Mobile Mountain Bike Trail Mapping

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Motivation

- Detailed trail data is useful for planning your ride
- Could auto-label the trail difficulty
- Professional racers want information for in-depth analyses of their performance.
- Aggregate statistics hide useful information
- Almost everyone rides with a phone on them

Trail Stats

Distance:	1,743 m
Altitude change:	-114 m
Altitude min:	275 m
Altitude max:	391 m
Altitude start:	389 m
Altitude end:	276 m
Grade:	-6.5%
Grade max:	-40%
Grade min:	21.7%
Vertical climb:	22 m
Vertical descent:	-136 m
Distance climb:	336 m
Distance descent:	1,242 m
Distance flat:	165 m
Avg time:	00:07:47

Motivation

- Maps can be continuously optimized using data from riders
- Apps such as trailforks are already doing this for aggregate statistics
- Can also capture trail modifications
- I can be “studying” and riding at the same time!

The Problem

To recover both the **path** and the **orientation** of a rider on a mountain bike trail using only data collected on a smartphone.

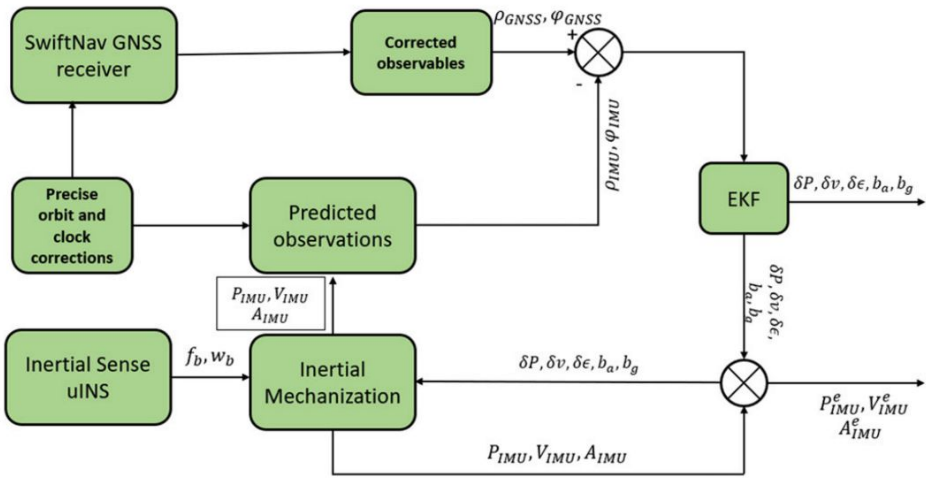
The Problem

1. Estimating global position from GPS pseudoranges and an IMU
2. Estimating attitude from IMU + magnetometer
3. Modelling sensor uncertainties and estimating sensor biases
4. Dealing with possible GPS occlusions such as narrow valleys and dense tree cover

Literature
IMU-GNSS Fusion

- **(Vana et al. 2020)** used a MEMS IMU to support GNSS with PPP. The IMU is used to predict pseudoranges, which are then compared to the measured values. These differences are used as the measurement for an EKF

- **(Girrbach et al. 2017)** employed a moving horizon optimization based approach to GNSS and IMU sensor fusion. Formulated the optimization problem using direct collocation

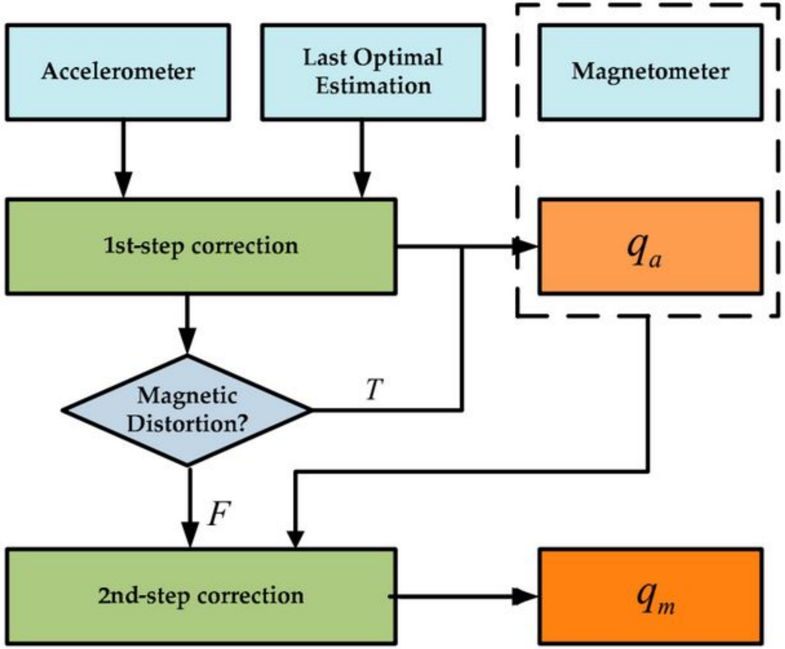


Literature
Attitude Estimation

- **(Feng et al. 2017)** Use a quaternion based EKF with a two step geometric correction from the accelerometer and magnetometer outputs.

- **(Ma et al. 2012)** Developed a different quaternion EKF where the quaternion kinematics were used for the prediction step and the measurement model explicitly accounts for non gravitational accelerations

- **(Markley 1999)** Analyzes the MEKF framework for accurately capturing the multiplicative nature of rotation errors.



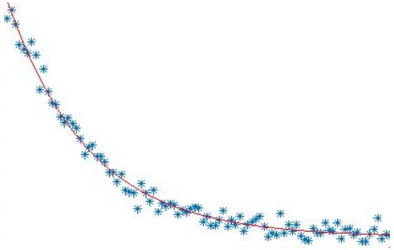
My approach

1

Data Collection

The fun part… I will attach an android device to my bike and ride it around a well mapped route while logging the sensor data

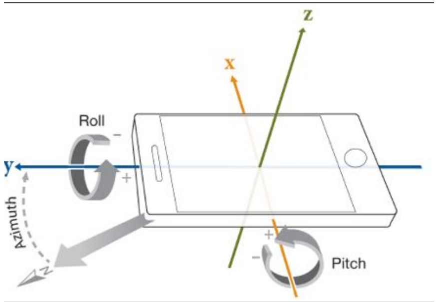
2



Sensor Modelling

Model the sensor errors for the Gyro, Accelerometer and Magnetometer to correct for scale factors etc.

3



Attitude and Heading Estimation

Implement a quaternion based EKF to estimate the attitude using the two inertial sensors and the compass

My approach

Extensions

If time (and hardware) allows, I will investigate PPP based processing to try and improve the navigation accuracy

GNSS Position Estimation

I will fuse raw pseudoranges with a motion model based on the accelerometer and estimated attitude using an EKF

5

Extensions

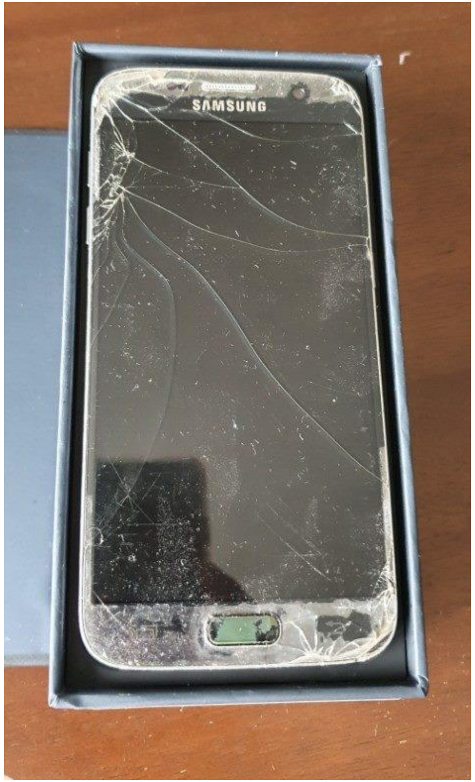
GNSS integrity with RAIM based framework.

Progress

01 | Have purchased some top quality hardware.

02 | Have begun working out the logging system

03 | Setting up sensor modelling tools



Timeline

Set up logging.
Collect Data.
Calibrate sensors

Week 6

Week 7

Attitude Filter
Implementation

Position Filter
Implementation

Week 8

Week 9

Finalize
Results and
Collate

Present

Week 10

Thank you.