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VitaFALL: NXTGeUH System for Well-Being Monitoring with Fall Recognition and Real-Time Vital Sign Monitoring

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Abstract*: The blend of computerized data processing with the existing engineering and medic techniques has enabled explorers in the betterment of controlling of patients concerning the two at homes along with at clinics. In this work, numerous fall assessment for fall prediction and detection with vital signs monitoring techniques and methods particularly to establish a research gap and its allied research problems has been reviewed and incorporated using a triple-axis accelerometer and Vital Signs Parameters (Heartrate, Heartbeat, and Temperature monitoring) for the ancient people with a Internet of Medical Things based Vital Signs and Fall Detection (VitaFALL) is proposed which is well-timed and gives an effective judgment of the fall. The four layers comprise sensing, network, data processing and application layer. A caretaker and doctor can be notified by sending alert using a GSM and GPRS module in order that elder can be helped on time, however, a delay in the time is noticed when comparing the gradient and minimum value to predetermine the state of the old person. From a few decades, vital signs have been important parameters to find out the patient's health level. Vital signs estimation has always been the initial step for the evaluation of the patient and this is also possible by checking the pulse rate or checking the palpation of their forehead for high temperature. ADXL335 Three-Axis Accelerometer Module, tri-axial 14-bit ± 8g accelerometer collects motion information in the VitaFall device. The basic idea is to avoid falls and not to detect them after the loss is done. Walking, stumbling, sitting, falling (right, forward, backward and left) and all other normal motion data patters in the daily life of an older adult (who did no longer have any records or walking issues) are collected. The proposed VitaFall Fall detection model has achieved 85% accuracy, specificity of 100%, and sensitivity of 96% when detecting directional falls. The model uses motion data, real-time vital signs values, falls history to foresee the lows, medians and the highs of falls risks in hospitalized elderly people. When compared with the manual falls risk tools known as the Morse Falls scale, the system got an accuracy of 85%, predictability of 100%, and a sensitivity of 100% too.

Keywords: VitaFALL, Fall prediction and detection, Internet of Medical Things(IoMT), Triaxial Accelerometer, Activity of Daily Living(ADL), Vital signs, Emergency.

I. INTRODUCTION

- Globally, populations are getting older with increasing existence spans. the ordinary getting old technique and the resulting disabilities increase fall dangers.
- Falls are a critical reason for the institutionalization practical impairment, injury, loss of independence and disability and demise of humankind.
- Technologies had been developed to screen vital signs and symptoms, discover falls and decrease their results however their use and impact on the great of existence way of living stay debatable.
- From the literature [12,18,27], it's evident that only fall assessment is not more feasible to detect or predict fall as well to trigger true fall. If fall risk monitoring blend with the patient's vital signs, then provides higher accuracy in falls risk alarm generation and it will also minimize false fall alarm

After road accidents, the second significant cause of coincidental injury is loss of life by fall, as stated by the World Health Organization(WHO) [34]

- So, an advanced IoMT based system for fall detection with vitals sign monitoring is very fascinating to enhance independent living.

II. RESEARCH CHALLENGES AND NOVELTY

The collected data and the Morse Falls Scale would contrast the methodology for endorsement and comparison of our comparison. The literature took into consideration. Real-time and continuously varying erudition such as modern data and vital signs render essential accuracy combined with patient's fixed information about age, gender orientation, falls history and types of anaphylaxes prove essential accuracy in fall risk evaluation, as mentioned in literature [27,14].

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A graph between the fall injuries and Medicare [13] cost is a linear relationship has mentioned. By the end of 2030 [146], the cost of treating the fatal and non-fatal injuries may rise up to 101 billion within the USA, which was about $35 billion in 2016.

The range of falls and Medicare is predicted to increase every year, regardless, of extensive fall avoidance programs.

Increasing Older Adult Population: The density of people having age of either 65 years or else more has elevated rapidly in the previous couple of decades and has initiated a major challenging duty around the world. The count of old-aged needing non-stop monitoring has increased linearly with this expand in population and, by 2025, this group will attain a count of about 1.2 billion. By 2050, it's going to be 2 billion of them, with 80% in developing countries.

Worldwide Healthcare Costs: According to the US Bureau of the Census, the yearly U.S. investing for healthcare is approximately $4 trillion/year or 20% of the gross national revenue within the next decade. In this period, all United States healthcare expenditure is predicted to increase at a yearly mean tariff of 5.8% percentage points quicker than the predicted elevation in the GDP. By 2020, healthcare expenditure is estimated to be 19.8% of GDP, increasing from 17.6% in 2010. All healthcare funding will elevate up to $4.64 trillion by the year 2020.

Real-time Health monitoring systems can play an influential role in decreasing hospitalization, the workload on the medical staff, deliberation time, waiting time and other healthcare amounts [34].

The scientific field is kind of short for the fall and its associative injuries. Setting up safety measures and talk fall information with the caretaker is relatively crucial to lowering the admittance ratio of elderly human beings into the medical institution, so a dependable VitaFall device needs to discover early fall. Continuous technological improvement is seen to keep an eye on the fallen fellows.

Researchers nowadays could detect a falling event without any delay with the assistance of current advanced technology. Gyroscope, accelerometer, ultrasonic vibration, microphone or a combination of two or greater sensors [16] along with a camera are implemented in some of the many fall detection types of research. Body-mounted, particularly camera-based and environmental-based sensors are generally three categories of sensors used.

Body-mounted sensor[18] has always been a researcher choice for studying and it is precise in practical detection among the three. The telephone is being converged with microcontrollers and sensors together in a model. Phone utilization is a new branch towards which the fall detection developments are transferring.

III. PROPOSED METHODOLOGY

The functional diagram shown in Figure.1 gives us a pictorial representation of the workflow of NXTGeUH(VitaFALL). The diagram shows that the workflow is divided into three phases.

Figure 1 depicts the system approach with the all linkage between three phase.

The PHASE-I consists of all the essential elements like the patient, VitaFall device and other vital signs detection equipment. The flow is represented using arrows, first the patient experiences a fall which is further detected by a VitaFall device the data recorded by the device is transmitted to the local server and analyzed for obtaining the observations of vital signs.

In the current era, vital signs are being involved in every health estimation plan for calculating the physiological parameters that distinguish the data used to define the common parameters of a patient's health. These measures affect the conclusion of the medical professional the circumstances of the patient and also the cure suggested by them.

Statistics analysis the use of threshold and identification for the deployment of machine learning algorithms may be considered as the division into processes for a Fall detection device. The combination of the edge and the angle at which wearer deploys it is proposed by a system [54]. First, Vital Signs Monitoring like Heart Rate(HR), Temperature Sensor(Temp), Blood Pressure Sensor(BPS), Pulse Sensor and Pulse oximeter.

At least, four elements of the human body should be put with accelerometers under Fall Detection and Posture recognition using accelerometer placement [3] to discover the human frame falls and distinguish the gesture. Lesser cellular functionality inside an elderly body could be an action of too many accelerometers.

The wearable unit the usage of implanted observations, to identify whether the interval is due to rest or some action, recognizes the posture of the wearer, identifies occasions which include collapsing and walking, and gives an approximation of metabolic electrical cost brought onboard for implementing of a rea-tome human movement which classifies the usage of a triaxial accelerometer for immobile monitoring and vast signal processing.

This VitaFALL device uses an improved NXTGeUH algorithm to enticement results whether the elderly fall accompanied by an acceleration sensor ADXL335 accompanied with tri-axial capabilities to accumulate the acceleration signal attitude sign of an aged motion, finally sending a message using GPRS module

To determine the vicinity and the orientation of the moving object in recent years many researchers have used the wearable sensors, which include accelerometer or gyroscope. Enabling wi-fi communication permits users to be more comfortable and in day to day work with an inexpensive cost VitaFALL Device.

The first stage consists of doctors, patients and caretakers in a real-time system lead to real-time physical observations leading to vital signs monitoring where the patient's HR, SPO2, body temp, BPS is measured and compared with patient's history, consulted with doctors.

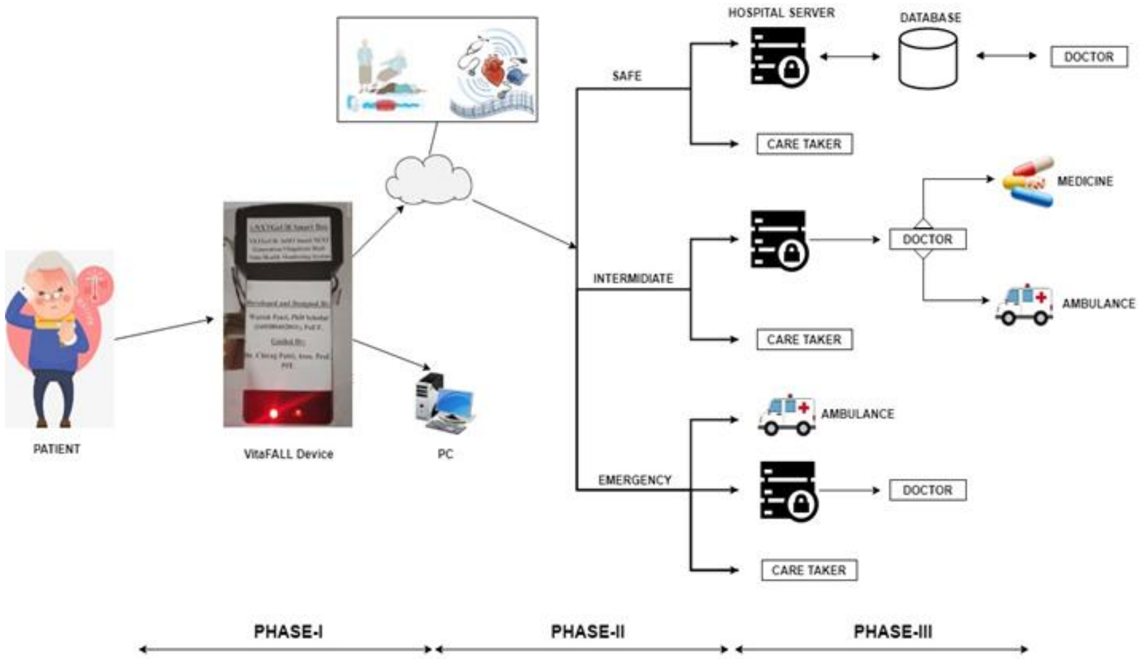

Figure 1.

Proposed Architecture of The VitaFALL System

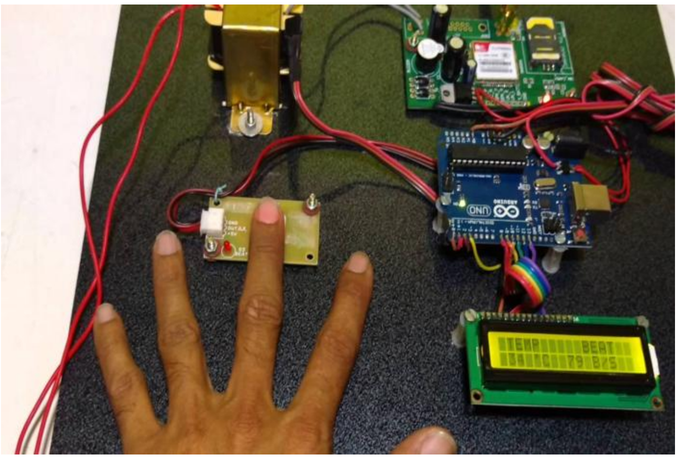

Figure.2 Practical Implementation of ECG sensor and Temperature sensor with Arduino Uno (Vitals Sign Monitoring) in NXTGeUH- VitaFALL system

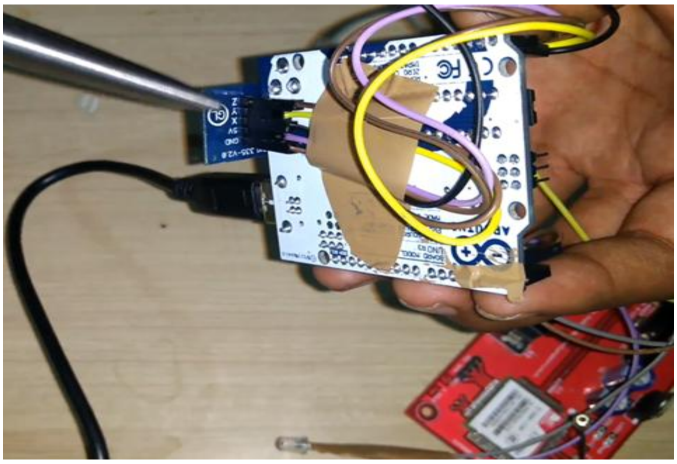

Figure.3 Tri-Axil Accelerometer Connection with Arduino Uno

For observing the physical, mental and emotional health condition of a user a sensing layer is designated; in a group of sensors can be fixed [22], the RFID sensors for identification, the GPS sensor to predict the positioning and localization with an ECG and blood pressure sensors to collect the biomedical parameters are the best examples.In a smart home, the sensors used in appliances are used for recognizing the surroundings depending on the condition and items used in a home[27].

As shown in Figure 4, For transmitting data secularly to respective data processing units [7] there is a network layer. ZigBee is an example of short-range communication rules which is widely applied. LoRa, NB-IOT [9] and 6LowPAN[8] are many new techniques which have been introduced. There is a third layer which is retrieved valuable knowledge from the sensor's database using the top layer and is known as the Data Processing module.

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To evaluate a report on the activity of daily living (ADL) and walking information, motion capture is consolidated into the NXTGeUH system uses a triaxial accelerometer. Just as the result of an interpretation model based on physical sign it is integrated with the vital signs in real-world from the IoMT sensors.

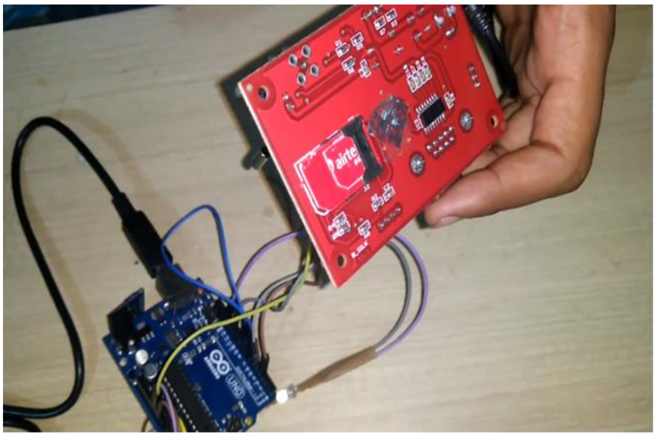

Figure.4 GSM Module Configuration and Connection

For data mining approach based on learning are considered best. At last, all top three layers, working together equally gives intelligent services and applications could come into existence.

Working of Proposed NXTGeUH System

1. Initially, switch on the circuits.
2. On the TX (Transmitter) circuit, insert the Temp, ECG and heart rate Sensor properly, connecting all the apparatus which is in working state.
3. As we switch on, the LED present on the TX which is also termed as stability LED gets turned ON and if the TX is constant then the stability LED switches off interpreting a signal of Stability which has been achieved.
4. The TX then calculates the values from, the heart sensor, ECG module, and body temperature, and initiates transferring details to the Rx(Receiver) circuit to encode the details and transfer sit cordlessly to receiver making use of HC-12 trans-receiver module.
5. Initially the mechanism gets connected to GSM module while the RX circuit receives power and when the connection is made it gives rise to call on that particular number by the user, the number is stored in the monitor as a doctor/caretaker and furthermore, GSM telecommunication is provided to that number soon after the user calls.
6. By making use of the ESP-01 WIFI module, the system gets in touch with the IoT. It is very important for the user to connect appropriately to the system, following with the creation of a hotspot in his/her mobile phone with the following qualifications.
   U.name – IOT
   Pass – project1234
7. After achieving the previous steps, the system will try to get in contact with the IOTGECKO Website as soon as the Wi-Fi module is successfully connected to the website the LCD will portray as IOTGECKO connected.
8. The transmitter sends details for further operations and the Values and Notification alert are indicated by the LCD.
9. At the RX, predefined fall and fall-a like/ ADL values are reserved earlier on the controller so the monitor estimates this user-defined measurements with the records received and if a malformation is detected in the measurements then the SMS is sent to the assigned doctor/caretaker mobile number and also via WiFi module the signs are sent to the iotgecko site.
10. IOTGECKO website received details sent by the receiver and it is publicized as well as the ECG data is then showed in a graphical manner and SMS will be sent to the caretaker and doctor if any abnormality found after verifying the Threshold value and vital signs, the doctor will start further diagnosis.

IV. NXTGEUH- VITAFALL MOTION DATA ANALYSIS

If ADXL335 Three-Axis Accelerometer Module, tri-axial 14-bit ± 8g accelerometer collects motion information in the VitalFall device.

The VitalFall device stores the information with a real-time stamp which is kept in contact with the patient's arm for 24 hrs. The VitalFall device can work up to 3 days constantly with a sampling rate of 6-200 Hz and is very compact. An internal 1GB flash drive stores the captured data. The effectiveness of an algorithm depends on a successful evaluation, many techniques have been written in the literature [22-31] depending on extracting motion capture from the tri-axial accelerometer, however, only those techniques are implemented whose success rate is high under a similar accelerometer.

The basic idea is to avoid falls and not to detect them after the loss is done. Walking, stumbling, sitting, falling (right, forward, backward and left) and all other normal motion data patters in the daily life of an older adult (who did no longer have any records or walking issues) are collected.

From a few decades, vital signs have been important parameters to find out patient's health level. Vital signs estimation has always been the initial step for evaluating a patient and is also possible by checking the pulse rate or checking the palpation of their forehead for high temperature. Under any circumstances, vital signs have to be observed crucially so as to get particulars related to health of the patient.

The tri-axis acceleration sensor assembles all advancing sign about elderly activities. X, Y, Z-axis delivers to the significance of the acceleration and is recognized on a space of rectangular organize the structure. Acceleration is considered as a three-dimensional vector.

The threshold calculation depends on the final acceleration (SVM) [14] which acts as the premises of perception because depending on the body center the gravity area is capricious and one bearing of acceleration cannot pass assumptions whether the body is going through a fall or not.

The connection of SVM with the bearing is none, it is acceleration appropriate just connected with the force of activity.

To diminish the possibility of misinterpretation caused by rapid squat activity, etc, join the acceleration minimum perception with the minimum angle of the human. This reduces the workload of watchmen that decide the degree and minimum again after 2s delay and
can also diminish the quantity of alert for elderly fall with no hurt.

This advanced approach advances a strategy that consolidates to the acceleration minimum calculation and the minimum degree achieved after calculation of the aged people accompanied by straight estimation of 2-D axis (X, Y) to pass judgement on fall experienced by aged which cannot be derived when there are numerous speed activities in which case SVM can fail.

The SVM can go up to 4g if everyday activities are weightlessness and genuinely include fast hunch down and fell at the extreme. In the trial, we can choose the SVM threshold to be 3g. The little changes that take place when a human is stationery don't affect the judgment falls, a static body express the degree that the body and the parallel X, Y bearing isn't greater than 10, which do not count.

VitaFALL Real-time vital signs monitoring, observation, and differentiation of fall risk are significantly benefitted by the use of various vital signs combinations into the fall risks evaluation system. A powerful relation has been established between the vital signs and falls[23] has been represented in a report but the literature[7, 22] has been poorly handled.

In the instance of postural hypotension, the only one adopted conditions are: 'When standing, the probability of falling increases when one has more than 10mmHg in diastolic blood pressure integrated with 20 mmHg or more blood pressure in a systolic manner.'

Filter circuit, microcontroller and an acceleration sensor ADxl335 with tri-axial characteristics are the three components of a Signal addition and the processing module of the fall monitoring device. The acceleration sensor ADXL335 is used in the acceleration signal acquisition module which uses the data from collected activities acceleration of the aged

In the coordinates of X, Y and Z. The acceleration and angular velocity signal can be collected simultaneously. This has an effect on a number of factors, starting with the scheduling of gyroscope which is prevented by the scheduler, values of presets are compromised, lowering of the data fusion algorithms, the operating device load operation performance of motion processing.

The final evaluation to see if the elderly fall and in the risk, the tri-axis acceleration sensor gives result analysis after receiving the acceleration and degree signals, provided by ATmega328 which is the MCU of the data processing module. The wireless communication Module in a way to transmit the information of an aged falling to the guardian accurately and promptly, the fall monitoring device used by aged verifies GPRS as a wireless mode of communication.

V. RESULT AND DISCUSSION

Implementation of the Proposed Work Using Tri-Accelerometer:

The Implementation of the Proposed Work has been carried out Using Tri-Accelerometer in two-phase. First Part is with Vital Sign Monitoring and Second Part is for fall detection The integration of the hardware and application of the NXTGeUH system. The LCD system is connected with the mainboard which displays the particular notification.

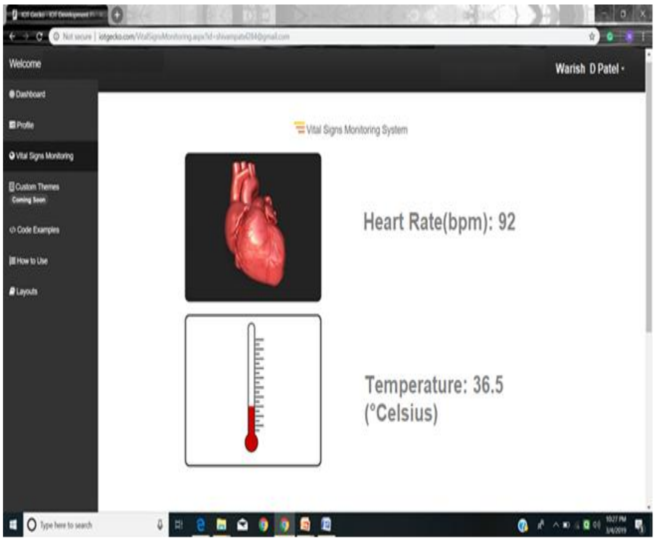

Figure. 5 Real Time Heart Rate and Temp Vital Signs Monitoring

Figure.5 and 6 shows us the data analysis of the sent data by the NXTGeUH- VitaFALL system by a web application with Real-Time Heart Rate and Temp Vital Signs Monitoring. The ECG graph shows the data in a graphical manner and the integration of hardware with software.

Comparison with Present Algorithms there is various benefits regarding privacy, success rate and design of using an implemented algorithm over the ubiquitous algorithm.

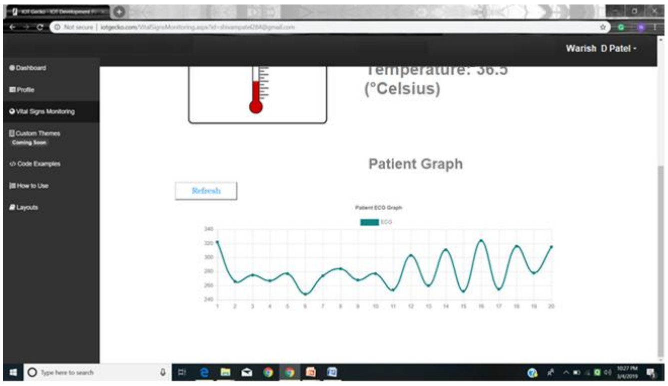

Figure. 6 Real Time Heart Rate and Temp and Heartbeat ECG Vital Signs Monitoring Alert on Web

As concluded from the experimental results the average rate of falls is 93%. The efficiency of the proposed algorithm is 82%.Comparison with Present Algorithms there is various benefits regarding privacy, success and design of using an implemented algorithm over the ubiquitous algorithm. As concluded from the experimental results the average rate of fall is 93%. The efficiency of the proposed algorithm is 82%. The proposed algorithm NXTGeUH monitor's the patient's count using an individual device with combining the decision of Fall assessment and Vital signs monitoring whereas the prior algorithm uses a one-to-one system. This increases the scalability of the algorithm.

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Using truncated multiplier to set the minimum limits increasing the complexity of the algorithm and considering computation involving simplifying the data, increasing by fusion of similar or different data. The real-time computation of the data using this algorithm is very quick.

The proposed algorithm's accuracy is 83.12%, as per Table 1, which a significant improvement over the presented. Also, there is less usage of power, which permits us to conclude that the VitaFALL System put forward by this research is more trustworthy.

Table- I: Comparison with other designs (Existing and Proposed)

Scenario	Waist (Existing System)		Wrist (NXTGeUH- VitaFALL) Proposed System	
	Success %	Failure %	Success %	Failure %
Falls	72	28	82	18
Non-Falls	74	26	71	29

VI. CONCLUSION AND FUTURE WORK

The proposed falls model was introduced to initiate a solidly built method which is used to minimize the risks assessment of effective falls and also reduces the personal and economic cost of affected injuries among old aged people in hospitals. It also had goals like how to minimize false alarms which is trouble for patients, caretakers and management staff and can settle the productiveness of care. User needs and doctor's preferences were bear something in mind and intrusive, wireless and body-worn detectors were used to plot the suggested system.

The initial point of algorithm plotting of fall awareness research studies has been achieved to maintain the magnitude on the equivalent and consistent lowest level. The suggested system proposed an innovative method which includes straight off mandatory signs and locomotive details and statistics with falls history and the various cures to minimize the faulty alarms, which causes major complications for the nursing staff.

To upgrade the current system, it includes various parameters. Also, false pressing of alarm because of the collision of range on one another can be improved by features like altitude. Accurate outcomes can be achieved by variations in altitude. So far the accuracy of the final algorithm can be intensifying by the necessary point of reference known as altitudes. The power amplifiers are used between the transmitter and receiver nodes in order to get a larger scope of the system. Also using a high voltage power unit into service may vanish consistent human surveillance by executing the application to activate a signaling device or call an emergency. Including the video in the device can help to caretaker and doctor to see the person fall is true or false and it will also help to further medications. Further research can be carried out on the bases of video based precision along with the considering the sentimental analysis.

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