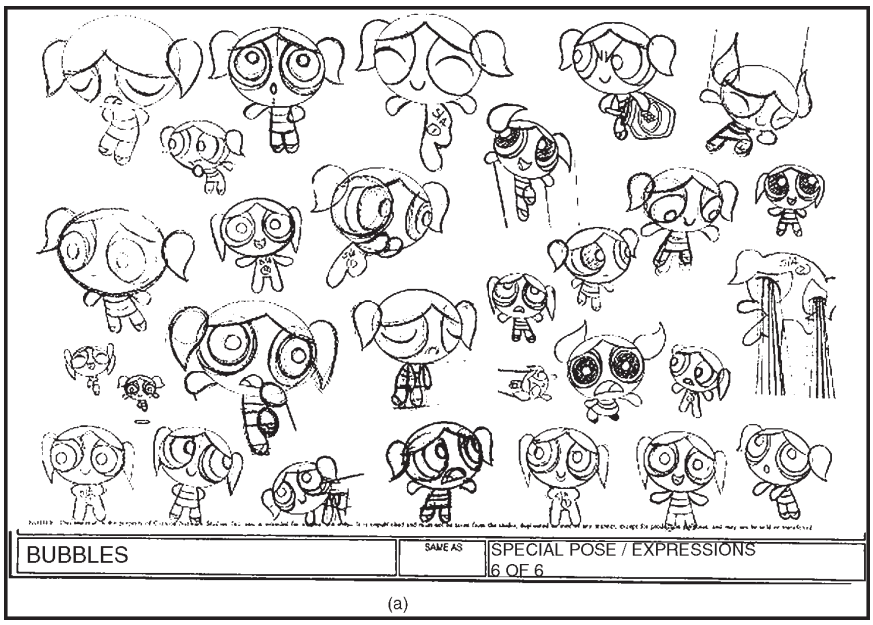
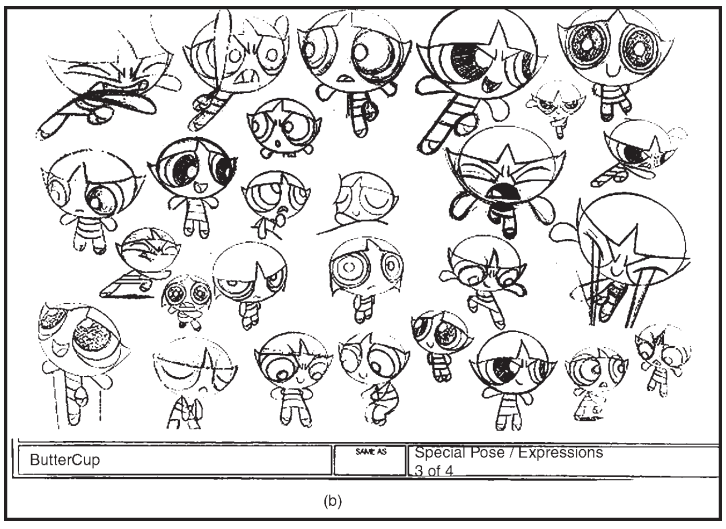


Figure: Bubbles (a) and Buttercup (b) from *The Powerpuff Girls* show off their Acting Skills on these Model Sheets.



Very little animation production is done in the United States due to the high costs. In feature production the visual

development artists may be working on both story and design at once, making many concept drawings before the final designs are chosen and refined for actual production. Background artists usually paint in the traditional way, but some or all elements can be painted digitally. Digital backgrounds can be changed more easily. Major designs require approval.

Colour

Colour stylists, who are supervised by the art director, set the colour palette for a show. It's important that they choose colours that not only look good together but that will make the characters stand out from the background.

Different palettes may be needed for different lighting conditions, such as a wet look, shadowing, bright sunlight, and so on. If the project is CGI, texturing or surface colour design is needed. Once again approvals are required.

Layout

Layouts are detailed renderings of all the storyboard drawings and breakdowns of some of the action between those drawings. These include drawings for each background underlay, overlay, the start and stop drawings for action for each character, and visual effects.

Layout artists further refine each shot, setting camera angles and movements, composition, staging, and lighting. Drawings are made to the proper size and drawn on model (drawn properly). Key layout drawings may be done before a production is shipped overseas, with the remainder done by overseas artists. Or layout may be skipped, basically, by doing

detailed drawings at the storyboard stage. Later these can be blown up to the correct size, and elements separated and used as layouts.

Exposure Sheets

The director or sheet timer fills out exposure sheets (X-sheets), using the information found on the audio track. These sheets will be a template or blueprint for the production, frame by frame and layer by layer. The recorded dialogue information is written out frame by frame for the animator, and the basic action from the storyboard is written in as well. If music is important, the beats on the click track are listed.

Animation

The animator receives the dialogue track of his section of the story, a storyboard or workbook that has been timed out, the model sheets, copies of the layouts, and X-sheets.

There are boxes on the X-sheets for the animator to fill in with the details, layer by layer, as the animation is being planned. Animation paper, as well as the paper used by the layout artists and background artists, has a series of holes for pegs so that it can be lined up correctly for a camera.

For an animated feature, animation pencil tests may be made prior to principal animation to test the gags and the animation. In television and direct-to-video projects, key animators may animate the more important action before it is sent overseas for the major animation to be completed. Animators might be cast to animate certain characters, or they may be assigned certain sequences. Clean-up artists or assistant animators clean up the rough animation poses

drawn by the animator and sketch the key action in between. A breakdown artist or inbetweener may be responsible for the easier poses between those. Visual effects animators animate elements like fire, water, and props. For a feature production where drawings are animated on ones (rather than holding the poses for more than a single frame for a cheaper production), a single minute of film may take over 1,400 drawings.

Scene Planning

Scene planners break down each scene with all of its elements and check that the scenes are ready for scanning or shipping. A scene planner will set up all of the elements in to computer or on a pegged animation disk and make sure that they will work correctly. These professionals have excellent technical knowledge. They check all math and verify that each scene and all the camera moves have been set up in the best way. They will also check that colour effects are set up properly for the painters.

Shipping

A production coordinator assembles all the pre-production elements. The coordinator verifies that everything is accounted for, that all information is clear, and that everything is correct before shipping abroad.

Traditional Production

Once all the pre-production elements arrive overseas, the subcontractor finishes the work. Animators, their assistants, and inbetweeners finish the animation. Background painters complete the remainder of the backgrounds. All the paper or

computer elements (X-sheets, animation, painted backgrounds) are checked by animation checkers to be sure they are complete and will work properly. Lines must be closed off for digital painting. The drawings are photocopied onto cels or scanned into the computer if they haven't been scanned already. Traditional painters receive colour models, painted onto cels, and stacks of the photocopied cels. They paint each cel with water-based paints on the side that has no raised and photocopied lines. Digital painters recheck for lines that are not closed off and touch their computer screens to fill sections of each drawing with colour from their palette. Final checkers check the work again.

If the artwork is digital, the final checker composites the work and makes sure it's ready for final output. For productions that are more traditional, the work is then shot frame by frame with an animation camera. Backgrounds are placed on a flat bed with pegs to hold them in place. Any underlays are placed on the bottom. The levels of cels are placed on top of the underlay one by one. Overlays are placed on top of that. Then the whole package is shot, replaced with the elements of another frame, and shot again until completion.

CGI Production

CGI productions are a merging of 2D animation and live action. Designs are usually created in 2D first, approved, and sent for modelling in 3D. Characters can be modelled on a computer—often from basic geometric shapes—and the parts fused, or sculptures can be digitized as a wire-frame model. Rigging adds a skeleton to the model. Animators then test movement possibilities. Modelling, rigging, and animation

continue until all problems have been resolved. Texture and colour are added with emphasis on correct lighting. Software Programmes also allow actors to be rigged with motion capture sensors, which convert the actor's movement to animation for a predesigned character. Locations, sets, or environments are modelled as well. These will also be rough at first, or live-action backgrounds may be added. A 3D workbook is created in low-resolution, with locations slowly refined. Characters are added to the locations and animation improved. Cinematography elements (camera position, angles, movements, lighting) are added and polished. Principal animation is done after the 3D workbook elements are approved. Refinements are made throughout the process. Once everything has been approved, the final animation focuses on subtleties. Lighting becomes the major focus after animation has been completed in each scene. Working with the technical directors, the effects animators then add visual effects. Along the line some rendering and compositing have been done to see how things are coming along. The full rendering and compositing of all the elements of a scene are not done until the end because fully developed scenes can take a long time to process. Rendered scenes are touched up, checked, and then rendered again for the final completed project.

Post-Production and Editing

The overseas studio returns the completed project. The director may require retakes from overseas or have a few minor changes made locally. Today overseas work can be monitored more closely over the Internet while it's being done so fewer changes will be required once the work is returned.

After approval, the editors mix the voice track with ADR, sound effects (Foley effects or effects from a sound effects library), and music tracks (which may be original or also from a library). The tracks are then blended. The videotape is combined with the sound, the opening titles, and the credits. Transitions are added, and this editing is completed in an offline or online assembly. Sometimes a film is generated, and it must be colour corrected. The directors, producers, and programming or financing executives view the completed work. Notes are given, changes are made, and retakes are done. Final approvals are given, and a release print is made. The completed project is now ready for delivery.

Character Animation

Character animation is a specialized area of the animation process concerning the animation of one or more characters featured in an animated work. It is usually as one aspect of a larger production and often made to enhance voice acting. The primary role of a Character Animator is to be the "actor" behind the performance, especially during shots with no dialog. Character animation is artistically unique from other animation in that it involves the creation of apparent thought and emotion in addition to physical action. Historically, Winsor McCay's Gertie the Dinosaur (1914) is often considered the very first example of true character animation. Otto Messmer imbued Felix the Cat with an instantly recognizable personality during the 1920s. The following decade, Walt Disney made character animation a particular focus of his animation studio, best showcased in productions such as *Three Little Pigs*, *Snow White and the Seven Dwarfs*, *Pinocchio*, and *Dumbo*.

Disney animation artists such as Bill Tytla, Ub Iwerks, Grim Natwick, Fred Moore, Ward Kimball, Les Clark, John Sibley, Marc Davis, Wolfgang Reitherman, Hal King, Hamilton Luske, Norm Ferguson, Eric Larson, John Lounsbery, Milt Kahl, Frank Thomas and Ollie Johnston all became masters of the technique. Frank and Ollie, as they were affectionately known by their proteges,taught that the thoughts and emotions behind the character were primary to the creation of every scene. Out of all the Nine Old Men, Frank and Ollie were the most known for their mentor /apprentice relationships, and the sharing of their knowledge about creating characters, most notably as transcribed through *Disney Animation: The Illusion of Life*. Other notable figures in character animation include the Schlesinger/Warner Bros. directors (Tex Avery, Don Bluth, Chuck Jones, Hanna-Barbera, Bob Clampett, Max Fleischer, Walter Lantz, Frank Tashlin, Robert McKimson, and Friz Freleng), independent animator Richard Williams, John Lasseter at Pixar, and latter-day Disney animators Andreas Deja and Glen Keane.

Character animation is not limited to Hollywood studios, however. Some of the finest examples of character animation can be found in the work of Nick Park of Aardman Animations and Russian independent animator Yuri Norstein. Though typical examples of character animation are found in animated feature films, the role of character animation within the gaming industry is rapidly increasing. Game developers are using more complicated characters that allow the gamer to more fully connect with the gaming experience. *Prince of Persia*, *God of War*, *Team Fortress II* or *Resident Evil* contain examples of character animation in games.

Character animation is augmented by special effects animation, which creates anything that is *not* a character; most commonly vehicles, machinery, and natural phenomena such as rain, snow, lightning and water, as well as the "non-natural" effects often seen in science fiction films. Sometimes, even special effect animation uses the principles of character animation; an early example is the pseudopod in The Abyss. On-going computer science research on character animation deals with the question of generating multi-layer level of detail at run-time to allow large crowd rendering in real time applications.

Chuckimation

Chuckimation is a type of animation created by the makers of the cartoon Action League Now! in which characters/props are thrown, or chucked from off camera or wiggled around to simulate talking by unseen hands, combined with traditional stop motion animation. An animation style similar to chuckimation is used in the show, "A Town Called Panic", where clay figures are posed and moved by a strange force. Every time they talk they move a little, and their mouths don't move.

Multi-sketch

Multi-sketch is an animation method of story-telling where a sequence of hand-drawn sketches are created simultaneously while narrating it with voice. To achieve this a Tablet PC or digitizing tablet can be used to create improvised progressive line sketches which are captured to video. Such types of cartoons are created in a freestyle unscripted manner, which makes them original, since the

whole cartoon does not need editing after it is completed. Originally invented by Renat Zarbailov when he combined two software applications—sketching software with screen capturing one. One of the pioneers of Multi-Sketch cartoon creation is Kenly Dillard, who, at the age of twenty four held the title of the world's third champion in speed sketching competition. The final multi-sketch can be sent to various formats, HDTV, DVD, web streaming, or WMV/FLV/ Quicktime/MPEG4.

Special Effect

The illusions used in the film, television, theatre, or entertainment industries to simulate the imagined events in a story are traditionally called special effects (often abbreviated as SFX, SPFX, or simply FX). Special effects are traditionally divided into the categories of optical effects and mechanical effects. With the emergence of digital film-making tools a greater distinction between special effects and visual effects has been recognized, with "visual effects" referring to digital post-production and "special effects" referring to on-set mechanical effects and in-camera optical effects. Optical effects, are techniques in which images or film frames are created photographically, either "in-camera" using multiple exposure, mattes, or the Schüfftan process, or in post-production processes using an optical printer. An optical effect might be used to place actors or sets against a different background. Mechanical effects, are usually accomplished during the live-action shooting. This includes the use of mechanized props, scenery, scale models, pyrotechnics and Atmospheric Effects: creating physical wind, rain, fog, snow, clouds etc. Making a car appear to drive by itself, or blowing

up a building are examples of mechanical effects. Mechanical effects are often incorporated into set design and makeup. For example, a set may be built with break-away doors or walls to enhance a fight scene, or prosthetic makeup can be used to make an actor look like a monster. Since the 1990s, computer generated imagery (CGI) has come to the forefront of special effects technologies. CGI gives film-makers greater control, and allows many effects to be accomplished more safely and convincingly – and even, as technology marches on, at lower costs. As a result, many optical and mechanical effects techniques have been superseded by CGI.

Developmental History

Early Development

In 1856, Oscar Rejlander created the world's first "trick photograph" by combining different sections of 32 negatives into a single image. In 1895, Alfred Clark created what is commonly accepted as the first-ever motion picture special effect. While filming a reenactment of the beheading of Mary, Queen of Scots, Clark instructed an actor to step up to the block in Mary's costume. As the executioner brought the axe above his head, Clarke stopped the camera, had all of the actors freeze, and had the person playing Mary step off the set. He placed a Mary dummy in the actor's place, restarted filming, and allowed the executioner to bring the axe down, severing the dummy's head. "Such… techniques would remain at the heart of special effects production for the next century." This was not only the first use of trickery in the cinema, it was the first type of photographic trickery only possible in a motion picture, i.e. the "stop trick". In

1896, French magician Georges Méliès accidentally discovered the same "stop trick." According to Melies, his camera jammed while filming a street scene in Paris. When he screened the film, he found that the "stop trick" had caused a truck to turn into a hearse, pedestrians to change direction, and men turn into women. Melies, the stage manager at the Theatre Robert-Houdin, was inspired to develop a series of more than 500 short films, between 1914, in the process developing or inventing such techniques as multiple exposures, time-lapse photography, dissolves, and hand painted colour. Because of his ability to seemingly manipulate and transform reality with the cinematograph, the prolific Méliès is sometimes referred to as the "Cinemagician." His most famous film, *Le Voyage dans la lune* (1902), a whimsical parody of Jules Verne's *From the Earth to the Moon*, featured a combination of live action and animation, and also incorporated extensive miniature and matte painting work. From 1910 to 1920, the main innovations in special effects were the improvements on the matte shot by Norman Dawn. With the original matte shot, pieces of cardboard were placed to block the exposure of the film, which would be exposed later. Dawn combined this technique with the "glass shot." Rather than using cardboard to block certain areas of the film exposure, Dawn simply painted certain areas black to prevent any light from exposing the film. From the partially exposed film, a single frame is then projected onto an easel, where the matte is then drawn.

By creating the matte from an image directly from the film, it became incredibly easy to paint an image with proper

respect to scale and perspective (the main flaw of the glass shot). Dawn's technique became the textbook for matte shots due to the natural images it created.(Baker, 101-4) During the 1920s and 30s, special effects techniques were improved and refined by the motion picture industry. Many techniques - such as the Schüfftan process - were modifications of illusions from the theater (such as pepper's ghost) and still photography (such as double exposure and matte compositing). Rear projection was a refinement of the use of painted backgrounds in the theater, substituting moving pictures to create moving backgrounds. Lifecasting of faces was imported from traditional maskmaking. Along with makeup advances, fantastic masks could be created which fit the actor perfectly. As material science advanced, horror film maskmaking followed closely. Several techniques soon developed, such as the "stop trick", wholly original to motion pictures. Animation, creating the illusion of motion, was accomplished with drawings (most notably by Winsor McCay in *Gertie the Dinosaur*) and with three-dimensional models (most notably by Willis O'Brien in *The Lost World* and *King Kong*). Many studios established in-house "special effects" departments, which were responsible for nearly all optical and mechanical aspects of motion-picture trickery. Also, the challenge of simulating spectacle in motion encouraged the development of the use of miniatures. Naval battles could be depicted with models in studio. Tanks and airplanes could be flown (and crashed) without risk of life and limb.

Most impressively, miniatures and matte paintings could be used to depict worlds that never existed. Fritz Lang's film

Metropolis was an early special effects spectacular, with innovative use of miniatures, matte paintings, the Schüfftan process, and complex compositing. An important innovation in special-effects photography was the development of the optical printer.

Essentially, an optical printer is a projector aiming into a camera lens, and it was developed to make copies of films for distribution. Until Linwood G. Dunn refined the design and use of the optical printer, effects shots were accomplished as in-camera effects. Dunn demonstrating that it could be used to combine images in novel ways and create new illusions. One early showcase for Dunn was Orson Welles' *Citizen Kane*, where such locations as Xanadu (and some of Gregg Toland's famous 'deep focus' shots) were essentially created by Dunn's optical printer.

Colour Era

The development of colour photography required greater refinement of effects techniques. Colour enabled the development of such *travelling matte* techniques as bluescreen and the sodium vapor process. Many films became landmarks in special-effects accomplishments: *Forbidden Planet* used matte paintings, animation, and miniature work to create spectacular alien environments.

In *The Ten Commandments*, Paramount's John P. Fulton, A.S.C., multiplied the crowds of extras in the Exodus scenes with careful compositing, depicted the massive constructions of Rameses with models, and split the Red Sea in a still-impressive combination of travelling mattes and water tanks. Ray Harryhausen extended the art of stop-motion animation

with his special techniques of compositing to create spectacular fantasy adventures such as Jason and the Argonauts.

Science Fiction Boom

Through the 1950s and 60s numerous new special effects were developed which would dramatically increase the level of realism achievable in science fiction films. The pioneering work of directors such as Pavel Klushantsev would be used by major motion pictures for decades to come. If one film could be said to have established a new high-bench mark for special effects, it would be 1968's *2001: A Space Odyssey*, directed by Stanley Kubrick, who assembled his own effects team (Douglas Trumbull, Tom Howard, Con Pedersen and Wally Veevers) rather than use an in-house effects unit. In this film, the spaceship miniatures were highly detailed and carefully photographed for a realistic depth of field. The shots of spaceships were combined through hand-drawn rotoscopes and careful motion-control work, ensuring that the elements were precisely combined in the camera – a surprising throwback to the silent era, but with spectacular results. Backgrounds of the African vistas in the "Dawn of Man" sequence were combined with soundstage photography via the then-new front projection technique.

Scenes set in zero-gravity environments were staged with hidden wires, mirror shots, and large-scale rotating sets. The finale, a voyage through hallucinogenic scenery, was created by Douglas Trumbull using a new technique termed slit-scan. The 1970s provided two profound changes in the special effects trade. The first was economic: during the industry's recession in the late 1960s and early 1970s,

many studios closed down their in-house effects houses. Many technicians became freelancers or founded their own effects companies, sometimes specializing on particular techniques (opticals, animation, etc.). The second was precipitated by the blockbuster success of two science fiction and fantasy films in 1977. George Lucas's *Star Wars* ushered in an era of fantasy films with expensive and impressive special-effects. Effects supervisor John Dykstra, A.S.C. and crew developed many improvements in existing effects technology. They developed a computer-controlled camera rig called the "Dykstraflex" that allowed precise repeatability of camera motion, greatly facilitating travelling-matte compositing. Degradation of film images during compositing was minimized by other innovations: the Dykstraflex used VistaVision cameras that photographed widescreen images horizontally along stock, using far more of the film per frame, and thinner-emulsion filmstocks were used in the compositing process. The effects crew assembled by Lucas and Dykstra was dubbed Industrial Light and Magic, and since 1977 has spearheaded most effects innovations. That same year, Steven Spielberg's film *Close Encounters of the Third Kind* boasted a finale with impressive special effects by 2001 veteran Douglas Trumbull.

In addition to developing his own motion-control system, Trumbull also developed techniques for creating intentional "lens flare" (the shapes created by light reflecting in camera lenses) to provide the film's undefinable shapes of flying saucers. The success of these films, and others since, has prompted massive studio investment in effects-heavy fantasy films. This has fuelled the establishment of many

independent effects houses, a tremendous degree of refinement of existing techniques, and the development of new techniques such as CGI. It has also encouraged within the industry a greater distinction between special effects and visual effects; the latter is used to characterize post-production and optical work, while *special effects* refers more often to on-set and mechanical effects.

Introduction of Computer Generated Imagery

A recent and profound innovation in special effects has been the development of computer generated imagery, or CGI, which has changed nearly every aspect of motion picture special effects. Digital compositing allows far more control and creative freedom than optical compositing, and does not degrade the image like analogue (optical) processes. Digital imagery has enabled technicians to create detailed models, matte "paintings," and even fully realized characters with the malleability of computer software. The most spectacular use of CGI has been the creation of photographically realistic images of fantasy creations.

Images could be created in a computer using the techniques of animated cartoons or model animation. In 1993, stop-motion animators working on the realistic dinosaurs of Steven Spielberg's *Jurassic Park* were retrained in the use of computer input devices. By 1995, films such as *Toy Story* underscored that the distinction between live-action films and animated films was no longer clear. Other landmark examples include a character made up of broken pieces of a stained-glass window in *Young Sherlock Holmes*, a shapeshifting character in *Willow*, a tentacle of water in

The Abyss, the T-1000 Terminator in *Terminator 2: Judgment Day*, hordes of armies of robots and fantastic creatures in the *Star Wars prequel trilogy* and *The Lord of the Rings* trilogy and the planet Pandora in Avatar.

Planning and Use

Although most special effects work is completed during post-production, it must be carefully planned and choreographed in pre-production and production. A Visual effects supervisor is usually involved with the production from an early stage to work closely with the Director and all related personnel to achieve the desired effects.

Live Special Effects

Live special effects are effects that are used in front of a live audience, mostly during sporting events, concerts and corporate shows. Types of effects that are commonly used include: laser lighting, Theatrical smoke and fog, CO2 effects, pyrotechnics, confetti and other atmospheric effects such as bubbles and snow.