Applying the 12 Principles to 3D Computer Animation

From Isaac Kerlow's recent presentation at the 3D Festival in Copenhagen, and from the 3rd Edition of his book **The Art of 3D Computer Animation and Effects**, being premiered at SIGGRAPH 2003.

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 behavior 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 catalog 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

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