

Smart Fall Detection System for Elderly People Using Arduino Uno

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ABSTRACT: Falling down is one of the major medical problems that faced by the elderly people. The consequences of falling may be fatal if there is no immediate medical attention provided. Hiring nurse and caregivers may be the best option to constantly monitor and support activities of daily living (ADL) of elderly people, but the cost would be very expensive. Moreover, it is difficult for the caregivers to constantly observe and assist elderly people all the time. Falling event among the elderly people may occur when the caregivers are not around to supervise which lead to the issue of reliability. Therefore, an intelligent fall detection system that is reliable and cost effective must be considered as an option to assist elderly people. Currently available techniques that are used to design fall detection systems are classified into three categories which are camera- based method, acoustic based method and kinematic based method. Each method has its own advantages and disadvantages over another. All of these approaches help to reduce the effort of nurse and caregivers to monitor daily activities of the elderly people. Furthermore, they provide proper medical attention urgently to the elderly in case of fall. Despite these advantages, there are still many problems and the state-of-the-art in fall detection is quite premature. There are still need for massive research in order to come up with a system that can solve all the drawbacks of current traditional approaches. Method that can predict a fall before it actually occurs needs to be developed so that preventive measures can be taken quickly before any severe injuries happen.

KEYWORDS: Wireless Sensor Networks, Fall Detection System, Elderly Monitoring, Heart Rate Fluctuation, Sensitivity.

I. INTRODUCTION

Every country in the world was focusing on developing their nation which includes growing the country's population. According to the findings on world population by United Nations in 2015[1], the global population is expected to have an increment of more than 1 billion people within 15 years which can accumulated to 8.5 billion in 2030. The fastest growing population which currently comprising 12% of global population is the people who are aged 60 years old or above. This population is growing by the rate of 3.26% per year and expected to reach up to 1.4 billion in 2030. With increasing number of older people, the demand for healthcare service increase rapidly. Most of the people aged 60 or above are hospitalized due to falls. A global report by the World Health Organization (WHO) [2] states that 28-35 percent of older people aged 65 and above experienced fall each year and it is increasing to 32-42 percent for those 70 years and above. Elderly people who live independently are exposed to higher risk of falls. Besides that, falling down frequently may cause psychological and physiological damage that lead to severe injury and even death if medical attention is not provided immediately. In order to reduce the risk of elderly people getting harm from fall, medical attention needs to be provided immediately. Therefore, a reliable fall detection system can help to detect fall in elderly people and contact the nearest healthcare service for help and support. The fall detection system need to be user friendly which means it is easier to be used by the elderly people. The system also must not interfere and disturb activities of daily living (ADL) of elderly people. The system needs to be cost-effective and durables.

Falling down is among the most common causes of medical attention required by the elderly people. Elderly people often injure themselves from falling down more especially when they are living alone. After a fall occurs, medical attention needs to be provided promptly in order to reduce the risk of victim. Several technologies have been developed which utilize webcams to monitor the activities of elderly people. However, the cost of operation and installation is expensive and only applicable for indoors... Current commercialized device required user to wear wireless emergency transmitter in form of wristwatch. This method will restrict the user movement and produce high false alarm due to frequent swinging and movement of the device. This project proposed a fall detection system which is cost effective

and reliable to detect fall and alert relatives for help and support. For fall detection, accelerometer and gyroscope was used to detect acceleration and body tilt angle of the faller respectively. By coupling accelerometer with gyroscope, the accuracy of the system was improved due to reducing in false positives and true negatives... Alert system in form of Short Message Service (SMS) was transmitted to the concerned authorities. Moreover, this wearable device requires less implementation cost and provides a quick response. As a result, this fall detection and alert system has the sensitivity and specificity of 95% and 90% respectively. However, the limitation of this device is unable to detect a user falling against a wall and falling end in sitting position. Recommendation for future work is to develop an interactive display which enables users to input relative's phone number.

II. LITERATURE SERVEY

1. AN AUTOMATED WEARABLE FALL DETECTION SYSTEM FOR ELDERLY PEOPLE

According to the World Health Organization (WHO), the number of individuals aged 60 or older is projected to reach around 2 billion by 2050, a significant increase from 900 million in 2015, constituting approximately 22% of the global population. Nevertheless, aging is commonly associated with a decline in physical, sensory, and cognitive abilities, which elevates the risk of experiencing falls. It has been reported that around 28-35% of elderly individuals aged 65 and above require hospitalization due to falls. The risk of falling further escalates with advancing age. For elderly adults aged 70 or older, the likelihood of falling stands at 32-42%, with the added burden of sustaining moderate to severe injuries, including fractures of the wrist, arm, ankle, and hip. [6]To prevent such issues, the author presents a machine learning method exploiting Gait Analysis. The proposed machine learning method uses walking patterns to test falls and non-falls. Ultimately, the model undergoes testing on publicly gathered datasets encompassing diverse activities and various types of falls. This holds considerable potential in addressing the issue of falls by promptly alerting emergency and relevant teams to take essential measures. It is expected to accelerate the assistance process, minimize the likelihood of prolonged harm, and potentially save lives. To achieve this, gait parameters such as human gait and balance, step time, stride time, step length, stride length, step velocity, and step count on heel and toe are gathered using Inertial Measurement Units (IMU) comprising accelerometer, gyroscope, and magnetometer. The real-time gathered data is then analyzed using the pattern recognition algorithm, Random Forest. On the other hand, health parameters such as body temperature, blood pressure, and pulse rate are checked. The real-time gait data is checked along with health parameters, and based on this information, an intimation is given through a mild alarm to the elderly persons. The article represents the novelty with six parameters and a mild alarm, contributing to fall prevention and improved safety for elderly individuals.

2. Real-time monitoring system for elderly people in detecting falling movement using accelerometer and gyroscope

Most of the elderly people is experiencing a decrease in physical quality, especially the weakness in the legs. This will cause elderly easy to fall and can have a serious impact on their health if not getting help very quickly. It is, therefore, necessary to take immediate action against the falling cases experienced by the elderly. One such action is by developing supervision and detecting of falling movements in real-time, which is then the connection to a member of the family. In this research, we used Arduino Uno as a microcontroller, sensor accelerometer, and gyroscope that serves to measure falling movement of the elderly person and supported by GPS technology Ublox Neo 6M to provide information about coordinates. The result was the high accuracy of delivering notification data to server and accuracy of data delivery to family notification equal to 93,75%. The system successfully detects the direction of falling: forward, backward, left or right and able to distinguish between unintentional falling and conscious falling like a bow or prostrate position

3. Design and Implementation of Fall Detection System Using MPU6050 Arduino

Fall is the most significant causes of injury for Elderly or Epilepsy. This has led to develop a many types of automatic fall-detection systems. However, prevalent methods only use accelerometers to isolate falls from activities of daily living ADL. This paper proposes combination of a simple threshold method and acceleration measurement to detect falls and fall-detection. To demonstrate the activity of proposed scheme a device has been designed. We used an Arduino-UNO, also we used MPU6050 as a sensor and we can measure the velocity and acceleration by calculate the derivative for the phase this program was C-language. Several fall-feature parameters and possible falls are calibrated through an algorithm. The implementation of program built to read an analogue variable from its port as an additional adjustment to fixed the upper and the lower. The total sum acceleration vector ACC to distinguish between falling and

ADL. The results using the simple threshold, PMU, and combination of the simple method and MPU were compared and analyzed. The proposed MPU reduced the complexity of the hardware also the algorithm exhibited high accuracy.

III. PROJECT DESCRIPTION

EXISTING SYSTEM

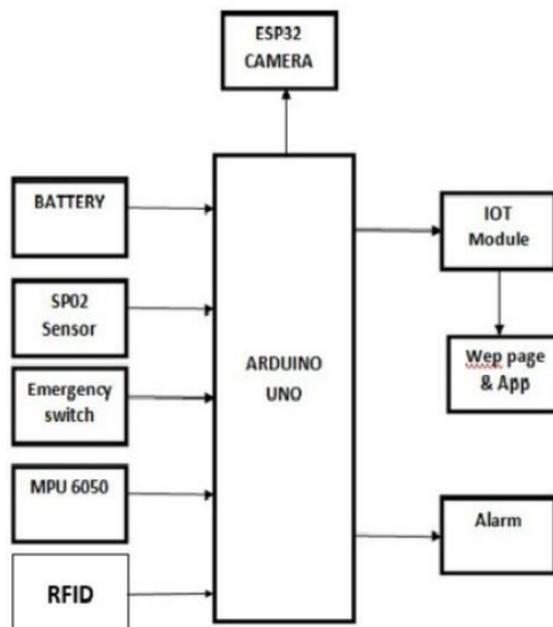
In the existing system, fall detection for elderly people is mostly manual or semi-automatic, relying on human intervention or basic monitoring devices. The commonly used approaches are:

- 1. Manual Supervision
- Elderly people are monitored by caretakers, family members, or hospital staff.
- In case of a fall, help is provided only if someone notices the incident.
- Not reliable for elderly people living alone.
- 2. Emergency Call / Panic Button Systems
- Elderly individuals wear a panic button or emergency switch.
- After a fall, the person must press the button manually to alert caregivers.

PROPOSED SYSTEM

- Smart Fall Detection System for Elderly People Using Arduino Uno
- The proposed system is designed to automatically detect fall incidents of elderly people and immediately alert caregivers or family members. The system uses an Arduino Uno as the main controller along with motion and position sensors to monitor the user's movements in real time.
- An accelerometer and gyroscope sensor (MPU6050) is used to continuously measure body acceleration and orientation. When a sudden change in acceleration followed by an abnormal body posture is detected, the system identifies it as a fall event. To avoid false alarms, threshold-based logic and time validation are applied.

BLOCK DIAGRAM

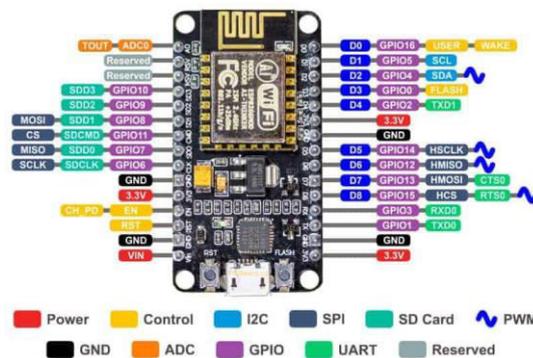


IV. HARDWARE REQUIREMENT

NODEMCU ESP8266

The NodeMCU (Node Microcontroller Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.

However, as a chip, the ESP8266 is also hard to access and use. You must solder wires, with the appropriate analog voltage, to its pins for the simplest tasks such as powering it on or sending a keystroke to the “computer” on the chip. You also have to program it in low-level machine instructions that can be interpreted by the chip hardware. This level of integration is not a problem using the ESP8266 as an embedded controller chip in mass-produced electronics. It is a huge burden for hobbyists, hackers, or students who want to experiment with it in their own IoT projects.



JUMPER WIRES

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

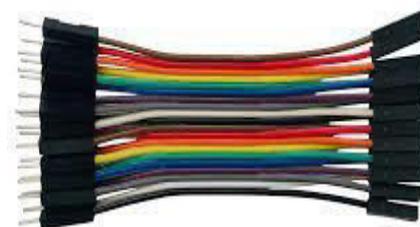


Fig 5.1.6 Jumper wires

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment. A jumper wire is an electric wire that connects remote electric circuits used for printed circuit boards. By attaching a jumper wire on the circuit, it can be short-circuited and short-cut (jump) to the electric circuit.

BUZZER

1. Passive Buzzer: This type of module generates sound through the vibration of a rotating magnetic field within a coil. It requires an external driver circuit and does not produce sound directly.

2. Active Buzzer: They have an integrated driver circuit and can operate directly with a sound signal. They are often more user-friendly due to the built-in driver circuit.
3. PiezoBuzzer: They produce sound by applying voltage changes to a piezoelectric crystal. They are widely used due to their small size and low power consumption.
4. Electromechanical Buzzer: They produce sound using the magnetic field of an electromagnet instead of the vibration of a coil. They can produce larger and more powerful sounds.
5. Sirens: Sirens are a specialized type of it used in emergency or fire alarm systems. They can generate very high sound levels and are powerful enough to be heard from a distance.



ESP32 CAMERA

The ESP32-CAM is a powerful and compact Wi-Fi-enabled camera module based on the ESP32 microcontroller. Known for its versatility and affordability, the ESP32-CAM has become popular among DIY enthusiasts, hobbyists, and professionals for a variety of applications, including IoT projects, home security, and image processing. This article will explore the ESP32-CAM's features, technical specifications, setup process, and applications in depth, helping you get started with this exciting module.

Key Features and Technical Specifications

Here are some of the ESP32-CAM's key features and specifications:

- Microcontroller: ESP32-D0WD
- Processor: Dual-core, 32-bit processor, up to 240 MHz clock frequency
- Camera: OV2640 (2 MP resolution)
- RAM: 520 KB SRAM + 4 MB PSRAM (externally added)
- Flash Memory: 4 MB
- Wi-Fi: IEEE 802.11 b/g/n (Wi-Fi 2.4 GHz)
- Bluetooth: BLE and Bluetooth v4.2



MPU6050 SENSOR

- The MPU6050 sensor module is an integrated 6-axis Motion tracking device.
- It has a 3-axis Gyroscope, 3-axis Accelerometer, Digital Motion Processor, and a Temperature sensor, all in a single IC.
- It can accept inputs from other sensors like a 3-axis magnetometer, a pressure sensor using its Auxiliary I2C bus.
- If the external 3-axis magnetometer is connected, it can provide complete 9-axis Motion Fusion output.
- A microcontroller can communicate with this module using the I2C communication protocol.

- Gyroscope and accelerometer reading along X, Y, and Z axes are available in 2's complement form. The temperature reading is available in a signed integer form.
- Gyroscope readings are in the degrees per second (DPS) unit; Accelerometer readings are in g unit, and Temperature reading is in degrees Celsius.



MAX30100 Pulse Oximeter

- If you are wandering to make a machine which is used to detect heart rate and pulse rate. then this sensor Module is Compatible with you.
- Heart Rate click carries Maxim's MAX30100 integrated pulse oximetry and a heart-rate sensor. It's an optical sensor that derives its readings from emitting two wavelengths of light from two LEDs – a red and an infrared one – then measuring the absorbance of pulsing blood through a photodetector. This particular LED color combination is optimized for reading the data through the tip of one's finger.
- The signal is processed by a low-noise analog signal processing unit and communicated to the target MCU through the mikroBUS I2C interface. Developers of end-user applications should note that the readings can be negatively impacted by excess motion and changes in temperature. Also, too much pressure can constrict capillary blood flow and therefore diminish the reliability of the data. A programmable INT pin is also available. The operates at the 3.3V power supply.
- Main Applications:
 - Medical Monitoring Devices
 - Fitness Assistant Devices
 - Wearable Devices



V. CONCLUSIONS

Considering the high mortality rate due to falls in the elderly we focused on developing a fall detection system prototype. We utilized third-generation Shimmer sensor in a wireless body area sensor network connected with the application. We first built the SMotion dataset of some activities performed by the elderly that could lead to falls. In this work, we employed the most commonly use classification techniques such as SVM, KNN, and neural network as a supervised learning approach. The data was visualized using SVM and KNN classification. The evaluation results of this study identified KNN as the most accurate classifier with the maximum accuracy of 96% for age groups and 93%

for weight groups as shown in [Tables 5](#) and [6](#), respectively. We also presented the confusion matrix and sensitivity and specificity of implementation for in-depth analysis. We also tested the end user experience using the Android app. Finally, we will focus on fall risk estimation using the Shimmer EMG sensor kit in the future.

VI. FUTURE ENHANCEMENT

A fall is characterized as an incident that leads to an individual unintentionally ending up on the ground, floor, or a lower level. Fall-related injuries can be either fatal or non-fatal, although the majority are non-fatal. With the global population aging, the well-being of older adults has become an increasingly worrisome matter. Among the various challenges associated with aging, falls have emerged as a prominent public health concern, impacting a significant number of elderly individuals worldwide.

According to the World Health Organization, falls are the primary cause of injury-related fatalities in people above a certain age. Falls rank as the second most significant contributor to unintentional injury fatalities on a global scale. Annually, they result in a considerable number of deaths and injuries among the elderly population, with approximately 684,000 people losing their lives due to falls worldwide. Over 80% of these incidents occur in low- and middle-income countries. Fatal falls disproportionately affect individuals aged 60 and above. Around

37.3 million falls necessitating medical attention are reported each year. Preventive measures should focus on educating and training individuals, promoting safer surroundings, prioritizing research on falls, and implementing effective policies to mitigate risks.

Falls among elderly individuals are a significant health concern with potentially severe consequences. As people age, their physical strength, balance, and coordination may decline, making them more susceptible to falls. Falls can lead to a range of injuries and negative side effects that impact the overall well-being and quality of life of older adults. Understanding the risks and consequences associated with falls is crucial for healthcare professionals, caregivers, and society at large to develop effective preventive measures and appropriate interventions. Fall detection is a field of research and technology focused on identifying and responding to instances when individuals, especially the elderly or people with mobility issues, experience a fall. Falls are a significant health concern, often leading to injuries, loss of independence, and even mortality. Rapid detection and timely intervention can greatly reduce the negative consequences of falls, making fall detection systems an essential component of healthcare and assistive technologies.

In 2020, the unintentional fall death rate among individuals aged 65 and above was 70.3 per 100,000 population for males and 61.8 for females. In every age group, males experienced higher rates of unintentional fall deaths than females. The lowest rates were observed in the 65-74 age group, with 23.8 for men and

13.3 for women. Conversely, the highest rates occurred in the 85 and over age group, with 329.6 for men and 269.8 for women. Among adults aged 65 and above, the rates of unintentional fall deaths increased as age advanced for both males and females.

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