6.S078 Update

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1 Plan Progress

As a quick reminder, we are working on building a low-cost, high precision 3D scanner. Beyond low cost and high accuracy, we have design goals of a modular design that can be expanded, and compact design that can fit on a desk. We see our target users as general consumers and budget-constrained professionals, e.g. small manufacturing plants, research labs, designers, artists, etc.

We have continued with our technology and market research from last week, and are more confident in our market assumptions. We are securing funding for prototype development, and working on software in parallel with the hardware development (developing software with larger camera/projector systems while our hardware is being developed).

2 Prototype Progress

We made a very crude initial CAD model, and have started writing general software that works with large scale projector and camera systems, but will also work with our sensors. We're working so that the hardware and software development can move in parallel.

We've established a few different imaging and projection techniques we're going to try, so we can see which will be most effective for us to achieve our design goals. The techniques we are trying are:

- Projection Ideas
  - Small grating in front of an LED. The shadow created by the grating on the object will create the lines necessary for structured light scanning. We will investigate having multiple static LEDs projecting from different angles, and having a single LED that casts a shifting shadow because the grating moves in front of it.
  - Overlapping color filters. Have multiple filter sheets (red, green, blue, etc.) with holes cut in them. Have the holes overlap irregularly, so a multi-colored grid is projected on the object to be scanned
  - Manufacture our own projector. This may be necessary in order to have a projection system with a very short focal distance, and may help us lower costs
  - Use a pico-projector. An off the shelf pico-projector like those being integrated in cell-phones might be the most cost effective solution. The usability of this option depends on the focal range of the projector. The object could be spun in front of this projector, or fiber-optics could be used to allow projection from different directions with the same projector
- Imaging ideas
  - Array of cheap off-the-shelf CMOS cameras. Could be the ones used cell phones. May have issues with a small focal range, and being in focus for very near objects.
  - Manufacture own pinhole camera. Can use the same CMOS array as those in cell phone cameras, but without the lens. Gives us a larger focal range, but may have issues with not enough light.

3 Baffling Variables

The most baffling variable is how well we are going to be able to execute on our design goals: high precision and low cost. We will not really be able to answer the high precision question until we have a working prototype. To help answer the low cost question, we are meeting with a consumer optics consultant to discuss different techniques we are considering.

These questions will be clarified after we have build working prototype.

4 Seven Day Plan

- Secure funding

- Order parts for initial prototyping
- Have a CAD model of a scanned object using a regular projector and a webcam
- Have a rough overall software model for how different components will interact, and for how we'll support multiple sources for depth data.

5 People to Meet

Professor Gifford has kindly introduced us to Dr. Stephen Fantone, who does some consulting work for consumer products requiring optical solutions. We are meeting with him next Tuesday.

We have been trying to get in contact Wojciech Matusik, since his lab does work in 3D scanning, but we haven't been able to get in contact with him over email. We may start waiting outside his office (a meeting isn't critical, so we haven't done this yet).

6 Desired Resources

We're in the midst of going through a funding process with Professor Gifford, and so are in the process of meeting all of our desires for resources. The slides we sent out for review by the course's VC partners are included in the email.

DCBA 3D Scanner

Low-Cost, High-Precision, User-Friendly

Vision

Our Vision:

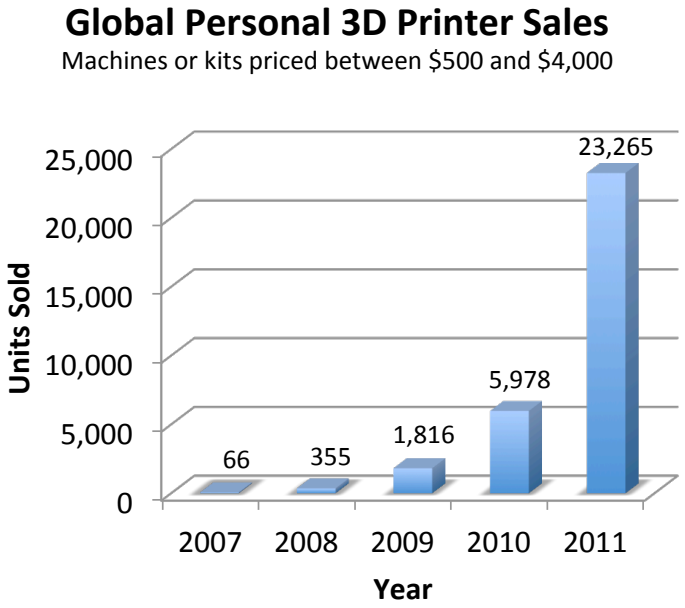
All work in measurement, design, art, and manufacturing will soon take advantage of the accuracy and speed of 3D scanning.

Our Goal:

We will develop high-quality 3D scanners accessible to individuals and businesses on small budgets.

Market

- Existing $350 million 3D scanning market targets large businesses – similar accuracy and lower price exposes a much larger market
- Potential users
  - Research labs
  - Hobbyist builders
  - Artists
  - Product Designers
  - Small manufactures
- Interest in and use in 3D of printing is growing wildly. 3D scanning is the other part of this revolution



Data from Wohlers Report 2012: Additive Manufacturing and 3D Printing State of the Industry

Relevant Technology Advances

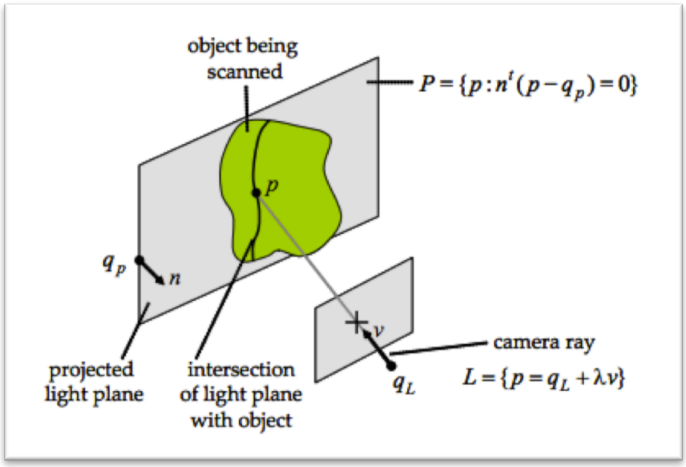
- **Optics and Digital Imaging**
  - Notably emergence of high-quality, compact, and cheap cell phone cameras
- **Computing**
  - High-power computers are practically ubiquitous
- **Digital Fabrication**
  - High-precision laser cutting and CNC machining is now easily attainable

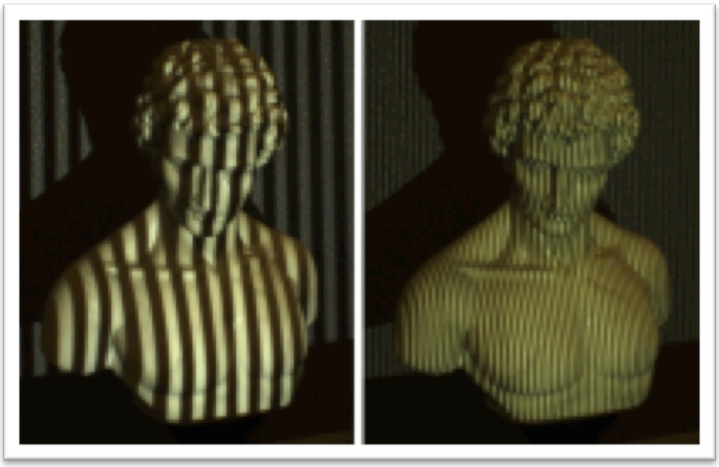
Scanning Techniques

- Existing methods include
  - Structured Light
  - Image Reconstruction
  - Laser Time of Flight
  - Laser Triangulation
  - Computed Tomography
  - Serial Sectioning
  - Contact Scanning
- Recent interest in 3D scanning has spurred academic research advances, particularly in structured light and image reconstruction

Structured Light Scanning

1. Known light pattern is projected onto scene
2. Scene is imaged using one or more cameras
3. Point cloud calculated by triangulation





Images from Douglas Lanman and Gabriel Taubin's SIGGRAPH 2009 Course Notes accessed on 3/4/2013 at http://mesh.brown.edu/byo3d/notes.html

Product Goals

- **Accurate**
  - 0.025 mm accuracy
  - This level of precision comparable to or better than most manufacturing processes
- **Low-cost –** less than $500
- **Usable**
  - Intuitive website and software UI
  - Computer-controlled calibration
- **Modular**
  - Easily alter the workspace
  - Enables scanning a single face of large objects, all faces of a small object, or even an entire room with one system
  - Allows easy upgrading, maintenance, and expansion
- **Compact –** fits on top of a desk

Our Team

Troy Astorino
Year: 2013
Major: Physics/AeroAstro
Job: Team Lead/Programming

Gus Downs
Year: 2013
Major: Physics, Math
Job: Mechanical & Electrical Engineering

Craig Cheney
Year: 2014
Major: Mech. Eng.
Job: Mechanical Engineering

Turner Bohlen
Year: 2014
Major: Physics
Job: Programming

Our Current State

- Ideas we want to explore:
  - Fixed and moving gratings over LEDs instead of projectors
  - Redundant arrays of cheap CMOS cameras
  - Merging multiple scanning techniques

[CAD model here]

Next Steps

- Prototype Prototype Prototype!
- Explore algorithmic methods for combining multiple scanning methods and reducing error
- Forward-facing software development to allow for various input devices (allows rapid modification during prototyping and future additions)