Continuous Wellbore Path Estimation Using Multiple Integrated MEMS Sensors

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47th General Meeting
April 11th, 2018
Inverness, Scotland

ISCWSA

Speaker Information

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- P.Eng, Ph.D.(Japan, Control & Robotics,2006), Ph.D. Candidate (Subsurface Sensing)
- April 11, 2018
- Micro Engineering Dynamics and Automation Lab (MEDAL)

  University of Calgary, Canada, 2015-present

  www.ucalgary.ca/medal
- University of Waterloo, Canada, 2013-2014
- R&D department of Isuzu Motors (Tokyo), 2006-2013

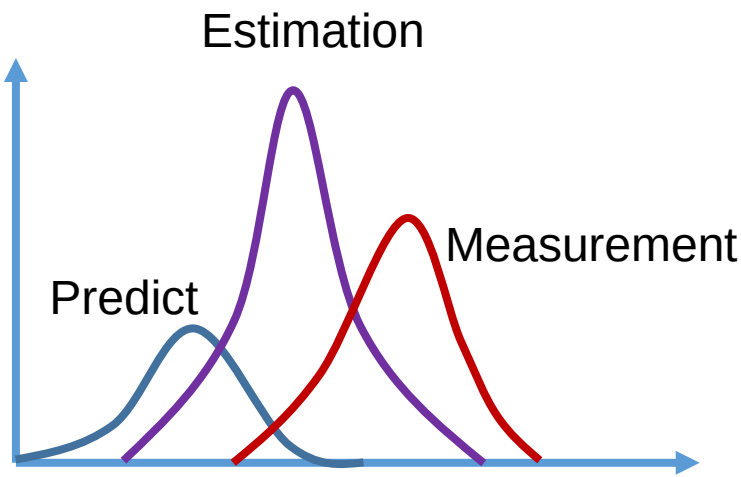
Specializes in:

Sensor fusion, data processing, control, mechanical system dynamics…

Outline

- Problems and Challenges
- Objectives
- Methods and Experiments
  - A. Methods (Angle & Position)
  - B. Tests (Lab Scale & Field Scale)
- Summary

Problems and Challenges



1) Low robustness to unknown interference
[Goodall, 2009]

2) Field calibration hard
[Li, 2015]

3)Low accuracy on position estimation
[Stockhausen, 2016]

Objectives

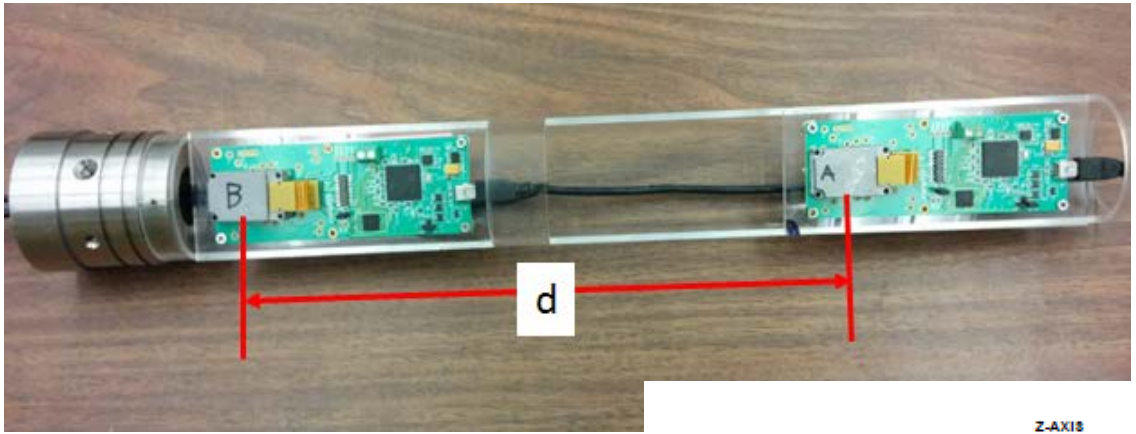
1. Hardware Design of Proposed Subsurface Measurement System

2. Robust Orientation Fusion-minimizing Magnetic Distortions for Azimuth Control

- Local Fusion –Quaternion Kalman Filter(QKF)
- Global Fusion –Adaptive Neuro-Fuzzy(ANFIS)

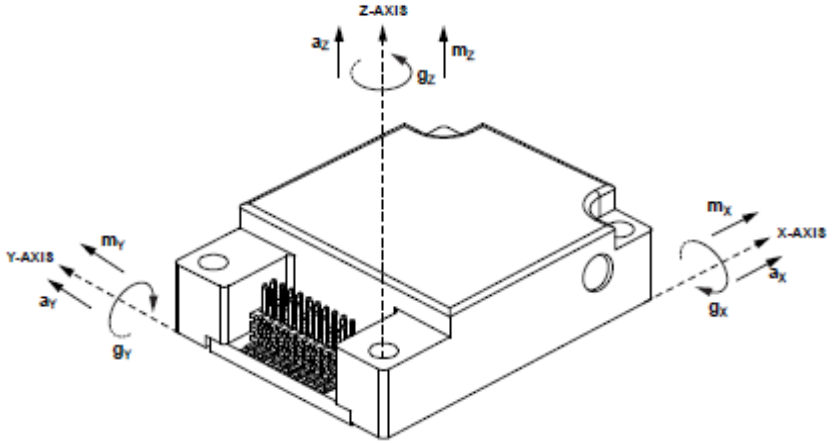
3. Identification of Position

Experimental Setup



2 MEMS IMU sensors

- 3 axis accelerometers
- 3 axis magnetometers
- 3 axis gyroscopes



MEMS based Monitoring System

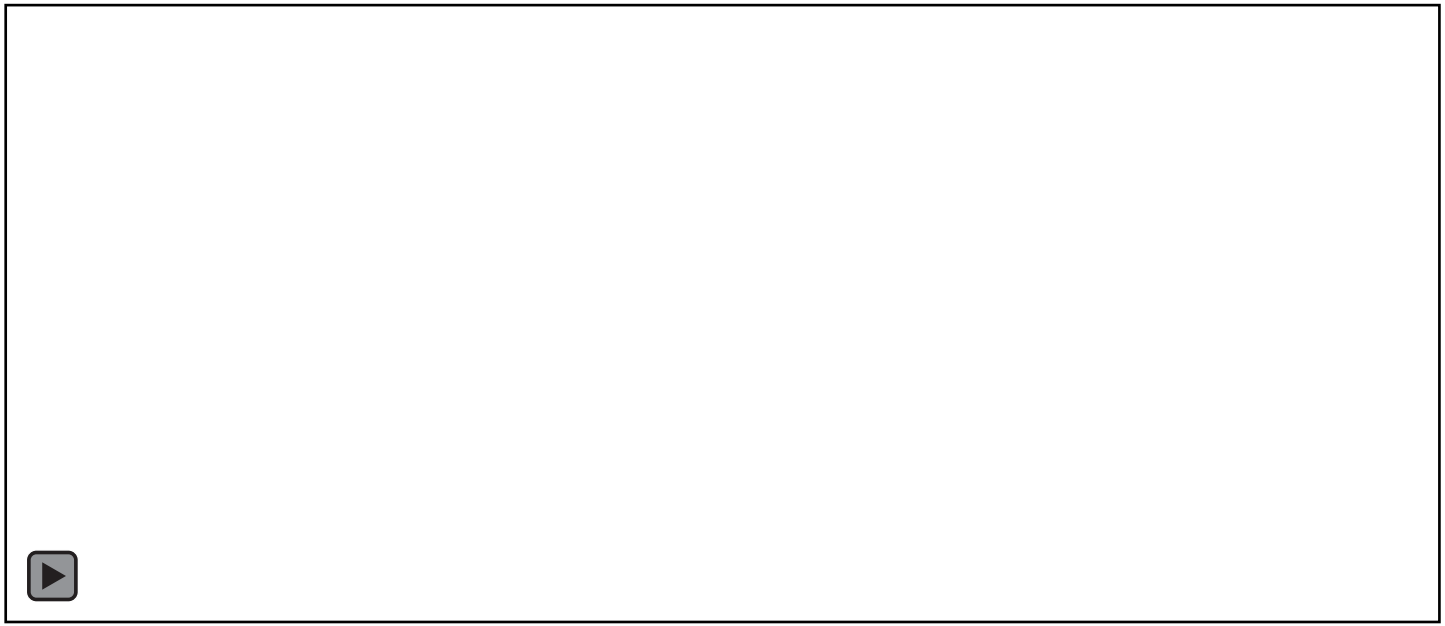
Sensor

100 feet
long cable

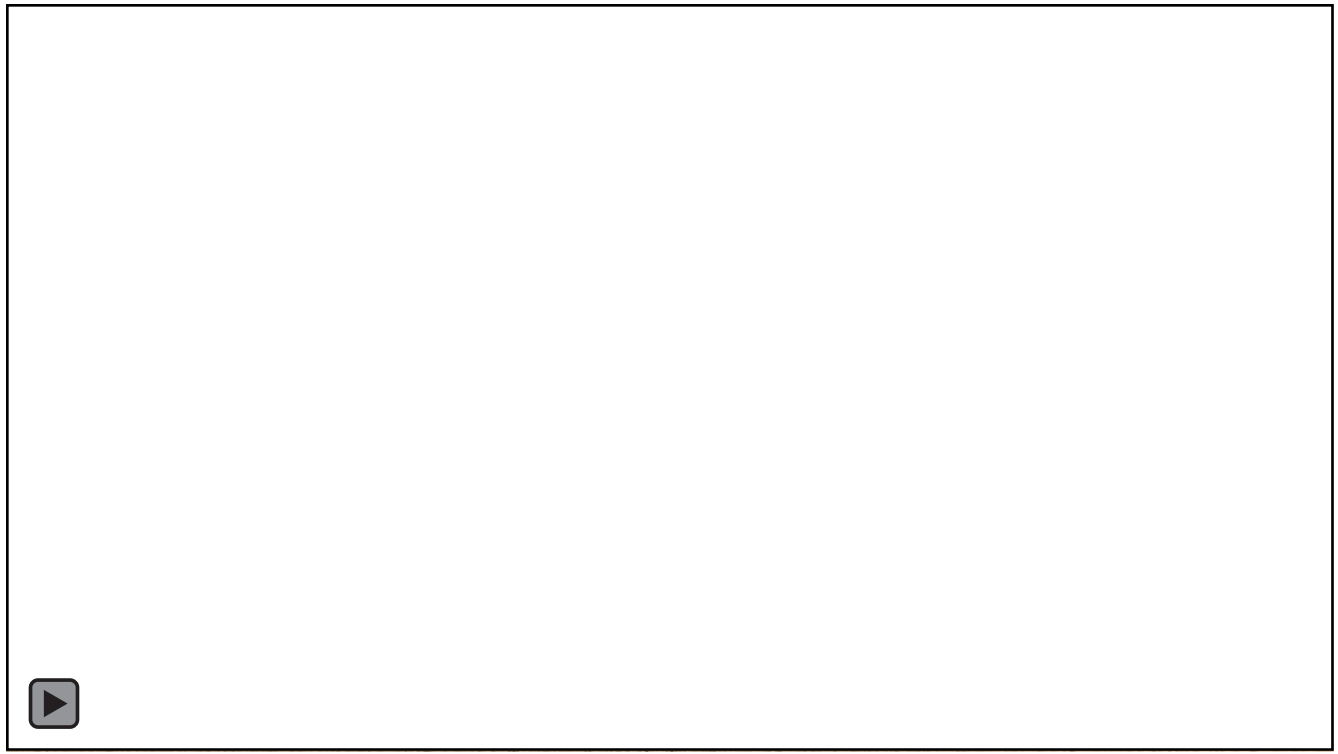
Data convert
box

Long distance
data transportation

Calibration (3D)

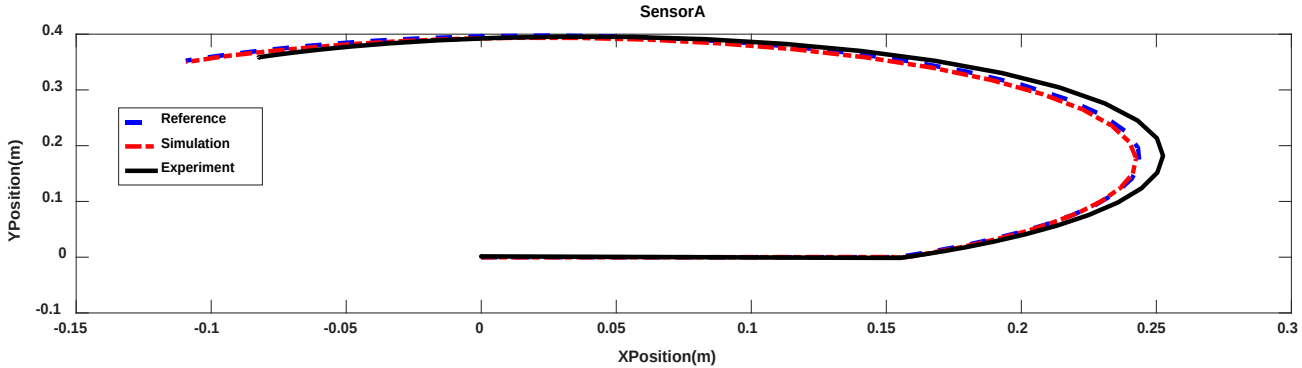


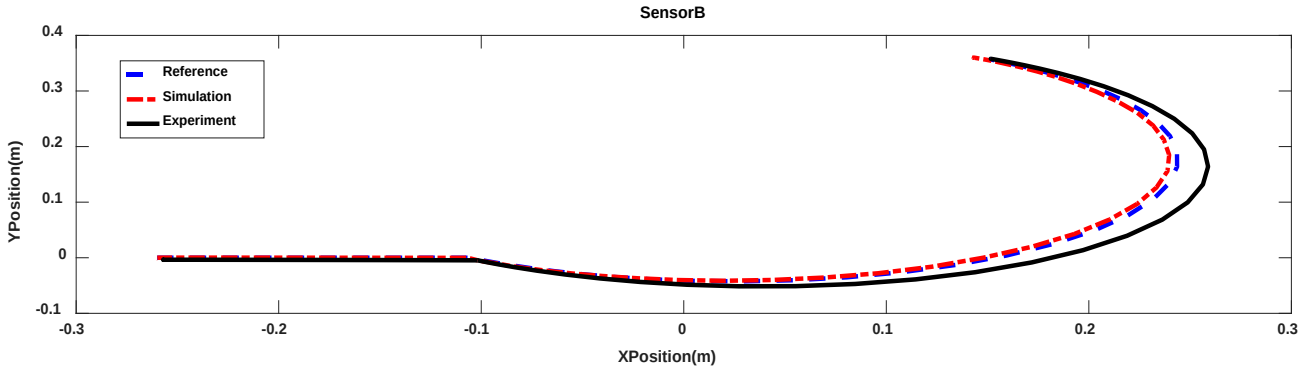
Calibration (2D)



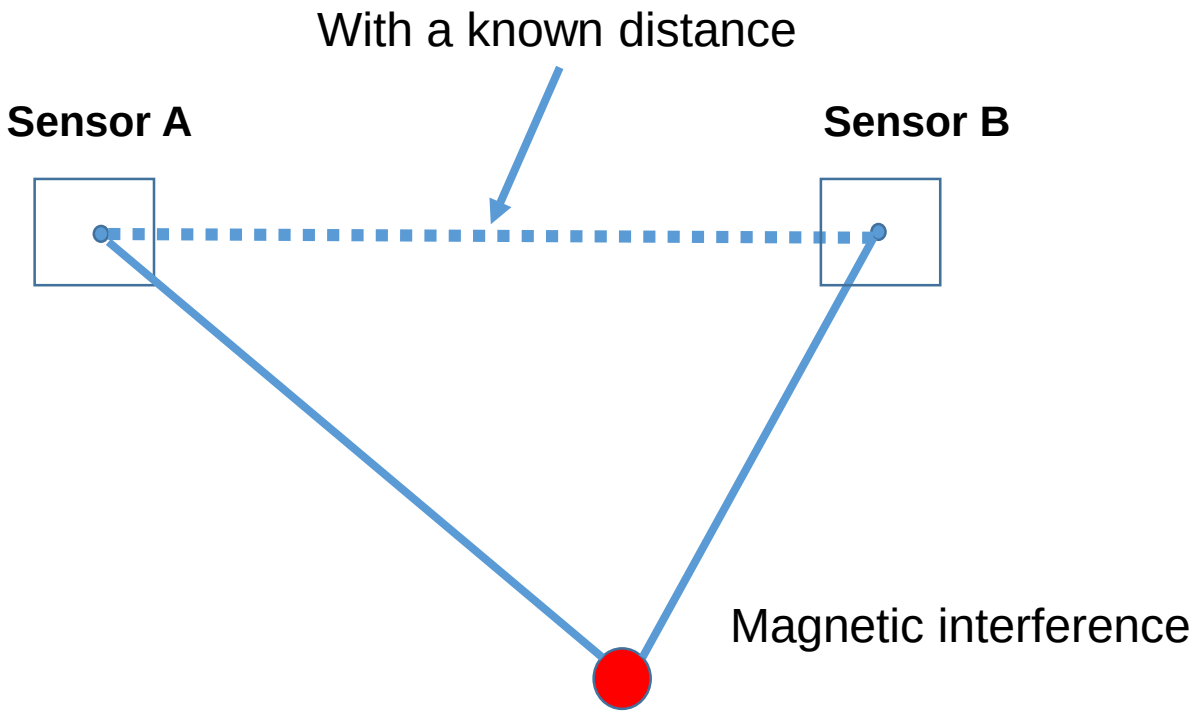
Horizontal movement

Calibration (Positions)

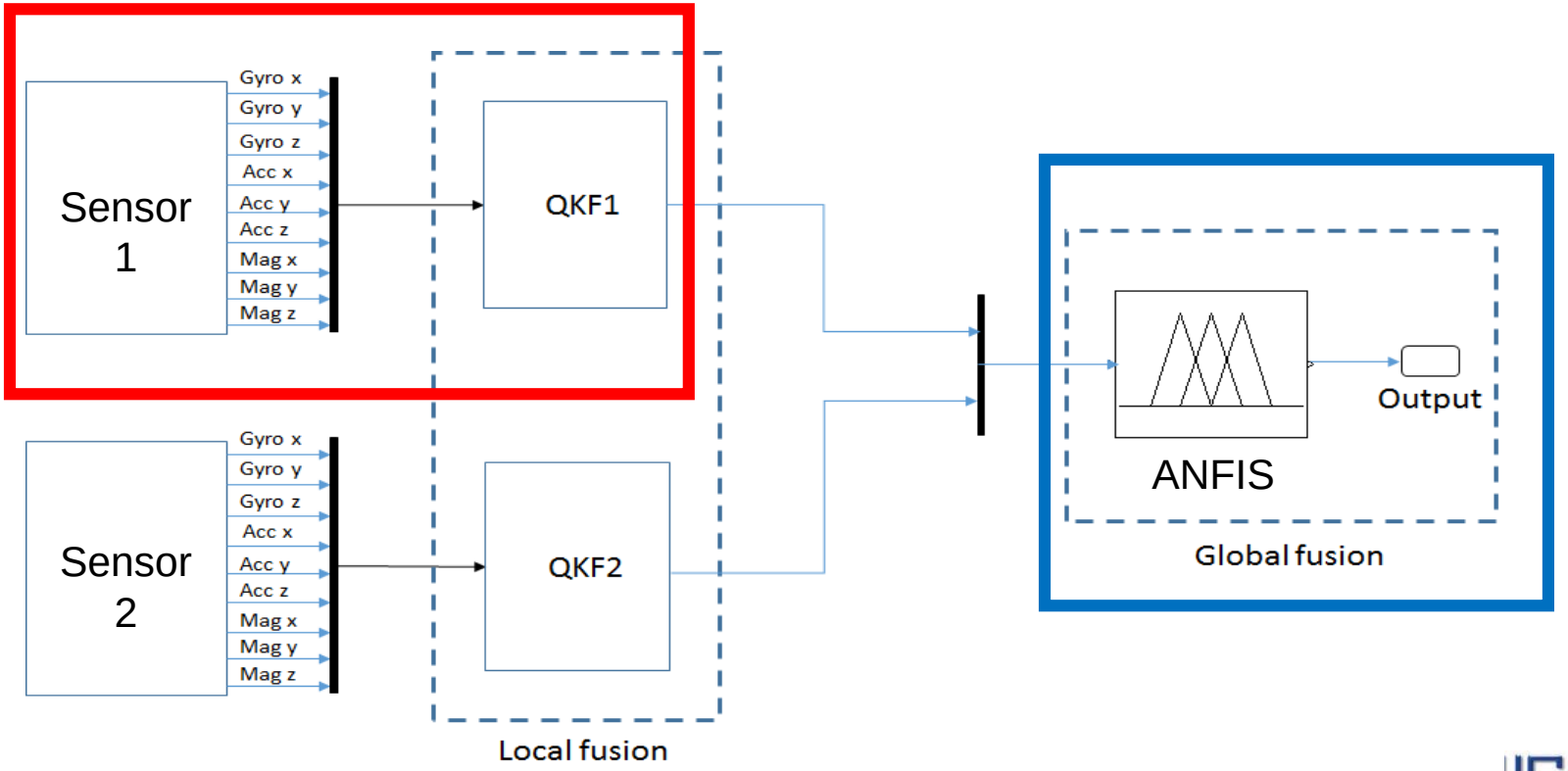




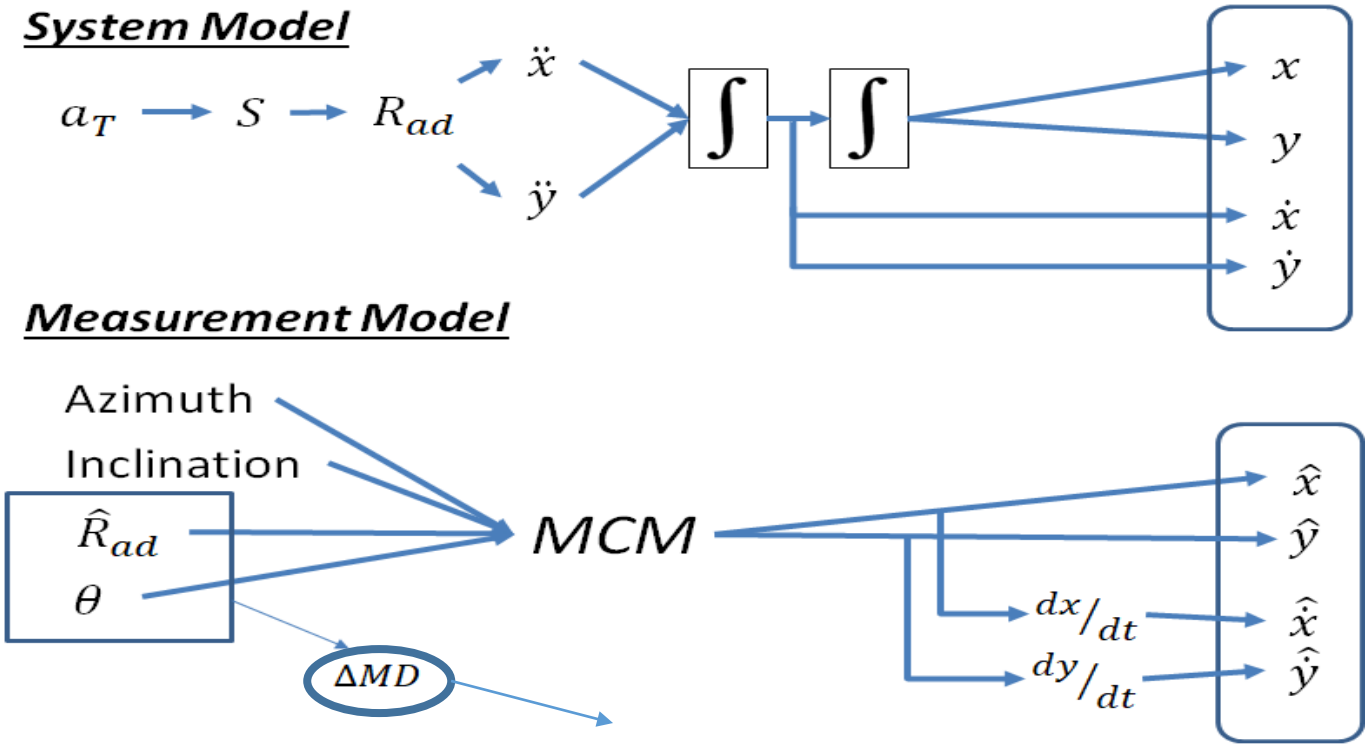
How to reduce the magnetic disturbances?



Angular Sensor Fusion

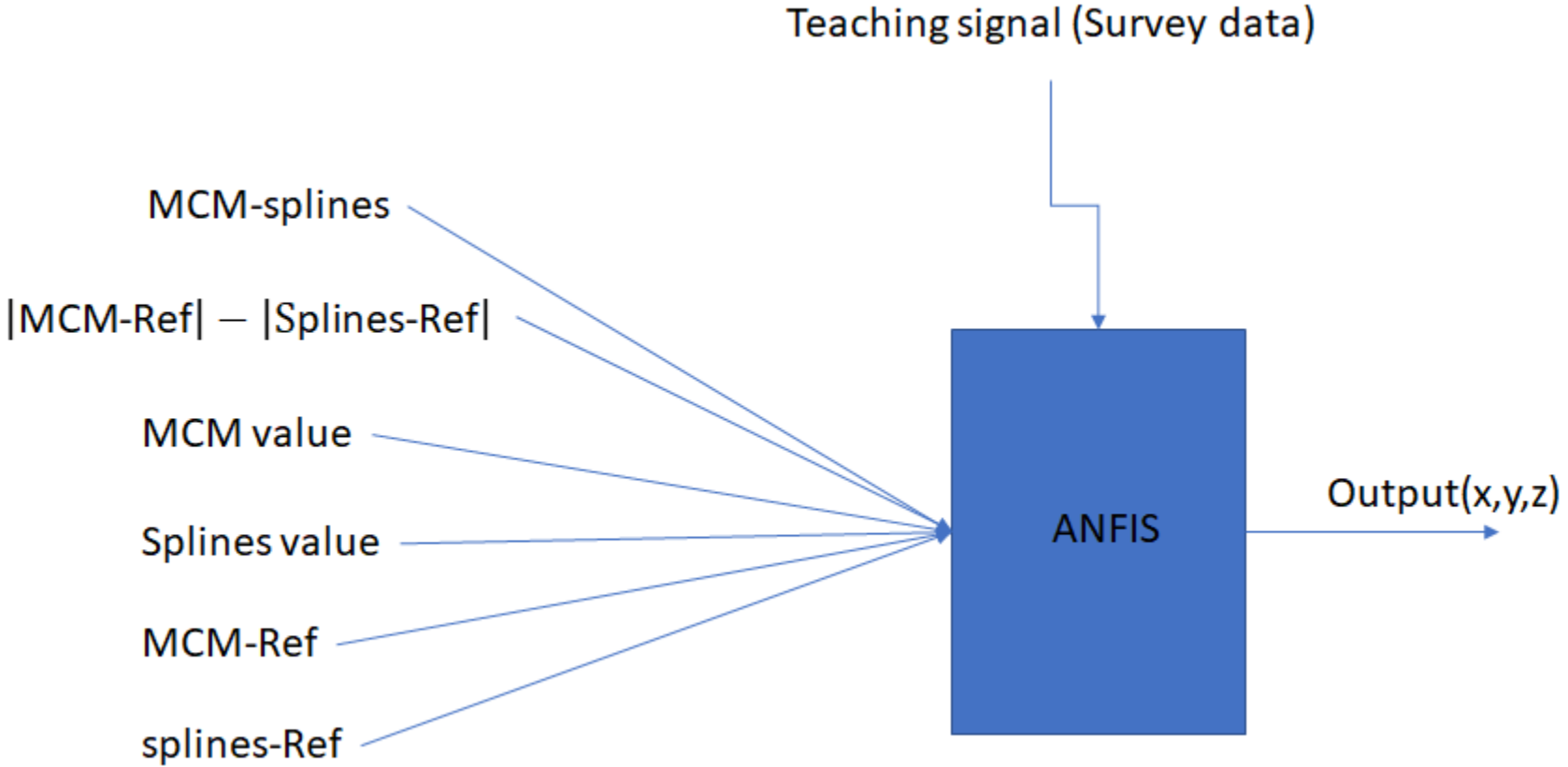


Sensor Fusion Method (Position,2D)

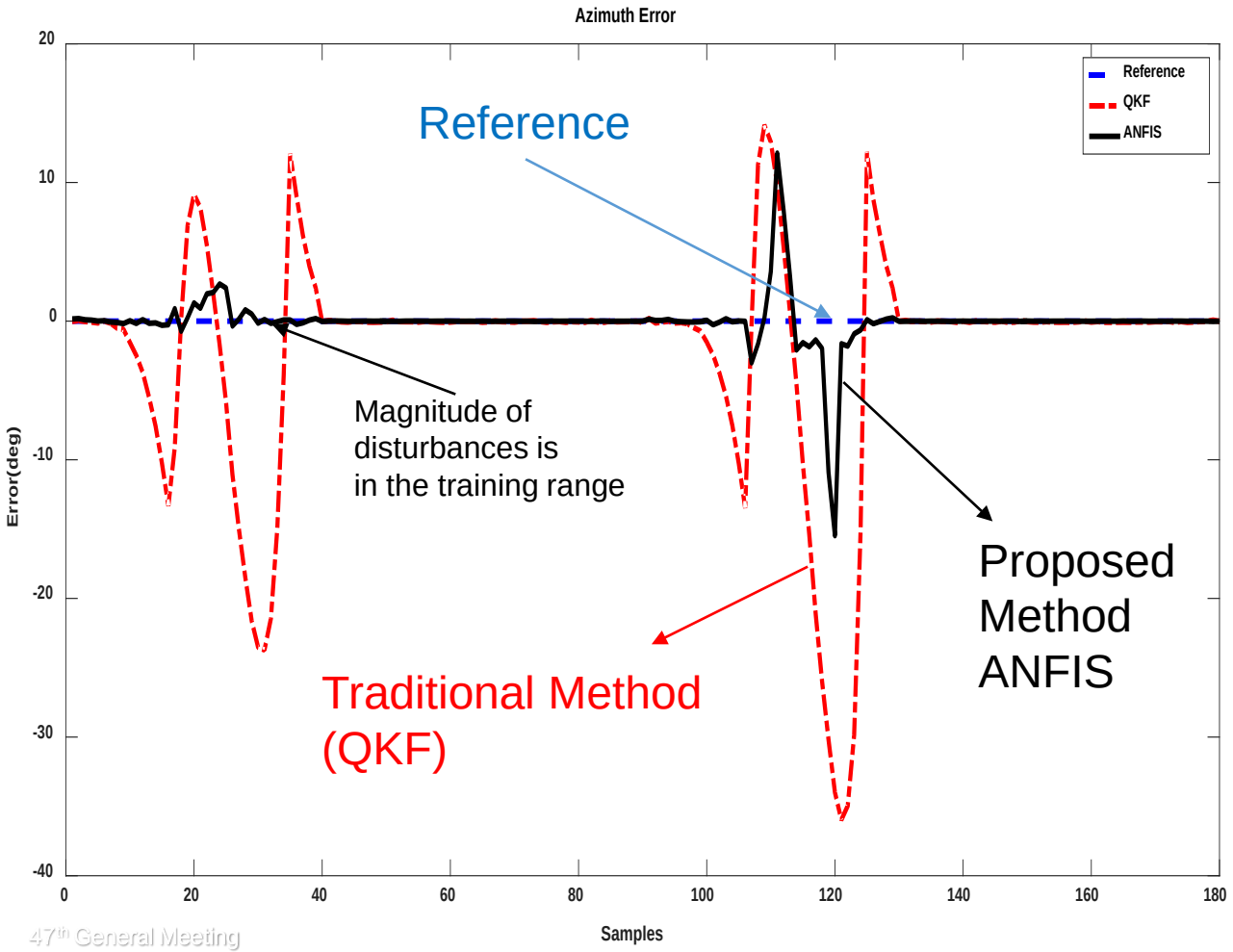


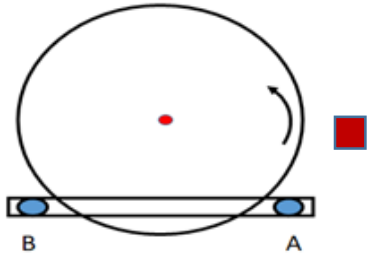
Not pipe length!

Sensor Fusion Method (Position,3D)



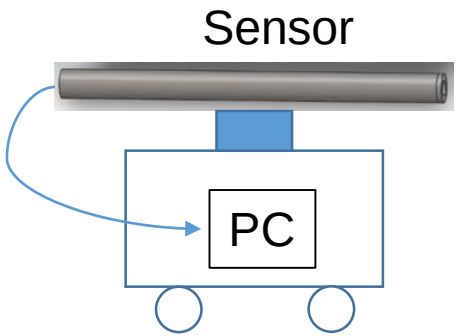
Lab Test (Angles)





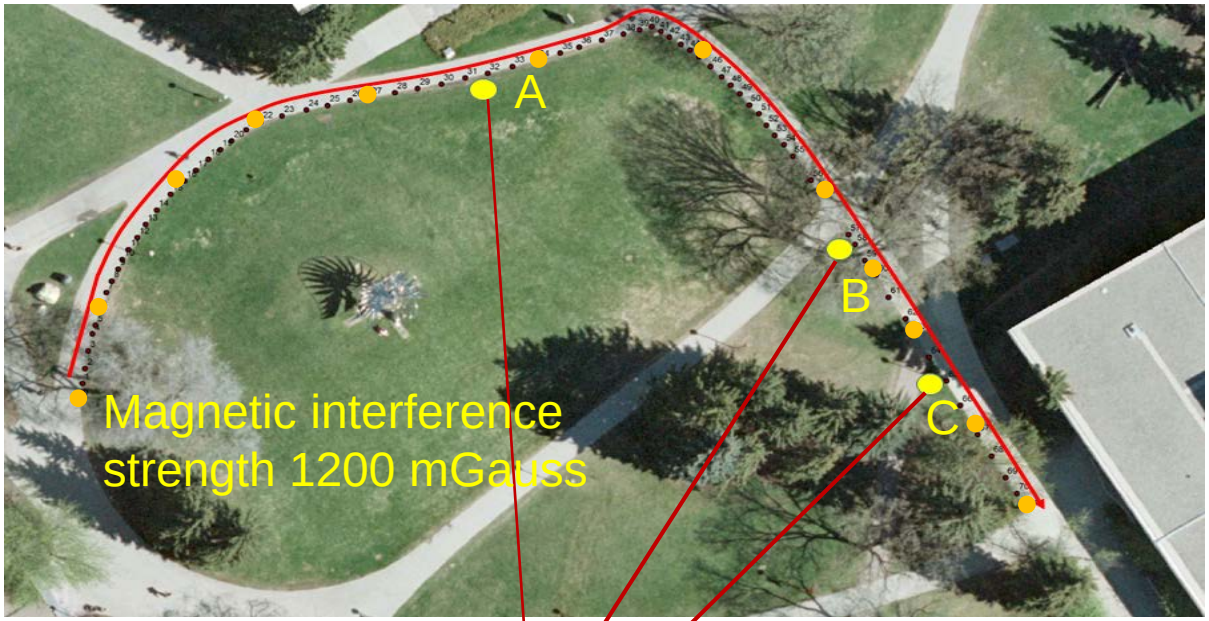
Curvilinear motion

Field Test (Angles)



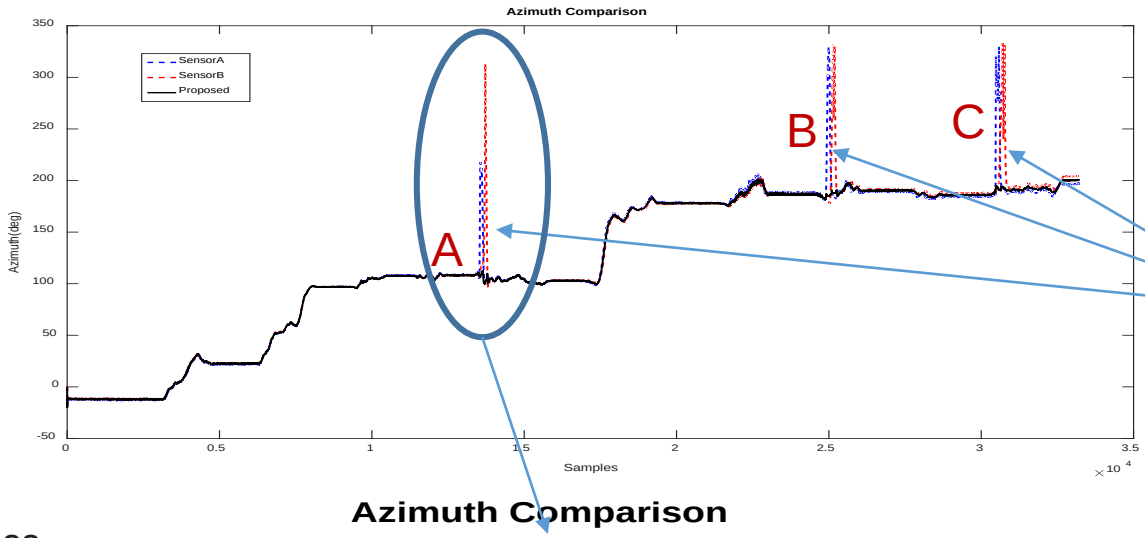
Data collection Equipment

Campus of University of Calgary

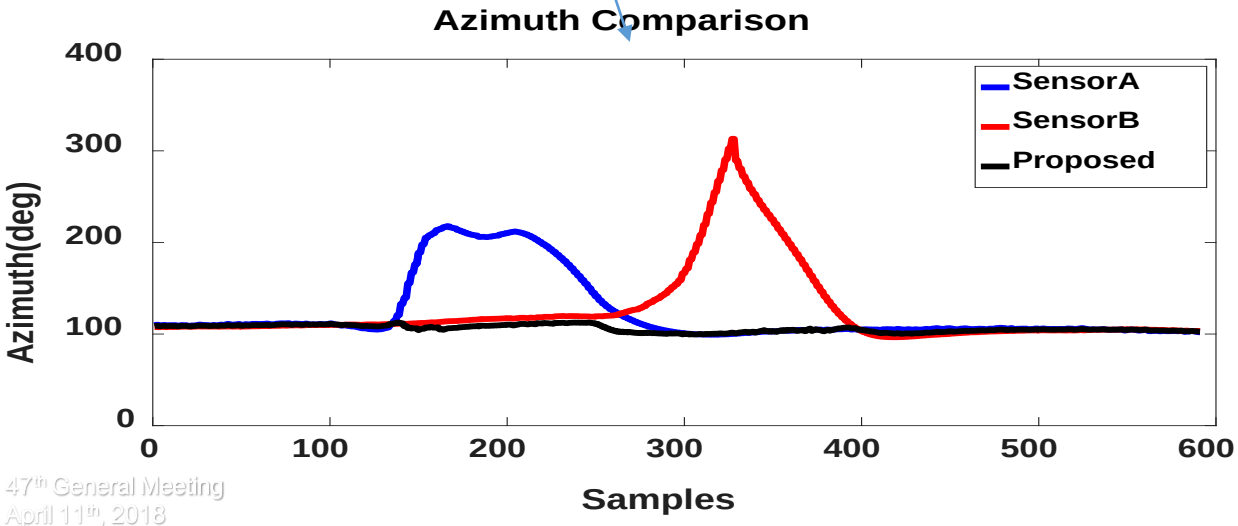


Three points of the locations of magnetic disturbance

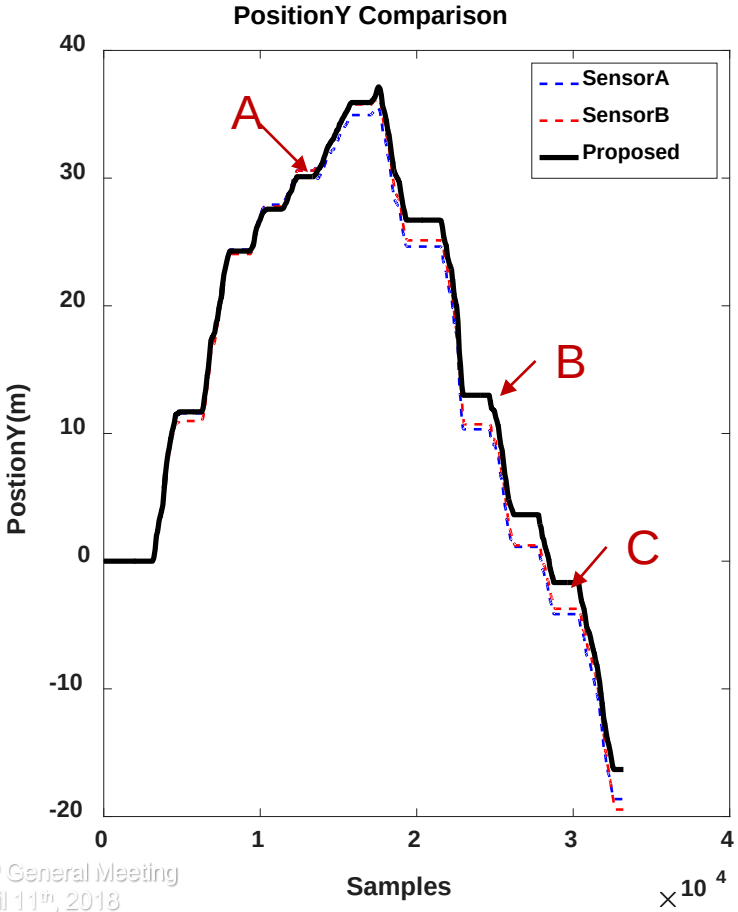
Continuous survey results

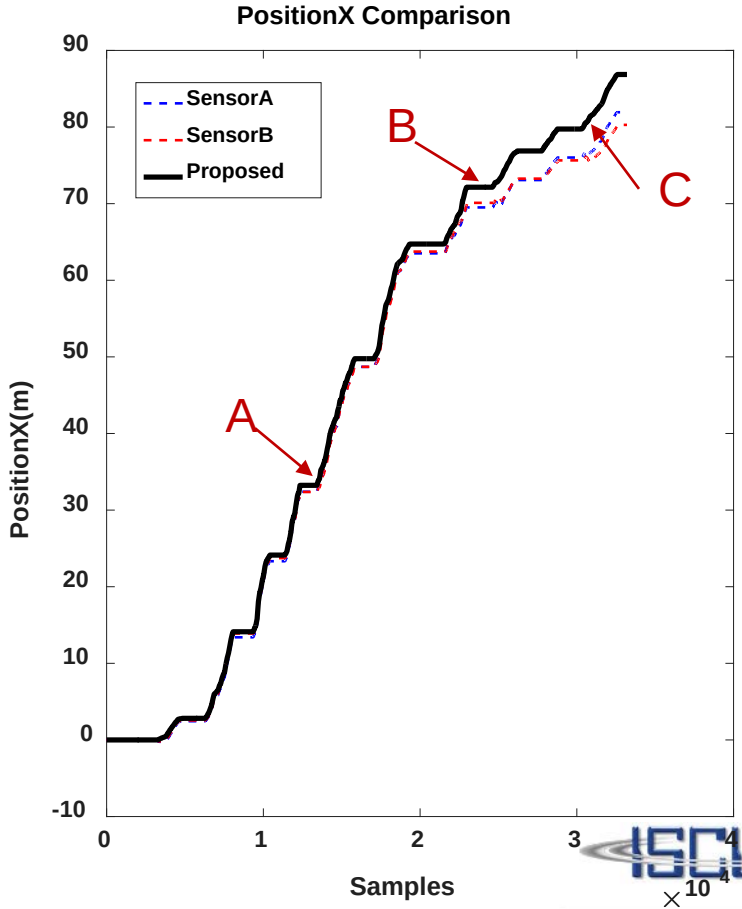


Magnetic disturbance



Results (Position)

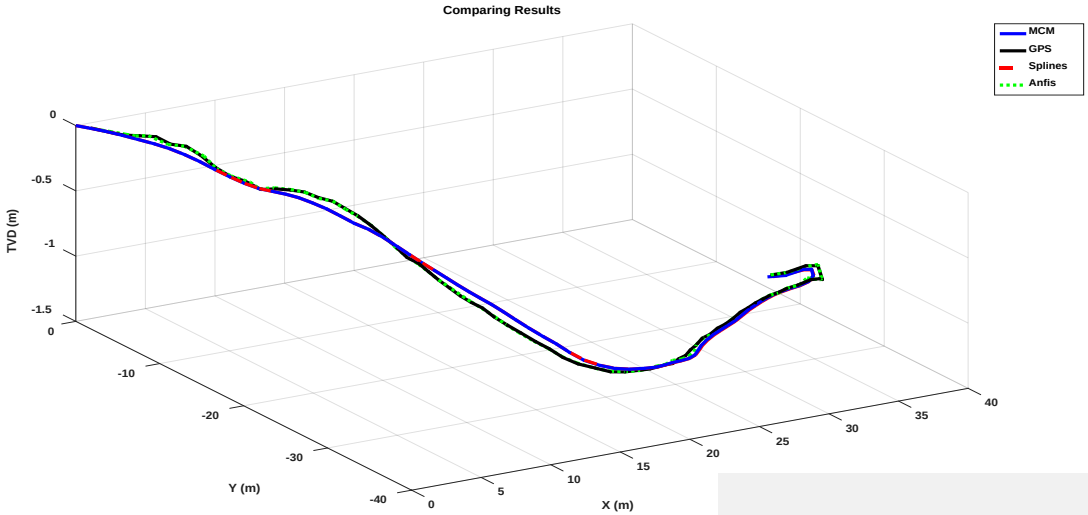




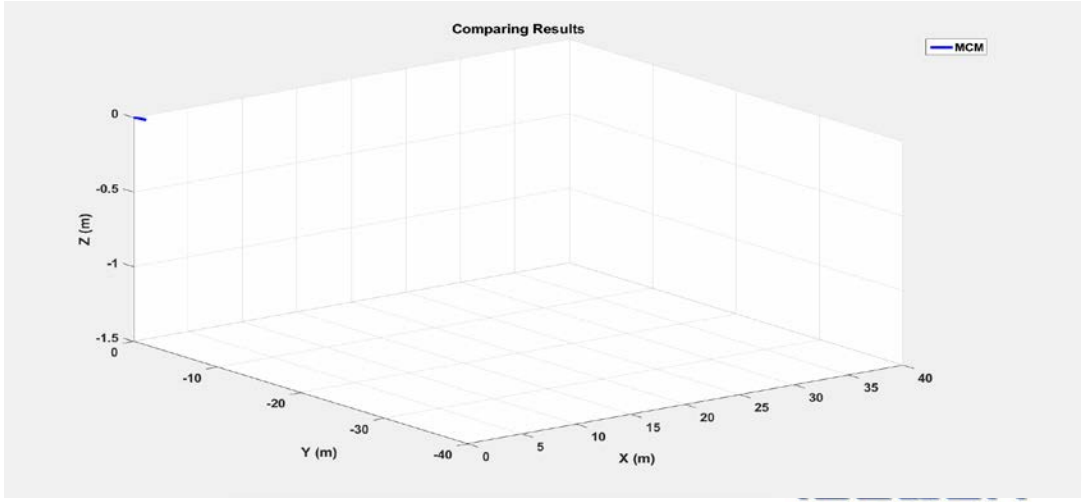
Field Test (Positions)

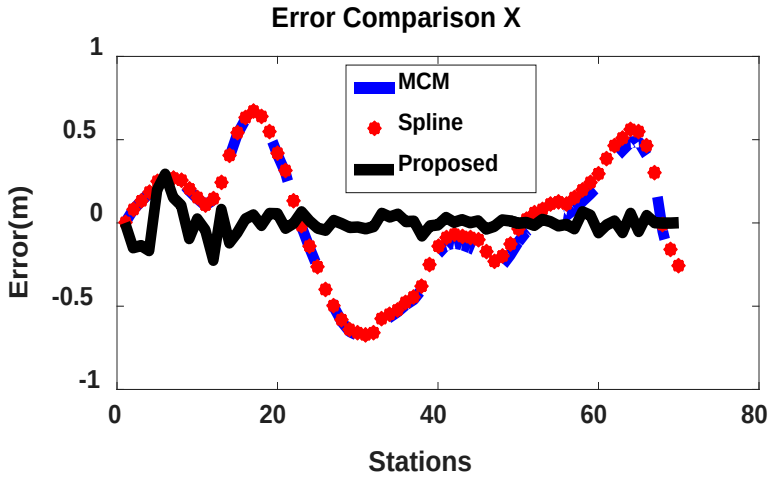
GPS signal was used as reference (survey)

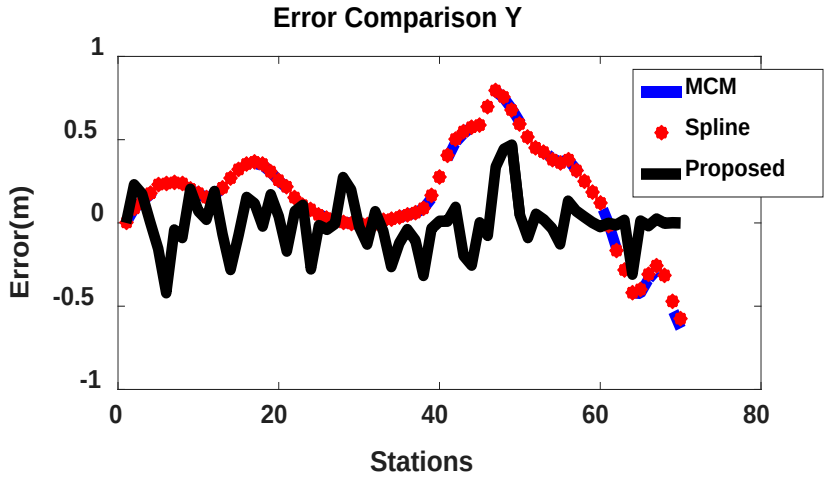
Route with rigid body and two IMU sensors

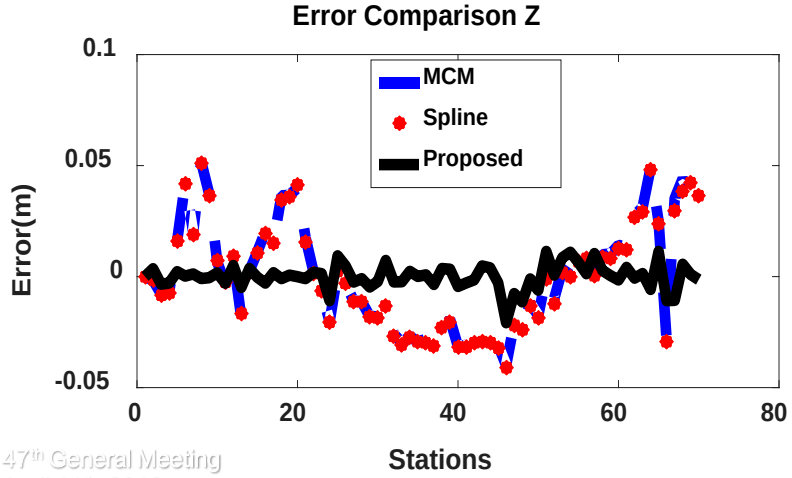

Comparing Results
MCM
GPS
Splines
Anfis
TVD (m)
Y (m)
X (m)

Results


Comparing Results
MCM
Z (m)
Y (m)
X (m)





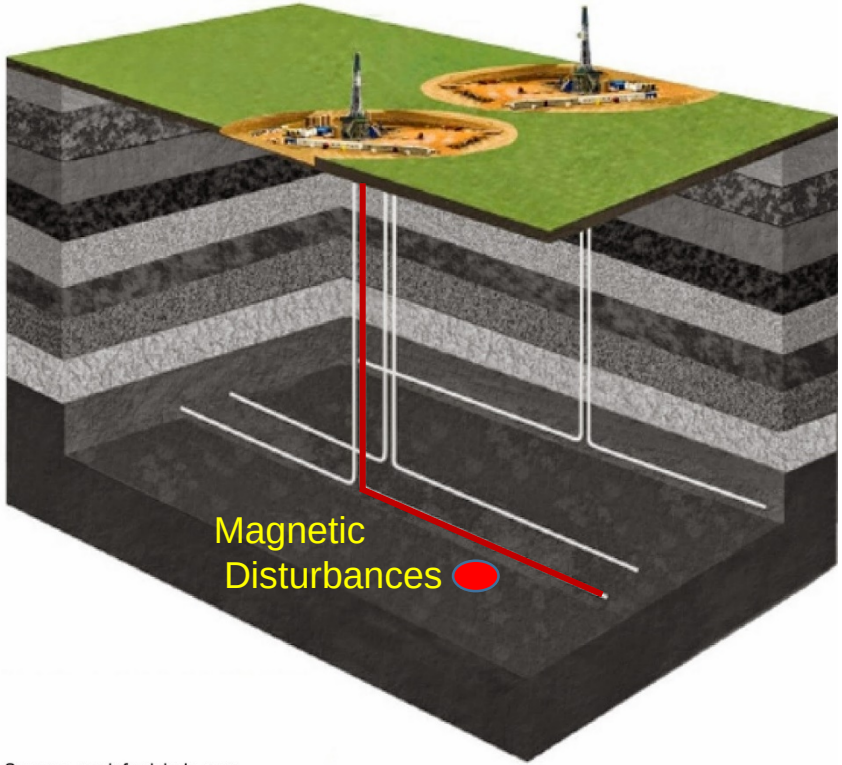


Accuracy

MCM & Spline [SPE 178796, 2016] same, proposed method is better

Potential Industry Applications

Pad Drilling: Many Wells Are Drilled by a Single Drilling Rig



Source: eaglefordshale.com

Multiple paths with same formation

↓

Same inclination and azimuth angles the moving distances are similar too

↓

One path can be used as teaching signal then high accuracy can be duplicated to the other paths

http://www.resilience.org/stories/2015-01-27/tight-oil-production-will-fade-quickly-the-truth-about-rig-counts/

Assumptions

- Two sensors were not influenced by magnetic disturba-nces at the same time with the same magnitude.

Limitations

- Need high accurate survey data as teaching signal.
- High accuracy only can be duplicated in the similar conditions

Summary

A subsurface measurement system with two redundant IMUs sit on a rigid body with a special distance *d* was designed.

Two level structure of filter which combined local and global to remove unknown magnetic disturbances was proposed and investigated.

High accuracy orientation and position estimation can be realized by this proposed method which proved by lab and field tests

This technique can be applied to pad drilling to reduce the drilling cost and manual work

Thank you for your attention!

Questions?

Contact

www.ucalgary.ca/medal

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