TorqueByte – Open Source Swarm Robotics

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# 🚀 Project Overview

TorqueByte is an open-source swarm robotics initiative built using ESP32 microcontrollers to demonstrate autonomous coordination among multiple robots.

## 🔹 Objectives & Goals

- Develop a scalable swarm robotics system using IoT-enabled ESP32 controllers.

- Integrate AI-powered decision-making for adaptive behavior.

- Build an interactive online platform for community contributions.

## 🔹 Key Features & Innovations

✔️ Swarm Coordination: Robots communicate autonomously.

✔️ Machine Learning Integration: AI-driven obstacle avoidance.

✔️ IoT Connectivity: ESP32 handles real-time data exchange.

✔️ 3D Model Viewer: Web-based interactive visualization.

# 🛠️ Hardware Specifications

TorqueByte utilizes ESP32, motors, sensors, and communication protocols to enable swarm intelligence.

## 🔹 Components List

ESP32 microcontrollers – Handles AI and networking.

DC Motors & Motor Drivers – Enables movement and navigation.

Ultrasonic & Infrared Sensors – Detects obstacles dynamically.

Li-Ion Battery Packs – Powers the robots efficiently.

## 🔹 Wiring Diagram

📌 (coming soon)

## 🔹 Assembly Instructions

✅ Connect ESP32 to motor drivers using PWM signals.

✅ Attach sensors to ESP32 GPIO pins for obstacle detection.

✅ Configure Wi-Fi for swarm communication using MQTT protocol.

# 💻 Software Architecture

TorqueByte employs IoT connectivity & AI-enhanced swarm coordination to automate tasks.

## 🔹 ESP32 Firmware & Code Structure

MQTT Protocol – Robots exchange data wirelessly.

PID Motion Control – Ensures precise movement.

Autonomous Navigation Algorithm – Adaptive pathfinding.

## 🔹 IoT Connectivity & Data Management

Robots publish & subscribe to MQTT topics for real-time updates.

Each unit can dynamically adjust its role within the swarm.

# 🧠 Machine Learning Integration

TorqueByte utilizes AI algorithms to improve autonomy, obstacle detection, and swarm coordination.

## 🔹 AI-Powered Swarm Intelligence

✔️ Obstacle Avoidance: ML models trained for real-time navigation.

✔️ Gesture & Voice Recognition: AI-driven control inputs.

✔️ Predictive Maintenance: Sensors track hardware degradation.

✔️ Task Allocation: Smart load distribution using neural networks.

## 🔹 ML Technologies Used

📌 TensorFlow Lite for lightweight AI inference on ESP32.

📌 OpenCV for vision-based gesture recognition.

📌 TinyML for embedded machine learning processing.

# 🌐 Web & 3D Model Features

The TorqueByte website provides open-source documentation and an interactive 3D visualization.

## 🔹 Website Features

✅ Documentation Hub – Guides on assembly and programming.

✅ ESP32 Code Repository – GitHub-hosted scripts.

✅ Video Series – Showcasing TorqueByte development.

✅ Interactive 3D Model Viewer – Users can manipulate the robot in-browser.

## 🔹 3D Model Integration (Three.js)

✔️ Zoom, Rotate & Pan – Users interact with the model dynamically.

✔️ Optimized Rendering – GLTF-based lightweight visuals.

# 🔮 Future Upgrades & Community Contributions

TorqueByte aims to expand its capabilities by integrating advanced AI & swarm robotics innovations.

## 🔹 Planned Features

AI-Powered Object Tracking using CNN models.

Enhanced Swarm Coordination via reinforcement learning.

Open API for developers to integrate custom automation behaviors.