Indian Institute of Technology, Kanpur

Proposal for a New Course

1. **Course No:**

2. **Course Title: Principles of Navigation techniques for autonomous systems**

3. **Per Week Lectures:** 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours[0-2]: (A), Credits (L+T+P+A): 9

4. Duration of Course: Full semester

5. Proposing Department/IDP: Department of Intelligent Systems

   Other Departments/IDPs which may be interested in the proposed course:

   Electrical Engineering, Aerospace Engineering, Mechanical Engineering.

   Other faculty members interested in teaching the proposed course:

6. Proposing Instructor(s): Prof. Anirban Roy

7. Course Description:

A) Objectives:

This course will provide a detailed introduction to the localization or navigational techniques used for various autonomous systems including Drone/Unmanned Aerial Vehicles (UAVs), Autonomous driver assistance systems (ADAS), Robotics and Unmanned ground vehicles (UGVs) applications. This course is distributed total four major sections – Concepts of Navigation theory and Inertial Navigational system fundamentals, Global Positioning System (GPS)/Global navigational satellite system (GNSS) based localization techniques, Hybrid navigation algorithms by fusing inertial navigation systems (INS) and GPS/GNSS and the alternate navigational methods like terrain reference navigation (TRN), celestial navigation in the event of GPS outage or artificially introduced GPS Jamming or spoofing. Brief aspects of receiver's autonomous integrated monitoring approaches will also be covered. Concepts of indoor navigation in GPS denied environment and slamming techniques will also be touched at high level. At the end of the course, the students will get a glimpse of navigation or localization concepts and solutions used in the field of autonomous systems including airborne platforms.

B) Contents (*preferably in the form of 5 to 10 broad titles)*:

S. No	Broad Title	Topics	No. of Lectures
1	Introduction to Navigation, dead reckoning concepts of Navigation, Navigation sensors – Self-contained Navigation, externally dependent and database matching solutions based navigational methods.		1
2	Inertial Navigation System Computations	- Inertial measurement unit fundamentals and various types of inertial navigation system (platform and gimballed) – **(1 classes)** - Review of attitude/orientation representation for rigid body platforms – Euler Angle and Direction cosine matrix, Quaternion and Eigen axis rotation and their conversion **(3 classes)** - Different coordinate systems for Navigation computations – **(2 classes)** - Strapdown navigation (SDINS) computations for horizontal and vertical channels, Baro inertial loop for vertical channel acceleration processing and control theoretic approach for SDINS lateral dynamics **(7 classes)** - Navigational system Alignment (Gyro-compassing and Transfer alignment methods (TA) – **(3 classes)**	16
3	GPS/SBAS based navigation	- Fundamentals of satellite-based navigation (GPS, GLONASS, GALLILIO, COMPASS, GAGAN) **(2 classes)** - Short review of spacecraft Orbital parameters and orbit determination **(2 classes)** - GPS errors and satellite positioning principles (SPS) based Receiver position determination (Least square and Kalman Filter approach) **(5 classes)** - Differential Positioning principle (DGPS method) **(1 class)** - Fundamentals of Space based satellite augmentation systems (SBAS – WAAS, EGNOS, MSAS, IRNSS) **(1 class)** - Hybrid navigation method **(3 classes)**	14
4	Alternate Navigation System	- GPS Jamming and spoofing, Receiver's autonomous integrity monitoring (RAIM) Principles **(2 Classes)** - Image registration principles and Terrain referencing concept **(3 classes)** - Concept of Indoor navigation and Slamming techniques (**3 classes**)	8
MATLAB simulation exercises and assignments will be given for better understanding of the course.			

Total Lectures per week: 3

C) Pre-requisites, if any

1. Basic Control System Fundamentals.

D) Short summary for including in the Courses of Study Booklet:

8. Recommended References:

1. **David Titterton, John Weston, "Strapdown Inertial Navigation Technology", IET Publication**
2. **Myron Kayton and Walter R. Fried, " Avionics Navigation System," Wiley & Sons**
3. **Esmat Bekir, "Introduction to Modern Navigation Systems," Cambridge Publication**
4. **Mohinder S. Grewal, P.E., Lawrence, "Global Positioning Systems, Inertial Navigation and Integration", Wiley and Sons**
5. **Amitabha Bose, K.N Bhat, Thomas Kurian, "Fundamentals of Navigation and Inertial Sensors," PHI Publication**
6. **Oleg S. Salychev, "Verified Approaches To Inertial Navigation," BMSTU Press Moscow Institute of Aviation**
7. **Li-Ta Hsu, Guohao Zhang, Weisong Wen, "Principles of Indoor Positioning and Indoor Navigation", Artech house**
8. **Hassan A. Karimi, "Indoor Wayfinding and Navigation," CRC Press**

A few good books to understand Kalman Filter:

9. **Brown and Hwang, "Random Process and Applied Kalman Filtering," John Wieley & Sons**
10. **Paul Zarchan and Howard Musoff, "Fundamentals of Kalman Filtering: A Practical Approach", AIAA.**

9. Any other Remarks

Evaluation procedure:

15% Class Assignment

40% Examination

45% Term Paper

Dated: 19.01.2025
Proposer: Prof. Anirban Roy

Dated:
DUGC/DPGC Convener:

The course is approved / not approved

Chairman SUGC/SPGC:
Dated: