Inter-disciplinary Minor Degree in "Drone Technologies"

Scheme:

S. No.	Department	Code	Subject	Sem	Scheme
1	DoECE	ECECM212	Drones Design, Communication, and Control	4	3-0-2
2	DoME	ECMEM371	Fundamentals of UAV Aerodynamics	5	3-1-0
3	DoEE	ECEEM396	Modelling and Control of Drones	6	3-1-0
4	DoCSE	ECCSM451	Machine Learning for Drone Applications	7	3-0-2

फ़ोन नं: संस्थान कार्यालय: २२२३३७१-७४, फैक्स नं: २२२८३९४,२२२७३३४ विभागीय प्रमुख: २२०१५५१, विभाग कार्यालय: २२०१५५२
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Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Department of Electronics Engineering

B.Tech. Electronics and Communication Engineering

B.Tech. II (ECE) Semester-IV Drones: Design, Communication, and Control (ECEC212)	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	Understand basics of drones and radio communications for drones
CO2	Apply the control theory to drone payload design and control
CO3	Analyze the drone control and navigation
CO4	Evaluate the performance and endurance of battery and fuel powered drones
CO5	Design navigation and control routines for drones
CO6	Explain the components of a drone

2.	Syllabus	
	Design of Drone Systems	**(06 Hours)**
	Introduction to Design and Selection of the System, Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types, Components and functions of a fixed wing and multi-rotor drones, Design Standards and Regulatory Aspects-India Specific.	
	Avionics Hardware of Drones	**(08 Hours)**
	Flight controller module, mission controller onboard computer, data link, telemetry module, servos, accelerometer, gyros, magnetometer, GNSS, actuators, Pressure sensor, velocity sensor, power supply-processor, integration, installation, configuration.	
	Payloads and Controls	**(08 Hours)**
	Type, size, and nature of Payloads, Payload versus endurance, Tracking, controls-PID feedback, memory system, simulation, Kalman filtering, kinematics of drones, control strategy of multi-rotors, Payload release and variation handling.	
	Communication	**(08 Hours)**
	Basics of radio wave communication, coherent and non-coherent transmission, modulation-demodulation, filtering, ADC and DAC, baseband signal processing of radio transceiver, Telemetry, radio control frequency range, modems, Servo receiver and remote controller.	
	Navigation and Testing	**(08 Hours)**

	Waypoints navigation, Code based positioning, phase-based positioning, Single Point Positioning, Differential positioning, Precise Point Positioning, RTK, ground control software, System Ground Testing, System In-flight Testing	
	Fuel powered drones	**(07 Hours)**
	Engines for drones, thrust control, configurations of fuel powered drones (FPDs), Analysis of range, power, and weight for FPDs, Vibration issues and mitigation, Dynamics of FPDs.	
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals**
1.	Introduction to basic components of drone
2	Introduction to Ardupilot and Mission Planner Environment Setup
3	Drone (Quadcopter) Assembly and Safety Rules and Regulations for drone operations
4	Configuration of Ardupilot parameter tuning: IMU, GPS, Telemetry, RC, GCS
5	Drone Testing on Gyro based Flight Tester (GFT)
6	Introduction of SITL tools and mission planning
7	Interfacing of BLDC motor with ESC and flight controller
8	PCB design of drone components
9	PCB fabrication of drone components
10	3D design for Drone Components
11	3D printing of Drone Components
12	Drone Flying

4.	**Books Recommended**
1	Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.
2	Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
3	Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007
4	Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998
5	Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics
6	B. P. Lathi and Zhi Ding, "Modern Digital and Analog Communication Systems", Oxford University Press, 2010.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

B.Tech. III (ME) Semester-V Fundamentals of UAV Aerodynamics (ECMEM371)	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**0**	**2**	**04**

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Understand fundamental principles of aerodynamics
CO2	Apply Bernoulli's equation to incompressible, inviscid flow analysis
CO3	Analyze the aerodynamic performance of airfoils
CO4	Evaluate the lift and drag characteristics of finite wings
CO5	Design three-dimensional incompressible flow models
CO6	Explain the aerodynamics of UAV configurations

2.	**Syllabus**	
	Introduction and Aerodynamics Fundamental Principles and Equations	**(06 Hours)**
	Fluid Statics, Classification of Flows, Continuity equation, Momentum Equation, Energy Equation, Pathlines, Streamlines, and Streaklines of a Flow, Angular Velocity, Vorticity, and Strain, Circulation, Stream Function, Velocity Potential, Relationship Between the Stream Function and Velocity Potential.	
	Inviscid, Incompressible Flow	**(08 Hours)**
	Fundamentals of Inviscid and Incompressible Flow, Bernoulli's Equation, lifting and non-lifting Flow over cylinder, The Kutta-Joukowski Theorem and the Generation of Lift.	
	Incompressible Flow over Airfoils	**(08 Hours)**
	Downwash and Induced Drag, The Vortex Filament, the Biot-Savart Law, and Helmholtz's Theorems, Prandtl's Classical Lifting-Line Theory.	
	Three-Dimensional Incompressible Flow	**(08 Hours)**
	Three-Dimensional Source, Three-Dimensional Doublet, Flow over A Sphere, Airplane lift and Drag	
	Aerodynamics of UAV	**(08 Hours)**
	Aerodynamics of UAV Configurations, Fixed-wing, Rotary-wing, Aerodynamic Performance Analysis of Different Unmanned Vehicles	

	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Books Recommended**
1	Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.
2	Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
3	Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007
4	Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998
5	Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics
6	B. P. Lathi and Zhi Ding, "Modern Digital and Analog Communication Systems", Oxford University Press, 2010.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Department of Electrical Engineering

Syllabus for B.Tech. Minor in Drone Technologies

B.Tech. **Modelling and Control of Drones** **(ECEEM396)**	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**1**	**0**	**04**

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Understand inertial and body frames, states, control inputs of drone
CO2	Obtain control relevant mathematical model of drone
CO3	Design controllers for controlling position and attitude of drone
CO4	Evaluate controllability, observability of drone
CO5	Apply state estimation techniques to estimate states of drone

2.	**Syllabus**	
	Drone Architecture from Control Systems point of view	**(03 Hours)**
	Introduction, Drone configuration, inertial and body frames, inputs and outputs of a 6 DOF drone, propeller rotation directions, various control actions, measurements with respect to body frame.	
	Kinematic and Dynamic Equations of Drone	**(14 Hours)**
	Kinematics vs Dynamics, measuring the UAV's position, introduction to describing attitudes, 3D rotation matrix formulation about Z axis, 3D rotation sequence, Introduction to Euler angles, Fixed vs Moving body frame rotations, Transfer matrix derivation, application of rotation and transfer matrix to drone, introduction to dynamics, dot product, cross product, mass moment of inertia, inertial tensor, translational motion, rotational motion, obtaining dynamic equations of drone.	
	Forces and Moments	**(05 Hours)**
	Obtaining state space model of drone, Force of gravity, Gyroscopic effect on drone, applying control inputs, control inputs to rotor angular velocities - blade element theory, drone plant model schematics, obtaining measurement model.	
	Controller design for Drone	**(12 Hours)**
	Obtaining linear transfer function and state space models, trim condition, lateral autopilot design, longitudinal autopilot, position control, attitude control, control allocation, motor control, digital implementation of PID loops, controllability, observability, stability, controllability of quadrotor, design of state feedback controllers.	

	State Estimation	**(11 Hours)**
	Discrete time state space model, attitude Estimation, measuring principle, linear complementary filter, nonlinear complementary filter, Kalman filter, position estimation, GPS-based position estimation, SLAM-based position estimation, velocity estimation, aerodynamic-drag-model-based velocity estimation method.	
	Tutorials will be based on the coverage of the above topics separately	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3.	**Tutorials**
	Tutorials will be based on the coverage of the topics given in the detailed syllabus separately for 15 hours.

4.	**Books Recommended**
1	Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
2	Randal Beard and Timothy W. McLain, Small Unmanned Aircraft: Theory and Practice, Princeton University Press, 2012.
3	Quan Quan, Introduction to Multicopter Design and Control, Springer, 2017.
5	Bernard Etkin and Llyod Duff Reid, Dynamics of Flight Stability and Control, John Wiley and Sons, Third Edition, 1996.
6	Bandhu N. Pamadi, Performance, Stability, and Control of Airplanes, AIAA Education Series, 1998.
7	Crassidis J.L., Junkins J.L, Optimal estimation of dynamic systems, CRC Press, 2004.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

Department of Computer Science and Engineering

B.Tech. MINOR in DRONE TECHNOLOGIES

B. Tech. IV (Semester-VII) **MACHINE LEARNING FOR DRONE APPLICATIONS (ECCSM451)**	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**0**	**2**	**04**

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	Understand data, data collection, data visualization, and machine learning approaches for drone applications
CO2	Apply machine learning paradigms for drone applications for captured data
CO3	Analyze machine learning algorithms for the development of intelligent drone applications
CO4	Evaluate the various machine learning algorithms to gain an understanding of different application area
CO5	Implement a drone application using machine learning algorithms

2.	**Syllabus**	
	Introduction	**(04 Hours)**
	Drone Multi-Modal Data: Sensor Data, GIS, Motion Data, 3D Imaging and Reconstruction; Data Collection: GPS, IMU, Video, Spectral, Thermal, etc.; Data Visualization: Trajectory Area using Digital Surface Model, Digital Terrain Models, Textured 3D Models, RGB Orthomosaics, Multispectral Model; Machine Learning Approaches: Supervised, Unsupervised, Semi-Supervised, Deep Learning; Applications: Precision Agriculture, Disaster Management, Delivery Service, Environment Monitoring: Earth Surface Monitoring (Soil, River, etc.), Forest Fire Monitoring, Entertainment, Surveillance and Security, etc.	
	Trajectory and Motion Planning	**(15 Hours)**
	Trajectory Planning, Representations, Selection and Speed Planning; Motion Planning: Types, Random Sampling based Motion Planning, Non-Holonomic Motion Planning; Collision Detection: Obstacle Types, Collision Detection for Static Obstacles, Motion Prediction of Obstacles, Collision Prediction for Dynamic Obstacles; Path Planning Approaches: Graph-Based Algorithms, Breadth-First Search Algorithm, Depth-First Search Algorithm; Usage and Configuring of Space for Motion Planning, Representation as a Graph, Planning using Visibility Graph, Finding the Shortest Path, Variants of A*, Reinforcement Learning for Planning Machine Learning, Markov Decision Process, Model-based/Model-free Monte Carlo.	
	UAV Vision and Image Processing	**(15 Hours)**

	UAV Vision-based Sensors, Photogrammetry, Types of UAV Images, Image File Formats, Image Model, Image Sensing and Acquisition, Image Operations: Sampling and Quantization, Aligning and Stitching Drone-Captured Images, Intensity Transformation Functions, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing and Sharpening Spatial Filters, Image Restoration, Color Based Image Segmentation, Hyperspectral Target Detection, Spectral Identification, Feature Extraction, Object Detection, Object Recognition and Object Tracking.	
	Swarm Management	**(04 Hours)**
	Introduction to UAV Swarm, Swarm Communication Architecture, Multi-UAV Coverage Path Planning and Estimation with Obstacles and With or Without Map Information, Local Path and Global Path, Best Flight Path Learning, Independent Path Optimization, Multi-Target Tracking.	
	Drone Applications	**(07 Hours)**
	Data Collection, Data Preprocessing, Designing of Machine Learning Approach	
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals**
1.	Collect drone sensor data (GPS, IMU, video, thermal) and preprocess drone data (e.g., normalize, handle missing values) for input into a machine learning model.
2	Create and visualize a Digital Surface Model (DSM) and a Digital Terrain Model (DTM) from collected data.
3	Generate textured 3D models from drone imagery using photogrammetry software.
4	Perform image operations like alignment and stitching on a set of drone-captured images.
5	Implement a supervised machine learning model for the classification of regions using drone data for precision agriculture.
6	Simulate trajectory planning using graph-based algorithms (e.g., A* or Dijkstra's algorithm) in a predefined environment.
7	Implement feature extraction techniques and perform object detection on UAV images using computer vision libraries (e.g., OpenCV).
8	Develop a simple simulation to test collision detection algorithms with static and dynamic obstacles.
9	Perform object movement detection
10	Conduct hyperspectral analysis to identify materials in a specific area using drone-collected spectral data.

4.	**Books Recommended**
1	Randal W. Beard and Timothy W. McLain, “Small Unmanned Aircraft: Theory and Practice”, Princeton University Press, 2012.
2	Stephen Marsland, “MACHINE LEARNING An Algorithmic Perspective”, CRC Press, 2015.
3	Amy Frazier, Kunwar Singh, “Fundamentals of Capturing and Processing Drone Imagery and Data”, CRC Press, 2021.
4	Chein-I Chang, “Hyperspectral Data Exploitation: Theory and Applications”, Springer, 2007.
5	U. Snekhalatha, K. Palani Thanaraj, Kurt Ammer, “Artificial Intelligence-based Infrared Thermal Image Processing and its Applications”, CRC Press, 2022.

5.	**Additional Books Recommended**
1	Steven M. Lavalle, "Planning Algorithms", Cambridge University Press, 2006.
2	Reg Austin, “Unmanned Aircraft Systems: UAVS Design, Development and Deployment”, Wiley, 2012.
3	Wei Shyy, Ella Atkins, Anibal Ollero, Antonios Tsourdos, Richard Blockley, “Unmanned Aircraft Systems”, John Wiley & Sons, 2017.
4	S. Manfreda, E. B. Dor, "Unmanned Aerial Systems for Monitoring Soil, Vegetation, and Riverine Environments", Elsevier, 2023.