*Production Line Augmented Reality Application*

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*Abstract*—This project aims to create a Digital Twin (DT) of carts in a production line, provide monitoring services and bridge the gap between industrial operations and educational training through an accessible, immersive augmented reality experience.

Keywords—digital twin, augmented reality, industrial internet of things, requirements engineering

# Introduction

This paper presents an engineering approach to enhancing the transparency and educational accessibility of the production line system through Augmented Reality (AR) integrated with Industrial Internet of Things (IIoT) sensor-driven technologies. In modern industrial and educational settings, understanding and visualizing production line operations can be a complex task. Traditional monitoring systems often rely on static dashboards and abstract representations, limiting comprehension—especially for students and trainees unfamiliar with the underlying processes.

This gap is particularly pronounced in engineering education, where hands-on experience and real-time feedback are critical for understanding system behavior and production dynamics. Furthermore, as sensor-driven data becomes increasingly prevalent with the advent of IIoT, there remains a challenge in presenting such data in an intuitive and meaningful format.

# Ease of Use

* 1. *User-Friendly Interface and Accessibility*

## One of the primary goals in developing the AR-based production line monitoring application was to ensure ease of use for both educational and industrial users.

Users with Android OS can simply point their mobile device to place the production line and see a DT in real-time visualizations. These include 3D presentation of cart positions, speed indicators, status notifications, and multimedia content such as instructional description, images and quiz.

Navigation within the app is straightforward, with clear visual cues and tap-based interactions. All elements were tested with target users to ensure clarity, responsiveness, and ease of interaction. Furthermore, the system's backend server handles sensor data processing, removing technical complexity from the user’s side and delivering real-time updates seamlessly.

## Educational Integration

The AR application is enhanced for an educational environment. Lecturers can use it as a teaching tool to walk students through the production stage in real-time, while students can explore independently without needing specialized equipment or system knowledge. The use of everyday mobile devices eliminates hardware barriers and facilitates broad accessibility.

# Functional Requirements

The AR application is designed to provide real-time visualization and interaction with a simulated production line. The following functional requirements define the core behaviors and features of the system.

## AR Visualization

The system must render 3D models of carts and production station images within an augmented environment. Carts move dynamically along predefined waypoints, reflecting their real-world locations based on sensor data. These visualizations offer users an intuitive understanding of the flow and operation of the production line.

## Production Line Representation

## Users can interact with individual stations by tapping on their 3D representations in the AR interface. Upon selection, descriptive text, images, and quiz ill be displayed, enhancing user comprehension. Additionally, each cart displays its current speed (in meters per second) above its model in real time, providing users with immediate visual feedback on system activity.

## Tracking Logic

Each cart is uniquely identified by an ID and is tracked as it moves along the production line. The system calculates a predicted arrival time for each cart at its next designated station using its current speed and path data. If a cart does not arrive at a station within the expected time window, an alert is generated and displayed in the AR interface, indicating a potential delay or system issue.

# Non-Functional Requirements

In addition to its core functionality, the system must meet several non-functional requirements to ensure reliability, usability, and performance under real-world conditions.

## Capacity and Compatibility

The application must support all four existing stations in the production line, including the ability to display associated station descriptions, media, and sensor data. The system is designed for mobile deployment and requires Android 14 (API Level 34) or higher to ensure compatibility with the latest AR and sensor integration libraries.

## Reliability and Fault Tolerance

The application must operate continuously without crashing for a minimum of 30 minutes under full system load, including real-time AR rendering, data synchronization, and user interaction. In the event of a temporary loss of server connectivity, the system must handle the disconnection gracefully and automatically attempt to reconnect without data loss or application failure.

## Usability

The user interface is optimized for touchscreen devices, offering an intuitive and responsive interaction model. Users should be able to engage with the AR environment, select stations, and retrieve relevant information with minimal effort or instruction.

## Sensor Update Performance

The QR-Code sensor must transmit updates every 100 milliseconds upon changes in station occupancy, ensuring accurate tracking of cart movements. The IMU sensor calculates cart speed data that is collected and updated every 10 milliseconds to maintain synchronization with real-time cart behavior.

## Prediction Accuracy

The application must predict the arrival time of each cart at its next station with an accuracy margin of ±0.5 seconds. This predictive capability enhances the system’s value for both real-time monitoring and anomaly detection.

1. AR Application Protype . (*DTs of carts*)
2. Production Line (At Lab D106)

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