QuickScan Mapping Device

Dec 10 2012

Welcome

Rahul Thomas	Chris Kwong	Yumin Oliver Huang	Jack Zhang	William Chiang
CEO	CTO	CFO	COO	Managing Director

dimension technologies

Outline

Team Breakdown

Motivation

System Design

- Overview
- Structural
- Electrical & Mechanical
- QuickScan Software System

Business Aspects

- Budget & Financing
- Market Analysis
- Project Timeline

Reflections

- Lessons Learned
- Future Improvements
- Acknowledgements

Conclusion

Q&A Session and Demo

Team Breakdown

Team Breakdown

Rahul Thomas (CEO)

- Overall management of team dynamics, project progress & document creation
- Determined overall system functional specifications

Chris Kwong (CTO)

- Major contributor in QuickScan R&D
- Headed electromechanical subsystem

Yumin Oliver Huang (CFO)

- In charge of managing team finance & purchasing
- Design & Development of QuickScan GUI

Team Breakdown - cont

Jack Zhang (COO)

- Development of Data Processing Software Algorithms
- Overall QuickScan tests & calibration with GUI

William Chiang (Managing Director)

- Mechanical Design
- Meeting scheduling – Agenda & Minutes

Team Dynamics:

- Weekly meetings were held to discuss progress and debug different problems
- Team dynamics were excellent throughout the semester

Motivation

Motivation

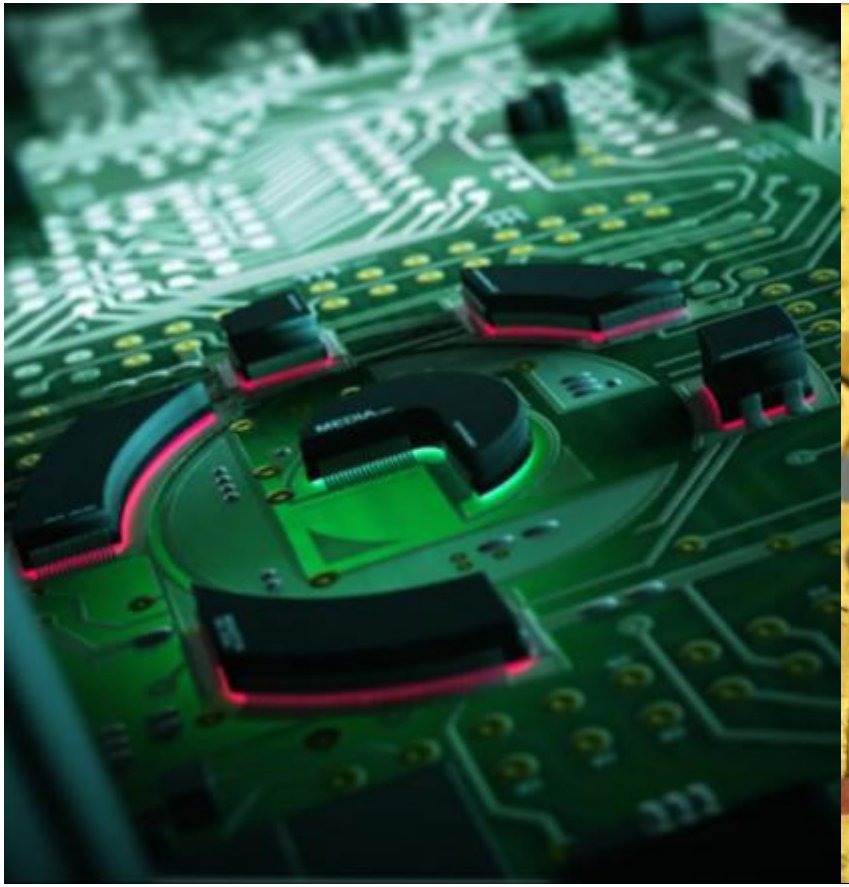
- Many drafters & architects spend hours dimensioning a given room
- This process involved manually measuring distances using conventional measuring tape methods
- A typical drafter earns between $20-$25/hr. [1]
- **Increased time & costs!!!**

Our solution: Fast Track the Drafting Process!!! A standalone device that generates point cloud data which can be easily used to measure the dimensions of a room. This point cloud data can be processed using industry standard CAD tools.

Motivation

QuickScan:

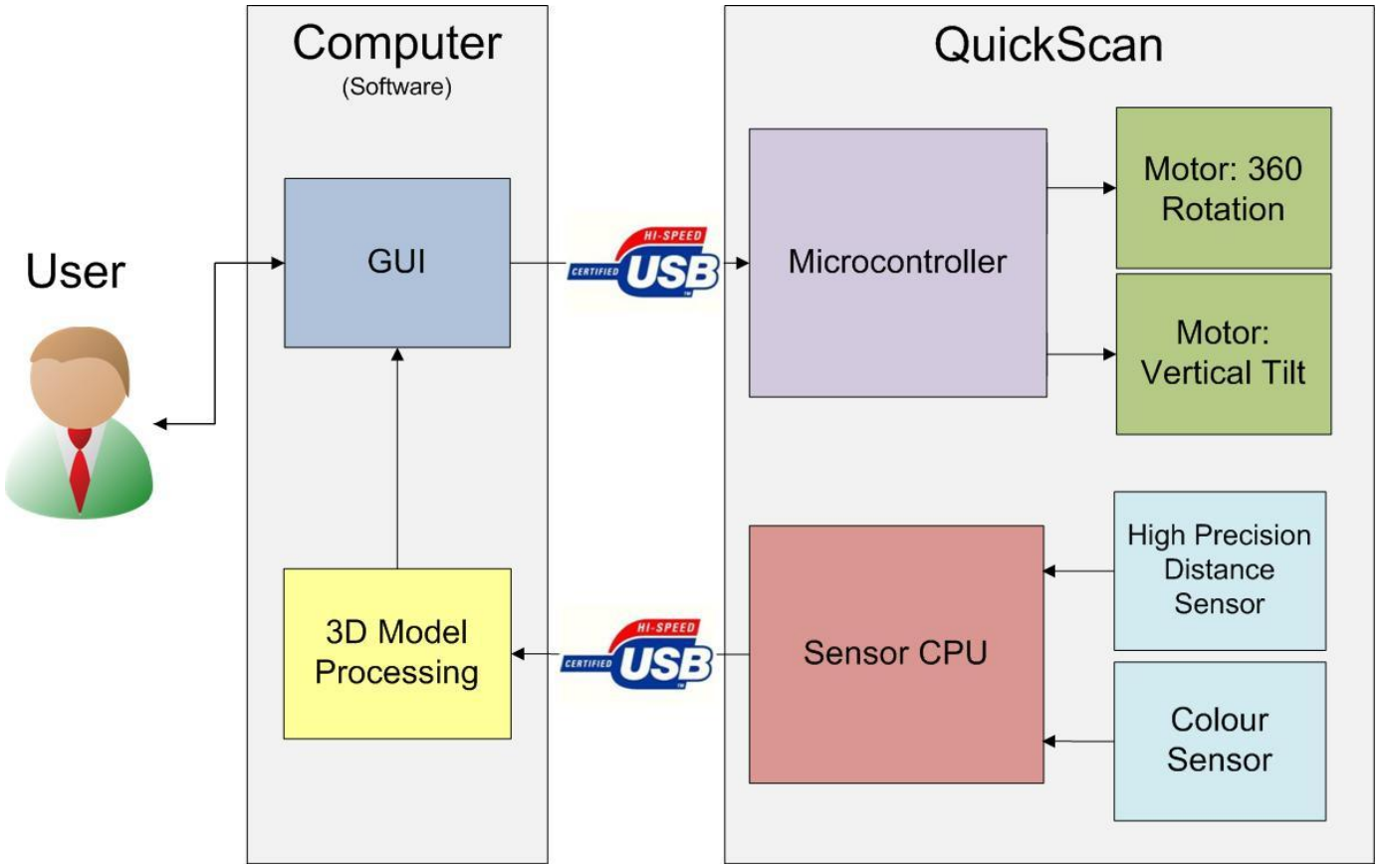
- Creates 3D meshes of a given room
- Two degrees of freedom
- Uses Microsoft Kinect depth sensor – but compatible with other 3D point cloud sensors



System Design

Overview

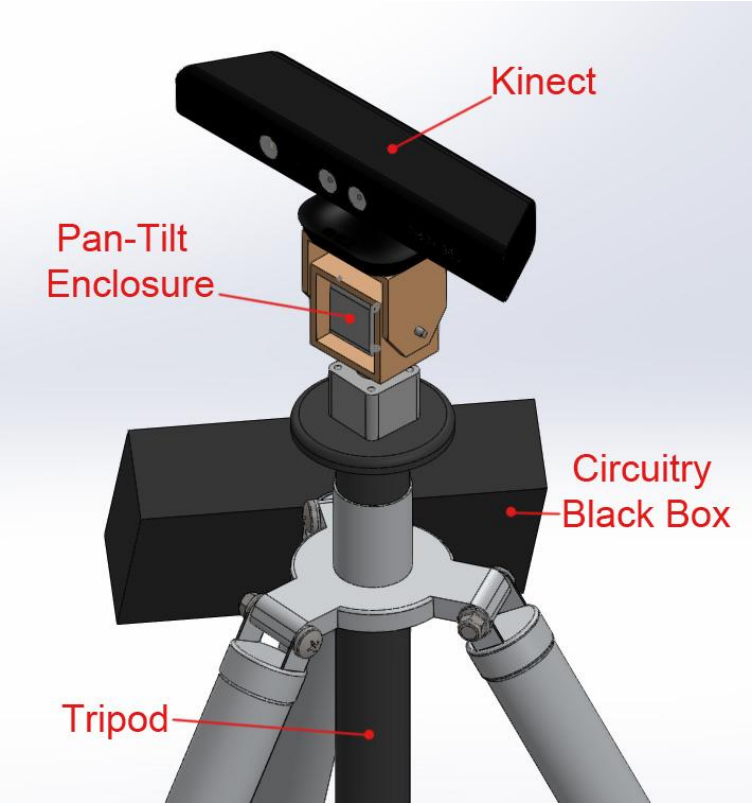
Functional Overview:



Structural

Key Components:

- Tripod base
- Mounted Circuitry & Battery Unit
- Scan Module mounted onto tripod

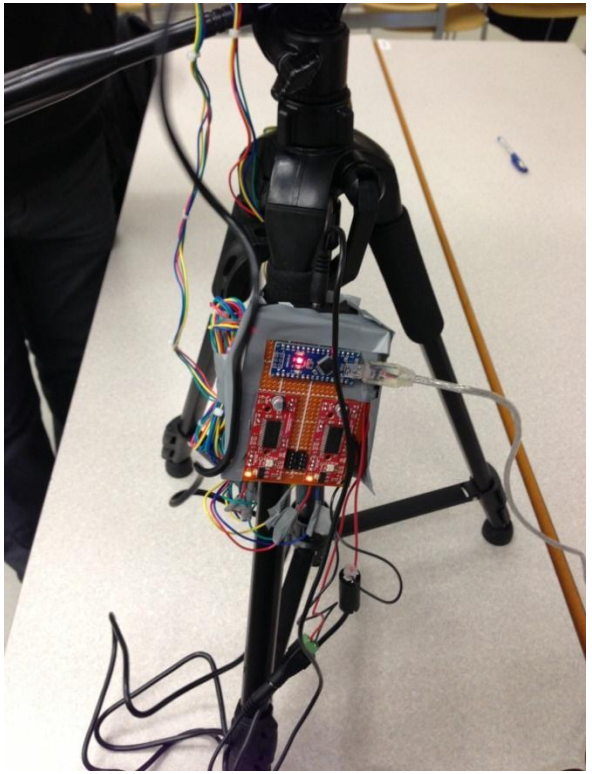


Structural - cont

Implemented Structural Features:

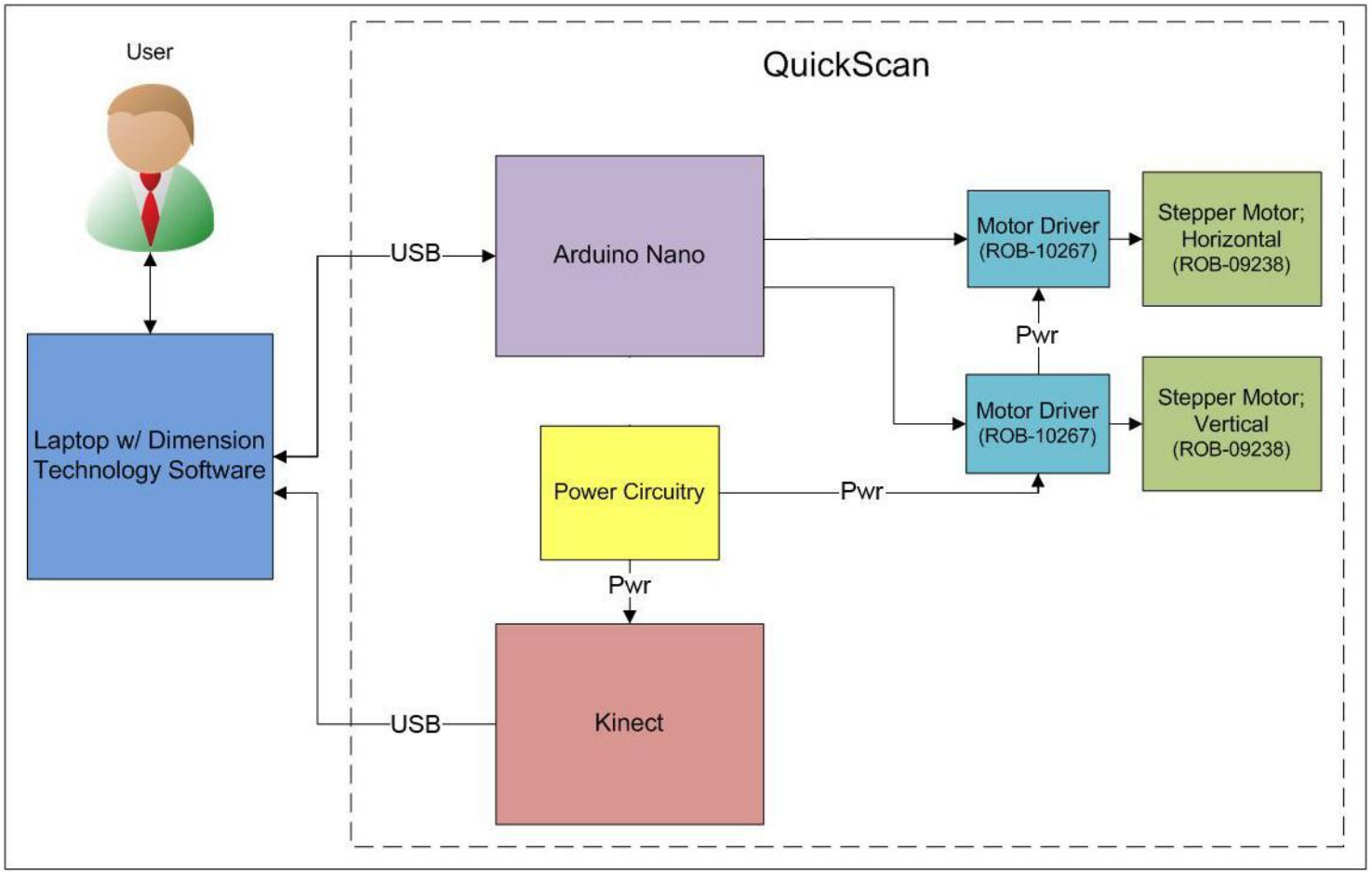
- Successfully mounted QuickScan module onto the tripod base
- Tripod is adjustable in height – up to 57”
- Battery and circuitry modules are securely fastened onto device
- Overall, a standalone device which user can connect to via. USB

Structural - cont



Electrical & Mechanical

Subsystem Overview:



Electrical & Mechanical - cont

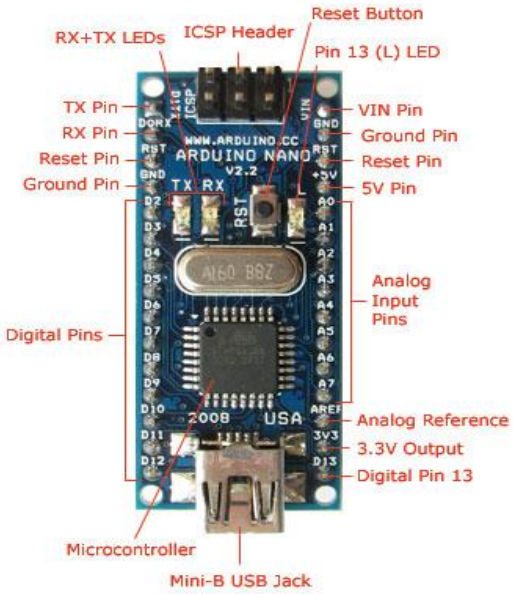
1. **Microsoft Kinect**

- Used for 3D depth sensing
- Outputs point cloud data
- ~20m acquisition range

Electrical & Mechanical - cont

2. Arduino Nano

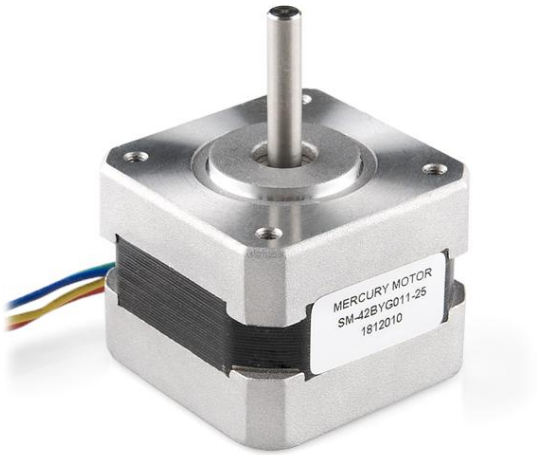
- Optimal component for relaying data between the computer and external hardware
- 14 Digital I/0 Pins
- 16 MHz Operating Clock



Electrical & Mechanical - cont

3. Stepper Motor – x2

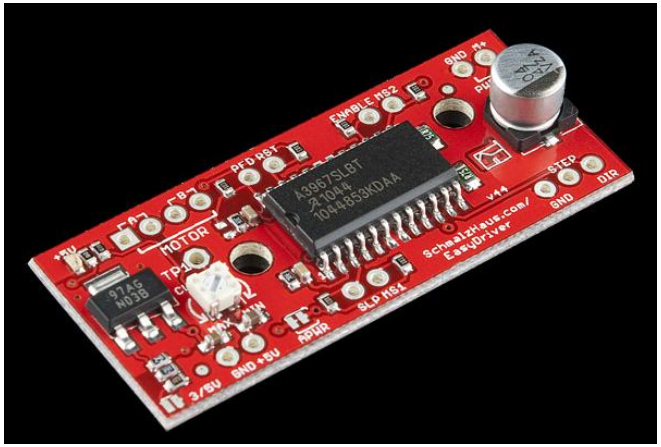
- Used for horizontal and vertical rotation to increase device acquisition coverage
- Step Angle = 1.8° ± 0.09°
- 2 Phase Motor



Electrical & Mechanical - cont

4. **Stepper Motor Driver – x2**

- Increases flexibility and decreases complexity in controlling stepper motors via. Arduino
- Wide operating Range: 7-30V
- Enables micro-stepping for increased accuracy
- Adjustable current control



Electrical & Mechanical - cont

5. Li-Ion Battery – x2

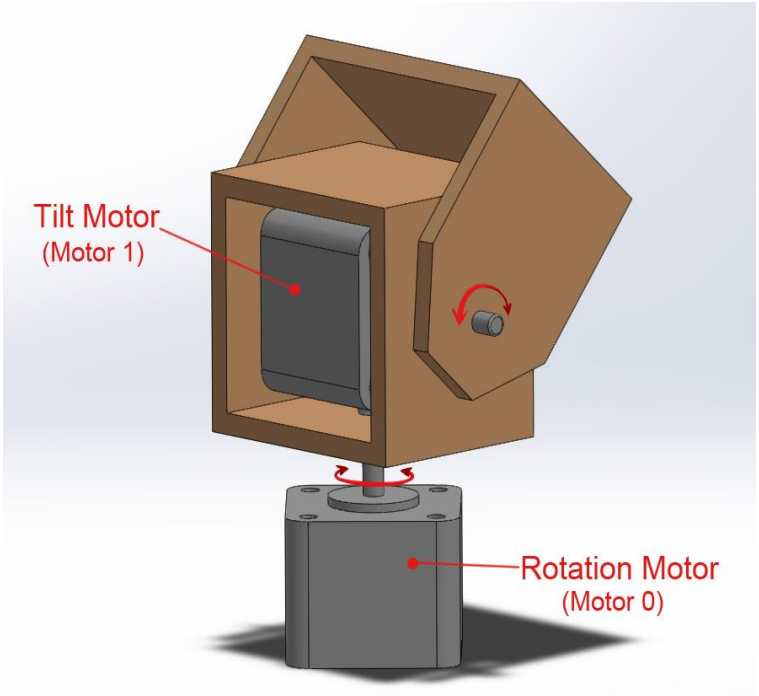
- 12V output, 3.8 Ah
- Rechargeable Li-ion battery
- Approximately 3.5 hours of operation with QuickScan device

Electrical & Mechanical - cont

Pan/Tilt Enclosure

- Designed to support Kinect and incorporate 2 degrees of freedom
- Stepper Motors control horizontal and vertical rotation
- Increase QuickScan's acquisition coverage

Initial Design:



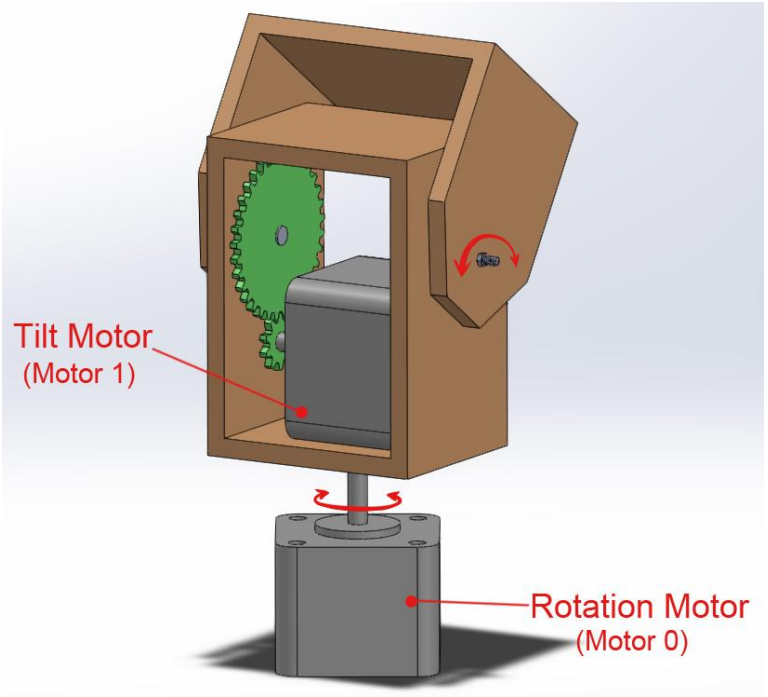
Electrical & Mechanical - cont

Problem with Initial Design:

- Vertical Tilt Motor could not provide enough torque to support the Kinect at angles greater than 10°

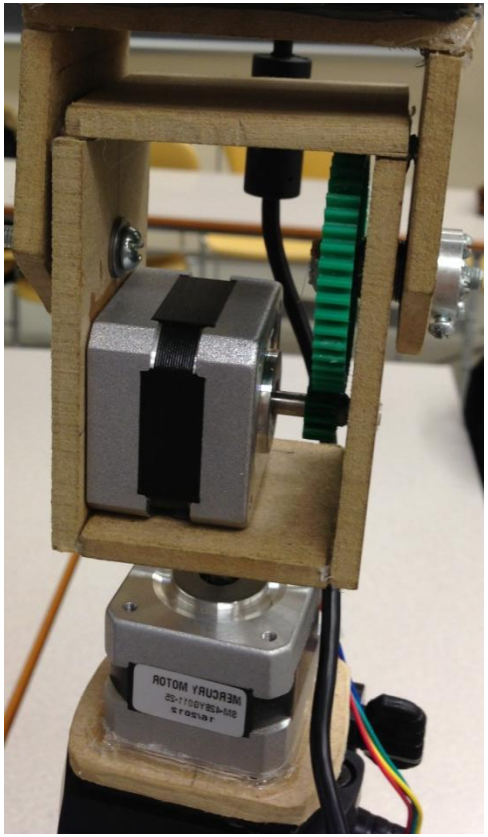
Solution:

- Incorporate gearing system!
- Gear Ratio = 50:12
- Increased torque
- Increased accuracy



Electrical & Mechanical - cont

Current Design w. Gearing System:



QuickScan Software System

Software System:

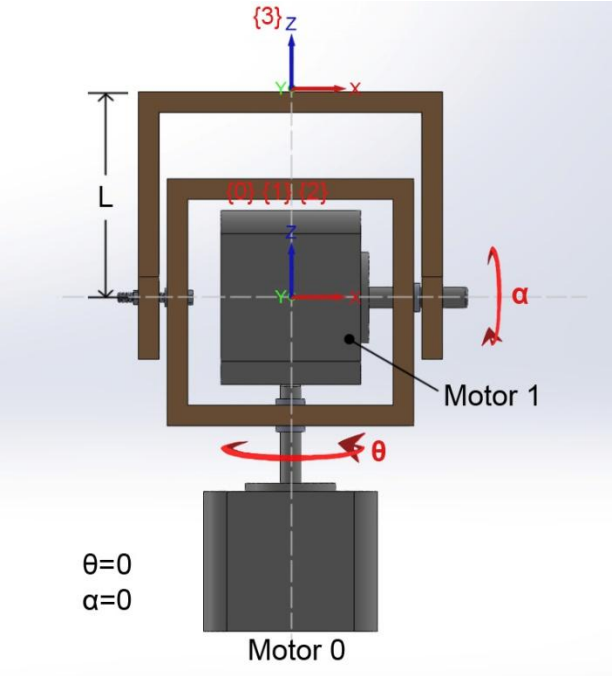
Consists of two key parts:

1. **Data Processing System**
    - Stitches different point cloud shots together to create a complete 3D scan of a given room
    - Implements the concept of Forward Kinematics
2. **QuickScan GUI**
    - User's main source of interaction with QuickScan device
    - Scan process can be initiated via. GUI
    - Displays 2D floor plan of scanned room

QuickScan Software System - cont

Forward Kinematics:

- Mathematical transformations that enable measurements from each shot to be relative from a fixed location



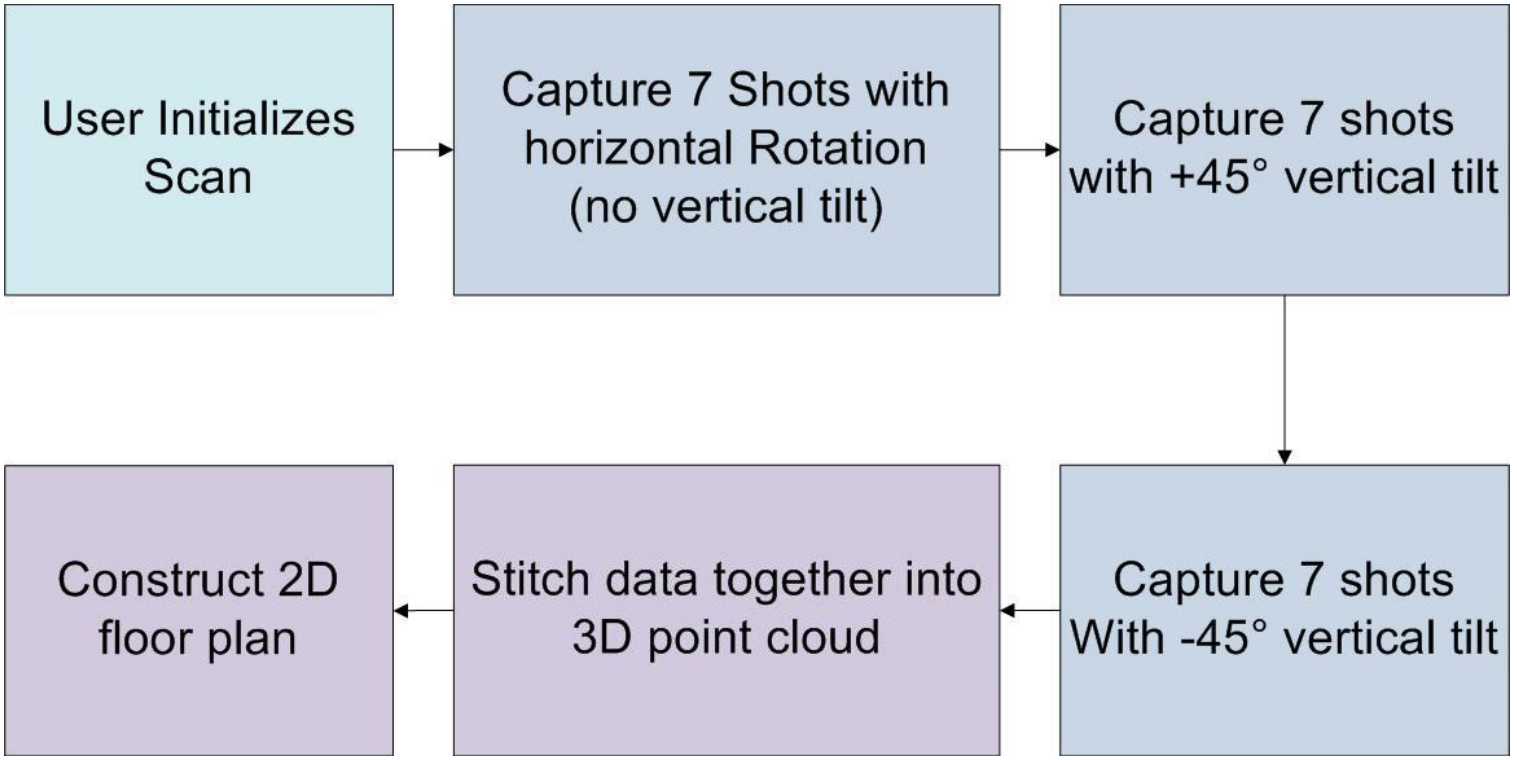
$$^{3}_{0}P_x = P_x \cos(\theta) - P_y \cos(\alpha)\sin(\theta) + Lsin(\alpha)\sin(\theta) + P_z \sin(\alpha)\sin(\theta)$$

$$^{3}_{0}P_y = P_x \sin(\theta) + P_y \cos(\alpha)\cos(\theta) - Lsin(\alpha)\cos(\theta) - P_z \sin(\alpha)\cos(\theta)$$

$$^{3}_{0}P_z = Lcos(\alpha) + P_z \cos(\alpha) + P_y \sin(\alpha)$$

QuickScan Software System - cont

QuickScan Procedure:



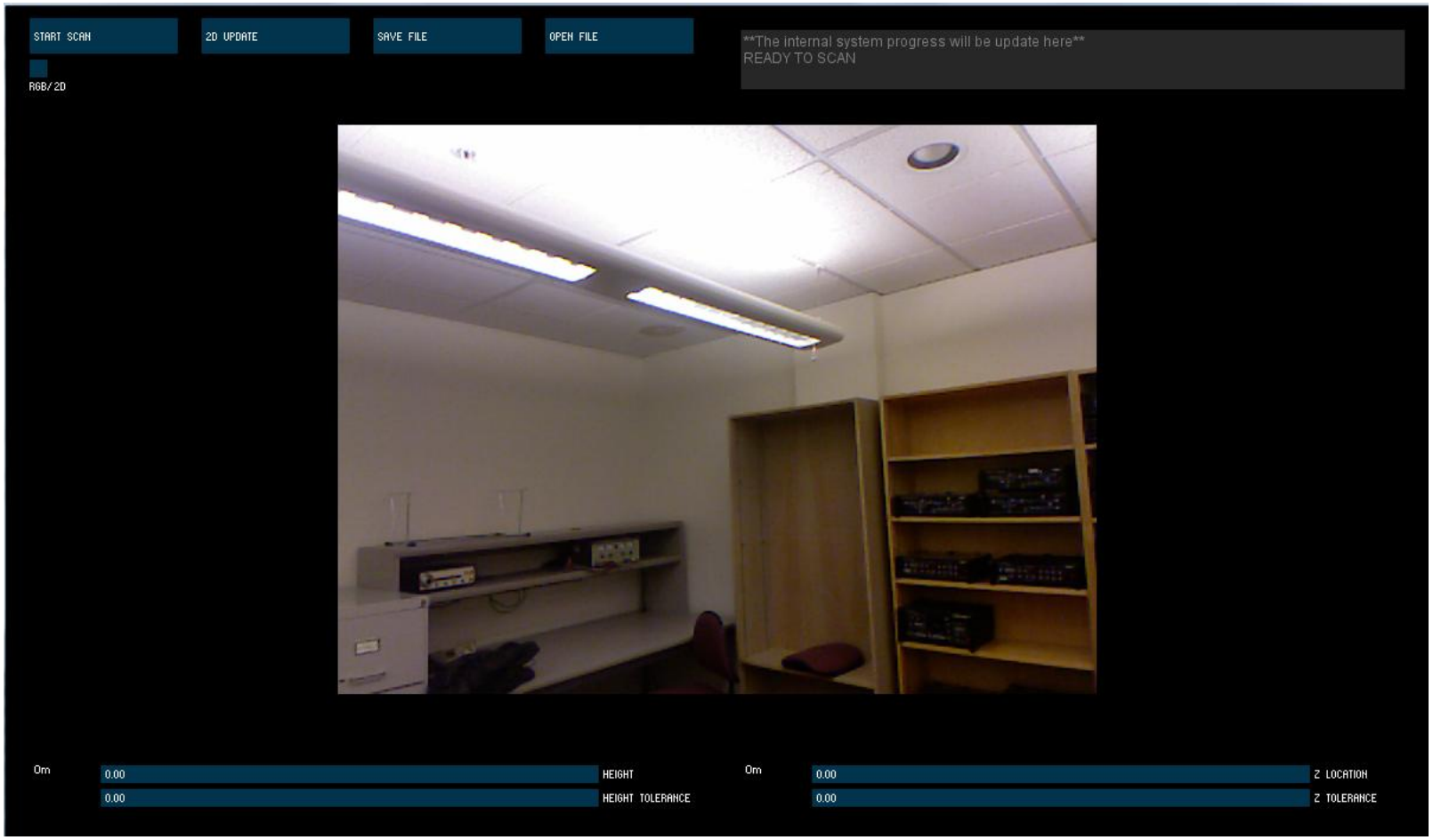
QuickScan Software System - cont

GUI:

- Sole method of interaction between the user and QuickScan device
- GUI contains the following features:
  - Execute a full room scan – approximately 1 minute in duration
  - Open and save point cloud files
  - View 2D floor plans – top and side perspectives
  - Dialogue messages to inform user of current status
  - Ability to view 2D live image

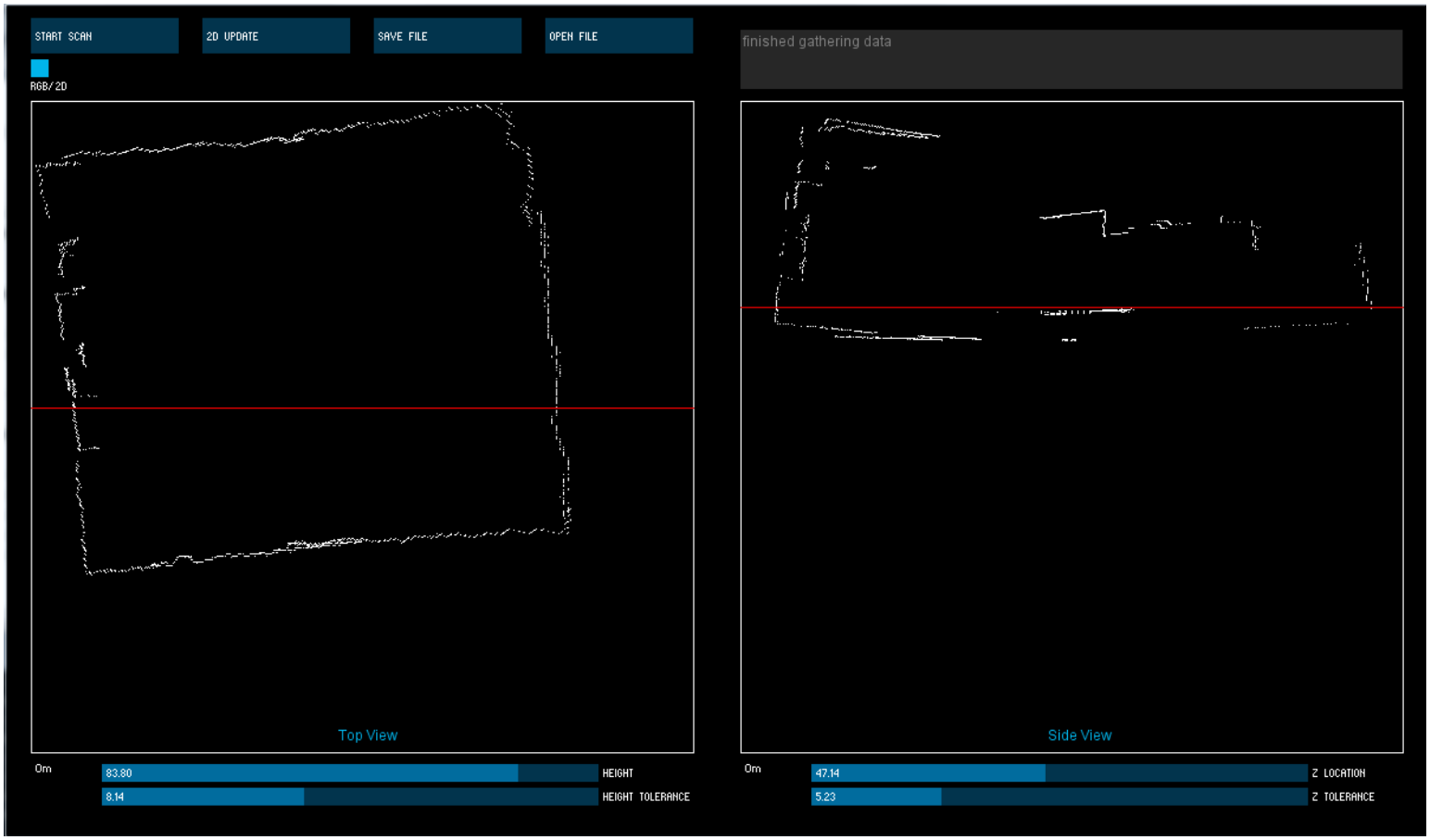
QuickScan Software System - cont

QuickScan GUI:



QuickScan Software System - cont

QuickScan GUI – 2D Floor Plan:

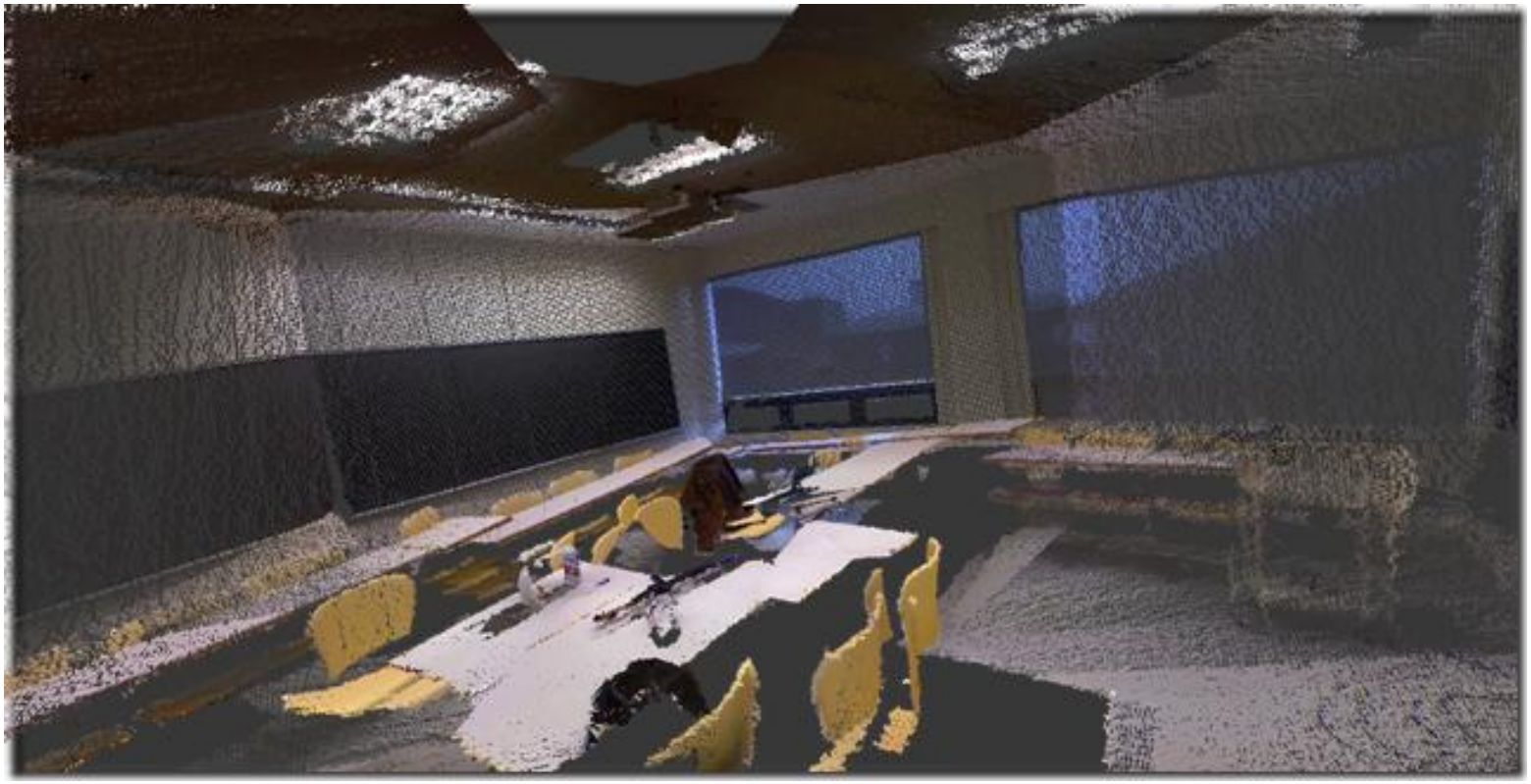


QuickScan Software System - cont

Sample #1: WMC 3515 – Real Image

QuickScan Software System - cont

Sample #1: WMC 3515 – Point Cloud Reconstruction

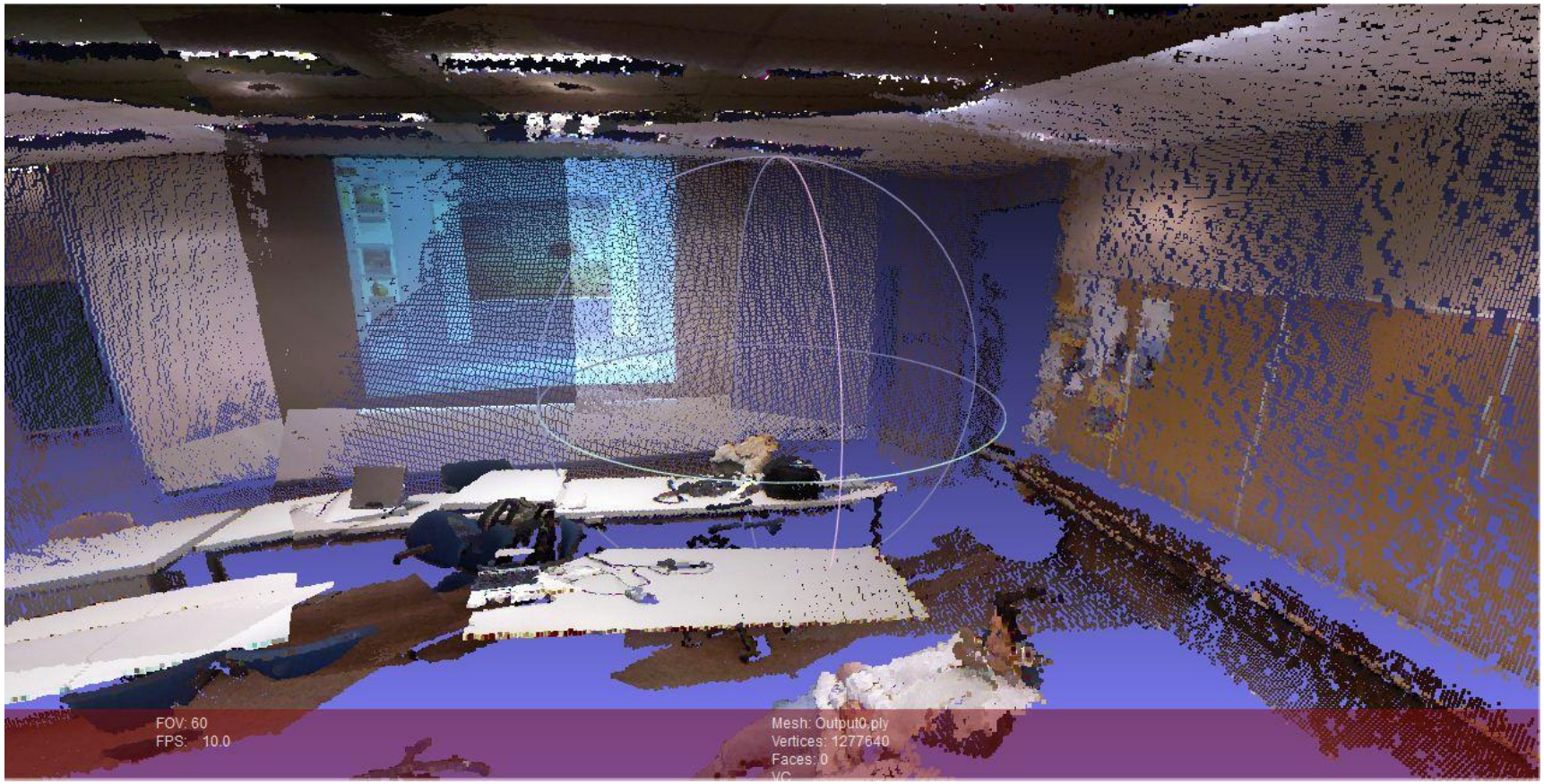


QuickScan Software System - cont

Sample #2: ASB 9705 – Real Image

QuickScan Software System - cont

Sample #2: ASB 9705 – Point Cloud Reconstruction

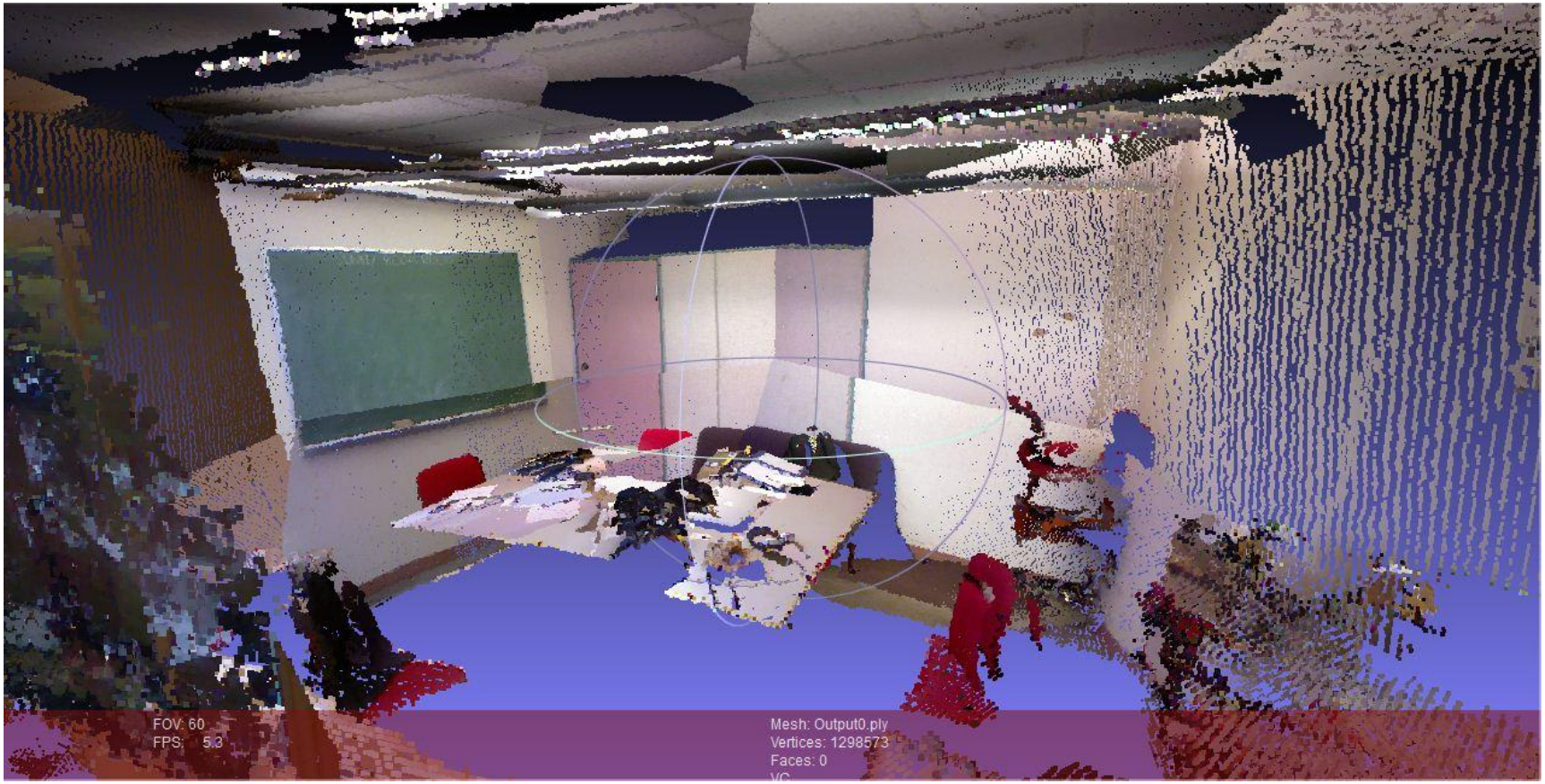


QuickScan Software System - cont

Sample #3: ENSC Sunny Room – Real Image

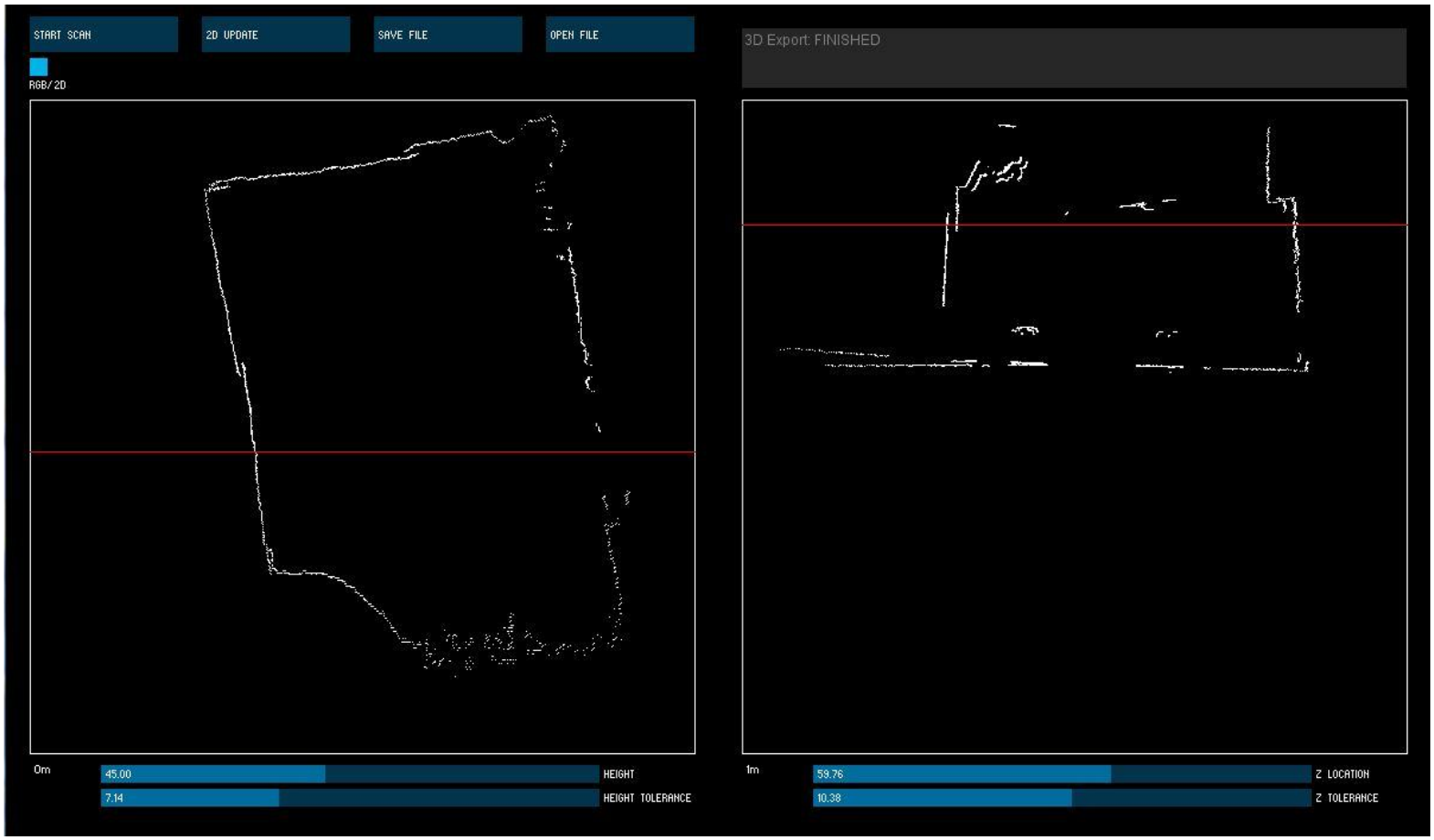
QuickScan Software System - cont

Sample #3: ENSC Sunny Room – Point Cloud Reconstruction



QuickScan Software System - cont

Sample #3: ENSC Sunny Room – 2D Floor Plan



Business Aspects

Business Aspects

Overview

Budget & Finance

- Funding
- Development Costs

Market Analysis

- Audience and Competitors

Project Timeline

Budgeting & Finance

Funding Source: ESSEF Endowment Fund = **$550.00** CAD

Estimated vs. Actual Budget:

Component	Estimated	Actual
Development Board – Arduino Mega 2560	$55.00	$10.99 [1]
XBOX Kinect	$125.00	$80.00
Scanner Chassis Kit	$80.00	$40.63
Servo Motor	$20.00	$29.90 [2]
Arduino Bluetooth Module	$30.00	$0.00 [3]
Batteries/Charging Kit	$100.00	$30.00
Custom PCB Board Design	$150.00	$1.98 [4]
HMC5883L Compass	$30.00	$15.00
Miscellaneous – Wires, cables, etc...	$50.00	$300.00 [5]
Total	**$640.00 CAD**	**$508.50 CAD**

Budgeting & Finance - cont

Difference between Estimated and Actual Budget:

[1] Arduino Nano was sufficient for the scope of our product

[2] Decided to use stepper motors instead of servos – increased costs

[3] Decided not to support Bluetooth connectivity due to high level of complexity

[4] Created our own 'home-made' PCB circuit rather than a professional custom PCB design

[5] Many miscellaneous costs were incurred such as:

- Research materials
- Shipping costs – to ensure timely delivery of parts
- Cables, screws, nuts, plywood, etc.

Market Analysis

Target Audience

Drafting & Architecture Sector

- Assist in measuring room dimensions & floor plan creation

Real-estate Market

- Enables realtors to create 3D walkthroughs of houses or other real-estate

Market Analysis - cont

Competitors

XMeasures – 3D Laser Scanning surfaces

- Provides 3D Point Cloud creation services on a project-to-project basis
- XMeasures will bring their scanning equipment and provide client with extracted point cloud data

3Deling

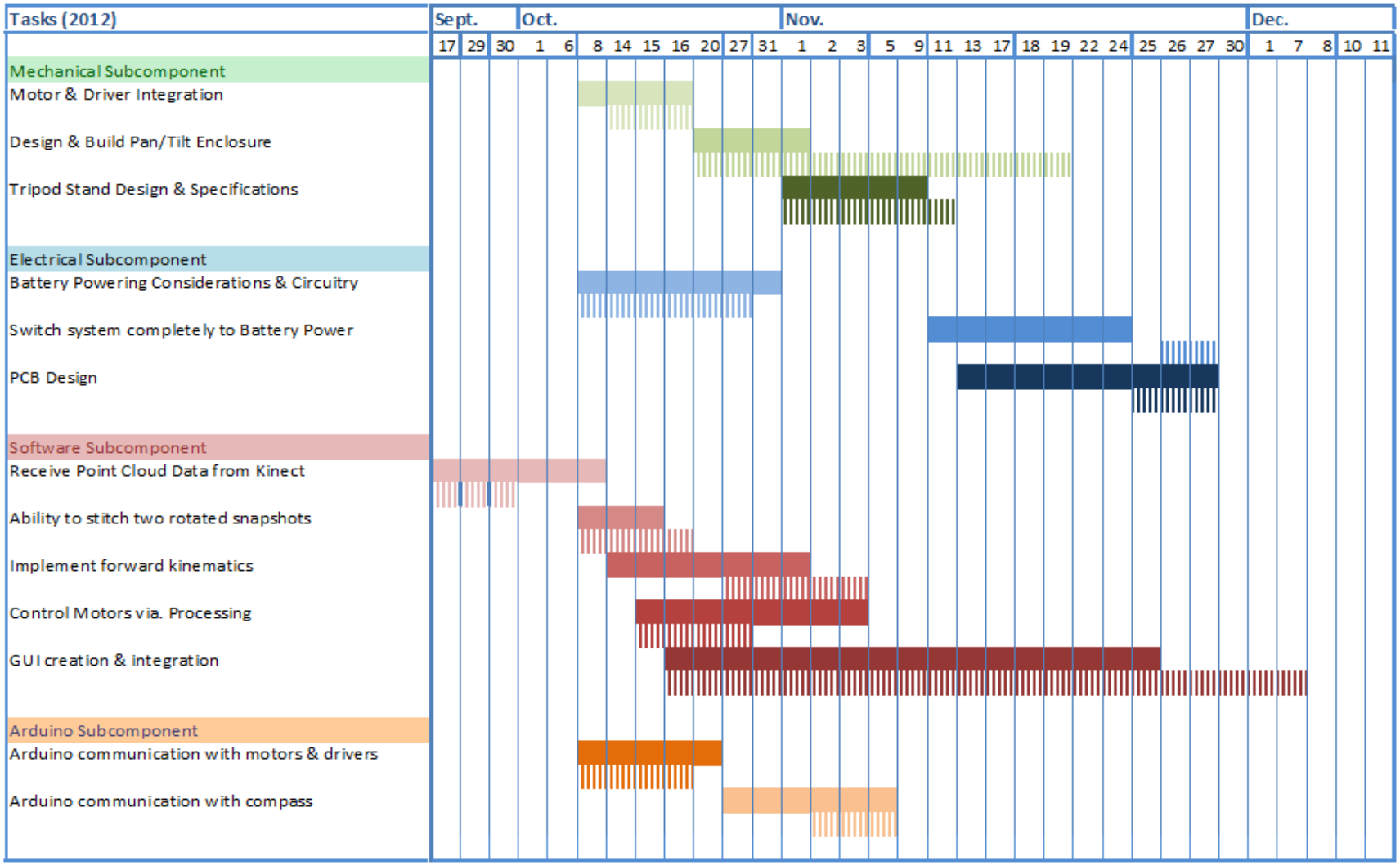
- Similar to XMeasures

Market Analysis - cont

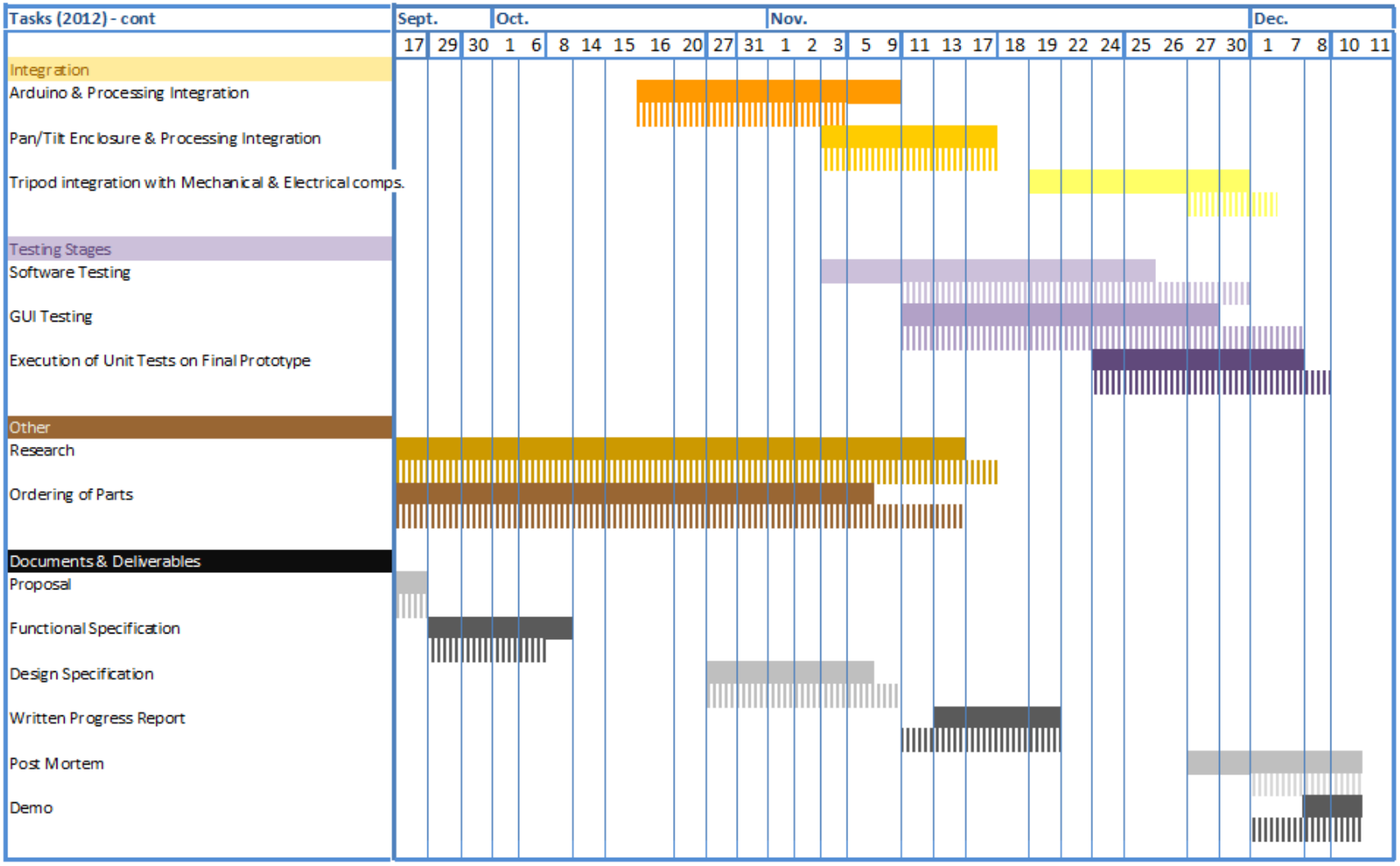
QuickScan Advantages:

- Provides customers with their own **standalone** device!!!
- Enables reuse of device in future projects
- Eliminates the need of paying companies like Xmeasure every time they need a point cloud scan – i.e. **one time fee**

Project Timeline



Project Timeline - cont



Reflections

Lessons Learned

- Conduct thorough research before pursuing a certain feature
- Narrow down device functionalities and features at beginning of development stage
- Don‘t be too hasty in parts purchasing!!!
- Don’t underestimate the magnitude & complexity of the ENSC305 documents!!!

Future Improvements

- Incorporate Open-Source Point-Cloud Library (PCL)
  - Enables effective stitching of consecutive scans
  - Can be used for surface reconstruction
- Use a more robust depth sensor
  - Laser sensor will provide extended scan range and higher accuracy
  - Enables use in larger areas – i.e. industrial sector
- Construct a more professional pan/tilt cage – laser cut from 3d model design
  - Increases accuracy & precision
- Professional PCB design

Future Improvements - cont

- Develop solutions to make QuickScan usable on different platforms
  - iPhone & Android connectivity and control – increases portability
- Integrate compass module into QuickScan device
  - Enables cardinal directions to be displayed on floor plan
- GUI should create PDF with floor plan indicating major dimensions
  - Helps in the automation process

Acknowledgments

Course Instructors:

- Dr. Andrew Rawicz
- Steve Whitmore

Course TAs:

- Ali Ostadfar
- Jamal Bahari
- Michelle Cua

…and our Family & Friends

Conclusion

Conclusion

- Fully functioning proof-of-concept device has been designed and implemented
- To create a fully marketable device QuickScan still needs quite a few features and functions to be implemented
- Overall, project was completed under budget and on-time
- Future of QuickScan?
    - TBD…

Questions

Demonstration

Simon Fraser University,
8888 University Dr.
Burnaby, BC Canada
Email: rmt3@sfu.ca

References

[1] http://www.indeed.com/salary/Drafter.html
[2] http://www.curvetomorrow.com/2010/06/15/microsoft-kinect-and-the-xbox-360-game-changing/
[3] http://arduino.cc/en/Main/ArduinoBoardNano
[4] https://www.sparkfun.com/products/9238
[5] https://www.sparkfun.com/products/10267
[6] http://2.bp.blogspot.com/-omtbuXnoXEc/ToeEaDuvpTI/AAAAAAAAAK4/mf_wHQyxiWg/s1600/nasa+shuttle+launch.jpg
[7] http://mdwallpapers.com/gallery/wallpapers_13/lake_reflection_5_16_x_12.jpg