DIPLOMA IN ROBOTICS AND ARTIFICIAL INTELLIGENCE

Course Name: Diploma in ROBOTICS and ARTIFICIAL INTELLIGENCE

Duration: 1 Year

Eligibility: 10+2 with PCM

DETAILED SYLLABUS

Semester I	**Semester II**
Fundamentals of Robotics	Robot Sensing and Vision
Artificial intelligence,	Machine learning
Research methodology and IPR	Embedded control system
Robot Design and Programming Laboratory	Embedded Control System laboratory
Microcontroller Architecture and Programming	Mobile and Micro-robotics

SEMESTER I

PAPER 1: FUNDAMENTALS OF ROBOTICS

CONTENT:

Unit 1: Robotics-Introduction-classification with respect to geometrical configuration (Anatomy), Controlled system & chain type, Serial manipulator & Parallel Manipulator. Components of Industrial robotics, precession of movement, resolution, accuracy & repeatability, Dynamic characteristics, speed of motion, load carrying capacity & speed of response, Sensors, Internal sensors, Position sensors, & Velocity sensors, External sensors, Proximity sensors, Tactile Sensors, & Force or Torque sensors.

Unit 2: Grippers – Mechanical Gripper, Grasping force, mechanisms for actuation, Magnetic gripper vaccume cup gripper considerations in gripper selection & design. Industrial robots specifications, Selection based on the Application.

Unit 3: Kinematics-Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, DH transformation matrix, DH method of assignment of frames. Direct and Inverse Kinematics for industrial robots. Differential Kinematics for planar serial robots. Robot Applications, Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots, economics of robots.

Suggested Readings

1. Groover M P, Industrial Robotics, Mc Graw Hill Ltd.
2. John J. Craig, Introduction to Robotics, Pearson Education Asia
3. Jazar, Theory of Applied Robotics, Springer.
4. Ghosal, Robotics, Oxford India.

PAPER 2: INTRODUCTION TO ARTIFICIAL INTELLIGENCE

CONTENT:

Unit 1: Searching Techniques: uninformed search strategies, informed (heuristic) search strategies, local search algorithms, searching in non-deterministic and partially observable environment, adversarial search.

Unit 2: Temporal Probability models and inference in temporal models: filtering, prediction, smoothing, most likely explanation, Dynamic Bayesian Networks, Hidden Markov Model, Kalman Filter, Extended Kalman Filter, Particle Filter, Learning Probabilistic Models.

Unit 3: Decision making: Markov Decision Processes (MDPs), Partially Observable MDPs (POMDPs).

Unit 4: Learning: Introduction to supervised learning, unsupervised learning, and reinforcement learning

Suggested Readings

1. Stuart Russell and Peter Norvig, Artificial Intelligence a Modern Approach, 3rd Edition, Pearson, 2014.
2. C. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3. R.S. Sutton and A.G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, MIT Press, 2018.

PAPER 3: RESEARCH METHODOLOGY AND IPR

CONTENT:

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Unit 4: Nature of Intellectual Property- Patents, Designs, Trade and Copyright. Process of Patenting and Development, technological research, innovation, patenting, development. International Scenario, International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights- Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR- Administration of Patent System. New developments in IPR, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Suggested Readings

1. Stuart Melville and Wayne Goddard, Research methodology: an introduction for science& engineering students
2. Wayne Goddard and Stuart Melville, Research Methodology: An Introduction

3. Ranjit Kumar, 2 ndEdition, Research Methodology: A Step by Step Guide for beginners
4. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd,2007.
5. Mayall, Industrial Design, McGraw Hill, 1992.
6. Niebel, Product Design, McGraw Hill, 1974.
7. Asimov, Introduction to Design, Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in New Technological Age, 2016.
9. T. Ramappa, Intellectual Property Rights Under WTO, S. Chand, 2008

PAPER 4: ROBOT DESIGN AND PROGRAMMING LABORATORY

CONTENT:

ROBOT DESIGN:

1. Demonstrations on Robot Mechanisms and their design.
2. Studies on Existing Robots, Computer-Aided-Design of Robots.
3. Robot Hardware and Control System Design
4. ROS
5. Topics in Machine Elements.

PROGRAMMING LAB

1. Introduction: why Python
2. Ecosystem: installation, workflow, data types, control flow, functions, scripts and modules, input, output, standard library, Numpy arrays, Pandas Basic, Generators, List Comprehensions, Multiple Function Arguments, Regular Expressions, Exception Handling, Sets, Serialization, Partial functions, Code Introspection, Closures, Decorators, Map, Filter, Reduce,
3. Visualization with Matplotlib, Libraries for AI.

Suggested Readings

1. Python Data Science Handbook, O'REILLY
2. Sandor G.N. and Erdman A.G., Advanced Mechanism Design: Analysis and Synthesis, Vol.
3. Prentice Hall, New Jersey, 1984.
4. Zeid, Ibrahim. CAD/CAM theory and practice. McGraw-Hill Higher Education, 1991.

5. Rivin E.I., Mechanical Design of Robots, McGraw Hill, New York, 1988.
6. D.J. Bell, P.A. Cook, N. Munro, Design of Modern Control Systems, IEE Control Engineering Series, Institution of Engineering and Technology, 1982.
7. G. Budynas and J. K. Nisbett, Shigley's Mechanical Engineering Design, 10th Edition, McGraw Hill, 2015.
8. Joseph L., Mastering ROS for Robotics Programming, Packt Publishing, Birmingham, 2015.
9. Nnaji B.O., Computer-aided Design, Selection and Evaluation of Robots, Manufacturing Research & Technology, Elsevier Science Ltd, 1986.

PAPER 5: MICROCONTROLLER ARCHITECTURE AND PROGRAMMING

CONTENT:

Unit 1: Introduction to Microprocessors- Registers, File registers, Memory Organization, Tristate logic, Buses, Memory Address register, Read/Write operations. ROM, RAM, PROM, EPROM, E2PROM. Introduction to elementary processor, Organization, Data Transfer Unit (DTU)operation, Enhanced Data Transfer Unit (EDTU), opcode, machine language, assembly language, pipeline and system clock. Architecture of 8085, Addressing modes, Data transfer, data processing and program flow control instructions, Simple assembly language programs.

Unit 2: Introduction to Microcontrollers- PIC16F877 Architecture, Program and Data memory organization, Special Function Registers, addressing modes, Instruction set. MPLAB Integrated Development Environment, Introduction to Assembly language and Embedded C programming, Stack, Subroutines, Interrupt structure, Peripherals, Input/Output Ports.

Unit 3: PIC Peripherals- Timers, Counters, Watchdog Timer, Capture, Compare, PWM (CCP), Analog to Digital Converter(ADC), EEPROM, Serial Communication, USART, Development of Application Programs and interfacing, LED, LCD, Keyboard, DC and Stepper motor interface. Introduction to 8051 Microcontroller Architecture, Ports, Timers.

Suggested Readings

1. Kenneth J. Ayala, "The 8051 Microcontroller Architecture, Programming & Applications", Penram International.
2. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", Tata McGraw-Hill Education, 2008.

SEMESTER II

PAPER 1: ROBOT SENSING AND VISION

CONTENT:

Unit 1: Robotic vision sensors and their interfacing

Unit 2: Fundamentals of Computer Vision- Image accusation and representation, image transformation, filtering, restoration, morphing, Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, RANSAC

Unit 3: Position and Orientation: Feature based alignment, Pose estimation, Time varying pose and trajectories, Structure from motion, dense Motion Estimation, Visual Odometry (Semi-direct VO, direct sparse odometry), Bundle Assignment

Unit 4: Localization and Mapping- Initialization, Tracking, Mapping, geometric SLAM formulations (indirect vs. direct error formulation, geometry parameterization, sparse vs. dense model, optimization approach), Relocalization and map Optimization, Visual SLAM, Examples: Indirect (Feature based) methods (MonoSLAM, PTAM, ORB-SLAM), Direct methods (DTAM, LSD-SLAM), Sensor combinations (IMU, mono vs. Stereo, RGB-Depth), Analysis and parameter studies.

Unit 5: Recognition and Interpretations- Concepts of machine learning and deep learning, sequence modeling, learning for robotic vision, Active learning, incremental and class incremental learning identify unknowns, uncertainty estimation, Embodiment for robotic vision: active vision, spatial and temporal embodiment, reasoning for object, scene and scene semantics.

Suggested Readings

1. H. R. Everett, Sensors for Mobile Robots: Theory and Application, A K Peters/CRC Press, 1995.
2. Dahiya, Ravinder S., Valle, Maurizio, Robotic Tactile Sensing, Springer, 2013.
3. S. R. Deb, Sankha Deb, Robotics Technology and Flexible Automation, 2nd edition, McGraw Hill Education, 2017.
4. Milan Sonka, Vaclav Hlavac and Roger Boyle, Image Processing, Analysis and Machine Vision, Cengage, Third Edition (2013)
5. Abdessalan Bouzerdoum, George Mamic and M. Bennamoun, Object Recognition: Fundamentals & Case Studies, First Edition, Universities Press, 2008.

PAPER 2: MACHINE LEARNING

CONTENT:

Unit 1: Introduction to supervised and unsupervised learning frameworks

Unit 2: Dimensionality reduction: Feature selection; PCA

Unit 3: Supervised learning: Bayesian classification, Perceptrons, Multi-layer perceptron, RBF Networks, Decision Trees, Support Vector Machines, Convolutional Neural Networks, Recurrent Neural Networks

Unit 4: Unsupervised learning- K Means clustering, DBSCAN, Non-parametric Estimation, Mean-shift clustering, Classification performance analysis, Ensemble methods, Boosting and Bagging.

Unit 5: Applications and Case Studies in Robotics.

Suggested Readings

1. E. Alpaydin, Introduction to Machine Learning, 3rd Edition, Prentice Hall (India) 2015.
2. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, 2nd Edn., Wiley India, 2007.
3. C. M. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer, 2006.
4. S. O. Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Education (India), 2016
5. I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2017

PAPER 3: EMBEDDED CONTROL SYSTEM

CONTENT:

Unit 1: Introduction to Embedded Systems, Its Architecture and system Model, Introduction to the HCS12/S12X series Microcontrollers, Embedded Hardware Building Block. HCS12 System Description and Programming: The HCS12 Hardware System, Modes of Operation, The B32 Memory System, The HCS12 DP256 Memory System, Exception Processing–Resets and Interrupts, Clock Functions, TIM, RTI, Serial Communications, SPI-Serial Peripheral Interface, I2C, HCS12 Analog-to-Digital Conversion System.

Unit 2: Basic Input /Output Interfacing Concepts: Input Devices, Output Devices and their Programming, Switch Debouncing, Interfacing to Motor, LCDs, Transducer, The RS-232 Interface and their Examples.

Unit 3: Development tools and Programming: Hardware and Software development tools, C language programming, Codewarior tools- Project IDE, Compiler, Assembler and Debugger, JTAG and Hardware Debuggers, Interfacing Real Time Clock and Temperature Sensors with I2C and SPI bus.

Unit 4: Real-time Operating Systems (RTOS): Basic concepts of RTOS and its types, Concurrency, Reentrancy, Intertask communication, Implementation of RTOS with some case studies.

Suggested Readings

1. Barrett, S.F. and Pack, J.D., Embedded Systems, Pearson Education (2008).
2. Haung, H.W., The HCS12 / 9S12: An Introduction to Software and Hardware Interfacing, Delmar Learning (2007).

3. Fredrick, M.C., Assembly and C programming for HCS12 Microcontrollers, Oxford University Press (2005).
4. Ray, A.K., Advance Microprocessors and Peripherals – Architecture, Programming and Interfacing, Tata Hill (2007), McGraw

PAPER 4: EMBEDDED CONTROL SYSTEM LABORATORY

CONTENT:

1. Programming of HCS12 with Code warrior for Interrupts, Clock Functions,
2. TIM, RTI, SPI, LCD interfacing,
3. Use of JTAG and Hardware Debuggers, Interfacing Keypad,
4. ADC, DAC, LCD, Real Time Clock
5. Temperature Sensors with I2C and SPI bus
6. Interface 7 segment LED to 8051 to generate flashing action
7. Interface Analog to Digital converter to 8051 and display the result on LCD display
8. Interface Digital to Analog converter to 8051 and view the output on CRO Interface stepper motor to 8051 it through given number of steps.
9. Perform serial communication using 8051
10. Decentralized motion control and Centralized motion control
11. Feed-forward compensation,
12. Force control,
13. Visual serving
14. Stepper motor control (Single motor and two motor).
15. Linear controller (P, PI, PD and PID) design for simple position control of mechanical systems.

PAPER 5: MOBILE AND MICRO-ROBOTICS

CONTENT:

Unit 1: Introduction to Mobile Robots - Tasks of mobile robots, robot's manufacturers, type of obstacles and challenges, tele-robotics, philosophy of robotics, service robotics, types of environment representation.

Unit 2: Ground Robots- Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots. Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, Omni-directional and macaque wheeled robots).

Unit 3: Sensors for localization- magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, GNSS and Sensors for navigation: tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual system, Kinect. Localization and Mapping in mobile robotics.

Unit 4: Motion Control of Mobile Robots (Model and Motion based Controllers)- Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots. Introduction to Mobile Manipulators and Cooperative Mobile Robots.

Unit 5: Micro Robotics- Introduction, Task specific definition of micro-robots, Size and Fabrication Technology based definition of micro robots, Mobility and Functional, based definition of micro-robots, Applications for MEMS based micro-robots.

Unit 6: Implementation of Micro Robots- Arrayed actuator principles for micro-robotic applications, Micro-robotic actuators, Design of locomotive micro-robot devices based on arrayed actuators. Micro-robotics devices, Micro-grippers and other micro-tools, Micro-conveyors, Walking MEMS, Micro-robots, Multi-robot system, Micro-robot powering, Micro-robot communication. Microfabrication and Micro assembly,

Micro-fabrication principles, Design selection criteria for micromachining, Packaging and Integration aspects, Micro-assembly platforms and manipulators.

Suggested Readings

1. R Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots, The MIT Press, USA, 2011,
2. SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014,
3. A Kelly, Mobile Robotics, Mathematics, Models, and Methods, Cambridge University Press, USA, 2013,
4. G Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA,
5. Mohamed Gad-el-Hak, The MEMS Handbook‖, CRC Press, New York, 2002.
6. Yves Bellouard, Microrobotics Methods and Applications, CRC Press, Massachusetts, 2011.
7. Patnaik, Srikanta, "Robot Cognition and Navigation an Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
8. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, ―Principles of Robot Motion-Theory, Algorithms, and Implementation, MIT Press, Cambridge, 2005.
9. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.