Multi-View 2D Image-Based 3D Modeling of Objects: Mid-Semester Progress Report

Project Number 18 — Group Number
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***Abstract*—This report presents the mid-semester progress of our project on multi-view 2D image-based 3D modeling of objects. We have completed the extraction of object silhouettes from BMP images and constructed a voxel-based 3D representation. The voxel grid serves as a foundation for future steps including visual hull carving and mesh generation. This report details the methods implemented, preliminary results, and insights gained.**

***Index Terms*—3D reconstruction, silhouette, voxel grid, visual hull, computer vision**

I. Introduction

3D reconstruction from multiple 2D images is a fundamental problem in computer vision and graphics. Silhouettes are binary images representing the outer contour of an object, essential for visual hull construction. Voxel grids discretize 3D space, allowing volumetric representation of objects. Our project aims to reconstruct 3D objects using multiple views of 2D images captured from a turntable setup.

So far, we have completed:

- Extraction of object silhouettes from BMP images.
- Construction and visualization of voxel grids representing 3D space.

II. Methodology

A. Silhouette Extraction

The first step in 3D reconstruction is to isolate the object from the background in each image.

1) Region of Interest (ROI) Selection: ROI selection reduces computational load and improves silhouette quality. We used OpenCV's `cv2.selectROI` to interactively select the object in the first image, then applied the coordinates to crop all images.

2) Grayscale Conversion and Thresholding: BMP images are converted to grayscale (if not) using PIL, and a threshold is applied to obtain a binary silhouette:

$$\text{binarized} = \begin{cases} 1, & \text{if pixel intensity} < 128 \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

3) Hole Filling: Binary silhouettes may contain small gaps due to noise. We applied `scipy.ndimage.binary_fill_holes` to fill these gaps, producing clean silhouettes.

4) Storage of Silhouettes: Processed silhouettes are stored as PNG images for future 3D reconstruction.

B. Voxel Grid Creation

Voxel grids discretize 3D space into small cubes (voxels). We implemented a uniform cubic grid using `numpy.meshgrid` and visualized the sampled points in 3D using Matplotlib.

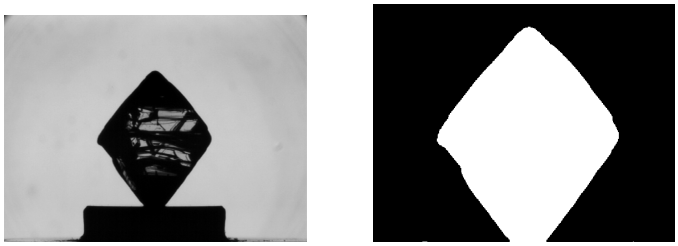
Algorithm Overview:

1) Define a normalized 3D space from -1 to 1 along X, Y, Z axes.
2) Sample the space at regular intervals to form a 3D grid.
3) Visualize a subset of voxels using 3D scatter plots to inspect structure.

III. Results

A. Silhouette Extraction

Figure 1 shows a comparison of the original BMP image and the extracted silhouette.



(a) Original BMP Image (b) Extracted Silhouette

Fig. 1: Comparison between original image and silhouette.

B. Voxel Grid Visualization

Figure 2 shows a visualization of the 3D voxel grid generated from sampled points. The grid forms a cubic volume, ready for future carving based on silhouettes.

IV. Discussion

- Silhouettes simplify the 3D reconstruction problem by providing clear object boundaries, eliminating background and texture complexities.
- Voxel grids discretize space, making subsequent visual hull carving feasible.
- Sampling resolution of the voxel grid balances memory usage with spatial detail.

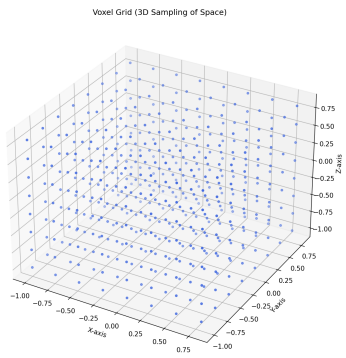


Fig. 2: Visualization of voxel grid points in 3D space.

V. Conclusion

The mid-semester progress of the project includes:

- Successful extraction and storage of silhouettes from BMP images.
- Construction and visualization of a 3D voxel grid representing the object space.
- Establishing a foundation for visual hull carving and mesh generation in the next phase.

VI. References

References

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