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GPS based smart wheelchair monitoring and control system

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Abstract
Wheelchairs are essential for people with physical disabilities, seniors, and those temporarily incapacitated due to illness or injury. This study focuses on developing a wheelchair prototype and fall detection system using Raspberry pi Pico W. The system, which includes MEMS Sensor, Bluetooth, and GPS module, triggers an emergency buzzer alert and sends a notification to the affected person in case of a fall. This innovative system improves patient safety and security, offering a reliable fall detection solution that can be customized to meet specific patient needs.

Keywords: Physical disabilities, wheelchair, fall detection, raspberry pi Pico W, MEMS sensor, bluetooth GPS, buzzer, caregiver

Introduction
The WHO defines a fall as "an unexpected event that takes the person to the ground or lower level without loss of consciousness [1]. A fall can cause immobility, head injuries, tissue injuries, joint dislocations, bone fractures, and head trauma [2]. Several techniques exist for fall identification.

Common fall detection solutions encompass wearable sensors, camera monitoring systems, and hybrid systems that integrate both methods. These three systems are extensively elaborated upon in the" classification of fall detection strategies". The developed approaches to fall detection can be split into two categories: threshold-based and machine learning (ML)-based [3].

One of the most common fall detection strategies used is wearable sensors based. In this strategy, an accelerometer and a gyroscope are the most commonly used sensors. These sensors are attached to the person's body. Thus, these sensors sense the movements of the person and hence detect the fall. A threshold is set so that, when the readings go beyond the threshold value a fall is detected which ensures the safety of the elder person.

Employs wearable sensors such as a 3-axis accelerometer and a 3-axis gyroscope [4]. The data sensed is transferred to the cloud for storage. The stored data is accessed using an Android application. The Raspberry Pi board is used to store data received from a cloud server. The medical expert can access the information saved in the program to notice the fall quickly and take appropriate action. MPU6050 is a wearable sensor used to detect falls. The triaxial accelerometer detects inertial shifts, whereas the gyroscope measures angular velocity. When a person falls, the X and Y axes of the accelerometer become parallel, and the reading is obtained through the Z axis. Acceleration is measured in meters per second square units. To monitor the complex movements, fusion algorithms employ a 3-axis accelerometer and a 3-axis gyroscope, which, along with an onboard digital motion processor (DMP), are integrated on the same chip. The data collected from the MPU-6050 is transferred from the Raspberry Pi to Google Cloud using the Google Sheets API. To facilitate this data upload, a service account was created, requiring the account's JavaScript file for authentication. Once verified, the data will be uploaded. This research describes how IOT is used to detect falls and how accurately the detection has been occurring. As technology advances, IOT-based fall detection strategies enable individuals to care for the elderly and prevent frequent falls.

A technique for fall detection that utilizes computer vision and IoT is outlined in the

document [2]. The system employs a Raspberry Pi Model B controller equipped with with integrated Wi-Fi and an Ethernet connection. A high-resolution Pi camera is deployed to monitor the entire room. To identify a fall event, four characteristics are analyzed: aspect ratio, centroid, orientation angle, and Hu moment invariants. The programming is conducted using Python 2.7 and the OpenCV library. In the event of a fall, the Pi camera captures and records a screenshot and video, which are then emailed to the designated caregiver. Additionally, if an individual at a distant location wishes to observe the live feed, they can access it by entering the IP address of the Raspberry Pi to view the room's live broadcast. Motion detection software examines video signals from cameras. Making necessary adjustments to the motion. conf file will result in Remote access to webcams allows for live video viewing from any computer connected to the local host. Flask is a micro web application framework based on Python. It supports live streaming through the use of generator functions that yield multiple outcomes in sequence. Flask's streaming capability employs the "Motion JPEG" technique, which streams individual JPEG images. This feature is commonly used in various surveillance systems.'

The ML-based technique was explored in [3]. The person's information is collected using a smartphone equipped with tri-axial accelerometer and tri-axial gyroscope sensors. It tries to detect falls in a huge number of people. Whoops is an application built to gather people's data and deliver it to a data center, where the data is utilized to form a person's profile on the edge side. Whoops serves two functions: retrieving data from sensors and delivering it to the cloud, as well as presenting data processing and analysis conclusions. It can automatically call an emergency service after a predetermined time in the application. The IOT hub is responsible for transferring sensor data to the cloud. This data is supplied as a JSON object. This research describes a dedicated cloud- based approach to fall detection. The classification ML model has been implemented on the cloud. Different classifiers have been tested. Not only cloud-based but also the edge-based monitoring also mentioned here. The transferred data is separated into data streams and processed in a 3-second hopping and overlapping frame to extract features. Each time frame computes the highest magnitude of acceleration, maximum magnitude of angular velocity, and Pearson's correlation coefficients for all axis pairings of accelerometer and gyroscope. The retrieved features are provided as request parameters to the ML service, which detects the fall. The results are saved in BLOB storage space. Whoops also depends on classification while detecting falls. An ML-based model was trained, packaged, and deployed as a web service using AZURE ML Studio. The ML Model was trained on the publicly accessible SiSFall dataset.

Design and implementation

Wheelchairs are used by those who are physically disabled or impaired. Wheelchairs provide mobility, support, and freedom to people who are unable or have trouble walking. It enables them to participate in daily activities. Obstacles such as smooth or uneven surfaces, such as steps, might cause a fall. As a result, the person sitting in the wheelchair may sustain serious injuries. It can sometimes be fatal. Thus, the wheelchair fall detection system is an ideal solution for detecting falls. The chances of falling in a wheel chair are the same as in manually operated wheel chairs. So, the suggested microcontroller-based wheelchair fall detection system assists the physically impaired or old by notifying the fall to the appropriate caregiver. Not only does it warn the caregiver, but it also provides the location of the elderly person who fell from their wheelchair. Thus, this system outperforms the automated wheelchair. It also allows the caregiver to take rapid action following the fall. Most importantly, if the caregiver is not there with the patient, the fall can be detected via the website "ThingSpeak.com". In this paper, Hardware components such as Raspberry pi Pico W micro controller, MEMS Sensor, Bluetooth, GPS module, power supply. 'C' language is used for programming in this paper.

Raspberry Pi Pico W is micro controller, to which all other peripherals are linked. We have used Dual-core ARM Cortex M0+ processor, with flexible clock running up to 133 MHz it has 264kB of SRAM, and 2MB of onboard Flash memory, with a Built-in Wi-Fi. This system just has one sensor, the MEMS sensor. MEMS stands for "MICRO ELECTRO MECHANICAL SYSTEM". MEMS sensor is a 3-axis single-chip accelerometer with Reliable operation, Low power dissipation and cost effective. Organic Light-Emitting Diode (OLED) is a form of LED with an emissive electroluminescent layer composed of organic chemicals. The layer is composed of polymers that emit red, green, or blue light when a voltage is applied. SSD1306 is the model's name of OLED used in this system pixel size is given by 128x64. Height of OLED is 0.96 inches and 3.3-5 volts of power supply is given to the OLED. The Global Positioning System (GPS) is a navigation system that determines the ground position of an object. Bluetooth is a short-range wireless technology standard used to exchange data between fixed and mobile devices over short distances. Range of Bluetooth is 5 meters and frequency is 2.4GHz. The above are the main components of a fall detection system. Additionally, a transformer, bridge rectifier, capacitor, and satellite signal receiver are utilized. These primary components are connected to the following pins on the Micro controller:

MEMS Sensor: The sensor's X and Y axes are connected to the microcontroller's 26th and 27th general purpose input output pins.

OLED: The SDA and SCL pins of the OLED are connected to the microcontroller's GPIO 6 and GPIO 7 pins.

GPS: The transmitter pin of the GPS is connected to the receiver of the controller, which is GPIO 1. Bluetooth: Bluetooth is connected to the microcontroller's eighth and ninth pins.

Buzzer: Buzzer is connected to the microcontroller's GPIO second pin.

5volts of power supply is provided to the raspberry pi Pico W microcontroller.

When the microcontroller receives power, it attempts to connect to the specified Wi-Fi module, while the GPS antenna attempts to receive a signal from the satellite. When the microcontroller is connected to Wi-Fi, information is sent to the caregiver as soon as the fall is recognized.

The MEMS Sensor detects a change in acceleration values,

i.e., when the values surpass the threshold values for both the X-axis (+500/-500) and the Y-axis (+600/-600), a fall is recognized. When the caregiver is in a remote place, they can get the information via the website "Thing Speak.com". A channel has to be developed on this website to obtain information about the fall. Steps to Create Channel in The Website “ThingSpeak.com”:

Step 1: Sign up with mail. Step 2: Create new channel.

Step 3: Give appropriate name and describe about it in the description. Step 4: Label the fields and then save the channel.

Step 5: Set your channel status as private.
To protect the privacy of the caregiver, the patient, and their information, the channel access can be private, meaning that only the appropriate caregiver and the patient can access information about the fall, guaranteeing the patient's details remain secure.

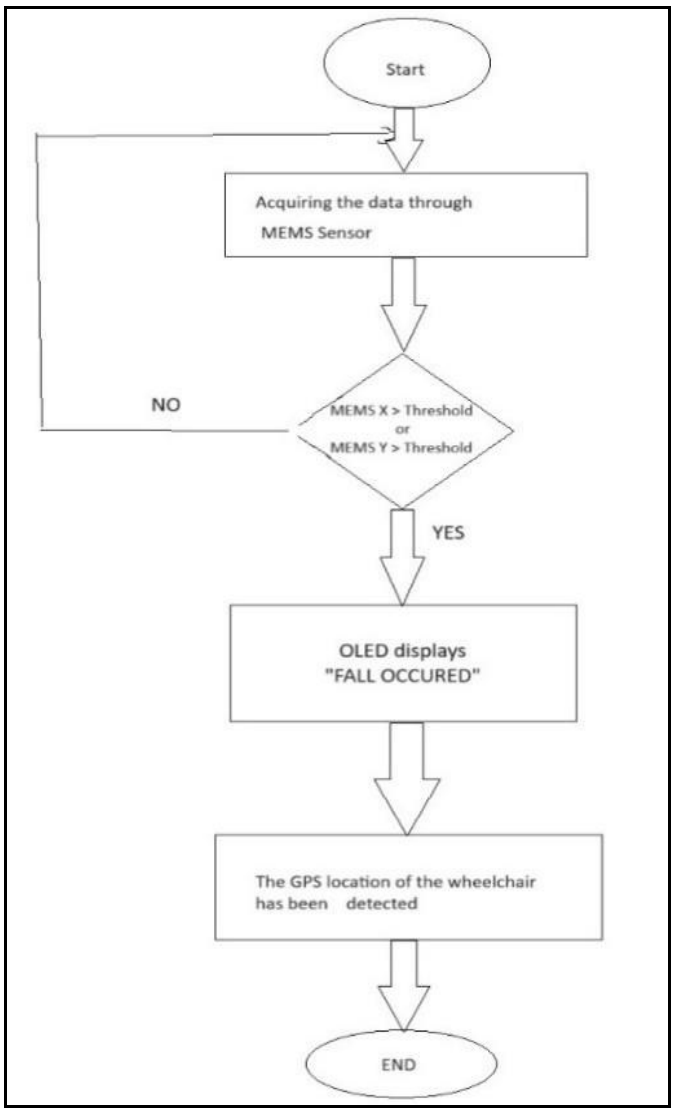

Fig 1: flowchart of the proposed system

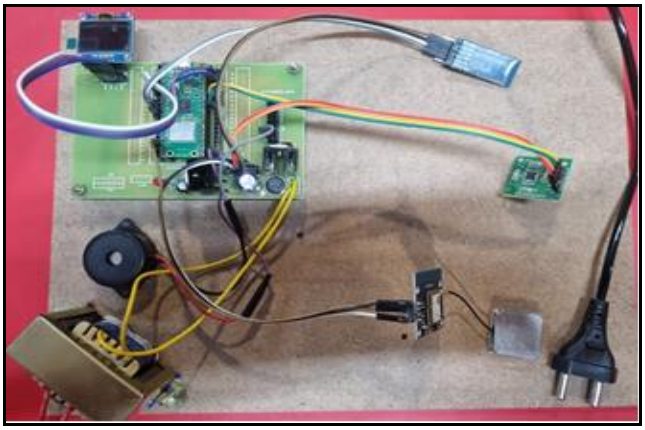

Fig 2: Demonstration of hardware configuration of the proposed system

Result and Discussion

A MEMS accelerometer, a very sensitive sensor, is used to measure the rate of change in velocity with respect to time, also known as acceleration. The acceleration can be measured in two orthogonal axes (X and Y). A threshold is established for both orthogonal axes. If the value exceeds the threshold, a fall is noticed. The accelerometer is tested with various X- and Y-axis values, and the results are obtained in the following scenarios. The threshold value of X-axis of MEMS sensor is +/- 500

Case 1: If the value of X-axis of MEMS Sensor is less than 500 the OLED displays “FALL OCCURRED”

Case 2: If the value of X-axis of MEMS Sensor is greater than 500 the OLED displays "FALL NOT OCCURRED" Similarly for Y-axis of MEMS sensor threshold value is +/- 600

Case 3: If the value of Y-axis of MEMS Sensor is less than 600 the OLED displays "FALL OCCURRED"

Case 4: If the value of Y-axis of MEMS Sensor is greater than 600 the OLED displays "FALL NOT OCCURRED"

These 4 cases mentioned above were tested and the result was accurate and this system accurately detects the fall that helps the caregiver take a necessary action.

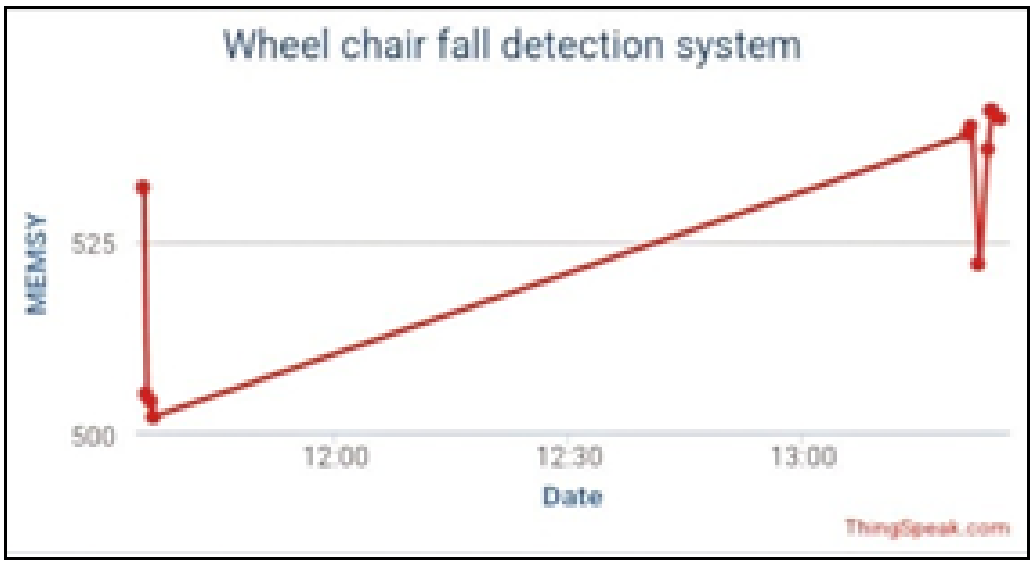

Fig 3: MEMS Sensor Y-axis values represented in a graph

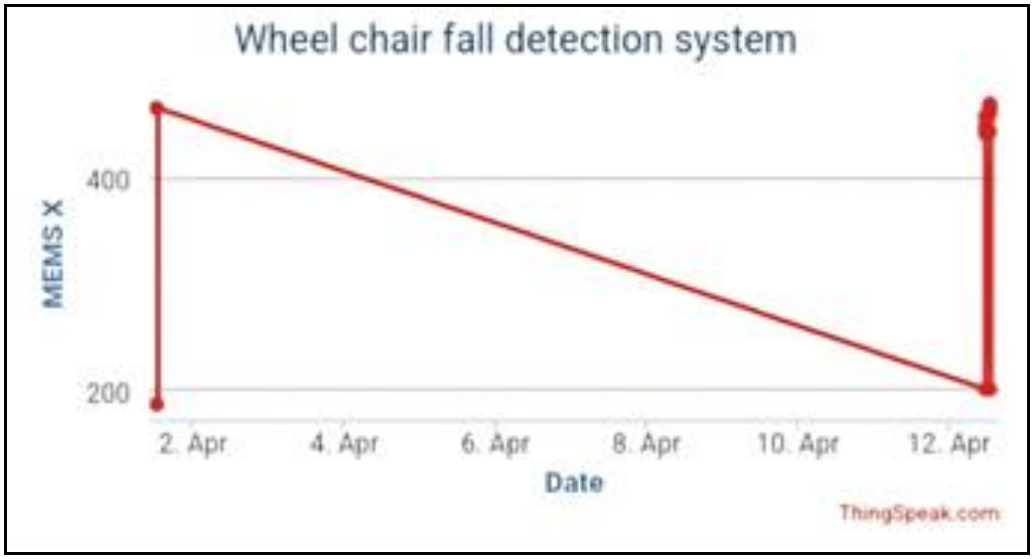

Fig 4: MEMS sensor X-axis values represented in a graph

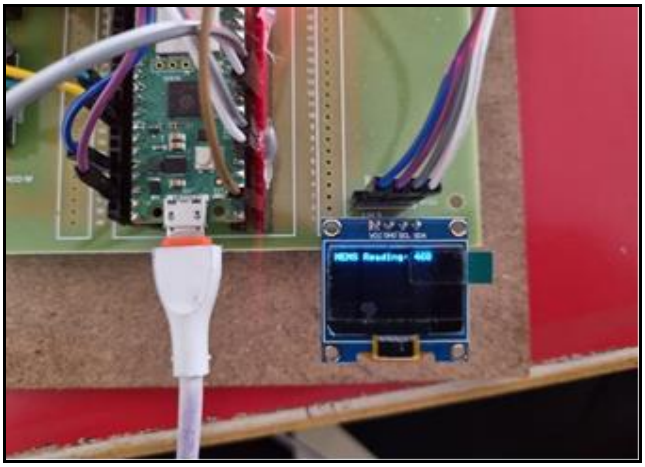

Fig 5: Displaying MEMS sensor readings on an OLED

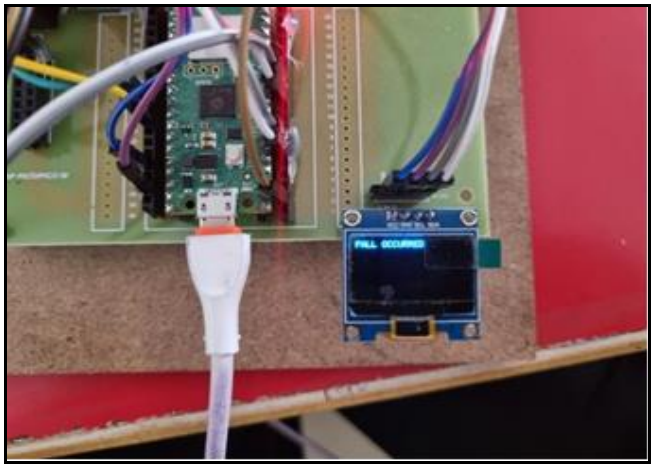

Fig 6: OLED displaying "FALL OCCURRED" after detecting the fall

Conclusion

It is concluded that a wheelchair falls detection system equipped with a controller and GPS module offers crucial data, enabling caregivers to react swiftly to falls. For caregivers at distant locations, the website "ThingSpeak.com" proves to be useful. This method yields satisfactory results and is particularly advantageous for seniors. The system's Bluetooth technology is essential for short- range communication, providing prompt alerts to caregivers. In summary, the system is practical, effective, and suitable for various real-time applications. Additionally, there is potential for future enhancements using machine learning and artificial intelligence.

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