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A 3D modeling methodology based on a concavity-aware geometric test to create 3D textured coarse models from concept art and orthographic projections

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ABSTRACT

Creating textured 3D meshes of objects for real-time applications can be a laborious, slow and expensive task, demanding specific, highly specialized human resources such as 2D and 3D artists. In this paper, we present a fully automatic 3D modeling methodology based on silhouette carving, capable of creating textured 3D meshes from three pieces of concept art. Our method takes a set of the target object concept art in different views as input and generates a coarse 3D mesh alongside a diffuse color map for texturing the model. The coarse mesh is intended to replace the initial primitive mesh used on the modeling technique known as Box Modeling to accelerate the whole 3D model production. Although, in current 3D model production pipeline there are some more sophisticated methods based on sculpting and retopology, Box Modeling is still a heavily adopted technique used for man-made objects that do not require organic modeling. Our experiments show that it speeds up the 3D content production time up to 40% by providing the coarse model automatically. Also, our method preserve the artist's trace and can create more accurate meshes compared to a similar approach, photoconsistency-based, and learning-based methods.

1. Introduction

Three-dimensional models are ubiquitous structures in a myriad of computer graphics applications. Generation of synthetic images, virtual scenarios, characters for games and movies, architectural modeling and scientific visualization are some popular examples. High-quality 3D meshes play a central role in achieving good results in both rendering and animating algorithms as they are the kernel of 3D graphical applications and they interact directly with an important sense: our sight.

The task of three-dimensional modeling is a hard and painstaking process that demands considerable effort even from a skilled 3D artist. Also, virtually all tools for 3D modeling have a steep learning curve, which reflects the cost of its utilization. In the game industry, most specifically AAA productions (blockbuster games with budget of millions of dollars), the artistic process is one of the most time consuming and expensive step in the entire production pipeline. The 3D content creation appears in the early stages of the game production, being demanded in prototypes and concept validation of graphics and gameplay. Thus, methodologies that facilitate the three-dimensional modeling task by speeding up the process and consequently decreasing its cost are a valuable tool that has a strong appeal in several industries, such as game industry, retail, industrial design and films.

The production of a 3D model asset has 2 main steps: (i) it starts with the creation of pieces of concept art, which is a 2D illustration to convey information of a visual structure such as characters, and scenario props. Typically, a 2D artist tries different designs by illustrating the object to finally deliver a set of concept art as blueprint — a technical illustration that depicts a target object in canonical viewpoints (front, side, and top) in an orthogonal perspective — to a 3D artist; (ii) the set of concept art is used by a 3D artist to create the final 3D model. The task of three-dimensional modeling from 2D drawings is a hard and painstaking process that demands considerable effort and time even from a skilled 3D artist.

Motivated by the game industry high demand of art content and the lack of smart and automatic solutions for 3D mesh and texture generation that do not change the artistic pipeline, we intend to reduce the cost of the 3D content creation for entertainment purposes by increasing its production speed. We propose a methodology capable of generating a 3D mesh to be used as a head start for 3D artists in the early stage of the modeling process. We place our work as a gathering of the best of multi-view

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reconstruction and sketch-based modeling approaches. Thus, methodologies that facilitate the three-dimensional modeling task by speeding up the process and consequently decreasing its cost are a valuable tool that has a strong appeal in several industries, such as game industry, industrial design, and films.

Our approach is based on the box modeling technique, which is a heavily adopted approach within Digital Games industry. Even though there are some more robust approaches for organic 3D modeling, Box Modeling is a paradigm stands as a useful technique for modeling human-made objects. The most common modeling techniques within film and digital games industries are Box Modeling, Cage Modeling, Edge/Contour Modeling, NURBS/Spline Modeling and Digital Sculpting. In the Box Modeling technique, the artist starts from a 3D geometric primitives (cube, sphere, cylinder, etc.) and, with refinement stages, edits this primitive until the 3D geometry presents the desired shape. The edition is achieved by operations of sub-diving, extrusion, and smooth.

In the Cage Modeling technique, the artist creates a cage out of curves that will form the object geometry, and then it is created a surface out of these curves. In the Edge/Contour Modeling the 3D geometry is achieved by building the model piece by piece of the loop of polygonal faces along prominent contours and filling gaps among these loops. NURBS in contrast to all aforementioned techniques does not represent the object surface using faces, edges, and vertices. Instead, NURBS curves are created with tools that work very similar to Spline editors (having 3D points that form the curve and handling anchors to define their curvature). In Digital Sculpting the 3D geometry is created organically. By mimicking real-life sculpting, the artist has their geometry that acts as a piece of clay and many brush options to modify their model to convey the object shape. Notice that despite our method being inspired by the box modeling technique, the generated coarse model created by our methodology can be used as a basis for sculping techniques.

Over the last few decades, several systems and methodologies have been developed for automating the creation of detailed 3D models. Multi-view reconstruction and sketch-based modeling are the most representative approaches of this automation effort. The multi-view approaches have shown impressive results by using digital images of scenes and objects; however, it has to tackle the issues related to digital image processing such as noise and camera parameter estimation. Sketch-based modeling, on the other hand, has gained the attention of the industry since these techniques may fit perfectly in the current artistic workflow; on the flip side, it demands changes in the production pipeline due to the new tool addition. This may not be desirable and is the major drawback of most of sketch-based modeling approaches.

In order to be akin to the artistic creation pipeline, our methodology requires the blueprint set (three pieces of concept art from well-defined viewpoints: front, side and top, the canonical viewpoints used in the modeling process) as input. Although one can argue that adding more viewpoints could aid to solve any ambiguity issue, one of our main motivations is not to increase the already heavy content creation workflow. We accomplish that by mimicking the artistic creation pipeline. The concept art must be drawn in orthogonal projection, just as artists usually do. Thus, we place our work as a gathering of the best of multi-view and sketch-based approaches. Multi-view reconstruction is used as we perform a 3D mesh construction using three 2D images and sketch-based modeling is used as we use synthetic images rather than photographies.

Furthermore, our methodology can handle self-occlusion, which is hard to model due to the restricted number of views, and create a texture map that is applied to the final mesh, providing color to its surface. We estimate the texture map based on the color information within the input concept art. Fig. 1 presents an overview of our methodology.

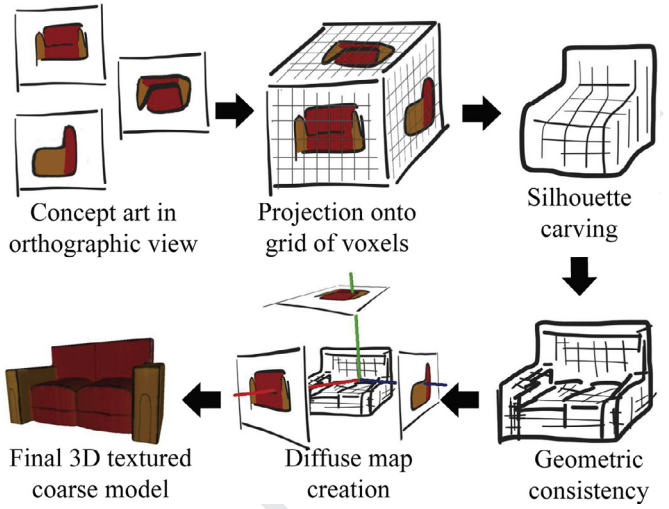

Fig. 1. The overview of our method. By using as input three pieces of concept art of front, side and top view viewpoints of an object, it starts with a grid of voxels projecting the drawings onto the grid, performing a silhouette carving. Then, it applies the geometric consistency check to model concave parts and generates a texture color map based on the concept art.

Our experiments show that the proposed methodology is capable of generating models that provide a significant head start to the artistic pipeline. We demonstrated that an artist could start from the generated model and reach the final model faster, saving on average 31% of the model production time. Our main contributions are as follow:

- a fully automatic methodology for creating 3D meshes from three pieces of concept art based on silhouette carving methodology;
- a consistency check to overcome the ambiguity problem presented in the regular silhouette carving;
- an approach to extract and build a color texture map based on colors within the concept art.

The most encouraging result of this paper is, by the use of the new consistency check combined with a texture generation procedure, the final textured 3D model for use as a head-start in 3D content creation for entertainment purpose. Our methodology for 3D modeling outperforms both carving-based and photo-consistency-based method, which are not able to model concave regions or work properly with textureless images respectively. Moreover, the whole methodology (3D modeling and the texture color map generation) is a full application that considers the 3D artist work pipeline, for instance, the viewpoints used and how the artist work in the workflow.

2. Related work

State of the art for three-dimensional modeling and reconstruction problems can be roughly divided into the multi-view reconstruction methods and sketch-based systems. The most representative advances of the former category are in computer vision field, and they use digital images and are strongly dependent on texture regions. The sketch-based systems, which are more related to ours, in general, provide different interactive tools to help in the task of modeling and, therefore, forces the artist to change and adapt its workflow.

The computer vision community has witnessed a large body of proposed approaches of 3D model creation from digital images and based on volumetric description [1–4], shape-from-stereo [5], shape-from-motion [6], reconstruction from

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