

Animation Production Pipeline for Matching Dissimilar Modeling, Animation, and Compositing Tools

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Abstract

This paper provides a first-person account of a large-scale commercial project that required integration of dissimilar modeling, animation, and compositing tools. The author discusses the identification and solutions of production problems, as well as, the development of a custom production pipeline for the project. Specifically, a team of modelers, animators and compositors developed a production pathway based on the integration of organic NURBS and architectural polygonal models used to accurately depict the city of Chicago. The utilization of motion-capture data and the use of custom program scripts to repair NURBS defects are discussed.

Introduction

As educators we must prepare our students to perform in a marketplace that often requires them to assume a wider set of roles than in the past. It is not uncommon for graduates of engineering design programs to be asked to create technical and non-technical animations. This can be, in part, attributed to the fact that the underlying technology that drives most CAD packages is the same that drives 3D animation packages. For example, Electric Image's Universe is based on the ACIS kernel that many CAD packages such as AutoCAD are based upon. Thus, if a student knows how to visualize three-dimensional surfaces and is familiar with their manipulation in a CAD package, he/she will have the base requisite skills to be functional in an animation package.

A cursory look at the curricula offered at a sample of U.S. institutions of higher-education which address engineering design graphics, reveals that most offer animation either as a stand-alone course or as a portion of an existing course. Within the Computer Graphics Technology department at Purdue University, we offer multiple courses that address both animation and CAD. Thus, we can conclude that at least some engineering design programs have acknowledged the need to impart animation knowledge within their graduates.

To effectively prepare our students to undertake their wider roles, we must educate them on how to function in realistic environments that call on them to integrate dissimilar modeling and animation tools. It is common for companies to undertake projects that require these skills. Graduates must have the skills and experience to identify and solve integration problems, and the ability to develop customized production pipelines based on the project specifications, client's mandates, and specific software utilized.

This paper aims at presenting the type of knowledge that we must pass on to our students to be successful in such a scenario by providing a first-person account of a large-scale commercial project that required integration skills.

The Chicago Bulls Organization contracted High Voltage Software (HVS) to develop a 3D animated opening to be shown on the JumboTron at the United Center and on television before each home game. The client asked for the animation to include a series of 3D rendered bulls running from numerous places in the city toward the United Center. Along the way, the bulls would pass Chicago landmarks. Each landmark passed by the bulls was to "include enough detail so that the average Chicagoan could recognize it."

(Fiore, 1999). The total production time for the project was set at 46 days.

HVS assigned a total of six people to the project. Three would form the core production team responsible for generating all of the graphic elements that would actually comprise the final animation. The core production team was comprised of one character animator, responsible for creating all organic NURBS models; one architectural animator, responsible for creating all non-organic polygonal models; and one technical director/compositor, responsible for assembling the final renderings. The author served as the technical director. The remaining personnel formed the support staff comprised of one storyboard artist, one art director, and one project administrator.

Planning

The art director and storyboard artist concluded that the entire city should be built using 3D software. The look would be a hyper-realistic yellowish over-cast similar to what film makers call the golden hour. The bulls were to be fully textured using bitmap images. Buildings and street elements would be left untextured, and given definition through the use of creative lighting and basic color. The length of the animation was to be 32 seconds and take place over a series of 18 shots (Russell, 1999). A grayscale set of storyboards was prepared showing the sequence of the animation (Figure 1) and a set of three color still images to depict the look and feel of the animation (Figure 2). Combined these two documents would serve as an objective reference to which the production team could look

to for guidance.

The client signed off on the contract based on the storyboards and color stills. The art storyboards functioned to give the client an idea of the look and feel envisioned by the production team and the sequential stills served to communicate the timing and locations for the events in the animation. The client could see the textured NURBS bull composited against the polygonal architecture of the city, helping sell the project.

Production



Figure 1. Sequential storyboards



Figure 2. Sequential still frames

While the art director and storyboard artist finalized the vision for the animation, the production staff worked on establishing a production pathway to meet the project needs. In the course of producing the sample scene, the production team would select software and hardware that could deliver the look established by the storyboards, test new techniques, and start to create the production models. In short, the production of the sample scene would serve to establish the milestone schedule, map out the production pipeline, and also secure the final approval from the client to start production.

To maximize production time while maintaining creative control, the production team decided to render all scenes in multiple passes. Individual elements would be created in the package of choice by the expert in his/her respective area and composited together by the technical director. This approach would allow all of the members of the team to use the software most appropriate for the task.

The character animator decided that only a high-end NURBS based animation package with support for expressions would be appropriate. SoftImage 3D Extreme™ was selected (Jeffrey, 1999). The architectural animator determined that a polygonal based package such as LightWave 3D would allow Chicago to be modeled, textured, and animated much faster than using SoftImage (Schultz, 1999). The technical director decided that After Effects Production Bundle™ would be used for compositing. Organic models would be built and animated in SoftImage 3D, inorganic models in LightWave 3D, and everything put together in After Effects.

Once team members selected the tools they would be using for completing the sample scene, they focused their attention on making the necessary preparation to ensure a successful composite. To enable the production team to composite organic elements rendered in SoftImage with inorganic elements rendered in LightWave 3D, all of the objects in a scene

would have to exist in both SoftImage and in LightWave at the same scale. Second, a texture that would receive and cast shadows, but not render would have to be developed. This would allow the bulls rendered in SoftImage to cast shadows on the streets and sidewalks rendered in LightWave. Finally, the movement of the camera and any lights would have to match exactly in both scenes.

Model Preparation

While the team exercised creative freedom in several aspects of production, they felt it was important to model the selected locations for the animation as accurately as possible. The team visited each of the selected locations, took photographs, and gathered architectural plans. All architectural features were built in LightWave using these documents as a guide. To create a sense of power and strength for the bull, its scale was changed to approximately four times the size of a real bull. The modeling of the bull proceeded rapidly using standard NURBS modeling techniques. The bull was modeled in SoftImage using primarily loft surfaces and proportional modeling. Construction history and the “select by U/V” made it possible to make small changes to the model effortlessly (Jeffrey, 1999). The character animator finished the basic model of the bull in three days.

To prepare the model of the bull for animation, an Inverse Kinematics (IK) skeleton was built and assigned to an automatic global envelope. The weights of the generated envelope were then edited manually and nulls added to the end effector of the IK chains. With the body of the bull set up for IK animation, it was time to prepare the head of the bull for shape or morph target based animation.

The head of the bull was replicated multiple times and modeled to reflect different facial expressions. Each instance of the bull’s head was then assigned to a null object that would control how much of that instance would be reflected in the original head. SoftImage’s expressions and channel

drivers were used to connect the null to the influence of the individual shapes on the target bull head. This made it possible to animate the bull's face by just moving the null objects (Jeffrey, 1999). Finally, textures for the bull's skin were generated using Metacreations Detailer and Adobe Photoshop and applied as a UV map. Figure 3 shows the final bull model with textures applied. The entire process, including modeling, texturing, and enveloping the bull took approximately one week. When tessellated for rendering the bull weighed in at approximately two million polygons.



Figure 3 Bull Model

Models of the city streets were created using LightWave's standard polygonal tool set. Photographs gathered by the project administrator were used as a guide in modeling the street elements. The Bloom and Gaffer plug-ins were then used to give the buildings the look designated in the storyboards. It took approximately 1.5 days to set up the street scene (Schultz, 1999).

To allow for proper shadow interaction between the SoftImage and LightWave objects, a DXF model was made of a bull modeled in SoftImage. The bull was imported in LightWave and assigned the "unseen by camera" shader, which allows an object to cast a shadow onto the scene without appearing in the final render [4]. The net effect was that by placing the dummy DXF bull object in the same position to where the bull would be rendered in SoftImage, it was possible to properly cast a shadow onto the LightWave background plate without showing the dummy bull. The same was accomplished in SoftImage by importing a dummy DXF version of the street under the bull and assigning it a "shadow object" shader (SoftImage, 1998). This arrangement resulted in four unique layers rendered from the two packages (Table 1).

One of the most significant problems encountered by the team was that surfaces created in SoftImage would experience tears





Layer	Software	Example	Layer	Software	Example
Foreground	LW3D		Bull Shadows	SI 3D	
Bulls	SI 3D		Background & Foreground	LW3D	

Table 1 Rendered layers

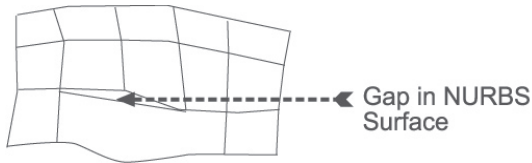


Figure 4 Geometric Tear

at places where there was a non-uniform subdivision of patches. Figure 4 shows a typical tear in SoftImage.

To correct this problem the author wrote a script, which repaired the gaps after the NURBS model had been tessellated, by taking the directional derivative at points on the mesh adjacent to the gap and adjusting them until the rate of change across the gaps was continuous.

$$D_u f = \frac{\partial f}{\partial x} u_1 + \frac{\partial f}{\partial y} u_2 + \frac{\partial f}{\partial z} u_3$$

Another problem in the production pipeline was figuring out how to match camera movements in SoftImage to camera movements in LightWave. Commercial conversion utilities tried by the team transferred geometry, but not animation data (PolyTrans, 2003).

The team solved the problem by writing a program that converted LightWave's proprietary motion capture format to Biovision BVA, which could be imported by SoftImage. The LightWave motion data file differed from BVA in formatting and the orientation of the z-axis. Tables 2 and 3 show sample Lightwave and BVA motion capture files.

0.0225	0.12	-1.0837	0	0	0	1	1	1
0.0232557	0.117897	-1.0526	0	0	0	1	1	1
0.024022	0.115758	-1.02118	0	0	0	1	1	1

Table 2 Lightwave motion dump

Rendering

With the 3D elements matched, the production team was able to focus on rendering. SoftImage elements would be rendered using the Mental Ray renderer and LightWave elements using LightWave's internal renderer. The technical director decided to field render all elements for smoother motion at a resolution of 720 pixels by 486 pixel at D1 aspect ratio. Initial tests proved that while the field dominance could be set for SoftImage and LightWave, the method that both programs use to calculate field motion was incompatible. SoftImage rendered its fields to separate files and compressed the vertical size of the images to only constrain the information for that field (Softimage, 1998). This generated images that were half the height of the corresponding LightWave pictures. LightWave interlaced its fields into one file (Newtek, 2003). The technical director decided that it would be best to render the scene at 60 frames per second and then conform it to 29.97 frames per second with the appropriate field dominance during compositing.

After rendering the 3D elements of the test scene, the production team directed its attention to compositing. The 3D elements had been completed in four days, including building the scene elements, matching the camera, and rendering the scene. The produc-

Segment: TEST

Frames: 3

Frame Time: 0.033333

XTRAN	YTRAN	ZTRAN	XROT	YROT	ZROT	XSCALE	YSCALE	ZSCALE
INCHES	INCHES	INCHES	DEGREES	DEGREES	DEGREES	DEGREES	DEGREES	DEGREES
0.0225	0.12	01.0837	0	0	0	1	1	1
0.0232557	0.117897	01.0526	0	0	0	1	1	1
0.024022	0.115758	01.02118	0	0	0	1	1	1
0.0247978	0.113586	00.989462	0	0	0	1	1	1

Table 3 Biovision motion dump

tion team could use this figure as a guideline for how long the 3D portion of each scene would take to complete. Before benchmarks could be set for the entire process and the production pipeline could be finalized, the individual layers would have to be composited successfully.

Compositing and Editing

The integration of the discreet 3D rendered layers was accomplished by using Adobe After Effects Production Bundle. The process consisted of interlacing the frames, color correcting the layers, masking and keying out the shadow areas, and finally applying camera shake. The main premise of the compositing phase was to put everything together while keeping all image files uncompressed.

The first step was to conform the frames to 29.97 frames per second to adhere to the NTSC standard. This was accomplished via the After Effect interpret footage option (After Effects, 1998). With the footage properly interlaced, the technical director concentrated on color correcting the layers and adding effects. The materials rendered with Mental Ray had a different gamma than those rendered in LightWave. After Effects levels were used to match the color qualities of the renders. The bull's shadow layer was added by keying the non-shadow elements in the layer via a chroma-key and softened via a gaussian blur. The layer with the bulls was then given motion blur. The entire composition was nested into a second



Figure 5 Composite Frame

composition where camera motion could be added via the wiggler plug-in to simulate the weight of the bulls as they ran past the camera. The composition was output as an uncompressed QuickTime movie file at 720 pixels by 486 pixels at D1 aspect ratio lower field dominant. The composited animation was then output as MJPEG to BetaCam SP for delivery to the client. Figure 5 shows the composite of the layers shown in Table 1.

The successful completion of the test scene finalized the production pathway for the rest of the project. Through the completion of the scene, the team had derived a production methodology which each team member could use as a guiding reference for determining individual responsibilities. Not only had the team formed a procedural plan that dictated the order for the completion of the task by the team members, but they also generated a time schedule, that could be used to orchestrate the rest of the production (see Table 4). This made it possible for the team to use an assembly line approach in completing the project, and to accurately parcel out the time devoted to each task. Compensating for tasks that would not have to be replicated for each scene, such as writing the SIL application or building the bull model, the team estimated that it would take approximately five days to complete a single scene. The only unaccounted event was the final edit, because it could not be completed until all of the scenes had been composited.

Conclusion

By relying on multi-pass rendering, the HVS production team was able to exploit the best qualities offered by SoftImage and LightWave in the production of the Bulls animated opening. By concentrating on using the tools best for each task and then relying on compositing to integrate the results into a finished animation, the production team was able to bring the vision depicted on the storyboard to the screen.

The production model employed by the HVS production team identified two issues. First, the selection of the two 3D animation packages employed by the animators in this project had to be considered. The character animator selected SoftImage 3D Extreme. The architectural animator elected to use LightWave 3D. Choices were made not because of a limited budget or limited resources, but instead based on which software could best deliver organic form required of the character animator or inorganic elements needed by the architectural animator.

Second, the reliance on compositing and the implications for the production pipeline employed by the team must be considered. Each scene contains elements completed by all members of the team. Each scene has bulls completed by the character animator, street elements by the architectural animator, and effects composited by the technical director. This level of interdependence of scene elements necessitated an exact production pipeline. The 3D animators had to exchange camera positions before they could animate their scenes. The character animator needed DXF versions of the street elements produced by the architectural animator before shadow layers could be rendered. The technical director could not composite anything until all of the layers had been properly rendered. It was imperative that all production members follow the production model developed while producing the test scene. If any of the steps in the pipeline model were skipped or not followed in order by any of the production members, the scenes would not composite correctly.

As educators, we must provide our students with the skills to be successful in scenarios like the one encountered in the realization of this project.

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