Estimating the Earth's magnetic heading in a moving vehicle

Advisors: *Nicolas Le Bihan and Christophe Prieur*

GIPSA-Lab, Grenoble.
Email : `Nicolas.Le-Bihan@gipsa-lab.fr` and `Christophe.Prieur@gipsa-lab.fr`

Attitude and position estimation as well as tracking is a crucial problem that occurs in a wide range of applications. It has attracted continuous attention in the last decades in satellite positioning, radar, robotics, to name just a few. Being able to track a vectorial quantity/direction with a real-time algorithm is still not a completely solved problem and only approximate solutions are available today.

In the context where the recording sensors are inside a moving vehicle, many external perturbations add up and performing a thorough estimation of the time varying magnetic heading is an even more complicated challenge. Among the possibly recorded datas, the magnetic field is exposed to many non-stationary noise sources and a smart denoising scheme needs to be developed to fully exploit the signal.

Developing algorithms which are able to accurately track, in a noisy environment, the true magnetic north is thus a challenging problem with many potential applications. When the measurements (magnetic and inertial) are made inside a vehicle, external sources of noise are the one that alter the most the recorded signals. In addition, as the recorded quantities are vectorial by nature (magnetic field and motion), the extension of classical optimal tracking filters/algorithms (Kalman) is not trivial. One needs to take into account the non-linear nature of the system evolution to tackle the problem, together with a high robustness to model error and/or variability. Extended Kalman filter (EKF) is a known approximate solution that allows to deal with non-linearity [1, 2]. Some authors have also incorporated the directional nature of the measurement by using different noise model based on directional statistics (von-Mises Fisher) rather than Gaussian.

The proposed work will consist in exploring different approaches to propose Earth magnetic north estimation/tracking algorithms. A possible track will consist in developing a thorough model of the measured signals (continuous time and discrete time) in the context of tracking the north pole inside a vehicle; and in developing a filtering algorithm to track accurately the magnetic north in this very noisy/perturbated environment. This could be done using global linearization in the EKF (using the anti-development technique [4]), or by refining the model using directional statistics [3] rather that projected distributions. An other possible way to tackle this problem will be to make use of geometric and spectral description of trivariate signal to filter and estimate the time-varying vector valued signal.

The simultaneous use of different sensors output will need to be taken into account to take advantage of the signal redundancy and noise decorrelation between sensors. Choices will need to be made during the algorithm development to account for efficiency and rapid convergence, together with real-time implementation.

This work will be conducted in collaboration between an academic lab (Gipsa) and the SYSNAV company. Real datasets acquisition will be made using SYSNAV facilities and will be used to benchmark the developed algorithms. Depending of the achieved tasks, this postdoc may be followed by a work contract in the industrial partner or in an academic organization.

- **Profile:** The candidat should have a PhD in signal processing (filtering, estimation) or control theory (observers, nonlinear dynamics).
- **Location:** GIPSA-Lab, Grenoble University East Campus, Grenoble, France.
- **Salary:** 2025 euros/month after taxes (gross: 2515 euros).
- **Dates:** Start in Dec. 2017, for one year. The position may be closed before if a competent candidate has applied.
- **How to apply:** Applications should include a detailed resume, the CV and a list of (at least) two references to one of the advisors

References

[1] D.O. Anderson and J.B. Moore, Optimal filtering, Dover Books on Electrical Engineering, Mineola, N.Y., Dover Publications, 2005.

[2] C.-I. Chesneau, M. Hillion, and C. Prieur, Motion estimation of a Rigid Body with an EKF using Magneto-Inertial Measurements, 7th Conf. on Indoor Positioning and Indoor Navigation (IPIN'16), Madrid, Spain, 2016.

[3] K.V. Mardia and P.E. Jupp, Directional Statistics, Wiley series in probability and statistics, 2008.

[4] J. Boulanger, S. Said, N. Le Bihan and J.H. Manton, Filtering from Observations on Stiefel Manifolds, Signal Processing, Vol. 122 , pp. 52-64, 2016.