3D Reconstruction Using Time of Flight Sensors

Project Plan

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1. Problem Statement

Currently there is a disconnect between the expectations and results of plastic surgeon clients. This project aims to simulate various procedures that can be performed on a patient through 3D reconstruction with time-of-flight sensor data and advanced 3D morphing algorithms. Using data acquisition with a Kinect v2, depth and color data of a patient will be acquired and analyzed to create a 3D model that can then be quickly and easily displayed and modified by the surgeon for consultation purposes.

2. Process Details

Our development approach consists of 3 main phases that were specified by VirtuSense Technologies. Whether the third phase of the project is to be implemented is dependant on whether the first and second phase will be completed faster than expected.

2.1 Phase One

In phase 1, an initial application will be developed that generates a 3D model of a face using using Kinect v2 (2nd generation) time-of-flight sensor data. This model will be smoothed, cleaned and converted to a surface-rendered mesh that is easier to manipulate.

2.2 Phase Two

In phase 2, a UI will be developed to select particular area on the face. This UI will be developed either in OpenGL or other a other high level tools, such as Blender.

2.3 Phase Three (Optional)

In phase 3, the application will be extended to create and manipulate a 3D reconstruction of of the whole body. The sensor data will be obtained from multiple Kinects placed in fixed predetermined locations.

3. Deliverables

Phase One

- Conversion of 3D model to 3D mesh of face using time-of-flight sensor data
- Merging of multiple meshes
- Smoothing algorithm for 3D mesh
- Texture overlay on 3D model
- UI for capturing sensor data and generating 3D model

Phase 2

- Algorithms for 3D morphing on selected regions on the face
- UI for selecting individual regions on a 3D model
- UI for manipulating 3D models

Phase 3 (Stretch Goal)

- Geometry Calculations for locating sensors for whole body capture
- Algorithms for 3D morphing on selected regions on the whole body

4. Specifications

This application will only work on a Windows 8 computer with Kinect v2 hardware.

5. System Requirements

5.1 Project Requirements

A 3D mask is first captured using a Microsoft Kinect for Windows and the Kinect Development. The 3D mask must be converted to a 3D mesh, and create an accurate representation of a person's face. Colors, using a texture map, need to be applied to the 3D mesh. This all needs to happen before any user gets access to the data.

The data is imported into a user interface, developed using open-source software Blender. This UI allows the user to modify the 3D model previously created using the Kinect. Other tools are available, but Blender is the optimal solution to create a user interface. Blender must then be simplified to allow the user access to a small number of tools. The tools need to be able to manipulate the 3D model, but maintain the texture map and stay true to the person's face. Morphing algorithms need to be developed to make sure all this happens.

5.2 Assessment of Proposed Solution

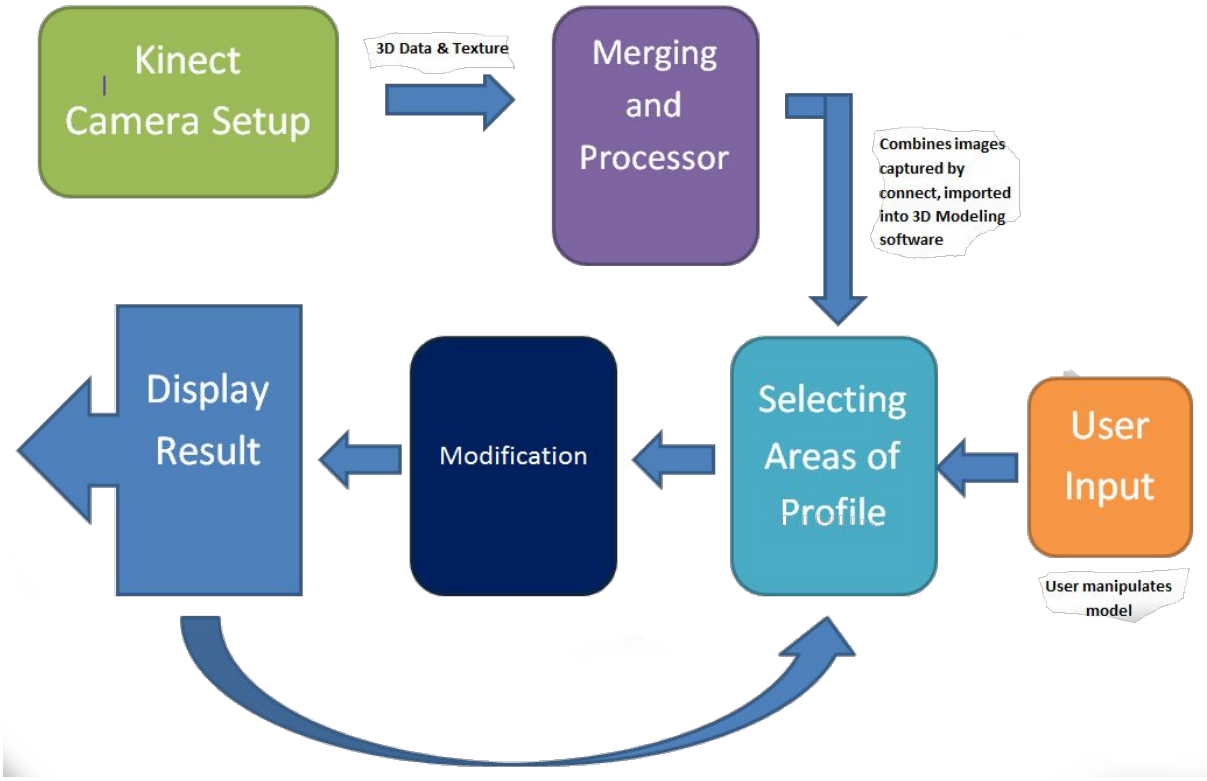
Importing any data from the Kinect to Blender is a process that has been done before. The first part of the project's requirements has a lot of outside and open source resources that can be applied and used to strengthen the ideas of this plan.
Using Blender to create a specific user interface for the needs of the project has less strategic integrity. The overall skill level and experience with programming associated with 3D rendering of the group is low, so any potential strategy has a chance of failure due to inexperience.

5.4 Validation and Acceptance Test

All user-end tests will be performed on Windows 8/8.1. UI design will be tested for clarity and ease of use; this will be tested by users outside of the project scope. Each programming milestone will be tested and examined by the client. By the team, the code will undergo extensive unit testing.

6. Interface/system Description

Process Flow Chart



6.1 Functional Requirements

A. Create 3D model by the use of the Kinect that will collect depth data and overlaying light on objects
    a. import mesh into Blender to manipulate the data through the UI
B. 3D reconstruction for post-plastic surgery.
    a. Smoothing textures and morphing 3D models by the use of algorithms and force fields
    b. Edit meshes to produce desired shape of the model
C. User can rotate, expand and edit model through interface design tools
D. Python plugin is compatible with Blender
E. User can view original model on separate screen after modifying it

6.2 Non-functional Requirements

UI Design

A. After picture is captured, model renders to Blender in less than 20 seconds
B. Size of rendered model before editing is less than 50 MB
C. Commercially licensable
D. Software has no network requirements

6.3 Test Plan

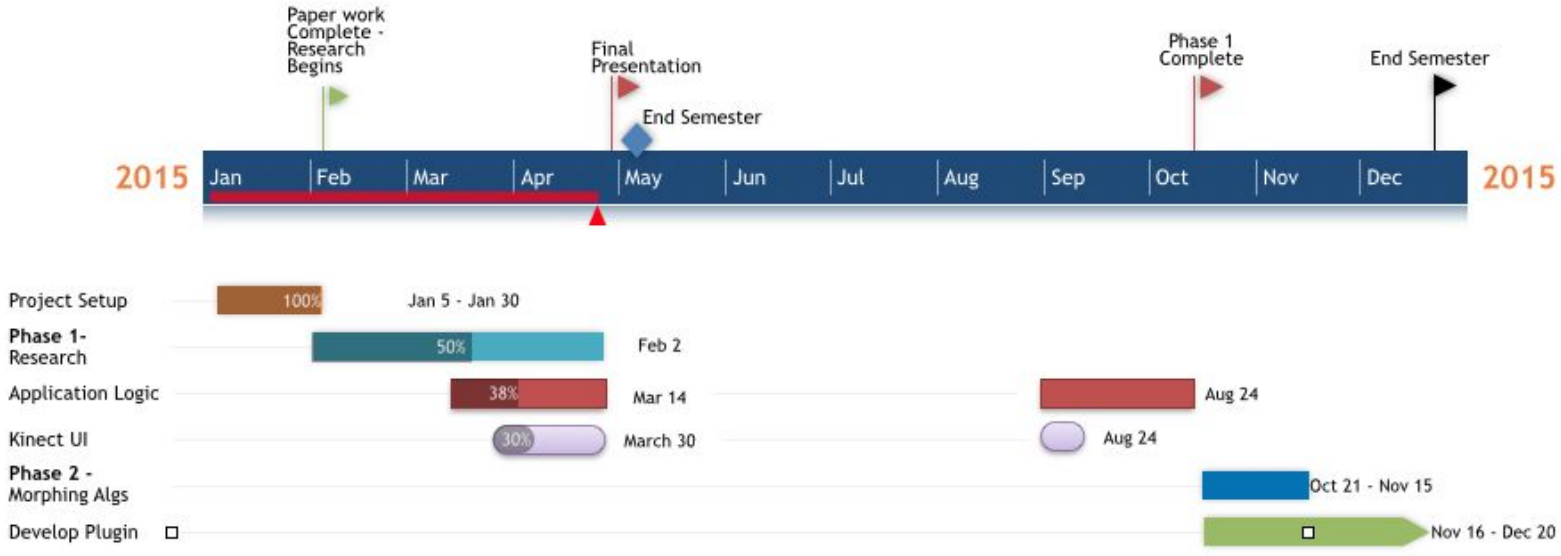
There is a lab set aside to use Kinect sensors and 3D cameras to generate 3D models of a person based on depth data and overlays the registered color. These 3D models shall be imported to a blender program with the functionalities to alter the shapes and sizes set by the user. Surgeons will validate/test the interface features to make sure it satisfies their goal requirements to simulate a post-plastic surgery. Testing of the program include measurement distance of how far kinect can collect accurate data of a person's figure and the strength of the light sensors. Researching geometric mapping and algorithms to create the best texture for the models.

7. Work Breakdown Structure

There is at least a job for every team members to accomplish for the project. In order to get the project done in time, everyone should help each other to out if there is a problem. For instance, efficiency can be increased effectively by breaking down the workload to the person that is more capable of doing it. Since we have 4 people in a group, so the jobs are split perfectly.

Monica Kozbial - Team Leader
Sarah Files – Team Webmaster
Kyle Williams – Team Communication Leader
Yee Zhian Liew – Team Key Concept Holder

7.1 Project Schedule



Note: Gaps in project schedule indicate summer break, and any work contributed during these months are arbitrary.

7.2 Risks/Feasibility Assessment

Risk	Mitigation
Loss of Backups or current work	Online private repository
Project schedule miscalculations	Update client and reschedule further work time
Lack of usable computers	Request extra computers for team members
Integrated graphics card not sufficient to create an ideal model	Opting for more powerful options

7.3 Resource Requirements

Resource	Method of Acquisition	Cost
Kinect v2	Provided by client	N/A
Kinect SDK	Download from site	N/A
Blender	Download from site	N/A
Laptop with Windows 8 and USB 3.0	Provided by client	N/A
Senior Design Lab Computer	Provided through ISU	N/A
USB 3.0 PCI-E Card	Advisor Daniels	$20.00

8. Market/Literature Survey

While there exist 3D visualization technologies that simulate various cosmetic body-sculpting treatments, these mainly rely reconstructing the body from images and target the patient. Our implementation will employ 3D time-of-flight sensor data to reconstruct the body to simulate a more accurate representation of the client. This tool will be designed to target plastic surgeons to allow them to easier simulate and convey the effect of various procedures for a client.

9. Conclusion

The goal of this project is developing a finished application with a refined UI that will be used by plastic surgeons to effectively communicate to their patient the results of various cosmetic procedures on their body. The application will convert Kinect v2 sensor data taken of the patient into a 3D model of the patient and allow for the surgeon to quickly edit the model by marking specific areas of the mesh and applying transformations to simulate the effects of various procedures.