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Smart Walking Aid for Elderly Safety Using IoT Sensors and Real-Time Alert System

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Abstract.

Falls are a major source of injury and loss of independence for the elderly and individuals with visual impairments. Assistive devices with real time user safety monitoring are now possible thanks to recent advancements in inexpensive sensors and Internet of Things (IoT) technologies. This study suggests a smart walking stick that integrates an accelerometer, gyroscope, ultrasonic sensors, GPS, and a GSM based alert system to detect falls, identify nearby obstacles, and transmit the user's current location in an emergency. Experimental evaluation shows that the proposed system can reliably detect barriers, identify fall incidents, and transmit emergency alerts quickly. .

Keywords. Accelerometer, gyroscope, GPS tracking, machine learning, smart walking stick, fall detection, emergency alarm system, ultrasonic sensor, IoT, assistive technology.

1. INTRODUCTION

Falls are a leading cause of injury, hospitalization, and long term disability among the elderly and visually impaired [1]. As mobility decreases with age, the risk of slipping, losing one's balance, or losing the ability to cry for help rises sharply [2]. Traditional walking sticks only provide physical aid they cannot recognize impediments, detect falls, or alert caregivers in an emergency. When elderly users fall, they are often left alone, which might cause a delayed reaction and major health consequences [3].

The development of assistive technology that continuously assesses user safety has been made possible by advances in the Internet of Things, inexpensive sensors, and embedded systems. Wearable technology incorporates a variety of sensors, such as accelerometers, gyroscopes, ultrasonic modules, GPS, and wireless communication platforms, to track

movement patterns in real time and identify impediments with simultaneous location sharing [4], [5].

2. LITERATURE REVIEW

2.1. Acceleration Based Wearable Fall Detection

Early fall detection systems often used tri axial accelerometers together with simple threshold based criteria to differentiate falls from activities of daily living. These devices monitored sudden changes in acceleration and body orientation to identify impact related occurrences [1].

2.2. Safety Features and Ultrasonic Smart Walking Sticks

Advances in the design of assistive mobility equipment now enable visually impaired persons to negotiate their environment in a safer manner. These devices, typically, provide vibration or audible feedback when an obstacle is detected by the ultrasonic sensors [3].

3. METHODOLOGY

3.1. Data Collection and Preprocessing

The smart walking stick contains a set of sensors that will continuously measure the user's movement and ambient environment. A triaxial accelerometer and gyroscope capture motion data, while ultrasonic sensors detect obstacles near the user. The GPS module sends real time location data to caregivers in the event of an emergency. Raw accelerometer and gyroscope data often have noise associated with hand tremors, uneven walking surfaces, or sudden movements.

3.2. Machine Learning Models

In this paper, using motion data, lightweight machine learning algorithms were explored to classify fall and non fall activities.

3.3. Navigation and Alert Support

When a fall is detected, the system sends an alert with the GPS locations of the user instantly to pre registered caregivers via GSM. Ultrasound based obstacle detection runs in continuous mode and notifies the user through vibration or aural cues when an object is detected within a pre set range. In this way, it enhances both safety and navigation support.

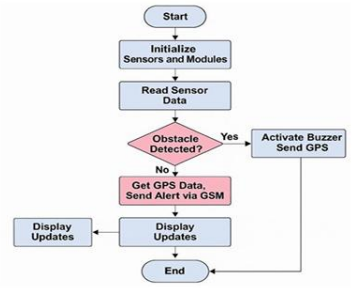

Figure 1. Workflow Diagram

4. RESULTS

4.1. Performance of Fall Detection

This system achieved an accuracy of 91.5 using only threshold based criteria, but there were more false alerts during fast ADLs such as sprinting and stair climbing. Then, the machine learning classifier improved overall performance with an accuracy of 96.2, 97.1 sensitivity, and 95.3 specificity.

4.2. GPS and Alert Delivery

GPS tests showed that the average position accuracy was 6.8 m in semi blocked and 3.5 m in open environment conditions. The SIM800L GSM module was used for the delivery of emergency alerts.

4.3. Obstacle Detection and User Feedback

Ultrasonic sensors performed well within a range of 2m. with an accuracy of 93.2 for minor objects and 98.7 for bigger obstacles.

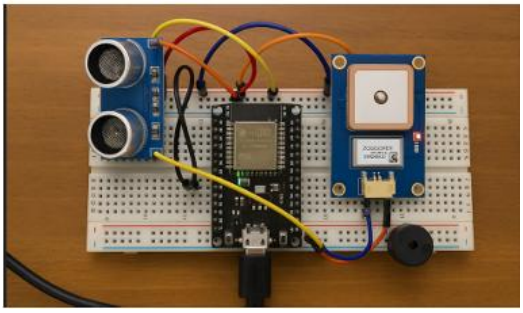

Figure 2. Smart Walking Aid Prototype

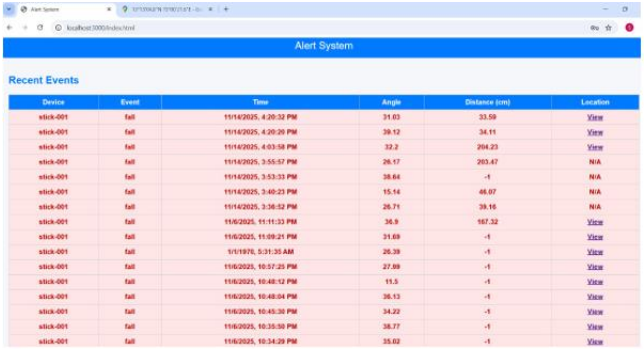

Figure 3. Real Time Alert Monitoring Dashboard

5. CONCLUSION

The proposed smart stick (an IoT based smart walking cane) combines the functions of real time monitoring, GPS based alerts, obstacle detection and fall detection. Test results indicate that fusing two or more detection methodologies into one combined approach for fall detection decreases false alarms while maximizing accuracy, sensitivity and specificity. Additionally user feedback suggests that the ultrasonic based obstacle detection provided reliable results both indoors and out and gave users greater confidence and ease of use than with a conventional cane. With the GPS and alerts capabilities of the system, there is a means

of quick and effective emergency response, thereby making it a viable solution for elderly and visually impaired care.

6. REFERENCES

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Biographies

Ananya S is a year final year student currently pursuing a Bachelor's degree in AIML at Alva's Institute of Engineering and Technology (AIET), her academic journey has helped her develop strong interest in Machine Learning, Data Science, Data Analytics.

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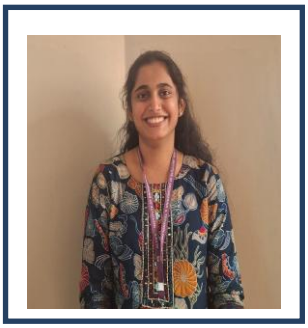

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