

Open Challenges For Mobile Mapping Systems

Craig Glennie

Asst. Professor, University of Houston

Geosensing Systems Engineering

clglennie@uh.edu

Presentation Outline

- 2 ☐ NCALM
- ☐ Technical Challenges
 - ☐ GNSS Outages
 - ☐ Measurement Correlation
 - ☐ Lower Cost Sensors
- ☐ Challenges from An Industry Perspective
 - ☐ TRB Survey
 - ☐ Data Storage, Visualization
 - ☐ Fusion
- ☐ Summary and Conclusions



The National Center for Airborne Laser Mapping

UNIVERSITY of HOUSTON • UNIVERSITY of CALIFORNIA, Berkeley

Director: Ramesh L Shrestha • **Co-Director:** Bill Dietrich (Berkeley)

Co-PIs: Bill Carter and Craig Glennie

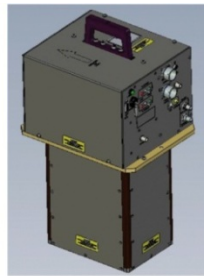
Funded by:

Division of Earth Sciences, Instrumentation and Facilities, NSF

- Separate Operational Budgets for UH and UC Berkley
- Additional funds to UH from NSF peer reviewed PI projects
(Over 100 national and international projects completed)



Cessna 337



Gemini



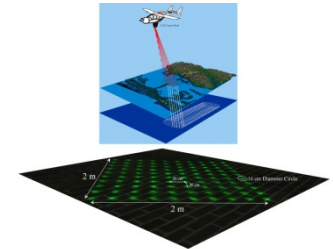
Aquarius



DiMAC



CASI 1500



CATS

Research Grade LiDAR Data For the Scientific Community

Technical Challenges in MMS

Challenge #1 – GNSS Outages

5

- GNSS Only Works With Line of Sight
- Obstructed Environments Require Additional Observations
 - ▣ DMI Constraints Not Sufficient for Highest Accuracy
- Desirable to Use Optical Sensors Onboard (Digital Image, LiDAR) for Updates.

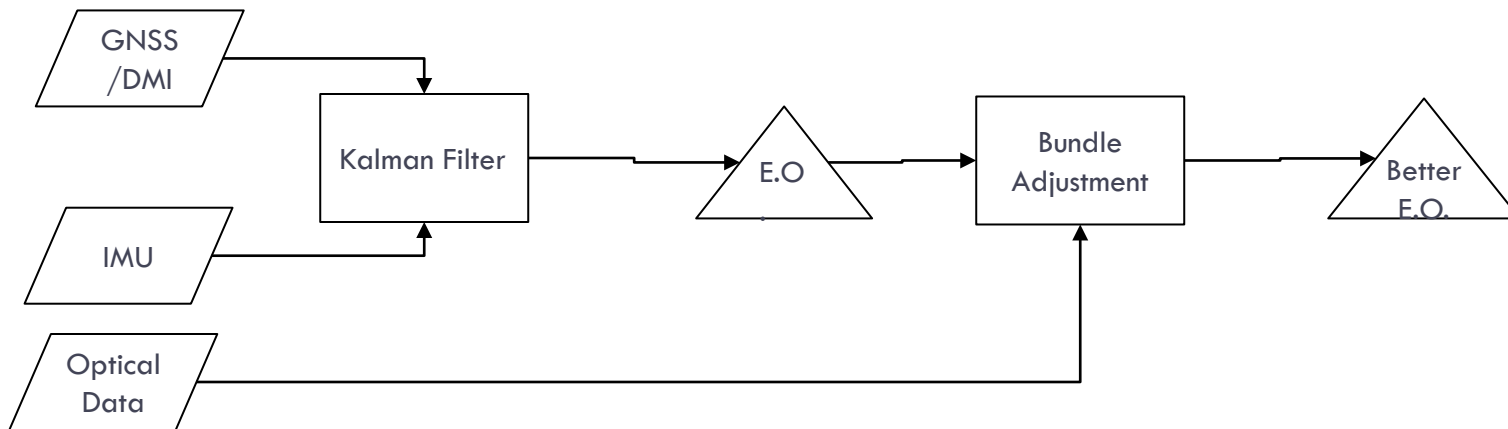


Optical Approach #1

6

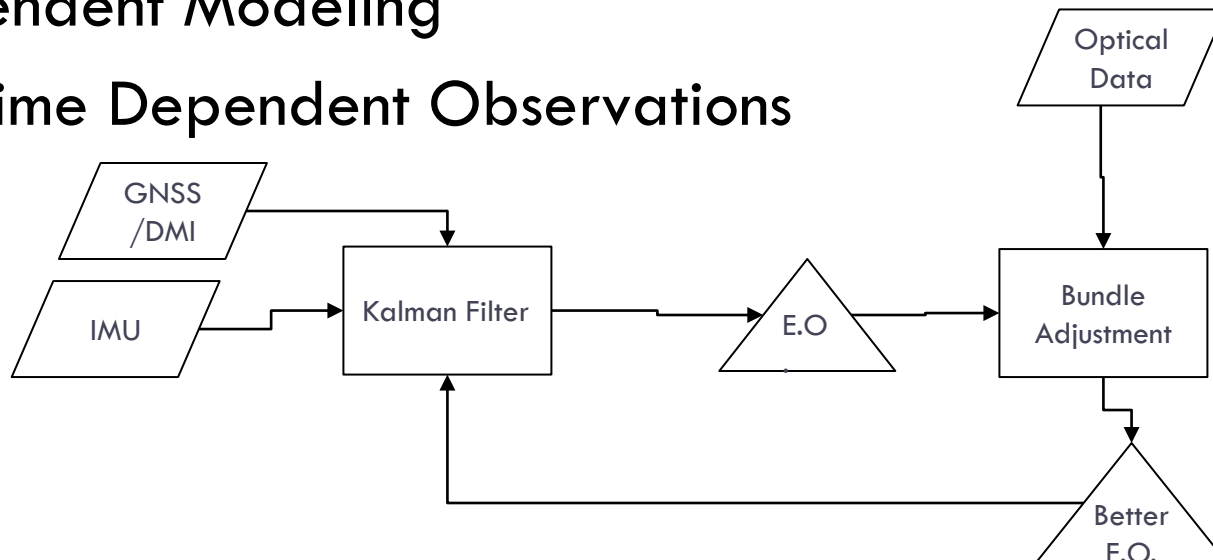
□ Photogrammetric Solution

- Use Tie-Features to Correct Trajectory at Exposure Times
- No Corrections in between Exposures
- No Feedback to Kalman Filter



Optical Approach #2

- SLAM(Simultaneous Location and Mapping) Solution
 - Optical Measurements Fed Back Into Filter As Updates to States
 - Allows Model of Inertial System Behaviour
 - Solution Resembles an Open Traverse With Time Dependent Modeling
 - No Time Dependent Observations



Additional Information?



Rigorous Solution

9

- Addition of Time Correlated Measurements
- Methodology to Handle Both Space and Time Dependency
- Dynamic Network Adjustments To Combine Navigation and Optical Data at Measurement Level
- Initial Implementations
 - 2005 – Colomina, Blazquez, Térmens – Gravity Disturbances
 - 2011 – Rouzaud, Skaloud – Mobile Mapping Platforms (Simulations)

Obstacles to Implementation

10

- Correlation Process Should Be Automated
- Implementation is Challenging
 - Large System of Normal Equations
 - Successful Inversion Requires Mathematical “Tricks”
- Increased Complexity Might Not Be Warranted In All Cases

Challenge #2 – Measurement Correlation

11

- For All Mapping Calibration (LiDAR and Photogrammetric) Errors Are Assumed to Be Time Independent Random Variables
 - Inertial Errors Modeled As Gauss Markov Processes With hour(s) time constants. They are Cumulative, even in presence of GNSS and filtering
 - GPS Errors Also Correlated In Time (atmospheric, orbital, reference multipath)
- Assumption Normally Circumvented By Increasing Sigma Values for Observed Position/Orientation

Correlated Observations – What to Do?

- Are Correlations Significant?
 - ▣ Especially When High Accuracy Required

- Change Mathematical Model
 - ▣ Blázquez and Colomina (2012). “Relative INS/GNSS Aerial Control in Integrated Sensor Orientation: Models and Performance” ISPRS Journal, 67, 120-133.

- Include Correlations In Weighting Matrix

Lower Cost Sensors

- Current MMS Platforms Can be $> 500K$ EUR
- Desirable to Reduce Cost but Maintain Accuracy With Lower Cost Sensors:
 - Tactical Grade IMU
 - Alternative Laser Scanners (Velodyne, Ibeo Lux)
- To Be Successful, Both Challenges Need to Be Overcome

Calibration Procedures

- LiDAR – Traditionally Only Calibrate for boresight angles, and perhaps scale
 - Lower Cost Sensors Have Increased Temporal Instability
 - May Need Additional Calibration Parameters
 - Glennie, C., (2012), “Calibration and Kinematic Analysis of the Velodyne HDL-64E S2 LiDAR Sensor,” PE&RS, 78(4).

Industry Perspective on Challenges

TRB Mobile Laser Scanning Guidelines

- 60% of Mobile Data in N. America for Departments of Transportation

- Problems with Adoption:
 - Most DOTs are still designing in 2D, 2.5D
 - No Appropriate Software for Design and Analysis
 - Lack of Technical Expertise Within DOT
 - No Methodology to QA/QC of Products

Challenges From A Commercial Perspective (1 / 2)

17

- “Massaging” of Trajectory Takes Significant Amount of Time.
 - ▣ Methods are Mostly Manual
 - ▣ Empirical Data Driven Adjustments
 - ▣ Focused on Vertical Adjustments Only

Challenges From A Commercial Perspective (2/2)

18

- Lack of Specialized Software for:
 - Data Analysis
 - Data Fusion
 - Automated Feature and Object Extraction
 - Delivery Formats to Client (75% of DOTs get ASCII)

- Privacy Concerns
 - e.g. December 15, 2010 Belgium Privacy Commission Recommendation on Mobile Mapping

Challenges From a User Perspective

- Validation of Delivered Product
 - Airborne has focused on vertical only. Mobile mapping clearly needs horizontal validation
 - COTS software packages for data fusion (e.g. imagery and LiDAR) are lacking
 - Information Extraction Is Mostly Manual
 - Data Does Not Yet Fit Into Design and Engineering Processes

Summary

- Technical Challenges Include Better Trajectory Estimation, More Rigorous Calibration and Integration of Lower Cost Sensors
- From a Commercial Adoption Perspective, Software to Analysis/Process/Extract from data is clearly lagging far behind the Hardware to collect it.

Questions?

Craig Glennie
University of Houston

clglennie@uh.edu

www.ncalm.org