**Journal of Theoretical and Applied Information Technology**
28th February 2022. Vol.100. No 4
2022 Little Lion Scientific

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

# INTERNET OF THINGS (IOT) FOR SMART CITY, AGRICULTURE AND HEALTHCARE

**KAMAL ELHATTAB[1], KARIM ABOUELMEHDI[2], ABDELMAJID ELMOUTAOUAKKIL[3]**

[1]LAROSERI Laboratory, FS of Chouaib Doukkali University, Eljadida, Morocco

[2]LAROSERI Laboratory, FS of Chouaib Doukkali University, Eljadida, Morocco

[3]LAROSERI Laboratory, FS of Chouaib Doukkali University, Eljadida, Morocco

E-mail: [1]kamal.elhattab@gmail.com, [2]karim.abouelmehdi1@gmail.com, [3]elmsn@gmail.com

**ABSTRACT**

The Internet of Things (IoT) technology has revolutionized all areas of human life, making it more comfortable. IoT refers to the current trend of The Internet of Things (IoT) technology that has revolutionized all areas of human life, making it more comfortable. IoT refers to the current trend of connecting all kinds of physical objects to the Internet, even the most unexpected ones, without human intervention, which constitutes a self-configurable network. The Internet of Things (IoT) enables organizations to automate the process and improve service delivery via Internet technology and data transfer to the cloud. Nowadays, the Internet of Things (IoT) is becoming a widely discussed topic among researchers, specialists, and experts. It is seen as the next step in the evolution of the Internet. This paper covers the application of (IoT) technology in three different areas: smart cities, health, and agriculture.

**Keywords:** *Internet of Things, Smart City, Smart Parking, Smart agriculture, Smart Healthcare*

## 1. INTRODUCTION

The term Internet of Things (IoT) first appeared in 1999 in the speech of Kevin ASHTON, a British engineer. It was used to refer to a system where physical objects are connected to the Internet. Over time, the term has evolved to encompass the entire ecosystem of connected objects. Currently, the Internet of Things (IoT) is becoming a widely discussed topic among researchers, specialists, and experts. It is seen as the next step in the evolution of the Internet. With the IoT, we are heading towards a phase where all elements of our environment will be connected to the Internet and will have the ability to communicate with each other with minimal human effort [1]. The IoT contains a variety of objects that can be connected with both wired and wireless networks. These objects have an addressing system that allows objects to interact and cooperate with others to create new IoT applications and services such as smart homes, smart cities, smart energy and networks, smart transportation and traffic management and control, and others [2].

The emergence of various sensors and software tools that allow the reading of information from the sensors allows the improvement of the living environment and the maximum use of all available resources. A human can monitor and manage his environment, habits and define his daily needs with the help of various IoT-supported systems. The main benefit of using IoT in daily life is to reduce the user's involvement in their life responsibilities. Why should the user activate the light if the sensor is able to recognize the darkness? A simple example, which shows how many sensors and software tools that collect information from the sensors can improve the life of the users and solve certain obligations. The smart city concept is used to describe a better use of public resources, increasing the quality of service presented to citizens, and at the same time, reducing the operating costs of administrations [3].

The IoT provides several benefits in the management and optimization of public services, such as transport, parking, lighting, surveillance, maintenance of public areas, preservation of cultural heritage, and waste collection. In addition,

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

the availability of different types of data collected by IoT devices can be used to raise awareness about the status of their city [4]. The application of IoT in agriculture allows the improvement of the production process, monitoring, and maintenance of planted areas. One of the advantages of implementing innovative technologies is the ability to control systems from remote locations and control working machines used for land cultivation Zanella et al.2014 [4]. The implementation of appropriate software architecture (such as well as upgrading the current software architecture used) that can support the use and control of sensors in agriculture reduces the need for human involvement in a wide variety of processes [5]. In the field of smart health, (IoT) plays an important role to improve and deploy a wide range of applications such as monitoring of patient behavior change and treatment observation. Smart health allows people (e.g., doctors, nurses, patient caregivers, family members, and patients) to access the right information and get the right solutions, which are mainly aimed at minimizing errors and improving efficiency, as well as to reduce costs at the right time in the medical field [6].

The organization of the article is as follows, in Section II: We will present the related work, Section III: We will discuss and analyze the iot smart parking application proposed by Balhwan et al. [19], Section IV: We will study the iot smart agriculture application presented by Krishnan et al. [20], section V: in this section we will analyze and discuss the smart healthcare application developed by Islam et al. [21], Section VI: issues and limitation, Section VII: critical analysis and future work and Section VIII: Conclusion of the paper.

In this paper we will show the strengths and weaknesses of each iot application, and we will propose improvements for each IOT application and help researchers improve their work with the latest technologies, tools, and techniques.

## 2. RELATED WORKS

Some important work has been done in the IoT field. For example, smart parking is one of the Smart Initiatives that tries to provide a solution to the classical problems of parking environments in big cities. Smart parking is one of the topics that is becoming more and more popular and is often associated with the Internet of Things. The Internet of Things is the main actor in the concept of smart cities [7].

The Smart Parking research conducted by Wang [8] was applied by building a parking IoT application using the reservation method. In 2015, Pham [9] proposed a parking system using cloud services so that it could provide better performance. Fraifer [10] contributed to the topic of Smart Parking through his research which proposed the architecture of Smart Parking systems using CCTV devices. Then the research conducted by Khanna [7], built a Smart Parking using the Internet of Things integrated with cloud services.

In the field of agriculture, Thakur et al. [11] proposed a device that can measure temperature, soil moisture, and automatic irrigation. To monitor farms with camera sensors and monitor data transmission, Sanchez et al. [12], have designed a system to do so. Jahnavi et al, [13] proposed an intelligent wireless sensor network system for greenhouse. Thakur et al, [14] conducted a survey to obtain accurate information on various sensors and crops in which wireless sensor networks and the Internet are compatible. For the health domain Related work in this area is described as follows:

Acharya et al. [15] introduced an IOT application for medical monitoring in an IoT environment. The developed system monitored some basic human health parameters like Heartbeat, ECG, body temperature, and respiration. The components used here are pulse sensor, temperature sensor, BP sensor, ECG sensor, and Raspberry Pi. The data was collected from sensors and sent to raspberry pi for processing and again transmitted to the IoT network. The major drawback of the system is that no interface for data visualization is developed.

Trivedi et al. [16] suggested a mobile device for monitoring health parameters based on Arduino. The collected sensor data is analog and sent to the Arduino Uno board. Using the built-in analog-to-digital converter, the recorded analog values are converted into digital data. The Bluetooth transmits the digital data to the developed device. The major disadvantage is that the Bluetooth device uses a module that does not cover a large area.

Gregoski et al. [17] introduced a smartphone-based heart rate monitoring system. The system uses a moving light and a camera to track finger blood. The system developed describes an integrated device that wirelessly transmits a person's pulse to a computer, allowing people to test their heart rate by simply looking at their

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

phones instead of using their hands each time. This is an excellent design but is not feasible if continuous heart monitoring is required.

Kumar et al. [18] developed an IoT safety monitoring application. A sensor was used for body temperature measurement and a pulse sensor is used for pulse measurement. The data was uploaded from Arduino to the cloud via the Wi-Fi and Ethernet shield module. However, Arduino Uno was used here, and therefore many sensors cannot be processed properly. In our survey paper, we will study the three fields of IoT applications which are: smart city, health, and agriculture.

## 3. SMART PARKING

### 3.1 System components

For the smart city domain Balhwan et al. [19], proposed a smart parking system (Smart parking) to find a vacant parking space in the parking areas without involving manual efforts and thus avoid the need to spend fuel and time on efforts. Various sensors deployed in the parking area determine the availability of parking spaces, and the information can be easily accessed through the use of the Internet by users. The developed prototype of smart parking detects whether the parking area is free or occupied, and the information/data collected by the sensors is uploaded to the cloud from where the user can access the information using an Android application (fig1).

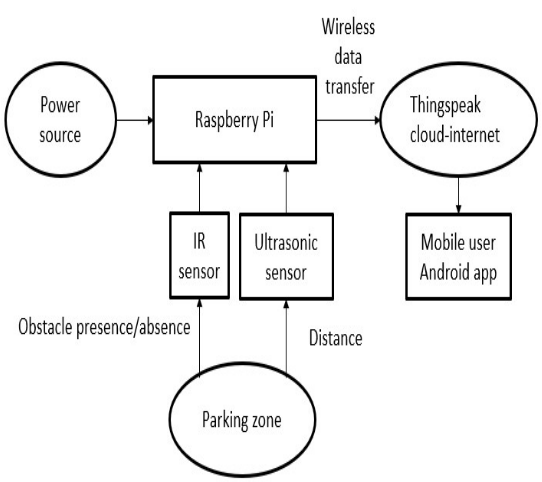


*Figure 1: Architecture of smart parking system [19]*

The following steps are performed by Balhwan et al. [19]:

- ✓ The occupancy of a parking space is measured using the sensors (ultrasonic sensor and IR Sensor) with Raspberry Pi.
- ✓ After measuring the data, the presence or absence of an obstacle the data is sent to "ThingSpeak" using RPi's internal wi-fi.
- ✓ The data is saved on the ThingSpeak cloud. The data is displayed graphically.
- ✓ A user's mobile application connects to the cloud and provides information about parking spaces (free or occupied).

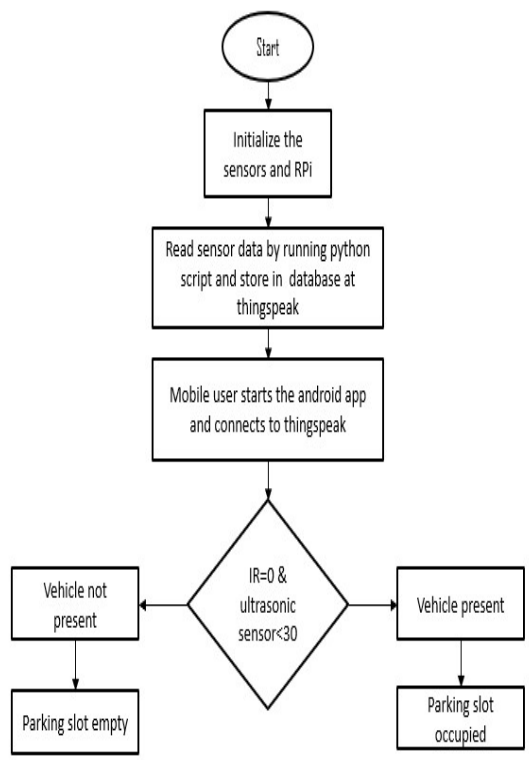


*Figure 2: Diagram of smart parking system [19]*

### 3.2 Discussion

Among the strengths of the IoT application proposed by Balhwan et al. [19], the Smart parking system is capable of finding a vacant parking space in the parking areas without involving manual efforts and thus avoiding the need to spend fuel and

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time on efforts, but did not consider online reservation with payment hence the need to improve this prototype as follows:

To reserve a parking space online, the user must query the system to check if a space is available. The system will display the available slots in the database and when the user selects the slot, the user will be directed to the payment page. If the payment is successful, the barcode will be generated for the user and the database will be updated.

The barcode will be used to gain entry to the parking area. Without the barcode, the doors will not be opened. The parking system will also provide an offline reservation if the parking spaces are free, in which case the user must pay manually at the gate, then their display screen will show the available spaces. At the entrance, there will be a display screen, a barcode reader, and a DC motor to open the door.

A secure web application to be managed by the administrator and a mobile application to be managed by the users should also be developed. The hardware when we can add to improve the functioning of our system a motor, a display screen and a barcode reader to open the door and to save time and fuel we can add GPS to indicate the free parking places in our smart parking.

According to the study of IoT smart parking application proposed by Balhwan et al. [19], we will change the smart city domain to the agriculture domain and we will study the IoT application developed by Krishnan et al. [20].

## 4. SMART AGRICULTURE

### 4.1 System components

For the agriculture sector, it is known that farmers agricultural fields may be located many kilometers from their homes. Sometimes farmers have to go to their agricultural fields several times a day to start and stop the water (irrigation pumps). They cannot protect the crops from unconditional rain every time. In order to overcome these practical difficulties, a system is designed by Krishnan et al. [20] to take care of all these problems automatically.

The general block diagram is shown in Fig.3. The monitoring system consists of four main units: the end device node, the coordination node, the webserver node, and the mobile (control unit). The end device node includes an Arduino controller, a GSM, a motor, a plant leaf image soil moisture sensor, a temperature sensor, and a humidity sensor. The microcontroller device is also used as the end device as a coordinating device in the wireless sensor network. It is used for data communication in the network. Data is continuously collected from the sensors and then transmitted to the node coordinator, which is connected to the web server system via the serial RS232 data bus. Data acquisition is done in the web server for real-time monitoring of farmland parameters. From the server, the data can be obtained and displayed on the Android phone. Then the signal control is automatically sent to the coordinator node Whenever the end device receives a signal from the coordinator node, it acts according to the received signal whether the motor is turned on or off. The on-off process of the motor for irrigation is framed using fuzzy logic. The controller is programmed based on fuzzy rules. As a result, the system helps farmers to control the motor and water use according to the needs of the farmland, even through remote monitoring of the farm field. Arduino and GSM Modem / GPRS are initialized upon power on. After the initialization process, the system asks users to select either manual or automatic mode. When automatic mode is selected, the Arduino initially checks the availability of solar power using the light-dependent resistor (LDR), which is used to detect sunlight. Here, the solar panel is mounted on the stepper motor to expose the solar panel to light according to the movement of the sun. When there is no availability of solar power, the system runs on a battery. The water level sensor attached to this system is used to indicate the water level in the farm field tank. The relay is linked to the pump, which starts pumping water to the agricultural field and the moisture sensor identifies how dry the soil is. The moisture sensor is used to detect the moisture of the soil in the crop field. The temperature sensor detects the surrounding temperature of the agricultural field. When it starts to rain, the pump automatically stops pumping water into the field to save electricity and updates the information to the user using GSM/GPRS. The protective panels are automatically closed to protect the crop affected by the rain. The data collected from the sensors is displayed using the alphanumeric display. Figure 3 shows the working principle of the proposed system, and Figure 4 shows the flow chart of the proposed system.

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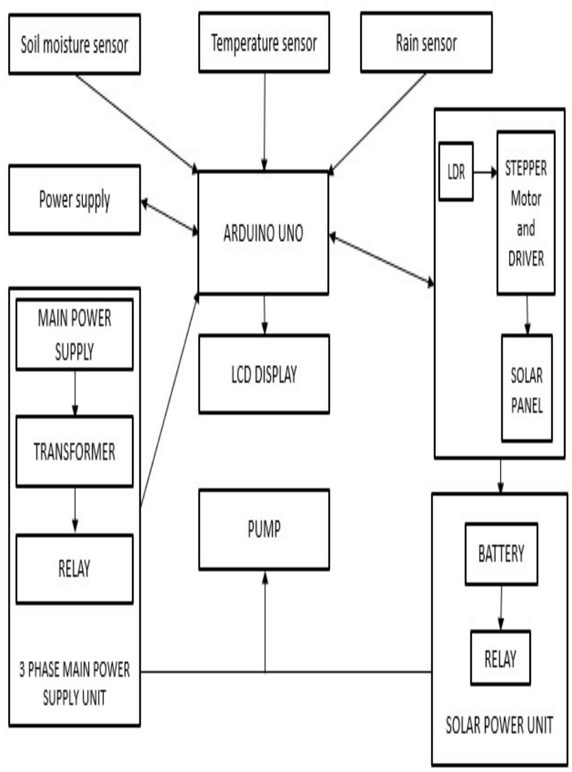


*Figure 3: Architecture of smart irrigation system [19]*

The steps of the work done by Krishnan et al. [20].

- ✓ The GSM modem is initialized as soon as the power supply is turned on.
- ✓ Using AT commands, the GSM modem communicates with Arduino.
- ✓ The LCD screen is linked to Arduino so that the data monitored by the sensors is displayed correctly.
- ✓ First, the processor checks the availability of solar energy with the help of a light-dependent resistor (LDR) to detect sunlight. The solar panel is interfaced with the stepper motor, which in turn is linked to the stepper motor driver.
- ✓ The solar panel rotates both clockwise and counter-clockwise and stops where the maximum sun intensity is obtained and stores the energy in the battery.
- ✓ In the case of availability of solar energy, water is pumped to the agricultural field with the help of solar energy or with the help of mains (3 phase lines).
- ✓ The soil moisture sensor checks the soil moisture content, which is maintained at a maximum of 850 (indicating dryness) and a minimum of 500. When the soil moisture content is above 700, the engine will pump water to the agricultural field.
- ✓ The temperature sensor measures the ambient temperature of the farm.
- ✓ The rain sensor detects heavy rain and shuts down the engine to save electricity. It also shuts down the panel to protect the crop.
- ✓ All information collected from the sensors will be transferred to the user using GSM technology.

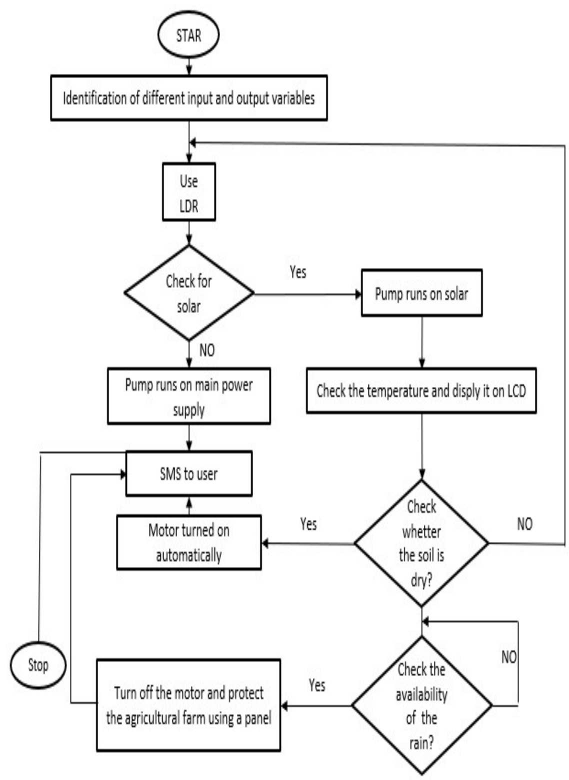


*Figure 4: Diagram of smart irrigation system [19]*

### 4.2 Discussion

Krishnan et al. [20] proposed a smart irrigation system that helps farmers water their agricultural fields using a mobile application, as traditional agricultural systems require a huge amount of energy for watering the fields. The system provides acknowledgment messages on job statuses such as soil moisture level, the temperature of the surrounding environment, and the status of the engine concerning the main power supplies or solar energy. The fuzzy logic controller is used to calculate input parameters (moisture, temperature, and humidity) and to produce engine status outputs. In addition, the system also shuts down the motor to save energy when it rains. The results prove that water and energy savings are achieved with the proposed smart irrigation system. The flowchart shown in Fig. 4 and the schematic shown in Fig. 3, contains three main functionalities the first functionality is the temperature check, the second functionality is the soil moisture check and the third functionality is the rainfall availability check, but they did not take into account the security of the fields hence the need to improve this prototype by adding the functionality of the field intrusion detection. This functionality is used to detect intrusion and is measured using a passive infrared (PIR) sensor whenever there is an intrusion detection in the field, users will get to know it using GSM technology. The functionality of intrusion detection will increase the level of security against field intrusion which has not been considered by Krishnan et al. [20].

According to the study of smart irrigation IOT application proposed by Krishnan et al. [20], we will change the smart agriculture domain by smart health domain, and we will study the IoT application developed by Islam et al. [21].

## 5. SMART HEATHCARE

### 5.1 System components

Continuous online monitoring of patients and patient room status is the main idea of the system proposed by Islam et al. [21]. The system is implemented using a combination of hardware components. All the hardware components are assembled in the implementation phase. The circuit diagram of the developed system is shown in Figure 5. All sensors are connected to ESP32 using physical pins. ESP32 is used as a processing device as it has a built-in Wi-Fi module. The user prototype is shown in Figure 5 where the system is tested with a user and the data is displayed on the webserver.

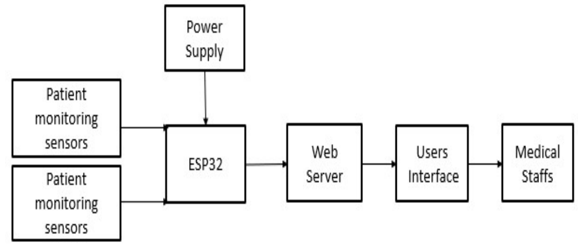


*Figure 5: Architecture of smart healthcare system [21]*

### 5.2 Discussion

Islam et al. [21] have proposed a system of healthcare monitoring in hospitals. Healthcare monitoring systems with emerging technologies are now becoming a great concern for many countries around the world. The advent of the Internet of Things (IoT) technologies is facilitating the progress of healthcare. The smart health system proposed by Islam et al. [21] in the IoT environment it can monitor the health status of a patient as well as the status of the room where the patients are in real-time. In this system, five sensors are used to capture the data from the hospital environment called heart rate sensor, body temperature sensor, room-temperature sensor, CO2 sensor and Co sensor.

The percentage error of the developed scheme is within a certain limit (<5%) for each case. The status of the patients is transmitted via a portal to the medical staff, where they can process and analyze the current situation of the patients. The developed prototype is well suited for healthcare monitoring which is proven by the efficiency of the system.

This system overcomes the drawbacks of the existing mechanism by making it a more efficient method of monitoring the health parameters of patients. It has the advantage of less cost, less time, low power. Accurate measurement of heart rate and other health parameters of patients are possible and play a vital role in monitoring the health status of patients. The sensors send data wirelessly to the server using IoT. The basic physical parameters are measured continuously. It makes the patient more comfortable using these portable devices. The values recorded by this system are more accurate and precise. It reduces the time consumed by the manual method. As these

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

values are recorded continuously [22], the workload of the doctors is reduced. These values can also be sent to other specialists by e-mail.

According to the analysis of the IoT application proposed by Islam et al. [21], it is found that it is important to keep the information of a patient's medical statistics in the cloud [23], as it can be extremely beneficial in the future. Keeping the records will allow the patient to make many of the choices such as whether they want to lose weight or not, which medications are mainly allergic to the patient, and much other necessary information [24]. This database should also help the doctor to interpret the patient's physical problem and its origin, to provide a better diagnosis. In order to show the overall workflow, Fig. 6 is proposed.

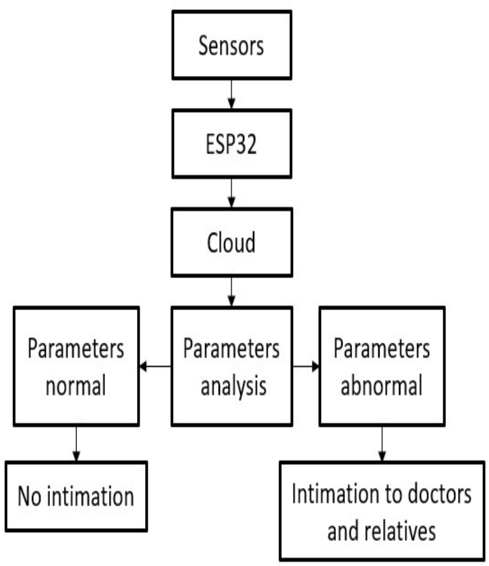


*Figure 6: Diagram of smart healthcare system [21]*

To improve this system in the future, the analysis of part of the design can be developed by applying machine learning and artificial intelligence algorithms.

## 6. ISSUES AND LIMITATIONS

According to our study of the three areas of smart agriculture, smart healthcare, and smart parking, much has been done and much remains to be done. The following table summarizes some of the shortcomings of the three prototypes studied previously and suggests improvements.

*TABLE 1: SUGGESTS IMPROVEMENTS*

| Article | Application IOT | Gaps | Improvements | Techniques and tools |
|---|---|---|---|---|
| Balhwan [19] | Smart parking | The absence of an online booking system with payment. | Add an online booking system. | Develop a secure web application managed by the administrator.<br><br>Develop a secure mobile application managed by the user.<br><br>A barcode to get an entrance to the parking area. |
| Krishnan [20] | Smart agriculture | The lack of safety in agricultural fields. | *Detect intrusions into agricultural fields.* | *Detect the intrusion using a passive infrared (PIR) sensor.* |
| Islam [21] | Smart healthcare | The absence of machine learning algorithms and artificial intelligence | Analyzed the design part of the application | Using machine learning algorithms and artificial intelligence |

## 7. CRITICAL ANALYSIS AND FUTURE WORK

In this article we studied three IOT applications (Smart City, smart healthcare, and smart agriculture) and we managed to show the strengths and weaknesses of each IOT application and to propose improvements for each IOT application with the latest technologies, tools, and techniques.

## 8. CONCLUSION

In this paper, we focused on the study of the three domains (Smart City, Health, and Agriculture) of IoT. we showed the weaknesses and strengths of each and proposed improvements for each IoT application. In the future this work will help researchers to improve their work with the latest technologies, tools, and techniques.

Future research should focus on the development and implementation of new IoT application models based on the above recommendations for each IoT application, which are mainly aimed at minimizing errors and improving the efficiency of each IoT application.

In the next work, we will propose a new IoT application model in the field of agriculture that enters into the framework of enhancing the use of IoT in the development of our country MOROCCO.

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