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Human Fall Detection using IoT and Machine Learning

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ABSTRACT: Nowadays, remote monitoring systems have developed gradually to respond for particular needs in healthcare sector, which is an essential pillar in the modern concept of smart living, we propose a smart health monitoring system to monitor patient health conditions, as a smart healthcare system based on the widely spread and evolved technologies. Statistics show that severe Falls, hypertensive heart disease and blood pressure are risk factors for high death rate. To decrease it a preventive measure should be applied providing a real-time health monitoring system, to save patients life at acceptable time.

The objectives of this project are to provide an effective system model that will track, trace, and monitor patient's movement, location, vital readings like heartbeat pulses, body temperature in order to provide efficient medical services in time. In proposed system data will be captured using sensors and compared with a predefined threshold. After processing it will send the Message for support to Relatives/Caretakers which will contain the Location, Heartbeat Values and Body temperature.

KEYWORDS: Smart Healthcare, Health Monitoring System, Sensors, Human Fall, Embedded System

I. INTRODUCTION

The project is about identifying the accident fall of elderly people; aiding and providing support as early as possible. It also differentiates between Activities of Daily Living and accident fall and reduces false alter. Successful deployment of a fall detection system among elderly population depends on various factors: usability, battery lifetime, privacy issues, cost, and reliability.

Contemporary techniques employed for automatic detection of imminent real-life falls can be broadly classified into two categories:

i. Context Aware Systems
ii. Wearable Systems

The categories concern the deployment of sensory gadgets such as cameras, microphones, infrared, and pressure sensors to track the movement of people in limited environments. The main strength of these systems lies in usability amongst the elderly as no dedicated device is needed to be worn. Nonetheless, such systems are vulnerable to issues such as limited coverage; high installation cost, high false alarms due to other mobile entities, and privacy. Fall detection methods, based on wearable motion sensors that rely on kinematic signals, like tri-axial accelerometers and gyroscopes fall under the latter category. While these body-worn systems provide several advantages over video-based systems, the person is still required to carry at least a device which may be intrusive and increase usability concerns.

Using the available GSM services and GPS technologies to build an improved and enhanced real time monitoring, smart health monitoring system, where: for anytime global communication from anywhere GSM services are used, and for outdoor positioning GPS technology is applied.

Starting with reading the continuous movements of user, the heartbeats and body temperature by using specific sensors: pulse sensor and temperature sensor; the captured data will be compared via microcontroller i.e. Raspberry Pi with a given threshold. The Raspberry Pi has continuous monitoring on the values sensed by the sensors on wearable devices. The readings will be compared with a machine learning model which will classify and check that the measured values were out of the allowed threshold range or not; & if a fall occurs, the system will fetch the user's GPS location through a GPS module attached to a Microcontroller. The system will send an SMS sent immediately to the relative's of the user which will contain: the patient name, heart rate, body temperature, the patient's location and the corresponding UTC time-stamp.

II. RELATED WORK

Thiago de Quadros, André Eugenio Lazzaretti, and Fábio Kürt Schneider have proposed a system for Human Fall Detection using wrist wearable device. Different Sensors used by them were accelerometer, gyroscope, and magnetometer. They used the Threshold-Based value Method for detecting human fall. Using TBM a maximum accuracy of 91% was acquired.

The next steps of this work are related to a deeper evaluation of machine learning algorithms for fall detection and a more extensive data acquisition protocol, involving additional non-fall activities, different fall events and extensive prolonged tests.

Kai-Chun Liu, Chia-Yeh Hsieh, Student Member, IEEE, Steen J. Hsu, and Chia-Tai Chan proposed a system is developed for Human Fall Detection using Wearable Device equipped Sensors. In this system, the effects of decreasing sampling rates on wearable based fall detection systems are inspected based on four machine learning models: Support Vector Machine (SVM), k-Nearest Neighbor (k-NN), Naïve Bayes (NB), and Decision Tree (DT). To allow an objective investigation of sampling rates, two fall datasets, the Sis-Fall public dataset and the proposed dataset of this study, are used.

The accuracy obtained through this model using SVM and RBF kernel was approximately up to 97%.

Soon Bin Kwon, Jeong-Ho Park, Chiheon Kwon3, Hyung Joong Kong, Jae Youn Hwang, And Hee Chan Kim developed A wearable system with an inertial measurement unit sensor was first developed. Then, to classify the different types of falls at various sampling frequencies the novel algorithm, temporal signal angle measurement (TSAM), was used, and the results were compared with those three different machine learning algorithms.

The altogether performance of the machine learning algorithms and that of the TSAM were similar. However, the TSAM performed better than that the machine learning algorithms at frequencies in the range of 10–20 Hz. The accuracy of the TSAM ranged from 93.3% to 91.8%, as the sampling frequency dropped from 200 to 10Hz.

They also mentioned that for future study, they would be using appropriate dataset to validate the algorithm with actual fall data in real-time from elderly subjects. Also, the system could be improved by implementing the algorithm in the device and give an emergency alarm when it detects the fall in real-time.

III. PROPOSED SYSTEM

The following figure describes the Architecture of the implementing system. The main features are continuous monitoring of user's movement through sensors, detection if fall happens or not, Heartbeat monitoring, Temperature Sensing, Location Tracing.

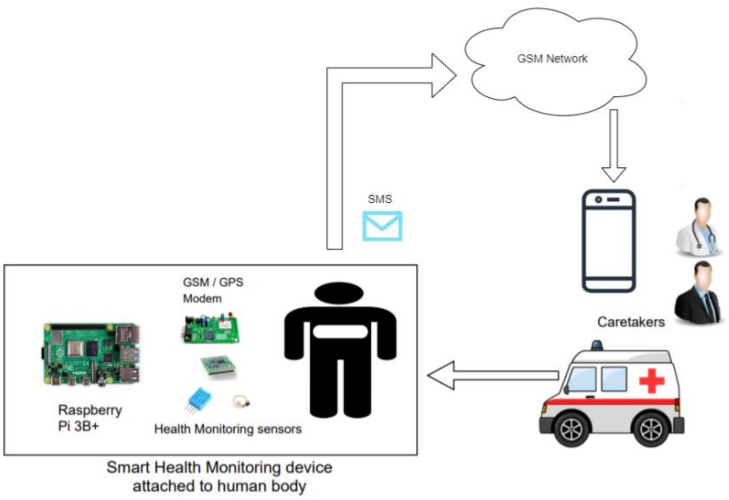

Figure 1: Block Diagram

The main components of the system are

i. Microcontroller (Raspberry Pi 3B+).
ii. Heartbeat Sensor.
iii. Temperature Sensor (DHT 11).
iv. GPS Module.
v. MEMS Sensor ADXL345 (Accelerometer, Gyroscope, Magnetometer).
vi. LCD Display

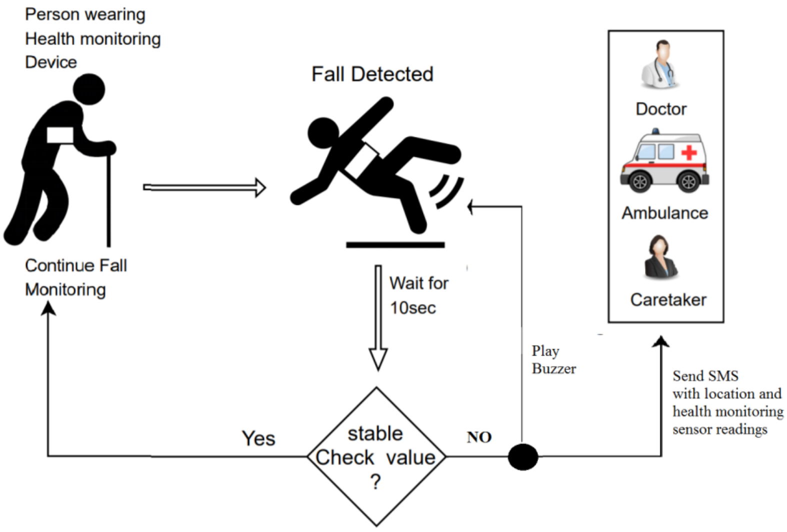

Figure 2: System Flow Diagram

In the start, User can wear a prototype model which will be a Sensor Equipped device. The sensors mounted on the device are MEMS Sensor, DTH11 Temperature Sensor, and Heartbeat Sensor. The Device is also embedded with a GPS module, Buzzer and a LCD screen. The Device will also contain a microcontroller which is able to capture the data from sensors and will keep continuous monitoring on captured data. The Sensed values will be checked by the Microcontroller. Using Machine Learning Model, the values will be classified according to the actions of user. The Machine Learning Model will be trained with dataset containing the sensor values of Fall and Non-Fall. The dataset will also contain the ADL's (Activity of Daily Living) values of Human Movement.

If Fall occurs, then the sensed values will be checked by the microcontroller, If the values are again stable after 10 secs i.e. the values are according to normal value from dataset then fall will not be detected; and if the values are from fall Dataset, the Microcontroller will fetch the user's Heartbeat rate and Temperature using Sensors, i.e. When fall occurs, The Heartbeats of Human change i.e. increase/decrease in Heartbeat Rate and the Body temperature also increases/decreases. So, if the fall is identified, then the Location of user will be fetched through GPS module. The Location of the user which is fetched will be converted to text message with the link of location.

The text message will be sent to user's relative Mobile number feed in Microcontroller using the ClickToSend API. The ClickToSend API is an API which gives free service for sending messages to the mobile number feed in API code. When Fall occurs it will automatically send the alert message to the relatives/caretaker whose mobile number is feed in the API code. The Device will be connected to internet which will send the text message of support. The text message will contain the Location Link Values, Heartbeat Pulse Rate, Temperature Values and Timestamp which were present when fall occurred.

The processing of ADL's is done by ML model which correctly classifies the fake fall and real fall. Nowadays, Wearable Devices are mostly based on ML & AI model techniques to deal with the disadvantages and improve accuracy while testing or real time usage. From training data ML builds a model to predict or solve the given problem.

We are using SVM (Support Vector Machine) to classify the ADL and Fall position. For testing we have used Sis-Fall and UMA Fall dataset. These datasets contain all the values for ADL's and Fall, which will make the ML model more accurate.

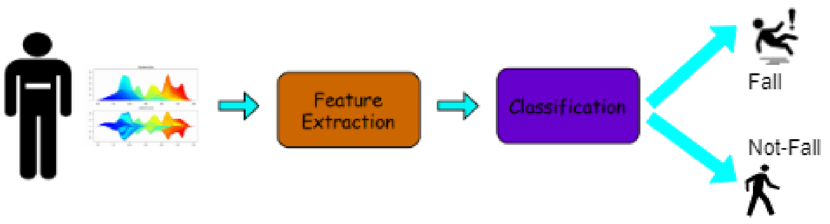

Figure 3: Classification of Sensed values

In addition we are using Decision-Tree and K-NN algorithm in numpy library in python. The following algorithms are used to classify and find the correct value from the dataset and classify between fake fall and real fall.
When fall is detected, the IoT device is capable of sending a notification to the Relatives / Caretaker of the patient. Additionally we have also attached a buzzer which will be activated when fall occurs to get attention of peoples. Also, we have attached an LCD display which will display the heartbeats, temperature and Position of the Person/Patient, which will be useful when fall occurs. If heartbeats are greater or less than the normal pulse rate then it will be easy for caretaker / doctor to take immediate action regarding his health.

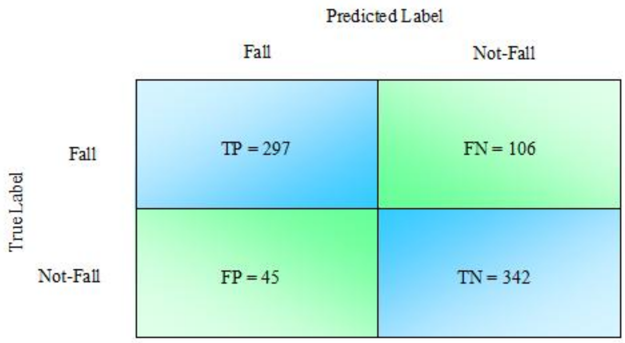

Figure 4: Fall or Not-Fall Confusion matrix

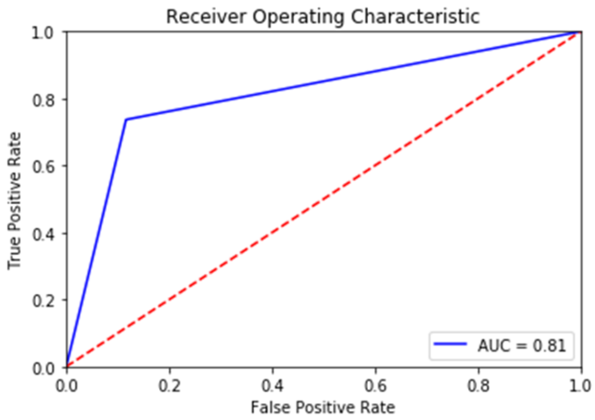

Figure 5: ROC Curve.

This is the result when fall will occur. Using ClickToSend API, we are sending a text message to the Relative/ Caretaker of the Patient who is using the device. When Fall will occur, the message will be sent directly.

The API code for this is written in the python main file. The values will directly be fetched, and a message is already created in the message body, which will send the correct message when fall will occur. The following is the output window for the Relatives/Caretakers who will receive such message for support.

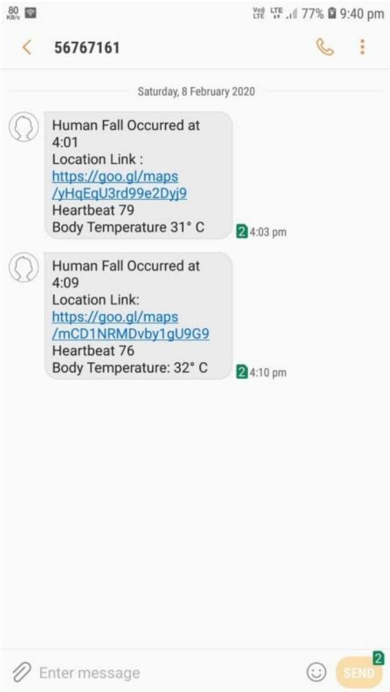

Figure 6: SMS received after Fall Detection

IV. CONCLUSION

We have developed a wearable sensor device for fall detection and emergency alert system which can be easily carried to anywhere. The proposed two step classification algorithms will achieve excellent classification results on fall like events. We have build this prototype model which will play important role in healthcare.

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