

# Industry 4.0 assembly line using mixed reality and data lake systems.

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**Abstract:** This article presents an Industry 4.0 assembly line that employs mixed reality (MR) and data lake systems to optimize the assembly process. MR devices such as HoloLens are used to provide operators with real-time assistance. The data generated by the MR devices is stored in a data lake system, which allows for real-time monitoring of the assembly process. This case study demonstrates the potential for MR and data lake systems to revolutionize traditional manufacturing processes and improve productivity and quality in Industry 4.0.

**Keywords:** ASSEMBLY PROCESS, MIXED-REALITY, DATA LAKE, BEARING, INDUSTRY 4.0,

## 1. Introduction

The assembly line discussed in this study comprises eight stations, which include both assembly stations and quality control stations. The goal is to leverage the power of cutting-edge technologies to streamline and optimize the production process, ensuring precise assembly and thorough quality control measures. By incorporating data lake systems and mixed reality goggles, manufacturers can unlock new possibilities for increased efficiency, reduced errors, and improved overall productivity.

Data lake systems, characterized by their ability to store vast volumes of structured and unstructured data, offer significant advantages in managing the diverse data generated by assembly line processes. With the integration of sensors, Internet of Things (IoT) devices, and other data collection mechanisms, real-time data can be collected, stored, and processed in the data lake. This facilitates data-driven decision-making, predictive maintenance, and proactive troubleshooting, enabling manufacturers to address potential issues before they escalate into major disruptions. [1-3]

This paper aims to explore the benefits and challenges associated with implementing data lake systems and mixed reality goggles in an Industry 4.0 assembly line. It investigates how these technologies can enhance the bearing assembly process by improving efficiency, accuracy, and quality control. Additionally, the study examines the potential barriers and considerations for successful adoption, including data privacy and security, infrastructure requirements, and training needs.

## 2. Assembly process

The assembly process of the bearing with housing and bearing cap consists of eight stations, where the product is systematically moved along the assembly line. The initial four stations utilize a conveyor system to transport the product, while the subsequent stations incorporate Cartesian manipulators, vision quality control, and operator intervention to ensure a seamless and high-quality assembly.

Station One: In this station, an operator places the housing of the bearing onto the conveyor. To identify the specific product for the assembly line, an RFID system is employed, allowing for accurate tracking and traceability.



Fig. 1 Assembly line.

Station Two: A Cartesian manipulator operates in this station, precisely inserting the bearing into the housing. The manipulator's controlled movements ensure proper alignment and fit between the bearing and the housing.

Station Three: Another Cartesian manipulator (Fig. 1) takes charge in this station, positioning the bearing cap onto the housing. The manipulator's precise movements guarantee a secure and accurate placement of the bearing cap.



Fig. 2 Third station. Bearing cap is positioned on housing.

Station Four: In this station, the bearing cap is securely screwed onto the housing. The assembly line incorporates a screwing mechanism to ensure consistent and reliable attachment, enhancing the overall integrity of the assembly.

Station Five: The assembly line reaches the station where vision quality control is implemented. Advanced vision systems perform a comprehensive visual inspection of the assembled product. Any flaws or defects detected are promptly recorded and sent to a database for further analysis and corrective actions.

Station Six: The product is transported from the fifth station to the sixth station using a Cartesian robot. This robot ensures a smooth and precise transfer of the product, maintaining the workflow along the assembly line.

Station Seven: If any flaws or defects are identified during the quality control inspection, the assembly line stops at this station. Skilled operators stationed here correct the detected issues or, if necessary, disassemble the bearing assembly for proper corrective measures.

Station Eight: In the final station, an industrial robot takes over to move the completed product to the repository field. This robot handles the transfer of the assembled product efficiently, ensuring smooth logistics and storage operations.

## 3. Management system

In the context of managing data generated in an assembly line, a data lake system proves to be an invaluable and comprehensive tool. Its utilization in this specific scenario is of utmost significance as it takes on a crucial role in effectively handling a multitude of aspects inherent to the assembly process.[4]

In the assembly line system, every product is associated with its own unique data packet, which serves as a comprehensive repository of information. This data packet contains essential details about the product, including the specific components that have been selected for assembly. The components typically include four screws, a bearing, a bearing cap, and a bearing housing, which are vital for the product's functionality and structure.

Additionally, the data packet includes an identification (ID) number assigned to each product, enabling efficient tracking and traceability throughout the assembly process. This ID number serves as a unique identifier, ensuring that each product can be easily distinguished and monitored as it progresses along the assembly line.

Moreover, the data packet captures information about the current station where the product is located within the assembly line. This station information provides real-time visibility into the product's position and allows for effective management of the production flow. It ensures that each product moves through the designated stations in a sequential manner, facilitating a streamlined and organized assembly process.

Furthermore, the data packet includes a status attribute, providing insights into the product's current state. The status can indicate whether the product is "under assembly," signifying that it is currently being worked on by operators and undergoing the assembly process. Alternatively, the status can indicate if the product has been identified as "defective," requiring further inspection or rework. Finally, the status can indicate that the product is "ready," indicating that it has successfully completed the assembly process and is prepared for the next phase, such as quality control or packaging.

By encapsulating this vital information within each product's unique data packet, the assembly line system ensures efficient and accurate tracking, monitoring, and management of each individual product. This data-driven approach allows for improved quality control, enhanced productivity, and effective decision-making throughout the assembly line workflow.

One notable component integrated within the system is a mobile application that empowers users to effortlessly place orders and customize them according to their specific requirements. This feature offers a high degree of flexibility, allowing orderers to select from a range of options, such as choosing the desired elements from a selection that includes four screws, a bearing, a bearing cap, and a bearing housing. This level of customization enhances customer satisfaction and ensures the precise fulfillment of individual needs. Another

the mobile app to retrieve relevant information and submit orders, ensuring a smooth and efficient flow of data.

Within the data lake system, a robust and organized database serves as a centralized repository for all the data generated throughout the assembly line process. It efficiently stores and retrieves information related to orders, customization preferences, and assembly data. This comprehensive database ensures that all relevant data is readily available and accessible when needed, enabling swift retrieval and analysis to support decision-making processes and optimize overall operations.

Integral to the assembly line system are Programmable Logic Controllers (PLCs) that seamlessly interface with the data lake system. These controllers have direct access to the data stored in the database, enabling them to retrieve pertinent information about each order. As the product progresses through different stations along the assembly line, the PLC controllers can modify the status of an order, ensuring accurate tracking and monitoring of the product's journey.

In summary, the data lake system orchestrates seamless coordination between the mobile application, web API, database, and PLC controllers. This integration allows for real-time access to order information, customization options, and assembly data. The system enables efficient management and tracking of the assembly line process, empowering decision-makers with timely and accurate insights, optimizing resource allocation, and facilitating streamlined operations from order placement to final product delivery.

#### 4. Mixed-reality

Mixed reality is leveraged in the assembly line to introduce innovative and transformative capabilities that enhance various aspects of the manufacturing process. In this context, mixed reality technology plays a crucial role by enabling the creation of a digital twin of industrial robots and providing virtual Human Machine Interfaces (HMIs) for operators. Additionally, mixed reality offers the potential to conduct training sessions for workers, utilizing immersive and interactive experiences.

One notable application of mixed reality in the assembly line is the creation of a digital twin of industrial robot. A digital twin is a virtual representation of a physical robot that closely mimics its behavior, characteristics, and movements. By developing a digital twin using mixed reality, manufacturers gain the ability to simulate and test robot movements, sequences, and tasks in a virtual environment before executing them in the physical realm. This virtual prototyping helps optimize robot performance, reduce errors, and minimize downtime, ultimately improving overall productivity and efficiency.[5]

Mixed reality also enables the deployment of virtual Human Machine Interfaces (HMIs) in the assembly line. HMIs are graphical interfaces that allow operators to interact with machines and control systems. By utilizing mixed reality, HMIs can be visualized and accessed in an immersive and intuitive manner. Operators can view and interact with virtual control panels, indicators, and buttons overlaid onto the real-world environment. This augmented visualization enhances operator efficiency, reduces errors, and provides real-time access to critical information and controls, leading to improved overall operational performance.[6]

Moreover, mixed reality offers the opportunity to conduct training sessions for assembly line workers. Through immersive and interactive experiences, workers can receive virtual training in a simulated environment that replicates real-world assembly line scenarios. Mixed reality technology allows trainees to interact with virtual components, tools, and machinery, providing a safe and controlled learning environment. This immersive training approach helps to develop skills, improve efficiency, and ensure consistent quality standards across the workforce.

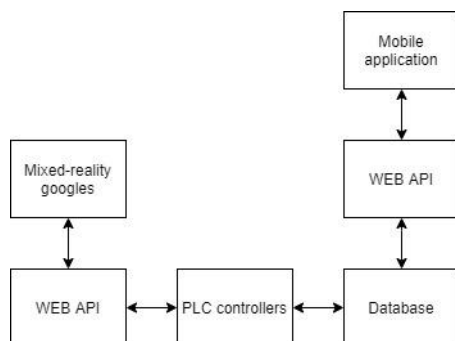


Fig. 3 Schematic diagram of the system

To enable seamless communication between the mobile application and the underlying data management system, the mobile app is connected to a web API. This connection serves as a vital conduit, facilitating the exchange of data between the application and the central database. The web API acts as a gateway, enabling

## 5. Summary

In summary, the integration of data lake systems and mixed reality goggles in an Industry 4.0 assembly line offers numerous benefits, including increased efficiency, reduced errors, improved quality control, and enhanced productivity. However, there are challenges to overcome, such as data privacy and security concerns, infrastructure requirements, and the need for proper training. By addressing these challenges, manufacturers can unlock the full potential of these technologies and optimize their assembly line operations.

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