August, 2019

M.TECH ROBOTICS AND AUTOMATION (2019)

Robotics, the branch of technology that deals with the design, construction, operation, and application of robots, has become a highly relevant and upcoming discipline. It is being increasingly applied to almost every field of activity including improving the standard of living of humans, handling dangerous and hazardous situations, relieving mankind of repetitive and tiring activities, exploring outer space and performing complex medical procedures. Many industries also use robots in their manufacturing facilities and research. For instance, robots are used in areas like high heat welding and continuous handling of heavy loads. They can function tirelessly even in the most inhospitable working conditions. Owing to this, robots are taking over from man most of the manipulative, hazardous and tedious jobs in factories, mines, atomic plants, spaceships, deep-sea vessels, etc. The automation of work through robotics has led to substantial increase in productivity in these areas.

Given its diverse applications, the robotics field today demands in-depth knowledge of a broad range of disciplines such as electronics, computers, instrumentation and mechanics. A graduate entering the workforce in the area of robotics must be thoroughly familiar with intelligent systems and proficient in computer vision, control systems, and machine learning, as well as the design and programming of robotic systems. Specialization in automation also requires the student to apply a wide range of engineering principles in order to understand, modify or control the manufacture, delivery and maintenance of technology components in a broad range of industries. Graduates must know how to develop and maintain systems that cost-effectively optimize productivity and quality control.

The Amrita Vishwa Vidyapeetham Robotics and Automation M.Tech.program is unique in that it provides an academic curriculum that pulls from mechanical engineering, electronics and instrumentation engineering and computer science disciplines, exposing the students to the breadth of and interdependence among the engineering disciplines and offering the students exactly what is required to master the technical knowledge required.

This M.Tech program will provide a comprehensive educational environment and enable students to gain expertise in next generation robotics and automation systems. By exposing our students to do course work from multiple disciplines and preparing them to think about robotics from a holistic approach, our program will prepare a skilled industry workforce as well as expert researchers who will be able to provide leadership in a world that is increasingly dependent on technology.

CURRICULUM

Semester 1

Course Code	Course Type#	Course Title	Credits			
			L	T	L	Total
19MA611	FC	Mathematics for Robotics and Automation	3	0	0	3
19RA601	FC	Embedded System Design	3	0	1	4
19RA602	FC	Digital Control Systems	2	0	1	3
19RA611	SC	Kinematic and Dynamic Modeling of Manipulators	2	1	1	4
19RA603	FC	Robot Operating System (ROS)	1	1	2	4
19HU601	HU	Amrita Values Program*				P/F
19HU602	HU	Career Competency I*				P/F
		Total Credits	**18**			

*Non-credit course

Semester 2

Course Code	Course Type#	Course Title	Credits			
			L	T	L	Total
19RA604	FC	Probability and Statistics	3	0	0	3
19RA605	FC	Design and Analysis of Algorithms	3	0	1	4
19RA612	SC	Autonomous Robots	3	0	1	4
	E	Elective - 1	3	0	1	4
19RA613	SC	Digital Image Processing	3	0	1	4
19RM600	SC	Research Methodology	2	0	0	2
19HU603	HU	Career Competency II*	1	0	0	1
		Total Credits	**22**			

Semester 3

Course Code	Course Type#	Course Title	Credits			
			L	T	L	Total
	E	Elective – 2	3	0	0	3
	E	Elective – 3	3	0	0	3
19RA798	P	Dissertation				8
		Total Credits	**14**			

Semester 4

Course Code	Course Type#	Course Title	Credits
19RA799	P	Dissertation	**12**

Total Credits : 66

ELECTIVES

Course Code	Course Type	Elective – 1 Courses	Credits			
			L	T	P	Total
19RA701	E	Industrial Automation I	2	0	2	4
19RA702	E	Machine Learning	3	0	1	4

Course Code	Course Type#	Elective – 2 & 3 Courses	Credits			
		Stream 1: Career oriented	L	T	L	Total
19RA711	E	Industrial Automation – II	2	0	1	3
19RA712	E	Process Control and Instrumentation	3	0	0	3
19RA713	E	Advanced Process Control	3	0	0	3
19RA714	E	FPGA based System Design	3	0	0	3
19RA715	E	Embedded Real Time Systems	3	0	0	3
19RA716	E	Robot Simulation and Offline Programming	3	0	0	3
19RA717	E	Advanced Embedded System Design	3	0	0	3

Course Code	Course Type#	Elective – 2 & 3 Courses	Credits			
		Stream 2: Research Focus	L	T	L	Total
19RA718	E	Humanoid Robotics	3	0	0	3
19RA719	E	Swarm Intelligence	3	0	0	3
19RA720	E	Behavioral Based Robotics	3	0	0	3
19RA721	E	Frontiers of Biomechanics	3	0	0	3
19RA722	E	Optimization Theory	3	0	0	3
19RA723	E	Haptic Interfaces	2	0	1	3
19RA724	E	Innovating in Technology	3	0	0	3
19RA725	E	Measuring User Interface Quality	3	0	0	3
19RA726	E	Design for People: Principles and Practices of Human Centred Design	3	0	0	3

Course Code	Course Type#	Elective – 2 & 3 Courses	Credits			
		Stream 2: Software Focus	L	T	L	Total
19RA727	E	Advanced Perception for Robotics and HCI	3	0	0	3
19RA728	E	Computational Intelligence	3	0	0	3
19RA729	E	Machine Vision	3	0	0	3
19RA730	E	Advanced AI for Robotics	3	0	0	3
19RA731	E	Virtual Reality and Applications	3	0	0	3
19RA732	E	Non-Linear Control Theory	3	0	0	3
19RA733	E	Experimental Haptics	3	0	0	3
19RA734	E	Unmanned Aerial Vehicles	1	0	2	3

19MA611MATHEMATICS FOR ROBOTICS AND AUTOMATION 3-0-0-3

Linear Algebra: Review of Matrices: Geometry of linear equations, Vector spaces and subspaces,linear independence, basis and dimensions, linear transformations, applications of linear transformations, inner product space, orthogonality, Gram Schmidt orthogonalization process, projections and least square applications, Eigen values and Eigen vectors. Ordinary Differential Equations and applications of integration: Separable first order differential equations, exact first order differential equations, applications of differential equations, Linear homogeneous differential equations with constant coefficients, method of undetermined coefficients, Variation of Parameters, techniques and applications of integration.Complex numbers: Different ways of representing complex numbers, arithmetic operations on complex numbers. Linear Programming and Optimization: Formulation of Linear programming problem, Graphical method of Linear programming problems, Simplex method, Big M. Method, Transportation Models, Assignment Models.

TEXT BOOKS/REFERENCES:

[1.] P.C. Tulsian and Vishal Pandey, "Quantitative Techniques", Pearson Education.
[2.] Ronald L. Rardin, "Optimization in Operations Research".
[3.] Singiresu S. Rao, "Engineering Optimization Theory and Practice".
[4.] Stephen D. Fisher, "Complex Variables".
[5.] Emil G. Milewski , "The Complex Variables Problem Solver".
[6.] Kreyszig, "Advanced Engineering Mathematics".
[7.] Howard Anton, "Elementary Linear Algebra with Applications".
[8.] Bernard Kolman and David R. Hill, "Introductory Linear Algebra with Applications".
[9.] David C. Lay, "Linear Algebra and its Applications", Pearson Education.
[10.] Thomas and Finney, "Calculus".

19RA601 EMBEDDED SYSTEMS DESIGN 3-0-1-4

Microcontroller fundamentals: ARM ASM programming and basic of C; IO Interfacing: LED and Switch; Design and Development Process: Architecture, Micro architecture, Design, Implementation, Verification and Validation; Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines; The Parallel Interface: GPIO; The Serial Interface: UART; PLL programming; Timer: SysTick; Fixed Point; Software: Structs, Stacks and Recursion; Device Driver: Interfacing with an Hitachi HD44780 display; IO Synchronization; Interrupts; DAC: Music Synthesis and Music Playback; ADC: Real world interfacing and Data Acquisition.

Labs include prototypes of actual embedded systems, e.g., Traffic Light Controller (FSM), LCD Device Driver (Hitachi HD44780), Digital Piano (DAC, Interrupts), Digital Vernier Caliper (ADC, Interrupts, LCD), Distributed Data Acquisition (Interrupts, ADC, LCD, UART)accomplished using Arduino based system.Basics of system booting and Boot Loaders. Concurrency, Timeouts, Inter Process Communication. Capstone Design Project, A popular video game, e.g., Space Invaders, Connect-4, Pipe Dream, etc.

TEXT BOOKS/REFERENCES:

[1.] Jonathan Valvano, “Embedded Systems: Introduction to ARM® Cortex™-M Microcontrollers”, Fourth Edition, Create Space Publishing, 2013.
[2.] Michael Margolis, “Arduino Cookbook”, O'Reilly Media, 2014
[3.] Massimo Banzi and Michael Shiloh,“Getting Started With Arduino”,Third Edition, 2014.
[4.] Edward A. Lee, and Sanjit A. Seshia, “Introduction to Embedded Systems- A CyberPhysical Systems Approach”,Second Edition, 2015.
[5.] Jeff C. Jensen, Edward A. Lee, and Sanjit A. Seshia, “An Introductory Lab in Embedded and Cyber-Physical Systems”, First Edition, 2015.

19RA602 DIGITAL CONTROL SYSTEMS 2-0-1-3

Introduction to Digital Control Systems.Review of Z transforms. Pulse transfer function. Digital control system: sampling, quantization, data reconstruction and filtering of sampled signals. Z transform analysis of closed loop and open loop systems, multirate Z transform. Stability analysis of closed loop systems in the z plane: root loci, frequency domain analysis, stability tests. Discrete equivalents. Digital controller design forSISO systems: design based on root locus method in the z plane, design based on frequency response method, design of the lag compensator, lead compensator, lag lead compensator, design of PID controller based on frequency response method, direct design, method of Ragazzini.Controllability, observability, control law design, decoupling by state variable feedback, effect of sampling period. Estimator/Observer design: full order observers, reduced order observers, regulator design.Introduction to Robot controller, linear and nonlinear controls.

TEXT BOOKS/REFERENCES:

[1.] Gene F. Franklin, J. David Powell, Michael Workman, “Digital Control of Dynamic Systems”, Pearson, 2000.
[2.] Loan Dore Landau, GianlucaZito, “Digital Control Systems: Design, Identification and Implementation”, Springer, 2006.
[3.] K. Ogata, “Discrete-Time Control Systems”, Pearson Education, 2011.
[4.] M. Sami Fadali, Antonio Visioli, “Digital Control Engineering: Analysis and Design”, Elsevier, 2013.
[5.] M. Gopal, “Digital Control and State Variable Methods”, Tata McGraw-Hill, 2006.
[6.] C.L. Philips, Troy Nagle, AranyaChakrabortty, “Digital Control System Analysis and Design”, Prentice-Hall, 2014.

19RA611 KINEMATIC AND DYNAMIC MODELLING OF MANIPULATORS 2-1-1-4

Robot types, trends, applications, classification - Anatomy and Architecture of Manipulators – Transformations - Robot Kinematics:Forward and Inverse - Manipulator Jacobian - Force relations - Dynamics: Forward and Inverse - Feedback Control: Position and force - Trajectory planning in Joint space and Cartesian space -– Matlab Simulations of Kinematic dynamic and control models - Programming of ABB Industrial Robots (RAPID Language).

TEXT BOOKS/REFERENCES:

[1.] John J. Craig, "Introduction to Robot Mechanics".
[2.] Reza N. Jazar, “Theory of Applied Robotics Kinematics, Dynamics and control”
[3.] Peter Corke, "Robotics, Vision, and Control: Fundamental Algorithms in MATLAB", Springer, 2011.
[4.] S K Saha, “Introduction to Robotics”

19RA603 ROBOT OPERATING SYSTEM (ROS) 1-1-2-4

Introduction to ROS - ROS Basic Concepts: Nodes, topics, parameters, services - Simple ROS programs to publish and subscribe messages. Simulation of typical robot system in ROS: Manipulators, wheeled robots in scenarios such as in a maze etc., legged robots and UAVs in various environments.

TEXT BOOKS/REFERENCES:

[1]. ROS Wiki
[2]. Jason M. O’Kane, "A Gentle Introduction to ROS" ISBN 978-14-92143-23-9

19RA604 PROBABILITY AND STATISTICS 3-0-0-3

Probability:Introduction to data analysis and statistics, Algebra of sets, Counting, Axioms of probability, Conditional probability, Law of Total Probability and Bayes' rule, Independence of events, Random variables; Types of data, Descriptive statistics (measures of central tendency and variation), Graphical representation of data, Distribution functions, Expectation, variance, and moments of discrete & continuous random variables, Functions of random variables, Discrete Uniform, Bernoulli, Binomial, Poisson, and Geometric distributions, Continuous Uniform, Normal, and Exponential random variables; Measurement errors - accuracy and precision; Framing hypothesis statements (practical statement vs. statistical statement), Concept of statistical hypothesis tests; Type I Error, Type II Error, and p-value, Point estimation vs. interval estimation, Test of single mean, Test of comparison of two means (independent and paired t-tests), Test of single variance, Test of comparison of two variances, Test of comparison of more than two means (ANOVA), Test of independence of two discrete random variables (Chi-square), Correlation and covariance, Concept of Linear Regression.Estimation Theory,Bayes and Kalman filter. Introduction to SPSS/Minitab/Matlabfor data Analysis.

TEXT BOOKS/REFERENCES:

[1.] K.M. Ramachandran and Chris P. Tsokos, "Mathematical Statistics with Applications"
[2.] Douglas C. Montgomery and George C.Runger, "Applied Statistics and Probability for Engineers", 3rd Edition, John Wiley, 2008.

19RA605 DESIGN AND ANALYSIS OF ALGORITHMS 3-0-1-4

Algorithm Analysis: Methodologies for Analyzing Algorithms, Asymptotic Notation, Recurrence Relations. Data Structures: Linear Data Structures (Stacks, Queues, Linked-Lists, Vectors), Trees (Binary Search Trees, AVL trees, Red-Black trees, B-trees), Hash-Tables (Dictionaries, Associative Arrays, Database Indexing, Caches, Sets) and Union-Find Structures. Searching and Sorting (Insertion and Selection Sort, Quicksort, Mergesort, Heapsort, Bucket Sort and Radix Sort), Comparison of sorting algorithms and lower bounds on sorting.
Fundamental Techniques: The Greedy Method, Divide and Conquer, Dynamic Programming. Graph Algorithms: Elementary Algorithms, i.e., Breadth-first search, Depth-first search, Topological sort, strongly connected components. Minimum Spanning Trees, Single-Source Shortest Paths, All-Pairs Shortest Paths, Maximum Flow, Network Flow and Matching, Flows and Cuts. Nondeterministic Polynomial Time Problems: P and NP, NP-Complete, NP-Hard, Important NP-Complete/Hard Problems. Significant labs: Implementation of algorithms using a structured or object-oriented programming language.

TEXT BOOKS/REFERENCES:

[1.] T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, "Introduction to Algorithms", MIT Press, 2009, 3rd Edition
[2.] S. Dasgupta, C. Papadimitriou and U. Vazirani, "Algorithms", McGraw-Hill, 2006
[3.] J. Kleinberg and E. Tardos, "Algorithm Design", Addison Wesley, 2005
[4.] R. Sedgewick and K. Wayne, "Algorithms", Addison Wesley, 2011, 4th Edition
[5.] K. Mehlhorn and P. Sanders, "Data Structures and Algorithms: The Basic Toolbox", Springer, 2008
[6.] E. Lehman, T. Leighton and A. Meyer, "Mathematics for Computer Science", MIT Press, 2010

19RA612 AUTONOMOUS ROBOTS 3-0-1-4

Introduction, Types of Mobile Robots, Kinematic models for Mobile Robots, Maneuverability, Workspace & Motion control, Sensors & Actuators for Mobile Robots, Sizing and Torque Calculations, Design and implementation of estimation algorithms for state estimation, Localization, Map-representation and Map building, Map-based localization scheme, Planning and Navigation: Dijkstra's algorithm, A* algorithm, Potential field method, Wandering standpoint algorithm, DistBug algorithm etc.Simulation of Husky Mobile Platform using ROS - Online Control of Husky in a structured environment.Relevance of Machine learning, Neural Network and Fuzzy logic in defining the autonomy of a robot.

TEXT BOOKS/REFERENCES:

[1.] R. Siegwart andIllah R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", MIT Press, 2004.
[2.] Thomas Braunl, "Embedded Robotics", Second Edition, Springer, 2006.

[3.] SicilianoandKhatib, “Handbook of Robotics”, Springer, 2008.
[4.] WitoldJacak, “Intelligent Robotic Systems: Design Planning and Control”, Kluwer Academic Publishers, 1999.

19RA613 DIGITAL IMAGE PROCESSING 3-0-1-4

Two-Dimensional Signals and Systems: Two-dimensional convolution, 2D Discrete-SpaceFourier Transform, Inverse 2-D Fourier Transform, Fourier Transform of 2-D or SpatialConvolution, Symmetry properties of Fourier Transform, Continuous-Space Fourier Transform.Sampling in two dimensions: Sampling theorem, Change in Sample rate, Down sampling, Ideal decimation, Up sampling, Ideal interpolation. Continuous Image characterization: Psychophysical vision properties, Photometry, Colorimetry. Fundamentals of Digital Image Processing: Image acquisition - Various modalities, Image sampling and quantization, mathematical representation, Image reconstruction based on interpolation. Gray level transformation, Histogram processing, Arithmetic and logic operations. Transform and filtering: Intensity transformation and spatial filtering, filtering in frequency domain, Image restoration and reconstruction, Binary image morphology. Smoothing and sharpening filters, Line detection, Edge detection, Zero crossings of the second derivative. DFT, smoothing in frequency domain filtering, Sharpening in frequency domain filtering. Degradation model, noise models, restoration in spatial domain, restoration in frequency domain. Estimation of degradation function, inverse filtering, Wiener filtering, constrained least square filtering. Color Image Processing: Color Models, the RGB Color Model, the CMY and CMYK Color Models, the HSI Color Model, Pseudo color image processing, Basics of Full-Color Image Processing, Smoothing and Sharpening, Image Segmentation Based on Color.Image Segmentation-Point, Line, and Edge Detection, Thresholding-Types Boundary based and Region-Based Segmentation.Representation of Boundary Descriptors,Regional Descriptors-Texture descriptors.

TEXT BOOKS/REFERENCES:

[1] John W Woods, "Multidimensional Signal, Image and Video Processing and Coding", Academic Press, 2006.
[2.] Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Third Edition, Pearson Education, 2009.
[3.] William K. Pratt, “Digital Image Processing”, John Wiley, New York, 2007.
[4.] Kenneth R. Castleman, "Digital Image Processing", Prentice Hall, 1996.
[5.] Gonzalez, Woods and Eddins, "Digital Image Processing using MATLAB", Prentice Hall, 2004.

19RM600 RESEARCH METHODOLOGY 2-0-0-2

Unit I:

Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research,Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach,Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. ConfirmatoryResearch, Experimental vs Theoretical Research, Importance of reasoning in research.

Unit II:

Problem Formulation, Understanding Modeling& Simulation, Conducting Literature Review,Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval,Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement SystemsAnalysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, FieldExperiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical DataAnalysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract,introduction, methodology, results and discussion, conclusion sections of a manuscript. References,Citation and listing system of documents

Unit V:

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct.Plagiarism, Unscientific practices in thesis work, Ethics in science

TEXT BOOKS/ REFERENCES:

1. Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8thEdition, McGraw-Hill, 2011
2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
4. Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6th Edition July 2012

19RA701 INDUSTRIAL AUTOMATION I 2-0-2-4

Introduction to Automation, Introduction to Pneumatic System: Introduction to pneumatic systems: advantages and limitations, applications, structure and signal flow of pneumatic systems; pneumatic power pack: air generation and distribution, air reservoir, filter, lubricator, pressure regulator,actuators,direction control valves, check valves, flow control valves, pneumatic counter. Pneumatic Symbols. Pneumatic system design

Introduction to Hydraulic systems: advantages and limitations, physical principles of oil hydraulics, hydraulic power pack, hydraulicfluids, filters, types of hydraulic pumps, hydraulic actuators and accessories,accumulator, hydraulic valves: pressure control valves, flowcontrol valves. Hydraulic symbols. Hydraulic system design

Programmable Logic Controllers (PLCs): Introduction,Architecture of PLC, PLC networking, programming and wiring, PLC installation, troubleshooting and maintenance, Design of HMI.

TEXT BOOKS/REFERENCES:

[1.] Anthony Esposito, "Fluid Power with Applications", 7th ed., Pearson Publishers.
[2.] VedamSubrahmaniam, “Electric Drives (Concepts and Applications)”, Tata McGraw-Hill, 2001.
[3.] Nagrath I.J. and Kothari D.P., “Electrical Machines”, Tata McGraw-Hill, 1998.
[4.] Pillai S.K. “A First Course on Electric Drives”, Wiley Eastern Limited, 1998.
[5.] Groover M. P., "Industrial Robotics, Technology, Programming and Application", McGraw Hill Book and Co., 2012.
[6.] Siemens "PLC Handbook".
[7.] Frank D. Petruzella, "Programming Logic Controllers", McGraw Hill Book Company
[8.] Ries and Ries, "Programming Logic Controllers", PHI.
[9.] Werner Deppert and Kurt Stoll, “Pneumatic Control”, VOGEL Buchverlag Wurzburg, Germany.
[10.] Majumdar S.R., “Pneumatic Systems Principles and Maintenance”, Tata McGraw Hill, New Delhi.
[11.] Peter Croser and Frank Ebel, "Pneumatics Basic Level TP 101" Festo Didactic GMBH & Co, Germany.
[12.] Hasebrink J.P. and Kobler R., “Fundamentals of Pneumatic ControlEngineering”,Festo Didactic GMBH & Co, Germany.
[13.] MerkleD.,Schrader B. and Thomes M., "Hydraulics Basic Level TP 501" Festo Didactic GMBH & Co, Germany.
[14.] Peter Rohner, “Industrial Hydraulic Control” John Wiley and Sons, Brisbane.

19RA702 MACHINE LEARNING 3-0-1-4

Supervised learning: Supervised learning setup, LMS, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naive Bayes, Support vector machines, Model selection and feature selection, Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms. Learning theory: Bias/variance tradeoff, Union and Chernoff/Hoeffding bounds, VC dimension, Worst case (online) learning, Practical advice on how to use learning algorithms. Unsupervised learning: Clustering, K-means, EM, Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis). Reinforcement learning and control: MDPs, Bellman equations, Value iteration and policy iteration, Linear quadratic regulation (LQR), LQG, Q-learning, Value function approximation, Policy search, Reinforce, POMDPs.

TEXT BOOKS/REFERENCES:

[1.] Russell and Norvig, "Artificial Intelligence: A Modern Approach", Prentice Hall.
[2.] http://www.stanford.edu/class/cs229/materials.html
[3.] http://www.stanford.edu/class/cs221/handouts.html
[4.] Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
[5.] Richard Sutton and Andrew Barto, "Reinforcement Learning: An Introduction", MIT Press, 1998.
[6.] S. Thrun, W. Burgard and D. Fox, "Probabilistic Robotics", MIT Press, 2005.

19RA711 INDUSTRIAL AUTOMATION II 2-0-1-3

Overview of MES (Manufacturing Execution Systems) including computer integrated manufacturing (CIM) and computer integrated automation (CIA) and their integration into manufacturing execution systems. Overview of the applications of robotic systems in industrial automation. Recap of pneumatic and Hydraulic system design, Selection and control of motors for an application, motor drives - Variable Frequency Drives and Servo Drives. Supervisory Control and Data Acquisition: operation and use of SCADA commercial packages, application of SCADA in controlling and monitoring the control of both local and remote processes using standard communication protocols. Distributed Control Systems in Automation: The theory and operation of DCS in large, medium and small automation applications, current development. Robot programming- RAPID language, Robot software- Pick Master, Robot studio. Project - Design and control of a process using PLC, HMI, SCADA including sensors and actuators.

TEXT BOOKS/REFERENCES:

[1.] Groover M. P., "Automation, Production Systems, and Computer-Integrated Manufacturing", Third Edition, 2007.
[2.] J. Craig, "Introduction to Robotics: Mechanics and Control", Third Edition, 2003.
[3.] Jürgen Kletti, "Manufacturing Execution System - MES", 2007.
[4.] Srinivas Medida, "Pocket Guide on Industrial Automation", First Edition, IDC Technologies, 2008.

19RA712 PROCESS CONTROL AND INSTRUMENTATION 3-0-0-3

Process Modeling: hierarchies. Theoretical models: transfer function, state space models, and time series models. Development of empirical models from process data- chemical reactor modeling. Feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio control. Multi-loop and multivariable control: process interactions, singular value analysis. PID design, tuning, trouble shooting, tuning of multiloop PID control systems. Decoupling control: strategies for reducing control loop interactions. Instrumentation for process monitoring: codes and standards, preparation of P&I diagrams. Model predictive control. Statistical process control, supervisory control, direct digital control, distributed control, PC based automation. Programmable logic controllers: organization, programming aspects, ladder programming, final control elements. SCADA in process automation.Case studies.

TEXT BOOKS/ REFERENCES:

1. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar and Francis J. Doyle “Process Dynamics and Control”, John Wiley and Sons, 2010.
2. Ernest O. Doebelin, “Measurement Systems Application and Design”, McGraw Hill International Editions, 2006.

3. Johnson D Curtis, “Process Control Instrumentation Technology”, Prentice Hall India, 2013.
4. Bob Connel, “Process Instrumentation Applications Manual”, McGraw Hill, 1996.

19RA713 ADVANCED PROCESS CONTROL 3-0-0-3

Introduction: Review of basics of Process Control, Control objective and benefits, Control system elements. Mathematical modeling and dynamic performance analysis process for control: BasicConcepts in modeling, models from fundamental laws, empirical model identification, dynamic performance analysis of first order, second order, multi-capacity processes, Effect of Zeros andtime delay. Multivariable Process control: Cascade control, Ratio control, feedback-feedforward control, override control, selective control, modeling of multivariable process, Design ofMultivariable controllers. Model Based control: Feedback-feedforward, delay compensation, Internal Model controller (IMC): Concept, IMC design Procedure. MPC: General Principles, Model forms, DMC, SISO unconstrained DMC Problem, controller tuning. Statistical Process Control (SPC): Concept, Design procedure. Mini project: Design of Fuzzy-Logic based controller. Mini project: Design of Neural Network based controller.

TEXT BOOKS/REFERENCES:

[1.] Thomas E. Marlin, "Process Control", McGraw-Hill International Edition.
[2.] Jose A. Romagnoli and AhmetPalazoglu, "Introduction to Process Control", CRC Taylor and Francis Group.
[3.] Statistical Process Control –ISA.
[4.] B.G. Liptak, "Handbook of Instrumentation - Process Control".
[5.] Les A. Kane, “Handbook of Advanced Process Control Systems and Instrumentation” Springer.

19RA714 FPGA BASED SYSTEM DESIGN 3-0-0-3

Introduction to ASICs, CMOS logic and ASIC library design: Types of ASICs - Design Flow CMOS transistors, CMOS design rules - Combinational Logic Cell - Sequential logic cell - Datapath logic cell - transistors as resistors - transistor parasitic capacitance - Logical effort - Library cell design - Library architecture. Programmable logic cells and I/O cells: Digital clock Managers-Clock management- Regional clocks- Block RAM – Distributed RAM-Configurable Logic Blocks-LUT based structures – Phase locked loops- Select I/O resources –Anti fuse - static RAM - EPROM andEEPROM technology. Device Architecture: Spartan 6 -Vertex 4 architecture- Altera Cyclone and Quartus architectures. Design Entry and Testing: Verilog and VHDL - logic synthesis - Types of simulation –Faults- Fault simulation - Boundary scan test Automatic test pattern generation. Built-in self-test. – scan test. Floor Planning, Placement and Routing: System partition - FPGA partitioning - partitioning methods - floor planning placement - physical design flow - global routing - detailed routing - special routing - circuit extraction - DRC.

TEXT BOOKS/REFERENCES:

[1.] M.J.S. Smith, "Application Specific Integrated Circuits", Addison Wesley Longman Inc., 1997.
[2.] Wolf Wayne, "FPGA Based System Design", Pearson Education.
[3.] Design Manuals of Altera, Xilinx and Actel.

19RA715 EMBEDDED REAL TIME SYSTEMS 3-0-0-3

This course looks at components, interfaces and methodologies for building systems. Specific topics include microcontrollers, design, verification, hardware/software synchronization,interfacing devices to the computer, timing diagrams, real-time operating systems, data collection and processing, motor control, analog filters, digital filters, and real-time signal processing. Topics include Computer Architecture review, Design of I/O Interfaces, Software Design, RealTime Operating Systems, Multitasking (preemptive scheduling, resource sharing and priority determination), Digital Signal Processing, High-Speed Interfacing, File system management, Interfacing Robotic Components, High-Speed Networks, Robotic Systems.

TEXT BOOKS/REFERENCES:

[1.] Jonathan Valvano, “Embedded Systems: Real-Time Operating Systems for Arm Cortex M Microcontrollers”, CreateSpace Publishing, 2012.
[2.] Joseph Yiu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newnes, 2013.
[3.] Martin, "The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach", First Edition, Newnes, 2009.

19RA716 ROBOT SIMULATION AND OFFLINE PROGRAMMING 3-0-0-3

This course provides the student with a background in the programming and application of industrial robots and general purpose synchronized mutli-axis motion control. The topics covered include safety rules and devices for working with or around industrial robots; advantages, functions, components, operation and applications of industrial robots and end effectors; the function, operation, storage and retrieval of robot programs and position points; the use, function and operation of on-line programming, off-line programming, teach pendants, operator stations, and digital inputs and outputs for industrial robots. Use a PC and robot programming software for various operations. Use the Cartesian coordinate system to command robot position and program with World Coordinates and Tool Coordinates. Connect, configure, program and operate a robot in conjunction with both servo-driven and non-servo-driven conveyors. Use robot simulation software to design a workcell. Use PLC Open motion function blocks to implement a synchronized mutli-axis motion application. Troubleshoot a multi-axis motion system. Robot Simulation using Gazebo and ROS.

TEXT BOOKS/REFERENCES:

[1.] MotoSim EG Basic Training Manual.
[2.] MotoSim EG Advanced Training Manual.
[3.] MotoSim VRC Basic Training Manual.
[4.] MotoSim VRC Advanced Training Manual.

19RA717 ADVANCED EMBEDDED SYSTEM DESIGN 3-0-0-3

Review of Computer Architecture, Logic Design, Electrical and Electronic Circuits.System Design Process, Software Design Principles and Debugging Theory. ARM Cortex-M processor,Programming in Assembly Language and C. OS Principles – Threads, FIFO, Memory Management. Hardware Software Synchronization, Timing, Interrupts. Timer, PLL, PWM, Period and Frequency Measurement.Serial Interfacing – RS232, USB, SSI, I2C.Analog Interfacing – Op Amps, Filters, DAC and ADC.Data Acquisition – Discrete Calculus, Noise Analysis, Transducers. Wired and wireless communication systems. System Level Design – Design for Manufacturability, Power, Tolerance, Testability, Performance and Cost. PCB
Design.

TEXT BOOKS/REFERENCES:

[1.] Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to Arm® Cortex(TM)- M Microcontrollers", CreateSpace Publishing, 2013, 3rd edition
[2.] Joseph Yiu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Newnes, 2013, 3rd Edition
[3.] Martin, "The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach" Newnes, 2009, 1st Edition
[4.] E. A. Lee and S. A. Seshia, Introduction to Embedded Systems, Online Book at berkeley.edu,2012

19RA718 HUMANOID ROBOTICS 3-0-0-3

The course aims at giving the students a basic understanding of the theory of humanoid robots, i.e. bipedal walking robots with an approximately humanlike shape, and a practical knowledgeconcerning humanoid robots, through a robot construction project. The contents of the course include Theory of humanoid robots, kinematics and dynamics. Methods for gait generation,including classical control theory, central pattern generators and linear genetic programming.Applications of humanoid robots.Humanoid robots in society - current and future applications, comparison with other types of robots. Hardware construction, including the use of microcontrollers and servo motors in connection with humanoid robots. Simulation in ROS

TEXT BOOKS/REFERENCES:

[1.] GoswamiAmbarish, VadakkepatPrahlad, "Humanoid Robotics: A Reference", Springer, 2019
[2.] J. Craig, "Introduction to Robotics: Mechanics and Control", Third Edition, 2003.

[3.] Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators".
[4.] Jean-Claude Latombe, "Robot Motion Planning".

19RA719 SWARM INTELLIGENCE 3-0-0-3

Introduction to swarm intelligence and key principles (e.g., self-organization), natural and artificial examples, computational and real-time SI.Foraging, trail laying/following mechanisms.Open-space, multi-source foraging experiments: biological data and microscopic models. From real to virtual ants: Ant System (AS). Application to a classical operational research problem: The Travel Salesman Problem (TSP). From AS to Ant Colony Optimization (ACO). Ant-based algorithms (ABC, Ant-Net) applied to routing in telecommunication networks. Introduction to unsupervised multi-agent machine-learning techniques for automatic design and optimization: terminology and classification, Genetic Algorithms (GA) and Particle Swarm optimization (PSO). Application of machine-learning techniques to automatic design and optimization in single-robot and multi-robot experiments. Collective movements in natural societies; focus on flocking phenomena. Collective movements in artificial systems: Reynolds' virtual agents and experiments with multi-robot systems (flocking, formation). Multi-level modelling of self-organized robotic systems: microscopic and macroscopic models; Markov formalism; linear and nonlinear micro-to-macro mapping, model analysis. Combined modelling and machine-learning methods for off-line system design and optimization.Diversity and specialization metrics.Division of labour and task-allocation mechanisms, threshold-based algorithms, market-based algorithm.Aggregation, segregation, and collective decisions, social insects, sensor networks, and multi-robot systems, clustering data and distributed structure building in natural and artificial systems.

TEXT BOOKS/REFERENCES:

[1.] E. Bonabeau, M. Dorigo and G. Theraulaz, “Swarm Intelligence: From Natural to Artificial Systems", Santa Fe Studies in the Sciences of Complexity, Oxford University Press, 1999.
[2.] Camazine, Deneubourg, Franks, Sneyd, Theraulaz andBonabeau, "Self-organisation in Biological Systems", Princeton University Press, 2002.
[3.] Mitchel Resnick, "Turtles, Termites, and Traffic Jams", MIT Press, 1997.
[4.] Stuart A. Kauffman, "The Origins of Order: Self-Organization and Selection in Evolution", Oxford University Press, 1993.

19RA720 BEHAVIORAL BASED ROBOTICS3-0-0-3

This course is designed to investigate and study methods and models in embodied cognitive science and artificial intelligence, with particular focus on behaviour-based techniques on robots. All models and architectures will be theoretically scrutinized and evaluated with respect to their conceptual clarity, support by empirical data, plausibility, etc. without neglecting issues of practicality such as feasibility of implementation, real-time/real-world issues, computational resources, etc. Topics include introduction to embodied cognitive science and behaviour-based robotics, reactive behaviour-based architectures, perception, deliberative systems, hybrid systems.

TEXTBOOKS/REFERENCES:

[1.] Arkin, C. Ronald, “behaviour-Based Robotics”, MIT Press, Cambridge: MA, 1998.
[2.] Pfeiffer R. and Scheier Ch., "Understanding Intelligence", MIT Press, Cambridge: MA, 1999.
[3.] Murphy, R., "Introduction to AI Robotics." Second Edition, MIT Press, Cambridge: MA, 2002.
[4.] Bekey, G., "Autonomous Robots: From Biological Inspiration to Implementation and Control (Intelligent Robotics and Autonomous Agents)". MIT Press, Cambridge: MA, 2005.

19RA721 FRONTIERS OF BIOMECHATRONICS 3-0-0-3

Topics consist of rehabilitation engineering, artificial tissue and organs, implantable neural prosthesis, orthopaedic implants and implanted devices, biology-machine interface, minimally invasive surgical instruments, surgical robot, introduces its basic principle, key technology and its development and application. They include introduction to Bio-mechatronic Systems, design and manufacturing of Bio-mechatronic products, musculoskeletal mechanics, review of multi-body dynamics, principles of motor control and sensorimotor integration, simulation of human movement, human locomotion and gait studies, motor control in patients with neurological disorders, artificial tissue and organ, orthopaedic implants, Biology-Machine Interface, implantable neural prosthesis, minimally invasive surgical instruments, surgical robot.

TEXT BOOKS/REFERENCES:

[1.] Myer Kutz(Editor), "Biomedical Engineering and Design Handbook", Volume 1: Fundamentals, Second Edition, McGraw-Hill Companies, 2009.
[2.] Mark J. Schulz, Vesselin N. ShanovandYeoheung Yun, "Nanomedicine Design of Particles, Sensors, Motors, Implants, Robots, and Devices", Artech House, 2009.
[3.] Graham M. Brooker, "Introduction to Biomechatronic: The Application of Mechatronic Engineering to Human Biology", SciTech Publishing, 2012.

19RA722 OPTIMIZATION THEORY 3-0-0-3

Topics covered will include linear programming, nonlinear programming, calculus of variations and dynamic programming. Introduction to optimization, linear programming.simplex technique, Duality and Sensitivity, Unconstrained Nonlinear Programming, Constrained Nonlinear Programming, Numerical methods, Duality and Applications. Basics of the Calculus of Variations, theory of the Calculus of Variations, Applications of the Calculus of Variations, Dynamic Programming: Theory and Dynamic Programming: Applications.

TEXT BOOKS/REFERENCES:

[1.] D. A. Pierre, "Optimization Theory with Applications", Dover, 1986.

[2.] R. Fletcher, "Practical Methods of Optimization", Second Edition, John-Wiley and Sons, 1987. [3.] D. G. Luenberger, "Linear and Nonlinear Programming", Second Edition, AddisonWesley, 1989.
[4.] J. Nocedal and S.J. Wright, "Numerical Optimization". Springer, 2000.

19RA723 HAPTIC INTERFACES 2-0-1-3

Introduction to haptics, Kinesthetic haptic devices: Kinematics and dynamics, rendering, control, dynamic simulations, sensors and actuators. Tactile haptic devices: Types and applications. Tele-operation: Implementation, Transparency and Stability. Surface Haptics. Human haptics: Mechanoreceptors, Kinesthesia.

TEXTBOOKS/REFERENCES:

[1]. Kern, Thorsten A. Engineering haptic devices: a beginner's guide for engineers. Springer Science & Business Media, 2009.
[2]. Lin, Ming C., et al. Haptic rendering: Foundations, algorithms and applications. AK Peters, Ltd., 2008.

19RA724 INNOVATING IN TECHNOLOGY 3-0-0-3

The need for innovation. Core innovation lenses: attitudes, activities, conversations, rhythm and examples. Business, Technology and Experience goals.Working with Technology and Business constraints. Assessing one’s Innovation Readiness. Innovation Truths and Innovation Myths.Cross-discipline research.Targeting Social Impact.Women Innovators in Technology.Innovation games.Asking skilful questions.Lateral thinking.Cultivating Curiosity.Effective brainstorming.Expanding and Contracting phases.Refining existing ideas.Innovation in methodologies and techniques.How to have collaborative conversations. Design and User Experience led innovation. Sketching vs. Prototyping.Working with end users. Project Management and organizational agility to support innovation. Developing an “Innovation Studio”.

TEXT BOOKS/REFERENCES:

[1.] Berkun, Scott. The myths of innovation. O'Reilly Media, Inc., 2010. [2.] Sawyer, Keith. Zig zag: The surprising path to greater creativity. John Wiley & Sons, 2013.

19RA725 MEASURING USER INTERFACE QUALITY 3-0-0-3

How to conduct a usability study. What to measure: Identifying top tasks, Common metrics, Task completion metrics, Performance metrics, Qualitative and quantitative metrics, Biometrics. When to measure: Before development, During development, Pre launch, Post Launch, Common problems and solutions to effective timing. How to measure: overview of approaches, usability labs, automated measurement, remote testing, field testing. With Who to measure: understanding user samples, identifying valid participants, techniques for finding

participants. Taking Action: communicating findings, presenting usability issues, strategies for resolution.

TEXT BOOKS/REFERENCES

[1.] Albert, W., Tullis, T. Measuring the User Experience: Collecting, Analyzing, Presenting Usability Metrics. Morgan Kaufman: 2013.
[2.] Krug, S. Don't Make Me Think. New Riders: 2005.
[3.] Norman, D. The Design of Everyday Things. Basic Books: 2013.
[4.] Gothelf, J. Lean UX: Applying Lean Principles to Improve User Experience. O'Reilly Media: 2013

19RA726 DESIGN FOR PEOPLE: PRINCIPLES AND PRACTISES OF HUMAN CENTERED DESIGN3-0-0-3

Introduction to Usability: History, Classic Examples, Core Principles Representing Users: Goal and task analysis, Personas, User scenarios, Agile user stories and epics. Methods of Data Gathering and Analysis: Lean UX, Ethnographic observation, Interviews, Surveys, User studies, Usability labs, Eye tracking, Biometric measurement, Qualitative and quantitative data methods. Creating Personas: Collecting data sources, Initial drafting, Assessing with stakeholders, Final crafting and prioritization. Working with Personas: Scenario definition with personas, Functionality prioritization with personas, Quality Assurance with personas. User-centred design processes: User participation, Iteration, Identifying expand/collapse phases. Collaboration with Engineering: Managing the tech-centred and human-centred design processes together.

TEXT BOOKS/REFERENCES:

[1.] Norman, D. The Design of Everyday Things. Basic Books: 2013. [2.] Gothelf, J. Lean UX: Applying Lean Principles to Improve User Experience. O'Reilly Media: 2013

19RA727 ADVANCED PERCEPTION FOR ROBOTICS AND HCI 3-0-0-3

This course is an advanced survey of the state of the art in machine vision, focused primarily on robotics applications and human-computer interfaces. Topics covered will be related to 3D reconstruction of objects and scenes from video, camera motion estimation from video, object detection and recognition, and tracking, cloud robotics as it relates to robot vision. They include optical flow estimation: motion field and optical flow, calculating optical flow, flow-based motion analysis, robust incremental optimal flow. Object detection and recognition: Global methods, transformation search-based methods, geometric correspondence-based approaches, flexible shape matching, interest point detection and region descriptors, three-dimensional object recognition. Tracking and video analysis: Point tracking, deterministic methods, statistical methods, kernel tracking, template and density-based appearance models multi view appearance models, silhouette tracking, contour evolution, shape matching.

TEXT BOOKS/REFERENCES:

[1.] D. Forsyth and J. Ponce, "Computer Vision: A Modern Approach". Prentice-Hall, 2003.
[2.] E. Trucco and A. Verri, "Introductory Techniques for 3-D Computer Vision", PrenticeHall, 1998.

19RA728 COMPUTATIONAL INTELLIGENCE 3-0-0-3

Computational intelligence (CI): Adaptation, Self-organization and Evolution, Biological and artificial neuron, Neural Networks Concepts, Paradigms, Implementations, Evolutionary computing: Concepts, Paradigms, Implementation, Swarm Intelligence, Artificial Immune Systems, Fuzzy systems: Concepts, Paradigms, Implementation, Hybrid systems CI application: case studies may include sensor networks, digital systems, control, forecasting and time-series predictions.

TEXTBOOKS/REFERENCES:

[1.] R.C. Eberhart, "Computational Intelligence: Concept to Implementations", Morgan Kaufmann Publishers, 2007. [2.] A Konar, "Computational Intelligence: Principles, Techniques and Applications", Springer Verlag, 2005.

19RA729 MACHINE VISION 3-0-0-3

Active contours Model Snake- Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts and energy-based methods, Clustering based segmentation. Detectors and Descriptors, Chain Codes, Polygonal Approximations Boundary Descriptors-Fourier Descriptors, Statistical Moments Regional Descriptors-Texture-Moment Invariants, MOPS, GLOH,SIFT,PCA-SIFT,SURF. 2D and 3D feature-based alignment ,3D Pose estimation,Geometric intrinsic calibration,Feature Matching-Object Recognition, The Use of Motion in Segmentation Optical Flow & Tracking, Introduction to Object Recognition and Bag-of-Words Models, KLTracking, Object tracking using mean- shift and Kalmanfilters,Face detection (Viola Jones),Face Recognition using PCA, LDA. Image Formation: Geometric image formation, Photometric image formation -Camera Models and Calibration: Camera Projection Models – orthographic, affine, perspective, projective models. Projective Geometry, transformation of 2-d and 3-d, Internal Parameters, Lens Distortion Models, Calibration Methods – linear, direct, indirect and multiplane methods.Visual servo. Stereo correspondence-Epipolar geometry, Fundamental matrix, Computation- Normalized 8-point algorithm (Hartley), Robust Fundamental Matrix Estimation by Zhang, Stereo Pairs and Depth Maps Image Rectification for Stereo, Correlation Based Stereo Methods Barnard's Stereo Method Multi-view stereo. Introduction to SLAM (Simultaneous Localisation and Mapping).

TEXTBOOKS/REFERENCES:

[1] Richard Szelinski, "Introduction to Computer Vision and its Application"

[2] E. Trucco and A. Verri, “Introductory techniques for 3D Computer Vision”, Prentice Hall, 1998. [3] Marco Treiber, “An Introduction to Object Recognition Selected Algorithms for a Wide Variety of Applications”, Springer, 2010.
[4.] Forsyth and Ponce, “Computer Vision – A Modern Approach”, Second Edition, Prentice Hall, 2011.
[5]R. C. Gonzalez, R. E. Woods, ‘Digital Image Processing’, Addison-Wesley,2002

19RA730 ADVANCED AI FOR ROBOTICS 3-0-0-3

Problem solving: Graph based search, Algorithms for searching, Heuristic search, Robot path planning. Knowledge representation: Descriptive representation, Procedural representation, Rule-based representation, Semantic networks, Frames, Ontologies, Knowledge based systems. Expert systems. Artificial neural networks: Perceptron, Learning, Associative memories, Self-organised networks, Applications of neural networks in robotics. Fuzzy logic systems: Fuzzy logic, Fuzzy reasoning, Fuzzy logic-based techniques, Fuzzy relations, Fuzzy control, implementing fuzzy controllers, Fuzzy decision making. Genetic algorithms
: Principles, Working, Design, Applications in robotics

TEXT BOOKS/REFERENCES:

[1.] Russell, S.J. and Norvig, P., "Artificial Intelligence – A Modern Approach", Prentice Hall, 2003. [2.] Negnewitsky, M., "A Guide to Intelligent Systems", Addison-Wesley, 2005. [3.] Inger, G.F., "Artificial Intelligence: Structures and Strategies for Complex Problem Solving", Addison-Wesley, 2005.
[4.] Nilsson, N.J., "Artificial Intelligence: A New Synthesis", Morgan-Kaufmann, 1998.

19RA731 VIRTUAL REALITY AND APPLICATIONS 3-0-0-3

Introduction: The three I’s of virtual reality, commercial VR technology and the five classic components of a VR system. VR design principles, Input Devices: Three-dimensional position trackers, navigation and manipulation, interfaces and gesture interfaces. Output Devices: Graphics displays, sound displays & haptic feedback. Modelling: Geometric modelling, kinematics modelling, physical modelling, behaviour modelling, model management. Human Factors: Methodology and terminology, user performance studies, VR health and safety issues. Applications: Medical applications, military applications, robotics applications. VR in Unity 3D.

TEXT BOOKS/REFERENCES:

[1.] Gregory C. Burdeaand Philippe Coiffet, "Virtual Reality Technology", Second Edition, John Wiley and Sons, Inc.
[2.] Andrew Davison, "Killer Game Programming in Java, "O’Reilly-SPD, 2005.
[3.] William R.Sherman and Alan Craig, "Understanding Virtual Reality, Interface, Application and Design", Elsevier(Morgan Kaufmann).
[4.] Bill Fleming, "3D Modeling and surfacing", Elsevier(Morgan Kaufmann).

[5.] David H.Eberly, "3D Game Engine Design", Elsevier. [6.] John Vince, "Virtual Reality Systems", Pearson Education.

19RA732 NON-LINEAR CONTROL THEORY 3-0-0-3

Topics include Nonlinear Behaviour. Mathematical Language for Modelling Nonlinear Behaviour: Discrete Time State Space Equations, Differential Equations on Manifolds, Input/Output Models, Finite State Automata and Hybrid Systems. Linearization: Linearization Around a Trajectory, Singular Perturbations, Harmonic Balance, Model Reduction, Feedback Linearization. System Invariants: Storage Functions and Lyapunov Functions, Implicitly Defined Storage Functions, Search for Lyapunov Functions. Local Behaviour of Differential Equations: Local Stability, Centre Manifold Theorems, Bifurcations. Controllability of Nonlinear Differential Equations: Frobenius Theorem, Existence of Feedback Linearization, Local Controllability of Nonlinear Systems. Nonlinear Feedback Design Techniques: Control Lyapunov Functions, Feedback Linearization: Backstepping, Dynamic Inversion, etc., Adaptive Control, Invariant Probability Density Functions, Optimal Control and Dynamic Programming.

TEXT BOOKS/REFERENCES:

[1.] Hassan K. Khalil, "Nonlinear Systems", Prentice Hall. [2.] Shankar Sastry, "Nonlinear Systems: Analysis, Stability, and Control", Springer.

19RA733 EXPERIMENTAL HAPTICS 3-0-0-3

The goal of this course is to develop virtual reality simulations and applications that incorporate haptic interaction. Theoretical topics include haptic rendering in 3-D virtual environments, simulation of haptic interaction with rigid and deformable objects, haptic interfaces, psychophysics of touch. Applied topics include an introduction to the CHAI 3D/Unity 3D haptics library, implementation of algorithms for haptic rendering, collision detection, and deformable body simulation.

TEXT BOOKS/REFERENCES:

[1.] Ming Lin and Miguel Otaduy,"Haptic Rendering", A K Peters, 2008.

19RA734 UNMANNED AERIAL VEHICLES 1-0-2-3

Introduction to UAV - Types of UAV - Geometry and Mechanics of UAVs including transformations, angular velocity, principle moment of inertia, equations of motions, ROS based Control, Trajectories and Motion Planning, Sensing and Probabilistic State Estimation, Visual Motion Estimation, Visual SLAM.

TEXT BOOKS/REFERENCES:

[1.]Thrun, Sebastian, Wolfram Burgard, and Dieter Fox. Probabilistic robotics. MIT press, 2005.
[2.] Carrillo, Luis Rodolfo García, et al. Quad rotorcraft control: vision-based hovering and navigation. Springer Science & Business Media, 2012.
[3.] Corke, Peter. Robotics, vision and control: fundamental algorithms In MATLAB® second, completely revised. Vol. 118.Springer, 2017.