# SECOND SEMESTER 2022-2023

Course Handout Part II

Date: 10-01-2023

## In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

*Course No.* : **BITS F327**

Course Title : **Artificial Intelligence for Robotics**

Instructor-in-Charge : Dr. Abhishek Sarkar

# Course Description:

**BITS F327 Artificial Intelligence for Robotics 2 1 3**

Introduction to AI, Application of AI in Robotics. Introduction to Robot Operating Systems (ROS), Python and programming with application of RaspberryPi and Arduino. Practical Robot Design Process, implementation of pick and place process. Basic robot sensing techniques (Vision and Listening), Beam Models of Range Finders, sensor models. Object Recognition Using Neural Networks and Supervised Learning. Robot learning process, Reinforcement learning and Genetic Algorithms. Basic concepts of speech recognition and natural language. Path planning, SLAM, decision trees, classification techniques, wave front, the A\* (A star) and D\* (D star) algorithms, and node-based planners. Non-deterministic simulation technique and Monte Carlo modeling, the Robot Emotion Engine, the Human Emotion Model.

# Scope and Objective:

The objective of this course is to introduce basic Artificial Intelligence techniques applied in the domain of Robotics. The course is focused on experiential learning, where the programming languages/systems such as Python and ROS are introduced. Hardware such as Raspberry-Pi and Arduino are implemented to develop a real time mobile robot. Gradually, the AI techniques are implemented on the robot to enable pick and place, listen, vision, and pathfinding operations. In this experimental process the theoretical parts of robot vision sensing, localization, SLAM and MCL etc. are introduced. The course will certainly interest students aiming to build-up professional and research career in the field of Robotics.

# Text Book:

(T) Russell, Stuart J., and Peter Norvig, ***Artificial intelligence: a modern approach,*** 3rd Edition, Pearson Education India, 2015. [4th Edition is also available now]

# Reference Books:

(R1) Thrun, Sebastian, Wolfram Burgard, and Dieter Fox, ***Probabilistic robotics,*** MIT press, 2006.

(R2) Martin T. Hagan et al., ***Neural Network Design,*** 2nd Edition.

(R3) S N Sivanandam & S N Deepa, ***Introduction to Genetic Algorithms,*** Springer, 2008.

(R4) Robin R. Murphy, ***Introduction to AI robotics,*** MIT press, 2000.

(R5) Richard Szeliski, [***Computer Vision: Algorithms and Applications***](https://www.amazon.in/Computer-Vision-Algorithms-Applications-Science/dp/3030343715/ref%3Dsr_1_1?crid=3O5NW69J8Z3DK&keywords=Computer%2BVision%3A%2BAlgorithms%2Band%2BApplications%2B2nd%2BEdition%2BRichard%2BSzeliski&qid=1672830208&s=books&sprefix=computer%2Bvision%2Balgorithms%2Band%2Bapplications%2B2nd%2Bedition%2Brichard%2Bszeliski%2Cstripbooks%2C392&sr=1-1)(Texts in Computer Science)**,** Springer, 2021.

# Course Plan:

|  |  |  |  |
| --- | --- | --- | --- |
| **Lecture No.** | **Learning Objectives** | **Topics to be covered** | **Chapter in the Text Book** |
| 1-2 | Students will become familiar with robotics and  artificial intelligence | **Introduction to AI, Application of AI in Robotics** | [T-1]  [R4-1] |
| **Agent, Motion model** |
| 3-6 | Student will learn the mathematics behind the uncertainty computation | **Bayes filters** | [T-13, 14]  [R1-2,3] |
| **Probability, Gaussian distribution, α−β−γ*,* Kalman Filters** |
| 7-10 | Student will be able to apply Kalman filter for uncertainty in motion and perception | **Basic robot sensing techniques** | [T-15]  [R1-5,6]  [R4-9,10]  Classnote |
| **Dijkstra, A\*, D\*** |
| **Beam Models of Range Finders, sensor models.** |
| 11-12 | Student will learn to develop an optimal path using genetic algorithms | **Terminologies, optimization, Evolutionary computations** | [R3-1,2,3,4]  Classnote |
| **Genetic algorithm, advance**  **operations** |
| 13-18 | Students will learn SLAM problem | **Localization** | [R1-7,9,10] [R4-11] |
| **Mapping** |
| **Visual SLAM** |
| **Graph SLAM** |
| 19-22 | Student will learn ANN | **Introduction, decision trees, classification techniques** | [R2- 1,2,3,4,7,  11] |
| **Perceptron Learning, Hebbian learning for obstacle avoidance,** |
| **Backpropagation** |
| 23 | Student will learn techniques about Object recognition | **Object recognition, Image recognition for learned navigation without a map, Structure and process of solving the problem**  **using AI.** | [R5-6, 7, 8,  9] |
| 24-26 | Student will learn Reinforcement learning methods for  autonomous driving | **Markov Chains, MDP, POMDP** | [T-21]  [R1-14,15] |
| **Temporal difference, Q-learning** |
|  |  |  |  |
| P1-P2 | Familiarizing students to Linux, Python & Raspberry Pi | **Introduction, RaspberryPi coding, sensors** | Class-demo, Online resources |
| **Python – Variables, Loops, Matrix Multiplication/ operation, Functions, Pandas, matplotlib,**  **seaborn** |
| P3 | Student will learn to code path planning  algorithms with Python | **Kalman Filter, Dijkstra, A\* D\*, GA** | Class-demo, Online  resources |

|  |  |  |  |
| --- | --- | --- | --- |
| P4-P6 | Students will learn to code for vision sensor | **Open CV, Image processing** | Class-demo, Online resources |
| **Feature, pattern recognition** |
| **Smart car navigation, data collection** |
| P7 | Students will learn to use neural networks and supervised learning techniques | **Training and evaluation of neural networks using Keras and**  **TensorFlow, Speech recognition.** | Class-demo, Online resources |
| **Object Recognition Using Neural Networks and Supervised**  **Learning, Basics of image recognition** |
| P8-P9 | Learn to code SLAM problems | **Depth estimation, Graph SLAM** | Class-demo,  Online resources |
| **Introduction to Deep Learning** |
| P10-P11 | Objecct detection algorithms will be introduced | **CNN, YOLO, etc.** | Class-demo, Online  resources |
| P12 | Student will learn to code for RL | **Dynamic Programming, RL** | Class-demo,  Online resources |

**Evaluation Scheme:**

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weight (%)** | **Date & Time** | **Nature of Component\*** |
| Assignments | -- | 15% | Coding based assignments | OB |
| Quiz | -- | 10% | To be announced in class (One before  mid-sem and one before compre exam) | CB |
| Project | -- | 15% | Submission of Presentation and Report (1 week before the start of  Comprehensive exams) | OB |
| Mid-sem Examination | 90 min | 25% | 13/03 9.30 - 11.00AM | CB |
| Comprehensive- Examination | 180 min | 35% | 08/05 FN | CB |

**\*Close Book, Open Book**

**Chamber Consultation Hour:** Tuesday 4-5 PM & Friday 3-5 PM (Except holidays).

## **Notices:** All notices will be put up on CMS/Google classroom.

**Make-up Policy:** Make-up will be given with prior concern and genuine reasons only. **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

# INSTRUCTOR-IN-CHARGE