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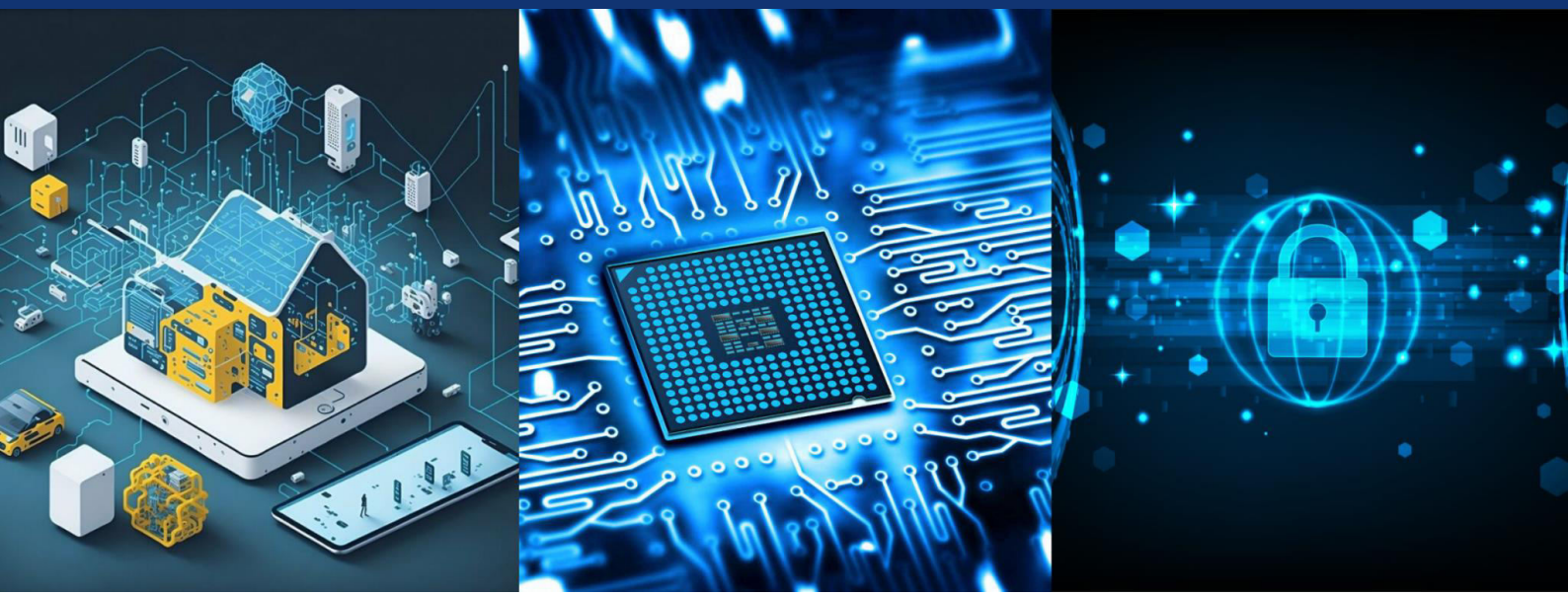

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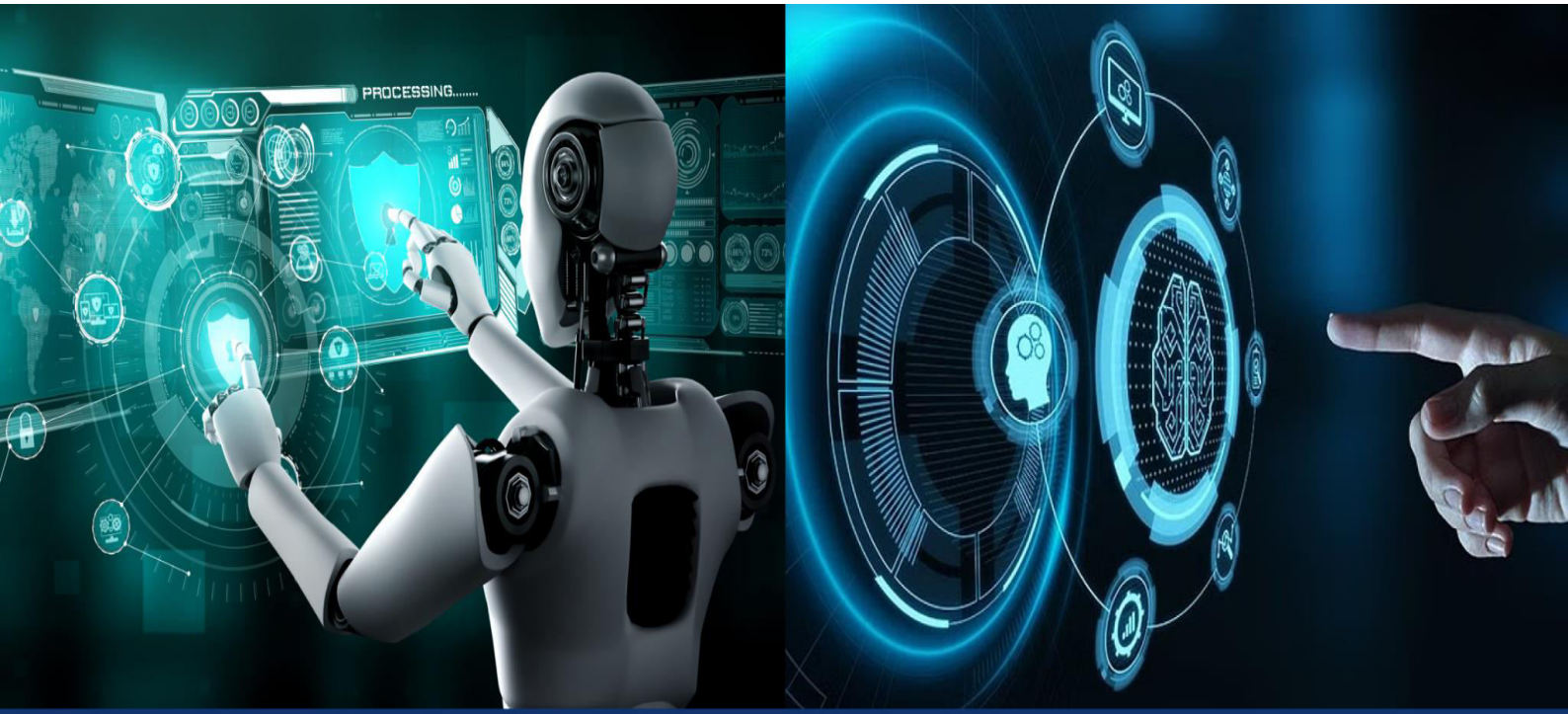

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Design and Development of Wearable Air Bag System with Health Monitoring and Alert System

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ABSTRACT: This paper presents the design and development of a wearable airbag system integrated with health monitoring and Internet of Things (IoT)-based alert mechanisms to enhance personal safety during accidental falls. The proposed system continuously monitors the user's movement using an accelerometer and detects fall events based on sudden changes in acceleration and orientation. In addition, physiological parameters such as heart rate are measured to assess the user's health condition during critical situations. When a fall is detected, the system first provides a vibration alert to confirm the event and reduce false alarms. If the user does not respond within a specified time, the system automatically deploys an airbag to minimize the impact of the fall and prevent severe injuries.

Simultaneously, the IoT module transmits real-time emergency alerts, including the user's location and health data, to caregivers or emergency contacts for immediate assistance. The integration of motion sensing, health monitoring, and automatic protection ensures improved accuracy and faster response compared to conventional fall detection systems. Simulation results demonstrate that the proposed system effectively detects falls, reduces false positives, and ensures timely airbag deployment and alert transmission. This system is particularly beneficial for elderly individuals, patients, and workers in high-risk environments, offering a reliable and efficient solution for real-time safety and remote monitoring.

KEYWORDS: AT mega 328 Microcontroller, Air Bag, Internet of Things (IOT), Heart Beat Sensor, Vibrator

I. INTRODUCTION

Accidental falls are a major concern for older adults, people with movement problems, and workers in factories. These falls can become more dangerous if help is delayed, the fall isn't noticed, or the person can't call for help. Most fall-detection systems only provide a warning or alert, but they don't actually protect the person when they fall. Many health devices people wear don't have features that automatically help in an emergency. To solve these issues, this project introduces a smart wearable airbag system. It can detect falls, monitor health, and send alerts through the internet. It uses sensors like accelerometers, gyroscopes, heart rate monitors, and optionally oxygen level sensors to track movement and body condition. If a fall is detected, the system gives a vibration warning to prevent false alarms. If there's no response, it quickly inflates an airbag to help prevent injury. At the same time, it sends real-time messages and location information to caregivers or emergency services using internet-based communication. This system improves safety by offering impact protection and makes sure help arrives on time, making it useful for healthcare, living assistance, and workplace safety.

Falls are a serious issue for older adults around the world, as they can limit movement, independence, and quality of life if not stopped quickly. Falls often cause serious injuries like hip fractures, and if the person is hurt or unconscious, they might not be found for several hours. To avoid these problems, fall-detection systems are important for monitoring and preventing the harm caused by falls. But many existing systems use separate sensors and aren't very effective because they often give too many false warnings and can't protect people if they fall. The main idea of this project is to create an Arduino-based system that not only detects falls in the elderly but also protects them by inflating an airbag. A new Android app has been developed to receive alerts and send an SMS to the elderly person's family with their location using smart phone features. The system was designed using Solid Works. The airbag is worn around the waist and is connected to an Android phone via Bluetooth. The fall detection uses a gravity sensor attached to an Arduino board to sense a fall. If a fall is detected, the system triggers an air valve to inflate the airbag from an air tank and sends

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a warning to the elderly person's app. The system also uses the phone's GPS to track the person's location and sends an SMS to the chosen emergency contact.

II. RELATED WORK

B. S. Mostafa, A. H. Miry, -In this work, a system is proposed and made to monitor important health signs using IoT and artificial intelligence, specifically through fuzzy logic. The system uses AT Mega and ESP32 microcontrollers to help with health monitoring. To help caregivers or doctors make decisions, the results are shown on a dashboard. Several sensors are used to get three applications, two of which are directly related to health, and one is related indirectly. The first application is the most important one, which checks the person's condition and tells if it's normal, abnormal, or dangerous by measuring three vital signs—heartbeat, body temperature, and blood oxygen level. Fuzzy logic is used in the controller (Arduino) because it provides fast and accurate data processing, which leads to smart health services that are close to real life. The second application is for detecting the corona virus, which is especially risky for the elderly. It uses two important signs: body temperature and blood oxygen percentage

S. Saleh, B. Cherradi, O. El Gannour, -In the past ten years, healthcare systems have played a key role in improving medical services by allowing remote monitoring and diagnosis of patients' health. These systems, whether in hospitals or other health centers, have grown a lot with the help of new technologies. They are now of great interest to many countries around the world. Portable healthcare monitoring systems (HMS) rely heavily on IoT technology because of its effectiveness and reliability in many areas, including telemedicine. This paper introduces a portable healthcare system that works in an IoT environment and can be controlled via a smartphone app. The goal is to make it easy to use. The system tracks a patient's body signals and their living environment in real time and manages databases automatically. Also, the paper compares three servers to see which one is best for transferring data from the system to the servers.

M. Beri, B. Kumar, S. Tiwari -This system uses gadgets and sensors to monitor health, and it uses light to measure the amount of oxygen and other gases in the user's blood. This is something new and innovative in this era, and we have developed and achieved this IoT-based health monitoring system based on the ESP32 project. It checks the patient's levels and shows the results to the doctor online. It's small and easy to carry. It helps in finding and stopping illnesses by providing many results that show the patient's status. It is based on IoT theories. It is cheaper and smarter compared to similar hardware.

D. Hercog, T. Lerher, M. Trunti, -The Internet of Things (IoT) has become a big change in many areas, including home automation, industrial control, environmental monitoring, agriculture, wearables, health monitoring, and more. The growing number of IoT devices has encouraged schools and colleges to include IoT in their education because there is a high demand for these skills in the job market. This paper introduces educational tools and technologies that make it easier to design, build, and test IoT applications. The paper also describes an introductory IoT course that students take first, and then presents some of the projects they develop and implement later on their own.

III. EXISTING SYSTEM

In the current systems used for fall detection and personal safety, most devices use simple motion sensors like accelerometers and gyroscopes to spot sudden movements or falls. These systems usually send a warning to a phone or caregiver when a fall is detected, but they don't offer any physical protection to help lessen the impact of the fall. They also don't include health monitoring features, so they can't track changes in heart rate or other important body signs that might show the user is in trouble after a fall. Because of this, there are often false alarms, and help might be delayed if the alert isn't seen or heard right away. Also, most of these systems don't have advanced features like automatic air bag deployment or continuous monitoring through the internet of things (IoT), which limits how well they work in dangerous situations. So, the main job of these systems is to warn the user or caregiver, not to stop injuries from happening.

IV. PROPOSED SYSTEM

The proposed system uses advanced sensors, health tracking, and automatic protection all in one wearable device. The device has vibration alerts and motion sensors that keep watching the user's movement to catch a fall. At the same

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time, it monitors the user's heart rate to detect signs of stress, loss of consciousness, or sudden changes in body condition. When the system detects a fall along with a drop in heart rate, it first sends a vibration alert to confirm the situation and help avoid false alarms. If the user doesn't respond quickly, the system automatically inflates an air bag to help protect the body from injury. Along with this physical safety feature, the device connects to the internet to send instant alerts with health information and the user's location to caregivers or emergency contacts. This helps get help quickly and lowers the risk of serious harm. The whole system is built to offer real-time protection and quick support from a distance, making it very useful in emergencies.

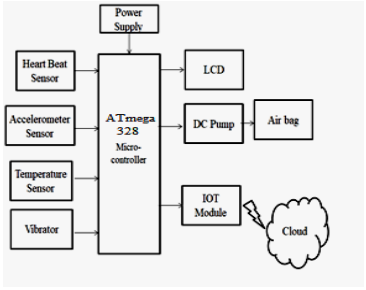

Fig.1.Block Diagram

V. PSEUDO CODE

Step 1: Initialize all sensors (Accelerometer, Pulse Sensor, IoT Module).
Step 2: Continuously read motion and health data from sensors.
Step 3: Calculate total acceleration using threshold condition.
Step 4: Check the below condition for fall detection till system is active
if (Acceleration ≥ Fall_Threshold)
Detect orientation change
else
Continue normal monitoring
end
Step 5: Verify the fall condition
if (Orientation_Change == TRUE)
Activate vibration alert
Wait for user response
else
Go to Step 2
end
Step 6: Check user response
if (User_Response == TRUE)
Cancel airbag deployment
else
Proceed to next step
end
Step 7: Calculate heart rate condition
if (HR < Min_HR OR HR > Max_HR)
Trigger airbag deployment
else
Trigger airbag deployment
end
Step 8: Send alert through IoT module
- Send location (GPS)
- Send health data
- Send emergency message

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Step 9: Update system status and reset parameters.
Step 10: Go to Step 3.
Step 11: End.

VI. SIMULATION RESULTS

The proposed wearable airbag system with integrated health monitoring and IoT-based alert mechanism was simulated to evaluate its performance under different conditions. The simulation results demonstrate that the system effectively distinguishes between normal human activities and fall events using acceleration threshold analysis. During normal activities such as walking and sitting, the acceleration values remained within a stable range, whereas a sudden spike in acceleration was observed during fall conditions, enabling accurate fall detection.

To minimize false alarms, the system incorporates an orientation check and a user verification stage through vibration alerts. If the user fails to respond within the predefined time, the system proceeds with emergency actions. Additionally, the heart rate monitoring module plays a crucial role in validating the severity of the fall. The simulation shows that the heart rate remains stable under normal conditions but exhibits abnormal variations, such as a sudden drop, during fall scenarios, improving the reliability of detection.

Once a fall is confirmed, the system successfully triggers the airbag deployment within a very short response time, thereby reducing the potential impact of injury. Simultaneously, the IoT module transmits real-time alerts, including location and health data, to caregivers or emergency contacts. The communication delay observed during simulation was minimal, ensuring timely assistance.

Overall, the simulation results confirm that the proposed system achieves high accuracy in fall detection, reduces false positives, ensures rapid protective action, and provides reliable emergency communication, making it highly effective for real-time safety applications.

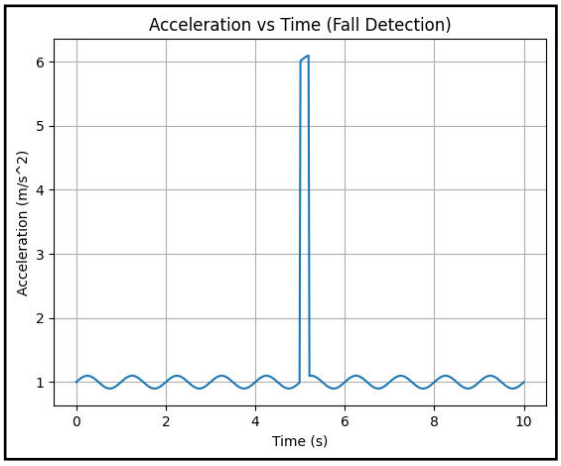

Fig.2.Acceleration vs Time (Fall Detection)

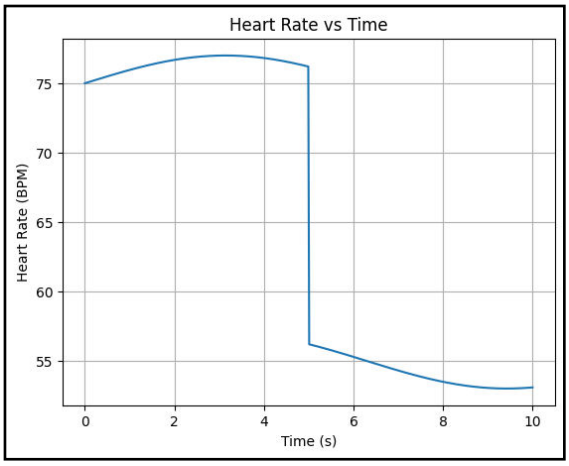

Fig. 3. Heart Rate vs Time

VII. CONCLUSION AND FUTURE WORK

The proposed wearable airbag system integrated with health monitoring and IoT-based alert mechanisms provides an effective solution for enhancing personal safety during accidental falls. The system successfully combines motion sensing, physiological monitoring, and automatic protection to detect fall events accurately and respond in real time. By incorporating accelerometer-based fall detection along with heart rate analysis, the system reduces false alarms and improves reliability. The automatic deployment of the airbag minimizes the impact of falls, thereby reducing the risk of serious injuries. Additionally, the IoT-enabled alert system ensures that emergency notifications, along with the user's location and health status, are promptly transmitted to caregivers or emergency services. Overall, the system

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demonstrates high efficiency, quick response, and reliability, making it suitable for elderly individuals, patients, and workers in hazardous environments.

In future work, the system can be further enhanced by integrating advanced machine learning algorithms to improve fall detection accuracy and adapt to different user behaviors. Additional physiological parameters such as blood oxygen levels (SpO_2) and ECG signals can be incorporated for more comprehensive health monitoring. The design can also be miniaturized and optimized for better comfort and longer battery life. Furthermore, the inclusion of GPS-independent localization techniques and cloud-based data analytics can improve tracking and long-term health assessment. Enhancing wireless communication reliability and incorporating smart emergency response systems can make the device more robust and scalable for real-world deployment.

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