Life Drawing and 3D Figure Modeling with MAYA: Developing Alternatives to Photo-Realistic Modeling

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The development of computer graphics has been driven in part by the pursuit of photo-realistic rendering. As seen in recent films such as Final Fantasy: The Spirits Within [1], the film industry seeks to create images of human beings that are indistinguishable from reality. In contrast to this impulse is a very long history of image making seen in many different cultures in which the human form is represented in both believable and recognizable ways. Yet the means of representation—that is, the individual gestural mark made with the paintbrush or pencil directly by the artist—is a celebrated part of the aesthetic. With photo-realistic computer graphics the means of representation is meant to disappear and not be visible. In the Western tradition, the figurative works of Titian, Rembrandt, Degas, Cassatt, Picasso, or Alice Neel would lose their meaning and vitality if the gestural line of drawing were removed.

MOTIVATION

I was motivated to develop a workshop, Life Drawing and 3D Figure Modeling with MAYA, in part by a number of questions that naturally come to mind when comparing the process of 3D modeling with that of drawing. Can the “natural way to draw” be preserved in the process of modeling the human figure using 3D computer graphics? Can the photo-realistic impulse be set aside in favor of exploring personal expression by means of the individual mark? Using pencil, charcoal and paint, a previous generation of artists sought to investigate the very nature of the medium, aiming at a different truth of representation. Does this approach have any meaning in the world of computer graphics? Is the gestural line of drawing, long considered the signature of personal expression and individual vision itself, rendered irrelevant?

Are there alternatives to the dominant modes of representation such as photo-realism, pumped-up superheroes, international anime culture or Disneyesque stylization? How can the exploration of alternative approaches be best encouraged and developed? Can 3D modeling provide a similar pathway to discovery and revelation of aesthetic truths and personal meanings as seen elsewhere in the worldwide history of drawing, painting and sculpture? Do the technical demands, such as the modeling process of 3D computer graphics and ultimately the marketplace, make such concerns obsolete and irrelevant?

INSPIRATION

Using language informed by Taoism and Buddhism the painter Ching Hao (900–960) wrote over a millennium ago: “Resemblance reproduces the formal aspects of things but neglects their spirit. Truth shows the spirit and the essence in its perfection” [2]. In his book The Natural Way to Draw, Kimon Nicolaïdes aims for something quite similar: “You should draw, not what the thing looks like, not even what it is, but what it is doing” [3]. He developed a series of drawing exercises in which the artist focuses alternately upon contour gesture, weight, modeling, memory, analysis of contrasting curved and straight lines, predominating shapes and their design within the frame. Through such exercises Nicolaïdes strives for a deeper understanding and empathy with the subject in learning how to represent it. How can these values be preserved in the task of 3D modeling?

Texts like Mastering MAYA Complete [4] cover the function and operation of the main capabilities of MAYA, the powerful 3D modeling, rendering and animation software application from Alias Wavefront. The authors introduce a very simple technique for modeling an arm by lofting a series of circles into the appropriate shape. Although the authors devote only a short section to this exercise as a demonstration of the modeling process, it was a natural step to expand this simple approach for modeling the human figure and make it the focus of an extended workshop.

DRAWING AS DISCOVERY

For Nicolaïdes, learning to draw is an ongoing process of discovery. Fundamentally it is learning how to observe the living world not only with the eyes but using all the senses. A contour drawing made without looking at the paper is about touching the edges of form, of pushing and pulling edges that move forward and backward in space. A gesture drawing is learning how to empathize, identify and participate with what...
For Nicolaïdes, this is more than action or attitude: “Gesture describes the compound of all forces acting in and against, and utilized by, the model” [5]. Through weight and mass drawings we seek to feel the effect of the forces and discover the core motivation of a form. All the senses should be used to feel and empathize with the subject. This is not unlike a modern dance technique where performers focus on the midpoint of their bodies as the locus of energy from which to initiate movement. A skilled animator naturally empathizes with the subject in order to understand how the character acts, moves and behaves. For Nicolaïdes the exercise of “drawing from memory” utilizes one’s own muscles to remember the movement of the model. “Drawing at right angles” requires the artist to draw the model from an imagined perspective 90 degrees to the observed viewpoint. This is a skill that a director/animator uses in determining camera angle and placement.

Another exercise emphasizes the use of memory and imagination by consciously relating the direct sensory experience of viewing a model to past experience. This free association could involve any one of the senses. Like Proust’s madeleine, our conscious life is made up not only of the present, but also of a flood of memories, thoughts and sensations that reflect our own unique lives, which color our current experience. Drawing becomes a dance between objective observation and subjective, even subconscious, reactions and recalled experience, mediated by the marks left on the paper. For Nicolaïdes, “drawing depends on seeing. Seeing depends on knowing. Knowing comes from a constant effort to encompass reality with all of your senses, all that is you” [6].

THE HEGEMONY OF STYLES
Recent computer graphic techniques of modeling, rendering and animation have captured the likeness of the human figure with ever increasing photo-realism. Examples such as the synthesized characters in Final Fantasy: The Spirits Within, the digital version of the actor Kevin Bacon in the movie Hollow Man [7] or the virtual James Brown created for the Experience Music Project in Seattle, Washington, challenge the viewer to distinguish between the “real” and the “virtual.” Yet all too often what appears realistic today, within a year or so appears as yesterday’s artifice. At the same time, character design for games such as Tomb Raider’s Lara Croft are highly stylized. For gaming, stylization can be in part determined by storage requirements and display constraints, which require fast polygonal rendering. The international comic book and anime culture also plays an important role in this stylization and simplification of 3D characters. In full-length computer animated films such as Shrek [8] the stylization actually helps create a more believable character. The audience can forget that the character is not real, whereas attempts at realistic actors still betray the artifice.

Successful stylization even with surreal distortions and exaggerations requires a command of anatomy, proportion, form and a sense of color and design. Creating convincing characters with believable
movement requires much more than anatomical correctness. Whether designing a photo-realistic virtual actor or a highly stylized action character for gaming animators, artists and designers need to start with observing the human form from multiple perspectives and in motion. A mastery of drawing and understanding of anatomy and proportion lay the groundwork for making believable corrections, enhancements or distortions to polygonal meshes created from 3D scanning. Even with cartoon-like characters or highly stylized comic book action figures, 3D artists need to quickly realize ideas through 2D sketches that can be used as references in 3D modeling. Even with cartoon-like characters or highly stylized comic book action figures, 3D artists need to quickly realize ideas through 2D sketches that can be used as references in 3D modeling. To bring a polygonal model to life requires reaching beyond the surface and somehow investing the character with a personality, a sense of a lived life. As Nicolaïdes wrote, “To what the eye can see the artist adds feeling and thought. He can, if he wishes, relate for us the adventures of his soul in the midst of life” [9].

THE END JUSTIFIES THE MEANS

Does the end justify the means with regard to the task of 3D scanning, modeling, motion tracking, rendering and compositing as used in a typical commercial production? What amount of individual expression contained in a drawing will survive the steps of digitizing, modeling, curve rebuilding, reparameterization and all the rest throughout the production pipeline? Individuality is often suppressed because the final outcome is usually the product of many hands. Characters are created by committee and often shaped directly by market forces and audience feedback. Occasionally artwork in commercial productions may display the influence of values advocated by Nicolaïdes. Yet such examples are typically subordinated to plotline and constraints dictated by mass marketing. Nicolaïdes himself considered his drawing exercises as learning tools intended not for exhibition but rather as a by-product of the required mental and physical activity. But it is through these exercises that we begin to sense a deeper aesthetic meaning.

For Nicolaïdes, the observation of movement in nature provides the basis to understand the very nature of existence. When Nicolaïdes uses the word “design” in relation to painting and drawing he means “simply that it has been organized in relation to movement.” Movement generates change and contrast and is the very manifestation of existence. By observing, understanding and selectively intensifying contrasts revealed in movement, form, light, shade and color, the artist engages in a process of analysis through design. In drawing, the most fundamental contrast is between the straight and the curved line. Rather than a process of simplification, this analysis is a process of emphasis that reinforces through rhythms of contrasts the meaning of the whole gesture of the model’s pose. Motif and variation, action and reaction ripple through interlocking forms that make this approach to design in drawing dynamic and not mere static ornamentation.

Aesthetics subordinated to photo-realism greatly restricts the kind of experimentation that is intrinsic to the natural way to draw. The impulse toward photo-realism can blind the artist to the full spectrum of creative possibilities inherent in the medium of 3D computer graphics. The Natural Way to Draw is really a guide to learning how to observe the world of existence with all of one’s faculties, senses, intelligence and creativity. It is essential training for anyone involved in arts of visualization whether it be traditional painting or 3D computer graphics. As such it is preparation and a foundation applicable to many other disciplines. Mastery of life drawing is but one part of a larger pursuit, which contributes to the formation of a cultivated, creative and self-aware aesthetic sensibility.

THE WORKSHOP

This workshop was first offered in the spring of 2001 at the Yale University Digital Media Center for the Arts [10]. A shorter version of the workshop was held in August at ACM-SIGGRAPH 2001 in Los Angeles [11] using the facilities of the Creative Applications Laboratory Interactive Learning Classroom. At Yale and in Los Angeles many participants were students from the School of Architecture and had experience with programs such as AutoCAD and MAYA. Others were undergraduate majors in computer science who had limited knowledge of end-user applications and little experience drawing. Others were fine arts students in the MFA degree program. The SIGGRAPH workshop attracted over 200 attendees from novice to advanced users of MAYA. In both workshops, introductory and advanced tutorials were provided, which matched...
attendees’ previous experience, interests and capabilities.

The workshop was conceived as an update to the traditional life drawing course while serving as an introduction to 3D modeling and the MAYA Graphical User Interface. The workshop took a hands-on approach to link the expressive world of drawing to the mechanical tasks of modeling. While introducing powerful tools used for character animation the workshop pointed to unexplored creative possibilities that go beyond the literalness of technical drawing and computer-aided design.

The Technique

The workshop introduced a simple technique of lofting to model the human figure using sketches drawn from life. Generating a surface using lofting is often compared to building the hull of a wooden ship. A frame is made of equally spaced ribs and the hull follows the shape of this frame of ribs. The result is a smooth but complex curved surface. To model an arm, leg or even torso with computer graphics, a series of “ribs” made of geometric primitives such as circles is required to create a scaffolding or frame for the surface. The lofted surface follows the form created by the frame of circles.

The Tutorial

For the first tutorial of the workshop, attendees were provided with sample tutorial drawings representing front and side views of a leg. To create a proportionally correct model of a subject, two orthogonal views of pose should be prepared. These drawings can be realistic, stylized or even abstract. If correct proportions are desired, the drawings must be executed to be the same size and should capture the contours of the subject. Graph paper is often used to facilitate alignment. Major topological features should be clearly visible so that size comparisons are easily seen in the front and side views. Measurements such as from the patella (kneecap) to the lateral malleolus of the fibula (outer ankle) should be roughly the same length in both drawings of the respective views.

After scanning, the digitized drawings can be retouched and edited to improve clarity. The spatial resolution (horizontal and vertical number of pixels) must match to preserve alignment. For the tutorial examples the drawings were scanned as grayscale images at 72 pixels per inch and saved as TIFF (Tag Image File Format) files. These tutorial images are imported into MAYA and set up as orthogonal image planes (Fig. 1). As image planes, the images could then be used as accurate references for the task of adjusting the location, size and shape of each circle in three dimensions.

Two methods are introduced to build the geometry. With the first method, the NURBS (Non-Uniform Rational B-splines) Circle tool is used to create one circle at a time. Starting in the front view, either at the top or bottom of the drawing, each circle is moved and scaled to align to the contours of the drawing (Fig. 2). More circles are added as needed to match the detail of the drawings (Fig. 3). Fewer circles are used where there is less detail. Through this process, some of the individuality of the drawing and the gesture embedded in the lines and proportions can be potentially translated into a 3D model. In general it is desirable to make a model as simple as possible, as greater complexity requires more computation and processing time. After a sufficient number of circles are placed and adjusted in the front view, the view is changed to the side view and each circle is adjusted to match the contours of the drawing of that view.
With the second method, instead of adding one circle at a time, the user duplicates surface curves from a NURBS Cylinder that has been roughly adjusted to the size and shape of the drawings in the front and side views. This yields a stack of equally spaced NURBS Circles (Fig. 4). All of these circles are made up of the same number of curve segments and Edit Points (also called knots) where each segment joins to the next. Parameterization is the calculation of where these knots are placed along the curve. When all the circles have the same parameterization, the resulting lofted surface is smooth and without unanticipated pinching or twisting. The final step is to select each circle one by one in an orderly fashion from top to bottom (or vice versa) and to apply the Loft Tool.

MAYA remembers each step in the construction history of the resulting lofted surface. With each further transformation of a circle, the lofted surface is immediately updated. This permits adjustments and corrections similar to the trial-and-error process of modeling in clay. At the same time, such adjustments offer the opportunity for experimentation with deliberate distortions (subtle or not) to discover new forms nearly impossible to visualize through drawing alone (Fig. 5). An obsession with photo-

Fig. 4. Method II (left to right): Duplicated surface curves from a NURBS Cylinder create a stack of equally spaced NURBS circles. Each circle is scaled and moved to align to the contour of the drawings in the side and front views. (© Gregory P. Garvey)

Fig. 5. After alignment the NURBS circles are selected and lofted. MAYA stores the construction history as the geometry is created. The lofted surface can be interactively edited by adjusting the size, position and rotation of the circles. The Outliner window permits selection of the geometry. (© Gregory P. Garvey)
realism inhibits the exploration of these possibilities.

The Advanced Tutorial

An advanced tutorial provided step-by-step instructions for adding a skeleton with a simple hinge joint. This step involves binding the lofted surface (the skin) to the skeleton. The IK (inverse kinematics) Handle tool allows the animator to bend and position the limb while the skin conforms appropriately (Fig. 6). A NURBS Sphere is added as an Influence Shape to the leg at the position of the calf (gastrocnemius) muscle. The Set Driven Key tool allows the animator to use the bending of the knee measured in number of degrees of rotation about the local z-axis to change the scale or the size of the sphere (Fig. 7). The result is that as the knee bends the calf muscle (the sphere) swells like the contraction of a real muscle and deforms (influences) the skin accordingly. The second tutorial also demonstrated the use of the Artisan Paint Weights Tool. The user can “paint” as if using a brush to change the amount of influence of the bend of the joint on the skin. The final step “Playblasts” the animation to generate a frame-by-frame shaded rendering of the animated leg.

Additional examples demonstrated modeling other parts of the body. Participants were provided with sample tutorial drawings of front and side views of an arm in a pose of supination, the torso and the head. Unlike the drawings of the front and side views of the leg, the drawing of the front of the arm in supination does not align with the side view of the same pose (Fig. 8). In fact there is quite a disjunction. Once the circles are lofted, the bend in the arm becomes clearly visible, with a very naturalistic curve in three dimensions. This suggests the possibility that drawings imported into image planes could be deliberately misaligned to generate new surfaces impossible to visualize in any other way.

While the technique of lofting circles does approximate the overall shape of the torso, it results in artifacts that appear a bit like a series of distracting ridges or terraces. In the modeling of a head these artifacts become even more pronounced. Even with skillful use of the Paint Surfaces Tool it is difficult to eliminate unwanted geometries. There are several other methods for modeling the head outside the scope of these tutorials that give superior results.

DEVELOPING THE WORKSHOP

A workshop with a focus on modeling the human figure could serve as a more general introduction to MAYA, covering additional topics as follows:

Session I: Selecting poses and drawing orthogonal views.
Session II: Scanning, image processing and correction.
Session III: Setup and creating primitive geometry. Using lofting, transformations and component editing.
Session IV: NURBS, polygonal and subdivision modeling for hands and feet.
Session V: Selecting and inserting isoparms, dividing into patches, rebuilding the parameters, stitching, mirroring, deleting history and global stitching.
Session VI: Adding a skeleton, IK Handles, skinning and binding.
Session VII: Adding constraints, influence objects, other deformers,
character setup, hierarchy and weighting.

Session VIII: Basic texturing, paint effects and lighting.

Session IX: Rendering.

Session X: Printing and rapid prototyping.

NATURAL WAYS TO MODEL

There are many avenues for developing an approach that links the study of life drawing to that of 3D modeling. The study of the human figure provides many essential lessons for conceptualizing form, space and composition that can be taken well beyond the dictates of photo-realism. A more broad-based curricular development appropriate to a fine arts-based animation program could offer courses that incorporate a range of strategies.

Three-dimensional modeling can permit the study and implementation of proportional systems from different historical periods for rendering the figure such as the Canon of Polyclitus or that of Leonardo. Multiple drawings of the same pose can be executed using the different methods described by Nicolaïdes (contour, gesture and mass studies). Digital photographs could be taken of the pose or of clay maquettes. These different studies could be used as multiple reference image planes to guide the modeling process.

Inspiration could be drawn from the legacy of expressionism, cubism, futurism, surrealism and even abstraction. The example of the arm in supination suggests experimentation with non-orthogonal or even deliberately misaligned views. Multiple perspectives juxtaposed in a cubist fashion could be combined, leading to surface geometries very difficult to anticipate or visualize through any other means. This lends itself to an iterative, trial-and-error process of exploration analogous to the drawing process. The resulting complex surfaces can be further articulated by recent developments in non-photo-realistic rendering. For example, cross-hatching rendering algorithms such as those developed by Emil Praun et al. [12] could articulate Cézanne-esque planar facets.

Dynamics permit the development of movement that simulates physical forces such as gravity and weight. A work like Unique Forms of Continuity in Space by Italian futurist Boccioni [15] inspires a number of ideas for exercises. Particle systems, dynamics, influence objects and deformers can all be used to explore movement in entirely non-realistic—even surreal—ways. Marcel Duchamp’s Nude Descending a Staircase offers another vivid example for the exploration of time and motion that is ignored by photo-realism. An entire course could be built around learning to use the input from musical instruments or motion sensing transducers using MIDI (Musical Instrument Digital Interface) to control animation and deformations. Finally, motion-tracking technologies offer numerous possibilities for further explorations.

THE PERSONAL

At first glance the pursuit of a personal artistic aesthetic simply seems irrelevant when using 3D computer graphics to model the human form. With sculpture or painting there are myriad techniques and approaches to modeling the human form that celebrate self-expression. Perhaps, in a similar fashion, a talented artist could explore the use of NURBS, polygons or subdivision modeling in unique ways to develop new sculptural forms guided by a personal vision and an individual aesthetic.

Can this exploration be linked to “a natural way” to draw? A provisional answer is yes, as seen with the technique of using imported scanned drawings set up as reference image planes. The biggest shortcoming with this approach is that the drawing is one step removed from the modeling process. It is possible to use a pressure-sensitive tablet along with tools for drawing curves. But this approach suffers from the need to heavily edit the resulting curves because of the “unnaturally” large number of edit points, which make inefficient curves for surface modeling.

Another approach used with impressive results is to import gesture drawings as part of the rendering process. An example of this approach is the video installation Hand-drawn Spaces by Paul Kaiser and Shelley Eshkar. By means of motion capture, 3D hand-drawn figures perform the choreography of Merce Cunningham [14]. It is also here that algorithmic approaches to non-photo-realistic rendering will offer artists new avenues to explore the mapping of gestural drawings to models at the rendering stage.

CONCLUSION

From the Paleolithic Venus of Willendorf to the sensational work of Jake and Dinos Chapman, the human figure remains a subject of aesthetic interest and also the site of contested narratives. In recent years the “body” has been exhumed and dissected by extensive theorizing. The purported male gaze has been blindsided and displaced by competing viewpoints with very different agendas. The territory of human skin and flesh has been colonized as an aesthetic object by artistic visions that previously had been marginalized. While this workshop provided an introduction to using 3D computer graphics to model the human figure, it also aimed to bring to this undertaking the many different viewpoints and approaches found in modern and contemporary artistic practice. Exercises that recapitulate cubist or futurist experiments are simply one path of many to move beyond the myopia of photo-realism. To paraphrase Nicolaïdes: 3D modeling depends on drawing, drawing depends on seeing. Seeing depends on knowing. Knowing comes from a constant...
effort to encompass reality with all of your senses, all that is you.

References and Notes

10. As an Associate Artist of the Digital Media Center for the Arts (DMCA) at Yale University I organized the workshop while developing the VELVIS (Virtual Elvis) interactive installation, exhibited in June 2001. The DMCA was originally conceived as a multimedia facility created to explore new areas of education and cross-disciplinary interaction.

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