Combining Multiple, Inexpensive GPS Receivers to Increase Accuracy and Reliability

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Introduction

Current State of Consumer-Grade GPS

- GPS receivers have become small & inexpensive enough to be fairly ubiquitous

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- Consumers can expect accuracy of about 10 meters, assuming no augmentation is used **

* http://www.sparkfun.com/products/465

** Product User Manual GPS Receiver Engine Board EM-406A

Significance of the Problem

- As our reliance on GPS continues to increase, our demand for accuracy and reliability increases, too
  - GPS is seeing more and more applications
- Most users cannot afford (or even get access to) survey-grade or military-grade GPS equipment
  - Need restricted access to P-code receivers for military-grade
  - Need a big budget for survey-grade

Significance of the Problem

- Methods of improving GPS already exist
  - Such as DGPS, WAAS, IMUs
- Military/survey-grade equipment can cost $25,000 or more *
- GPS (and therefore, traditional augmentation) struggles without a sky view
  - Method/algorithm that can use pseudolites, as well as GPS, has an important advantage

* Wing, M. G., Eklund, A., & Kellogg, L. D. (2005, Jun). Consumer-grade Global Positioning System (GPS) Accuracy and Reliability. Journal of Forestry, 103 (4), 169-173.

Significance of the Problem: Example

- Robots were used in rescue operations following the World Trade Center attacks *
  - Position sensors, such as IMUs and GPS receivers, were not used
  - Audio/video devices can easily become useless

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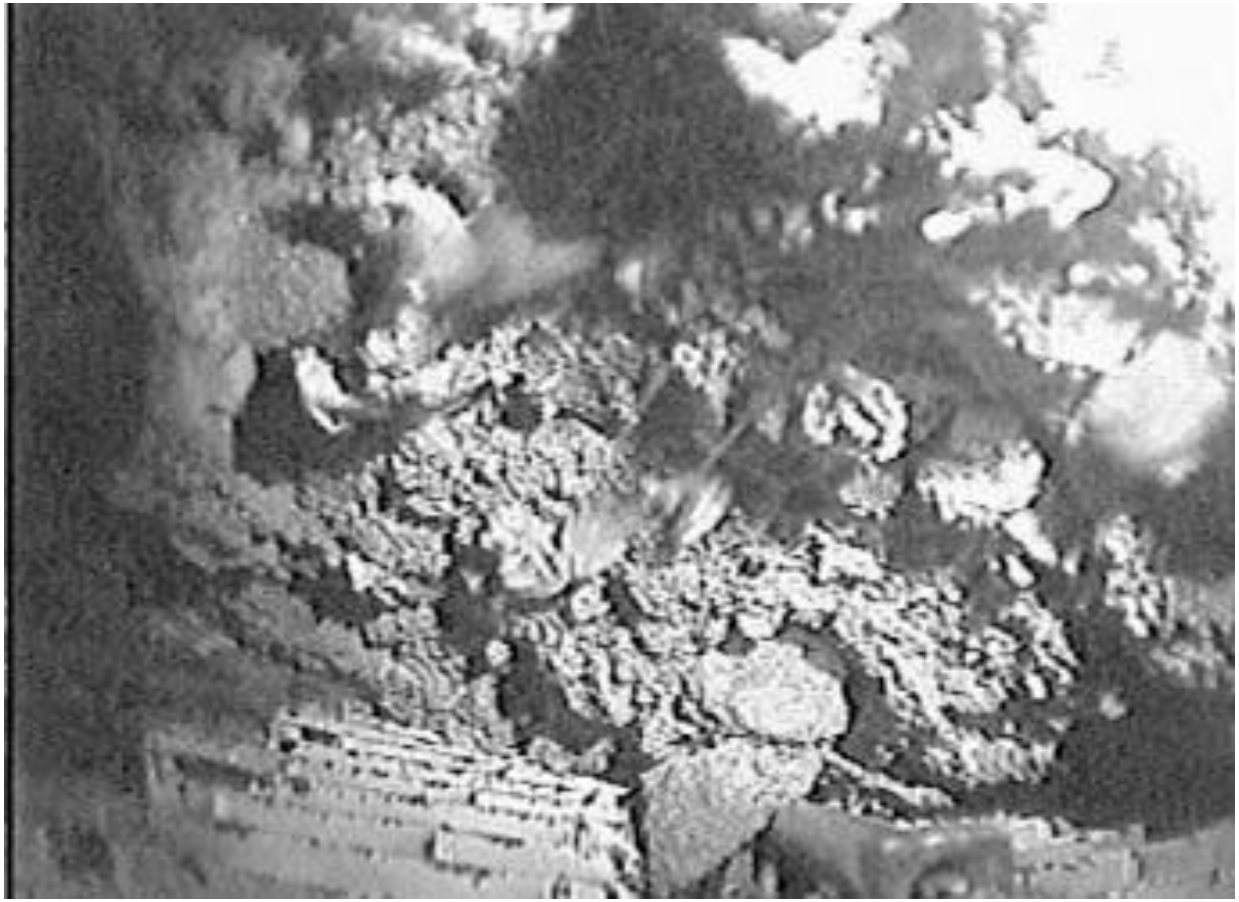
* Casper, J., & Murphy, R. (2003, June). Human-Robot Interactions during the Robot- Assisted Urban Search and Rescue Response at the World Trade Center. Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on, 33 (3), 367 - 385.

Disorienting view when a rescue robot was flipped upside down in a void in the WTC rubble.



Significance of the Problem: Example

- Simply putting a "standard" GPS receiver on the robot would probably not be sufficient
  - Rescuers would only know the robot's location to within 10 m
    - Search area of about 314 square meters

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* Casper, J., & Murphy, R. (2003, June). Human-Robot Interactions during the Robot- Assisted Urban Search and Rescue Response at the World Trade Center. Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on, 33 (3), 367 - 385.

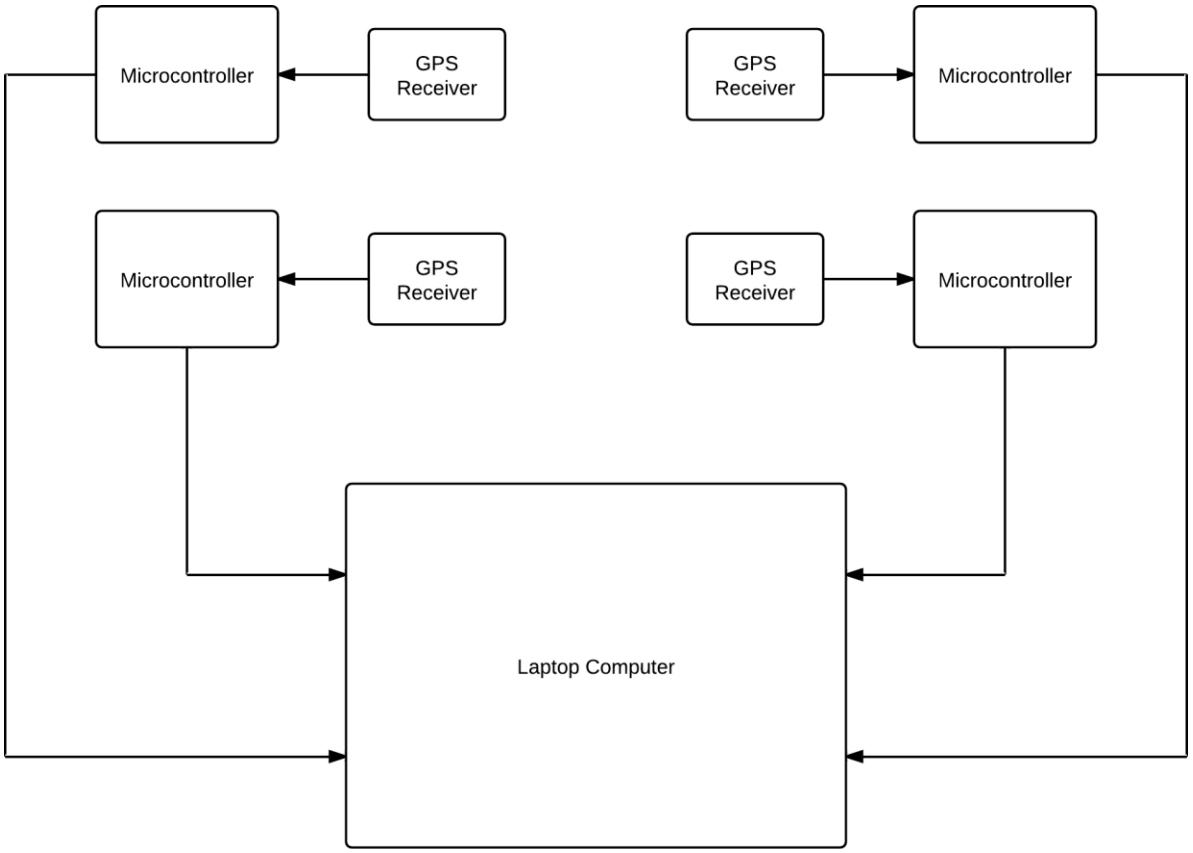
A large (approximately 12 m deep) crater near WTC Tower 2. The white square marks the entrance to a small void (0.3 x 0.5 m) searched.

Methodology

CHAPTER 3

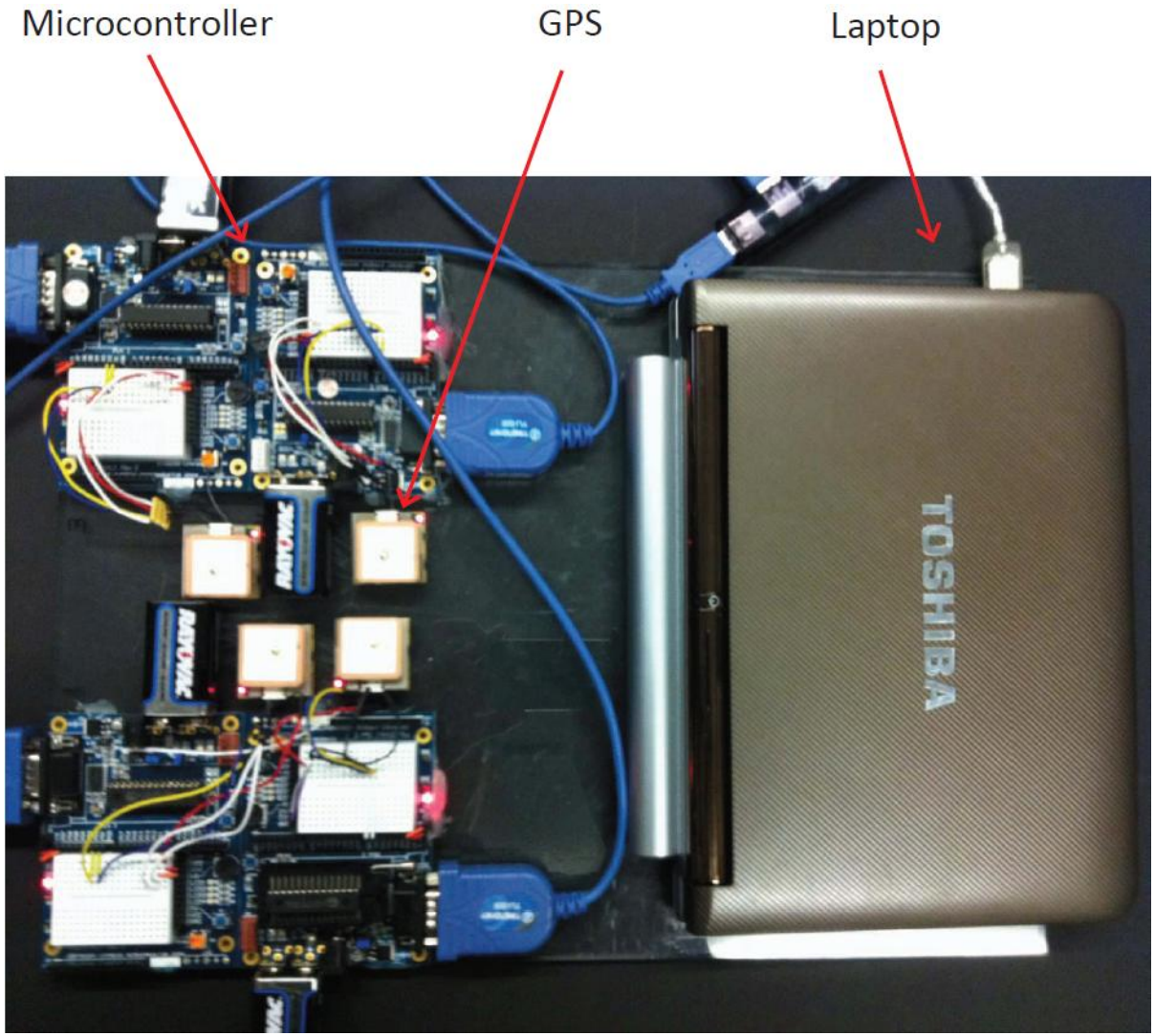
Proof of Concept

Diagram of test setup for proof-of-concept stage



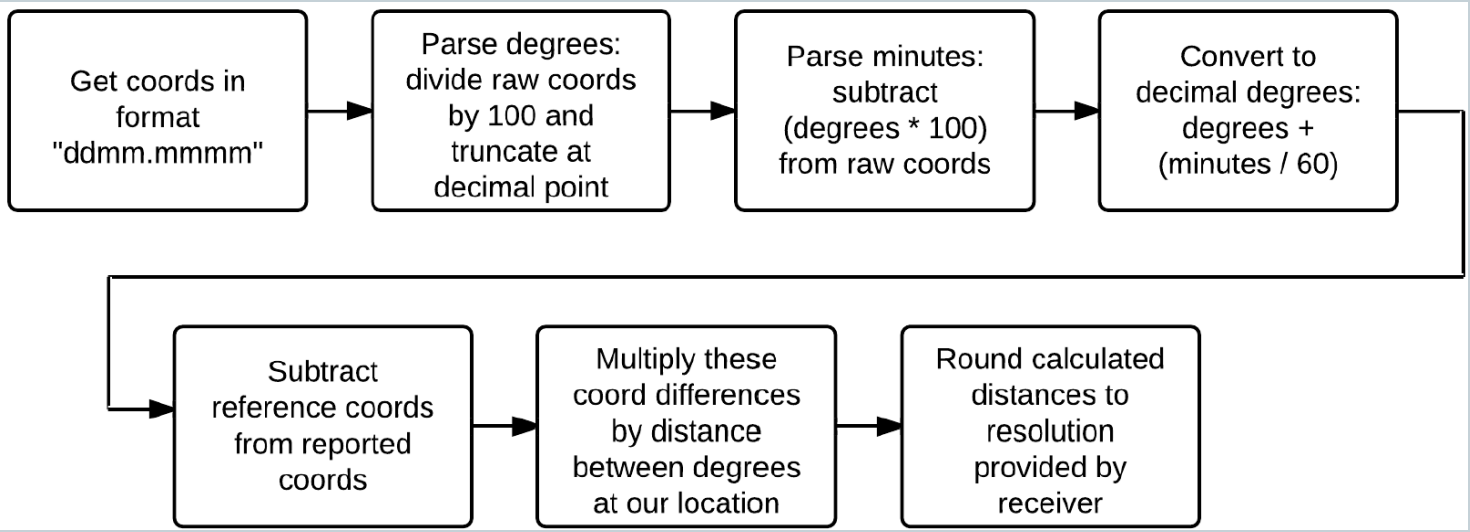
Proof of Concept

Picture of test setup for proof-of-concept stage



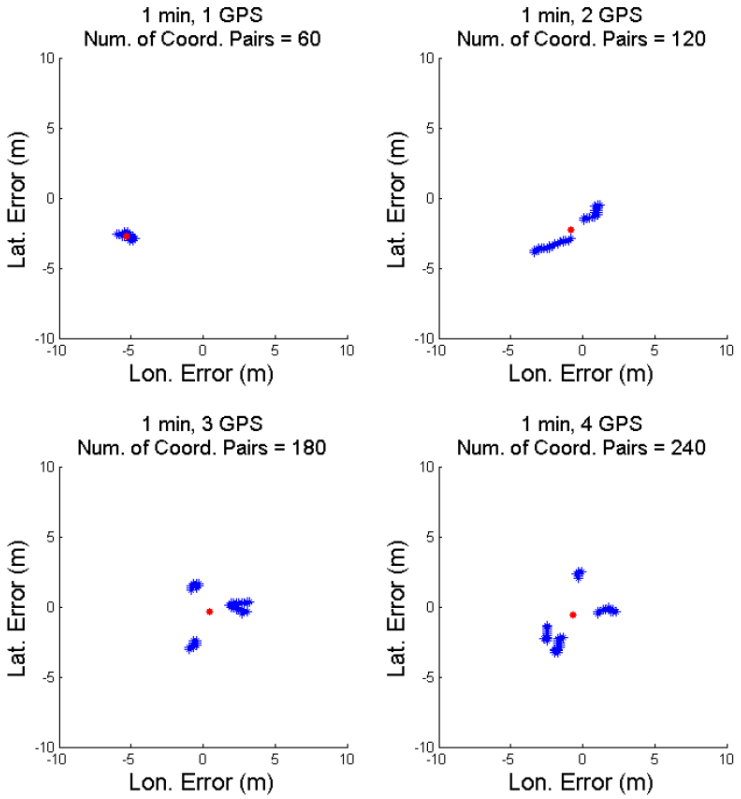
Proof of Concept

- Process used for converting “raw” GPS coordinates into errors (distances from the reference point):

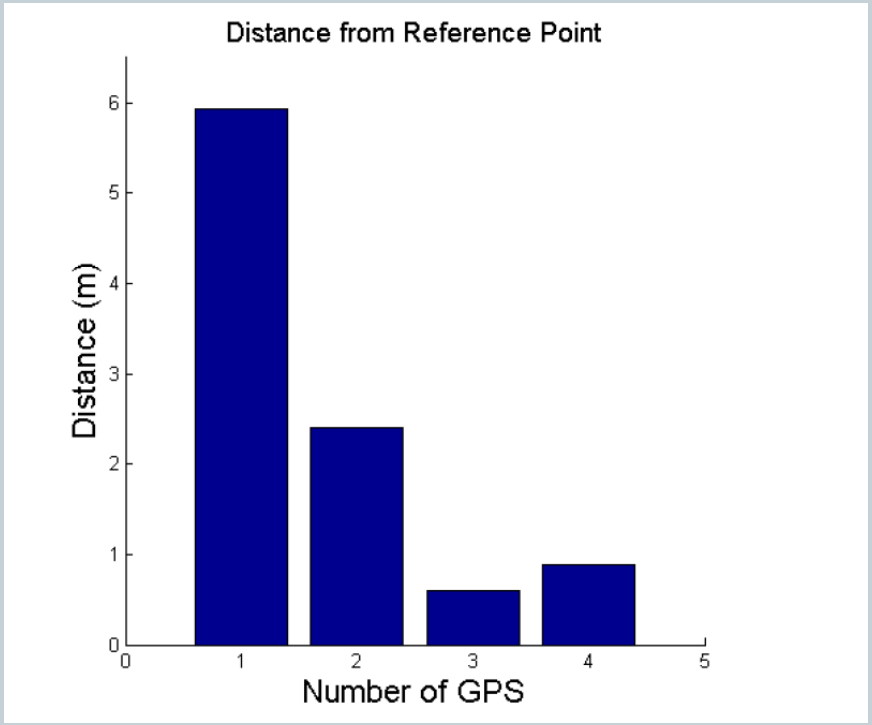


- This was done for each set of coordinates, then these results were simply averaged

Proof of Concept

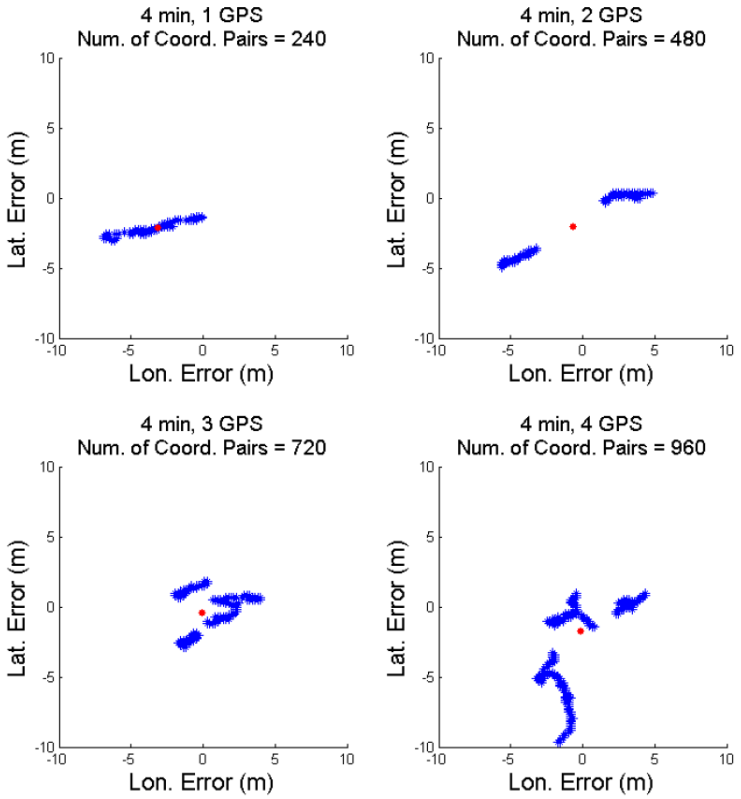


Latitude and longitude errors for a 1 minute trial

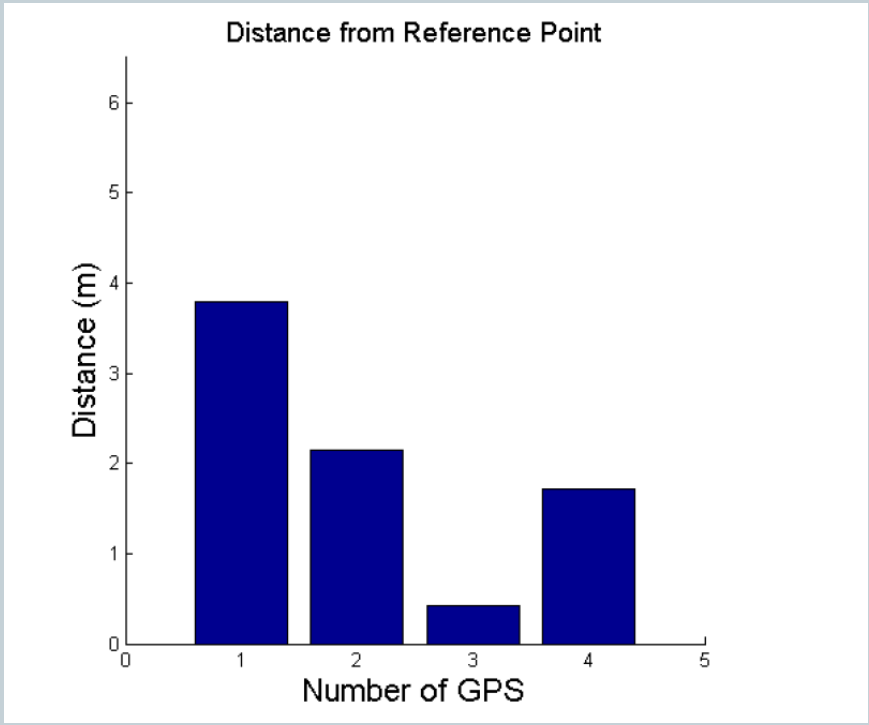


Average errors for a 1 minute trial

Proof of Concept

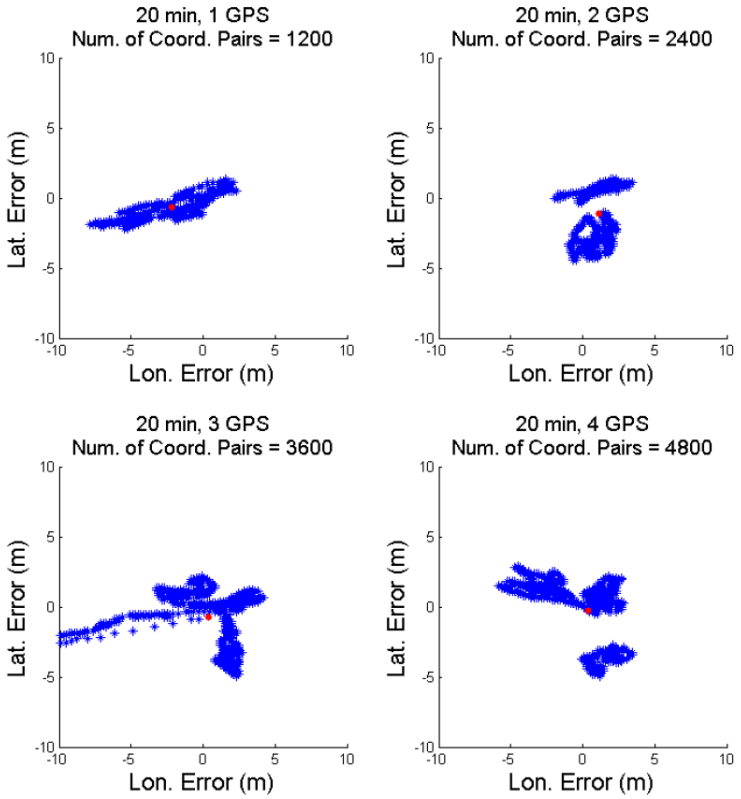


Latitude and longitude errors for a 4 minute trial

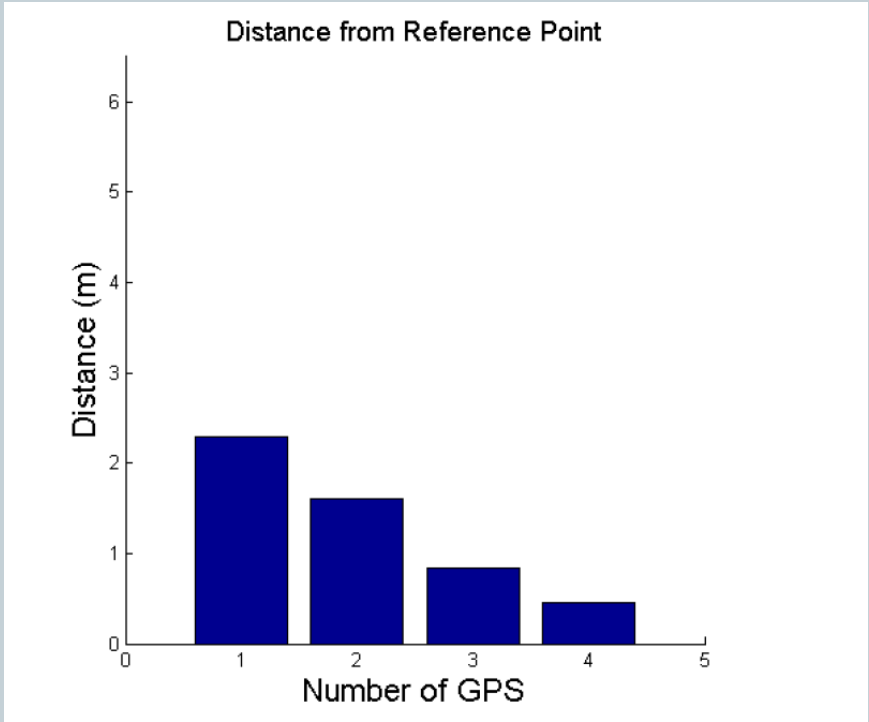


Average errors for a 4 minute trial

Proof of Concept



Latitude and longitude errors for a 20 minute trial



Average errors for a 20 minute trial

Summary

- Hypothesis of using multiple receivers to improve accuracy appears valid
  - According to preliminary data
  - Some anomalies need investigation
- Moving forward, issues will likely arise when a more integrated system is developed
  - Power requirements of larger numbers of GPS receivers
  - Interference from surrounding electronics
  - Diminishing returns

Thank you!