**Problems in Calibrating GPS with SLAM**

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Early August 2017

**Assumptions**

* GPS track and SLAM track are known from independent sources.
* SLAM track generation is blackboxed.
* SLAM track is accurate.
* GPS position error is blackboxed.

**Modelling**

SLAM generates an accurate track without global coordinates, while GPS track is less accurate but has global coordinates. The goal is to register (2D curve registration) SLAM track to GPS track, or vice versa. This gives a calibrated track with global coordinates and is more accurate. In this process, it might be necessary to deform GPS track and / or SLAM track. Both tracks have timestamps for alignment (point correspondence known).

Key words: 2D curve registration, nonrigid, timestamp aligned.

**Problems**

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| Current status | Possible improvement |
| Timestamped ICP  ICP minimizes distances between aligned points. Does not recognize feature or shape of curve. | Shape aware methods such as active contour. Feature extraction methods for 2D curve. |
| Rigid  Both GPS and SLAM tracks are rigid. GPS track with one-sided error or small bumps cannot be handled efficiently. | Nonrigid  Allow GPS track to deform during curve registration. Can also allow nonlinear / localized deformation. |
| Equal weights  All points are given the same weight. “Bad” points considerably affect result. | Weights assigned to points based on confidence level, i.e. probability of accuracy. Low confidence points have less or even no impact. |
| Fixed step size  Completely based on time, regardless of vehicle speed. May lead to unequal length between GPS and SLAM tracks. May cause oversampling problems when vehicle is at low speed or at stop. | Adaptive step size  Step size changes based on both time and displacement. Fewer points needed when vehicle is at low speed or stop. |
| Non-overlap  SLAM segments for ICP have no overlap. Good registration results are not used for adjacent segments. | Overlap  Overlap between adjacent SLAM segments. Helps to determine accurate course (directional angle) and correct systematic error in GPS. |
| No vehicle GPS position can be used as ground truth. | In theory, I don’t think this can be fixed. Need more independent sensors as information source to alleviate this problem. |

**What to do next**

* Change of ICP method requires an overhaul of our current framework. Nonrigid deformation also needs extensive work. They will not be considered in the near future.
* Add weight matrix to ICP module. Minor changes needed. Work to find out proper assignment of weights.
* Add “stop mode” module that detects when vehicle is at stop. Ignore oversampled points. Collected data show that GPS position has a high probability of drifting in this scenario.
* Do SLAM segments with overlap. E.g. SLAM segment size = T and overlap = T/2. Use both overlapped SLAM and GPS track to register next SLAM segment.

**Reference**

Data and results from 2017-05-14 and 2017-06-14.

From Internet: various academic papers, course materials, Wikipedia pages.