*Production Line Augmented Reality Application*

# Context

Augmented Reality (AR) is increasingly integral for enhancing industrial operations and educational training across various sectors, including manufacturing, engineering education, and digital twin systems [1]. As such, stakeholders such as system developers, educators, industrial operators, and students necessitate varying levels of interaction and visualization capabilities for production line systems to enhance their understanding, trust, and operational effectiveness. The growing reliance on AR as a bridge between physical and digital environments in these critical areas underscores the need for AR systems to be accessible, comprehensible to their users, ensuring their use is safe, educational, and operationally effective [2].

# Background

The AR application is designed to provide real-time visualization and interaction with a simulated production line, installed in an educational lab in an engineering college (See Fig.1):

***Fig 1****. The production line*

## 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.

## 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.

# RELATED WORK

Industry 4.0 guidelines stress transparency, advocating for intuitive AR processes for all stakeholders [3]. However, challenges persist in stakeholder-specific AR design, notably the lack of accepted interaction paradigms and varied user requirements [5]. Educationally, AR is essential for effective learning and knowledge transfer [7]. From an industrial perspective, comprehensible visualizations build operational trust crucial for AR adoption [4]. For engineers, stakeholder-aware design aids system optimization across diverse scenarios [3]. There’s an overarching need for unified AR effectiveness metrics [6] and research on stakeholder requirements in ethical AR design. These gaps underscore the necessity for interdisciplinary collaboration to foster AR systems that are technically advanced, educationally sound, and widely accepted.

IV**.** METHODOLOGY

We aim to identify key stakeholders that necessitate tailored AR production line systems, interpretation of system requirements from their perspective, functionality requirements for AR systems, and measurement techniques or metrics for measuring effectiveness in a quantitative manner, addressing the following research questions:

* **RQ1** Which key stakeholders necessitate tailored AR production line systems for successful implementation and operation of these systems?
* **RQ2** What are functionality requirements for AR production line systems from the key stakeholders' perspective?
* **RQ3** What are the key indicators of successful AR implementation from stakeholders' perspective, and how can these be measured?

We performed an exploratory study to address RQ1 and RQ2. To identify key stakeholders and their requirements for AR functionality, we performed a literature review combined with prototype development and testing, yielding several results [1][2][3][7]. From the examined studies and prototype development, we identified the key stakeholders and functionality requirements for AR systems from those stakeholders' perspective (See Table 1):

**Table I. System requirements**

|  |  |  |  |
| --- | --- | --- | --- |
| **Stakeholder** | **Requirement Category** | **Description** | **Ref** |
| Students/  Trainees | Understanding and Learning | Clear visualization of production processes with interactive 3D models and real-time cart tracking | [7] |
| Accessibility and Engagement | Touch-based interactions with minimal technical complexity requiring only Android devices | [3] |
| Educational Content Integration | Interactive stations with descriptive text images and quiz functionality for enhanced learning | [7] |
| Educators/Instructors | Teaching Tool Integration | Ability to guide students through production stages in real-time | [7] |
| Assessment Capabilities | Built-in quiz functionality and interactive elements for student evaluation | [7] |
| Classroom Accessibility | Support for multiple concurrent users with standard mobile devices | [3] |
| Industrial Operators | Monitoring and Control | Real-time visualization of cart positions speeds and production line status | [4] |
| Alert and Anomaly Detection | Predictive arrival time calculations with ֲ±0.5 second accuracy and alert generation for delays | [4] |
| System Reliability | Continuous operation for minimum 30 minutes under full load with fault tolerance capabilities | [5] |
| Performance Optimization | Sensor updates every 100ms for QR-Code tracking and 10ms for IMU speed calculations | [4] |
| Monitoring and Control | Real-time visualization of cart positions speeds and production line status | [4] |

In the future, we will conduct an interview study and a broader survey to evaluate the results of the literature review and gather broader insights from practitioners in both industrial and educational settings.

V. PRELIMINARY RESULTS AND CONTRIBUTION

Key stakeholders who necessitate tailored AR production line systems: Our research identified three critical stakeholders: a. Students/Trainees, b. Educators/Instructors, and c. Industrial Operators.Students require intuitive interaction and clear educational content [7]; Educators need comprehensive teaching tools and assessment capabilities [7]; Industrial operators require reliable monitoring and real-time system feedback [4]. The AR application addresses diverse stakeholder needs through educational accessibility, technical complexity, and industrial reliability necessitate a holistic approach that includes adaptable, modular AR components to accommodate diverse stakeholder needs while maintaining system performance and educational value [5][6] (See Fig.2):

* A screenshot of a computer

  AI-generated content may be incorrect.

***Fig 2****. The AR solution prototype*

**VI. CONCLUSION**

##### We identified key stakeholders who necessitate tailored AR production line systems for successful development and operation in educational and industrial contexts. We defined functionality requirements from stakeholders' perspectives and partially identified effectiveness metrics.Currently, we are synthesizing data from literature review and prototype testing. We intend to evaluate results and gather more information from educational institutions and industrial partners using interviews and surveys to validate our stakeholder-centric approach.

##### References

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ANNEX: DEMO TOOL

We will present an interactive demonstration tool at the RE25 conference that showcases the AI-driven irrigation system's stakeholder-centric features:

**A. Live AI Recommendation Engine**

**Real-time Prediction Interface**: Attendees can input different environmental parameters (soil moisture, temperature, weather conditions) and observe how the AI generates irrigation recommendations with explanations

**Stakeholder View Toggle**: Switch between farmer-friendly explanations, educator-focused technical details, and engineer-level model parameters

**Confidence Scoring**: Visual display of AI recommendation confidence levels with reasoning transparency

**B. Interactive Stakeholder Requirements Explorer**

**Requirements Mapping Tool**: Navigate through the stakeholder requirements table with clickable elements showing how each requirement translates to system features

**Use Case Scenarios**: Pre-loaded scenarios demonstrating different stakeholder interactions with the AI system

**Explainability Showcase**: Examples of how AI decisions are presented differently to farmers vs. educators vs. engineers

**C. Mobile AR Prototype Preview**

**Sensor Data Visualization**: Live demonstration of mobile interface showing simulated sensor readings and AI-powered irrigation alerts

Link to visualization demo: https://bit.ly/405ecMW

**Educational Module Demo**: Interactive quiz functionality and learning components designed for product line education

Link to quiz demo: https://bit.ly/4n0aHBf

**Alert System Simulation**: Real-time demonstration of AI-generated alerts with stakeholder-specific explanations

**D. System Architecture Walkthrough**

**Interactive System Diagram**: Clickable architecture showing data flow from sensors through AI processing to stakeholder interfaces

**AI Pipeline Visualization**: Step-by-step demonstration of how machine learning models process agricultural data and generate recommendations

**Stakeholder Journey Maps**: Visual representation of how different users interact with and benefit from the AI-driven irrigation system

The demo tool will be available on tablets/laptops at the poster session.