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Design & Development of a Cost-Effective User-Friendly Fall Detection Device Using IOT Technology

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Abstract - Falls are a crucial health problem mainly among the older people and the newly born babies too. In recent years, there are many systems that aimed at detecting the falls has increased adequately. This kind of device is aimed to provide for helping out the both biomedical engineers and clinicians. Our team has implemented a new technology towards the integration of fall detection in smartphones with the use of IOT methods and gyroscope sensor in the detection algorithm. The main objective of our work is to build an android-based fall detection system at cheap price for the children and elderly. The challenges like power consumption, sensing limitation, real-life conditions, real-time operations are well identified by us. The hardware part comprises the sensor which detects the position of the body of the user whether it is on a falling mode or not and the Node MCU where all the processing is done. The software consists of some coding and some formulas that detect the fall and provoke to ring the alarm.

Key Words: fall detection, accelerometer, non-invasive tool, older adults, IoT

1. INTRODUCTION

In this fast pacing society, the professional growth and personal growth has caused a significant number of older adults to live alone. The dependency ratio of the young as well as elderly people have also increased. This will take a sharp rise as predicted by WHO from 2022 onwards. One among the top ten reason of injury for babies and death for older adults is the sudden fall. Mistakes can't be avoided in our daily work life yet we can take measures to minimize them.

Additionally, falling while sitting or lying is also common with falling while walking. Thereby, there is always a need for having a hand held portable device to get immediate support in home based setting and in medical settings as well. If quick medical support can be catered to these babies and adults, then many lives can be saved or quality of living can be enhanced. Existing systems are there which is not so cost-effective. Thereby, to support the people with simple, easy, user friendly economically viable tool for this purpose can be developed. [1-4]

One of the leading cause of death among the adults aged 65 years or more and that related injury is Fall. It is also observed that there is an increase in the age-adjusted fall death rate. Statistics shows that per 100000 older adults 64 deaths are due to age-adjusted fall death. From 2009-2018, this type of death rate has increased about 30%. In that case children and elderly suffers the most. Older people and children have a problem when their guardian are not with him or her. Some time for older people may have severe problem in their joints after fall events. It may happen that the orderly people or the children may fall when they are in bathroom, or walking on stairs like that. But they have no one to take care at that time. It can become a large severe injury for late medical assist. But surprisingly there is no such simple device available in the market that fulfills our need and assist for our close one. [5-8]

Many edge computing devices are there; with which we can use wearable sensors. These devices are capable of performing perform a bulk of data-processing tasks. After processing, they will send out a section of the collected dataset to the cloud. As a result, the data transmission times are reduced along with reduction in the usage of the network bandwidth. Next it will enable those devices with a facility for notification to authorities regarding the results of various important analytics.

It ensures that safety, security and immediate care for the elderly patients as soon as fall event occurs. [9-10]. World Health Organization defines the fall as an event in which an individual comes to rest either on the ground or on any lower level surface with a force [11]. An estimation shows that every year, 646,000 fatal falls occur across the globe and thereby it is marked as the second leading cause of death because of an unintentional injury, just after road traffic injuries [11].

2. METHODOLOGY

The fall detection circuit uses ITG MPU 6050 sensor module and node MCU microcontroller to operate the full operation without having any interruption of data transmission.

MPU 6050 sensor have an accelerometer and a gyroscope on one silicon chip. The accelerometer and the gyroscope are based on Micro-Electromechanical System(MEMS). The Gyroscope and the Accelerometer both sense three axis of X, Y and Z. Each of them have 16 bits analog to digital converter hardware. The MPU6050 uses I2C communication which allows to connect multiple number of sensor to the microcontroller. That means it is a multi-master, multi-slave, single ended serial bus. Operating speed relatively less. Here SCL(clock) and SDA(data) have the main role for interacting with the microcontroller. In the sensor module there are eight pin outs, out of them four pins are on point of interest here. Those are Vcc for taking voltage from microcontroller, GND pin for ground terminal, SCL and SDA are for make communication with microcontroller simultaneously.

Fall detection algorithm is based on linear movements (i.e. velocity, displacement, acceleration) and angular movements (i.e. angle, angular velocity and angular-acceleration).

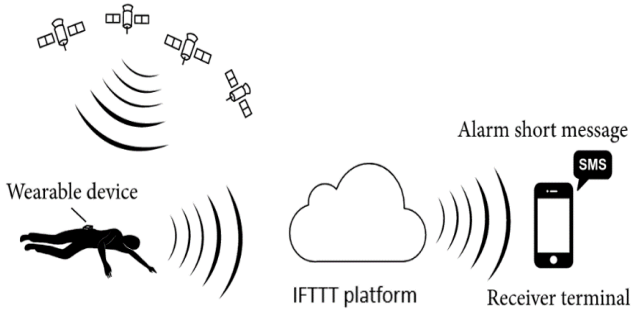

Fig -1: Basic Architecture

The sum total of acceleration-vector Ac, having both dynamic and static acceleration components, and calculated as the equation below for the raw data of the sensor:

Ac = $\sqrt{(A_x)^2 + (A_y)^2 + (Az)^2}$ where Ax, Ay, Az are the acceleration in the x, y and z axis respectively

Angular velocity, w = $\sqrt{(w_x)^2 + (w_y)^2 + (wz)^2}$ where Wx, Wy, Wz the acceleration in the x, y and z axis respectively. When stationary acceleration magnitude, Ac, from three axes is remain constant and angular velocity is 0°/s. When subject starts moving the Ac will start to give various raw values.

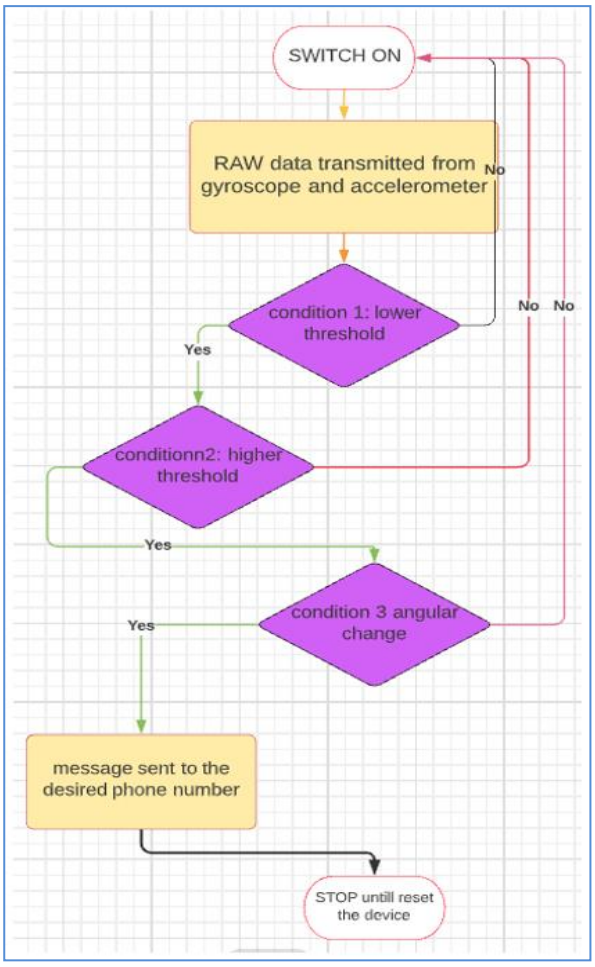

Fig -2: System Workflow

The algorithm design works threshold-based method here after successful adequate experiments. It is designed in such a way to discriminate the Activities of daily life (ADL) and sudden fall incidents.

A lower threshold value is set as first condition as when the device have some little more movement on the air.

If the first condition makes successful, then condition will be waiting for second condition's response until the next pulse comes.

If second conditions do not satisfy, then come to the end of the loop and again sense the movement and enters to the first loop.

And if the second loop satisfied, means if the device strikes with a sudden force and have 4g of sensation, then the code will be redirected to the third conditions for more accurate fall detection algorithm.

The third condition is for detecting angulation dislocation of the device. If three conditions successfully satisfied, then only the device will send a signal to the IFTTT free web platform.

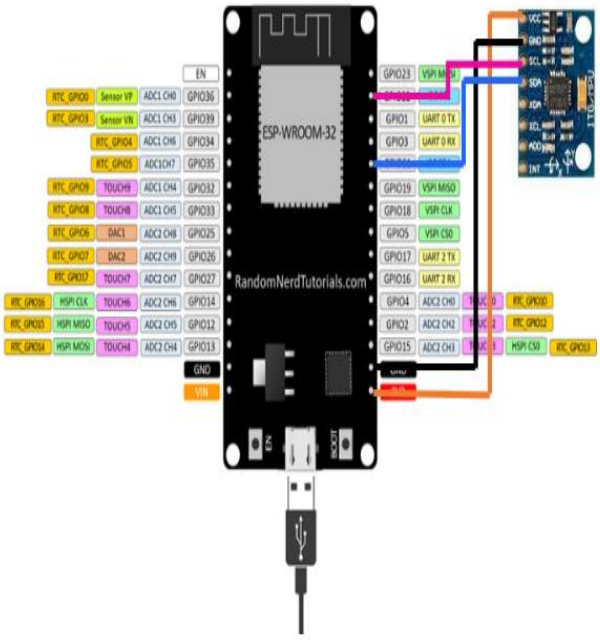

Fig-3: Pin Diagram

Then through the host's mobile smart phone's IFTTT application the message will be generated and text message or email is sent to the desired phone number or email id. (**Note:** it is not necessary to have internet connection for the desired phone for text message service. But for the host device and the micro controller internet connection is necessary for generating the message. And also there is no limitation of distance for desired mobile phone from the main device).

The main device is controlled by NodeMCU which is an open source IoT platform It includes firmware which runs on the **ESP8266** Wi-Fi SoC from Espressif Systems, and hardware, based on the ESP-32 module. The main mpu6050 sensor module is connected to the nodemcu by GPIO 21 or SDA pin and GPIO 22 or SCL pin. NodeMCU is able to connect with wi-fi directly.

3.RESULTS AND DISCULLSION

This "Fall detection circuit" will send the alert indication via sms or email to the family member or the caregiver. A person with whom the device is attached if he or she will fall or disbalanced from the previous condition by any chance at that moment angular velocity changed (with respect to any axis e.g. X,Y,Z).

In this work we are using MPU 6050 sensor which can work as both accelerometer and gyroscope equally. When acceleration magnitude is constant and angular velocity 0 Deg./s that means the device is in reset condition because if he/she falls at any condition the acceleration magnitude will start to change rapidly and also angular velocity produces varieties of output signal, at this moment within a few milliseconds sensor will started to react with sensitivity changes.

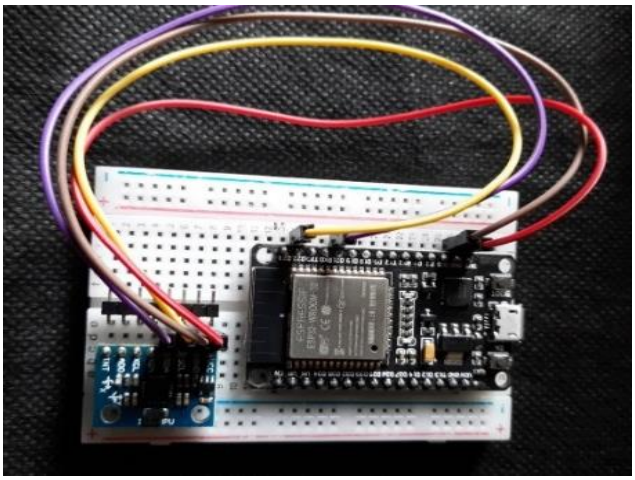

Fig -4: System Developed

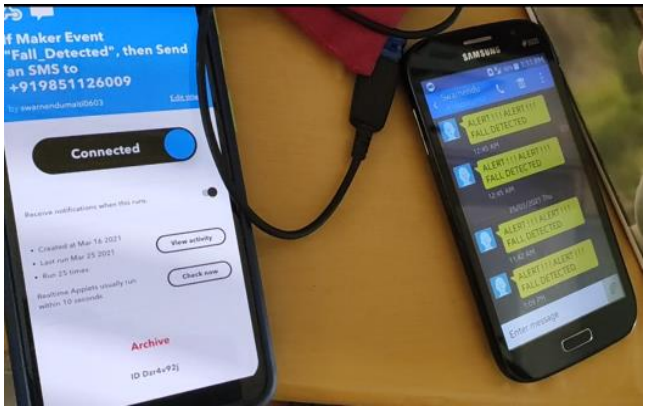

Fig -5: Alert Received

According to the methodology these sensitivity changes is directly proportional with the angular dislocation with respect to subject's previous axial position. When the sensor MPU 6050 is completely able to detect a fall at that time IFTTT application will start to generate alarming message from the host's mobile

The concept of tri-axial accelerometer is mainly used here to detect a fall, in this case entire system controlled by a Node MCU. After analyzing the result, we can say that the device can easily detect human fall and also send the fall notification to the host. The process of receiving data from the sensor and then compare the data with threshold values (Upper & Lower threshold) are always notifying the device to detect either fall is occurred or not. Using this wearable tiny device, a caregiver can rescue the subject as soon as possible from the further emergency condition. In future this easily wearable device may provide a strong support to elderly people or physically challenged people to walk alone.

4. CONCLUSIONS

We could realize the need and deficit of the innovation. Here we have come up with this idea and developed our device. We have developed a reliable fall detection device which is wearable for children and aged person both and can be operated by minimum devices specific to that work in very efficiently without any false notification. The device will be attached on the hand of the victim just like a wrist watch. This fall detection device is very useful for the elderly people. We have made the device in such a way that if the device detects any fall, it will send a message to the concerned person so that medical attention can be taken immediately.

Our device will basically detects fall within aged people and children. After detection of any fall, it will notify instantly to the family members or the concerned person for minimizing the delay of medical assist. It is a WIFI based user friendly device and very easy to use.

The most efficient point of this wearable device is that after interfacing with wifi-shield it starts to work automatically based on its principle. It is an essential device with full of societal impacts because it generates accurate FALL notification at anywhere and can change critical consequences with in a minimum span. In future based on this system we have different scopes to enhance this device as per requirement. As a host tracking the notification by using his/her smartphone is very easy to control from anywhere. Here we actually propose a novel real-time wearable device for those people who are unable control their body's balance. All the narrowed features directly merge with IoT and Biomedical domain.

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REFERENCES

1. Subhash Chandra Agrawal, Rajesh Kumar Tripathi, Anand Singh Jalal, "Human-fall detection from an indoor video surveillance" [2018] International Journal of Applied Pattern Recognition doi:10.1504/IJAPR.2018.090520
2. Ahmad. M Ahmad, "Fall Detection Based on RetinaNet and MobileNet Convolutional Neural Networks"[2020] 15th International Conference on Computer Engineering and Systems (ICCES) doi:10.1109/ICCES51560.2020.9334570
3. Supawadee Putthinoi, Peerasak Lerttrakarnnon, and Patima Silsupadol, "Development and Usability Testing of an Emergency Alert Device for Elderly People and People with Disabilities" [2020] The Scientific World Journal, vol. 2020 doi:10.1155/2020/5102849
4. Yangsen Chen, Rongxi Du, Kaitao Luo, Yuheng Xiao, "Fall Detection based on Real Time Pose-Estimation and SVM" [2021] IEEE 2nd International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE) doi: 10.1109/ICBAIE52039.2021.9390068
5. Dove Medical Press Ltd ,"Analyzing the problem of falls among older people" Yannis Dionyssiotis, Int J Gen Med. 2012; 5: 805–813.
6. Published online 2012 Sep 28. doi: 10.2147/IJGM.S32651 PMCID: PMC3468115 PMID: 23055770
7. European Group for Research into Elderly and Physical Activity, "Physical consequences of falls in the elderly: a literature review from 1995 to 2010", Miguel Terroso et all, 13 November 2013; Eur Rev Aging Phys Act (2014) 11:51–59 DOI 10.1007/s11556-013-0134-8
8. "Falls and Fall-Prevention in Older Persons: Geriatrics Meets Spaceflight!"; Nandu Goswami, Front. Physiol., 11 October 2017 https://doi.org/10.3389/fphys.2017.00603
9. "A Real-Time Patient Monitoring Framework for Fall Detection" ; Dharmitha Ajerla et all ,Volume 2019 |Article ID 9507938 | https://doi.org/10.1155/2019/9507938, 22 Sep 2019
10. SICE Annual Conference 2008, "Static Balancing Control of Humanoid Robot based on Accelerometer", Ching-Chang Wong et all, August 20-22, 2008, The University Electro-Communications, Japan
11. Phys Ther Kor 2013;20(2):52-59, "Reliability and Validity of the Postural Balance Application Program Using the Movement Accelerometer Principles in Healthy Young Adults", Seong-doo Park et all, ISSN (Print) 1225-8962, ISSN (Online) 2287-982X