BRADLEY UNIVERSITY

NORTHROP GRUMMAN

SATELLITE AND INERTIAL NAVIGATION AND POSITIONING SYSTEM (S.I.N.A.P.S.)

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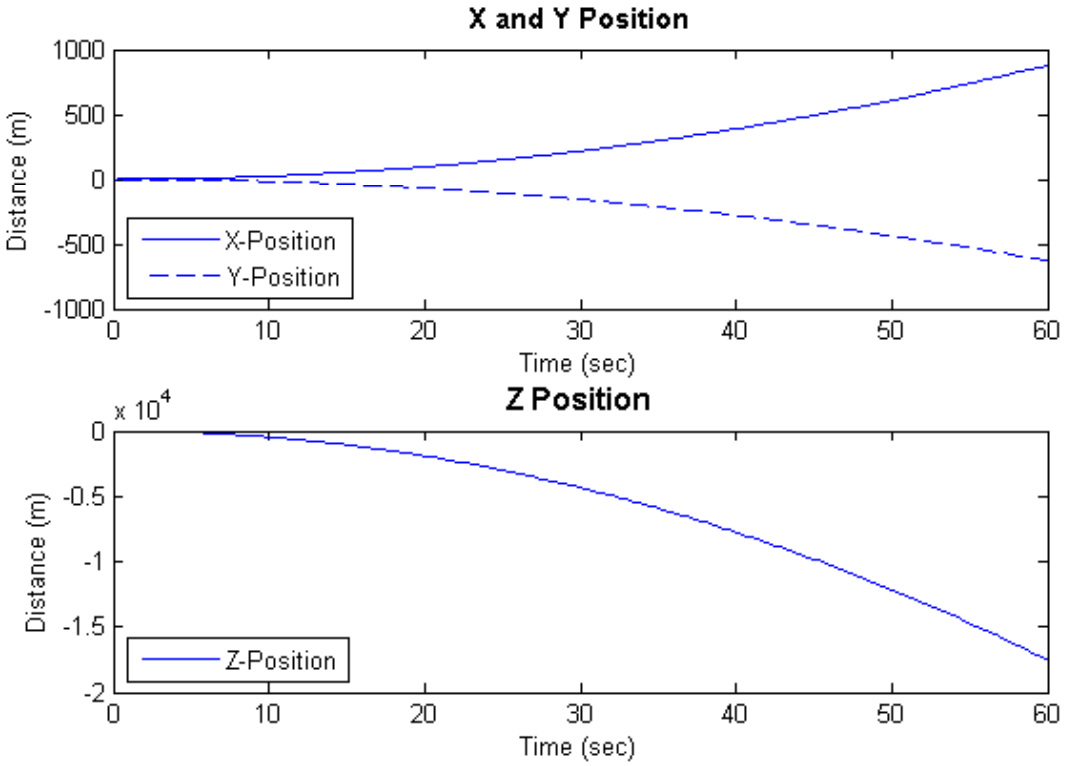
Introduction To Inertial Navigation

- Dead Reckoning
  - Accelerometers
  - Gyroscopes
- Magnetometers
- Traditional IMUs (RLG or FOG) : Robust but Expensive
- MEMS-based IMU: Very cheap in comparison but susceptable to measurement error

Sources of Error

- IMU Drift
- IMU Misalignment
- Random Walk

IMU Drift


X and Y Position
Distance (m)
1000
500
0
-500
-1000
0
10
20
30
40
50
60
Time (sec)
X-Position
Y-Position
Z Position
x 10^4
0
-0.5
-1
-1.5
-2
Distance (m)
Time (sec)
Z-Position

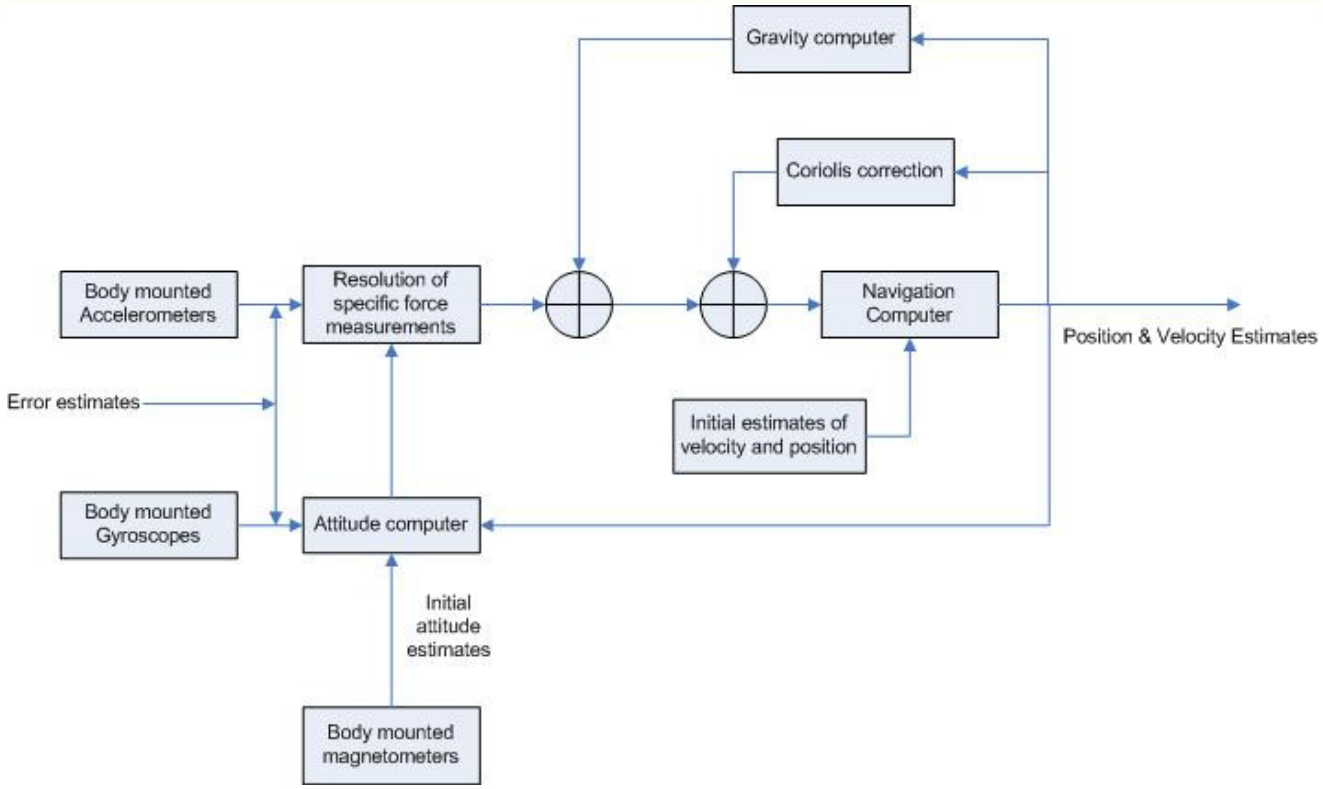
WHY GPS + IMU?

- IMU provides attitude information in addition to position and velocity updates
- GPS provides “truth system” to correct drift
- IMU can provide position information during GPS outage
- Unified system improves system robustness

Strapdown Navigation

- Navigation system is rigidly attached to the body and experiences all of the same forces (unlike stationary-platform)
- Determines vehicle attitude from accelerometer and gyroscope data
- Compensates for gravity and Coriolis forces
- Handles various frame mechanizations (LLC, ECEF, NED, etc)

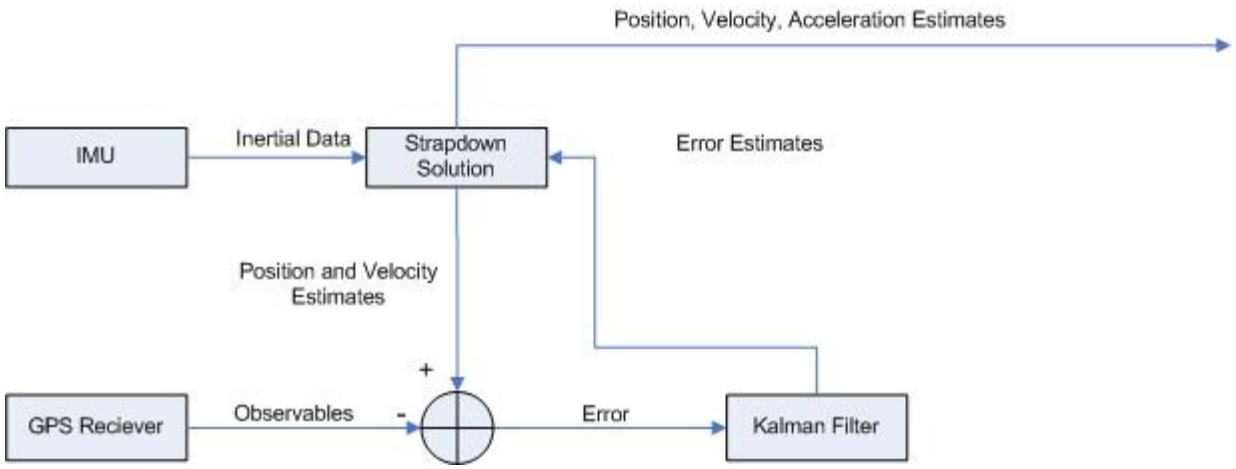
Strapdown Navigation



Types of Systems

- Loosely Coupled
  - Calculated corrections on processed data
  - Easier To Implement
  - Less accurate
- Tightly Coupled
  - Corrections on raw IMU data
  - Robust to measurement errors, more accurate
  - Computationally Complex

S.I.N.A.P.S. Overall System (Tightly Coupled)



KALMAN FILTER

- Kalman Filter is Optimal State Observer
- Can be used for post processing or real-time processing
- 16 error states
  - Position (3)
  - Velocity (3)
  - Acceleration bias (3)
  - Quaternion (4)
  - Angular rate bias (3)

System Requirements

- Inertial Sensor : VN-100
- GPS : Ublox GS407 (tentative)
- System programmed entirely in MATLAB, interfaced with USB
- Need to build a physical platform

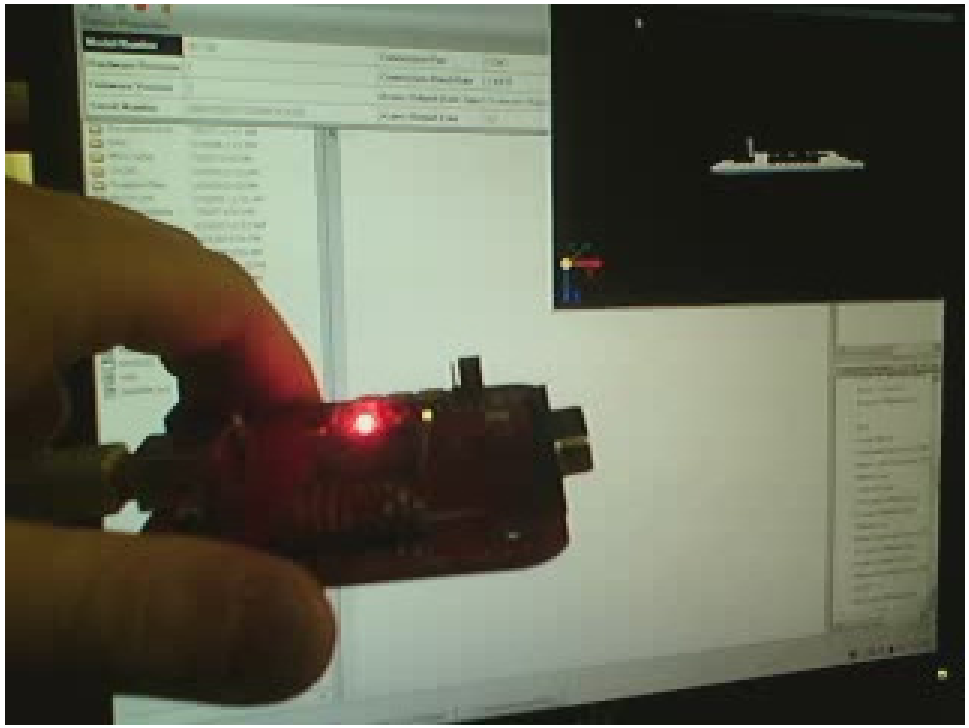
SPECIFICATIONS

- The overall position accuracy and robustness of the system will be determined by the initial components selected.
- The GS407 is capable of <2m accuracy
- The unfiltered IMU exhibits drift less than 50m within a GPS outage of 5 seconds .

Current Work

- Purchased IMU (VN-100)
- Interfaced VN-100 to MATLAB
- Strapdown Solution
- Kalman Filter

VN-100 In Action



Future Work

- Unfiltered Data From VN-100
- Purchase and Interface GPS with MATLAB
- Implement Strapdown
- Make Platform
- Model error Sources in State Space
- Test Tightly Coupled System with Extended and Unscented Kalman Filter

Project Schedule

Project Schedule

Break		Test IMU, Get Performance Specs, Interface With MATLAB, Buy GPS
Jan	25	Test GPS, Get Performance Specs, Interface With MATLAB
Feb	1	Read unfiltered Sensor data from IMU, Write Strapdown Solution and Conversions, Build Platform
	8	Standard Kalman Filter, Model in State Space
	15	Test Completed System, Get Performance Specs
	22	
Mar	1	Extended Kalman Filter
	8	Test Completed System, Get Performance Specs
	15	
	22	Unscented Kalman Filter
	29	Test System, Get Performance Specs
Apr	5	
	12	Final Report, Presentation
	19	
	26	

REFERENCES

[1] A. Waegli and J. Skaloud, *Optimization of two gps/mems-imu integration strategies with application to sports*, GPS Solutions, [Online], Available: {http://dx.doi.org/10.1007/s10291-009-0124-5}

[2] C. Hide and T. Moore, *GPS and Low Cost INS Integration for Positioning in the Urban Environment*, In Proceedings of the Institute of Navigation GNSS 2005, Long Beach, CA, September 2005.

[3] D.H. Titterton and J.L. Weston, *Strapdown Inertial Navigation Technology, 2nd Edition*, The Institution of Electrical Engineers, (2004)

[4] C. Verplaetse, *Strapdown Systems*, Created Friday, May 26, 1995, [Online], Available: {http://xenia.media.mit.edu/~verp/projects/smartpen/node8.html}

Any Questions?

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