Good-Eye: A Device for Automatic Prediction and Detection of Elderly Falls in Smart Homes

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***Abstract*—This is an extended abstract for a Research Demo Session based on our published work [1]. It is important to be able to reduce the frequency of elderly falls and their disastrous effects. Good-Eye proposes an edge device which predicts or detects falls based on image orientation and physiological sensors using the Internet-of-Medical-Things (IoMT). Using LED lights, the user is notified with the decision of fall prediction and detection if the observed change is greater than a set threshold. Along with a camera attached to the wearable, the Good-Eye system proposes a remote off-line on-wall camera to make more accurate prediction and detection of falls.**

***Index Terms*—Smart Healthcare, Smart Home, Healthcare Cyber-Physical System (H-CPS), Internet of Medical Things (IoMT), Fall Detection, Elderly Falls**

I. Introduction

Automatic fall detection has been a point of interest for decades. There are multiple research works which focus on the subject, but they are not effective as they have low sample sizes, and low success rate [2]. There are marketable devices for fall detection but they do not provide accurate results and often give false alarms [3].

We present Good-Eye which is an IoMT enabled edge device that can detect and also predict fall related accidents. This wearable uses physiological sensors, along with heart rate sensors and images from cameras to eliminate false positives. The camera is also used to capture the surroundings, allowing first responders to more accurately find the location of the fallen person.

Constant care, convenient accessories and immediate medical support are the motivating principles behind Good-Eye. Thus, Good-Eye is ready to be integrated in IoMT based H-CPS framework that builds smart healthcare to provide various healthcare related quality services [4].

II. The Proposed Good-Eye System

A. Architecture of Good-Eye

The sensor input data are processed in the physiological sensor unit. The image input data is processed to observe the changes in the environment and the orientation of images at on-site and off-site cameras. As per the set threshold ranges, the compared and analyzed data along with the decision are sent as notifications to the users. The representation of the architecture is shown in Fig. 1.

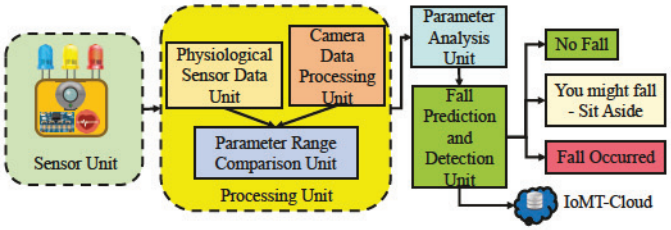

Fig. 1. Architecture of Good-Eye [1].

B. Parameters Considered in the Good-Eye System

Factors considered in fall prediction and detection in the Good-Eye system are:

- Accelerometer axes changes.
- A comparison with the resting heart rate to any sudden fluctuation in the heart rate.
- To be able to detect changes in orientation, to observe the environment and to understand the intensity of falls, a camera is placed on the wearable.
- An additional on-wall camera is used to monitor the falls inside rooms, which also connects to the wearable for making more accurate decisions.

C. Methodologies

1) On-site Design Flow of the Good-Eye System: The physiological signal data from the sensors on the wearable along with the image data attached to it are obtained here. The camera's orientation along with the spikes in heart rate variability are monitored whenever there is a change in the accelerometer values. Even if there is no orientation change detected, the sensor data is used to make the decision. The predictions and detection of falls are communicated to the users and their caregivers.

2) Off-site Design Flow of Good-Eye System: With a motion detected in the room, the camera starts tracking the person. In order to eliminate fake positive instances, the camera is connected to the wearable. The decisions of fall are made by considering the physiological sensor data and the image orientation. If the on-site wearable or off-site camera malfunctions, a "No Movement Detected" notification will be presented to the guardians and doctors. Incidents of strokes and false positive results can be reduced through this notification.

In case of a true negative incident, the image data from the wearable or from the camera can be easily transferred to the emergency help units allowing them to assess the fall, making the Good-Eye system trustworthy and minimizes resource waste. Its working model is shown in Fig. 2.

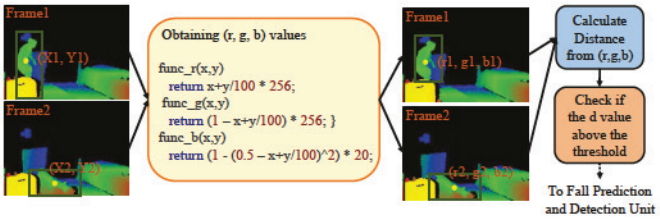

Fig. 2. Proposed Model of Good-Eye [1].

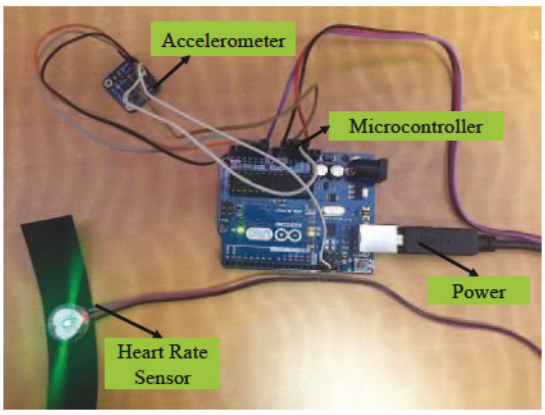

Fig. 3. Prototyping of Good-Eye [1]

D. Fall Prediction & Detection Unit

Studies shows that the heart rate at maximum for elder people is lower when compared to younger persons' rates. For elder people it is observed at around 162 +/- 9 beats/min (maximum). For younger people it is around 191 +/- 11 beats/min [5]. During a fall, there is a significant change in the y-axis of the accelerometer. This change is observed to be approximately 3 g [6]. Based on the Bayesian filtering method, the change in orientation of an image from the camera is observed in [7]. The decision based on the input data is represented in Table I.

TABLE I
ANALYSES FOR FALL PREDICTION AND DETECTION [1]

Accelerometer	HRV	Camera Orientation	Decision
Change in y value to ± 3 g	Sudden change in heart rate detected; Typically $\pm$10bpm	Change in 45% of pixels	Fall Detected
Change in y value to ± 3 g	No Sudden change in heart rate detected; Typically $\pm$10bpm	Change in 45% of pixels	No Fall Detected
No Change in y value to ± 3 g	Sudden change in heart rate; Typically $\pm$10bpm	Change in 45% of pixels	Fall Predicted
Change in y value to ± 3 g	Sudden change in heart rate; Typically $\pm$10bpm	No Change in 45% of pixels	Fall Predicted

III. IMPLEMENTATION AND VALIDATION

The microcontroller where the processing is performed is connected to a three-axis accelerometer, heartbeat sensor and a camera, as shown in Fig. 3.

The Person Falling Dataset [8] is used for validation of the Good-Eye system. 6 subjects and 144 different instances of sitting and falling are recorded with the use of depth cameras. An accuracy of 95% was observed when this dataset is fed into the Good-Eye system.

IV. CONCLUSIONS

A reliable method for fall detection in elderly is proposed through the Good-Eye system. The addition of physiological sensor data and image inputs along with the accelerometer data allows the Good-Eye system to make accurate fall prediction and detection decisions.

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