CIS 5810 Project Proposal

Ojas Mandlecha, Dheeraj Bhurewar, Rajnish Gupta, Dhruv Gupta

November 5, 2022

Title: 3D Object Reconstruction From Multi-View Images/Videos.

1 Project Summary

The project would aim to obtain a 3D model render from a video/set of images, stitched together and projected on 3D meshgrid to get a scaled version of the real objects. We will be using photogrammetry or videogrammetry (which essentially uses different frames from a video as a collection of images to process the information from it) and create a 3D render of the objects in the given images. The data for this project will be independently sourced, most-likely through a set up that we will create.

2 Goals and Objectives

Photogrammetry plays an important role in creating model that can allow us to place real-world objects in a virtual environment. Through our process, we should be able to obtain a 3D model of any reasonably-sized object, by taking multiple images of it from various perspectives. The same pipeline can possibly also be applied to creating a 3D model of an unknown object using image sequences and camera-tracking data.

3 Proposed Approach

1. Image Capture and Calibration - A sequence of images, or frames in a video, need to be captured from strategic points around the object. Every surface should be imaged with at least two shots and with some degree of overlap between them to match features efficiently. SIFT and Homography estimation (with RANSAC) would play an important role in this part of the process. Auto-calibrating the camera is also required and this can be done through something called Kruppa's Equation.

2. Structure From Motion (SfM) and Dense Reconstruction - Using the common features between images of a certain surface, we should be able to obtain the 3D structure and a rough mesh. This will employ depth maps and image registration. A reconstruction algorithm, PMVS (Patch-Based Multi-View Stereo), is used to improve the result of the SFM output and generate a 3D point cloud.

3. 3D Model Construction - The final mesh can be created using the 3D points obtained and the texture of the object has to be mapped to the 3D model using image transformations. Finally, changes can be made to correct for errors in the pipeline.

4 Related Work

1. 3D Reconstruction of Space Objects from Multi-Views by a Visible Sensor - Recovers the 3D structure of Satellites and similar space-objects from images taken from multiple view points.

2. Python Photogrammetry Toolbox - An open-access archive providing Python tools to do Photgrammetry.

3. Photo4D - An open-source package to conduct photgrammetry with a timelapse of images

4. Texture Mapping 3D Models of Real-World Scenes - Working on perspective transforms to effectively map a 2D texture to a 3D model/object.

5 Timeline

- 1 week
  - Devise a data-acquisition technique to be able to effectively gather images of an object from various perspectives.
- 2-3 weeks
  - Work on finding correspondence points for features of the object images, and stitching them together.
  - Create the pipeline to generate the initial mesh from the image data.
- 4-5 weeks
  - Use the PMVS algorithm to obtain a dense point cloud and have a decent model generated.
  - Work on the texture mapping to the model.

6 Duties

- Ojas:
  - Work on the image-capture framework.
  - Texture mapping from the 2D images to the 3D model.
- Dheeraj:
  - Correspondence between the multi-view images and homography estimation.
  - Use structure from motion to work on finding the rough 3D structure.
- Rajnish:
  - Work on the image-capture framework.
  - Use PMVS to fine-tune the results and create a refined 3D mesh.
- Dhruv:
  - Work on auto-calibration for the camera.
  - Bring the 3D mesh and the texture together and clean up any errors introduced during the pipeline.