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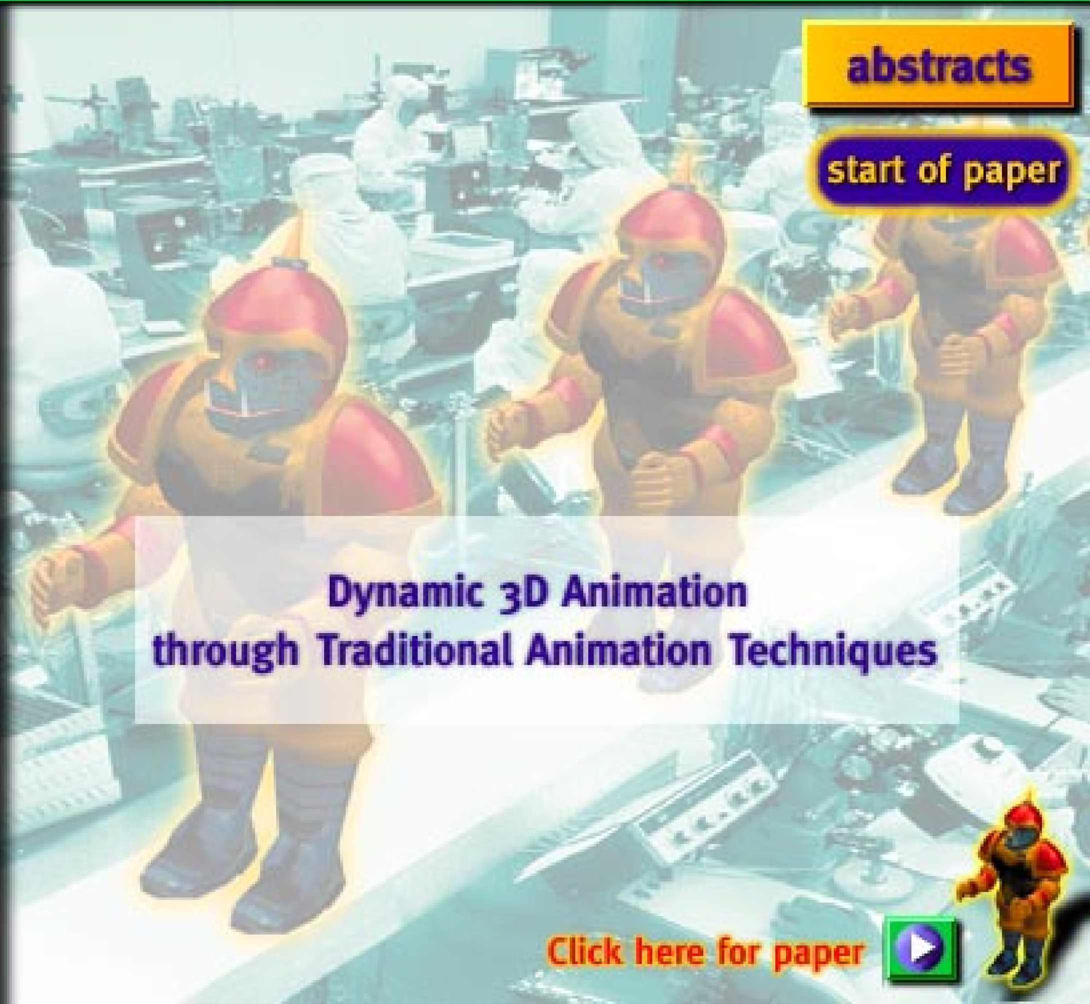

Dynamic 3D Animation through Traditional Animation Techniques

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Premise

It seems as though in recent years technological advances have pushed aside the animator's need for the study and understanding of motion. Many artists have allowed the computer to carry the burden of animating through high-end software, motion capture, and rotoscoping, often with poor results. Through my seminar and this paper, my hope is to help make the artist aware that these technologies should be thought of as the animator's tools and not the animator itself.

A good animation needs to appear smooth, fluid, and natural. However, these qualities alone do not necessarily convey the impact of a truly dynamic animation. Before applying dynamics in animating, realistic motion is required. To achieve natural motion, I believe that animators must study not only the motion around them, but also the work of other animators. We must understand all aspects of the figure to be animated, including the body type, size, speed, and the world in which the actor is placed. Each of these elements affects the way a character moves and reacts to his environment. The addition of dynamics serves to increase artistic intensity in these elements while preserving the realistic movement.

The Study of Motion

Becoming a 'student of motion' can be a powerful tool in your efforts to become a better animator. Having an understanding of another animator's frame of mind can be as important as having an understanding of the motion around you. A variety of examples, ideas, and techniques of other animators can be found in every type of media. No matter the source, similar animations will differ only with the personal touch of each individual artist.

Since realistic movement is all around us and is captured flawlessly on film, it often becomes commonplace. Dynamic movement is more difficult to find. Hand-drawn animations offer some of the best examples of exaggerated and dynamic motion because they are not restricted by the limitations of the human body. For example, Disney's "Legend of Sleepy Hollow" shows the effect that amplified dynamics can have on an animation. Ichabod Crane and his horse running frantically from the Headless Horseman push the boundaries of dynamic movement to the limit. In a segment of this animation sequence, the horse is running on its belly, with its hoofs as the uppermost part of the frame.

For a short period of time, Ichabod actually lifts the horse up between his legs and runs himself, as if to make us believe that the horse isn't fast enough.

There are as many good examples of traditional animation as there are animators who created them. Becoming familiar with the thought process of other animators will prove invaluable to those who wish to add a number of artistic styles to their own.

Reference and Research of Motion

Proper reference and research will often make the difference between the stiff, robot-like movements of the computer, and the fluid yet rugged motion characteristic of the human body. Video and film have become a major factor in an animator's search for the perfect action, as it applies to his or her model. Having a basic knowledge of the figure to be animated, and then finding a real life celebrity counterpart is common practice. "Let's have him move just like Arnold Schwarzenegger in Terminator," could be a typical description. Although a helpful technique, it does have its share of setbacks. Finding the ideal animation, with just the right camera angle, remaining on screen for the full cycle of the animation, all the while keeping the figure within the boundaries of the screen is difficult. Finding that same motion from both the front and profile views (which is what most animators need) is nearly impossible.

There are many methods and techniques that an animator can use to obtain the reference he or she is looking for. In the case of the Terminator video, a viable solution would be to find an actor or just a friend, with a large build, and a clear understanding of the figure and personality of the character he is to impersonate. This person would then act out the predefined list of animations, while being video taped from the desired angles. This may not be an exact replica of the action, but it is probably as close as one could come short of having Arnold himself swing by for a quick photo shoot.

Animators have several tools that aid their study of a particular motion. A mirror, for instance, is a valuable item in finding a dynamic pose with your own body before applying it to the 3-D model. But try simply drawing a grid on it to see which joints and body parts align with others in a longitudinal or latitudinal direction, and it becomes even more useful. This process could even be taken a step further by adding lines to the body as well. I first began by paying close attention to the lines which already existed, such as seams on a shirt, or the zipper and belt loop on a pair of pants. If while holding a pose in front of the mirror I could see my first belt loop was turned out of site, I knew that the pelvis segment of the 3-D model must rotate at least 45 degrees. If the belt buckle was out of site, then a rotation of at least 90 degrees was needed. Keeping an eye on the zipper also gave me a rough idea of the degrees of latitude and longitude that the pelvis needed to be turned. This method could be used for almost all segments of the 3-D figure.

Many of these methods need be as simple or as complex as the animator sees fit. For one particular project, which required very precise movement, a body suit was designed that consisted of a skin tight shirt and pants. A series of markings indicating segments, pivot points, and degrees of rotation were printed on the material. The actor, wearing this suit, performed a sequence of actions while being video taped from the front and right angles. The video images were then overlaid by a grid and an onscreen digital clock was added for increased timing accuracy. Obviously, not all reference techniques need to be so detailed. A number of factors such as deadlines, budgets, or accessibility to equipment will determine the time and effort that is practical, not only for the animation, but for the research as well.

Understanding the Character and His World

Many factors affect the motion of a character. Four components to understand about a character before animating are figure, personality, environment, and scenario. Understanding these elements will make the difference between a drab walk animation and a distinctive, dynamic animation specific to your project.

Figure

What is his body type? Is he a strong character? Is he so strong that he has almost no flexibility? What is he wearing? Is it jeans and a T-shirt? Is it a skin tight super hero outfit or heavy bullet proof body armor? Are his boots so thick that they leave little room for ankle movement? Is he wearing a heavy back pack that would cause him to lean forward to compensate for the extra weight? Is he carrying anything heavy in his arms that would cause him to lean back? Animators must ask themselves, ‘If I were wearing the clothing and equipment of this particular 3-D model, how would it affect my mobility?’ Bear in mind, every item on the body affects motion to some degree. The animator needs to be aware of whether or not these items are noticeable enough to be seen in the animation.

In many games, the standard human body is strong, sleek, and more visually stunning than other figures, bringing human characters to a nearly superhuman state. This appearance of the body should naturally reflect and define its motion.

Personality

Personality can be thought of as the fire that adds life to the polygonal figure. It can, to a small degree, define the character’s animation list, but its main function is to define how the character would carry out that list. Personality isn’t going to tell us that the figure will run, jump, and shoot, rather, it describes *how* the figure will perform these actions. For instance, in a military type scenario, our character encounters the enemy and fires his weapon. Does he carefully raise the weapon to his shoulder, take aim through the sites, and fire just one or two strategic shots, or would he just let loose, firing from the hip, cutting down everything in site, discharging more than enough ammunition. The possibilities are as different as James Bond to Rambo. A clear understanding of the character's personality must be made before animating. Just as a film actor 'gets into character' before his or her performance, so should the animator with the 3-D figure.

Because developing the personality of the character is so crucial, a high regard for the importance of a character biography should be maintained. A descriptive outline of the character's likes, dislikes and everything else that could possibly have an affect on the way this person moves and reacts. Is he outgoing or soft spoken? Does he constantly move around a lot or is he mellow to the point of almost no movement at all during an idle? Hopefully, after reading the character biography, you should have as such a clear understanding of him or her that the figure seems less like a computer generated image and more like a real, living, breathing person.

If an eight frame walk animation were asked for, and the description was left at that, it could be done. It might not be too visually stunning, but most animators have an idea what the standard "B-flat" walk animation looks like. So now, with the basic walk motion in mind, suppose a description is given of an eighteen year old, who dropped out of junior high school and is into grunge music and skateboarding. Suddenly, this basic animation has become much more clear. There is now a better idea of how this character would walk, run, jump, and idle.

Applying a personality to a character does not limit itself to human figures alone. As often as not, the characters in video games are non-human. These creatures, like the human characters, have styles and personalities all of their own. Would they move quietly through the shadows, watching and waiting for just the right moment to strike? Are they bold and dependent on brute force?

If nothing else, a biography will at least set the mood of the character to be animated and should be a requirement in any game design document.

Environment

Though the environment should be considered it usually does not play as important of a role as figure or personality in your animation. Only in extreme circumstances should it have a major impact on the character's motion. For instance, a run animation made to look natural would dramatically change if the figure were knee deep in water or snow. Rugged or slick terrain might slow and hinder the motion as well. Be sure that modifications to the animation are noticeable enough to justify the change. If the character is affected by the environment enough to the point that the animations, which looked good before, no longer appear natural, then modifying the motion would be justified. For the most part, a separate set of animations for a specific level would not be feasible.

However, before animating, consider the environment, even if it is asking not how, but if at all, is the character affected.

Scenario

Like the environment, the scenario is an outside force that will have a direct impact on the figure’s motion. It is a combination of the world, its inhabitants, the things they do, and the reasons they do them. As it pertains to our main character, we already know his structure, equipment, and personality. Now, with a world created around him, what is his mission in life? Why is he there? What is he supposed to do? Imagine a war-torn earth in the near future, destroyed by years of combat with nuclear and chemical weapons. Military special units are dispersed to search for survivors and eliminate enemy targets. The scenario dictates that the motion of the soldier be strategic and true to military fashion. A walk animation for this scenario might be a cautious step, leaning forward, with the weapon in the ready to fire position. The world defines the character’s motion.

Now imagine a world made completely of candy. A world that consists of fluffy hearts, rainbows, and unicorns with big eyelashes. Already, only knowing the environment, animation ideas come to mind. In this world, we find a character whose mission in life is to pop as many balloons as he or she can in a given time. This character’s motion will deviate drastically from that of the soldier in the previous scenario.

The world is the environment, the mission is the scenario. These outside influences, combined with the knowledge of the figure and his personality should give a crystal clear base of reference for the figure’s motion.

Animation Techniques

With the model completed, the animation list prepared, and the research gathered, the animator now has the proper frame of reference to begin animating. The core of an animation can be determined by the positioning of two primary types of frames, the most extended frame and the change of direction frame. Generally they are one and the same. As an example, we will use an eight frame run animation of a human figure. In this case, both primary frames would be when the body is in its most outstretched position, with the arms and legs at their furthest point forward and back. Along with being the most extended, these frames will also define just how dynamic the motion will be.

With the primary frames established, the next logical step is the insertion of the intermediate frames. These frames give your eye a fluid path to follow. The positioning of the intermediate frames should consider the speed of the figure’s motion in relation to the primary frames.

Acceleration and Deceleration

When the intermediate frames are being added, the animator must observe acceleration and deceleration. If the computer alone were to interpolate these frames, the result would be that the distance between every segment would be evenly spaced, unlike true-to-life motion. Depending on the placement of these frames, even spacing is usually synonymous with even speed. With regard to the motion of the human body, speed never remains constant. In the example of the run animation, once the body has reached its most extended position, a change of direction will occur. The leg, for instance, slows as it reaches its furthest point from the body and slowly starts back in the opposite direction, gaining speed as it goes.

A simple example of this motion is a pendulum. As a pendulum swings back and forth, its speed constantly changes. When it changes direction, it slows, stops, and starts back slowly again, gaining velocity on its downward arc. This is the natural process of objects in motion. Whether it is gravity in the case of the pendulum or muscle in the case of human anatomy, there must be a slow down period for a change in direction.

Most animation programs do not take change of velocity into account. Instead, they evenly space the inserted frames. To achieve realistic motion, the distribution of the intermediate frames must be placed solely in the judgmental eye of the animator. In human motion, this applies to the body as a whole, as well as its individual segments. Each segment is affected in every possible manner — latitude, longitude, rotation, etc. In the eight frame run animation, focusing solely on the rotation of the pelvis, assume that the first frame is a fully extended primary frame. The pelvis is rotated twenty degrees (with zero degrees facing straight forward). The frame immediately following should show little movement and hold at about eighteen degrees. Frame three falls directly midway between the most extended frames, one and five, and should move quickly jumping all the way to about two degrees. As we approach another change of direction frame we must slow down before the stop so a pelvis rotation of about negative sixteen degrees would suffice. A short four degrees later, we find ourselves at the next fully extended key frame at negative twenty degrees. Repeating those settings for the opposite direction would complete that part of the animation. Running the animation slowly, the frames might appear slightly bunched up in the areas around the key frames. But, when played at normal speed, you will be convinced of the importance that proper acceleration and deceleration can have on your animation.

Obtaining a Fluid Motion

By now, the primary frames have been placed and the required number of intermediate frames inserted. The next step is to align the individual segments and establish a fluid path for them. This must be accomplished segment to segment and not limb to limb. A common mistake in animations is that the figures movement is based solely on the distal most point of any given limb or extremity. For example, the motion of the arm is viewed by the motion of the hand and wrist alone, with little attention paid to the elbow and shoulder.

In most cases, the major segments of a 3-D model are directly proportional to the major bone groups and structures of the human body. Each segment must be thought of individually, in its own perspective, and dealt with accordingly. One should not think in terms of, “Is this arm movement fluid?” But rather, “Is this upper arm movement fluid?”, “Is this forearm movement fluid?”, “Is this hand movement fluid?”. Not only does the arm follow a fluid path, the individual segments that make up the arm each follow a fluid path of their own.

This technique offers an easy, practical way in which to view your animation. Focus your attention on one joint, beginning with the parent segment, and work your way out. Using the profile view as an example, concentrate on the shoulder. Follow it visually through many cycles of the animation. The desired effect is to have that particular joint follow a rotational path without quick jumps or deviations from its fluid rotation. Once achieved, repeat the process from the front view. After obtaining the fluid path from both the front and side, follow the same procedure with the elbow and then wrist. This does seem a tedious process, however, if every possible joint moves in a smooth, fluid motion, the figure as a whole will as well.

Realistic Torso Motion

A more realistic torso motion can be achieved by moving the actual vertices of the torso segment, rather than treating it as a large pivoted segment. Particularly with cinematic sequences, bending and twisting the torso geometry yields a better result than standard pivoting techniques can accomplish. However, few animation programs offer the ability to animate a human torso in a way similar to that of the natural motion of the human spine. Most rotate the segment as if the lower back were connected by ball and socket joint, leaving your animation with the characteristics common to that of most action figures. However, depending on the animation program used, movement of individual vertices could very easily double your work load and your time.

There are two primary factors that could help decide if the extra time and effort is needed: size of the character onscreen and visibility of the vertical lines of the torso. The relative size of the character is affected by not only the height and width of the character in pixels, but also the type of monitor it is being displayed on and the display’s resolution. The vertical lines are more complex. First of all, depending on what the figure is wearing could easily affect your decision. If we return to our previously mentioned military character, imagine him with straps coming over his shoulders and connecting to his belt. Any twisting of his body without vertex animation would give those straps the appearance of being stiff and highly unrealistic. Patterns and decals on shirts have the same unnatural result. For example, imagine a football referee wearing a black and white vertically striped shirt. If he were to do any torso movement, it would be blatantly unnatural and could be comparable to having a barrel mounted on his pelvis instead of a torso. This is an extreme example, but the condition applies and is noticeable on characters with much less of a vertical pattern. Now suppose the figure does not wear a shirt or anything else on his torso. If the 3-D model is built correctly and is true to human form, the vertical lines will be present. A visible line can be seen running down the back along the spine. If the character has muscular definition, which many game figures do, a noticeable line can be seen down the front of the torso, separating the pectoral and abdominal muscles. If these vertical lines do not twist and bend as a human's would, then even the best animators will find difficulty in approaching true realism.

Dynamics

A dynamic animation retains all of the attributes of a typical animation, but pushes the boundaries of reality to produce a more dramatic effect. Dynamics give animations the appearance of more flexibility, more strength, harder impacts, and more agonizing reactions.

In order to obtain the dynamic animation, one must first obtain the dynamic keyframe. Think of this frame as if the character were posing for a still shot, a pose that might be seen on an action movie poster or in a comic book. It should convey strength and even though only one frame, motion. To an outside observer, this frame should appear as though the figure were actually performing an action and someone simply took a photograph of him while in his most out stretched position. This same observer should be able to view this one frame and identify the motion, and to a small degree, some characteristics of the figure. Imagine the figure appearing in a comic book and the pose could be thought of as a one frame animation. With only one frame to describe the motion, it would have to be an extended, change of direction frame. That is what describes the motion and that is where most dynamics lie.

Applying dynamics to the keyframe is basically pushing the segment slightly more in the direction that it is already moving. A leg extended forward moves a little more forward, the head rotated at forty-five degrees might become a rotation of fifty-five degrees. Every segment can be affected.

To assist in finding the dynamics of a pose, one might try to duplicate it with his or her own body. Hold the pose of the keyframe, then slowly begin to push your body and limbs slightly more in the original direction it took to get them there. If the spine is twisted, twist it a little more. Bear in mind, this is still the same pose, just more extended. At a certain point, the extension reaches a limit, and a discomfort is felt around joints and muscles. If the entire pose is dynamic, then the entire body should ache just a little. If everything but the arm is aching, and hard to hold, then the arm could be stressed a bit more. It may seem odd, but if while holding a pose your body is in pain, it's either wrong or dynamic.

Consider the illustrations you have seen of Spiderman. Many of the poses the artists have put him in are very out stretched and extended. The result however, is a dynamic and impressive image. Thinking of that pose in more detail, it becomes apparent that having the body in a position like that would be very painful. Still, it works. Strangely, there is a fine line between the painful pose, and they dynamic one. Stressing the muscles and joints is what creates the dynamic frame.

The change of direction keyframes are the major factor in animation dynamics. However, intermediate frames with slight modifications can also contribute, primarily through acceleration and deceleration. The 'bunched up' frames mentioned earlier become even more so as dynamics are added. This accomplishes two things. The first is that grouping the 'change of direction' frames closer together fools the eye into seeing the dynamic frames longer as the animation slows around that point. The second is that by pushing those frames closer, it leaves larger distances through the center frames which causes them to move faster. This system basically allows more visual time spent on the dynamic keyframes, at the same time speeding up the amount of time it takes to reach them. A kick animation for example, would move faster on its way to the target, which would indicate that since the foot is moving faster, it will hit harder. When it does hit its target, at the most extended part of the animation, it would slow down enough after impact to enhance and show off the powerful blow.

In some circumstances, depending on the degree of dynamics one desires in his or her animation, the frame count could even be altered. In that same kick animation, if the animator used four frames to reach its point of impact, removing one frame from that sequence just made that kick twenty-five percent faster. In turn, it makes our character faster, more powerful, and more dynamic.

When establishing the game design and the characters within, one must decide on the amount of dynamics to be incorporated into the figures, even if it is none at all. Often, game animations call for a totally natural motion complete with all the imperfections, quirks, and limitations of true human form. However, dynamics are far more prevalent than one might suspect. There are specific animations used in many games that incorporate dynamics so often, that if dynamics were not included, the true human motion would seem odd and as far as games are concerned, no fun at all to play. For instance, how many games have there been where a character could not jump at least his own height and make it look easy? Incorporate a few flips and give him a two or three second hang time, and it still remains within the believable range of acceptance in games. Now imagine a realistic human jump. If the character's vertical leap were true to human form, crates, barrels, and other obstructions now pose a serious problem. In this circumstance, playability has forced dynamics into the animation. Game developers have, perhaps unknowingly, set the standard that in a jump animation, dynamics remain constant.

Dynamics transforms human to hero. It enhances almost any movement. Hopefully, the dynamics of the animation will be equaled by the accompanying sound effects and game play mechanics. With the appropriate support, a dynamic animation should leave the player responding to impact animations with exclamations of “Ouch, that looked painful!”, and “Did you see that?”.

Closing

Many people believe that modern technological advances in software packages and motion capture can replace a skilled animator. These advances themselves cannot account for all aspects of animating. A motion capture system accomplishes exactly what its title states, it captures motion. A well set up system can translate the movement of the actor to the computer almost perfectly. However, using that rational, we can conclude that the actions of the 3-D model can only be as impressive as the actor. His limitations of flexibility, agility, balance, and strength may restrain and hinder the possibility of an impressive, dynamic animation.

Though a computer remains an amazing part of today’s technology, it is still far from understanding human motion. It cannot comprehend and incorporate factors such as personality and dynamics. It is the animator who understands this and uses the technology as a tool to produce the final image, he decides if the motion is powerful enough as is or if dynamics are needed. As impressive as animation technology is today, it still does not have built-in talent. The animator combined with this technology is how truly great animations are achieved.