MTech in Mechatronics

Preface

Mechatronics is an exciting interdisciplinary field of engineering, based on mechanical and electrical engineering, control engineering as well as signal and data processing. Mechatronicsystems sense their environment through multiple sensors, process the sensor signals and act back on the world by actuators. They can be found in almost all technological fields. Examplesare current automobiles, airplanes, locomotives and train sets, smart home devices as there are washing machines or automated industrial production lines or agricultural robotic applications like ecological weed management or even wind power plant maintenance devices from the green energy sector.

Very typical for mechatronic systems is a high degree of integration of the different system components. The strong linkage between mechanical and electrical parts requires a new integrated design philosophy. It is no longer possible to develop the mechanical and electrical subsystems independently. Mechatronic system design simultaneously considers the mechanical, electrical and all other physical domains involved.

If you are a creative engineer interested in learning about the latest technology in this multidisciplinary field, have a closer look at the Mechatronics Master‘s degree programme offered by Amrita Center for Advanced Robotics, Amrita Vishwa Vidyapeetham, Amritapuri Campus.

Curriculum

SEMESTER 1

Course Code	Course Title	Credits
22MT601	Advanced Mechatronics Engineering	4
22MT602	Embedded Computing and Programming	3
22MT603	Sensors and Actuators	3
22MT604	Robot Design and Analysis	3
22MT605	Theory and Design of Control Systems	3
22MT681	Sensors and Actuators Lab	2
22MT682	Mechatronics Programming and Hardware Lab	2
21HU601	Amrita Values Program	P/F
21HU602	Career Competency I	P/F
22AVP103	Mastery Over Mind	2
	Total Credits	22

SEMESTER 2

Course Code	Course Title	Credits
22MT611	Mechatronics System Design	4
22MT612	Soft Robotics	3
22MT613	Advanced Topics in Intelligent Systems	3
	Elective I	3
	Elective II	3
22MT683	Mechatronics System Simulation and Hardware Lab	2
22MT684	Computer Vision and ML	2
22RM600	Research Methodology	2
21HU603	Career Competency II	1
	Total Credits	23

SEMESTER 3

Course Code	Course Title	Credits
22MT798	Mini Project	10

SEMESTER 4

Course Code	Course Title	Credits
22MT799	Major Project	16

Total Credits for MTech Program: 71

Electives List

MTech in Mechatronics		
	Title	**Credits**
22MT631	Industry 4.0 Technologies	3
22MT632	Electronic System Level Design	3
22MT633	Semiconductor device modelling	3
22MT634	Emerging Architectures for Machine Learning	3
22MT635	Data Structures and Algorithms	3
22MT636	Embedded Real Time Systems	3
22MT637	FPGA Based System Design	3
22MT638	Process Control and Instrumentation	3
22MT639	Advanced Process Control	3
22MT640	Digital Image Processing	3
22MT641	Kinematics and Dynamics of Robots	3
22MT642	Machine Learning and Algorithm Design	3
22MT643	Unmanned Aerial Vehicles	3
22MT644	Advanced AI for Robotics	3
22MT645	Computational Intelligence	3
22MT646	Medical Robotics	3
22MT647	Embedded Systems For Automotive Applications	3
22MT648	Embedded Systems in Biomedical Applications	3
22MT649	Design For IoT And Cloud Computing	3
22MT650	Micro Electro Mechanical Systems (MEMS)	3

22MT601 Advanced Mechatronics Engineering 4

Unit I

Similarity transformations, diagonal form and Jordan form, functions of a square matrix, Lyapunov equation, quadratic form and positive/negative definiteness; Singular value decomposition, norms of matrices, solution of LTI state equations; Input-output stability of LTI systems, internal stability, Lyapunov theorem; Controllability, observability, canonical decomposition, minimal realizations and coprime fractions, state feedback and state estimators.

Unit II

Qualitative behavior near equilibrium points, limit cycles, existence of periodic orbits, Lyapunov stability; Input output stability, *L* stability, *L*2 gain; Feedback system: The small gain theorem; Passivity, memoryless functions, state models, feedback systems: passivity theorem, absolute stability, circle criterion, Popov criterion; Feedback control: Stabilization via linearization, integral control, integral control via linearization.

Unit III

Real-time operating systems, requirements of real-time systems, deadlock, resource management, priority, pre-emption; Hard real-time scheduling algorithms: Rate monotonic and earliest deadline first, schedulability tests, real-time communication: introduction, necessity, hard and soft real-time, network topologies and main non-real-time protocols.

Text Book

1. Mechatronics: Electromechanics and Contromechanics (Denny K. Miu)

References:

1. Chen, Linear system theory and design, third edition, Oxford, 1999.
2. Khalil, Nonlinear systems, third edition, Prentice Hall, 2002.
3. Franklin, Feedback control of dynamic systems, Prentice Hall, 2006.
4. De Silva, Mechatronics: an integrated approach, CRC Press, 2005.
5. Bolton, Mechatronics: a multidisciplinary approach, 4th edition, Pearson, 2008.

22MT602 Embedded Computing and Programming 3

Unit I

STM32F Processor: Introduction to Embedded Systems - Introduction to ARM - Advanced RISC Features - Core Data path - Register Organization - System Architecture - Memory Organization - Low Power Modes - Power Control Registers – Backup Registers - Programming STM32F

Unit II

STM32F Peripherals: Introduction to Embedded C Programming – General Purpose Input Output - UART - ADC - DAC - Timers - Interrupts and Exceptions - PWM - SPI

Unit III

External Peripheral Interfacing: LCD - Keypad - Motor - Servo Motor - EEPROM - Seven Segment Interfacing - Sensor Interfacing

References

1. Muhammad Ali Mazidi, STM32 Arm Programming for Embedded Systems, 2019.
2. Donald Norris, Programming with STM32: Getting Started with the Nucleo Board and C/C++, McGraw-Hill Education, 2018
3. STM32F446xx advanced Arm®-based 32-bit MCUs, Reference Manual, 2020

22MT603 Sensors and Actuators 3

Unit I

Introduction: Sensors and Actuators, Definition, Classification, Principle of Operation, Selection Criteria, Calibration techniques, Time and Frequency Measurement, Time and Frequency Standards, Time and Frequency Transfer, Sensor and Actuator Characteristics. Thermocouples; Resistive sensors; Inductive sensors; Capacitive sensors; Piezoelectric sensors; Encoders and tachometers

Unit II

Linear and Rotational Sensors, Acceleration Sensors, Force Measurement, Torque and Power Measurement, Flow Measurement, Temperature Measurements, Distance Measuring and Proximity Sensors, Light Detection, Image, and Vision Systems

Unit III

Electromechanical Actuators, Electrical Machines, Piezoelectric Actuators, Hydraulic and Pneumatic Actuation Systems

Textbooks:

1. Robert H. Bishop (2017) Mechatronic Systems, Sensors, and Actuators: Fundamentals and Modeling; The Mechatronics Handbook, Second Edition

Reference

1. Clarence W. de Silva (2015) Sensors and Actuators: Engineering System Instrumentation, Second Edition
2. Andrzej M Pawlak (2006) Sensors and Actuators in Mechatronics: Design and Applications
3. S.K.Bhattacharya, Control System Engineering, 3rd Edition, Pearson, 2013.
4. Benjamin.C.Kuo, —Automatic control systems‖, Prentice Hall of India, 7th Edition,1995.

22MT604 Robot Design and Analysis 3

Unit I:

Introduction to product design and development; Design process and its Phases, Mechanical Design Review; Fundamentals of 3D modelling; Basic manufacturing processes; Various Robot Design

Unit II

Mechanical design review; Basic concepts of kinematics and dynamics; Modelling and analysis of robotics systems; Prototype basics – principles of prototyping – planning for prototypes.

Unit III

Material selection for Robot manufacturing - Economics - Cost Vs Performance - Weighted property Index - Value Analysis - Role of Processing and Design - Classification of

Manufacturing Process - Design for Manufacture - Design for Assembly - Design for castings, Forging, Metal Forming, Machining and Welding - Residual stresses - Fatigue, Fracture and Failure.

Textbooks:

1. Karl t. Ulrich and Steven d Eppinger "Product Design and Development ", McGraw Hill, Edition 2000.
2. Robotics: Designing the Mechanisms for Automated Machinery, Academic Press, 1999

References

1. Planchard, D. C. and Planchard, M. P., (2012). Engineering design with SolidWorks 2012: A step-by-step project based approach utilizing 3D solid modelling, Schroff Development Corporation, Mission, Kansas. ISBN 978-1-58503-697-4.
2. Service Robots and Robotics: Design and Application, Marco Ceccarelli (University of Cassino, Italy). 2012

22MT605 Theory and Design of Control Systems 3

Unit I

Modeling: transfer function and state-space representations of differential governing equations; time and frequency-domain system response.

Unit II

Analysis: stability of linear and nonlinear systems; nominal sensitivity functions; Nyquist stability criterion; stability margins; sensitivity, robustness, and the robust stability theorem; design specifications and characterization of constraints; effect of open-loop integrators, poles and zeros; frequency-domain design limitations; eigenvalue and eigenvectors; Jordan canonical form; controllability and stabilizability; observability and detectability; canonical decomposition.

Unit III

Design: pole placement techniques in both the frequency domain and via state feedback; full state and reduced-order observer design; output feedback design; transfer function interpretations of output feedback design; introduction to the linear quadratic regulator.

Text Book

1. Feedback Systems: An Introduction for Scientists and Engineers, Karl Johan Astrom and Richard M. Murray

References:

1. Multivariable Feedback Control: Analysis and Design, Sigurd Skogestad and Ian Postlethwaite, Wiley, 2nd Ed., 2005.
2. K. Ogata, Modern Control Engineering, 5th edition, PHI, 2012.

22MT611 Mechatronics Systems Design 4

Unit I

Mechatronic systems – Integrated design issue in mechatronic – mechatronic key element, mechatronics approach – control program control – adaptive control and distributed system

– Design process – Type of design – Integrated product design – Mechanism, load condition design and flexibility – structures – man machine interface, industrial design and ergonomics, information transfer, safety.

Unit II

Control devices – Electro hydraulic control devices, electro pneumatic proportional controls – Rotational drives – Pneumatic motors: continuous and limited rotation – Hydraulic motor: continuous and limited rotation – Motion convertors, fixed ratio, invariant motion profile, variators.

Unit III

Real time interface – Introduction, Elements of a data acquisition and Control system, overview of I/O process, installation of I/O card and software – Installation of the application software – over framing.

Unit IV:

Case studies on data acquisition – Testing of transportation bridge surface materials – Transducer calibration system for Automotive application – strain gauge weighing system – solenoid force – Displacement calibration system – Rotary optical encoder – controlling temperature of a hot/cold reservoir – sensors for condition monitoring – mechatronic control in automated manufacturing.

Text Books

1. Bolton (2015), "Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering", Pearson Education Limited, ISBN - 9781292076683.
2. Devdas Shetty, Richard A. Kolkm (2010), "Mechatronics System Design", Cengage Learning, ISBN - 9781439061992.

Reference Books

1. Brian Morriss (1994), "Automated Manufacturing Systems – Actuators Controls, Sensors and Robotics", McGraw-Hill Inc., ISBN - 9780028023311.
2. Bradley, D. Dawson, N.C. Burd and A.J. Loader (1993), "Mechatronics: Electronics in products and Processes", CRC Press, ISBN – 9780748757428.

22MT612 Soft Robotics 3

Unit I

New Concepts for Distributed Actuators and Their Control, Shape Memory Alloys as Flexible Actuators, Control and Feedback Control of Distributed Actuators, Musculoskeletal Robots and Wearable Devices on the Basis of Cable-driven Actuators, Capacitive Tactile Proximity Sensing

Unit II

Modeling, Simulation and Control, Perception of Deformable Objects and Compliant Manipulation for Service Robots, Soft Robot Control with a Behaviour-Based Architecture, Optimal Exploitation of Soft-Robot Dynamics, Simulation Technology for Soft Robotics Applications, Mechanics and Thermodynamics of Biological Muscle – A Simple Model Approach

Unit III

Nanostructured Materials for Soft Robotics – Sensors and Actuators, Fibrous Materials and Textiles for Soft Robotics, Opportunities and Challenges for the Design of Inherently Safe Robots, Soft Hands for Reliable Grasping Strategies, Task-specific Design of Tubular Continuum Robots for Surgical Applications, Soft Robotics Research, Challenges, and Innovation Potential, Through Showcases

Text Book

1. Soft Robotics: Transferring Theory to Application, Alexander Verl, Alin Albu-Schäffer, Oliver Brock, Annika Raatz, Springer

22MT613 Advanced Topics in Intelligent Systems. 3

Unit I

Introduction to Artificial Intelligence: definition of AI; Turing test; brief history of AI. Problem solving and search: problem formulation; search space; states vs. nodes; tree search: breadth-first, uniform cost, depth-first, depth-limited, iterative deepening; graph search. Informed search: greedy search; A* search; heuristic function; admissibility and consistency; deriving heuristics via problem relaxation. Local search: hill-climbing; simulated annealing; genetic algorithms; local search in continuous spaces. Dealing with geometry of physical agents: basic issues in robotics; degrees of freedom; Dijkstra's shortest path algorithm;

Unit II

Mathematical concepts review - Central tendency - Dispersion of data - Descriptive data summaries - k-nearest neighbour classifier - Bayes classifiers - Classifier performance measures. Decision tree - Ensemble methods - Ordinary Least Squares - Artificial neurons - Perceptron - Multi Layer Perceptron and backpropagation -Hyperparameter tuning - Cluster analysis

Unit III

Introduction to fuzzy set theory; Fuzzy set vs Crisp set; Problems on fuzzy set and crisp sets; Properties of fuzzy sets; Fuzzy Logic: Classical logic, multi valued logic; Fuzzy propositions; Fuzzy quantifiers; Fuzzy systems: fuzzy controllers;

Text Books

1. S.J. Russell and P. Norvig. *Artificial Intelligence: A Modern Approach (3rd edition)*, Prentice-Hall, 2010.
2. G.J.Klir & Bo Yuan, "Fuzzy Sets and Fuzzy Logic Theory and Applications", Prentice Hall of India, 2009
3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Second Edition, O'Reilly Media, 2019.

Reference Books

1. Timothy S.Ross, "Fuzzy Logic with engineering applications", Weily India Pvt. Ltd., 2011.
2. Kosko B, "Neural Networks and Fuzzy Systems: A dynamical system approach to machine intelligence", Prentice Hall of India, 2009.
3. R Beale & T Jackson, "Neural Computing, An Introduction", Adam Hilger, 1990.

4. Rao V.B and Rao H.V., “C++, Neural Networks and Fuzzy Logic”, BPB Publications, 2003.

22MT631 Industry 4.0 Technologies 3

Unit I

Human-machine interaction - Augmented-reality systems - Transferring digital instructions to the physical world - Advanced robotics and 3-D printing - Autonomous activities - Lean Manufacturing - Human-machine interaction - Touch interfaces, virtual reality and augmented-reality systems

Unit II

Advanced robotics - 3-D printing - Cloud Computing and Concept of “Equipment-As-a-Service,” EAAS - Connectivity Solutions: Bluetooth, BLE, Bluetooth 5.0, ZigBee, ZigBee 3.0, Z-Wave, 6LowPAN, RFID, WiFi, Mobile/Cellular, SATCOM, PLC, PLC Programming (Ladder Logic Programming) - Proactive/Predictive Maintenance and Continuous Monitoring

Unit III

Cyber-physical systems (CPS) in the Industry 4.0 vision - Cyber-physical systems key characteristics - Industry 4.0 building blocks - The (Industrial) Internet of Things - Industry 4.0 principles: horizontal and vertical integration; Principles of Big Data, Data Mining, Data Organization and Data Warehousing - Data security in Industry 4.0

Text Book

1. Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, Apress, 2017

References

1. The Fourth Industrial Revolution by Klaus Schwab
2. Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0 by Ibrahim Garbie

22MT632 Electronic System Level Design 3

Unit I

Introduction to Electronic System Level Design– Hybrid Design – ESLD Flows and Methodologies – Architecture Exploration–Hardware-software Partitioning.

Unit II

Models for ESL Design– Open-Source Languages–SpecC–ArchC and SystemC for ESLD– Transaction Level Modelling Building Platform Models in SystemC.

Unit III

High Level Synthesis– ESL Verification – Virtual Platform and Virtual Prototyping– Debugging SystemC Platform Models –SystemC Based Power Evaluation –SystemC Standards and Accellera Initiatives ESLD – Project Based Practice design

References

1. Sandro Rigo, Rodolfo Azevedo and Luizsantos, Electronic System Level Design – An Open Source Approach, Springer, 2011.

22MT633 Semiconductor Device Modeling 3

Unit I

Introduction to MOSFET – Output and Transfer Characteristics – MOS Capacitor —Long, short channel MOSFETS – Non Ideal Effects – MOSFET Scaling – Threshold voltage– Small signal model – Large Signal model – MOSFET parasitic capacitances.

Unit II

SPICE Models for semiconductor Devices –MOSFET Level1,Level2 and level 3 models –BSIM model– Model parameters– Models for semiconductor contacts and hetero junctions – Charge control models –Second order effects –Velocity Saturation and universal models– FINFETs –SOI MOSFETS: single gate to multi gate -Multigate MOSFET Technology –Physics of multigate MOS– Mobility in multigate MOSFET

Unit III

Radiation Effects in Single gate and Multi gate FETs – Single event effects - Multigate MOSFET Circuit Design - Digital, Analog circuit design - Double gate MOSFET- Drain current model - Scale length - Fabrication Requirements – Challenges – SoC Design- Technology Aspects

References

1. B.G Streetman and S.K Banerjee, Solid State Electronic Devices, Seventh Edition, PrenticeHall India,2010
2. D.A.Neamen, Semiconductor Physics and Devices: Basic Principle, Third Edition, McGraw –Hill International,2003.
3. J. P. Collinge, FinFETs and Other Multi-Gate Transistors, Springer, 2008
4. Y.Taur and T.H. Ning, Fundamentals of Modern VLSI Devices, Second Edition, Cambridge University Press,2009.

22MT634 Emerging Architectures for Machine Learning 3

Unit I

Accelerated Computing – GPUs – Overview of GPU Architectures – CUDA – OpenCL – Case Studies IoT and Cloud Architectures – Use Cases – VLSI Design Challenges for IoT– Power – Area and Security – Intel Dashboard Framework.

Unit II

Overview of Cloud Computing – Introduction to Hadoop Framework – Case Study – FPGA Architectures for Neural Networks and Bioinformatics – Review of Neural Networks and Deep Learning.

Unit III

Data Precision and Implementation Issues – Case Studies of Regression Implementation – FPGA and Reconfigurable Architectures for Bioinformatics – Database Search – Sequencing and Alignment.

References

1. David B. Kirk, Wen-Mei W. Hwu, Programming Massively Parallel Processors: A Hands-on Approach, Second Edition, Morgan Kauffman, 2016.
2. Bertil Schmidt, Bioinformatics: High Performance Parallel Computer Architectures, CRC Press, 2011

22MT635 Data Structures and Algorithms 3

Unit I

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.

Unit II

Searching and Sorting -Insertion and Selection Sort - Quick sort - Merge sort - Heap sort - Bucket Sort and Radix Sort - Comparison of sorting algorithms and lower bounds on sorting - Fundamental Techniques - The Greedy Method - Divide and Conquer.

Unit III

Dynamic Programming - Graph Algorithms - 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

References

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, “Introduction to Algorithms”, Third Edition, MIT Press, 2009.
2. Robert Sedgewick and Kevin Wayne, “Algorithms”, Fourth Edition, Addison Wesley, 2011.
3. Kurt Mehlhorn and Peter Sanders, “Data Structures and Algorithms: The Basic Toolbox”, Springer, 2008.
4. John V. Guttag, “Introduction to Computation and Programming using Python”, MIT Press, second edition, 2016

22MT636 Embedded Real Time Systems 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 realtime 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, HighSpeed Interfacing, File system management, Interfacing Robotic Components, High-Speed Networks, Robotic Systems.

Textbooks/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.

22MT637 FPGA Based System Design 3

Unit I

Programmable logic devices - PROM- PAL – PLA- CPLD - Gate arrays -MPGA - FPGA- Programming technologies - EPROM-EEPROM-FLASH-SRAM- FPGA fabric- Configurable logic block – LUT – Slice - SliceM - programmable interconnects - Input output blocks – keeper circuit – Xilinx 7 series architecture.

Unit II

FPGA Design flow and abstraction levels – Verilog design for synthesis-one hot encoding-Memory blocks- Block memory generator (BRAM/BROM)- single port memory- dual port memory- FIFO-distributed RAM-synthesis pitfalls-latch inference-static timing analysis-speed performance-timing constraints-clock management -clock buffers-clock tree routing

Unit III

Introduction to SoC design –Hard macros – multipliers –DSP block-hard core processors-interface circuits-– configuration chain – JTAG interface - Zynq7000

References

1. Amano, Hideharu, Principles and Structures of FPGAs, First Edition, Springer, 2018.
2. Readler, Blaine C., Verilog by example: a concise introduction for FPGA design. Full Arc Press, 2011.
3. Zainalabedin Navabi, Embedded Core Design with FPGAs, First Edition, McGraw Hill, 2008
4. Xilinx Inc, Vivado Design Suite User Guide, 2021

22MT638 Process Control and Instrumentation 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.

Textbooks/ 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.

22MT639 Advanced Process Control 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-feed forward control, override control, selective control, modeling of multivariable process, Design of Multivariable controllers. Model Based control: Feedback-feed forward, 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, Design of Neural Network based controller.

Textbooks/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.

22MT640 Digital Image Processing 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, 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. Matlab applications.

Textbooks/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.
   Kenneth R. Castleman, "Digital Image Processing", Prentice Hall, 1996.
4. Gonzalez, Woods and Eddins, "Digital Image Processing using MATLAB", Prentice Hall, 2004.

22MT641 Kinematics And Dynamics Of Robots 3

Robot types, trends, applications, classification - Anatomy and Architecture of Manipulators – Mobile Robots – Advanced Robots - Holonomic and Non-holonomic Robots - transformations – Quaternions - Robot Kinematics: Forward and Inverse - Manipulator Jacobian - Force relations – Multi-body Dynamics: Forward and Inverse – Lagrange-Euler Dynamic Model – Recursive Newton-Euler Formulation - Trajectory planning in Joint space and Cartesian space – Matlab/RoboAnalyzer Simulations of Kinematic and Dynamic models.

Textbooks/References:

1. S K Saha, “Introduction to Robotics”, 2nd edition, McGraw Hill Education (India) Pvt. Ltd., 2014.
2. Robert J Schilling, “Fundamentals of Robotics, Analysis and Control”, Prentice Hall, 2007.
3. Reza N Jazar, “Theory of Applied Robotics: Kinematics, Dynamics and Control”, 2nd Ed. Springer, 2010.
4. Peter Corke, "Robotics, Vision, and Control: Fundamental Algorithms in MATLAB", Springer, 2013.
5. John J Craig, “Introduction to Robotics: Mechanics and Control”, Pearson, 2018.
6. K S Fu, et al, “Robotics: Control, Sensing, Vision and Intelligence”, Tata McGraw Hill, 2008.
7. Springer Handbook of Robotics, B Siciliano, O Khatib, editors, 2nd Ed., Springer, 2016.

22MT642 Machine Learning and Algorithm Design 3

Unit I

Mathematical concepts review - Central tendency - Dispersion of data - Descriptive data summaries - k-nearest neighbor classifier - Bayes classifiers - Classifier performance measures

Unit II

Decision tree - Ensemble methods - Ordinary Least Squares - Artificial neurons - Perceptron - Multi Layer Perceptron and backpropagation -Hyperparameter tuning - Cluster analysis - Partitioning methods - Hierarchical methods -Density-based methods - Cluster evaluation

Unit III

Graphs - Definitions and applications - Graph Connectivity - Graph Traversal - Testing Bipartiteness - Breadth-First Search - Directed graphs - Directed Acyclic Graphs -Topological

ordering - Interval scheduling - Optimal caching - Shortest paths - Minimum Spanning Tree - Clustering - Huffman Codes - Data Compression - Partitioning Problems - Graph Coloring

References

1. Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques, Third Edition, Morgan Kaufmann Publishers (Elsevier), 2011.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Second Edition, O'Reilly Media, 2019.
3. Earl Gose, Richard Johnsonbaugh, Steve Jost, Pattern Recognition and Image Analysis, Pearson Education India, 2015
4. Jon Kleinberg, Éva Tardos, Algorithm Design, Pearson, 2006

22MT643 Unmanned Aerial Vehicles 3

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

Textbooks/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.

22MT644 Advanced AI For Robotics 3

Problem solving: Graph based search, Algorithms for searching, Heuristic search, Robot path planning. Knowledge representation: Descriptive representation, Procedural representation, Rulebased 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.

Textbooks/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.

22MT645 Computational Intelligence 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.

22MT646 Medical Robotics. 3

Introduction to Medical Robotics; Medical Robot (MR) History, MR Automation and Navigation Challenges; Robotically Assisted Minimally Invasive Surgery (MIS); MR Visual Servoing; MR-MIS Navigation and Deformation Tracking; Haptic Feedback in MIS; Learning and Perceptual Docking in MIS; Surgical Robotics (Laparoscopic and Endoscopic Manipulators); Oncology Robotics

Reading

1. http://www.springer.com/engineering/biomedical+engineering/book/978-1-4419-1125-4 Surgical Robotics: Systems Applications and Visions (by Rosen, Jacob, Hannaford, Blake, Satava, Richard M. (Eds.))
2. http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291478-596X (The International Journal of Medical Robotics and Computer Assisted Surgery)
3. http://medrobotics.ri.cmu.edu/node/128439 (Medical Robotics at CMU)
4. http://robotics.eecs.berkeley.edu/medical/ (Medical Robotics at UC Berkeley)
5. http://www.imperial.ac.uk/study/pg/courses/global-health-innovation/medical-robotics/ (MRes Curriculum at Imperial College)

22MT647 Embedded Systems For Automotive Applications 3

Automotive Fundamentals – Vehicle functional domains and requirements – Automotive Electrical subsystems- The systems approach to control and automotive instrumentation – Sensors and Actuators in various vehicle domains. Systems in Power Train Electronics: Engine Management Systems in Chassis control: ABS, ESP,TCS, Active Suspension Systems, Cruise Control and Adaptive Cruise control systems – Body Electronic systems – Automotive Safety systems HVAC – Electric Hybrid Vehicles and their configurations- Drive-by-wire systems – Autonomous and Connected Vehicles and their challenges-Introduction to

Embedded Automotive Protocols: CAN, LIN, Flex-Ray, MOST-AUTOSAR standard and its applications - OSEK VDX Open Systems in Automotive Networks.

Textbooks/References:

1. William B. Ribbens, “Understanding Automotive Electronics – An Engineering Perspective”, Eight Edition, Elsevier Inc., 2017.
2. Robert Bosch GmbH, “Bosch Automotive Electrics and Automotive Electronics - Systems and Components, Networking and Hybrid Drive”, Fifth Edition, Springer Vieweg, 2007.
3. Najamuz Zaman, “Automotive Electronics Design Fundamentals”, Springer, 2015.
4. V. A. W. Hillier and David R. Rogers, “Hillier’s Fundamentals of Motor Vehicle Technology on Chassis and Body Electronics”, Fifth Edition, Nelson Thrones, 2007.
5. Tom Denton, “Automobile Electrical and Electronic Systems”, Fifth edition, Routledge, 2017.

22MT648 Embedded Systems In Biomedical Applications 3

Overview of biomedical devices – Origin of bio potentials – bio potential electrodes – bio potential amplifiers, System Theory for Physiological Signals: Filters, Modeling – Embedded systems in Patient monitoring: ECG, EEG, EMG, Blood pressure, respiration, pulse oximeters, diagnostic devices.
Non-invasive Diagnosis Using Sounds from Within the Body, Non-invasive Measurement of Blood Pressure, Measurement of Electrical Potentials and Magnetic Fields from the Body Surface and Plethysmography. Healthcare and the Wireless Sensor Network, Smart m-Health Sensing, m-Health and Mobile Communication Systems, Data Collection and Decision Making. m-Health Computing m-Health 2.0, Social Networks, Health Apps, Cloud and Big Health Data, m-Health and Global Healthcare and the Future of m-Health – case study.

Textbooks/References:

1. John G. webster, Amit J. Nimunkar, “Medical Instrumentation - Application and Design”, Fifth Edition, John Wiley and Sons, 2020.
2. Subhas Chandra Mukhopadhyay and Aime Lay-Ekuakille, “Advances in Biomedical Sensing, Measurements, Instrumentation and Systems”, Springer, 2010.
3. Aime Lay-Ekuakille and Subhas Chandra Mukhopadhyay, “Wearable and Autonomous Biomedical Devices and Systems for Smart Environment - Issues and Characterization”, Springer, 2010.
4. Robert B. Northrop, “Noninvasive Instrumentation and Measurement in Medical Diagnosis”, CRC Press, 2019.
5. Roberts. H. Istepanian and Bryan Woodward, “m-Health Fundamentals and Applications”, Wiley, 2017.

22MT649 DESIGN FOR IoT AND CLOUD COMPUTING 3

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things -RFIDs, NFC, Web of Things - Embedded Systems Design: power and energy consumption; hardware design elements, software platforms –OS and

applications, code optimization, validation and robust code generation; system integration, debugging and test methodology; tools for coding, debugging, optimization, and documentation; measurement of system performance, Creating virtual prototypes - hardware software emulation. IoT Reference Architectures, Introduction to Node Red, Visual Prototyping with Arduino and connectivity to IoT platforms, Applications: Healthcare and home automation examples. Cloud Computing: Infrastructure as a Service (IaaS), Cloud Database, Cloud storage. Platform as a Service (PaaS) for Web Rapid Application Development (RAD), Distributed Storage, Distributed Computing frameworks. Connectivity to remote server database, data access-storage processing. Development of cloud server and web applications.

Textbooks / References:

1. Barry, P., and Crowley, P., "Modern Embedded Computing", Morgan Kaufmann, 2012.
2. Vijay Madisetti and Arshdeep Bahga, "Internet of Things: A Hands-on Approach", Hardcover Import, 2014.
3. Thomas Erl, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall, May 2013.
4. Michael J. Kavis, "Architecting the Cloud: Design Decisions for Cloud Computing Service
5. "Models (SaaS, PaaS, &IaaS)", Wiley ClO Series, January 2014.
6. George Reese, "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud", O'Reilly, 2009.

22MT650 Micro Electro Mechanical Systems (MEMS) 3

Unit I

Definition of MEMS. MEMS devices. Silicon as a MEMS material – mechanical properties of silicon. Mechanical components in MEMS. Design concepts of mechanical components. Working Principles of Microsystems. Engineering Science for Microsystems design and Fabrication. Scaling laws – Scaling in geometry, rigid body dynamics, electrostatic forces, electromagnetic forces, electricity-fluid mechanics and heat transfer.

Unit II

Materials for MEMS and Microsystems. Fabrication technologies – Photolithography – Ion implantation – diffusion – oxidation – CVD – Physical Vapor Deposition – Etching. Micro manufacturing – Bulk and surface micro machining – LIGA.

Unit III

Microsystems Design – Design considerations – Process design – Mechanical Design – CAD – Micro system packaging – Levels – Bonding – Interfaces – Assembly – Selection of Packaging Materials.

Text Book

1. Tai–Ran Hsu – 'Mems & Microsystems Design and Manufacturing' – John Wiley & Sons – 2008 – 2nd Edition References

References:

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Gaberiel M.Rebiz, “RF MEMS Theory, Design and Technology”, John Wiley & Sons,2003