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Comp 471 / Cart 498: Final Project Proposal

Work Presented to Dr. Sha Xin Wei

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Taste of Reality

A Project on 3D Mapping

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1 Introduction

1.1 Team Members

Pierre-Luc Bertrand	5330211
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Justin Mereb	4885368
Eric Zaino	4936957

1.2 Roles

Concept Lead: *Pierre-Luc*
Programming: *Justin, Eric, Ramzy*
Maths: *Pierre-Luc, Eric*
Set Construction: *Entire Group*
Storyline, applications: *Justin, Ramzy*

1.3 Purpose

The purpose of our project is to represent simple geometric shapes in the real world in a three dimension model on the computer using OpenGL.

1.4 Assumption

Due to the limitation of time, the simple geometric shapes will be cubes and if time permits, more complicated shapes. These do not include circular shape since we will not be using gradient contour analysis. If we would be using gradient contour analysis, the complexity would be too high and the scope of this project would not be respected.

1.5 Scenario

The main scenario of this system is that the user will be filming with two attached cameras to form a stereo pair a geometric shape. The user will turn around the geometric shape to get the complete set of corners of this geometric shape. The system will construct and show in real-time a 3D representation of this geometric shape.

1.6 Material Required

- Two cameras (iSight)
- Assortment of angular objects
- Computer with two firewire ports
- Max Jitter
- OpenGL
- C++ in XCode programming environment

1.7 Milestone

- Understanding the Math: 1 week
- Coding (Jitter and OpenGL): 2-3 weeks
- Testing/Debugging: 1 week
- Documentation: throughout the project

1.8 Deliverable

- Max patch and the C++ code
- Working patch (compiled code included in the patch)
- Input video example
- Output video of this example

2 System Breakdown

2.1 Cameras Input

The two inputs of the cameras will be stored in a pair of image since they are forming a stereo image. A stereo image is used to reconstruct from 2D a 3D representation.

2.2 Edge Detection

In order for the system to have an idea of the input objects, the images need to have a contour tracing utility. We will be using `jit.robcross` to get these contours.

2.3 Corner Detection

Once we have the contour traced, the system will analyze these contours and find the corners of the shapes. To do so, each line will be represented by a linear function and simple algebra will be used to find intersecting points.

The output of this function will be a set of coordinates for the corner with a name assigned to them and another set of corner name pair. The pairs are used to tell which corner is connected to which other corner.

2.4 Motion Detection

The camera will be moving around the object to acquire all the data needed to map all the corners of the geometric shapes. In order to not duplicate the corners, the motion detection module will identify the corners previously mapped.

2.5 Relative Camera Location

The first stereo pair will set the world reference frame. The corners' location will be measured from this reference frame. Once the camera is moving, camera frame reference will not be the same and so will the corners' coordinates. These new corner coordinates will be from the camera. The system will have to do a conversion from the camera reference frame to the world reference frame. In order to do so, the previously calculated points will be compared with their new coordinates and the transformation function will be applied to convert the coordinates of the newly acquired corners.

2.6 Calibration

A camera has internal parameters that have to be calculated. With a minimum of three displacements, we can obtain the internal parameters of the camera using a system of polynomial equations due to Kruppa.

By keeping these internal parameters constant, we will be able to measure the distance of the points in the real world.

2.7 Reconstruction Algorithm

We will be using the uncalibrated Euclidean Reconstruction described in the paper “Uncalibrated Euclidean Reconstruction” by Andrea Fusiello from the “Dipartimento Scientifico e Tecnologico, Università di Verona” written on March 14, 2000. It is based on the Euclidean Reconstruction. This paper describes a function to calculate the location of the corners on the image. We will implement this algorithm.

The function will have as input one pair of point coming from the stereo image. The output of this function will be a 3D coordinate of this point. The function will process every corner.

2.8 Three Dimensional Representation

We will be using OpenGL to represent corners' location. The input will be the corners' coordinates and the output will be a 3D representation of the real world.

2.9 Live OpenGL Camera Location

The system will calculate the location of the camera in the OpenGL world by taking previously calculated points as references and calculate the camera location by triangulation.

3 Diagrams and Pictures

3.1 Example of a Village Analysis

Here is a shot of a village and a 3D reconstruction of this village.



3.2 Storyboard

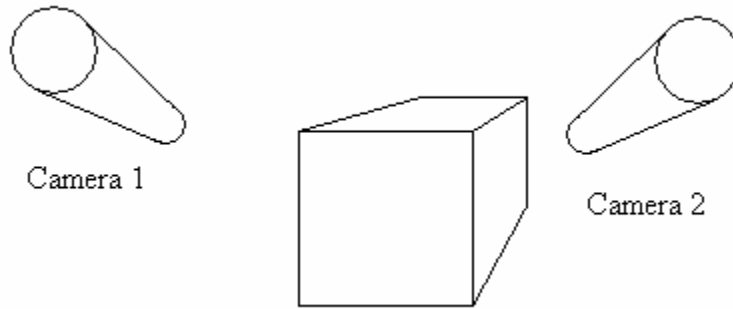


Figure 1: Two cameras filming the cube in the real world

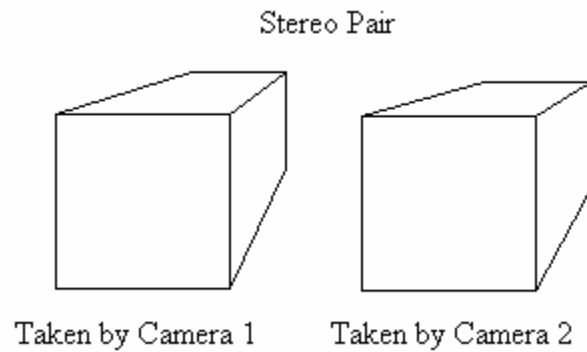


Figure 2: Stereo pair took from the two cameras

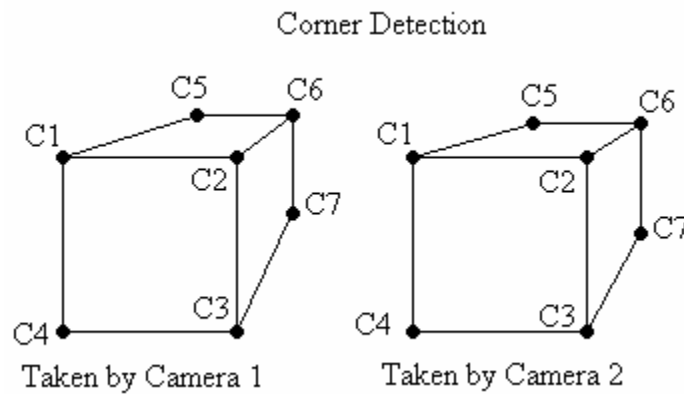


Figure 3: Edge detection result. Note that each corner is identified and mapped on both picture.

Math Calculation for Uncalibrated Euclidean Reconstruction

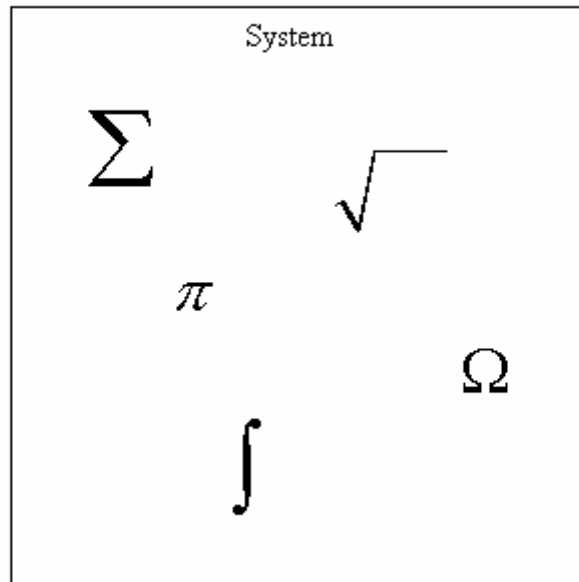


Figure 4: Math Calculation for mapping the 2D coordinates to the 3D coordinates

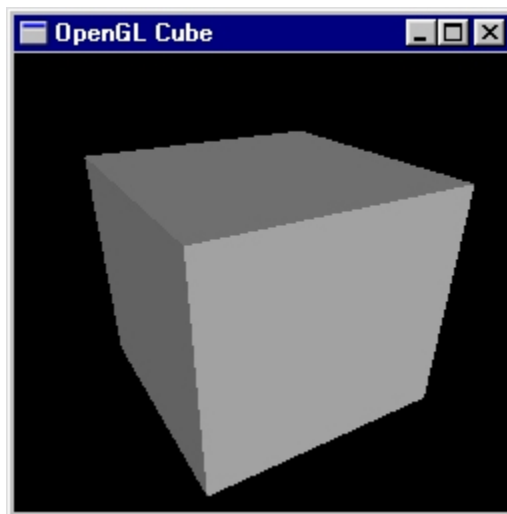


Figure 5: OpenGL representation of the object

4 Applications

There are several fields in which this type of mapping software is useful:

4.1 Medical

Internal organs of a patient can be mapped and magnified several times to aid a doctor in examination or surgery. A doctor can map a patient's heart, shown in figure 1 below, and then examine the 3d model on his computer screen to check for problems. Similarly the entire organ system of a patient can be mapped, as shown in figure 2.

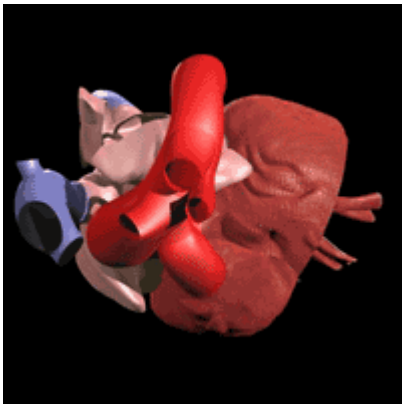


Figure 1: Human Heart

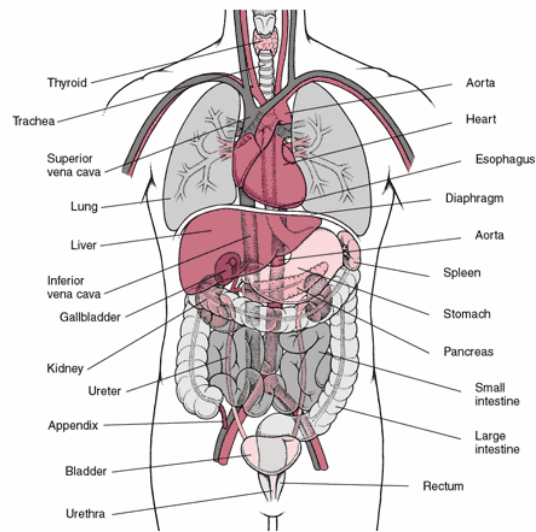


Figure 2: Organ system

ii) Mapping: An entire city landscape can be mapped, shown in figure 3 below. A more military approach can be taken; robotic agents can enter an area and send its camera/mapping footage back to base, where human personnel will determine if it is safe to enter the area.



Figure 3: Mapped city

4.2 Wonders

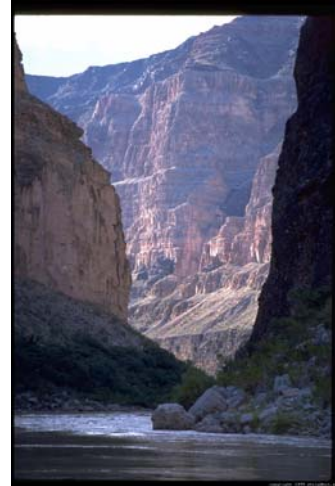
Wonders both Natural and man made, can be captured and reproduced in any number of applications: Update libraries, teach in a classroom setting, preserve natural wonder before it disappears, reproduce image on a 3d scale.



Eiffel tower



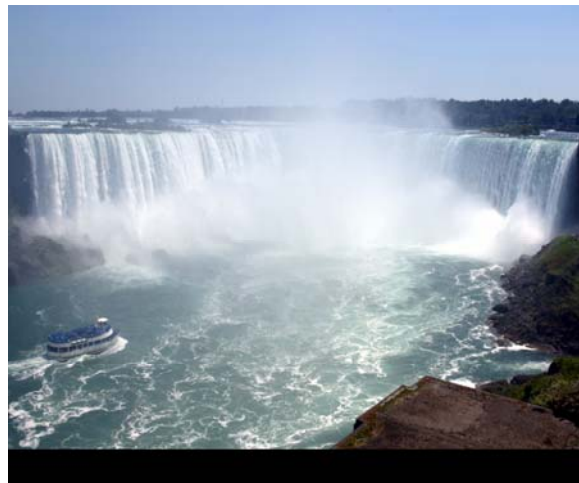
Leaning tower of Pisa



Grand Canyon



Times Square



Niagara Falls



Egyptian Pyramids

5 Discussion

5.1 What is the technical interest?

The technical interest of this project is mapping two projection of an object into a set of 3D coordinates. We will be using the Uncalibrated Euclidean Reconstruction algorithm to reproduce this object in OpenGL.

The corner detection module will have to find the two points corresponding to the same corner and follow it when there is movement.

5.2 How does it engage the human perception in live interaction?

This project will not be interactive in the traditional sense. The output will be a display of the objects we have mapped. However, the applications will engage the human perception in the following ways:

-Restaurant appeal: Computer screen menu that displays the actual images of the items on the menu, helping the customer in deciding what to order.

-Medical examination: During a surgery, the organ can be mapped in 3D for a better feel of what the doctor is doing.

Several more applications are shown in the Applications section below.

5.3 What is the project asking or exploring?

This project will be exploring tracking motion of corners, OpenGL construction and some strong mathematics for retrieving coordinates.

6 Challenges

One of the biggest challenges will be to apply the mathematics of the Uncalibrated Euclidean Reconstruction. The prerequisite for this algorithm is that we find the intrinsic camera parameter and keep them constant.

Another good challenge will be to incorporate C++ code to this project. This is the most important thing since we will be developing our own functions such as the corner detection algorithm. As for the Uncalibrated Euclidean Reconstruction, they are matrix operations. We can do these calculations in jitter.

7 References

Uncalibrated Euclidean Reconstruction by Andrea Fusiello

http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/FUSIELLO3/review_cv01.html