Cyber-Physical Systems of Industrial Robot Arm and Embedded Controller

CONTROL SYSTEMS AND INSTRUMENTATION ENGINEERING PROGRAM

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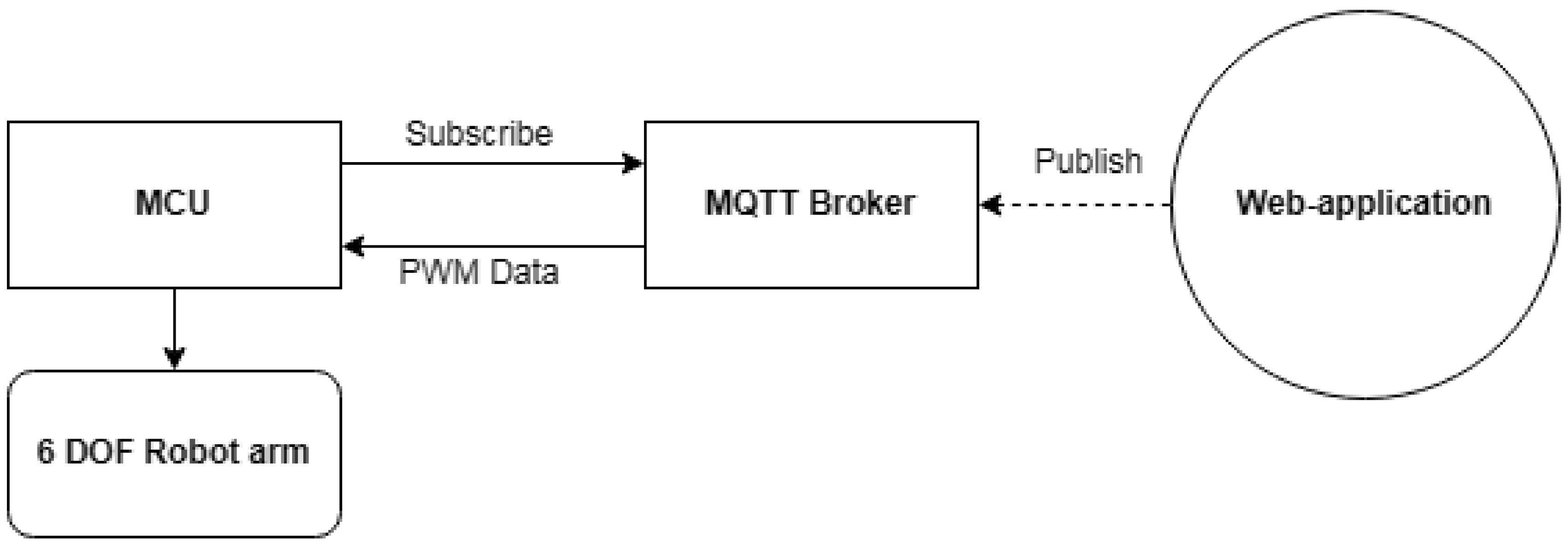
Objectives

The objective of this project is to design and develop a comprehensive cyber-physical system (CPS) that includes software running on the server side (back-end), embedded firmware for CPS-supported control and monitoring, a robot arm simulation system and control system, and a front-end application for monitoring and control.

Introduction

Embedded systems are specialized computer systems integrated into larger mechanical or electrical systems, designed to manage specific tasks using microcontrollers or microprocessors. They are essential in cyber-physical systems (CPS) that blend digital and physical elements to enhance automation, real-time monitoring, and system performance. This project aims to develop a platform that combines data analytics with CPS for improved interaction and real-time data visualization in various industries.

System Overview



The MQTT broker is used to efficiently manage message distribution and state synchronization across the network, enabling real-time control and monitoring of IoT devices. The system features a dynamic web application for 3D visualization, allowing users to interactively control and visualize components in real time.

Methodology

Our application integrates real-time 3D visualization, interactive controls, and IoT communication within a web-based interface to create a simulation environment. It utilizes MQTT for seamless data transmission, handling communication through a robust MQTT broker server that manages messaging between the web application and IoT devices. The system is accessed via a network server provided by a mobile hotspot, ensuring connectivity for all components. This setup includes a possible web server for serving static content and handling API requests, enhancing interaction capabilities. The application controls and monitors the servo motors through user-operated sliders. The 3D scene using WebGL dynamically renders models such as a robotic arm that can be manipulated in real-time, reflecting changes from user inputs and physical simulations.

Results

The deployment of our cyber-physical system has significantly enhanced real-time monitoring and control across various industries. Key achievements include the implementation of inverse kinematic control methods for precise manipulation of the robotic arm, leading to enhanced operational efficiency and precision. Seamless integration of hardware and software optimizes user engagement and accuracy in response. Real-time 3D visualization and interactive controls further enhance the user experience. Reliable data transmission via MQTT ensures efficient communication between IoT devices, bolstering decision-making and automation capabilities.

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