ROBOTICS CLASSES - EXPERT

This curriculum is designed for students who have foundational knowledge of Arduino, electronics, and programming. The course will introduce more complex topics like advanced sensors, communication protocols, artificial intelligence, machine learning, and autonomous systems. It spans **16 weeks** (4 months), combining theory with challenging, hands-on projects that encourage creativity and problem-solving.

Objectives:

- Gain an in-depth understanding of sensors, actuators, and communication protocols.
- Learn advanced robotics programming techniques.
- Develop autonomous and intelligent robotic systems.
- Explore artificial intelligence and machine learning applications in robotics.

Week 1: Review of Basic Robotics and Arduino

- **Topics Covered:**
  - Recap of key concepts: Arduino programming, motor control, sensors.
  - Discuss course objectives and expectations.
- **Activities:**

- Troubleshoot common issues in robotics.
- Build and present a simple project to demonstrate understanding of basic concepts.

Week 2: Advanced Programming with Arduino

- **Topics Covered:**
  - Functions, arrays, pointers, and data structures in Arduino.
  - Interrupts and timers for efficient task management.
- **Activities:**
  - Use interrupts to handle multiple tasks simultaneously (e.g., control motors while reading sensors).
  - Create a multi-tasking robot using timers and interrupts.

Week 3: Introduction to Microcontrollers and SBCs (Beyond Arduino)

- **Topics Covered:**
  - Overview of advanced microcontrollers (ESP32, STM32) and single-board computers (Raspberry Pi).
  - Differences between microcontrollers and SBCs.
- **Activities:**
  - Set up and program an ESP32 or STM32 for basic tasks.
  - Implement Wi-Fi control for a robot using ESP32.

Week 4: Communication Protocols (I2C, SPI, UART)

- **Topics Covered:**
  - Introduction to I2C, SPI, and UART communication protocols.
  - How to use these protocols to interface with sensors and actuators.
- **Activities:**
  - Connect multiple sensors (e.g., IMU, accelerometers) to Arduino using I2C.
  - Implement communication between two Arduinos using UART.

Week 5: Advanced Sensor Integration (IMU, GPS, and More)

- **Topics Covered:**
  - Introduction to advanced sensors: IMU (Inertial Measurement Unit), GPS, magnetometer.
  - Understanding sensor fusion for accurate motion tracking.
- **Activities:**
  - Interface an IMU with Arduino to measure orientation (roll, pitch, yaw).
  - Integrate a GPS module to track the robot's location.

Week 6: Introduction to ROS (Robot Operating System)

- **Topics Covered:**

- Understanding the Robot Operating System (ROS) and its architecture.
- Installing and setting up ROS on a Raspberry Pi or Linux environment.

- **Activities:**
  - Set up ROS on a Raspberry Pi.
  - Write simple ROS nodes to control a robot's movement and sensor data.

Week 7: Computer Vision with OpenCV

- **Topics Covered:**
  - Introduction to computer vision and OpenCV.
  - Basics of image processing (thresholding, edge detection).
- **Activities:**
  - Set up OpenCV on a Raspberry Pi.
  - Program a robot to detect and follow objects using a camera.

Week 8: Machine Learning for Robotics

- **Topics Covered:**
  - Introduction to machine learning concepts: supervised learning, neural networks.
  - Applications of machine learning in robotics (object recognition, path planning).

- **Activities:**
    - Train a simple machine learning model to recognize objects or gestures.
    - Use the model to make the robot respond to recognized objects.

Week 9: Autonomous Navigation with SLAM (Simultaneous Localization and Mapping)

- **Topics Covered:**
    - Introduction to SLAM and its importance in autonomous robotics.
    - Overview of algorithms like EKF (Extended Kalman Filter) and Particle Filters.
- **Activities:**
    - Implement basic SLAM using ROS and a lidar or ultrasonic sensor.
    - Program the robot to navigate autonomously in a mapped environment.

Week 10: Path Planning Algorithms

- **Topics Covered:**
    - Introduction to path planning algorithms (A*, Dijkstra, RRT).
    - Collision avoidance and obstacle detection.
- **Activities:**

- Implement A* or Dijkstra's algorithm to make the robot find the shortest path between two points.
- Program the robot to avoid obstacles while navigating a maze.

Week 11: Wireless Communication and Control (Bluetooth, Wi-Fi, XBee)

- **Topics Covered:**
  - Overview of wireless communication methods for robotics.
  - Setting up Bluetooth and Wi-Fi modules for remote robot control.
- **Activities:**
  - Control a robot remotely using a smartphone app and Bluetooth.
  - Implement Wi-Fi communication to control the robot over the internet.

Week 12: Advanced Actuators and Robot Arms

- **Topics Covered:**
  - Introduction to robotic arms and advanced actuators (servo motors, stepper motors).
  - Kinematics and inverse kinematics for robotic arms.
- **Activities:**
  - Build and program a 2-DOF (Degrees of Freedom) robotic arm.
  - Implement inverse kinematics to control the arm's movement based on end-effector positions.

Week 13: Swarm Robotics

- **Topics Covered:**
  - Introduction to swarm robotics and its applications.
  - Basic algorithms for coordinating multiple robots (flocking, foraging).
- **Activities:**
  - Program a group of robots to work together to complete a task.
  - Implement simple swarm behaviors (e.g., robots following each other in formation).

Week 14: Artificial Intelligence in Robotics

- **Topics Covered:**
  - Deep learning concepts and applications in robotics.
  - How AI can improve robot decision-making and autonomy.
- **Activities:**
  - Integrate a neural network for decision-making in a robot.
  - Develop a robot that learns to navigate a course using reinforcement learning.

Week 15: Project Development and Prototyping

- **Topics Covered:**
  - Tips on developing and prototyping advanced robotics projects.

- Project management and testing techniques for robotics systems.

- **Activities:**
  - Start working on the final project: Students choose a project idea that incorporates advanced robotics techniques (e.g., an autonomous drone, AI-based robot).
  - Plan the project, break down tasks, and begin prototyping.

Week 16: Final Project Presentation

- **Activities:**
  - Complete the final project, applying all the skills learned during the course.
  - Present the final project to the class, explaining the design, code, challenges, and solutions.

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