AE484 Inertial Navigation Systems

This course introduces the essences of inertial navigation systems (INS) and integrated navigation. The final aim is to understand what the inertial navigation system is; how it can be used to navigate around; what kind of errors the system has; how we can aid the system for improving the navigation outputs; and which methods we have to aid the INS and get more accurate navigation results. All of these topics will be discussed with up-to-date application examples such as drone localization, autonomous driving, pedestrian navigation, etc. Application examples will be enriched with coding practices and simulations.

Tentative Weekly Schedule

1) Introduction to inertial navigation systems: A historical perspective and concepts
2) Preliminaries: Coordinate systems and transformations
3) Navigation equations ***(HW1)***
4) Sensor models and error characterization
5) INS error equations
6) Principal sensors for inertial navigation: Types and applications ***(HW2)***
7) Aiding sensors and methods for inertial navigation
8) Estimation for inertial navigation: Least square, nonlinear least square
9) Recursive least square and Kalman filter ***(HW3)***
10) Advanced topics in estimation: Kalman filtering for nonlinear systems
11) Global Navigation Satellite System (GNSS)
12) GNSS/INS integration: Different integration methods ***(HW4)*** + Project description ***(PR)***
13) Integrating with other sensors
14) Advanced topics for integrated navigation

HW1: On preliminaries (derivation and coding) – 2 weeks due date
HW2: On sensor models and errors (data collection and evaluation) – 2 weeks due date
HW3: Kalman filtering for GNSS measurements (coding) – 2 weeks due date
HW4: NLS application (coding) – 2 weeks due date

PR: Integrated navigation application – > 4 weeks due date
Project will be a group task and each group should be formed of max. 4 students. Each group will submit a single report and make a presentation of 10 mins. Presentation will be on a fixed date during the final exam weeks.

Reference Material

Primary

1) A. Noureldin, T.B. Karamat and J. Georgy, Fundamentals of Inertial Navigation, Satellite-based Positioning and their Integration, Springer-Verlag, Heidelberg, Germany, 2013.

Supplementary

2) M.S. Grewal, L.R. Weill and A.P. Andrews, Global Positioning Systems, Inertial Navigation and Integration, Wiley, New Jersey, USA, 2007.
3) P.D. Groves, Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems, 2nd Ed. Artech House, Boston, USA, 2013.
4) P.J.G. Teunissen and O. Montenbruck (Eds), Handbook of Global Navigation Satellite Systems, Springer, Switzerland, 2017.
5) J.L. Crassidis and J. L. Junkins, Optimal Estimation of Dynamic Systems, 2nd Ed, Chapman & Hall/CRC, Boca Raton, USA, 2011.

Grading

4 x Homework	30%
2 x Quiz + Participation	10%
Project + Presentation	30% (20+10)
Final	30%

Make-up Policy:

There are no make-up homework assignments. In case of late submissions -20 pts/day rule is applied for next two days. Later submissions than that are not accepted. If you will miss an exam, you need to contact the instructor one week prior to the exam date. If you can't take the exam for some emergency reason, you still need to notify the instructor prior to the exam. Without prior consent, there will be no make-up exams.

Prerequisite(s):

None. However, the student is expected to have knowledge on linear algebra, rigid body dynamics, system dynamics and modern control.

Lecture Hours: Tuesdays 08:40 – 11:30

Q&A Session: I will organize few Q&A sessions out of the official lecture hours. Date/time will be fixed based on consensus.

Office Hours: No official office hour. You can drop by or better have an appointment in advance.

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