Artistic 3D Sculpture Composition

ABEER ALSAIARI
University of Illinois At Chicago
851 S. Morgan
Chicago, IL, USA
aalsai3@uic.edu

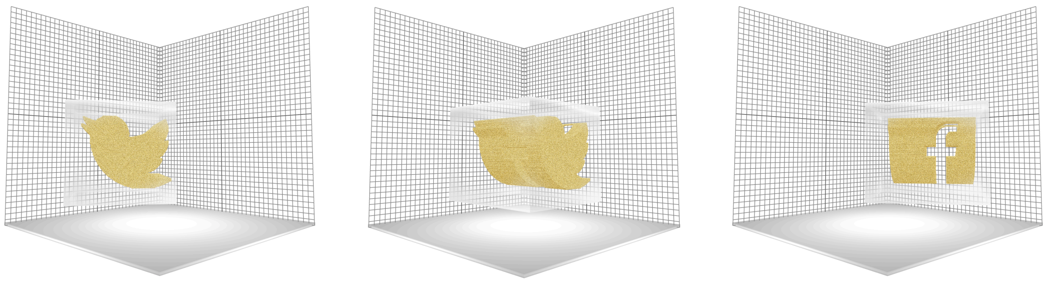

Figure 1. 3D volume that exhibits two distinct projections when viewed from orthogonal view points

ABSTRACT

A sculpture is one of the oldest forms of art than painting. Some Artists in the 20th century presented sculptures as Illusionistic work. For instance, the artist and the graphic designer Shigeo Fukuda applied his visual wit and allusion to a series of his work. Inspired by his work, we introduce in this paper an implementation of sculpture composition from a source of two images. Our composed sculptures project the two images when viewed from orthogonal viewpoints. We created multiple sculptures to demonstrate that our algorithm can create a variety of 3D sculpture from different binary images. We provided an evaluation of our current implementation and discussed the limitations and future work.

Author Keywords

Computational Aesthetic, 3D sculpture.

INTRODUCTION

Recently, shadow artists and sculptors Shigeo Fukuda, Tim Noble and Sue Webster have created random 3D collages from the assembly of everyday objects. The fascinating aspect about these 3D sculptures is that the shadows cast by them form the illusion of a recognizable scene, even as the ensemble itself doesn't resemble anything recognizable. They also presented a variation of this theme, where two or three distinct silhouettes viewed from orthogonal viewpoints are formed from the 3D ensemble.

Shigeo Fukuda, the Japanese artist, is the most creative and versatile among illusion artists. His stunning artistic compositions are world renown and displayed everywhere, in particular his native Japan where he has also authored three Japanese books on illusion. His two- and three-dimensional illusionistic art appear in an array of categories, from ambiguous sculptures and impossible objects, to anamorphic art and distorted project. An example of one such visually compelling piece of art he created was the construction of a bizarre piano using an Ames Projection, where the lines of the piano coincide with the lines of sight of a real piano. The reflection of the physical model looks perfectly normal when seen from one special angle. Another work which Fukuda is known for is his "Disappearing Column", a physical model of the famous impossible trident which it was believed could not be made as a physical three dimensional model, yet Fukuda made the impossible possible, although it works from only one angle. Yet another work of illusion he creased was a three-dimensional sculpture which alters from a pianist to a violinist as you move around.

In this paper, we introduced an algorithm for 3D sculpture composition. We implemented our algorithm to create a sculpture that can project two distinct images from different orthogonal viewpoints. Our current version works for two images projections, which we aim to extend to three projections. Our algorithm reads the data of two binary images and creates a corresponding 3D sculpture that can project one image at each specified viewing point by computing the intersection of the two images.

This paper is organized as follows. First, we discuss some related work. Then, our methodology is presented. Results are discussed in the following section. Next, we present an evaluation of our algorithm. Finally, we provide our future work and conclude the paper.

RELATED WORK

This work draws its inspiration from artists like Noble, Webster, and Fukuda, 3D shadow artists who also inspired other artists in their method of using illusion to assemble 3D sculptures.

For instance, Gal and colleagues [1] devised an interactive algorithm to design a 3D collage which is composed of a collocation of common geometric shapes. Their art is influenced by the surrealist work of Giuseppe Arcimboldo (1527-1593). The geometric shapes or elements are stored in a database, and the algorithm performs a partial matching by finding elements in the database which fit the points on the surfaces of the target shapes and their surroundings very well. The process steps are: first, the elements are selected by the user from existing online databases; second, the parts and target shape are pre-processed; the algorithm is applied and computes possible matches for the sample points on the target surface.

The method of Mitra and Pauly [5] is to allow the user to specify the desired shadow art, provide their own set of images, then use computational tools to construct shadow arts that cast from 3D sculptures. The Silhouettes of Jazz [3], an animated short movie depicting the history of traditional jazz music in a virtual tour of a shadow art museum, utilized the method of shadow art creation presented in [5].

In Sela and Elber's [6] non-realistic modeling based on B-splines surfaces, the user is prompted to load two 3D models. One model is used to extract a silhouette, the other is deformed so that its silhouette is used to match the silhouette that was extracted. The final result is a visually irregular 3D object that resembles two different objects when viewed from orthogonal locations. Although they presented a 3D object that resembles two different objects, they discussed that in some cases the results are not exactly match the original models.

Galyean and Hughes in [2] introduced an interactive modeling tool that is controlled by a 3D input device to sculpt a solid material represented by voxel data. In their technique they provided several tools to cut away or to add in materials. The tools work by modifying the values in the voxel array.

METHODOLOGY

Creating a 3D volume from a source of several images is similar to the construction of the visual hull introduced originally by Laurentini [4] to reconstruct 3D from silhouettes. The visual hull is defined as the intersection volume of a set of cones. These generalized cones are constructed from silhouette images with regard to corresponding camera locations. Laurentini defined the visual hull VH (S, R) of an object S on a viewing region R as the maximal object that is silhouette-equivalent to S (see Figure 2). Sinha and Pollefeys [7] also reconstructed a closed continuous surface of an object from multiple images and silhouettes.

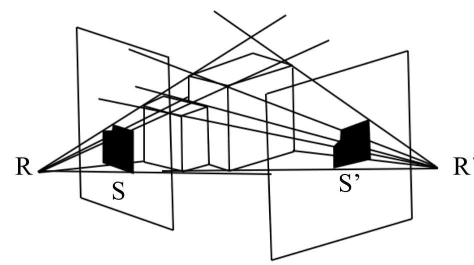

Figure 2. Volume intersection

In our implementation, we read the data of two binary images i.e. M1 and M2. The algorithm discards white spaces since our interest is to project a shape corresponds to the colored parts in the image. One limitation of the algorithm is that the two images have to be of the same dimension to ensure that there are no clipped out parts of the target image.

As shown in Figure 4, the algorithm reads the pixel data from the two input images. All data are stored by assuming that the first image lays on the X-axis while the second image lays on the Y-axis. This layout assumption facilitates the ability to compute the intersection of the two images. Each iteration reads one-pixel data from the first image and the corresponding pixel data from the second image. If the two pixels are parts from the target objects in the two images, a corresponding point is created in the 3D space at the position (x, y, z).

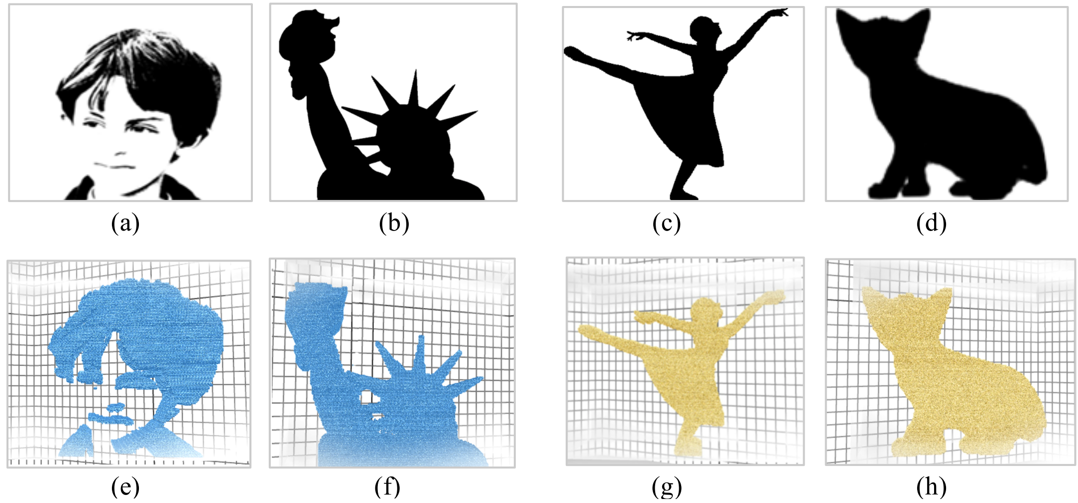

Figure 3. 3D volumes that exhibit two distinct projections when viewed from orthogonal view points

Algorithm 1

Input: M1, M2
Output: 3D volume

```
ImageData1 ← read M1 data
ImageData2 ← read M2 data
Width ← M1 or M2 width
Height ← M1 or M2 height
Geometry ← New 3D Geometry
BEGIN
For x = 0 to x = Width do
    For x = 0 to y = height do
        For x = 0 to z = Width do
            Pixel1 ← ImageData1[x][y]
            Pixel2 ← ImageData2[x][z]
            If Pixel1 & Pixel2 != white
                Point ← NewPointMesh
                Geometry = Geometry + Point
            End if
        End for
    End for
End for
END
```

Figure 4. Computing 3D sculpture from two input images.

As we can see from figure 2, there is an imaginary cone cast from each image and the algorithm above iteratively creates geometry that fills the intersection of the two cones.

RESULTS

We have created some different 3D sculptures that project two distinct images. The results showed that our tool could compute sculpture even for images of the object with the non-continuous shape as shown in Figure 3(e). However, more challenging images with sharp details are not promising as we can see in Figure 3(f) because the sharp edges allow the depth from the back to contribute slightly in the projection composition.

An optimization step would solve this problem by eliminating unnecessary voxels that might be removed without affecting the created sculpture. Since our algorithm creates the exact volumetric intersection of the two cones of images, several unnecessary voxels contribute to the final composition of the sculpture. Optimizing our sculpture by editing voxels would increase precision and efficiency, which we keep for future work.

EVALUATION

Our algorithm can successfully create a corresponding 3D sculpture for two binary images as shown in Figure 3(e-h). However, the current implementation has some limitations as we're going to discuss in the following. First, the algorithm discards any white spaces (pixels) so for any binary or colored image it's going to create a projection for the colored pixels only and the resulted sculpture is also one solid color. That limits our algorithm in handling colored images in its current version. Second, the two input images have to be of the same dimensions to ensure that there are no clipped out parts from the final results. Also, a 150x150 pixels dimension is preferred. The current version creates a complete volumetric sculpture, and the process runs on the CPU. Therefore, a higher image dimension means a more processing.

FUTURE WORK

We aim to improve the algorithm by extending it to handle the following. First, we're working on the third projection from the top of the sculpture. That's could be done by making the cone of the third image cast from the top. Second, we aim to extend for colored images, so a colored voxel matches in color a corresponding pixel from the image. However, in this case, an object extraction technique might be required so we can extract the target object from the image.

The last improvement is essential for performance efficiency. We aim to transfer the whole process of sculpture composition to run on the GPU by passing the image data to it.

CONCLUSION

In this paper, we presented our implementation of an artistic work. We presented a computational version of 3D sculpture creation adopted by many artists that exhibit different projections from different viewing points. Our algorithm creates a compound 3D model of target shape from data taken from a given input images. We devise our algorithm to finds the intersection of pixel data of the two images. That is defined by the intersection of the two imaginary cones casting from the two images. We discussed the limitations of our current algorithm and provided suggestions for improvement and future work.

REFERENCES

1. Gal R, Sorkine O, Popa T, Sheffer A, Cohen-Or D. 2007. 3D collage: expressive non-realistic modeling. *InProceedings of the 5th international symposium on Non-photorealistic animation and rendering*. 7-14.
2. Galyean TA, Hughes JF. 1991. Sculpting: An interactive volumetric modeling technique. *In ACM SIGGRAPH Computer Graphics*. 267-274.
3. Käser D. 2009. Silhouettes of jazz. *In ACM SIGGRAPH 2009 Computer Animation Fesitval*.. 132-132).
4. Laurentini A. 1994. The visual hull concept for silhouette-based image understanding. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*. 150-62
5. Mitra NJ, Pauly M. 2009. Shadow art. *In ACM Transactions on Graphics*.156-1.
6. Sela G, Elber G. 2007. Generation of view dependent models using free form deformation. *The Visual Computer*.219-29.
7. Sinha SN, Pollefeys M. 2005. Multi-view reconstruction using photo-consistency and exact silhouette constraints: A maximum-flow formulation. *In Computer Vision, 2005. ICCV 2005. Tenth IEEE International Conference on 2005*. 349-356).