Indian Institute of Technology, Kanpur

Proposal for a New Course

1. **Course No: IS741**

2. **Course Title: Perception algorithms 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, Computer Science Engineering,

   Mechanical Engineering, Mathematics

   Other faculty members interested in teaching the proposed course:

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

7. Course Description:

A) Objectives:

This course will provide a detailed introduction to the Environment perception algorithm blockchain for autonomous platforms – Drone/Unmanned Aerial Vehicles (UAVs), Autonomous driver assistance systems, Unmanned ground vehicles (UGVs), etc. Autonomous platforms gather perception information of the environment through multiple sensor measurements, such as Radar (FMCW/Pulse Doppler), EO/IRST, Multi-function Camera and Lidar (MFCL), ultrasonics, etc. This course will encompass three major object/target information processing stages as part of the entire Environmental Perception module: data association and multi-object tracking, Multi-Sensor data and information fusion, and Target classification.

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

S. No	Broad Title	Topics	No. of Lectures
1	Autonomous System functional stages	Introduction to Autonomous systems functions (Sense-plan-act, Observe Orient Decision and Act (OODA)), Sensing systems for autonomous vehicles.	4
2	Tracking	Target kinematic modelling, Sensor measurement and False alarm models, Detailed Kalman Filtering fundamentals including nonlinear Filtering techniques EKF, Pseudolinear filters, Sigma point Kalman Filters. Multiple model methods, Winner-Kolmogrov method of whitening colored noise, Class assignment and simulation exercises	12
3	Association algorithms	Solving Measurement origin uncertainties – Clutter, sensor misdetections, multi-target /extended target detection resolution - SNN, GNN, PDAF and MHT.	10

4	Multi Sensor data fusion	The information filter, Principles of Bayesian Fusion paradigms, covariance Intersection methodologies	5
5	Information Fusion	Bayesian techniques and Dempster-Shaffer methodologies – Class assignment and exercises	3
6	Classification algorithms	Target attribute/feature identification (Radar RCS, Micro-doppler, target kinematic information along with Camera/Lidar detection images), standard classification algorithms (SVM, CNN, Bayesian Classifier etc.)	4
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.
2. Knowledge in Probability and Statistics along with MATLAB simulation experience is required.

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

8. Recommended References:

1. **Samuel Blackman, Robert Popoli, "Design and Analysis of Modern Tracking Systems", Artech House, Boston.**
2. **J R Raol, "Multi-Sensor Data Fusion with MATLAB," CRC Press, Taylor and Francis Group.**
3. **Y Bar Shalom and X R Li, "Multitarget-Multisensor Tracking: Principles and Techniques, Artech House.**

A few good books to understand Kalman Filter:

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

9. Any other Remarks

Dated: 04.12.2025
Proposer: Dr. Anirban Roy

Dated:
DUGC/DPGC Convener:

The course is approved / not approved

Chairman SUGC/SPGC:
Dated: