Improving Inertial Sensors on the OVERBOT

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Project Motivation

- Current inertial sensors are vulnerable to temporal drift
- Sensor drift produces errors of 2-4 meters for every 100 meters of dead-reckoning on pavement [1]

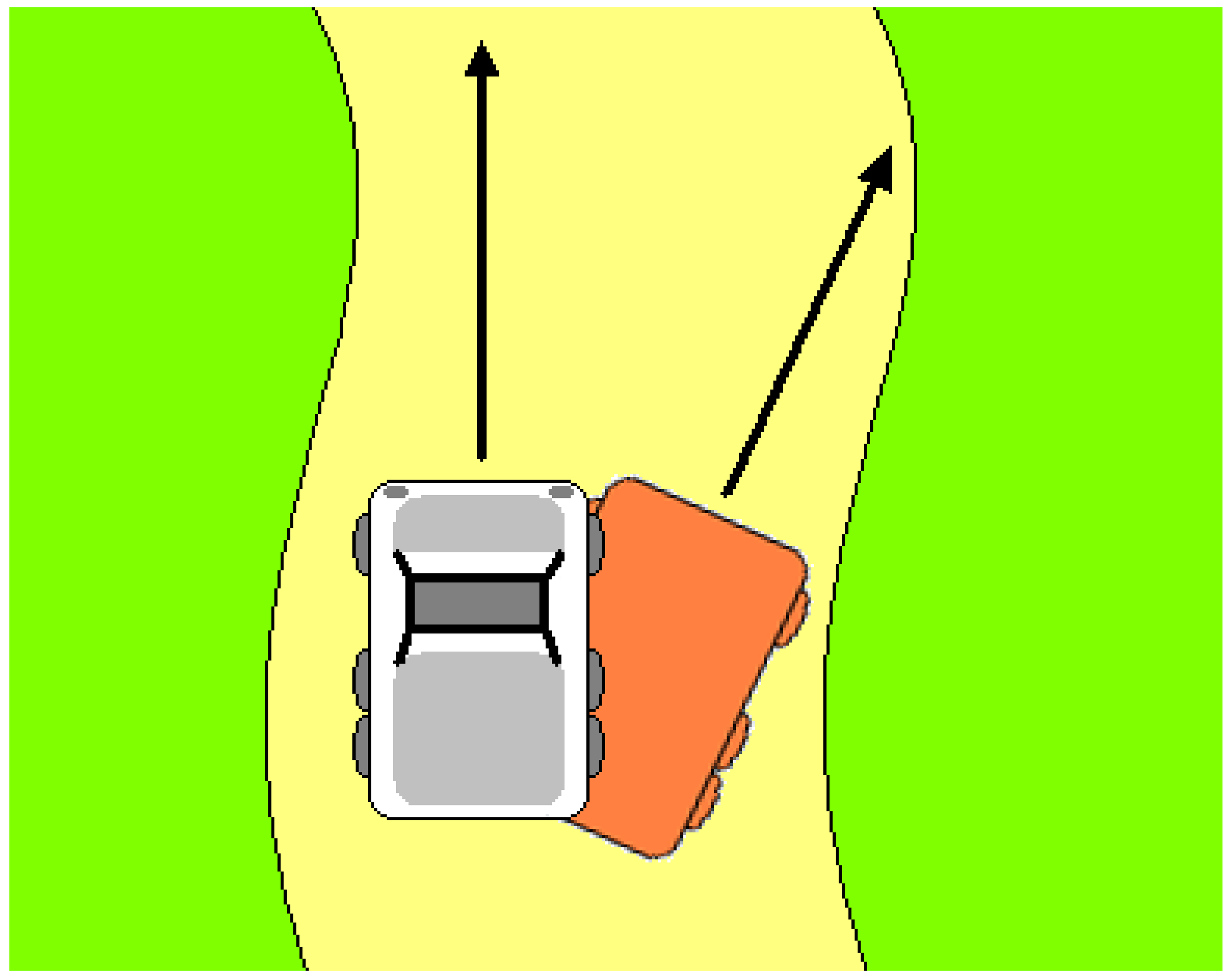


Figure 1. Actual vehicle heading (white), compared to erroneously estimated vehicle heading (orange)

Background: Sensor Fusion

High-level path finding is accomplished by blending information from three primary sensor groups:

SICK Laser Range Finder

- Scans terrain ahead of the vehicle
- Data used to build global "terrain map" of drive-able regions

Crossbow Inertial Unit

- Determines vehicle's attitude and heading
  - 3 axis MEMS linear accelerometer
  - 3 axis MEMS rate gyroscope
  - 3 axis MEMS magnetometer

NovAtel GPS

- Determines the vehicle's global position with varying levels of accuracy
  - 15 cm. accuracy – Ideal; Inertial unit ignored
  - 1 m. accuracy – Inertial unit used to correct position
  - No GPS – Inertial unit used to "dead-reckon"

Proposed Solution

- Replace existing Crossbow inertial unit with two separate, high-precision modules:
  1). MIDG INS/GPS Unit
  2). KVH DSP-3000 Fiber Optic Gyroscope
- Apply a Kalman filter to the output of both units to accurately estimate position and heading

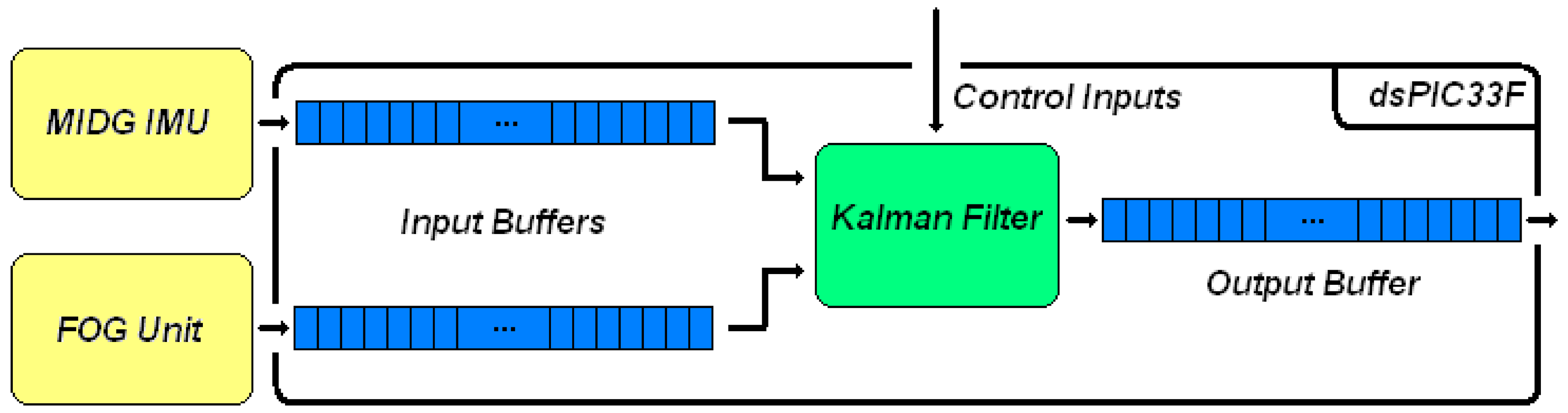
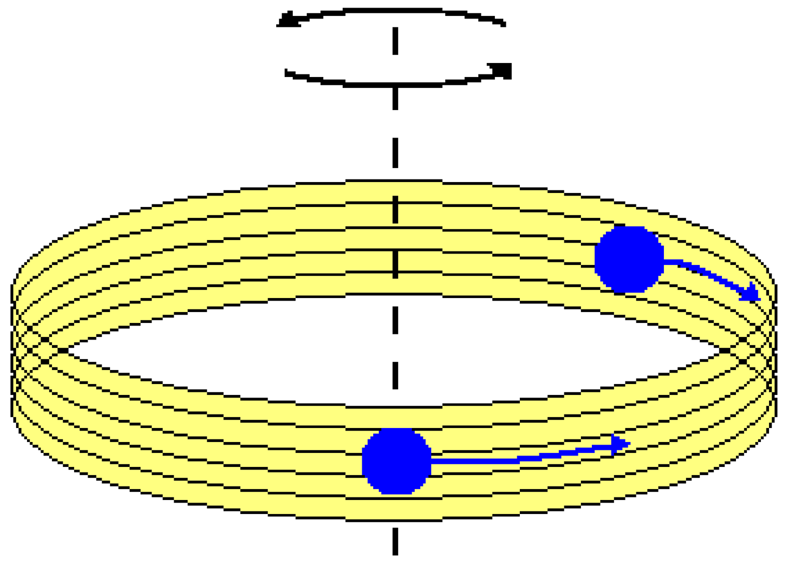


Figure 2. Block diagram of proposed solution. FOG unit was interfaced this summer through a dsPIC33F microcontroller

Fiber Optic Gyroscope (FOG)

- High-precision alternative to MEMS gyroscopes
  - 10 deg./hour drift vs. 200 with MEMS gyros [2]
- Optical interference used to determine rotation rate
  - Phase difference is dependent on the angular velocity



Implementation

- A dsPIC33F microcontroller is used to interface with the FOG module
  - Increases modularity
  - Lessens load on primary computer
- FOG input read in through built-in UART at 38400 baud
- Data passed through input and transmit buffers
- Transmit and receive are interrupt-driven, allowing microcontroller to perform background Kalman filtering

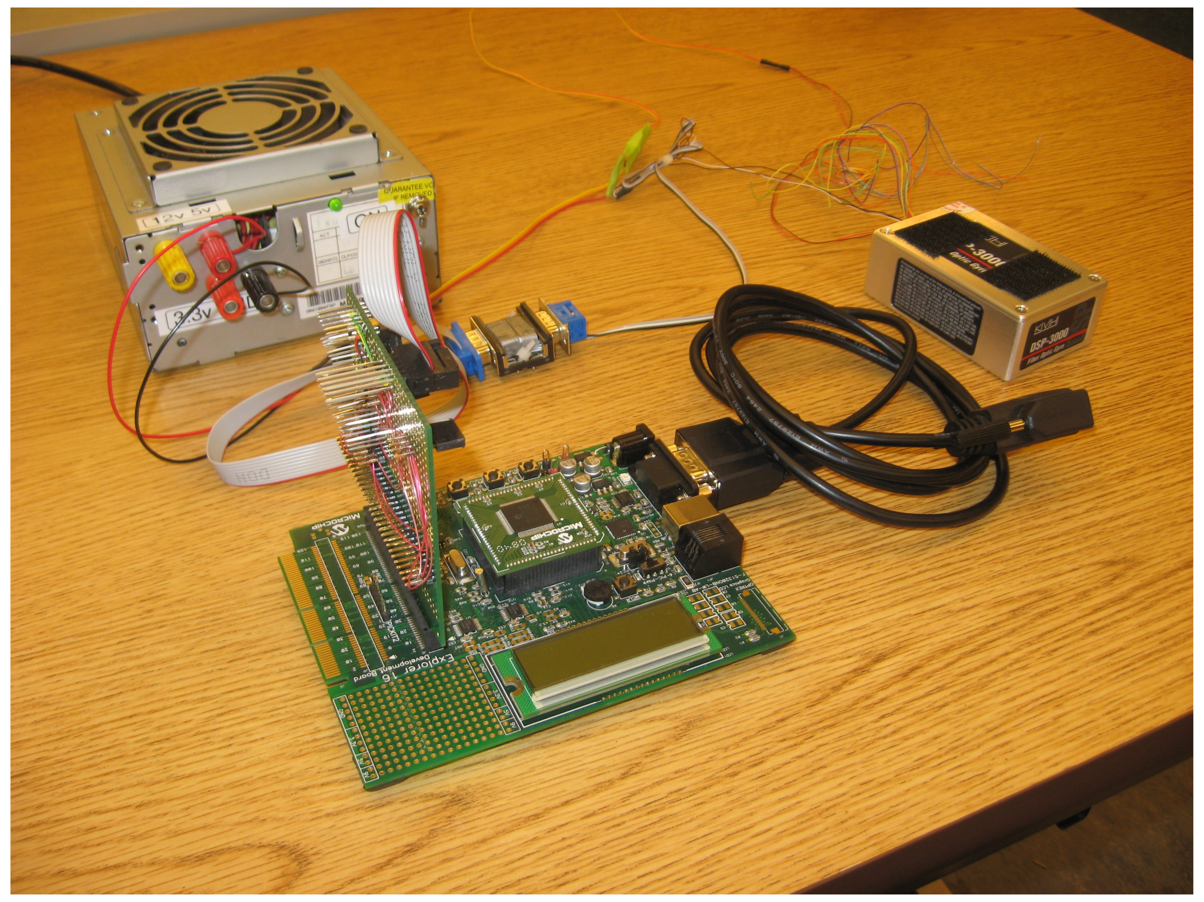


Figure 3. FOG unit interfaced to dsPIC33F board

Conclusion

- FOG unit effectively reduces temporal drift from 200 to 18 deg./hour
- A third UART module is needed in order to incorporate the MIDG. The dsPIC33F has two, so an external SPI to UART conversion chip will be used

References

[1] Team Overbot. (2005). DARPA Grand Challenge 2005 Technical Paper.
[2] Elkaim, G., Lizarraga, M., Pedersen, L., *Comparison of Low-Cost GPS/INS Sensors for Autonomous Vehicle Applications. 2008.*