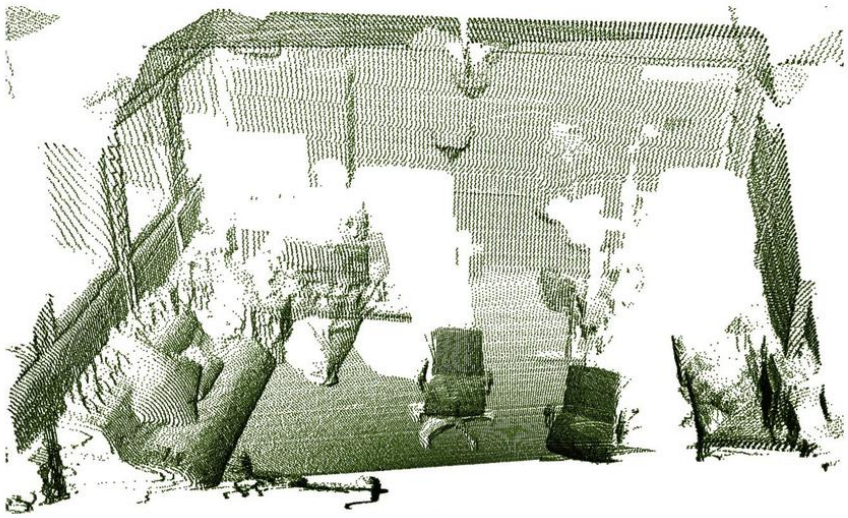
Rapid 3-D Environment Modeler



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University of Central Florida

Department of Electrical Engineering and Computer Science

Dr. Lei Wei

Dr. David J. Hagan

Senior Design I

Group 10

Daniel Batista – Photonic Sciences and Engineering

Aaron Coville – Photonic Sciences and Engineering

Matthew Cummings – Computer Engineering

Sean Huskey – Computer Engineering

Narrative Description

As the lines between virtual reality and augmented reality begin to blur, the need to rapidly generate a virtual model of a real environment will only increase. The applications are far reaching, including things like robot vision, video games, architecture mock-ups, cave-surveying, self-driving cars, and the list goes on. The goal of our project is to demonstrate a relatively cheap and portable device for creating such a model.

The definition of portable varies by application, so for this project, the definition of portable is that it can easily be carried around and placed in the center of a room to generate the model. This means that it shouldn't be too bulky in size or too heavy to easily carry around. The device itself will have to be built sturdily enough that it can handle being moved around without becoming misaligned as well. The method chosen to use for range-finding will significantly impact how sensitive the device will be to mechanical shock.

The device will not require being plugged into a computer directly, but instead connect with a wireless connection. If this isn't feasible, an alternative option would be to save the data collected to an SD card within the device, and then bring it to the computer manually. Implementing both features at once is also an option. In the situation where the device suddenly loses connection to the computer, it would be able to continue gathering data on the SD. The SD card could also serve as a place to store backups of previous models.

The device will also be powered by batteries so that it doesn't need to be plugged into a power outlet to function. This feature would serve to make the use of the device as convenient as possible, so it can be placed in the center of any room regardless of where power outlets may be located. It won't need a particularly long battery life either, as it wouldn't be in operation for any long periods of time.

The kind of model that the device will generate is a relatively simple one. It won't include textures or images of the world it's generating. Instead, it will be a point cloud where each point is recorded as a certain distance away from the detector. In this way, the generated world will be many points that are color coded to indicate distance from the "camera" as the user moves through the VR space. From this data, surfaces could be rendered, although they won't be perfect representations of the real world, especially depending on the resolution.

The device will be able to allow the user to specify a low quality vs high quality render as well, where the higher quality would collect many more points, with the tradeoff of taking more time to do so. For the low quality render, interpolation would be used to keep a constant point density throughout the cloud, but surfaces wouldn't be modeled quite as accurately. This idea of interpolation to keep a constant point density also applies to the high quality render as well. For distances that are further away, points will appear more spread-out, so the interpolation will help correct for that.

The model generated by the device will cover the full 180° above the device, which would be the northern hemisphere of a sphere surrounding the device. To achieve this field of view, the device is placed on a fully rotational stage such as a simple gimbal. The device will spin as it slowly sweeps upward, creating a spiral of points that converge directly above the device.

Project Requirements and Specifications

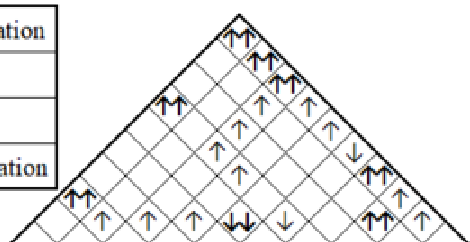
- Ability to either save or wirelessly transmit data
- Has a 180° field of view
- Time to generate a model $\leq$ 15 minutes
- Should fit in a box that is 1 ft^3 or smaller
- Power source is within the device
- Should be easy to set up/use
- Should weight < 10 lbs
- Data should be rendered into a 3D world that can be moved around in
- Resolution should be accurate to 10cm up to 10m away.
- Option to choose a "low res" or "high res" render
- Data model shall render outside of the device
- Autonomous ability to generate model
- Simple device start up
- Device shall power on when operator specifies

- Model rendered shall contain distance data for each point
- Distance data will be encoded in the color of each point
- Device will not be impact resistant
- Device will operate under standard conditions
- Cost shall be no more than $300

House of Quality

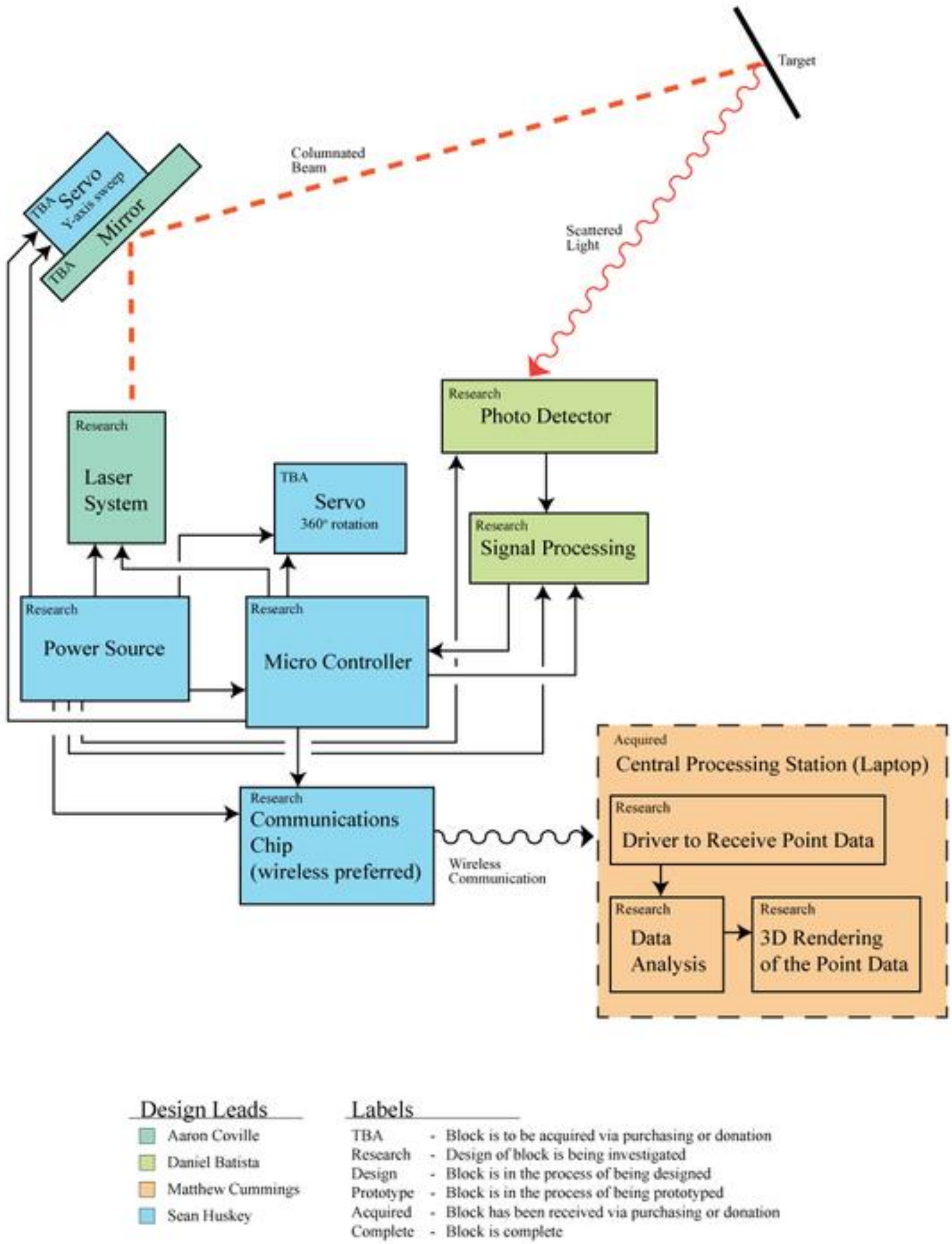
Legend

↑↑	Strong positive correlation
↑	Positive correlation
↓	Negative correlation
↓↓	Strong negative correlation



Design Goals \ Design Factors	Laser power	Laser wavelength	Detector	Hardware communication	Microcontroller processing	CPU processing	Power consumption	Size	Weight	Cost
3D image quality	↑	↑	↑↑	↑	↑↑	↑↑				↑
Depth of vision	↑↑	↑↑	↑↑				↑			↑
Range of vision	↑	↑	↑↑				↑			↑
Mechanical runtime							↓	↓	↓	↑
Computational runtime			↑↑	↑	↓↓	↓↓				
Signal to noise ratio	↑	↑	↑↑		↑					↑↑
Power consumption			↑		↑↑	↓	↑↑		↑	↑
Portability			↓	↑			↓	↓↓	↓↓	
Cost	↑↑	↑↑	↑↑	↑	↑	↓	↑↑	↑	↑	↑↑
Target Values →	≤ 50 mW	500-1000 nm	TBD	Wireless	TBD	TBD	TBD	1' x 1' x 1'	≤ 10 lbs	≤ $300

Block Diagram



Budget and Financing

Creating a real time optical imaging device requires multiple components to interact with each other. The components must process data at high speeds as well as communicate with precise timing. A microcontroller is needed to manage the components and tasks of the system. The microcontroller must have a high value for instructions per second to process data fast enough to create the image specifications.

The system will be contained in a small chassis and will be required to rotate. The rotation must be programmed to follow a precise revolution velocity. This servo must also contain enough torque to move around a certain weight value fast enough to respond to the imaging system. A small servo is also necessary for the smaller components to move around the laser for imaging. The small servo will attach to a mirror for the output laser will have movement.

A laser diode and detector is required to image the environment. The detector will be determined from the wavelength that the laser will output. An infrared diode will be used to reduce costs and improve financial efforts to the overall project. The laser diode must be able to vary based on the input parameters the microcontroller will assign. The modularity of the laser diode is considered to correctly choose a working photodiode for the device to work. The detector must communicate with the microcontroller through a timer with precise and quick data transfer. This hardware communication specifies which type of detector must be purchased.

A major variable of the device will be the device communication between hardware components. The components are required to interact quickly enough to enable the device to render and image within an acceptable range. The communication variable will increase the budget price to find the correct hardware that may enable the device to act a speed necessary to render a rapid image for the user.

Estimated costs

Microcontroller - $30

Large Servo - $10

Small Servo - $5

Small Mirror - $15

Laser system - $30

Detector - $75

Total - $160-$200

Task	***Begin***	***End***
Senior Design I **Fall 2017**	**08/21/17**	**12/02/17**
Ideas for project	08/21/17	08/28/17
Project approval & member roles	08/29/17	09/08/17
Project proposal – Divide and Conquer	09/01/17	09/22/17
Project idea finalization	09/08/17	09/29/17
Research and Design	09/29/17	11/03/17
Final Documentation	09/29/17	12/02/17
Laser and Detector orders	09/30/17	09/30/17
Proof of concept testing	10/14/17	10/21/17
Component orders	10/18/17	10/21/17
Rough prototype	10/22/17	TBD
PCB Design	10/22/17	TBD

Senior Design II **Spring 2018**	**01/08/18**	**04/23/18**
Final Documentation	01/08/18	04/10/18
Optimization and testing	TBD	TBD
Finalizing project	TBD	TBD
Final Presentation	TBD	TBD