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**MutliModal Fall Detection System**

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# Introduction

In terms of the tendency of an elderly person to fall in isolated conditions given the fact that they themselves may be experiencing issues and illnesses with joint related issues it may be seen that there has been a vivid increase in the rate at which elderly persons tend to retain injuries at their age due to being neglected in their given state, a study was conducted from the Departments of Medicine (M.E.T., S.F.G.) and Epidemiology and Public Health (M.S.) (Mary E. Tinetti, 1988) and it was found that of a group of 336 elderly persons over the age of 75, 32% (108 subjects) of them had fell at least once. 24% of them had experienced serious injuries, each of which had worsened their conditions. These studies were carried out within a controlled group of people as to where each of them had no chronic disease, thus proving the fact that elderly persons with disease as such may experience much more consequential aftereffects.

Regarding the Literature review provided here, it should be noted that each of the mentioned studies have some relevance to our project in terms of how we may utilize the resources they have developed and provided for their own projects. This is exclusive of utilizing the entire project but instead using small segments for each project as they each provide us with a key understanding into how we are to implement some of the components of out project.

# 2.0 Relevant Works

## 2.1 Posture Detection using Image Pre-Processing for fall detection

In today’s world it has been found that many elderly people are affected by falls due to isolation from the presence of a more capable and caring individual. A study was conducted by a group of individuals to monitor and record the effects of social isolation on the quality of life in elderly adults (Roger D. Newman-Norlund, 2022). It was found that it depreciates rapidly due to the forced and induced isolation that was projected onto these individuals.

In terms of how posture detection will be used to predict a fall, it may be seen that an object detection API will first feed the algorithm with real time data that is brought in it from a device that may be staged as a camera. The first task that will take place in terms of data pre-processing will be that of how the real time data will be actively fed into the model as raw/unprocessed data. Furthermore, it may be seen that the tendency of persons over the age of 80 to fall is quite high given risk factors such as isolation that affect them (Norsk forening for epidemiologi, 2012).

Thereafter once the data has been uploaded into the machine learning algorithm it will first be cleansed and set to a limit of **24** recorded frames per second. Thereafter feeding it into the algorithm, the first process to take place is [pose landmark projecting](https://ai.google.dev/edge/mediapipe/solutions/vision/pose_landmarker) using “MediaPipe”. What happens here is that the data being fed into the algorithm will first have each frame separated from one another and then processed separately. Thereafter, utilizing MediaPipe’s pose landmark detection API, we will be projecting these points onto a person’s detected joints.

Having projected these points onto them, the algorithm may then assume a series of thresholds that are to be surpassed to initialize a state where the person is about to fall. In other words, the algorithm will try to understand if a persons joints are surpassing a certain threshold (eg: Elbows are close to the Knees suggesting that the person may collapse), thereafter it will see if that threshold is maintained for a given period of time and then if it exceeded the necessary measure will be taken to ensure that the person falls safely while alerting the relevant authorities.

It is proposed that the peripherals utilized for this segment of the project may be cost-effective and affordable given the fact that most systems are mostly unaffordable to the necessary demographics (Eg: elderly people). So, we believe that through the use of a trained model we may be able to implement a cost-effective solution to the issue at hand.

A study for the mentioned process has already been carried out by (Saraswat & Malathi, 2024) who had already implemented a vision-based fall detection system utilizing “MediaPipe” as it’s backend for pose detection. To conclude, we propose that by utilizing an object detection API for posture detection we may greatly improve the overall accuracy of the systems ability to predict whether the user is about to fall or not.

# 3.0 Existing Works

Table 1: List of all the exisiting works

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Citation** | **Technology/Algorithm Used** | **Dataset** | **Advantages** | **Limitation** | **Metric** |
| **Posture Detection using Image Processing API for fall detection** | | | | | |
| (Lin, et al., 2022) | Object Detection API using neuromorphic computing hardware and cameras | N/A | Able to accurately detect whether a person has fallen or is about to fall given the fact that it utilizes "emulated' brain tissue elements | **False Alarms**: Occlusion, especially when the subject's skin is blocked by clothing or background elements, leads to **false positives** | Fall Detection Rate: 91.01%  False Detection Rate: 0.3% |
| (Liaqat, et al., 2021) | Utilizes deep learning and machine learning (random forest, KNN, SVM, etc) for posture detection | N/A | Detects sedentary behaviour by detecting poor postures in real time and the alerts the user to move | The postures detected are only when the user is sitting or standing (not when they are in any other position) | N/A |
| (Ogundokun, et al., 2022) | Utilizes  Convolutional Neural Networks (CNNs) Which is normally used for human posture detection due to their ability to extract multiscale high-level visual representations. | MPII Human Pose Dataset | By using image data augmentation, the model reduces overfitting issues typically seen in deep learning when training on small datasets. | Deep CNN models like AlexNet and VGG16 require significant computational resources and time due to the millions of parameters involved making it cost inefficient |  **AlexNet:**   * **Accuracy: 91.2%**    **VGG16:**   * **Accuracy: 90.2%**    **CNN:**   * **Accuracy: 87.5%**    **MLP:**   * **Accuracy: 89.9%** |
| (G. Diraco, 2010) |  | Synthetic Range Data | The use of geodesic distance as the Morse function ensures that the system is invariant to translation, scale, rotation, and isometric transformations, making it highly adaptable to different human postures. | The validation of the system was performed using synthetic range data, which may not perfectly replicate the noise and variability found in real-world scenarios. | N/A |
| (Yu, et al., 2012) | Utilizes background substraction which is may be utilized to extract the human body from the video by isolating the foreground from the background. | Small custom dataset of 15 people in a simulated home (controlled environment devoid of extraneous factors) | The system achieves a fall detection rate of 97.08%, making it highly reliable for monitoring elderly people in home care applications. | The system was tested with only 15 participants in a simulated environment. A larger and more diverse dataset, especially with real-world noise and variability, may be needed to confirm its generalizability. | Fall Detection Rate: 97.08%  False Detection Rate: 0.8% |
| (Feng, et al., 2014) | Utilizes a deep belief network where a deep learning model made up of multiple layers of restricted Boltzmann machines (RBMs) is used for unsupervised learning to extract features from the binary images. | Recordings from a real smart home care environment involving 15 participants creating **2904 postures**. This dataset is used for evaluating the fall detection models. | The use of deep learning methods such as Boltzmann Machines and Deep Belief Networks allows for better feature extraction from the binary images, leading to improved classification performance. | The use of deep learning models like Boltzmann Machines and Deep Belief Networks requires substantial computational resources and might be harder to deploy in real-time, resource-constrained environments. | N/A |

# 4.0 Summary

To conclude what our project is and what it aims to achieve, it may be condensed into the following paragraph. Our project is a multi-modal fall detection system that utilizes the IOT (Internet of Things) to detect whether a person is about to fall or not. It aims to utilize a gyroscope, accelerometer and externally placed image processing device (camera) that is to monitor the posture of a person into the algorithm to predict whether a person is about to fall or not such that emergency measure may be taken to alert the relevant authorities and initiate an airbag to be released behind the mounted device such that the user does not sustain any injuries. Our model aims to use a posture detection API with customized thresholds and a trained model to understand which values retained by the peripherals are to assume an urgent and risky state.

# 5.0 Bibliography

Feng, P., Yu, M., Naqvi, S. M. & Chambers, J. A., 2014. *Deep learning for posture analysis in fall detection.* [Online]   
Available at: https://ieeexplore.ieee.org/abstract/document/6900806  
[Accessed 11 October 2024].

G. Diraco, A. L. P. S., 2010. *An active vision system for fall detection and posture recognition in elderly healthcare.* [Online]   
Available at: https://ieeexplore.ieee.org/abstract/document/5457055  
[Accessed 11 October 2024].

Liaqat, S. et al., 2021. *A Hybrid Posture Detection Framework: Integrating Machine Learning and Deep Neural Networks.* [Online]   
Available at: https://ieeexplore.ieee.org/abstract/document/9343347  
[Accessed 10 October 2024].

Lin, B. S. et al., 2022. *Fall Detection System With Artificial Intelligence-Based Edge Computing.* [Online]   
Available at: https://ieeexplore.ieee.org/abstract/document/9667467  
[Accessed 10 October 2024].

Norsk forening for epidemiologi, 2012. *Fall risk factors in community-dwelling elderly people.* [Online]   
Available at: https://oda.oslomet.no/oda-xmlui/handle/10642/1474  
[Accessed 10 October 2024].

Ogundokun, R. O., Maskeliūnas, R. & Damaševičius, R., 2022. *Human Posture Detection Using Image Augmentation and Hyperparameter-Optimized Transfer Learning Algorithms.* [Online]   
Available at: https://www.mdpi.com/2076-3417/12/19/10156  
[Accessed 11 October 2024].

Roger D. Newman-Norlund, S. E. N.-N. S. ,. C. M. R., 2022. *Effects of social isolation on quality of life in elderly adults.* [Online]   
Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0276590  
[Accessed 11 October 2024].

Saraswat, S. & Malathi, G., 2024. *Pose Estimation based Fall Detection system using MediaPipe.* [Online]   
Available at: https://ieeexplore.ieee.org/abstract/document/10543522  
[Accessed 11 October 2024].

Yu, M. et al., 2012. *A Posture Recognition-Based Fall Detection System for Monitoring an Elderly Person in a Smart Home Environment.* [Online]   
Available at: https://ieeexplore.ieee.org/abstract/document/6279483  
[Accessed 11 October 2024].