**What to Do Next**

Lu Yu

Early September 2017

**Current status**

* Collected GPS data are limited. Source of GPS error and its error distribution are almost unknown.
* SLAM track generation is almost blackboxed.
* Only two sensors, GPS receiver and lidar, are used.
* ICP is used for calibration, which is inherently insufficient and cannot provide real-time solution.

**GPS**

* Systematic study of GPS [1].
* In urban area, especially urban canyons, multipath and shadowing are the most important factors of GPS error. Knowledge of the resulting error distribution helps to develop model that alleviates such error. See [2] and its reference.
* In our collected data, some error patterns are quite obvious. We need to find the link between error pattern and theoretical background.

**SLAM**

* LOAM algorithm by Zhang Ji [3] and its open source codes.
* Google’s cartographer project [4].
* Orb SLAM to be discussed in journal club 09/15 [5].
* Mathematics background: theory, stochastic model and performance. Two branches of SLAM algorithms: extended Kalman filter and particle filter.

**Hardware**

* Timestamp alignment can still be a problem.
* Lidar versus millimeter wave radar.
* Camera and computer vision.
* Centering of various sensors.
* Could use better GPS receiver, something similar to car/robot based GPS receiver in actual use.
* Adding IMU as another independent source of information helps. It also serves as input to current LOAM algorithm.

**Calibration**

This is essentially a project of data fusion. Data interface of and weight assignment to different sources is critical.

We can replace ICP by prediction-measurement system that resembles a classical Kalman filter. Parameters are updated at each step when new data come in.

* Recursive algorithm easy to realize.
* Adaptive weight assignment among sensors.
* Real time potential.
* Noise distribution estimate. Classical Kalman filter assumes that noise is white Gaussian, which cannot hold for GPS error in urban area.
* Convergence, stability and robustness.

**Reference**

[1] Understanding GPS Principles and Applications 2e - Kaplan

[2] Weiss PhD thesis - Modeling and Characterization of Multipath in Global Navigation Satellite System Ranging Signals

[3] Zhang - LOAM Lidar Odometry and Mapping in Real-time

[4] https://github.com/googlecartographer/cartographer

[5] ORB-SLAM a Versatile and Accurate Monocular SLAM System