IoT ENHANCED ELDERLY CARE: A COMPREHENSIVE MONITORING SYSTEM

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ABSTRACT: The elderly are left alone in their houses because of growing industry and the exodus of people seeking better prospects for employment and education. They usually have no one to take care of them. In very severe situations, such as medical problems or slipping and falling, they can be left to rely only on their elderly spouses for assistance. This project will integrate several features, such as fall detection, person tracking, and live video monitoring at home. It will also involve an IoT wearable device with sensors, a local MQTT server that can connect to the home's IoT devices, and communication with Google Cloud services. This project will provide features for elderly to live peacefully in their homes in addition to monitoring functions.

KEYWORDS: *Internet of Things; MQTT; Cloud Computing; Elderly Care*

1.0 INTRODUCTION

A population's mean or median age shifting toward older ages is known as population aging. Since the number of people 60 years of age and beyond is rising sharply in many nations, it is an intriguing global problem. Many elderly individuals live alone at home with their families' youthful members working outside the house. Approximately one billion individuals worldwide are 60 years of age or older, making up 12.5% of the total population. The aging population of the globe is predicted to reach 2.1 billion by 2050, making up 21.6% of the total population.

Internet of Things technologies have the potential to change the healthcare industry. By enabling better treatment and cost savings via at-home regular care, they may lessen the burden on the healthcare system and its resources. Wearable technology and the Internet of Things (IoT) may provide effective solutions for senior healthcare. These technologies have received a lot of attention lately and have the potential to help in a number of senior healthcare settings. They may also help senior people live longer and can continue leading independent lives. People may wear wearable devices, which are a component of IoT systems, to track their physiological data and physical activity. These gadgets can follow, evaluate, and direct users' movements, vital signs, and behavior since they are integrated with sensors and analytical algorithms.

The necessity for a real-time monitoring system has been made up for by the realization that older people are more susceptible to health problems because of declining physical function. An abnormality in the blood circulation system, which may be brought on by shock or falling, is the leading cause of mortality for the elderly. Elderly people who fall are at risk of serious injury or perhaps death if they do not get emergency medical attention.

IoT might have several uses in the field of senior healthcare. IoT research and applications in healthcare, however, are now focused on specific scenarios and regions. We thus want to use our work to enhance and add new features to IoT-based elder care systems.

2.0 TERRITORY SURVEY

An architecture that employs wearable sensors to monitor body vitals including blood pressure, heart rate, body temperature, and blood glucose was suggested by the authors of the article "Structural and behavioral reference model for IoT-based elderly health-care systems in smart home" [1]. The temperature sensor and gas sensors (CO and CH_4) were among the other environmental sensors that the researchers used. To greatly simplify the life of the elderly, the approach suggested in [1] also makes use of smart locks and prescription reminder systems. This is an extremely complex Wireless Sensor Network that allows precise acquisition of important bodily data. A few of the drawbacks include: The suggested method does not make use of any cloud setting. The approach could be functional for a few hundred users, but if this number is exceeded, usability issues might arise. It is not very scalable to use the recommended design. There is no machine learning or deep learning model that can forecast health issues or falls in the elderly population.

Based on the elderly person's heart rate, blood oxygen saturation, breathing rate, and body temperature, the researchers in [2] employed machine learning and the Gaussian algorithm to forecast whether the person is experiencing any health problems. In the event of an emergency, the caregiver is informed of the senior's whereabouts and health. A fall detector is made possible using an accelerometer. Utilizing the AWS cloud is a huge benefit. It makes two things possible: The first is effective web-based sensor monitoring. This feature allows the admin to be informed if any sensor node loses connectivity. It is possible to quickly identify and swap out this node. Utilizing the AWS cloud increases the architecture's overall scalability and futureproofing, which is the second argument. Among the drawbacks was the fall detection feature's weak logic foundation. Here, too, the smartphone app in use is basic and lacks some crucial information.

A single-board computer was used by the researchers in [3] to connect body temperature, heart rate, EEG, and ECG sensors. A Deep Learning model that predicts if an elder has a problem was trained using the gathered data. This architecture's deep learning model greatly improves the accuracy of the emergency events that are triggered. The fact that the suggested technique uses FPGA to process the deep learning model and visualize data appears excessive, among other drawbacks. AWS EC2 instances might take the role of FPGA, increasing the scalability of the whole system.

In article [4] put out another creative design that took advantage of the Social Internet of Things concept. This comprises wearable technology, such as smartwatches, and other health vital monitoring devices, as well as many sensors that are linked to one another. The construction of a local Internet of Things network may be relatively economical and straightforward. Among the drawbacks were: These notifications are not well-informed. This implies that there might be some erroneous negatives or positives sent out. This may be harmful. In [5], the machine learning model was trained by the researchers using the SisFall public dataset. They have identified the best kind of supervised learning for this application using Motion-DT sliding window SMA. 6LoWPAN has been used in the architecture suggested in [5] to enable communication between the IoT Gateway and the wearable fall detection device. The machine learning model and a web server to notify caregivers and medical professionals in the event of an emergency were both incorporated in the IoT Gateway. The primary benefit of the suggested design is that it makes use of 6LoWPAN to facilitate communication amongst Internet of Things devices in the household. Compared to WiFi/MQTT, which is used in the majority of other elder care service designs, this is more dependable.

Machine learning was used in the eldercare system suggested by [6] to categorize speech orders from the microphone and fall signals from the sensors. It is necessary to train the model. The model used in this study is separated into accelerometer-based and acoustic-based categories. Two categories of datasets are used in acoustic-based research: voice command sounds (which are recordings of senior voices saying things like "need help" in WMA format) and fall noises. The CNNs for KWS algorithm was used in this study. Voice Command 1, Voice Command 2, fall, not fall, idle, and so on are all included in the output class. An accelerometer and a wearable device connected to the old person detect a fall signal, which is then classified by the accelerometer-based model. In the event of a fall or irregular pulse, the system may sound a warning. The home unit will use a push mechanism to notify mobile devices if the system senses a fall. Among the drawbacks were: Each user must have their equipment calibrated accordingly. The model operates on the presumption that sound is recorded in the devices, which may not always be the case. According to the methods suggested by [7], a timestamp is appended to data that is collected and stored from various sensors. Three door sensors were utilized in the system described in [7], and the timestamp is used to record the door open event for each sensor. The organizer module will utilize the list that contains these values. The list is iterated over by the organizer, who separates the timestamp and event values. For a specified time period, the analyzer calculates the central trends of the time intervals between successive occurrences. The analyzer determines the mean of each day's mean for a specified time period once data are collected for analysis. The risk calculator makes a comparison between the duration of the old person's last activity and the tolerance limit. Elderly people do not need to wear any devices on their wrists or other body parts to use the system. Among the drawbacks were: The suggested technique prevented false catastrophe alerts, but it was still unable to prevent all of them, mostly because the elderly subject's routine had changed. [8] discussed possible uses of wearable IoT technology in the care of the elderly. In addition to the categories of data gathered and IoT devices used, [8] has identified 11 primary areas of IoT applications in the healthcare of the elderly. The hierarchy for such application areas is one of the study's most important conclusions. Comparing the study results to other literature, several developing areas of applications are provided.

Among the drawbacks were: To remedy the flaw in the coding system and update keywords, the study must include additional information about newly developing sectors. The architecture put out by [8] included wearable technology, servers, databases, and a mobile application that served as an information source and could instantly notify family members who were not at home with the elderly about their health. The system can detect falls with a 90% accuracy rate, and its battery source allows it to run for up to 6.5 hours. [10] has studied previous reviews and particular case studies in the field to find, identify, and analyze commonalities. Wearables, cameras, microphones, smart home sensors, and both indoor and outdoor tracking are examples of IoT technology. The evaluation of frailty, cognitive state, and other problems, together with fall prevention, support, and aid, are the main objectives. Some studies are actions in and of themselves to enhance the healthcare conditions of the individuals, in addition to evaluation and monitoring. Common frameworks for interoperability, privacy, and IoT-specific security management are among the outstanding concerns. A few of the drawbacks includes Acceptance criteria include battery life/energy consumption, size, weight, comfort, and simplicity of use of both hardware and software user interfaces. Performance, accuracy, and greater adaptability for biometric applications in healthcare are required, whereas an ideal balance between these comfort characteristics is often satisfied in lifestyle applications of retail items.

3.0 PROPOSED ARCHITECTURE

The basic concept behind the implementation is to make sure that family members of the elderly get prompt notice if a fall is detected and that the elderly enjoy their time living alone in their homes.

Figure 1 depicts the high-level system architecture that is being employed in this investigation. The cloud server and database, an Internet of Things wearable with sensors, and a local MQTT server—which can connect and interact with Google Cloud services—are the key elements of this project's design.

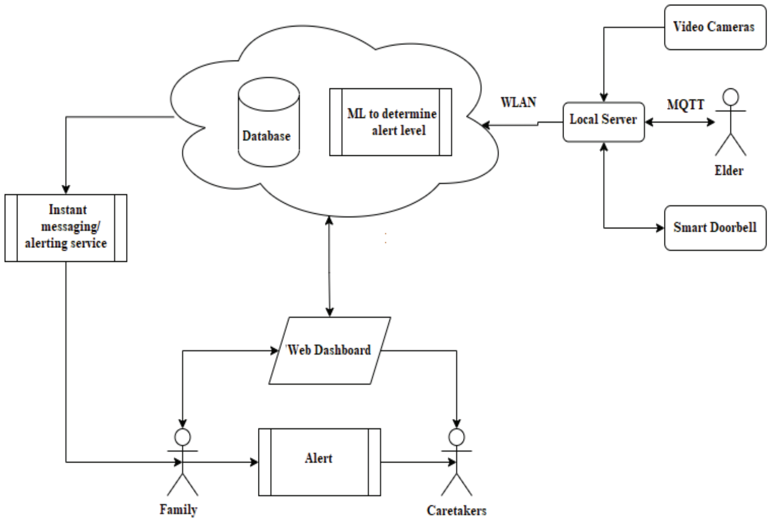

Figure 1: Proposed Architecture

3.1 The cloud architecture

Google Cloud Architecture is utilized in the suggested fix. This decision is based on the future scalability potential as well as the simplicity of setup and usage of Google's cloud services. Use is made of Google Cloud's real-time database, firestore, and Google Firebase's authentication services. Google Firebase's authentication services are used to provide user authentication on the web interface. Users are provided with the option to log in directly using their Google account or by using an email address and password.

The user will be able to see any recent events after logging in. In addition, the user's email address receives these alerts via the IFTTT and SMS services. The Twilio API service is used to send SMS messages.

3.2 IoT Wearables and IoT Devices being used

One of the IoT devices in the suggested architecture is a wearable one that has sensors to measure different physiological functions. The old person wears these sensors, which are interfaced with a NodeMCU, on their body. In the future, panic buttons will be placed around the home so that an elderly person may push them right away if they get distressed. All of their caregivers will get an alert as a result.

A gas sensor is added to detect gas leaks, which are frequently missed until the very last minute. It may identify leaks of cooking gas and other toxic gases, such as carbon monoxide, and notify the local emergency services via notifications on their web portal login. Additionally, a smart doorbell is being included in the design to improve senior citizens' safety at home. If the elderly person is unable to access their door due to immobility, family members may remotely unlock this lock on their behalf. Visitors will have the ability to ring the doorbell in the event that they arrive. This activates the Raspberry Pi's camera [9]. The elder will see a photo that the Raspberry Pi has taken. The elderly person may choose whether or not to remotely open the door based on this. Figure 2 shows the workflow and operation of the smart lock in detail.

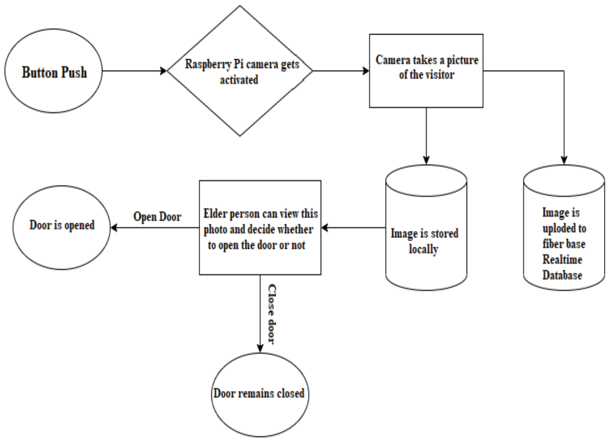

Figure 2: Smart Lock module implementation

All the fall detection warnings are sent to the Raspberry Pi using the MQTT communication protocol, and the Raspberry Pi then pushes these alerts to the Firebase Realtime Database. The following algorithm is used to detect falls:

Algorithm 1 Algorithm to detect falls

```
if Amp > 2 then
    if angleChange ≥ 30 & angleChange ≤ 400 then
        Alert ← "Seriousfalldetected!"
        Firebase ← Alert
    end if
end if
```

3.3 Local Web Server

A Raspberry Pi 4 with at least 4GB of RAM and networking capability will function as the local server. Any other machine that can run a Linux distribution based on Debian may take the place of this one. The prototype runs Raspbian, OS a customized system designed specifically for the Raspberry Pi 4. Python 3.11 will be used to integrate the MQTT server into the Raspberry Pi 4. To make it easier to create pub-sub channels for the MQTT server, we are utilizing the pip package. To deliver and store data, the local server will have to communicate with the cloud services. Other IoT nodes, such as wearables, gas sensors, and smart door locks, will use a lot less power when their IoT network is designed in a centralized manner with just one device linked to the internet. Researchers found that an ESP8266 board consumes 70.5 mA of electricity in regular operating mode and just 15 mA in modem-sleep mode in their study [12].

Put another way, the NodeMCU uses about 80% less power when it is not using any of its network components than it does when it is working normally. A caching mechanism is installed on the local server, allowing all the alerts to be saved locally on the Raspberry Pi in the event of an internet outage and posted to the Firebase Realtime Database as soon as the connection is restored.

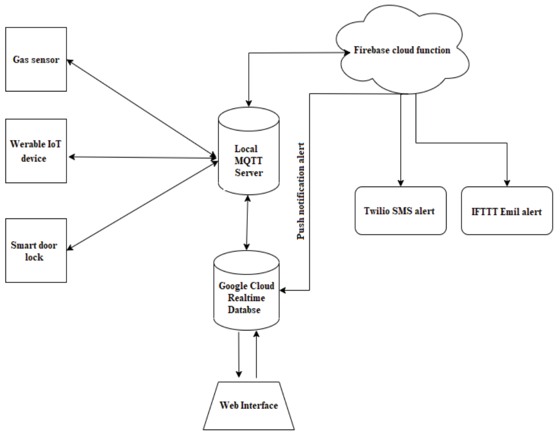

Figure 3: Cloud Infrastructure

Including an algorithm in the future that will be employed, depending on the data we get from the body's vital sensors, to decide the degree of alarm that is issued to the family and caretakers. A warning is delivered to the old person's family and any nearby caretakers after the algorithm has processed the information and, if necessary, assessed it. We utilize Google Cloud to run our machine learning models and to make data storage easier. Additionally, Twilio and IFTTT will get the notification so that email and SMS messages may be sent. Figure 3 depicts the cloud architecture that we will be using for this project.

4.0 DISCUSSION AND CONCLUSION

The need for accessible, economical, effective, and user-friendly health care monitoring of senior citizens and older patients is paramount. People in the current generation demand all new technology to be simple to use and comprehend in the context of today's contemporary lifestyle. The Medical Monitoring system portions also see an increase in demand. Video surveillance systems and the rapidly expanding IoT of wearable sensors may help to meet this expectation. Using selected studies published between 2019 and 2021, this paper reviewed 15 papers on IoT and surveillance-based applications for elderly monitoring. This allowed for an easy exploration of advanced application methods and implementations of cutting-edge wearable sensors and IoT devices that support the daily lives of the elderly. Three primary studies of different applications utilized for data processing, data gathering, and some of the future activities indicated are the major subject of this study. We may examine how wearable sensors and surveillance work together as the main idea behind significant senior monitoring programs.

The survey also found that battery and power consumption are the main challenges in using wearable sensors and the Internet of things. Furthermore, a great deal of recent research has overlooked end-user acceptability and usability. As a result, wearable sensors and internet of things apps are advancing methods for affordable remote monitoring, encouraging independent living, lowering the senior population's fall rate, identifying eternal conditions early, and much more. In conclusion, the aforementioned conflicts must be taken into account and resolved before to the WS, and IoT-based apps ought to be included into monitoring systems. Elderly people's everyday lives at home may be supported by wearable sensors, Internet of Things-based monitoring, and surveillance monitoring apps.

4.1 Issues in Existing Systems

As a result of the literature research, the bulk of current systems have the following problems:

(i) The system's accuracy and robustness should be increased [1], [13], (ii) more patient-related metrics are needed [2], (iii) the forecasting and analysis module has to be updated [3], (iv) it is possible for machines to collaborate and interact with one another[5], (v) it is necessary to recognize cardiac patterns[7], (vi) it is possible to improve classification models[8], (vii) it is required to examine and extract refined regular behavior patterns[9], (viii) a decrease in battery usage is necessary, (x) Different short-path algorithms should be tried[12], (xi) The type and scale of sensor data acquired can be improved[14], (xii) A hybrid kind of machine learning can be used to improve the algorithm [17], and (xii) a camera module can be added [18]. (ix) Both wearable and contextual sensors can be configured with a power autonomy regime [11], depending on their individual circumambience.

Future Work

In the future, anybody will be able to purchase the service of integrating high-performance components into the design and market. In the future, an interior and outdoor 24/7 monitoring system with the addition of a video camera will be available. The elderly and their families will be able to see this film on the website. The fall detection function might need some more work. It is intended to include a machine-learning model based on fall data that has been tried in the past. Consequently, there will be fewer false positives and false negatives and a more robust fall detection system.

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