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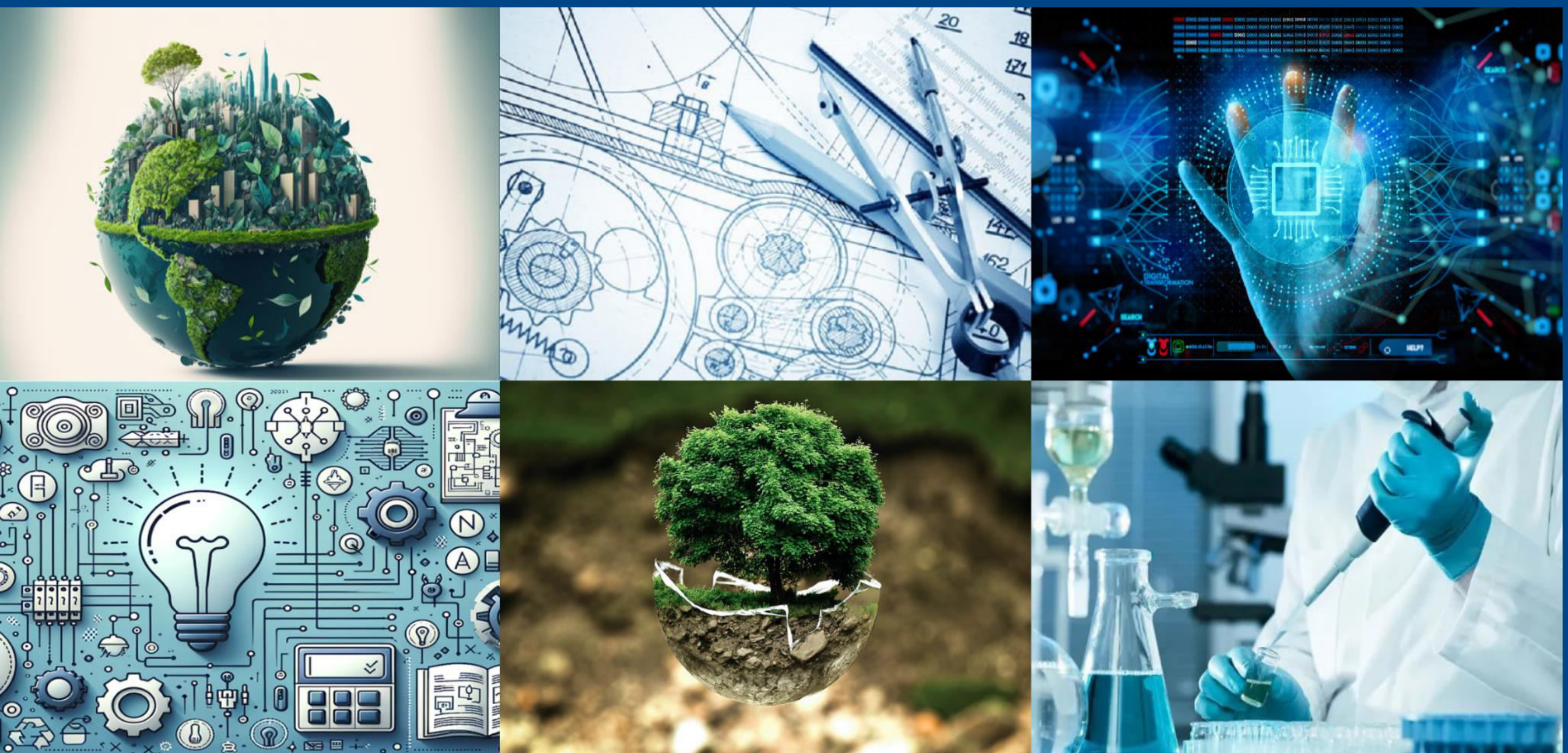

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Smart ICU: IOT-based Patient Health and Room Tracking Device

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ABSTRACT: The Internet of Things (IoT) empowers us to attain a better level of automation by way of developing systems that make use of sensors and join gadgets to the net. In essential care devices like ICUs, continuous monitoring is vital as even slight delays in selection-making concerning patient remedy can cause excessive outcomes, along with permanent disability or loss of existence. Included sensors, whether worn on the body or located inside the surrounding surroundings, enable the collection of comprehensive statistics for both physical and intellectual well-being. Inside the realm of healthcare, the capability and challenges of IoT are in particular highlighted. It offers the opportunity to develop advanced affected person monitoring systems that enhance medical care. A hybrid technique has been delivered, integrating numerous sensors and a multi- camera gadget into a single platform for a wise affected person tracking system referred to as automated Detection of chance conditions and indicators (ADSA) while many ICU devices are ready with sensors to measure vital symptoms, continuous monitoring is regularly missing. An IoT-primarily based framework is proposed to cope with this hole, facilitating fast communication, figuring out emergencies, and initiating conversation with healthcare groups of workers. Furthermore, it enables proactive and timely treatment, lowering the likelihood of errors, and verbal exchange delays, and allowing medical professionals to allocate extra time for particular observations.

KEYWORDS: Automation, Automatic Detection of Hazard Situations and Signals (ADSA), Communication, Communication delays, Continuous monitoring, Disability, Emergencies, Errors, Healthcare, Hybrid approach, Intensive Care Units (ICUs), Internet of Things (IoT), Medical professionals, Multi-camera system, Patient, Patient monitoring systems, Proactive treatment, Sensors treatment

I. INTRODUCTION

The entire populace is increasing each day. The expanding populace has placed considerable pressure on wellness facilities along with clinical jobs. The monitoring continuously deals with tremendous stress in managing numerous concerns such as person monitoring as well as air top quality. This hefty worry about medical care monitoring in city locations has prevented development plus renovation. As the variety of clinically analyzed people remains to increase remote healthcare has come to be a necessary component of our lives. Lately, there has been a raised passion for wearable sensing units as well and these gadgets are currently offered out there at a much more economical cost for specific health care and also health and fitness monitoring. Researchers are checking out using innovative gadgets for clinical applications together with information monitoring.

In most cases, individuals encounter critical circumstances such as cardiac arrest as well as various other health and wellness concerns, which frequently cause an absence of instant clinical aid throughout emergencies. The ICU is where individuals with serious problems are confessed for therapy. In such essential problems, medical professionals are required to have real-time updates on the people's essential indications consisting of high blood pressure, heart price, and also temperature level. An IoT- based individual health and wellness surveillance system is necessary for successfully keeping track of the health of individuals. This system can automate the procedure together with maintaining healthcare specialists upgraded from another location with the web. It is additionally valuable for keeping an eye on ICU individuals plus offering details to physicians, registered nurses and also members of the family. A cutting-edge solution is now available to mitigate the occurrence of sudden fatalities by employing a personal health monitoring device that integrates sensor technology with internet connectivity. This device utilizes temperature and heart rate sensors to track an individual's vital signs, transmitting real-time data over the internet with timestamps. Notably, intensive care units (ICUs) in hospitals rely on sophisticated monitoring systems for continuous patient surveillance. These systems operate in either real-time mode, providing immediate data access, or store-and-forward mode, collecting data for later analysis.

These monitoring systems employ diverse measurement techniques and signal processing algorithms, with their effectiveness influenced by software and communication technologies. To address this, a novel healthcare device based on the Internet of Things (IoT) is proposed. This device incorporates cost-effective sensors, including the ad8232 for ECG readings, a pulse rate sensor for heart rate monitoring, an lm35 sensor for temperature measurement, and a dht11 sensor for ambient temperature. Data collected by the device is stored on a cloud server and accessible via a local website, enabling continuous monitoring by healthcare professionals, caregivers, or family members using an API key. Additionally, SMS alerts can be sent to designated phone numbers in case of deteriorating health.

In countries like Bangladesh, where access to comprehensive healthcare is limited, such a system holds immense potential. The paper provides a foundation for future research in developing user-friendly health monitoring systems. The subsequent sections cover motivation, related works, the proposed system, experimental results, cost analysis, and conclusions, offering a comprehensive exploration of this innovative solution. Section VII concludes the paper.

II. SYSTEM MOTIVATION

A significant portion of a developing nation lacks adequate healthcare services, with a shortage of clinics to cater to the growing population. Many medical facilities are poorly equipped, resulting in a limited number of healthcare professionals available. If a basic health monitoring system incorporating sensors capable of measuring essential human body parameters is developed and linked to the medical office database, it could provide quality medical guidance and facilitate treatment for underserved patients. Additionally, this system could monitor the temperature and humidity levels in the intensive care unit.

III. PROJECT RELATED WORKS

Numerous studies have been conducted to develop various activities and technologies that cater to specific diseases, individuals, or geological levels. For instance, certain research projects, such as those mentioned in references [1-3], focus solely on addressing sleeping disorders. On the other hand, references [4-6] describe the development of a system that monitors individuals' brain bioelectrical activities.

Furthermore, in the realm of healthcare technology, there are specialized systems tailored to cater to the needs of elderly individuals. These systems go beyond mere monitoring and offer functionalities such as posture tracking and fall detection [7, 8]. Notably, in Bangladesh, there has been a surge in research aimed at developing innovative patient monitoring solutions [9]. One notable initiative by BRAC University introduces a comprehensive framework integrating an ECG sensor with a Raspberry Pi, facilitating real-time monitoring via an IoT-based system accessible to healthcare professionals. Similarly, Choton Kanti Das, affiliated with Chittagong College of Science and Technology, has proposed a novel framework focused on remote monitoring of patients' heartbeat and temperature [10]. These endeavours underscore the ongoing efforts to enhance healthcare delivery through technological advancements in Bangladesh. This framework [11, 12] utilizes a heartbeat sensor, temperature sensor, and an IoT-based approach to collect and monitor the data obtained from these sensors.

IV. PROPOSED SYSTEM

In this section, we aim to provide a comprehensive overview of the system, delving into its intricate architecture, a block diagram illustrating its components and connections, a circuit diagram elucidating the [8] electrical pathways, and a thorough examination of the data monitoring system, ensuring a complete understanding of its functionality and operation as shown in Fig. 1.

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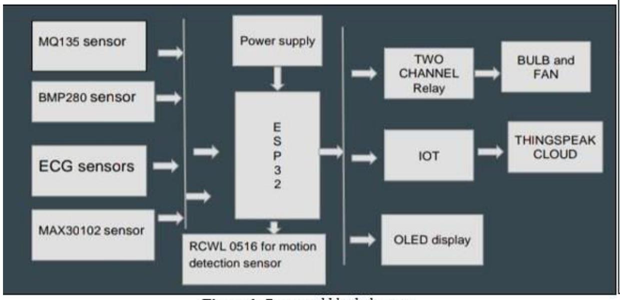

Figure 1: Proposed block diagram.

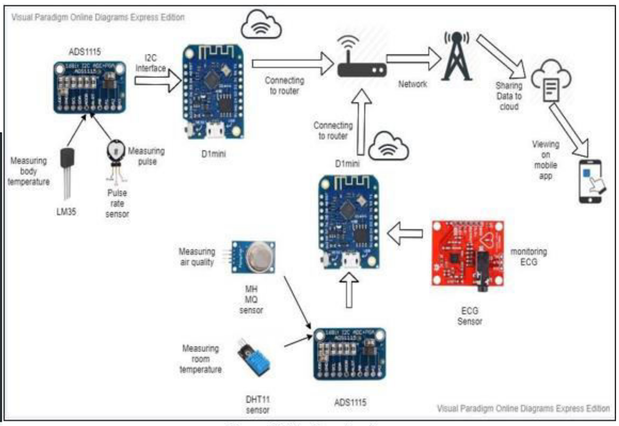

Figure 2: Device structure.

Project Workflow

The diagram presented below outlines the intricate device flow diagram detailing the process of information collection and messaging within the Wi-Fi care device. The device is intricately divided into subsystems, each playing a vital role in the seamless operation of the system.

One key subsystem involves the collection of data from the patient's body through the utilization of bio-sensors. This data is then securely stored in a cloud server for efficient management and accessibility. Subsequently, the collected information is transmitted to the dedicated application for continuous monitoring of the patient's health status.
Another crucial aspect depicted in the diagram is the messaging mechanism, highlighted within a separate Wi-Fi figure. Within this messaging system, proactive measures are taken whenever there is a deviation in the measured parameters such as temperature or heart rate from the established normal range. In such instances, an automated message is promptly dispatched from the mobile application to the designated healthcare professional or caregiver's phone number, ensuring timely intervention and support.

Hardware for this System
ECG sensor: The AD8232 serves as a highly sophisticated signal conditioning block engineered specifically for ECG and various bio-function measurement applications. Its intricate design allows for the meticulous separation, amplification, and filtration of delicate bio-potential signals, even amidst environments rife with interference, such as those characterized by motion or distant electrode connections.

Moreover, the inclusion of the LM35 temperature sensor further enhances the sensor's functionality. Serving as an internal heat level sensor, the LM35 continuously monitors temperature fluctuations within the patient's body. This precision-designed sensor generates an output voltage directly correlated with the temperature in Celsius, providing insights into the patient's thermal state.

Facilitating these intricate operations is the D1 Mini, a compact microcontroller boasting advancements over conventional Arduino devices. Featuring the ESP8266 microchip capable of operating at frequencies of up to 160MHz, the D1 Mini offers enhanced performance in a significantly reduced form factor. Additionally, its incorporation of a 4 MB flash memory segment ensures ample storage capacity for diverse applications.

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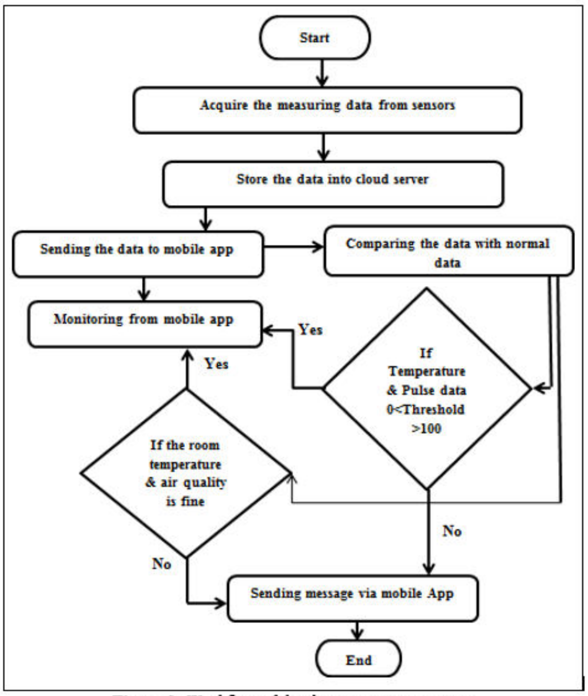

Figure 3: Workflow of the data monitoring system.

MHMQ Sensor: The DHT11 sensor is equipped with a thermistor, which is a type of resistor that changes its resistance with temperature. This allows the sensor to accurately measure the ambient temperature. The capacitive humidity sensor, on the other hand, measures relative humidity by detecting changes in capacitance caused by the absorption or release of water vapour in the air.

One of the key advantages of the DHT11 sensor is its ease of use and compatibility with various microcontrollers. It can be easily connected to popular development boards like Arduino and Raspberry Pi, making it accessible to both beginners and experienced users. The sensor communicates with the microcontroller using a single-wire digital interface, which simplifies the wiring process.

In terms of accuracy, the DHT11 sensor provides reliable measurements within a reasonable range. It has a temperature measurement range of 0 to 50 degrees Celsius with an accuracy of ±2 degrees Celsius. The humidity measurement range is 20% to 90% with an accuracy of ±5%.

Due to its affordability and simplicity, the DHT11 sensor is widely used in a variety of applications. One common use is in monitoring and controlling humidity and temperature levels in heating, ventilation, and air conditioning (HVAC) systems. By accurately measuring these parameters, the sensor helps maintain optimal conditions for comfort and energy efficiency.

Overall, the DHT11 sensor is a versatile and reliable tool for measuring temperature and humidity. Its compatibility with popular microcontrollers, affordability, and accuracy make it a popular choice for a wide range of applications, from home automation to industrial monitoring as shown in Fig. 3.

Software Program of this Model

The primary programming language utilized in ARDUINO for programming in D1 mini is C++. Additionally, Thingspeak has been employed as a cloud server. To enhance the Android software, the Android Studio software program has been utilized.

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Mobile Utility and Cloud Server

To store statistics in a cloud server, an account has been created on ThingSpeak as it can serve as a reliable cloud server.

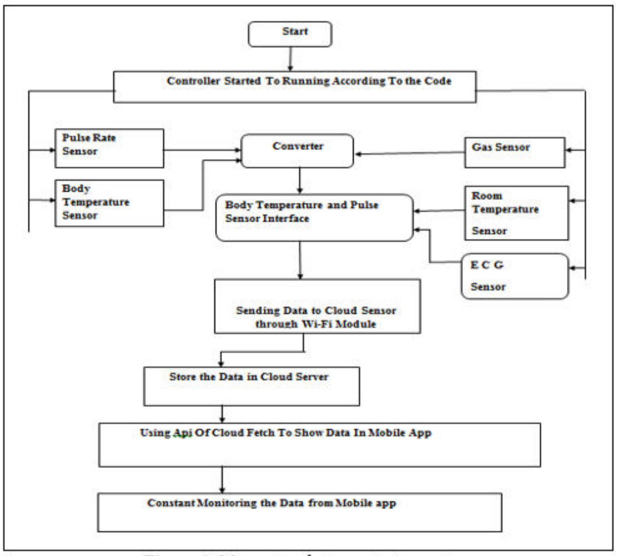
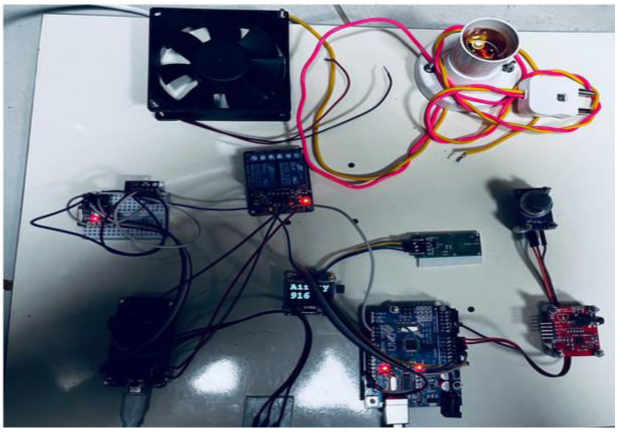


Figure 4: *Messaging data monitoring system.*

Subsequently, a mobile application specifically designed for the local community was developed, incorporating an API data retrieval system within its built-in software. This enables the monitoring of data stored in the cloud server directly from the mobile app. Additionally, a messaging mechanism was implemented within the app, ensuring that whenever the patient's health condition becomes critical, a notification message will be sent to the healthcare professional or caregiver, informing them about the situation as shown in Fig. 4.

V. RESULTS

We have collected data for both healthy and unwell individuals to validate the real-time performance of our device, demonstrating its effectiveness in real-world scenarios as shown in Fig. 5. Table 1 presents some of the experimental findings



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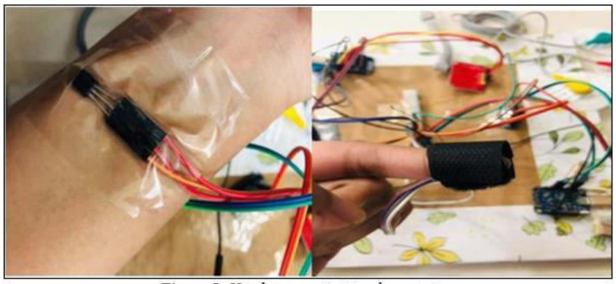

Figure 5: *Hardware project implementation.*

Table 1: *Data collected from the experiment.*

Create Date	Temperature	Pulse	Room Temperature	Air Condition
2024-02-11 09:21:52UTC	98.8	83	28	457
2024-02-12 10:03:38UTC	98.78	91	28	780
2024-02-13 10:07:51UTC	98.77	68	28	707
2024-02-14 06:35:26UTC	98.8	77	23.5	725
2024-02-15 06:59:03UTC	98.6	108	23.7	515
2024-02-16 07:01:25UTC	98.23	101	23.9	602
2024-02-17 14:10:18UTC	98.8	74	23.8	550
2024-02-17 14:11:09UTC	98.8	74	24.2	549
2024-02-18 09:18:22UTC	98.7	78	26.1	433
2024-02-19 09:21:33UTC	98.75	67	25.9	661
2024-02-19 09:31:48UTC	98.07	89	25.2	425
2024-02-22 09:24:08UTC	98.8	86	27	497

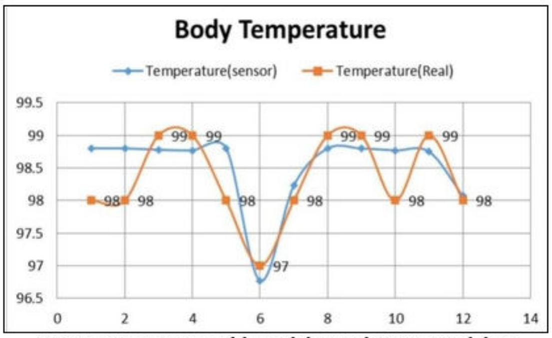

Figure 6: *Comparison of the real data and experimental data.*

The Table presents comprehensive data detailing the body temperature and pulse rates of multiple patients under observation. Accompanying this vital information is a meticulous recording of room temperature and air conditions within the vicinity. This sophisticated monitoring system has been meticulously crafted to ensure the continuous assessment of ICU patient well-being as shown in Fig. 6.

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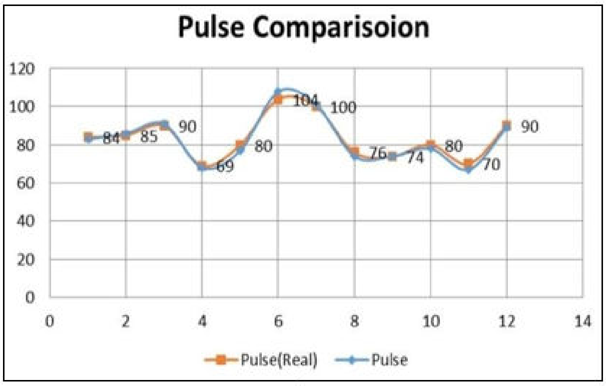

Figure 7: Pulse comparison.

Furthermore, the recorded air condition data consistently fell within the prescribed threshold range of 10 to 1000 parts per million (ppm), affirming optimal environmental quality conducive to patient recovery and comfort. In summary, this comprehensive monitoring system effectively ensures the continuous and accurate assessment of ICU patient health parameters, fostering an environment conducive to optimal care delivery. We collected real data from the same individuals using a thermometer for body temperature and a BP device for blood pressure. The average range from the BP device was 60- 120bpm, which closely matched the range of 60- 100bpm from our system. This was a fairly accurate result compared to the actual pulse rate. We conducted a thorough analysis by juxtaposing the room temperature readings obtained from a thermometer app on our smartphones with actual data. The results of this comparison are visualized in Fig. 6. Our meticulous evaluation revealed exceptionally high levels of precision: 99.6% accuracy for body temperature, 98% for pulse rate, and 99% for room temperature within our system. To quantify accuracy, we employed the formula: error = (Experimental Data - Real Data) / Real Data * 100.
In parents 7 and 8, we shall witness the data stored in the cloud server along with its corresponding cost, which will subsequently be displayed within the mobile application via the cloud server as shown in Fig.

VI. CONCLUSION

In the end, the improvement and implementation of the clever ICU system represent a substantial advancement in healthcare technology geared toward improving patient care and optimizing health centre sources. via the integration of IoT-primarily based sensors and tracking devices, our machine allows actual-time tracking of patient health parameters and environmental situations in the ICU setting. The vast trying out and validation of the machine exhibit its effectiveness in accurately tracking an affected person's vital signs and symptoms, detecting abnormalities, and providing timely indicators to healthcare providers.

Moreover, the clever ICU device offers precious insights into affected person fitness developments and room situations, facilitating records-pushed decision-making and proactive intervention techniques. By utilizing IoT technology, our system boosts the effectiveness of ICU operations, simplifies workflow methods, and ultimately enhances patient outcomes.

This project proves to be extremely beneficial in the current era as individuals are facing various health problems. It is specifically tailored for ICU patients requiring urgent care and continuous health supervision, especially those in critical conditions. The project aims to assist not just the patients, but also the medical professionals. Our innovative system is highly efficient and environmentally friendly. It is user- friendly and cost-effective. In our future endeavours, we aim to integrate advanced capabilities for real-time patient video surveillance or monitoring utilizing a mobile application. This innovative approach will enable healthcare providers to remotely monitor patients' conditions with enhanced accuracy and immediacy, ensuring timely intervention and personalized care.

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