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IoT: An Internet of Things-Based Intelligent City, Agriculture, and Healthcare System

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Abstract: The Internet of Things (IoT) has significantly improved the quality of life in every aspect of society. IoT denotes the prevailing paradigm of Internet of Things (IoT) technology, which has brought about a profound transformation in every facet of human existence, enhancing comfort. The term "IoT" denotes the contemporary phenomenon wherein physical objects of every conceivable nature—including the most unanticipated—are autonomously linked to the Internet, forming a self-configuring network. The Internet of Things (IoT) facilitates process automation and enhances service provision for organizations through the utilization of cloud-based data transfer and Internet technology. In contemporary discourse, the Internet of Things (IoT) is gaining significant traction among specialists, experts, and researchers. It is considered the subsequent stage in the Internet's evolution. This article discusses the implementation of Internet of Things (IoT) technology in three distinct sectors: agriculture, health, and smart cities.

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

I. INTRODUCTION

The phrase "Internet of Things" (IoT) was initially introduced in 1999 during a speech delivered by British engineer Kevin ASHTON. It formerly denoted a system in which tangible entities are linked to the Internet. The term has developed to incorporate the entirety of the interconnected object ecosystem as time has passed. The Internet of Things (IoT) is presently a subject of extensive discourse among specialists, experts, and researchers. It is considered the subsequent stage in the Internet's evolution. The IoT is poised to usher in a period in which every component of our surroundings will be interconnected via the Internet and capable of communicating with one another with minimal manual intervention [1]. A multitude of objects that are capable of being linked to both wired and wireless networks comprise the IoT. By virtue of their addressing systems, these objects are capable of collaborating and interacting with one another in order to develop novel Internet of Things (IoT) services and applications, including but not limited to smart cities, intelligent transportation, and traffic management and control [2].

The development of a multitude of sensors and software applications that facilitate the interpretation of sensor data enables the enhancement of living conditions and the optimal utilization of all accessible resources. Using a variety of IoT-enabled systems, an individual is able to oversee and control his surroundings, routines, and daily requirements. The primary benefit of incorporating IoT into daily life is that it reduces the user's workload and responsibilities. Why would the user need to manually turn on the light when the sensor is capable of detecting darkness? An uncomplicated illustration that demonstrates how numerous sensors and software applications that aggregate data from the sensors can enhance the well-being of users and fulfill specific responsibilities. The smart city paradigm is employed to delineate an enhanced utilization of public resources, concurrently augmenting the caliber of service rendered to the populace and diminishing the operational expenditures of governmental bodies [3].

The Internet of Things (IoT) offers numerous advantages in the optimization and administration of public services, including waste collection, transportation, parking, lighting, surveillance, and the preservation of cultural heritage and public areas. Furthermore, the accessibility of diverse categories of data acquired by IoT devices can be leveraged to generate consciousness regarding the condition of one's municipality [4]. The implementation of IoT in the agricultural sector facilitates enhancements to the monitoring and maintenance of planted areas, as well as the production process. One of the benefits of integrating cutting-edge technologies is the capability to remotely operate machinery utilized in land cultivation and manage systems. (2014) Zanella et al. [4]. By integrating suitable software architecture, or even by enhancing the existing software architecture, that facilitates the operation and management of sensors in the agricultural sector, the necessity for human intervention in numerous processes is diminished [5]. Internet of Things (IoT) is a significant factor in the advancement and implementation of numerous applications within the domain of smart health, including treatment observation and monitoring of patient behavior change. Smart health enables individuals (including patients, family members, physicians, nurses, and caregivers) to obtain accurate information and implement suitable solutions. Its primary objectives are to reduce costs and enhance efficiency, with a particular focus on error minimization and timely cost reduction within the medical domain [6].

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The article is structured as follows: Section II will consist of a presentation of the pertinent literature; Section III will be devoted to a discussion and analysis of the IoT smart parking application that Balhwan et al. proposed. [19], Section IV: The IoT smart agriculture application introduced by Krishnan et al. will be examined. [20], section V: We will analyze and debate the intelligent healthcare application that Islam et al. developed in this section. [21], issues and limitations in Section VI, critical analysis and future work in Section VII, and the conclusion of the paper in Section VIII.

This paper aims to assess the merits and demerits of each Internet of Things (IoT) application, while also suggesting enhancements for each IOT application to assist researchers in advancing their endeavors by utilizing the most recent technologies, tools, and techniques.

II. CONSPIRED WORKS

There has been significant progress made in the IoT domain. Smart parking, for instance, is one of the Smart Initiatives that attempts to resolve the traditional issues of parking environments in major metropolitan areas. One of the subjects that is gaining increasing attention and is frequently linked to the Internet of Things is intelligent parking. The Internet of Things assumes a central role in the smart city paradigm [7].

The application of Wang's [8] Smart Parking research involved the development of a parking IoT application that utilized the reservation method. Pham [9] proposed in 2015 a parking system that utilized cloud services in an effort to improve performance. Fraifer [10] made a scholarly contribution to the field of Smart Parking by organizing research that presented the conceptual framework for Smart Parking systems incorporating CCTV devices. Khanna's research [7] subsequently resulted in the development of a cloud-integrated, Internet of Things-based intelligent parking system.

Within the domain of agriculture, Thakur et al. [11] introduced a device capable of autonomously irrigation, temperature measurement, and soil moisture assessment. For the purpose of monitoring data transmission and farms with camera sensors, Sanchez et al. [12] have developed a monitoring system. A greenhouse intelligent wireless sensor network system was proposed by Jahnavi et al. [13]. A survey was undertaken by Thakur et al. [14] in order to acquire precise data regarding a range of crops and sensors that are compatible with wireless sensor networks and the Internet. Regarding the health field Further research in this field is elaborated upon as follows:
a
An Internet of Things application for medical monitoring was presented by Acharya et al. [15] in an Internet of Things environment. The system that was built monitored a number of fundamental aspects of human health, including the heartbeat, electrocardiogram, temperature of the body, and respiration. It is a Raspberry Pi, a pulse sensor, a temperature sensor, a blood pressure sensor, and an electrocardiogram sensor that are utilized here. The information was gathered from the sensors, then transferred to a Raspberry Pi for processing, and finally made its way back to the Internet of Things network. There is no interface for data visualization that has been built, which is the most significant disadvantage of the system.

The authors Trivedi et al. [16] proposed an Arduino-based mobile gadget that would be used for monitoring various health metrics. The data collected from the sensors is analog, and it is then transmitted to the Arduino Uno board. The analog values that were recorded are converted into digital data by use of the analog-to-digital converter that is included into the interface. Bluetooth is responsible for transmitting digital data to the gadget that has been designed. One of the most significant drawbacks is that the Bluetooth device makes use of a module that does not cover a sufficient amount of space.

Gregoski et al. [17] unveiled a heart rate monitoring system that operates on a smartphone. A moving light and a camera are utilized by the system to monitor finger blood. The developed system delineates an integrated apparatus that transmits an individual's pulse wirelessly to a computer, enabling individuals to assess their heart rate by exclusively glancing at their smartphones rather than exerting their palms manually on each occasion. While this design is commendable, it is impractical in situations where continuous cardiac monitoring is necessary.

Kumar et al. [18] created an application for IoT safety monitoring. A body temperature sensor was employed, while a pulse sensor was utilized to measure the pulse. Arduino transmitted the data to the cloud through the utilization of the Wi-Fi and Ethernet shield module. However, because an Arduino Uno was utilized, a significant number of sensors were unable to function effectively. We will examine the three domains of IoT applications—smart city, health, and agriculture—in our survey paper.

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III. INFORMAL PARKING

3.1 Anatomy of the System

In the context of smart cities, Balhwan et al. [19] introduced a smart parking system (Smart parking) that eliminates the necessity for fuel and time expenditures by automatically locating vacant spaces in parking lots. The Internet enables users to conveniently retrieve the information regarding the availability of parking spaces, which is determined by a variety of sensors installed in the parking area.

The intelligent parking prototype that has been developed is capable of discerning whether a given parking space is vacant or occupied. The data gathered by the sensors is subsequently transmitted to the cloud, where a user can retrieve the information through an Android application (see figure 1).

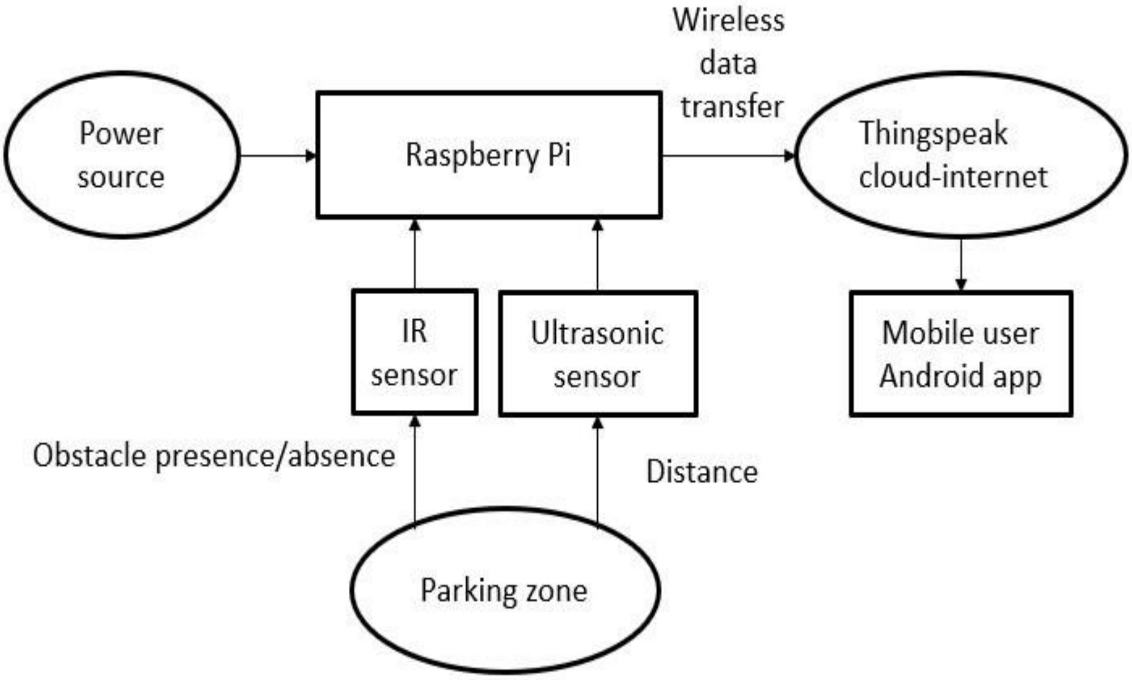

Fig.1 Intelligent parking system architecture

The procedures outlined by Balhwan et al. [19] are as follows:

✓ The occupancy of a parking space is determined by integrating Raspberry Pi with ultrasonic and infrared sensors.

✓ Upon determining whether an obstacle is present or absent, the data is transmitted to "ThingSpeak" via the internal Wi-Fi of the Raspberry Pi.

✓ Data storage is performed on the ThingSpeak cloud. The information is presented in graphical form.

✓ A user's mobile application establishes a connection with the cloud in order to furnish data pertaining to parking spaces, delineating whether they are vacant or occupied.

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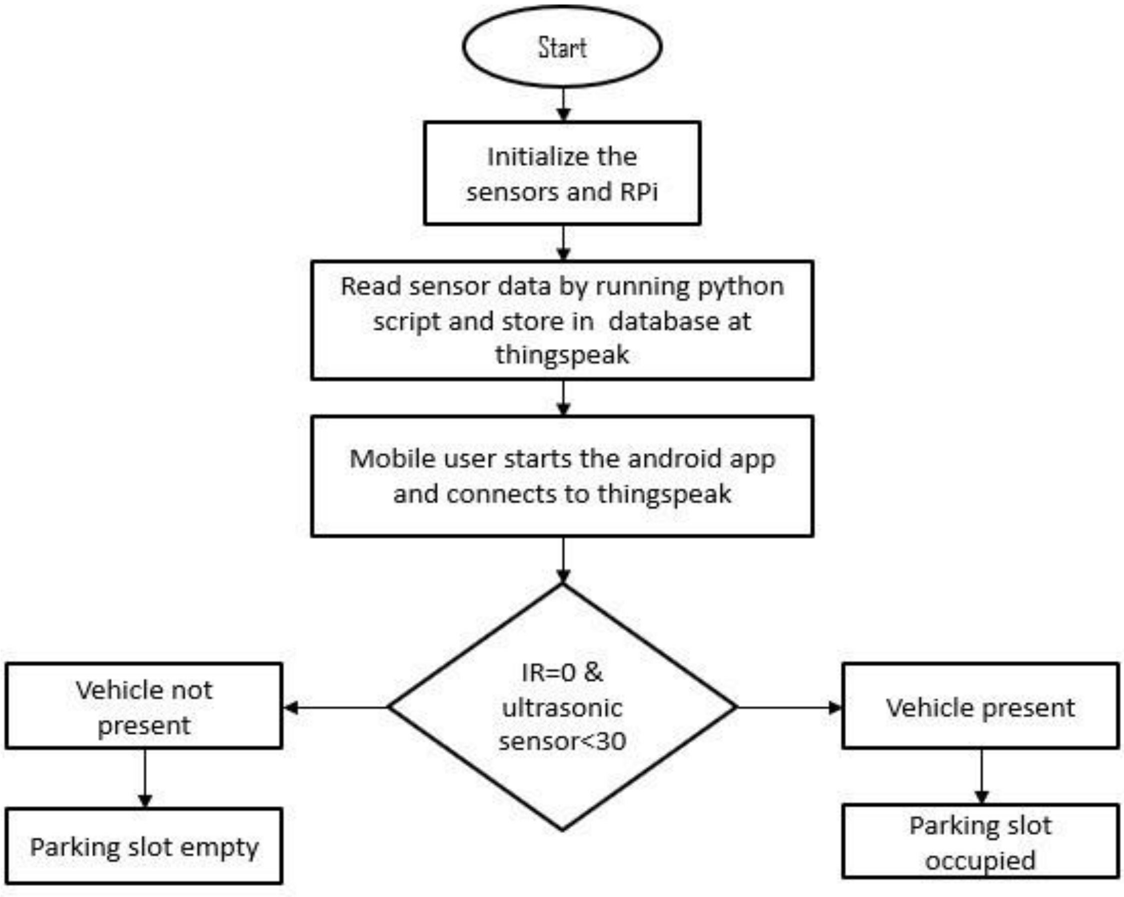

Fig2. Intelligent parking system diagram

3.2 Analysis

One of the merits of the Internet of Things (IoT) application suggested by Balhwan et al. [19] is the intelligent parking system's ability to locate available spaces in parking lots automatically, thereby eliminating the necessity to expend time and energy on manual labor. However, this feature does not account for online reservations requiring payment, which necessitates the following modifications to the prototype:

To reserve a parking space online, the user must perform a space availability query on the system. The user will be redirected to the payment page after selecting one of the available spaces from the database, which will be displayed by the system. The database will be updated and a barcode will be generated for the user upon successful payment.

Utilizing the barcode will grant access to the parking garage. Absent the barcode, access to the entrances will be denied. If parking spaces are available, the parking system will also offer offline reservations; in such cases, users will be required to make a manual payment at the gate. Subsequently, the available spaces will be displayed on the user's display screen. A DC motor, a display screen, and a barcode reader will be stationed at the entrance to facilitate door opening.

Additionally, a secure web application that requires administrator management and a mobile application that users should manage ought to be created. When it comes to hardware enhancements, we can incorporate a motor, display screen, and barcode reader to operate the door. Additionally, to optimize fuel consumption and time management, we can incorporate GPS to signify available parking spaces in our intelligent parking system.

In light of the research conducted by Balhwan et al. [19] on the IoT smart parking application, our focus will shift from the smart city domain to agriculture. In doing so, we shall investigate the IoT application developed by Krishnan et al. [20].

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IV. INSIGHTFUL AGRICULTURE

4.1 Anatomy of the System

It is common knowledge in the agriculture industry that the locations of farmers' fields may extend several kilometers away from their residences. Farmers are occasionally required to visit their fields multiple times throughout the day in order to operate and deactivate the water irrigation devices. They are unable to consistently shield the vegetation from unrelenting precipitation. Krishnan et al. [20] devise a system suitable for autonomously addressing these practical challenges with the intention of surmounting them.

The overall block diagram is illustrated in Figure 3. The monitoring system is comprised of four primary components: the mobile (control unit), the end device node, and the coordination node. An Arduino controller, a GSM, a motor, a plant leaf image soil moisture sensor, a temperature sensor, and a humidity sensor are all contained within the final device node. In addition to functioning as the end device, the microcontroller device coordinates activities within the wireless sensor network. It facilitates data transmission within the network. The sensors consistently gather data, which is subsequently transmitted to the node coordinator. The node coordinator is linked to the web server system through the serial RS232 data interface. The web server performs the data acquisition for real-time monitoring of agricultural parameters. The data may be acquired from the server and subsequently presented on the Android device. The signal control is then transmitted automatically to the coordinator node. The action of the end device is determined by the signal it receives from the coordinator node, which indicates whether the actuator is in the on or off state. The invocation and deactivation of the irrigation motor is represented by imprecise logic. Programming the controller is accomplished using fuzzy principles. Consequently, farmers are able to regulate the motor and water consumption in accordance with the requirements of the land, even via remote surveillance of the agricultural expanse. Upon powering on, the Arduino and GSM Modem/GPRS are initialized. Following system initialization, users are prompted to choose between manual and automatic mode. The Arduino initially verifies the presence of solar power by utilizing the light-dependent resistor (LDR), which is designed to detect sunlight, when automatic mode is activated. In this configuration, the solar panel is affixed to the stepper motor in order to be illuminated in response to the sun's motion. In situations where solar energy is not accessible, the apparatus is powered by a battery. The water level in the agricultural field tank is indicated by the water level sensor that is connected to this system. The relay is connected to the pump, which initiates the circulation of water to the agricultural field, while the moisture sensor detects the degree of soil dryness. The function of the moisture sensor is to determine the soil's moisture content in the crop field. The temperature sensor is responsible for detecting the ambient temperature of the agricultural field. In order to conserve energy, the pump ceases water circulation into the field when precipitation commences and notifies the user via GSM/GPRS. The protective panels are closed automatically in order to shield the crop from the precipitation. Alphanumeric display is utilized to present the data gathered by the sensors. The operational principle of the proposed system is illustrated in Figure 3, while the flowchart of the proposed system is presented in Figure 4.

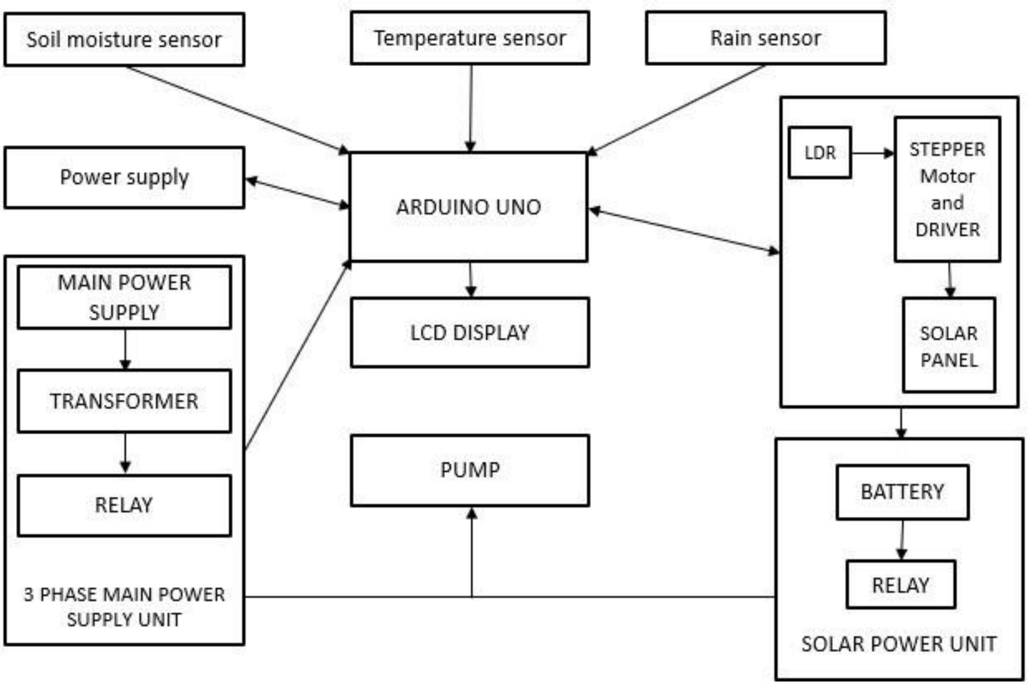

Fig.3 Intelligent irrigation system architecture

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The procedure followed by Krishnan et al. [20].

Initialization of the GSM modem occurs immediately upon power supply activation. The GSM modem establishes communication with Arduino via AT commands. The LCD screen is connected to Arduino in order to accurately display the data that is being monitored by the sensors.

- ✓ Initially, the processor determines whether solar energy is accessible by employing a light-dependent resistor (LDR) that detects sunlight. The photovoltaic panel is connected to the stepper motor via an interface, and the stepper motor driver is likewise linked to the motor.
- ✓ The solar panel exhibits bidirectional motion, ceasing its rotation at the point of optimum solar intensity to recharge the battery with stored energy.
- ✓ In situations where solar energy is accessible, water is supplied to the agricultural field through either solar energy pumps or mains (3 phase lines).
- ✓ The soil moisture sensor monitors the moisture content of the soil, ensuring that it remains within a controlled range of 500 to 850 (dryness or dryness, respectively). When the soil moisture content exceeds 700, water will be pumped to the agricultural field via the engine.
- ✓ The temperature sensor determines the farm's ambient temperature.
- ✓ When the rain sensor detects heavy precipitation, the engine is stifled to conserve energy. Additionally, it deactivates the panel for agricultural protection.
- ✓ The user will be provided with access to all data gathered by the sensors via GSM technology.

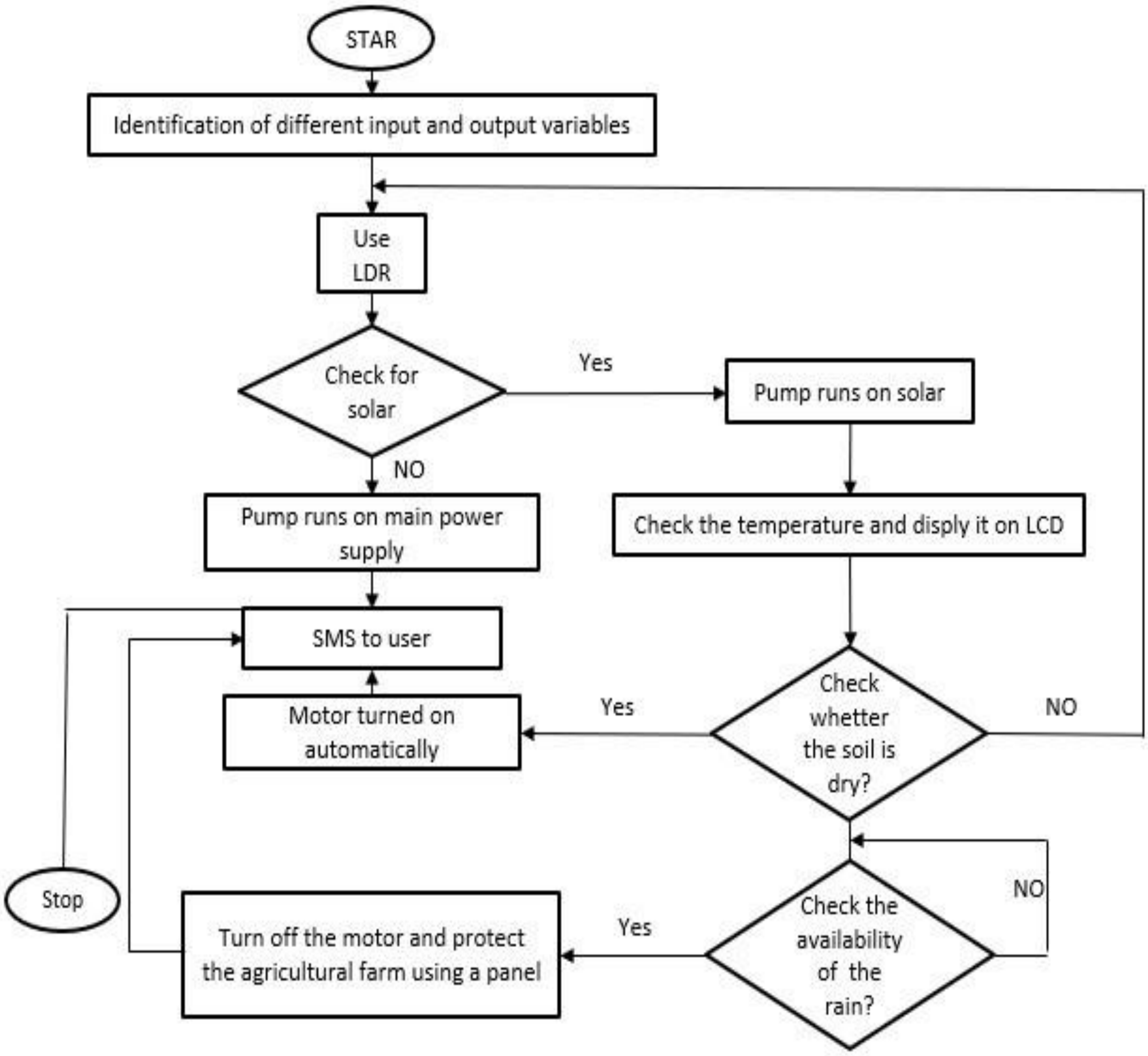

Fig.4 Diagram of a sophisticated irrigation system

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4.2 Discourse

A smart irrigation system was suggested by Krishnan et al. [20]. This system enables farmers to irrigate their agricultural fields through the use of a mobile application, in contrast to the energy-intensive nature of conventional agricultural systems. The system issues confirmation communications regarding job statuses, including environmental temperature, soil moisture level, and engine status in relation to solar energy or primary power sources. The fuzzy logic controller is responsible for generating engine status outputs and calculating input parameters (temperature, humidity, and moisture). Additionally,when it rains, the system powers down the motor to conserve energy. Water and energy savings are demonstrated to be realized by the proposed intelligent irrigation system. The flowchart depicted in Figure 4 and the schematic illustrated in Figure 3 comprise three primary functionalities. The initial function is to monitor the temperature, the second function is to assess the soil moisture level, and the third function is to determine the availability of rainfall. However, the security of the fields was not considered, which is why this prototype must be enhanced with field intrusion detection. This feature is employed for the purpose of intrusion detection and is assessed by means of a passive infrared (PIR) sensor; users will be notified via GSM technology whenever intrusion detection occurs in the field. Without Krishnan et al.'s [20] consideration, the functionality of intrusion detection will increase the level of security against field intrusion.

In light of the research conducted by Krishnan et al. [20] on the Internet of Things (IoT) application for smart irrigation, the focus will shift from smart agriculture to smart health. To achieve this, we will examine the IoT application developed by Islam et al. [21].

V. INTUITIVE HEALTHCARE

5.1 Components of the scheme

Islam et al. [21] propose a system whose central concept is the continuous online monitoring of patients and the status of their rooms. The implementation of the system comprises a variety of hardware components. The assembly of every hardware component occurs during the implementation phase. Figure 5 illustrates the circuit diagram of the developed system. ESP32 is connected to each sensor via physical ports. The ESP32 is utilized as a processing device due to its integrated Wi-Fi module. Figure 5 illustrates the user prototype, in which the system is evaluated by a user while the data is presented on the webserver.

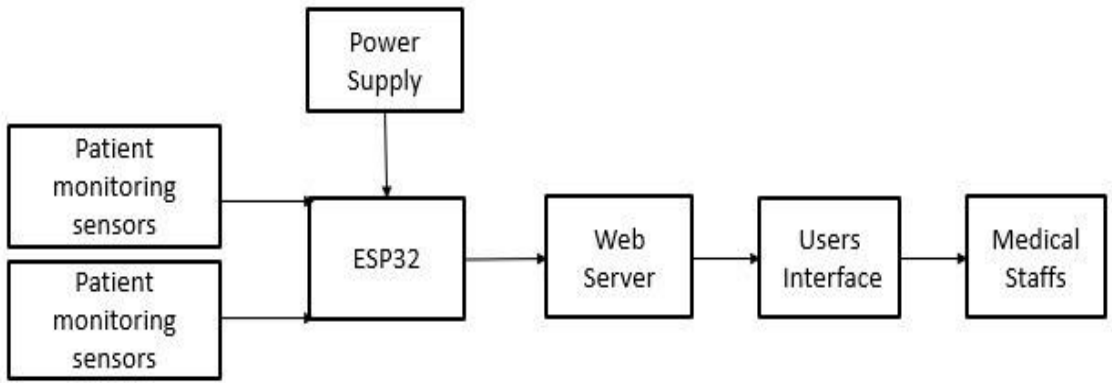

Fig.5 Intelligent healthcare system architecture

5.2 Discourse

A system for monitoring healthcare in hospitals has been proposed by Islam et al. [21]. Emerging technology-based healthcare monitoring systems are currently a major concern for many nations around the globe. Progression in healthcare is being facilitated by the emergence of Internet of Things (IoT) technologies. The IoT-based smart health system proposed by Islam et al. [21] is capable of real-time monitoring of both the patient's health status and the condition of the patient's chamber. This system collects data from the hospital environment using the following five sensors: heart rate sensor, body temperature sensor, room temperature sensor, CO2 sensor, and Co sensor.

In every instance, the developed scheme maintains a percentage error below a specified threshold (<5%). Through the utilization of a portal, the medical staff is able to receive and process the patients' current conditions in order to conduct analysis. Efficiency of the system demonstrates that the developed prototype is highly suitable for healthcare monitoring.

By increasing the efficiency of the current mechanism, this system manages to address the limitations associated with patient health parameter surveillance. It is advantageous in terms of cost, time, and power consumption. It is feasible to obtain precise readings of patients' heart rates and other vital health parameters, which are utilized extensively in the surveillance of patients' health status. IoT enables the sensors to wirelessly transmit data to the server.

The fundamental physical parameters are continuously measured. The patient experiences increased convenience when utilizing these portable devices. The values documented by this system exhibit enhanced accuracy and precision. The time required for the manual technique is decreased. Constant recording of these values [22] results in a reduction in the burden of the physicians. These values may also be communicated via email to other specialists.

The analysis of the IoT application put forth by Islam et al. [21] concludes that storing a patient's medical statistics in the cloud [23] is crucial, as it may prove to be extraordinarily advantageous in the future. Maintaining medical records will empower the patient to make numerous decisions, including determining their weight loss intentions, identifying their primary allergens to medications, and accessing a wealth of other vital information [24].

Additionally, this database ought to aid the physician in deciphering the source of the patient's physical ailment in order to deliver a more accurate diagnosis. To illustrate the comprehensive workflow, Fig. 6 is suggested.

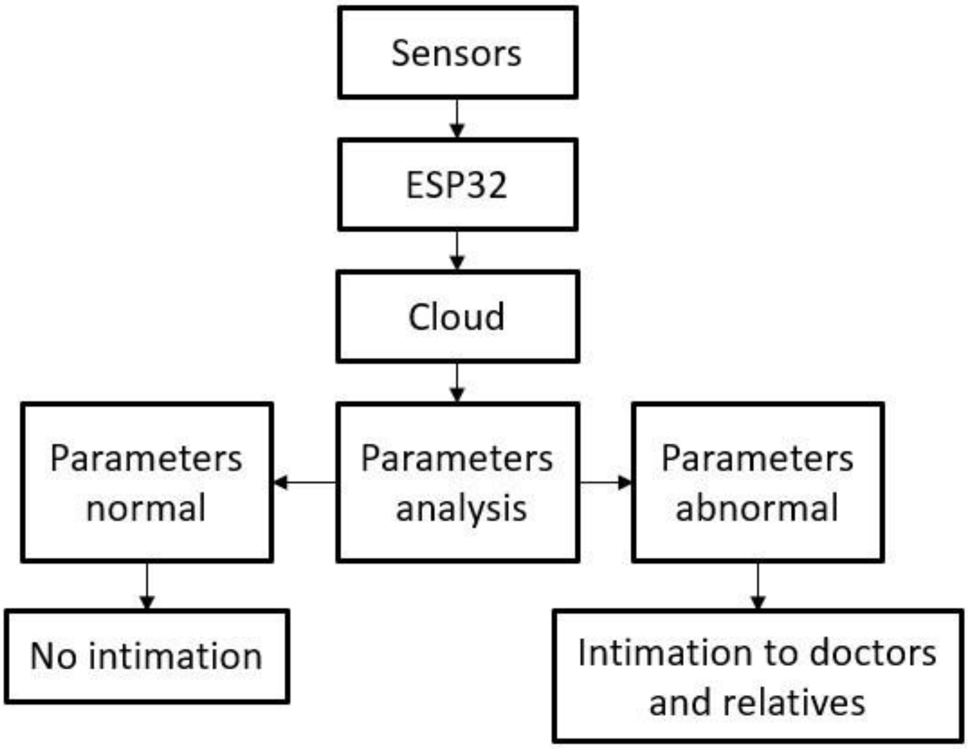

Fig.6 Diagram of an intelligent healthcare system

The analysis of a portion of the design can be enhanced in the future by implementing machine learning and artificial intelligence algorithms.

VI. CONCERNS AND RESTRICTIONS

Much progress has been made in the domains of intelligent agriculture, intelligent healthcare, and intelligent parking, but there is still much that needs to be achieved. The subsequent table enumerates several deficiencies of the three prototypes that were previously examined and proposes enhancements.

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TABLE 1: PROPOSALS FOR 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. Develop a secure mobile applicati on managed by the user. A barcode to get an entrance to the parking area.
Krishnan [20]	Smart Agriculture	The lack of safety in agricultural fields	Detect intrusions in to agricultural fields	Detect the intrusion using a Passive Infra Red (PIR) sensor
Islam [21]	Smart Health care	The absence of machine learning algorithm and artificial intelligence	Analyzed the design part of the application	Using machine learning algorithm and artificial intelligence

VII. COMPARATIVE ANALYSIS AND SUMMARY RESEARCH

This article examines three Internet of Things (IoT) applications: smart city, smart healthcare, and smart agriculture. Through our analysis, we are able to identify the merits and drawbacks of each IOT application and suggest enhancements using cutting-edge technologies, tools, and techniques.

VIII. LAST RESPONSES

The examination of the three domains of IoT—Smart City, Health, and Agriculture—was the primary focus of this paper. We assessed the merits and drawbacks of each IoT application and suggested enhancements. This work will eventually assist scientists in enhancing their work by utilizing the most recent technologies, instruments, and methods.

Subsequent investigations ought to concentrate on the creation and deployment of novel IoT application frameworks that borrow heavily from the aforementioned suggestions for every IoT application. These recommendations are intended to enhance the efficiency of every IoT application while mitigating errors.

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