M. TECH – ROBOTICS AND AUTOMATION

Amrita Multi Modal Applications and Computer Human Interaction Labs

The M.Tech Robotics and Automation program is offered at Amrita Vishwa Vidyapeetham by the Amrita Multi Modal Applications and Computer Human Interaction (AMMACHI) Labs and the Department of Mechanical Engineering, Amritapuri campus. AMMACHI Labs has numerous ongoing research projects on low cost haptic technology for vocational education and this M.Techprogram now broadens the lab's scope to include robotics and automation technology as well.

This 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 programme provides a comprehensive educational environment and enables students to gain expertise in next generation robotics and automation systems. By exposing our students to 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

First Semester

Course Code	Type	Course	L	T	P	Cr
16MA623	FC	Mathematical Foundations for Robotics and Automation	3	0	0	3
16RA601	FC	Embedded Systems Design	3	0	1	4
16CI622	FC	Digital Control Systems	3	0	0	3
16RA611	SC	Introduction to Robotics	2	1	1	4
	E	Elective I	3	0	1	4
16HU601	HU	Cultural Education*				P/F
					Credits	**18**

*** Non Credit Course**

Second Semester

Course Code	Type	Course	L	T	P	Cr
16MA622	FC	Probability and Statistical Inference	3	0	0	3
16WN604	FC	Design and Analysis of Algorithms	3	0	1	4
16RA613	SC	Mobile and Autonomous Robots	3	0	1	4
	E	Elective II	3	0	1	4
16RA612	E	Digital Image Processing	3	0	1	4
16EN600	HU	Technical Writing*				P/F
					Credits	**19**

*** Non Credit Course**

Third Semester

Course Code	Type	Course	L	T	P	Cr
	E	Elective III	3	0	0	3
	E	Elective IV	3	0	0	3
16RA798	P	Dissertation				8
					Credits	**14**

Fourth Semester

Course Code	Type	Course	L	T	P	Cr
16RA799	P	Dissertation				14
					Credits	**14**

Total Credits	**65**

List of Courses

Foundation Core

Course Code	Course	L	T	P	Cr
16MA623	Mathematical Foundations for Robotics and Automation	3	0	0	3
16MA622	Probability and Statistical Inference	3	0	0	3
16RA601	Embedded Systems Design	3	0	1	4
16WN604	Design and Analysis of Algorithms	3	0	1	4
16CI622	Digital Control Systems	3	0	0	3

Subject Core

Course Code	Course	L	T	P	Cr
16RA611	Introduction to Robotics	2	1	1	4
16RA612	Digital Image Processing	3	0	1	4
16RA613	Mobile and Autonomous Robots	3	0	1	4

Elective I

Course Code	Course – based on their background chosen by faculty coord	L	T	P	Cr
16RA701	Computer Programming Including Python and Embedded C	2	0	2	4
16RA702	Modelling Mechanical and Electrical Systems	3	0	1	4

Elective II

Course Code	Course	L	T	P	Cr
16RA703	Industrial Automation I	2	0	2	4
16RA704	Machine Learning	3	0	1	4

Electives III and IV

Course Code	Course	L	T	P	Cr
Stream 1 : Career oriented focus					
16RA711	Industrial Automation II	3	0	0	3
16CI 624	Process Control and Instrumentation	3	0	0	3
16RA712	Advanced Process Control	3	0	0	3
16RA713	FPGA Based System Design	3	0	0	3
16RA714	Embedded Real Time Systems	3	0	0	3
16RA715	Robot Simulation and Offline Programming	3	0	0	3
16RA716	Advanced Embedded System Design	3	0	0	3

Course Code	Course	L	T	P	Cr
Stream 2 : Research focus					
16RA721	Humanoid Robotics	3	0	0	3
16RA722	Swarm Intelligence	3	0	0	3
16RA723	Behavioral Robotics	3	0	0	3
16RA724	Frontiers of Biomechatronics	3	0	0	3
16MA702	Optimization Theory	3	0	0	3
16RA725	Haptic Interfaces	3	0	0	3
16RA726	Innovating in Technology	3	0	0	3
16RA727	Measuring User Interface Quality	3	0	0	3
16RA728	Design For People: Principles and Practices of Human Centered Design	3	0	0	3

Course Code	Course	L	T	P	Cr
Stream 3 : Software focus					
16RA731	Advanced Perception for Robotics and HCI	3	0	0	3
16CS701	Computational Intelligence	3	0	0	3
16RA732	Machine Vision	3	0	0	3
16RA733	Advanced AI for Robotics	3	0	0	3
16RA734	Virtual Reality and Applications	3	0	0	3
16RA735	Non Linear Control Theory	3	0	0	3
16RA736	Experimental Haptics	3	0	0	3

Project Work

Course Code	Course Code	L	T	P	Cr
16RA798	Dissertation				8
16RA799	Dissertation				14

16MA623 MATHEMATICAL FOUNDATIONS 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".

16RA601 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, Microarchitecture, 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.

Significant 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 Cyber-Physical 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.

16CI622 DIGITAL CONTROL SYSTEMS 3-0-0-3

Review of Z tranforms. 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 for SISO 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.

TEXT BOOKS/REFERENCES:

[1.] Gene F. Franklin, J. David Powell, Michael Workman, "Digital Control of Dynamic Systems", Pearson, 2000.
[2.] Ioan 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 ammd Design", Prentice-Hall, 2014.

16RA611 INTRODUCTION TO ROBOTICS 2-1-1-4

Robot types, trends, applications, classification - Robot Actuators: Electric, Hydraulic, Pneumatic - End effectors - Sensors: Types & measurements – 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 - 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”

16MA622 PROBABILITY AND STATISTICAL INFERENCE 3-0-0-3

Probability:Intro 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

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.

16WN604 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

16RA613 MOBILE AND AUTONOMOUS ROBOTS 3-0-1-4

Introduction, Types of Mobile Robots: Legged and Wheeled Mobile Robots, Kinematics 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., Mobile Robot Simulation systems, Mechanisms for negotiating with staircases and unstructured environments.ROS.

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.] Siciliano andKhatib, "Handbook of Robotics", Springer, 2008.
[4.] WitoldJacak, "Intelligent Robotic Systems: Design Planning and Control", Kluwer Academic Publishers, 1999.

16RA612 DIGITAL IMAGE PROCESSING 3-0-0-3

Two-Dimensional Signals and Systems: Two-dimensional convolution, 2D Discrete-Space Fourier Transform, Inverse 2-D Fourier Transform, Fourier Transform of 2-D or Spatial Convolution, Symmetry properties of Fourier Transform, Continuous-Space Fourier Transform. Sampling in two dimensions : Sampling theorem, Change in Sample rate, Downsampling, Ideal decimation, Upsampling, Ideal interpolation. Continuous Image characterization :Psycophysical 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.

16EN600 TECHNICAL WRITING P/F

(Non-credit Course)

Technical terms – Definitions – extended definitions – grammar checks – error detection – punctuation – spelling and number rules – tone and style – pre-writing techniques – Online and offline library resources – citing references – plagiarism – Graphical representation – documentation styles – instruction manuals – information brochures – research papers – proposals – reports (dissertation, project reports etc.)

TEXTBOOKS/REFERENCES:

1. H.L. Hirsch, *Essential Communication Strategies for Scientists, Engineers and Technology Professionals*, Second Edition, New York: IEEE Press, 2002.
2. P.V. Anderson, *Technical Communication: A Reader-Centered Approach*, Sixth Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008, (Reprint 2010).
3. W.Jr. Strunk and E.B.White, *The Elements of Style*, New York. Alliyan & Bacon, 1999.

16RA701 COMPUTER PROGRAMMING INCLUDING PYTHON AND EMBEDDED C 2-0-2-4

Programming in C, Basic Computer Organization and Architecture, Build and Compilation process, Debugging concepts.Data Types and Variables, Input/ Output implementation and usage. Control flow, Modular Programming with functions, Stack Frames and Activation Records. Arrays, Pointers, Strings, Structures and Implementation of Structures.Memory, Dynamic Memory Allocation, Stacks and Heap.Recursion. Program Runtime Analysis, Big-Oh Notation. Exception Handling, Watchdog and Fault Tolerance. Data structures such as maps, multi-maps, lists, etc. Assembly Language Programming.Programming in Python.Programming in Embedded C. Significant labs, e.g., implementation of a Spell Checker with a real dictionary, implementation of a data structure such as a Vector/Set, development of a Customer Relationship Management system, etc.Capstone Design Project, Game of Life, Data Compression, etc.

TEXT BOOKS/REFERENCES:

[1.] Brian Kernighan and Dennis Ritchie, "The C Programming Language", Second Edition, 1978.
[2.] K. N. King, "C Programming: A Modern Approach", Second Edition, 2008.
[3.] http://en.wikibooks.org/wiki/C_Programming
[4.] http://www.tutorialspoint.com/cprogramming/

16RA702 MODELLING MECHANICAL AND ELECTRICAL SYSTEMS 3-0-1-4

Introduction - Units and Dimensions, Laws of Mechanics, Forces: Coplanar forces, Collinear forces, Concurrent forces, Parallel forces - Resolution and composition of forces - Moment and Couple - Varignon's theorem - Equilibrium of rigid bodies - Supports and reactions - Free body diagrams - Centre of gravity. Mechanisms – static force analysis Links, Types of links - Joints - Types of joints - Degrees of freedom - Kinematic pair - Kinematic chain, Types - Kinematic inversions - Velocity and acceleration in mechanisms. Moment of inertia. - dynamic force analysis. Power transmissions: Rope, Belt & Pulley, Chain & sprocket, Gears. Modeling of Electrical Components - Kirchoff's Laws - Vector and Matrix Representations in Kirchoff's Laws - Mechanical/Electrical Analogies.

TEXT BOOKS/REFERENCES:

[1.] Engineering Mechanics (In SI Units) by S. Timoshenko, D.H. Young, J.V. Rao.
[2.] Theory of Machines and Mechanisms 4th Edition by John Uicker, Gordon Pennock, Joseph Shigley
[3.] Theory of Machines by R. S. Khurmi, J.K. Gupta

16RA703 INDUSTRIAL AUTOMATION I 2-0-2-4

Requirements for drives, classification of actuators, D.C motor actuator in robots, stepper motors, AC servo motors, electric drives.Pneumatic and HydraulicSystems : Introduction to pneumatic systems: advantages and limitations, applications, structure and signal flow of pneumatic systems; pneumatic power pack: air generation and distribution, air reservoir, constructional details and working of filter, lubricator, pressure regulator,actuators,direction control valves, check valves, flow control valves, pneumatic counter. Manual pneumatics: Symbols of pneumatic valves, traverse time diagram, design of manually operated circuits: direct and indirect control of actuators, control of single and multiple actuators.Introduction to Hbhiydraulic systems: advantages and limitations, physical principles of oil hydraulics, hydraulic power pack, hydraulic fluids, filters, types of hydraulic pumps, pump performance calculations, hose size calculations, hydraulic actuators and accessories,accumulator, hydraulic valves, pressure control valves, flow control valves, open-center and closed-center hydraulic systems. PLC: Programmable Logic Controllers (PLCs) Introduction,principles of operation,PLC programming, electromagnetic control relays, motor starters, latching relays, PLC ladder diagram,applications of PLC, networking of PLCs, PLC programming : basic PLC functions, intermediate and data handling

functions, controlling a robot with a PLC, PLC matrix functions, PLC installation, troubleshooting and maintenance.

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", Mc-Graw 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.] Merkle D.,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.

16RA704 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.

16RA711 INDUSTRIAL AUTOMATION II 3-0-0-3

Overview of MES (Manufacturing Execution Systems) including computer integrated manufacturing (CIM) and computer integrated automation (CIA) and their integration into manufacturing execution systems. Robotics and their application in Industrial Automation: Overview of the applications of robotic systems in industrial automation. Various robot configurations, Specifications such as accuracy, repeatability and load capability, and their importance in various applications.CAD/CAM and Robotics. Robot programming- RAPID languauge, Robot softwares- Pick Master, Robot studio Flexible control of batch processes. Distributed Control Systems in automation: The theory and operation of DCS in large, medium and small automation applications, current development of DCS and other automation systems in relation to PLC's, PC vs. PLC for machine and process control. 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 (e.g. Profibus and Foundation FieldBus). PLCs, in a distributed control system (DCS), and in a supervisory control and data acquisition (SCADA) system.Automation Theory and Applications using Emerson DeltaV.

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.

16CI624 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.

16RA712 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: Basic Concepts in modeling, models from fundamental laws, empirical model identification, dynamic performance analysis of first order, second order, multi-capacity processes, Effect of Zeros and time delay. Multivariable Process control: Cascade control, Ratio control, feedback-feedforward control, override control, selective control, modeling of multivariable process, Design of Multivariable 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 Ahmet Palazoglu, "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.

16RA713 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 - Data path 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 and EEPROM 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.

16RA714 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, Real-Time 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.

16RA715 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.

16RA716 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

16RA721 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 knowledge concerning humanoid robots, through a robot construction project. The contents of the course includes 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.

TEXT BOOKS/REFERENCES:

[1.] J. Craig, "Introduction to Robotics: Mechanics and Control", Third Edition, 2003.
[2.] Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators".
[3.] Jean-Claude Latombe, "Robot Motion Planning".

16RA722 SWARM INTELLIGENCE 3-0-0-3

Introduction to swarm intelligence and key principles (e.g., self-organization, stigmergy), 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 (Boids) and experiments with multi-robot systems (flocking, formation). Multi-level modeling of self-organized robotic systems: microscopic and macroscopic models; Markov formalism; linear and nonlinear micro-to-macro mapping, model analysis. Combined modeling and machine-learning methods for off-line system design and optimization.Diversity and specialization metrics.Division of labor and task-allocation mechanisms, threshold-based algorithms, market-based algorithms.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.

16RA723 BEHAVIORAL ROBOTICS 3-0-0-3

This course is designed to investigate and study methods and models in embodied cognitive science and artificial intelligence, with particular focus on behavior-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 behavior-based robotics, reactive behavior-based architectures, perception, deliberative systems, hybrid systems.

TEXT BOOKS/REFERENCES:

[1.] Arkin, C. Ronald, “Behavior-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.

16RA724 FRONTIERS OF BIOMECHATRONICS 3-0-0-3

Topics consist of rehabilitation engineering, artificial tissue and organs, implantable neural prosthesis, orthopedic 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 Biomechatronic Systems, design and manufacturing of Biomechatronic 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. Shanov andYeoheung Yun, "Nanomedicine Design of Particles, Sensors, Motors, Implants, Robots, and Devices", Artech House, 2009.
[3.] Graham M. Brooker, "Introduction to Biomechatronics: The Application of Mechatronic Engineering to Human Biology", SciTech Publishing, 2012.

16MA702 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, Addison-Wesley, 1989.

[4.] J. Nocedal and S.J. Wright, "Numerical Optimization". Springer, 2000.

16RA725 HAPTIC INTERFACES 3-0-0-3

This course focuses on low-level device design and control, and well as user interface issues (human psychophysics and evaluation in the context of user performance). Introduction to haptics, Kinesthetic haptic devices: Kinematics and dynamics, rendering, control, dynamic simulations, sensors and actuators. Tactile haptic devices: Types and applications. Teleoperation: Implementation, Transparency and Stability. Surface Haptics. Human haptics: Mechanoreceptors, Kinesthesia.

16RA726 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 skillful 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.

16RA727 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

16RA728 DESIGN FOR PEOPLE : PRINCIPLES AND PRACTISES OF HUMAN CENTERED DESIGN 3-0-0-3

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-centereddesign processes: User participation, Iteration, Identifying expand/collapse phases. Collaboration with Engineering: Managing the tech-centered and human-centered 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

16RA731 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 optial 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", Prentice-Hall, 1998.

16CS701 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.

16RA732 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).

TEXT BOOKS:

[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

16RA733 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.

16RA734 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. Input Devices : (Trackers, Navigation, and Gesture Interfaces): Three-dimensional position trackers, navigation and manipulation, interfaces and gesture interfaces. Output Devices: Graphics displays, sound displays & haptic feedback.Modeling : Geometric modeling, kinematics modeling, physical modeling, behaviour modeling, model management. Human Factors: Methodology and terminology, user performance studies, VR health and safety issues. Applications: Medical applications, military applications, robotics applications. VR Programming-I : Introducing Java 3D, loading and manipulating external models, using a lathe to make shapes. VR Programming-II : 3D Sprites, animated 3D sprites, particle systems.

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.

16RA735 NON LINEAR CONTROL THEORY 3-0-0-3

Topics include Nonlinear Behavior. Mathematical Language for Modeling Nonlinear Behavior : 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 Behavior of Differential Equations : Local Stability, Center 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.

16RA736 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 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.