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Development of Android-based Internet of Things Application for Data Tracking in Smart Marble Factories

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Abstract
Internet of Things is one of the most important technological components of Industry 4.0. Internet of Things technology has become an even more critical research subject by using it with cloud computing technology that is constantly evolving. In this study, it is aimed to contribute to digital transformation in the marble factories. Therefore, an Android-based Internet of Things application has been developed for data tracking during the drying stage of the marble. NodeMCU, DHT11 temperature and humidity sensor, Firebase Real-Time Database have been used to build the data tracking system. This system has been supported by the Android-based mobile application created in the Android Studio Integrated Development Environment using Java programming language. As a result, losses during the production stage can be minimized by ensuring data tracking during the marble's drying phase.
Keywords: Android; industry 4.0; internet of things; IoT; marble drying system; smart factory.

1. Introduction

The term of the industry is a field of study that has experienced revolution many times today. In this context, the methods and production processes used in industry have been developing day by day. Before the 21st century, there happened three major industrial revolutions in the World [1]. The term Fourth Industrial Revolution (Industry 4.0) was proposed by the Germans at Hannover Fair in 2011 [2]. The main objective of Industry 4.0 technological developments is to achieve advanced industrial automation and higher productivity. This industrial innovation has enabled the build of smart factories that emerged with the Internet of Things (IoT) nowadays. In addition, academic and industrial trends occur around components of smart factories such as cyber-physical systems, IoT, cloud computing, additive manufacturing (3D printing), cybersecurity, autonomous robots, system integration, simulation, virtual reality (VR), augmented reality (AR), big data, data analytics, and artificial intelligence [3]. IoT, one of the most important components of smart factories, is defined as intelligent and self-structuring objects used to ensure that factories' basic equipment and resources communicate with each other. In addition, IoT technology can transfer data. Also, the IoT has been presented as a term used to observe production resources on a cloud server. As a result of data analysis, the decision support mechanism created is used to make production planning for smart factories, follow up the service and maintenance needs of machinery and equipment, and automatically transmit this need and provide the high-quality control process [4-6].

In this paper, temperature and humidity with together time information have been obtained purpose of data tracking in the drying stage of marble in smart marble factories. The NodeMCU embedded system development board, including a built-in WiFi module and the DHT11 temperature and humidity sensor, has been used. Firebase's real-time database has been used in the cloud computing part. An Android-based mobile application has supported the system. The mobile application has been developed in Android Studio integrated development environment (IDE) using Java programming language. As a result, a real-time temperature and humidity sensor data tracking system supported by Android has been developed.

The rest of the submitted paper is organized as follows. In Section 2, the related works on IoT applications have been reviewed. Then, in Section 3, the utilized methodologies have been presented. In Section 4, the obtained results have been reported. Finally, in Section 5, the concluding remarks, including future works, have been presented.

2. Related works

Research in the literature on IoT applications is presented in this section.

Terroso-Saenz et al. proposed an IoT application for the control and monitoring of energy consumption of apartments. In the study, sensor data such as room temperature and get instant energy consumption of apartments were obtained [7]. Rashed et al. proposed a wearable embedded system sensor design that contains the WiFi module to track patients' heart rhythm, body temperature, and motion status. Obtained data from the sensors was transferred to the cloud-based server [8]. Taştan created smart irrigation and remote monitoring system for

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agriculture and landscaping by using DHT22 temperature and humidity sensor and HL-69 soil hygrometer moisture sensor together with NodeMCU [9]. Kumar et al. have tried to take data of a smart manufacturing factory and have done predictive data analysis for energy management based on historical information [10]. Hamilton proposed an IoT-based decision support system in cyber-physical smart manufacturing using wireless sensor networks. It supported this system with a real-time big data analytics algorithm [11].

3. Methodology

In this section, the utilized methodologies in the study are presented, including hardware and software details.

NodeMCU, DHT11 temperature and humidity sensor, and Firebase Real-Time Database have been used for data tracking with the Android-based application during the drying stage of marble in smart marble factories.

NodeMCU is an embedded system development board with a 32-bit processor also that contains the WiFi module. NodeMCU is often used in IoT applications with its low price advantage, low power consumption, and compact card design. NodeMCU development board design and pin diagram are shown in Figure 1. The 32-bit Tensilica L106 processor exists on NodeMCU. The operating frequency of this processor is 80/160 MHz. In addition, NodeMCU has 17 Input/Output pins and 1 ADC pin. The operating voltage is in the range of 3.0~3.6 V, while the operating current is in the range of 12~200 mA. NodeMCU's total flash memory is 4 MB. NodeMCU has a WiFi module and communication system based on the IEEE 802.11 b/g/n network standard. The sleep mode current is less than 10 µa, while the standby mode current is less than 10 mA.

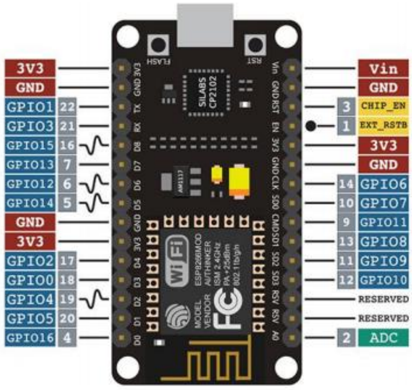


Figure 1. *NodeMCU development board design and pin diagram [9].*

The DHT11 temperature and humidity sensor, which contains an 8-bit microprocessor, have been used to obtain real-time humidity and temperature information in the study. For this sensor, which can receive data in the temperature value range of 0~50 ˚C, it is stated that there may be an error of ± 2 ˚C at the temperature value and ± 5% at the humidity value. Also, the operating voltage and current of this sensor are a range of 3.0~5.5 V and 0.5~2.5 mA, respectively. The DHT11 temperature and humidity sensor and NodeMCU development board connection scheme are shown in Figure 2.

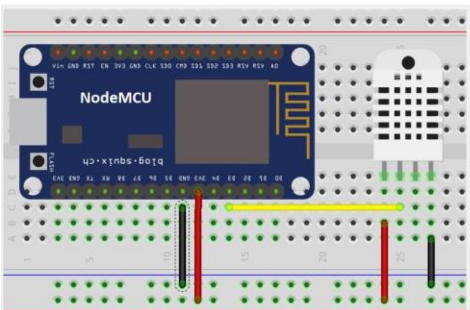


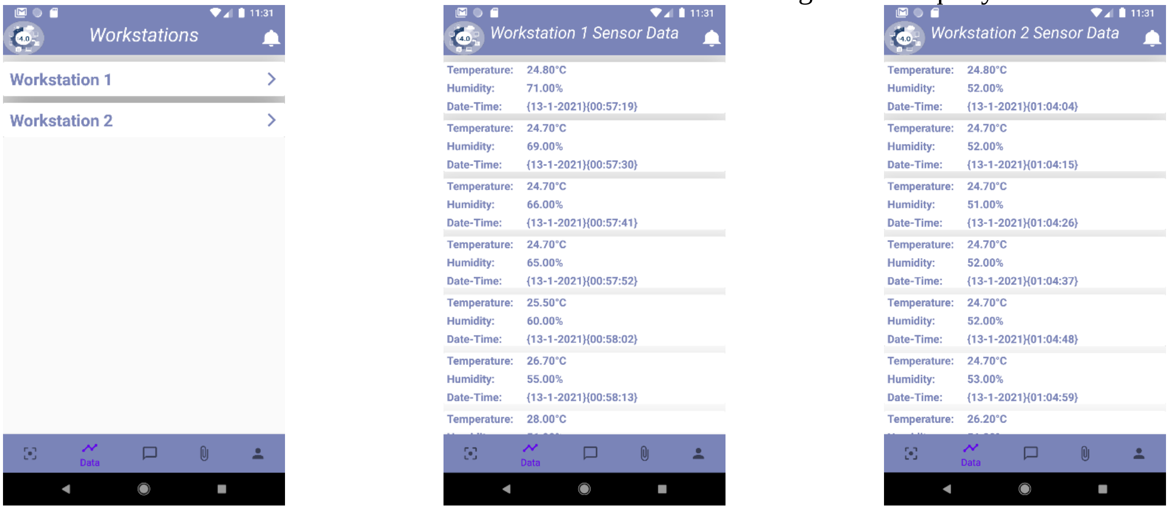
Figure 2. *The DHT11 temperature and humidity sensor and NodeMCU development board connection scheme [12].*

Temperature and humidity information has been obtained from the DHT11 sensor, while the Network Time Protocol (NTP) server has been used for the time information of when this sensor data have been received. Then, all this obtained real-time temperature and humidity data have been transferred from the Arduino Studio IDE to the real-time database using the https address of the Firebase Real-Time Database and the Firebase database identification password. After, this sensor data have been transferred to the mobile application developed in the Android Studio IDE in Java programming language using database query methods.

4. Results and discussion

This section presents the obtained results, including the layout and usage details of an Android-based mobile application.

Real-time temperature and humidity data have been received from two different workstations. These workstations have been controlled by creating two CardView designs, including hints as workstation 1 and workstation 2 in the user interface of the Android-based mobile application, as shown in Figure 3 (a). The workstation 1 and workstation 2 CardViews have been used inside ScrollView purpose of adapting different phone screen sizes. If these CardView designs are clicked, new user interfaces are passed, which are shown in Figure 3 (b) and Figure 3 (c). The CardView designs consist of three TextViews, which include temperature, humidity, and time information. The CardViews, which include TextViews, have been used inside RecyclerView, so the CardView has been designed as an adapter in a different XML file. Finally, the temperature, humidity, and time information have been transferred to these TextViews inside CardView using database query methods.



(a) (b) (c)

Figure 3. *(a) Location of Workstations, (b) Workstation 1 sensor data, (c) Workstation 2 sensor data.*

5. Conclusion and future works

Nowadays, with the development of internet technology, the number of applications using this technology are incessantly increased. These applications provide serious time savings to their users. Examples of these applications include e-commerce, online news sites, social media, and the industry. In this study, a contribution has been to the use of the internet in the industry, i.e. IoT. Real-time temperature and humidity data have been received from two different workstations using NodeMCU, DHT11 temperature and humidity sensor, Firebase Real-Time Database, NTP server, and Android mobile technology. As a result, an end-to-end structure has been created for data tracking during the drying stage of the marble in smart marble factories. To do in future studies can be summarized as follows. First, the number of workstations can be increased. Increasing the number of workstations allows the end-user to achieve higher data tracking system performance. New sensor structures, such as DHT22 and SI7021 temperature and humidity sensors, can be used. DHT22 and SI7021 sensor structures operate in a wider temperature and humidity range with high sensitivity than the DHT11 sensor. In this way, more exact sensor data can be obtained. IOS and web versions of the Android-based mobile application can be developed. Consequently, the developed IoT system becomes accessible for more end users.

Declaration of Interest

The authors declare that there is no conflict of interest.

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