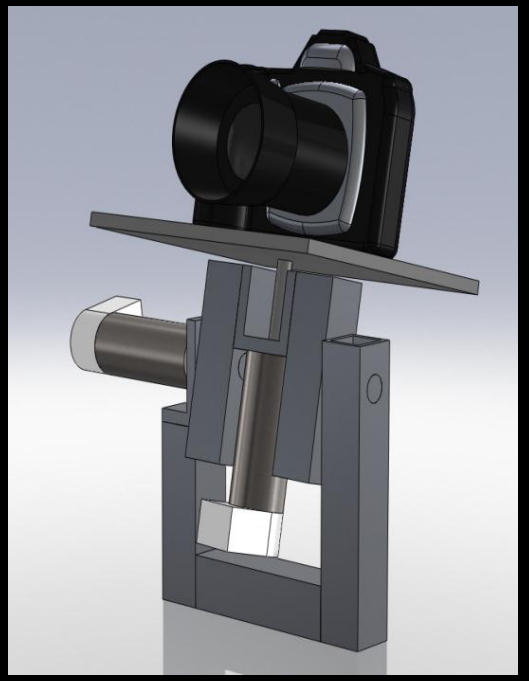
May 3, 2010

Final Presentation



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Automated Tracking Camera

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Overview

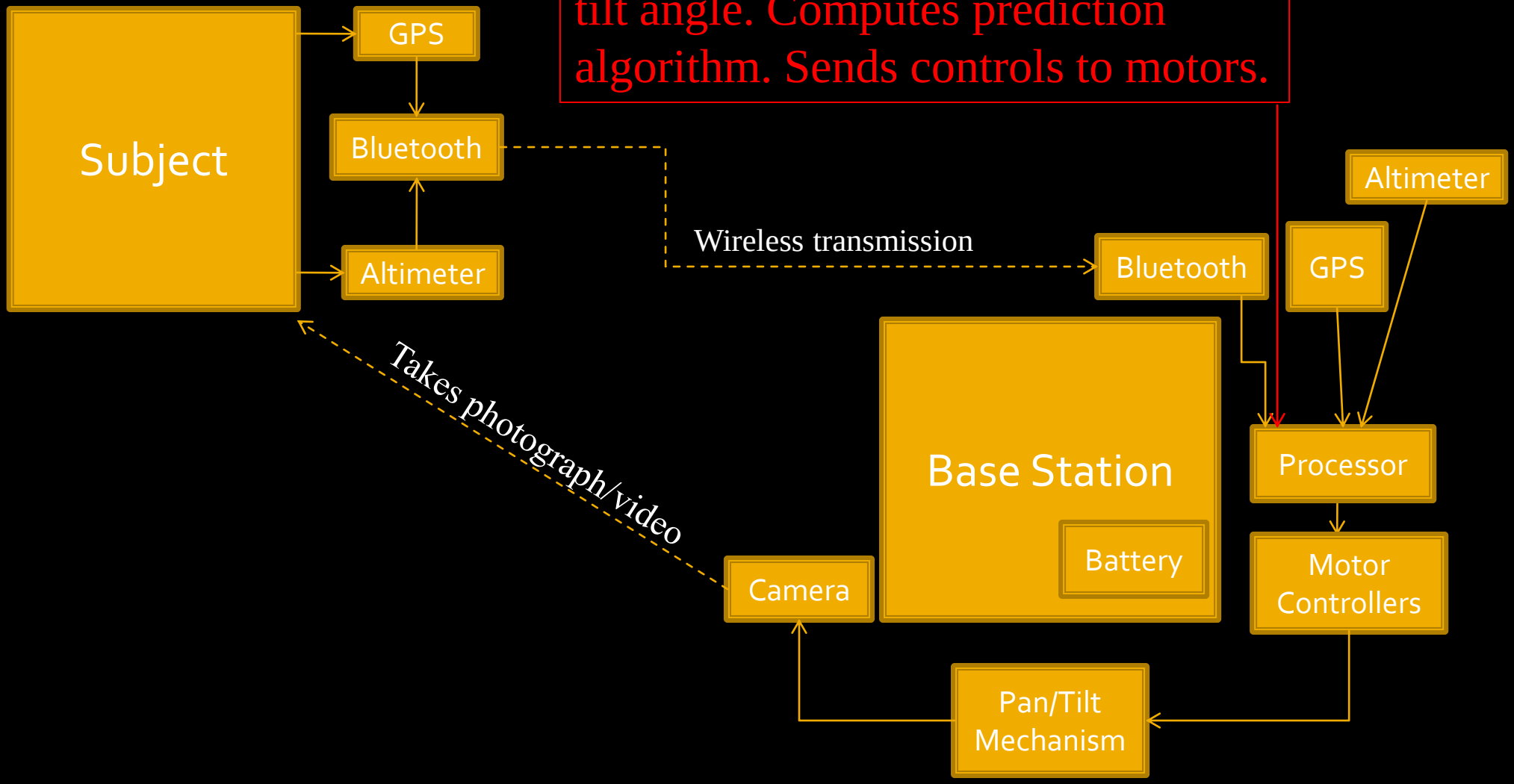
- Objective
- System overview
- Component Decisions
- Hardware Iterations
- Code Iterations
- Testing Results
- Final Product
- Conclusions

Objective

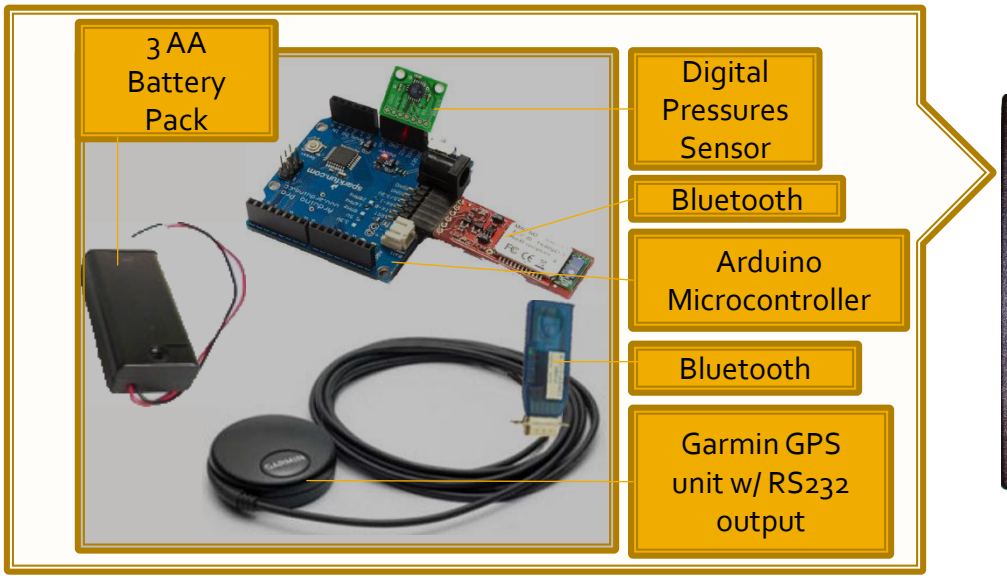
To develop a portable and weatherproof system that smoothly tracks a fast moving object with a camera, while recording professional quality video and photographs

System Overview

Computes distance, pan angle, and tilt angle. Computes prediction algorithm. Sends controls to motors.



Physical Setup

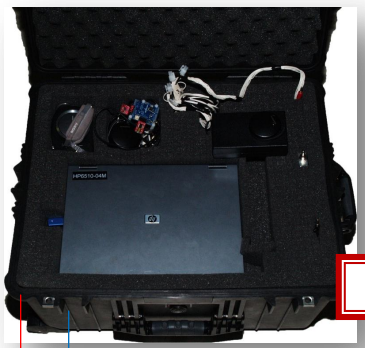


Tx

Rx

100m data transmission

RS232 to USB

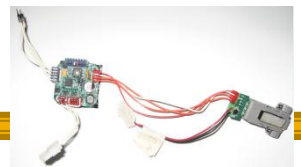


Power

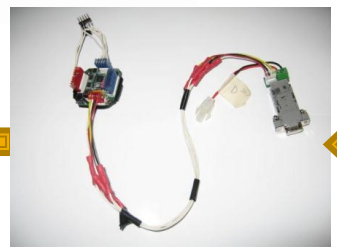
Computer Processor

In In In

Out Out



RS232 to RS485 converters to AllMotion EZSV17 motor controllers



Completed Goals
Tier 1

1. Accurate, real time tracking
   - 5-Hz instead of 10-Hz
2. Smooth/fast enough to provide unique value
   - More iterations of mathematical algorithm will make motions smoother, optimize prediction and decrease overshoot
   - Pan/Tilt rotates at specified speeds of 5.1 rad/sec(~50 RPM)
3. Practical range of motion
   - Range of motion complete to specs: 360 Pan, -90 to 90 degree tilt

Completed Goals
Tier 2

1. Image quality
   - Works with HD Cameras but no zoom control yet incorporated
2. Robust
   - System is fully padded to withstand falls
   - No wind testing has been conducted
3. Weatherproof
   - Waterproof and reliable at specified temperatures of 0 to 100° F
4. Low cost of manufacture
   - Cost below spec of $5,000
5. Fully portable system
   - System is fully portable as there is no need for an outlet

Completed Goals
Tier 3

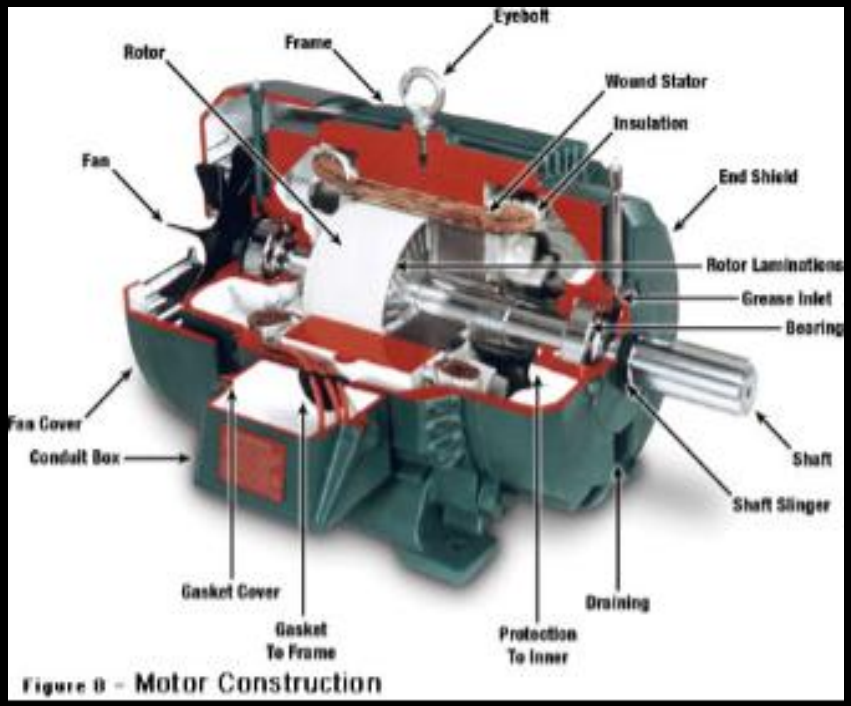
1. Unique subject identification and storage
   - Attempt was not made due to time constraints
2. Unobtrusive/simple to install
   - Simple to install though weight and size of system should be decreased
3. Full day of use, sustainable
   - Rechargeable battery, exceeds 8 hour specification
4. Modular mount
   - Conventional non-professional HD cameras fit ¼-20 screw
5. Maintains vision through snow/fog
   - This was never a priority due to time constraints

Necessary Component Decisions

- Actuators
- Actuator controllers
- Tracking system
- Wireless data transfer

Actuator

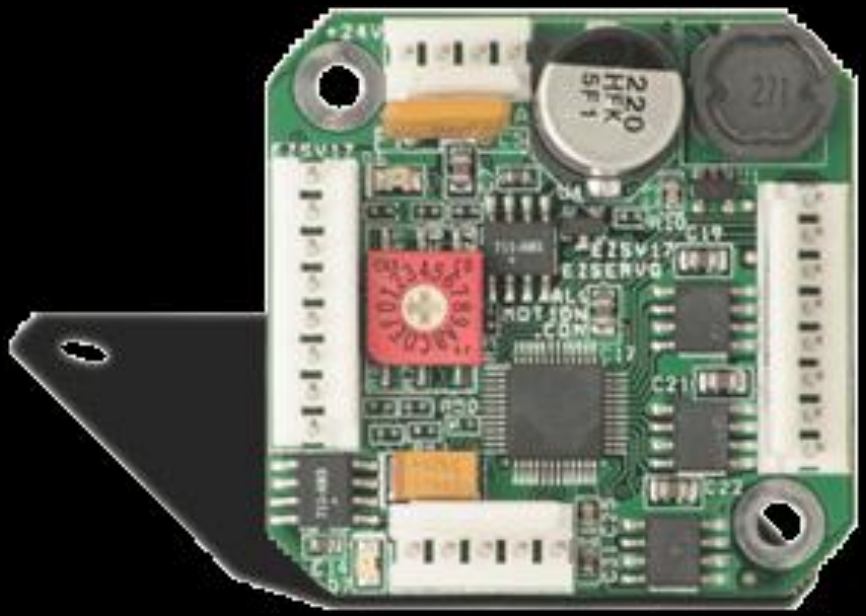
DC



- Most customizable option
- Unlimited control options (Position, Velocity and Acceleration can be controlled independently)
- High torque with gearbox
- Accurate control (Our encoder has 216,000 positions – 0.0017° accuracy)

Actuator Controllers: Motor Control System

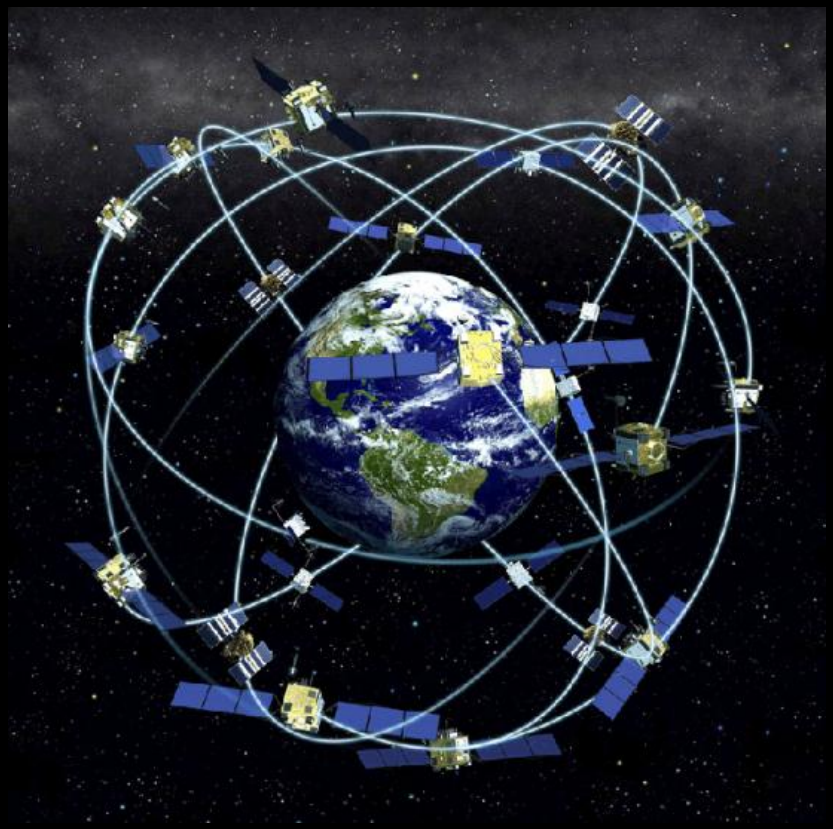
All Motion Motor Controllers



- Intuitive and simple commands
- RS232, RS485 or USB Based Communications.
- Homes to Encoder Index with single command
- Integrated PID closed loop control
- Motor outputs fully protected against shorts.
- 4 ADC Inputs
- Unlimited control options (Position, Velocity and Torque can be controlled independently)

Tracking

GPS



- Up to 10 Hz refresh rate
- 3m accuracy w/o differential
- Readily transferrable data (Via serial connection)
- Reasonably priced (typically 250 or less)
- Relatively simple electronic system

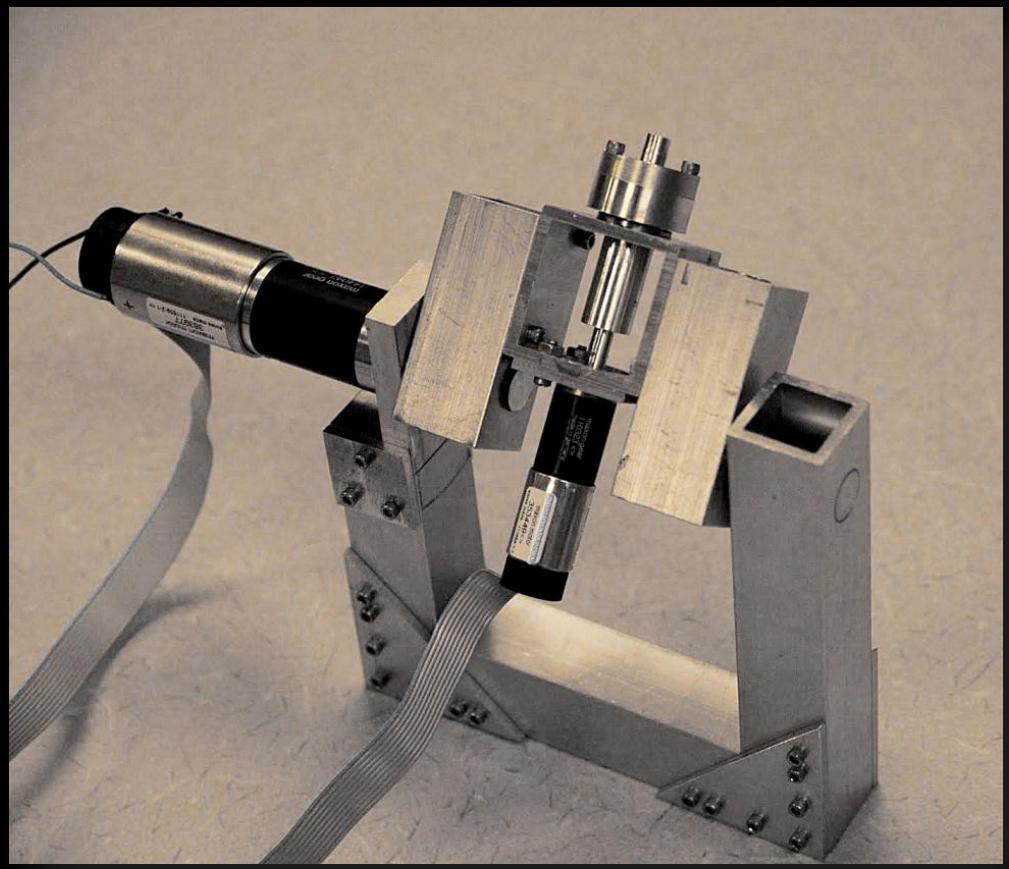
Wireless Data Transfer

Bluetooth

- High data transfer rate possible
- Cheap
- Plug and Play solution (No software, drivers or circuitry)
- RS232 adapter
- 100m range

Original Pan-Tilt Mechanism

- Fundamental Flaw
  - Pan motor above tilt motor
- Over-constrained
- Many components
- Many machining hours needed

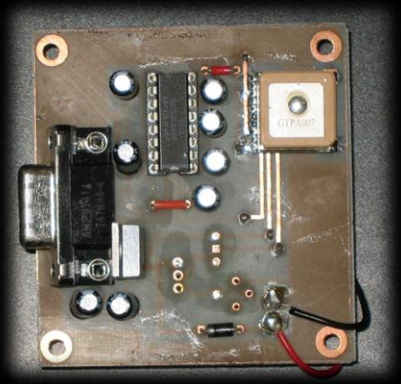


Current Pan-Tilt Mechanism

- Five components
  - Machined with CNC
- Efficient design
  - Center of mass of camera at center of rotation
  - Lightweight
  - Four bearings implemented
- Simple mount
- Flaw: No slip ring

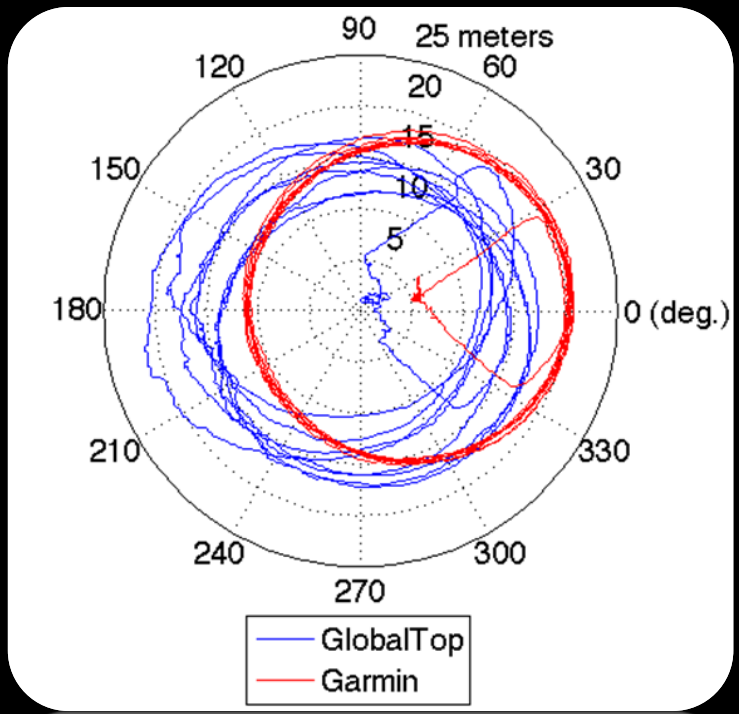
GPS Iteration

GlobalTop Module



- 10Hz update rate
- Requires data conversion circuit
- Exposed circuit
- $50.00

Module Comparison



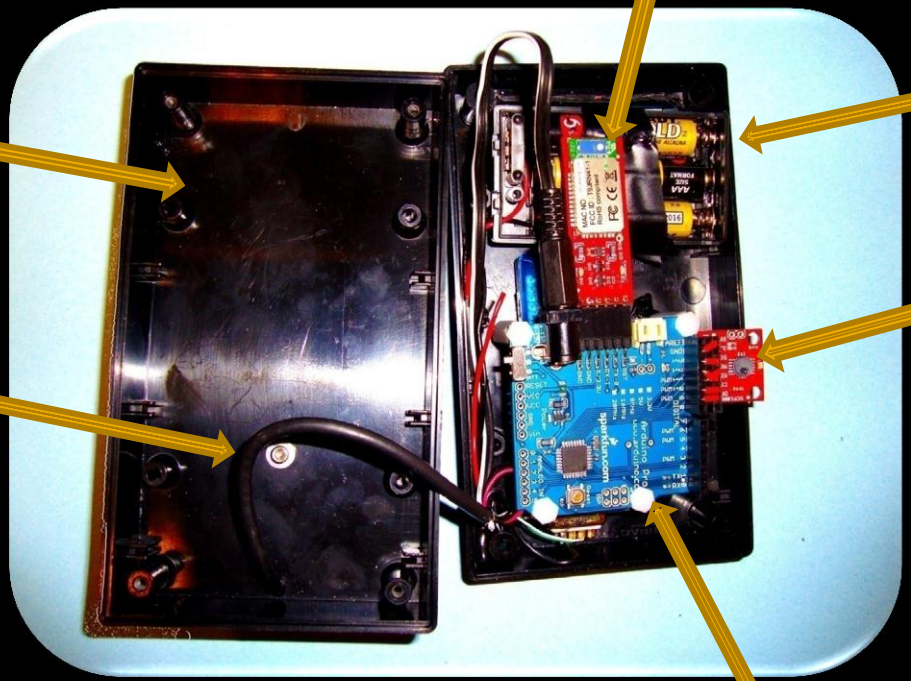
Garmin Module

- 5Hz update rate
- Compact with factory made circuit built in
- Trusted name
- $150.00

Pan-Tilt Housing

- Flaw: Optics are not ideal as can be seen by reflections

Rover Housing



Bluetooth

Waterproof Casing

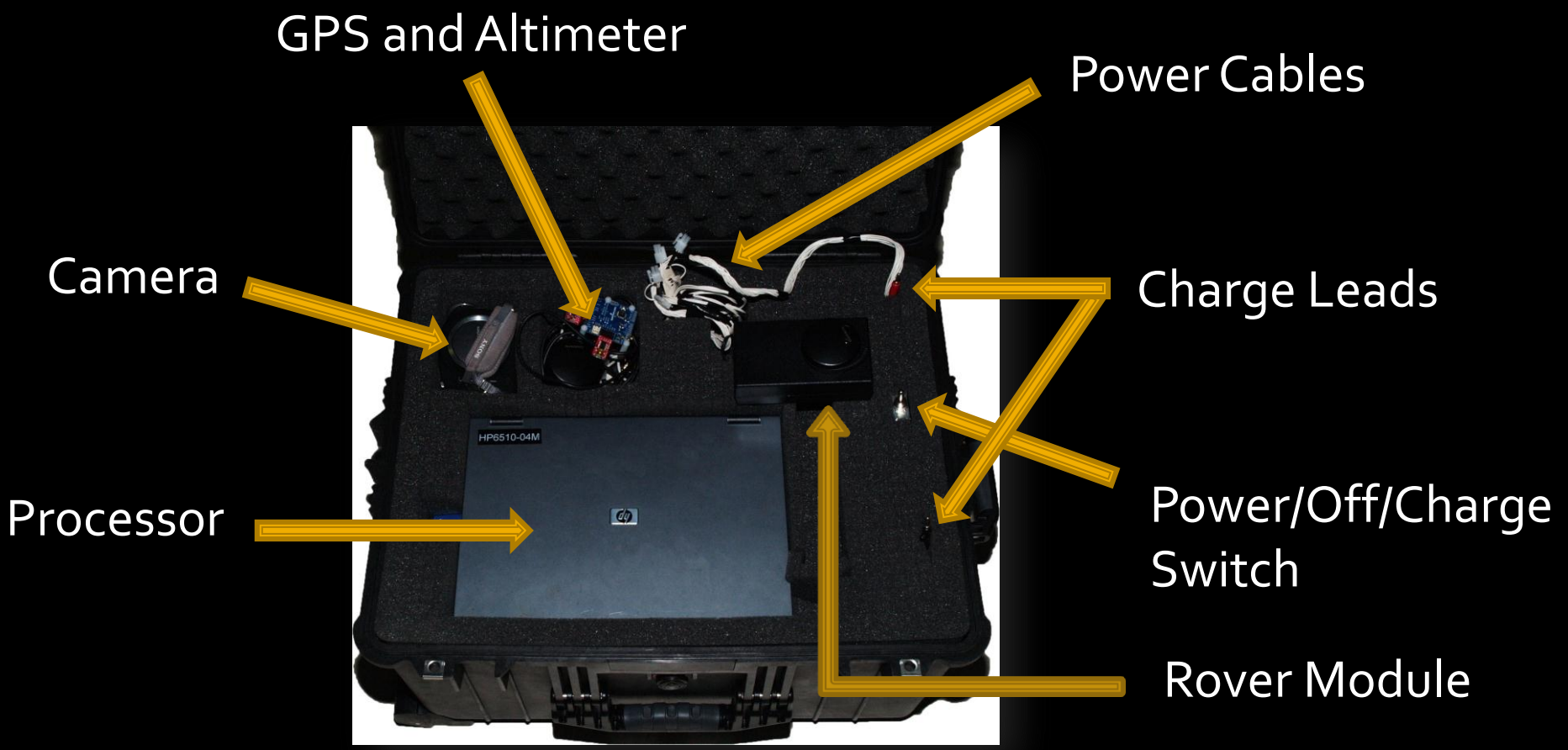
Battery Case

GPS Cable

Digital Barometer

Arduino Microcontroller

Component Housing



- All contained in portable and shock resistant Pelican Case
- Other components beneath: Battery, cables, and circuit

Circuit Design

24 V Deep-Cycle Battery

On/Off/On Switch

GPS

5 V Regulator

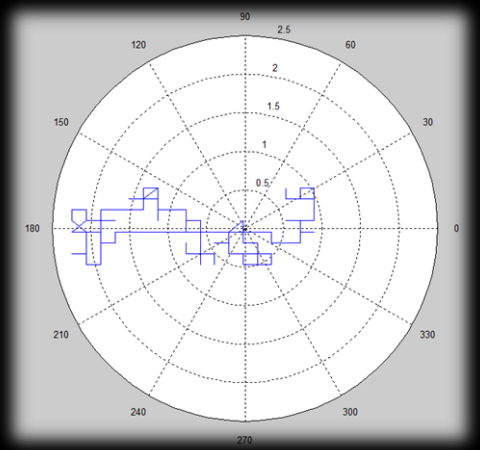
Tilt Motor Controller

Pan Motor Controller

Charge Leads

GlobalTop Testing

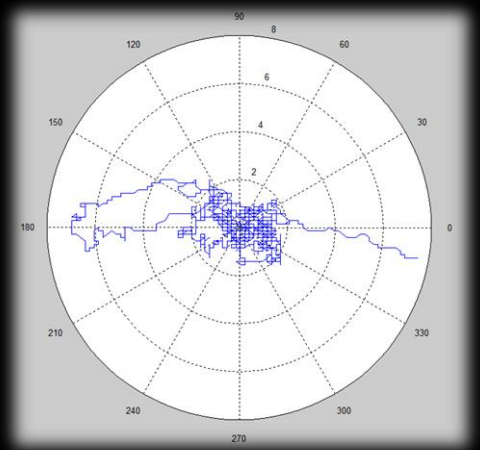
Stationary



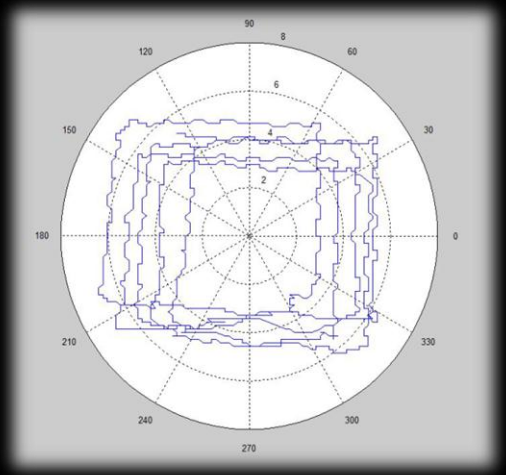
Conclusion:

GlobalTop GPS module is far too inaccurate

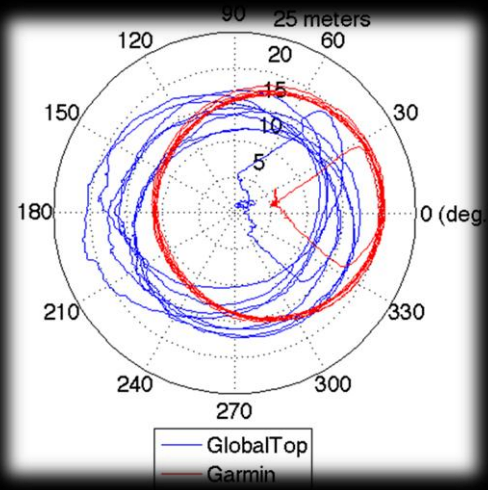
Stationary With Wiggle



Square Test



Garmin Comparison

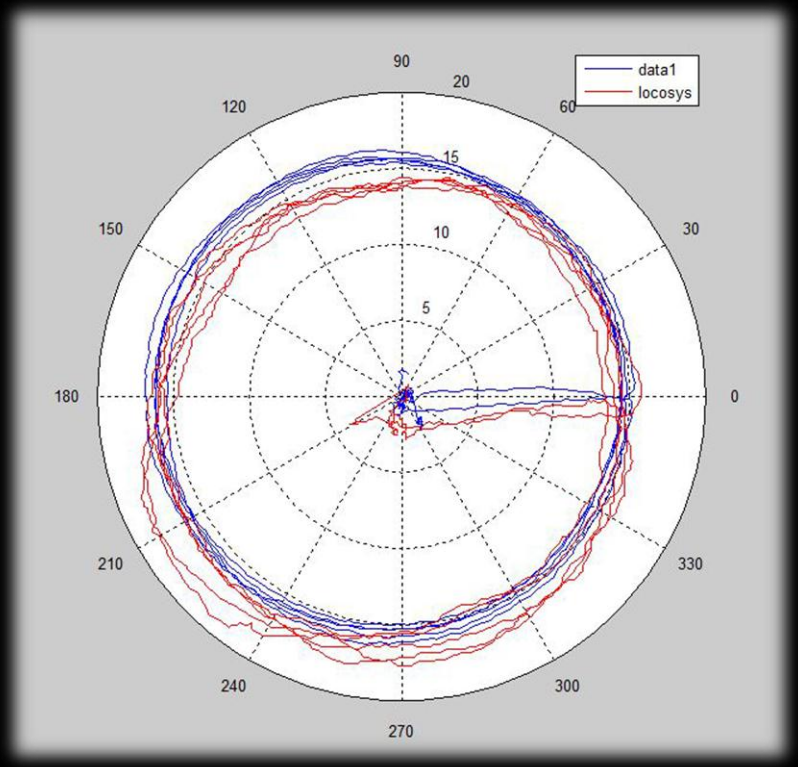


GlobalTop Testing

Two options to replace GlobalTop:

- Locosys 5 Hz Module
- Garmin 5 Hz Module

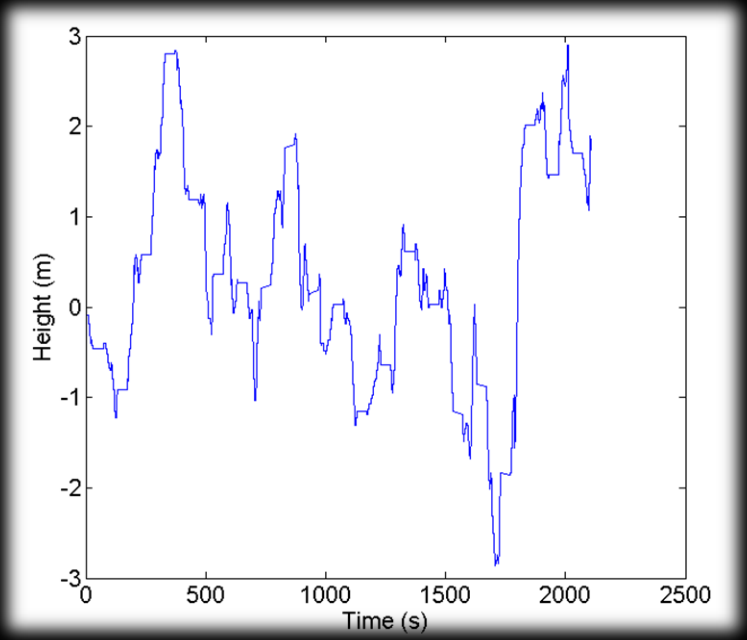
Locosys vs Garmin



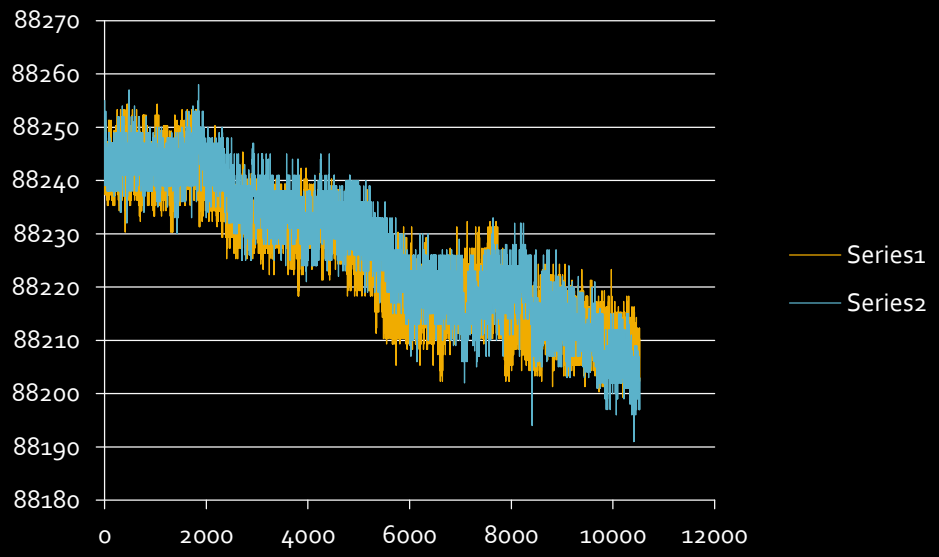
Conclusion: Garmin is the most consistent and the best option

Altitude Testing

GPS Altitude



Barometer Comparison



Note: Span of noise is 0.8 m which is within our specification

Conclusion: GPS altitude readings would not be sufficient, another method was needed

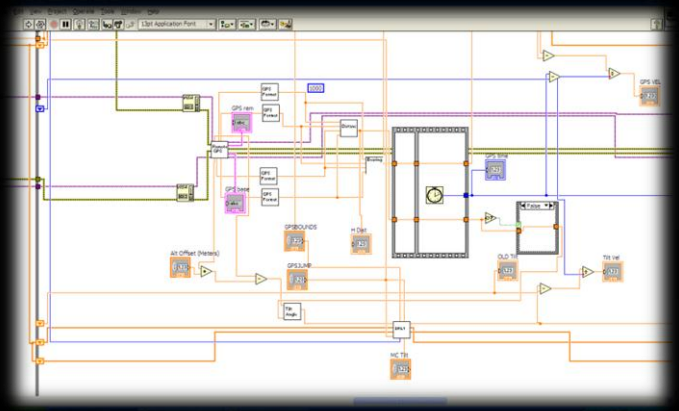
Final Product

Final Product

VIDEO

Challenges

- Technology research, selection, and implementation
- Learning and successfully implementing LabVIEW
- Signal processing and system controls
- Mathematical algorithm R&D
- Circuit design, construction, and implementation
- Hardware design and manufacturing techniques
- Independent funding (ME Department, UROP, EEF, and ITLL)



Lessons Learned

- Maintain a methodical and iterative design approach research and pursue every alternative until a clear choice emerges
- Do not waste time building something that can be easily purchased
- Keep prototypes SIMPLE
- Frequently seek expert advice
- Evenly distribute resources and responsibilities
- Test early and often to quantitatively analyze each element of system
- Be realistic about time and money (prepare for the worst)

Conclusions

- LabVIEW is a powerful tool
- Many methods of motion tracking are plausible for real-time applications
  - More research and testing needs to be done to find the best one
- GPS can be used for 2-dimentional tracking in real time
- GPS is inaccurate in measuring altitude
- Barometers are promising as an altitude measuring device
- Prediction software is key to tracking in real-time
- Innovation and entrepreneurship are inherently difficult endeavors

Recommendations

- Research alternative tracking methods (RF, Image Processing, IMU etc.)
- Integrate autonomous zoom functionality
- Proximity based system initiation
- Adjust system to track multiple subjects and uniquely identify them
- Implement more advanced mathematical algorithms to refine precision
- Investigate effects of combining multiple tracking methods
- Redesign hardware for manufacturability, assembly and aesthetics
- Improve optical subsystem for inclement weather
- Integrate a self sustained power supply (e.g. solar cells)