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DIGITIZATION OF EVENT SYSTEMS IN AUGMENTED REALITY USING INTELLIGENT TECHNOLOGIES

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Abstract:

We are at the brink of the 4th Industrial Revolution, in the implementation period of new information technologies into production. One such available technology is the augmented reality in the manufacturing process. The aim of this paper is to design and implement a data monitor and control of electronic devices in the production process using augmented reality. The work will employ Industry 4.0 standards. Technologies such as cloud computing, augmented reality, web applications and industrial communication protocols will be used. The presented work briefly characterizes the current situation and trends in terms of building Industry 4.0 with a focus on monitoring and control of event systems using the latest digital technologies. It describes the basic concept and structure of the proposed solution and the implementation procedure for the selected case study.

Keywords:

Augmented reality, PLC, Unity, Manufacturing process, Industry 4.0 .

ACM Computing Classification System:

Information systems, Information systems applications, Process control systems.

Introduction

We are entering a new industrial era, with the 4th Industrial Revolution (Industry 4.0) many new information technologies are coming and their interconnections. Just as in previous industrial revolutions, the driving force was the use of steam, electricity, or automation, so today the Internet and the interconnection of devices play a major role. Thanks to higher performance and smaller hardware dimensions, we can create intelligent devices for various purposes. This makes it possible to capture various process data in production, thus creating a large amount of data. To process such a large amount of data, it is necessary to ensure a sufficient hardware system, which allows the use of cloud technologies that allow us to create a digital production environment.

The work will deal with the implementation of Industry 4.0 standards into mechatronic systems in the production process. To begin with, we will look at the history of industrial production up to the current state and trends in Industry 4.0. Next, we will deal with the Internet of Things, which means the connection of all devices, objects and people with the Internet. Another important technology of Industry 4.0 is Cloud computing, which uses the Internet to store and manage data on remote servers.

1 Industry 4.0

The current state of the industrial revolution, the fourth level, is carried in the context of the term "Industry 4.0", which is already cooperating with the latest technological innovations. We were able to meet this deadline already in 2011 in Germany, when it was used in connection with changes in the field of information technology automation [1, 2].

The concept of **Industry 4.0** can also be seen as a milestone in three aspects such as smart plant, smart logistics and smart manufacturing. The smart plant is developed from a digital factory and is a key component for smart infrastructure in the future. It emphasizes the overall layout of the factory where we include production processes, systems and network distribution. (Fig.1) represents the integration itself between the mentioned aspects. Smart production is primarily related to logistics and its management. It connects with human-machine interactions (HMI) or applications of 3D / 4D technologies used in industrial processes. Smart Manufacturing cooperates through the use of the efficiency of logistics resources by supply and demand, in order to obtain services corresponding to logistics support. All three aspects are independent of each other, but together they form a coordinated production system Industry 4.0 [1, 2].

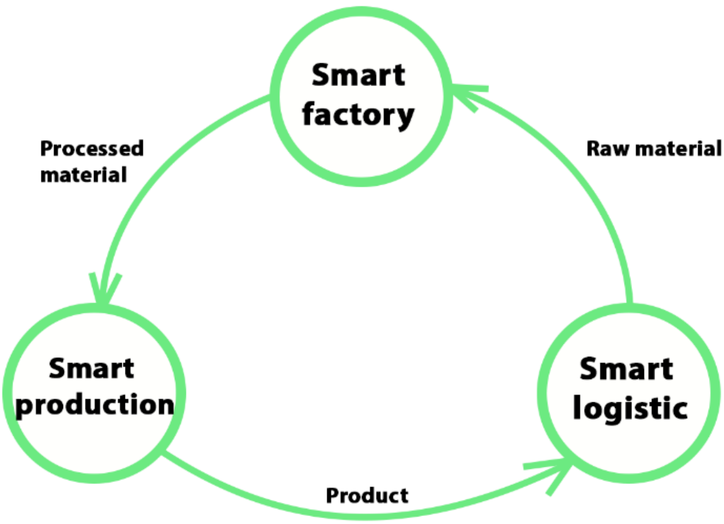

Fig.1. Key aspects of Industry 4.0 .

One of the key features of Industry 4.0 is the use of **cloud computing**. It is a technology that uses the Internet to store and manage data on remote servers. This technology provides access to data via an Internet connection [3].

The Internet of Things (**IoT**) is another key feature of Industry 4.0. It can be defined as the interconnection of computing devices, digital or mechanical machines, people, animals and objects equipped with certain identifiers (UIDs), which have a unique ability to transfer data without the need for human interaction [4].

2 Modern Technologies in Production

The work deals with the implementation of several elements of the new industrial revolution Industry 4.0 in the production process. This implementation consists of several steps using different technologies. Therefore, in this chapter we will describe the individual technologies that will be used in our design for the selected case study.

PLC devices

The basic building blocks of the new industrial revolution are PLC devices. These PLC devices are used to automate production lines and machines, collect data and then send it to HMI panels and the main computer. They can receive data that can be used to control the production line remotely [5].

Visualization systems

Visualization systems are responsible for consistent data display. All data must be sufficiently visible in compliance with ergonomic rules and psychological requirements. This means that the work environment in which the data is displayed must be configured and customized to the user. We implement visualization systems through SCADA applications. SCADA applications are adapted for data collection and control of the whole object from one monitoring point [6].

3D engines

Recently, augmented reality has also been used for data visualization, where game engines are entering the scene, which are constantly improving. There are countless game engines on the market. Two major competitors, Unity and Unreal Engine, are considered to be among the most widespread. Both game engines have been around for a long time as video game development platforms, which has added support for augmented reality game development. With the advent of augmented reality in the industry, these game engines also began to be used for data visualization in the industrial environment [7].

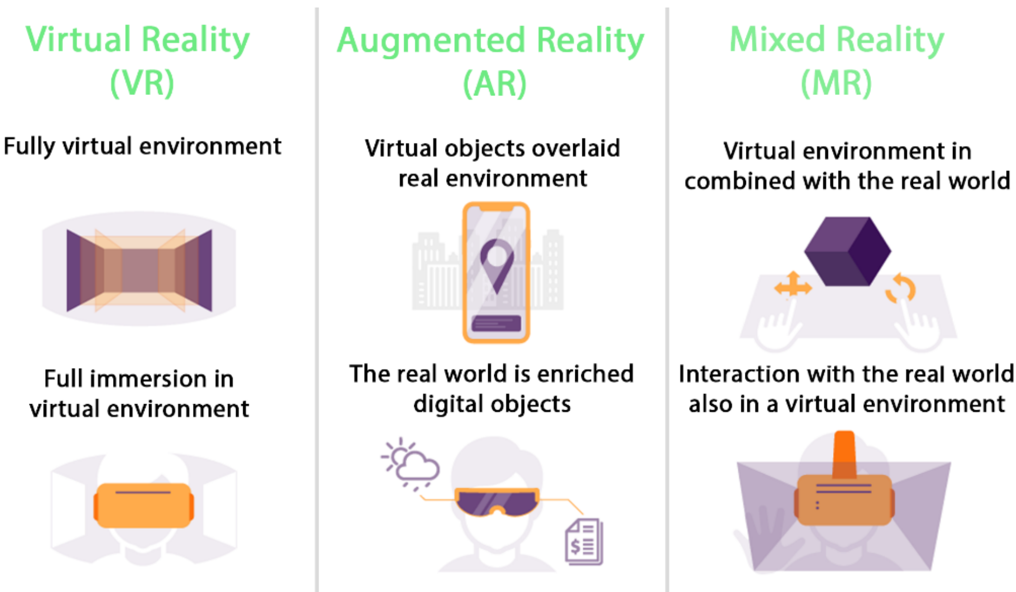

Fig.2. Comparison of VR, AR and MR.

Augmented reality XR

XR is further divided into 3 types of real estate: mixed reality MR, augmented reality AR and virtual reality VR. We could easily present a comparison of individual computer-generated properties on an example in which the user opens the door.

In virtual reality, the user would see virtual doors in the computer generated reality that he could open. In augmented reality, the user would see doors from the physical world that would wear "door" in computer-generated reality.

In a mixed reality, the user would see a physical door that would have a virtual button next to it. In contrast to augmented reality, the difference would be that when the button was pressed, a signal would be sent to the engine on the door and the physical door would open. In addition, mixed reality has interactivity with the physical world [8].

Cloud platforms

The term cloud platform refers to a package of applications, services, hardware, and the operating system of a server in an Internet data center. The cloud platform allows organizations to create, manage, test and back up products, as well as offer data analysis or video and audio streaming. In recent years, we have seen increased interest in cloud platforms and an increase in their use. Due to the high interest, many cloud platforms have emerged, of which we list the 3 largest and most used [9]:

- Amazon AWS
- Microsoft Azure
- Google cloud
- Technology frontend

Frontend development is the area of web application development that focuses on what users see on the screen. It involves the transformation of the code received from the backend (server) into a graphical interface. Like all technologies, frontend technologies are advancing and no longer require only knowledge of HTML, CSS and Javascript languages. Gradually, front-end frameworks began to grow, with their own programming languages becoming popular. Today, we already know a large number of frameworks that are used to create web applications [10].

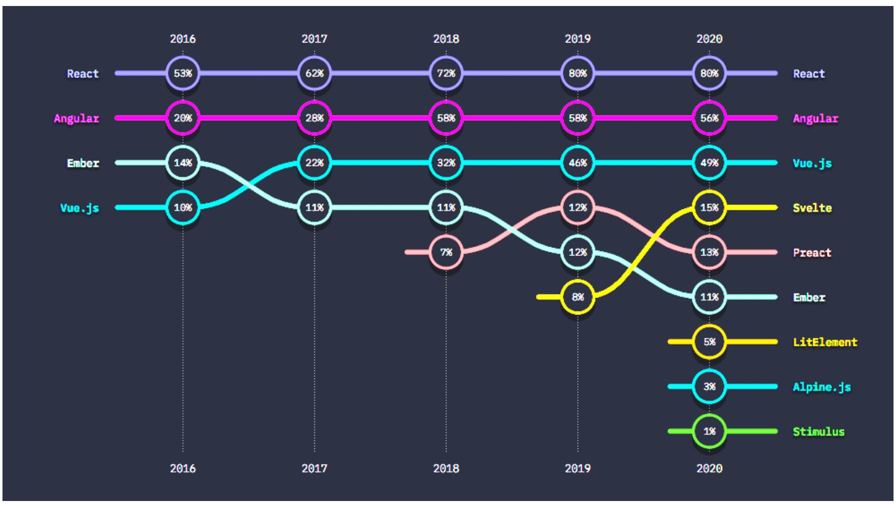

Fig.3. Frontend framework popularity chart [10].

3 Current State Analysis

We focused mainly on the results and the current state in the field of augmented reality and communication links between smart devices. We focus on the results devoted to the monitoring and control of mechatronic systems using computer-generated reality.

An important part of the analysis is to examine the possibilities of using communication technologies between smart devices, a local server and a cloud server. Thanks to this, we will be able to gain knowledge of the selection of optimal communication protocols, interfaces and also cloud technologies. One of the researched studies was a simulation factory [11]. The result of the study was the connection of a production device controlled by a PLC device to a local KEPServerEX server. Subsequently, the data was sent to the ThingWorx cloud server, from where the data was sent to the AR application. The system used two communication protocols, the Ethernet protocol and the OPC UA protocol.

Another experimental system was the P2P communications trading platform [12]. The work dealt with remote access to device data and remote device control. This project was implemented using P2P communication using the MQTT protocol. The work included two local servers, the first of which was Node-Red, which represented the position of MQTT broker. The second server provided a web user interface. After the user logged in, P2P communication with the devices was started.

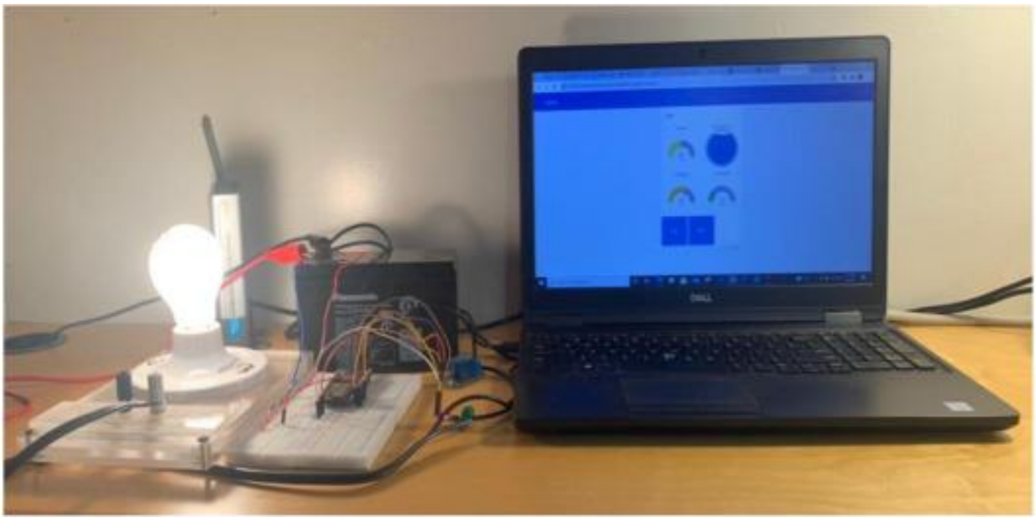

Fig.4. Experimental setup for the proposed platform.

In the next part of the analysis, we focused on the possibilities of displaying augmented reality and anchoring virtual objects in reality. The following studies have addressed this issue. The first is a project that aims to show new parts in construction using augmented reality [13]. The XR application includes the ability to add basic geometric 3D models such as cubes, cylinders, spheres, pyramids, etc. in various dimensions that the user can change. 3D models can be placed anywhere in space. The "save model" function scans the machine on which the 3D model is located. Scanning consists of shooting video while observing the machine at different angles. When the scan is complete, the video is divided into a series of images of the machine and sent to a cloud server. A machine forecast is then created on the cloud server, which the next time the machine is displayed in real-time, it recognizes the machine and allows it to add a virtual design. When you save a design, a virtual design is sent along with the video, which is sent as an array of voxels.

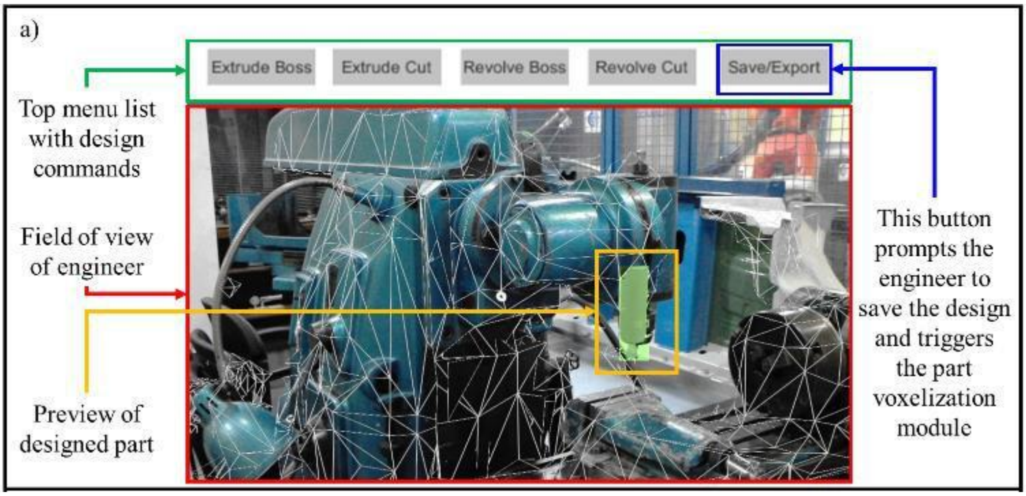

Fig.5. Augmented reality view a proposal for a new work.

Working [14] using a mobile device with an AR application allows you to display values from sensors in the device. According to the sensed values, it is possible to display a fault in the real device. In addition, the application allows you to stream the recording to other devices with an AR application or a web browser.

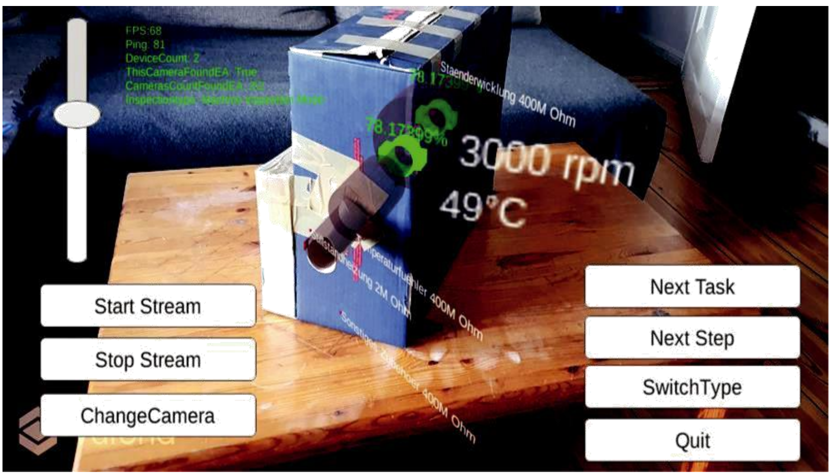

Fig.6. User interface.

Further work is Modern methods of control and monitoring of mechatronic systems using computer-generated reality [15]. The work is characterized by a combination of augmented reality, cloud technologies with Industrial Internet of Things (IIoT). The AR application was developed in the Unity 3D engine for iOS devices (iPad). Object recognition was performed using a 3D map created in Wikitude Studio. After the object was recognized, the AR application connected to the InfluxDB cloud server to a digital copy of the object. At the same time, it downloads the user interface definition from the local server, which is used to display the user interface in the 3D engine. The communication within the whole project is based on the MQTT protocol.

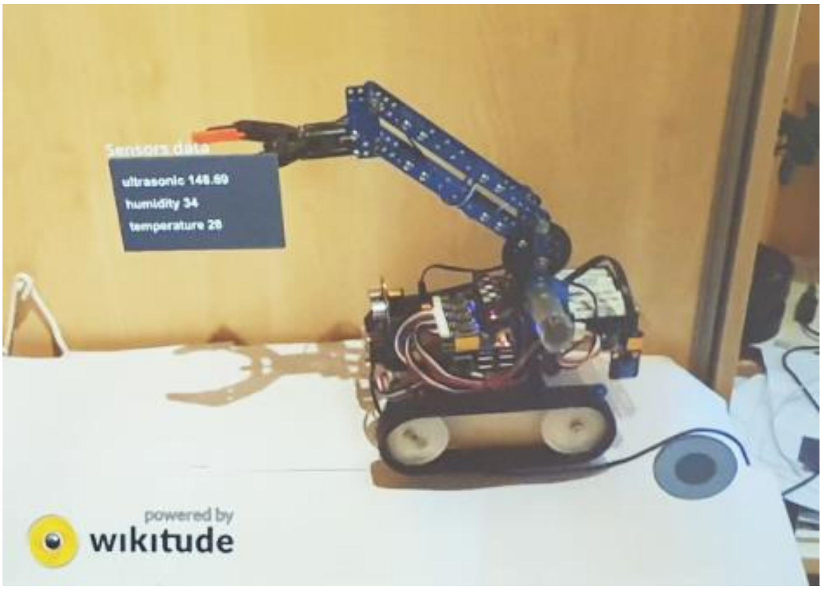

Fig.7. Augmented reality view of the device.

4 Solution Design and Implementation

Each of the examined solutions has its strengths as well as weaknesses compared to the others. The aim of this work is to design a smart workplace with data recording, backup on cloud storage, using exclusively IIoT standards in accordance with the concept of Industry 4.0 and management. It will be possible to interact with the physical system of the workplace through the application in augmented reality. A web application will be used for remote monitoring of analytical values. Based on research into the current state of use of cloud technologies and augmented reality in IIoT, we have encountered several shortcomings that can be improved:

- Communication of devices will be realized only using IIoT standards
- Dynamic display of the user environment based on the recognized device

Software and hardware selection

The first step will be to choose a suitable cloud platform. Here are a few options to choose from, the most popular of which are:

- Microsoft Azure
- Google cloud
- Amazon AWS

All options are suitable candidates for stable operation and project implementation. However, as this is an IIoT project, Microsoft Azure will be the ideal decision, as it is most associated with Industry 4.0.

Another big decision will be the choice of 3D engine. Here we have a choice of two competitors: Unity Engine and Unreal Engine. Both 3D engines were originally developed as game engines and over time began to be used in other industries. In the case of augmented reality in an industrial environment, the Unity Engine is used in most cases thanks to its support of several devices. Another advantage is that Unity has more documentation for creating AR applications. These facts make Unity Engine a clear choice for creating an AR application. Furthermore, it is necessary to appropriately select the Software Development Kit (SDK) for visualization of augmented reality. Here are some options that depend on each other for the augmented reality visualization device used:

- AR core
- AR kit
- AR Foundation
- MRTK

Before deciding which SDK will be suitable for our project, it is necessary to determine what equipment we will use to visualize augmented reality. If we opt for a mobile device, it will be ideal to use the AR Foundation, with which we can easily create a single application compatible with both iOS and Android operating systems. If we were to opt for the Microsoft Hololens 2 headset, we must choose the MRTK instruction set.

A thorough analysis revealed several possibilities for recognizing objects in the real world:

- Object recognition by position
- Object recognition by marks
- Object recognition according to the shape of the monitored object

Recognition of the object by location in our case will be inefficient, as we will only move in the room. Object recognition by tags is an effective way to recognize an object, the most common solution is to use QR codes. Nowadays, however, there is a more modern solution available in the latest versions of the SDK, namely object recognition according to the shape of the monitored object. In our case, the most effective use will be to recognize the object according to the shape of the monitored object.

Design of the solution implementation structure

We created a design for the smart workplace structure (Fig.8). The structure can be divided into several units according to the technology used.

The first part will be developed using the TIA Portal tool. In it, we program Siemens devices which include the touch panel HMI and PLC devices. We will set up communication and network settings of individual devices. The devices in this section will communicate with the local server using the OPC UA protocol.

The second part is made up of a Node-Red local server. It is a server that will be able to communicate with devices from the previous part using OPC UA communication, AR devices using MQTT protocol and a cloud server using TCP / IP protocol and MQTT. It will also provide the HMI on the appropriate port on the local network.

The third part is a cloud server. Here we chose to use the Microsoft Azure cloud platform. The cloud server will contain a database with RESTful API, to provide data to devices. The server will record hourly, daily, weekly and monthly records to provide analytical data. The server will also contain individual devices in production and their user interfaces.

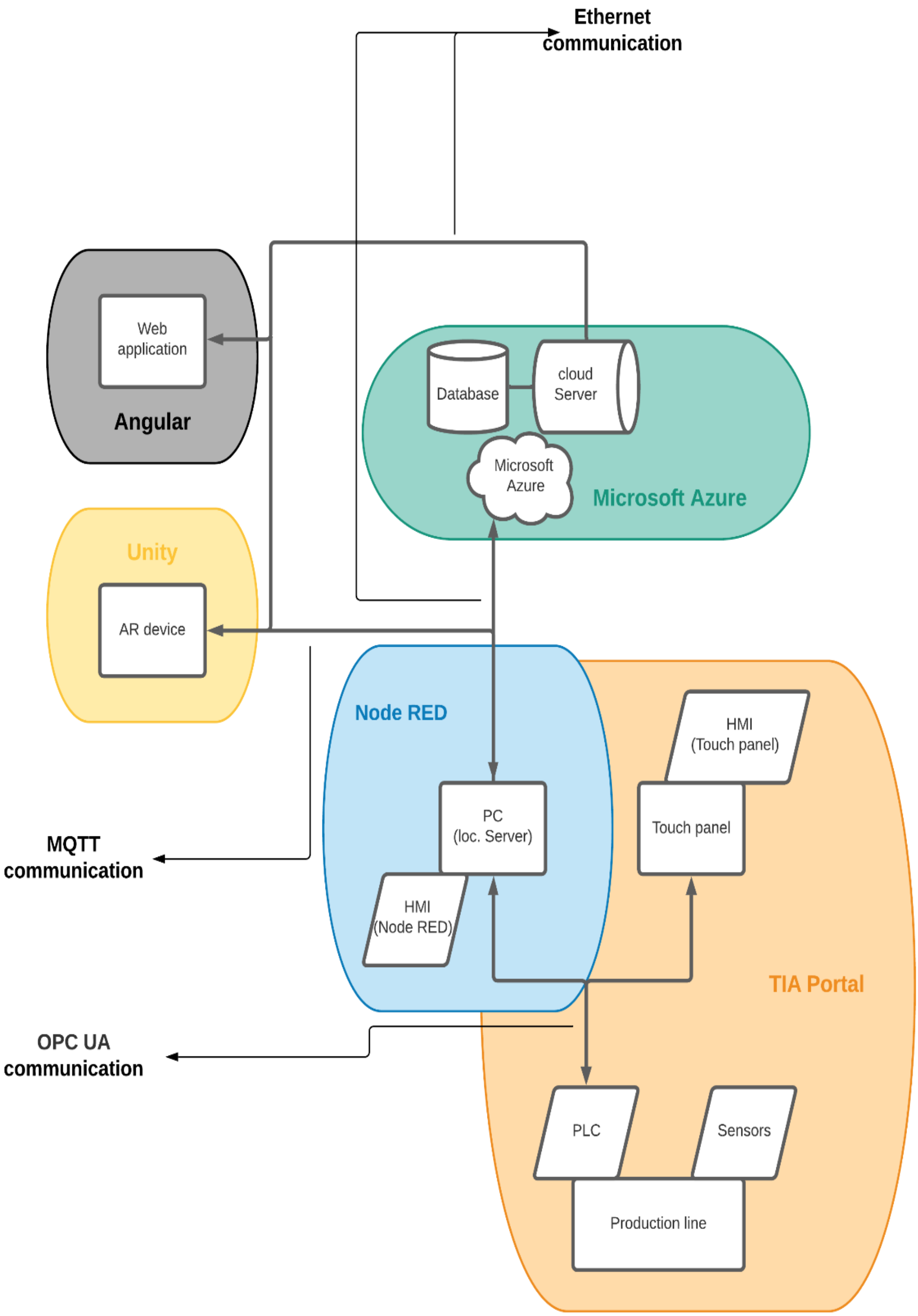

Fig.8. Solution structure design.

The fourth part is an augmented reality application that will be created in Unity Engine. The application will recognize devices in production and then provide the appropriate HMI obtained from the cloud server according to the recognized device. After recognizing the device and successfully displaying the HMI, the application will connect to the local server, from which it will obtain current device data. This communication will take place using the MQTT protocol. The application will also be able to switch to analytical mode, in which data is obtained from the cloud server.

The last part is made up of a website created in the Angular framework. The web application will provide analytical data for remote production monitoring. The security of the web application will consist of user authorization.

Utilizing augmented reality in the manufacturing process can streamline production speed, maintain machines, reduce machine downtime, and effectively provide information about the machine. Implementation of dynamic visualization, based on the display according to the data in the database by the respective machine will provide us to effectively add visualizations for new equipment in production. This eliminates the lengthy process of programming new versions of the application and allows you to easily add a new device with its visualization to the database.

Conclusion

The work deals with the implementation of augmented reality and cloud systems into the production process using Industry 4.0 standards. A significant extension is the use of 3D object recognition based on the observed object in the physical world. The system is supplemented by an algorithm for rendering the user environment based on the data received from the server in JSON format. This will make it possible to easily add new equipment by adding to its user experience and edge mapping.

The solution will be designed and verified for a specific smart system. The proposal will be based on the principles of Industry 4.0 so that the overall concept and methodology is generally applicable in accordance with industry standards.

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