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AN IOT LOW-POWER DEVICE BASED WEARABLE DEVICES FOR FALL DETECTION.

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ABSTRACT :

Automatic fall detection is crucial for ensuring the well-being of elderly individuals, facilitating increased autonomy and independence while mitigating the risks associated with living alone. This paper addresses the growing demand for effective fall detection solutions by leveraging advancements in sensing and wireless communication technologies. Our proposed system utilizes readings from pulse rate and accelerometer sensors, processed by a microcontroller, to detect falls. By comparing sensor data against predefined thresholds, the system identifies potential falls in real-time. Additionally, the wearable device incorporates algorithms for analyzing motion patterns and foot orientation to recognize abnormal configurations indicative of a fall event. Importantly, the developed algorithm is lightweight, enabling efficient execution onboard the wearable device. This research contributes to the ongoing efforts to enhance elderly care through innovative technology solutions.

INTRODUCTION :

Nowadays, aging population shows a drastic increasing during the past decade; it's one of the greatest social and economic challenges of the 21st century. Advances in medicine and public health services have improved the overall longevity of people, and it is expected that over the next 50 years, the proportion of people aged more than 60 years is expected to be doubled from 10% to 22%. Those people prefer growing old at home and saving their independent lifestyles that often come with high risks. According to the statistics of Centers for Disease Control and Prevention (CDC), one out of three adults age 65 and older falls each year in the United States, and 61% of these falls occur at homes that cause 10,000 deaths. Yet obtaining a quick assistance after a fall reduces the risk of hospitalization by 26% and the death by 80%.

Accordingly, many supportive technologies and systems have been developed to track and monitor activities of elderly persons at home in order to assist their independent living and reduce the cost of premature institutionalization. But generally, all of these systems are relying on only one data provider (movement-sensor, camera, or accelerometer, etc.) that have their own limitations and do not ensure 100% reliability. Moreover, there still is a lack in experience and systematic knowledge to intelligently assemble the components into a robust, friendly-user and effective system, making no false alarm and detecting each fall case, without affecting elderly daily living patterns.Falls are a major threat to the health of older people. It is estimated that approximately one in three people over 65 years of age fall at least once every year, and these falls account for 90% of hip and wrist fractures and 60% of head injuries. In addition to physical injuries, many older people develop a fear of falling, which significantly reduces confidence to live .Recent research and advancement in wireless communication and physiological sensing have resulted in the manufacture wearable devices

LITERATURE SURVEY :

In [1] **AUTHOR NAME:** Lorenzo Chiari, Jorunn L Helbostad.

TITLE NAME: Fall Detection with Body-Worn Sensors.

PUBLISHED IN: 2013

Falls among older people remain a major public health challenge. Body-worn sensors are needed to improve the understanding of the underlying mechanisms and kinematics of falls. The aim of this systematic review is to assemble, extract and critically discuss the information available in published studies, as well as the characteristics of these investigations (fall documentation and technical characteristics). Methods: The searching of publically accessible electronic literature databases for articles on fall detection with body-worn sensors identified a collection of 96 records (33 journal articles, 60 conference proceedings and 3 project reports) published between 1998 and 2012. These publications were analysed by two independent expert reviewers. Information was extracted into a custom-built data form and processed using SPSS (SPSS Inc., Chicago, IL, USA). Results: The main findings were the lack of agreement between the methodology and documentation protocols (study, fall reporting and technical characteristics) used in the studies, as well as a substantial lack of real-world fall recordings. A methodological pitfall identified in most articles was the lack of an established fall definition. The types of sensors and their technical specifications varied considerably between studies. Conclusion: Limited methodological agreement between sensor-based fall detection studies using body-worn sensors was identified. Published evidence-based support for commercially available fall detection devices is still lacking.

In [2] **AUTHOR NAME:** Wiebren Zijlstra, and Jochen Klenk

TITLE NAME: Evaluation of Accelerometer-Based Fall Detection Algorithms On Real-World Falls

PUBLISHED IN: 2012

Despite extensive preventive efforts, falls continue to be a major source of morbidity and mortality among elderly. Real- time detection of falls and their urgent communication to a telecare center may enable rapid medical assistance, thus increasing the sense of security of the elderly and reducing some of the negative consequences of falls. Many different approaches have been explored to automatically detect a fall using inertial sensors. Although previously published algorithms report high sensitivity (SE) and high specificity (SP), they have usually been tested on simulated falls performed by healthy volunteers. We recently collected acceleration data during a number of real- world falls among a patient population with a high-fall-risk as part of the SensAction-AAL European project. The aim of the present study is to benchmark the performance of thirteen published fall-detection algorithms when they are applied to the database of 29 real-world falls. To the best of our knowledge, this is the first systematic comparison of fall detection algorithms tested on real-world falls. We found that the SP average of the thirteen algorithms, was (mean±std) 83.0%±30.3% (maximum value = 98%). The SE was considerably lower (SE = 57.0%±27.3%, maximum value = 82.8%), much lower than the values obtained on simulated falls. The number of false alarms generated by the algorithms during 1-day monitoring of three representative fallers ranged from 3 to 85. The factors that affect the performance of the published algorithms, when they are applied to the real-world falls, are also discussed. These findings indicate the importance of testing fall-detection algorithms in real-life conditions .

In [3] **AUTHOR NAME:** Jo-Ann Eastwood, Suneil Nyamathi

TITLE NAME: Improving Compliance in Remote Healthcare Systems through Smartphone Battery Optimization

PUBLISHED IN: 2015

Remote health monitoring (RHM) has emerged as a solution to help reduce the cost burden of unhealthy lifestyles and aging populations. Enhancing compliance to prescribed medical regimens is an essential challenge to many systems, even those using smartphone technology. In this paper,we provide a technique to improve smartphone battery consumption and examine the effects of smartphone battery lifetime on compliance, in an attempt to enhance users' adherence to remote monitoring systems. We deploy WANDA-CVD, an RHM system for patients at risk of cardiovascular disease (CVD), using a wearable smartphone for detection of physical activity. We tested the battery optimization technique in an in-lab pilot study and validated its effects on compliance in the Women's Heart Health Study. The battery optimization technique enhanced the battery lifetime by 192% on average, resulting in a 53% increase in compliance in the study. A system like WANDA-CVD can help increase smartphone battery lifetime for RHM systems monitoring physical activity.

In [4] **AUTHOR NAME:** Jian Yuan, Kok Kiong Tan

TITLE NAME: Power-Efficient Interrupt-Driven Algorithms for Fall Detection and Classification of Activities of Daily Living

PUBLISHED IN: 2015

Falls lead to major health problems for the elderly. Immediate help could lower the risk of complications and death and greatly increase the likelihood of returning to independent living. Automatic fall detectors are useful devices that can alert family members and caregivers at those life-critical moments. Traditional accelerometer-based fall studies focus on accuracies and largely neglect the fact that algorithms will mostly be implemented in microcontroller units (MCUs) with limited speed and random access memory. In addition, it is desirable for a fall detector to have a battery life of several weeks or months. This paper presents a fall detection algorithm and a classification algorithm for activities of daily living using a wrist-worn wearable device. Both algorithms are power-efficient and can be implemented easily in an 8-bit MCU. They adopt an interrupt-driven approach based on a modern digital micro electro mechanical systems accelerometer which supports interrupts and data buffering. The approach is completely different from conventional algorithms which must examine and process every piece of data sampled at high frequencies. The interrupt-driven approach allows a host MCU to examine significantly less data and only process upon accelerometer or timer interrupts.

In [5] **AUTHOR NAME:** Federico Bianchi, Stephen J. Redmond

TITLE NAME: Barometric Pressure and Triaxial Accelerometry Based Falls Event Detection.

PUBLISHED IN: 2010

Falls and fall related injuries are a significant cause of morbidity, disability, and health care utilization, particularly among the age group of 65 years and over. The ability to detect falls events in an unsupervised manner would lead to improved prognoses for falls victims. Several wearable accelerometry and gyroscope-based falls detection devices have been described in the literature; however, they all suffer from unacceptable false positive rates. This paper investigates the augmentation of such systems with a barometric pressure sensor, as a surrogate measure of altitude, to assist in discriminating real fall events from normal activities of daily living. The acceleration and air pressure data are recorded using a wearable device attached to the subject's waist and analyzed offline. The study incorporates several protocols including simulated falls onto a mattress and simulated activities of daily living, in a cohort of 20 young healthy volunteers (12 male and 8 female; age: years). A heuristically trained decision tree classifier is used to label suspected falls. The proposed system demonstrated considerable improvements in comparison to an existing accelerometry-based technique; showing an accuracy, sensitivity and specificity of 96.9%, 97.5%, and 96.5%, respectively, in the indoor environment, with no false positives generated during extended testing during activities of daily living. This is compared to 85.3%, 75%, and 91.5% for the same measures, respectively, when using accelerometry alone. The increased specificity of this system may enhance the usage of falls detectors among the elderly population.

In [6] "Fatigue and Collision Alert System Using Smart Technique," Chen et al. Developed smart glasses capable of detecting driver fatigue. The system automatically flashes the vehicle's rear lights and sends messages via an IoT module or cloud environment. Kinage and Patil proposed a fatigue detection system utilizing eye blinking sensors and integrated vibration and heart rate sensors to alert authorized users of accidents or collisions. This system also includes GPS and GSM devices for location tracking and message transmission. Siva Reddy and Kumari (Year) introduced an Arduino-based system for controlling unforeseen mishaps efficiently and at a low cost using camera-operated sensors. Jang and Ahn implemented a solution for detecting alcohol addiction and drowsiness in drivers by integrating sensors with a Raspberry Pi controller module. IoT modules are utilized to monitor abnormal driver activities, supported by webcam-based image processing and controller units. Their approach incorporates facial detection, eye blink monitoring, voice recognition, and machine learning methods to enhance the alert process.

EXISTING SYSTEM :

This research work is very helpful for critical patients like coma patients, dialysis patients and for those who were on bed for a long period. Because in these conditions, a minor movement done by the patient is detected that plays an important role in their treatment. In older systems there are no techniques to detect the patient's movement and it is very hard to monitor them by using manual power only. Now using sensors we can easily monitor the patient's movement.Conventional system has developed a wearable inertial sensor for human motion analysis to continuous track motions and positions of aging people. This system is comprised inertial measuring unit such as MEMS sensor for motion tracking. Also for monitoring the health condition of elderly people and reports are transmitted by RF to the doctor. This system consists of heart rsate sensor, pulse sensor, ECG sensor and Muscle sensor and a local monitoring RF transmitter and receiver.

This paper presents a comprehensive review of existing fall detection systems designed to address the pressing healthcare needs of elderly individuals. With a focus on enhancing autonomy and minimizing risks associated with independent living, we survey a range of technologies and methodologies employed in fall detection. Existing systems utilize various sensors, including accelerometers, gyroscopes, and pressure sensors, coupled with machine learning algorithms or rule-based approaches for fall detection.

COMPONENT DESCRIPTION :

1. **Microcontroller:** Provide details about the specific microcontroller you've used, including its model number, manufacturer, architecture, and any other relevant specifications. Explain its role in the project, such as processing data from sensors, controlling actuators, and managing communication with external devices.
2. **GSM Module:** Describe the GSM module you've utilized, specifying its model, manufacturer, supported communication standards (e.g., 2G, 3G, 4G), and any additional features (e.g., SIM card support, data transmission rates). Explain how it's integrated into your system and its function, such as sending alerts or data to remote servers via cellular networks.
3. **LM35 Temperature Sensor**: Detail the LM35 temperature sensor, including its specifications (e.g., temperature range, accuracy), manufacturer, and any calibration considerations. Explain how it's employed in your project, such as monitoring ambient temperature for detecting environmental conditions relevant to fall detection.
4. **Heart Rate Sensor:** Provide information about the heart rate sensor you've chosen, including its model, manufacturer, operating principles (e.g., photoplethysmography), and performance metrics (e.g., accuracy, sampling rate). Describe its role in the project, such as monitoring the wearer's heart rate for assessing health status or detecting anomalies.
5. **Accelerometer:** Specify the accelerometer model, manufacturer, measurement range, sensitivity, and output resolution. Discuss its application in your project, such as detecting changes in acceleration indicative of a fall event.
6. **Buzzer:** Describe the type of buzzer (e.g., piezoelectric buzzer), its operating characteristics (e.g., frequency, sound pressure level), and how

it's utilized in your system, such as emitting audible alerts in response to fall detection or system status indications.

7. **LCD Display:** Detail the LCD display module, including its dimensions, resolution, interface type (e.g., parallel, serial), and any additional features (e.g., backlight). Explain its purpose in the project, such as providing real-time feedback to the user or displaying system status information.
8. **Power Supply:** Specify the power supply requirements of your system, including voltage levels, current capacity, and any special considerations (e.g., battery-powered operation, energy-efficient design). Describe how power is distributed to different components and any power management techniques employed to optimize energy usage and extend battery life.

The method for fall detection utilizing wearable sensors and microcontroller integration, aiming to address the critical need for automated fall detection systems in elderly healthcare. Our method leverages pulse rate and accelerometer sensors embedded within a wearable device to monitor the user's physiological and movement data in real-time. The microcontroller processes the sensor readings and employs a threshold-based algorithm to detect abnormal patterns indicative of a fall event. By analyzing both the subject's motion and foot orientation, our approach enhances accuracy and reduces false alarms.

PROPOSED SYSTEM :

Doctors will observe breathing patterns to help diagnose the cause of the fall. They also check the skin for signs of any bruises due to trauma. To determine the affected person's level of consciousness, doctors may speak loudly or press on the angle of the jaw or nail bed. Doctors will watch for signs of arousal, such as vocal noises, eyes opening or movement. And also will test reflexive eye movements. These tests can help determine the cause of the fall and the location of brain damage. For monitoring the patient physically it is usually happening in hospitals where two or three hospital staff needed to monitor the patient 24*7 for watching if there is movement or not, but this is not efficient method to get maximum efficiency. So this project helps to monitor the patient physically for every moment. The system developed based on MEMS body sensor, Heartbeat sensor, Temperature sensor and the Obstacle sensor which is used to design a system which monitors the movement of the person at fall stage and alerts automatically by sending a message to the concerned person using IOT.

ADVANTAGE OF PROPOSED METHODOLOGY :

1. **Real-time Monitoring:** The system offers real-time monitoring of elderly individuals, enabling immediate detection and response to fall events, thereby reducing the risk of prolonged immobilization and associated complications.
2. **Wearable Convenience:** As a wearable device, the system provides a non-intrusive and convenient solution for fall detection, allowing elderly individuals to maintain their daily activities without disruption.
3. **Integrated Sensors:** By integrating pulse rate and accelerometer sensors, the system captures both physiological and movement data, enhancing the accuracy of fall detection and reducing false alarms compared to single-sensor systems.
4. **Onboard Processing:** The use of a microcontroller for onboard processing minimizes the need for external computational resources, ensuring efficient and low-latency fall detection without reliance on external devices or networks.
5. **Lightweight Algorithm:** The developed algorithm is lightweight and computationally efficient, enabling its execution onboard the wearable device without significant resource overhead, ensuring continuous monitoring without draining the device's battery quickly.
6. **Increased Autonomy:** With reliable fall detection capabilities, the system promotes increased autonomy and independence for elderly individuals, providing peace of mind for both users and caregivers while minimizing the need for constant supervision.
7. **Potential for Early Intervention:** Early detection of falls allows for timely intervention and assistance, reducing the severity of injuries.

METHODOLOGY :

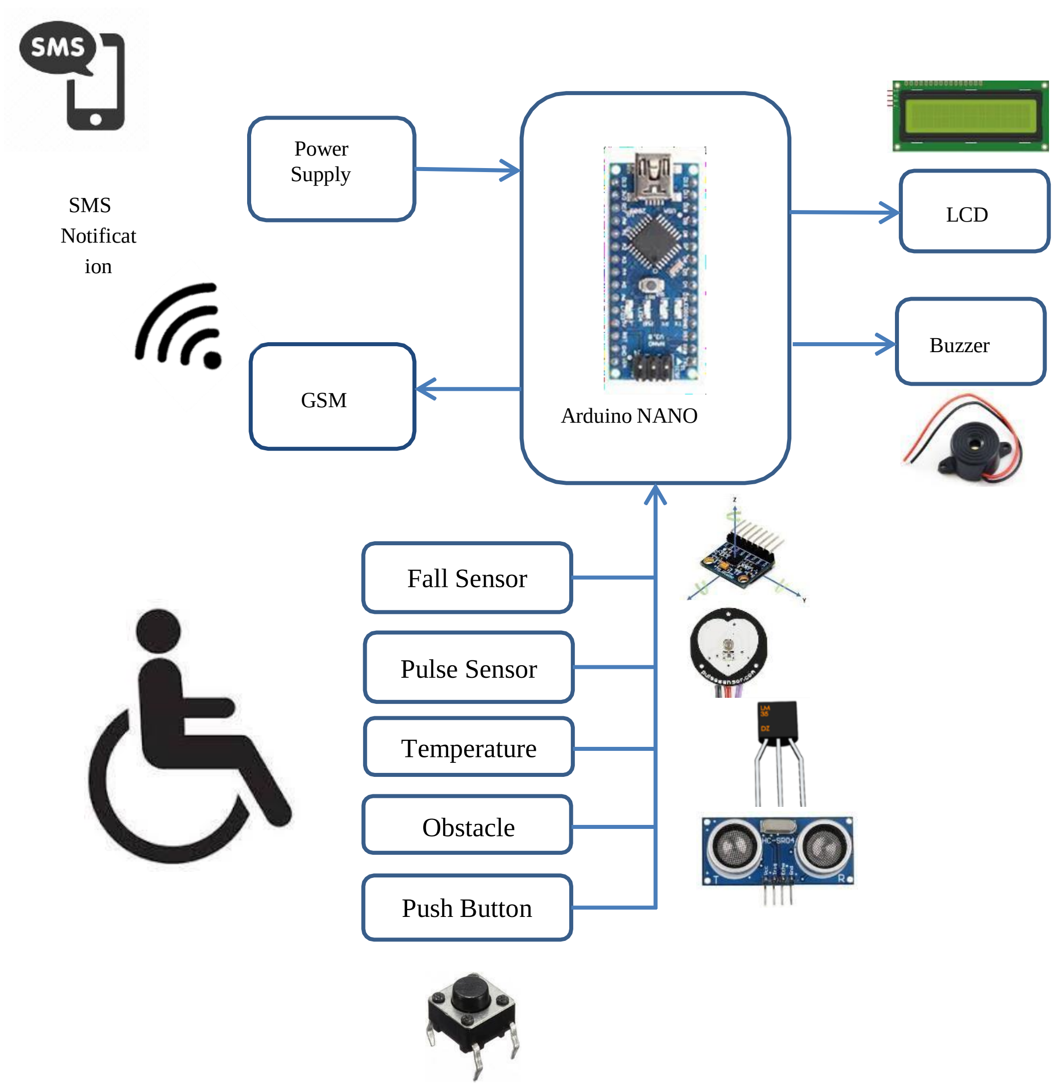
1. **Sensor Selection:** Identify and select appropriate sensors for the fall detection system. In this case, pulse rate and accelerometer sensors are chosen due to their ability to capture both physiological and movement data.
2. **Hardware Integration:** Integrate the selected sensors with a microcontroller platform (e.g., Arduino, Raspberry Pi) to facilitate data acquisition and processing. Ensure compatibility and establish communication protocols between the sensors and the microcontroller.
3. **Data Collection:** Conduct experiments or simulations to collect sensor data representative of various movements, including normal activities and simulated fall events. Gather a diverse dataset to train and validate the fall detection algorithm.
4. **Algorithm Development:** Develop a fall detection algorithm that utilizes the sensor data to identify patterns indicative of a fall event. Consider factors such as pulse rate variations, sudden changes in acceleration, and orientation to distinguish falls from other activities.
5. **Threshold Determination:** Determine appropriate thresholds for sensor readings that signify a fall event. This may involve statistical analysis of the collected data to establish baseline values and define thresholds for abnormal deviations.
6. **Algorithm Implementation:** Implement the fall detection algorithm on the microcontroller platform. Optimize the algorithm for efficiency and ensure compatibility with the available hardware resources.
7. **Validation and Testing:** Validate the performance of the fall detection system through extensive testing and evaluation.
8. **Iterative Refinement:** Iterate on the algorithm and hardware design based on feedback from testing results. Fine-tune parameters, adjust thresholds, or consider alternative sensor configurations to improve the system's performance and reliability.
9. **User Interface Design (Optional):** Develop a user interface, such as a mobile application or web dashboard, to visualize fall detection alerts

and provide additional features for users and caregivers, enhancing the usability and accessibility of the system.

10. **Deployment and Evaluation:** Deploy the finalized fall detection system in real-world environments, such as assisted living facilities or homes of elderly individuals. Monitor its performance over an extended period and gather feedback from users and caregivers to assess its effectiveness and practicality in everyday use.

By following this methodology, the proposed fall detection system can be systematically designed, developed, and evaluated to meet the needs of elderly individuals and caregivers, providing a reliable and user- friendly solution for enhancing safety and well-being.

Block Diagram :



Firstly, the proposed method is tested to select the discriminative parameters on synthetic data and evaluate its efficiency compared to well-known methods in literature. After that, we will show the results of parameters' extraction and selection, and then the change detection on real data. Note, that the accelerometer isused to enforce the differentiation between the falling and the lying down posture.

EXPERIMENTAL ANALYSIS :

- The system developed based on MEMS body sensor, Heartbeat sensor, Temperature sensor and the Obstacle sensor which is used to design a system which monitors the movement of the person at fall stage and alerts automatically by sending a message to the concerned person using IOT.
- In this project, it includes device and hardware part comprise of GSM/GPS module, LCD (16*2), Controller and different type of required sensor. Software is used to interface the elements with each other.
- The main motive of the project is to provide a protective ride and also to decrease the death rate.
- The implemented network characterized by patients indoor location, fall alert, temperature and heart rate measurement capability through

the usage of patients and remote monitoring.

  - For each sensor the sampling rate associated with analog channel is programmed in order to assure good accuracy of health parameter calculation.

- The remote service center receives the message; a medical monitoring group can contact the user, and then decide whether to send assistance.
- As mentioned in the discussion, the proposed fall detection has been developed and evaluated on data sets acquired from young volunteers rather than from an older cohort.

RESULT DISCUSSION AND PERFORMANCE ANALYSIS :

This work proposed the development of a fall detection system based on a wearable system. In this project, a low-power fall detector proposed fall detection and reduces its power consumption using both hardware- and firmware-based approaches. In the development of the firmware, human trials of simulated falls and real ADXLs were conducted by prototype, and the collected data sets were split into two parts for training and testing the fall classifier, respectively. Considering the pressure is the main power-consuming component in the proposed fall detection, future work will involve investigating methods of collecting and processing pressure data in a more energy-efficient manner. Moreover, coding efficiencies will be improved by replacing floating-point calculations with fix-point calculations. As mentioned in the discussion, the proposed fall detection has been developed and evaluated on data sets acquired from young volunteers rather than from an older cohort.

Moreover, these data will also enable investigation of the relationship between false alarm rate and user behavior. Although the latter requires the generation of a much larger event log than was collected in this study, it will pose a technical challenge as we try to simultaneously try to minimize and assess battery life. Moreover, the size and the shape of the LPFD will be improved with developments in the hardware and the enclosure to allow future subjects to wear the device both during the day and night with increased comfort and reduced obtrusiveness.

WORKING PRINCIPLE :

- The system developed based on MEMS body sensor, Heartbeat sensor, Temperature sensor and the Obstacle sensor which is used to design a system which monitors the movement of the person at fall stage and alerts automatically by sending a message to the concerned person using IOT.
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- The remote service center receives the message; a medical monitoring group can contact the user, and then decide whether to send assistance.
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SYSTEM IMPLEMENTATION :

The implementation of the proposed system involves integrating various components and modules to create a cohesive solution for detecting driver drowsiness and assessing collision severity. Key components include the Raspberry Pi3 model B module and the Pi camera module, which enable continuous recording of facial landmarks and calculation of the Eye Aspect Ratio (EAR) to detect drowsiness. Additionally, sensors are incorporated to measure collision impact, while GPS tracking facilitates accurate location tracking of accidents. The system is programmed using Python to manage data processing, communication with sensors, and generation of alerts.

In the development of the firmware, human trials of simulated falls and real ADXLs were conducted by prototype, and the collected data sets were split into two parts for training and testing the fall classifier, respectively. Considering the pressure is the main power-consuming component in the proposed fall detection, future work will involve investigating methods of collecting and processing pressure data in a more energy- efficient manner. Moreover, coding efficiencies will be improved by replacing floating-point calculations with fix-point calculations. As mentioned in the discussion, the proposed fall detection has been developed and evaluated on data sets acquired from young volunteers rather than from an older cohort.

Some preferences can be set in the preferences dialog (found under the Arduino menu on the Mac, or File on Windows and Linux). The rest can be found in the preferences file, whose location is shown in the preference dialog.Boards.The board selection has two effects: it sets the parameters (e.g. CPU speed and baud rate) used when compiling and uploading sketches; and sets and the file and fuse settings used by the burn bootloader command. Some of the board definitions differ only in the latter, so even if you've been uploading successfully with a particular selection you'll want to check it before burning the bootloader.Arduino Software (IDE) includes the built in support for the boards in the following list, all based on the AVR Core.

CONCLUSION :

This work proposed the development of a fall detection system based on a wearable system. In this project, a low-power fall detector proposed fall detection and reduces its power consumption using both hardware- and firmware-based approaches. In the development of the firmware, human trials of simulated falls and real ADXLs were conducted by prototype, and the collected data sets were split into two parts for training and testing the fall classifier, respectively. Considering the pressure is the main power-consuming component in the proposed fall detection, future work will involve investigating methods of collecting and processing pressure data in a more energy-efficient manner. Moreover, coding efficiencies will be improved by replacing floating-point calculations with fix-point calculations. As mentioned in the discussion, the proposed fall detection has been developed and evaluated on data sets acquired from young volunteers rather than from an older cohort.

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