

ABSTRAK

Nama : Andhika Ardianto (140 2022 008);
Muhammad Isa Agiya Ashari (140 2022 042);
Bernando Idayah (140 2022 012)
Program Studi : Sarjana Teknik Informatika
Judul : Simulasi Real-Time Digital Twin untuk Ruang Operasi

Penelitian ini membahas pengembangan sistem Simulasi Real-Time Digital Twin untuk ruang operasi berbasis integrasi Internet of Things (IoT) dan visualisasi tiga dimensi menggunakan Unity 3D. Sistem dikembangkan sebagai media pembelajaran interaktif yang mampu merepresentasikan hubungan antara prototipe miniatur fisik dengan simulasi digital secara waktu nyata (real-time).

Sistem menggunakan mikrokontroler ESP32 sebagai pengendali utama yang terhubung dengan beberapa sensor lingkungan, yaitu BME280 Environmental Sensor Module untuk membaca suhu dan kelembapan, LDR GL5528 Light Sensor Module untuk mendeteksi intensitas cahaya, serta PIR HC-SR501 Motion Sensor untuk mendeteksi pergerakan di dalam ruangan. Data sensor dikirim menggunakan protokol MQTT dan divisualisasikan pada aplikasi Unity 3D dalam bentuk Digital Twin.

Sistem memiliki tiga kondisi utama status ruang operasi, yaitu Idle, Preparation, dan In-Use. Pada kondisi Idle, seluruh sensor dan perangkat berada dalam kondisi tidak aktif. Pada kondisi Preparation, sensor cahaya dan sistem pencahayaan aktif, sedangkan cooling fan berada dalam kondisi standby. Pada kondisi In-Use, seluruh sensor aktif dan cooling fan bekerja menyesuaikan kondisi suhu ruangan. Sistem juga dilengkapi mekanisme perubahan status otomatis berbasis sensor gerak untuk meningkatkan efisiensi energi dan mengurangi ketergantungan terhadap pengaturan manual pengguna.

Hasil penelitian menunjukkan bahwa sistem mampu menampilkan kondisi lingkungan ruang operasi secara dinamis dan interaktif melalui integrasi antara sistem fisik dan sistem digital. Penelitian ini diharapkan dapat menjadi penelitian tahap awal (preliminary study) dalam pengembangan sistem simulasi Digital Twin ruang operasi yang lebih kompleks pada penelitian selanjutnya.

Kata kunci: Digital Twin, Internet of Things, Unity 3D, ESP32, MQTT, ruang operasi.

ABSTRACT

*Name : Andhika Ardianto (140 2022 008);
Muhammad Isa Agiya Ashari (140 2022 042);
Bernando Idayah (140 2022 012)
Study Program : Bachelor of Informatics Engineering
Title : Real-Time Digital Twin Simulation for Operating Room*

This research discusses the development of a Real-Time Digital Twin simulation system for operating rooms based on the integration of Internet of Things (IoT) technology and three-dimensional visualization using Unity 3D. The system was developed as an interactive learning medium capable of representing the relationship between a physical miniature prototype and a digital simulation in real time.

The system uses an ESP32 microcontroller as the main controller connected to several environmental sensors, namely the BME280 Environmental Sensor Module for temperature and humidity monitoring, the LDR GL5528 Light Sensor Module for light intensity detection, and the PIR HC-SR501 Motion Sensor for movement detection inside the room. Sensor data are transmitted using the MQTT protocol and visualized in the Unity 3D application as a Digital Twin representation.

The system consists of three main operating room statuses: Idle, Preparation, and In-Use. In the Idle condition, all sensors and devices are inactive. In the Preparation condition, the light sensor and lighting system are active, while the cooling fan remains in standby mode. In the In-Use condition, all sensors are active and the cooling fan operates according to room temperature conditions. The system is also equipped with an automatic status transition mechanism based on motion detection to improve energy efficiency and reduce dependence on manual user control.

The results show that the system is capable of dynamically and interactively visualizing operating room environmental conditions through the integration of physical and digital systems. This research is expected to serve as a preliminary study for the development of more complex Digital Twin operating room simulation systems in future research.

Keywords: *Digital Twin, Internet of Things, Unity 3D, ESP32, MQTT, operating room.*