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Automatic Fall Detection And Alert System For Home Safety

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***Abstract*—Falls are a regular issue for the elderly and the disabled, and they can result in serious injuries or even death. We have created fall detection systems that use image processing methods to quickly identify falls in order to solve this problem. The device employs a camera to take pictures or videos of the person it is watching, then analyses the images to determine whether a fall has occurred. The photos are analyzed to see if a fall has occurred using image processing techniques like object recognition, motion analysis, and background subtraction. To ensure quick assistance, the system then notifies a carer or emergency contact. The use of image processing in a fall detection system offers a potentially effective way to address the issue of falls among the elderly and disabled. It offers an efficient, trustworthy, and affordable substitute for conventional fall detection techniques and can significantly increase the safety and well-being of people who need it most.**

I. Introduction

Given that falls are a leading cause of injury and death, particularly among older persons, fall detection is a significant issue in the fields of image processing and computer vision. The detection of falls via image processing can be done in a number of ways, such as utilizing motion sensors, depth sensors, or machine learning algorithms to evaluate video or still photos. The monitoring of elderly people who live alone, aiding workers in dangerous surroundings, and spotting falls during sports or other physical activities are some potential uses for fall detection systems. Accurately detecting falls in a variety of settings and lighting situations, reducing false alarms, and protecting the privacy of those being observed are some of the issues in building a fall detection system.

In recent years, image processing techniques have been used more and more to improve the precision and efficiency of fall detection systems. In order to extract relevant information and base judgments on it, image processing entails examining and modifying digital images or video feeds. Image processing can be used in fall detection to recognize falls and assess the severity of the fall by analyzing photos or video feeds. For older or disabled people who might not be able to call for aid on their own in the case of a fall, this can be especially helpful. Additionally, image processing can be used to keep an eye on people's movements and behaviors to spot potential fall hazards and notify caretakers or emergency services if a fall is likely to happen.

Overall, the application of image processing in fall detection systems can assist increase the systems' precision and speed, allowing them to better safeguard people from damage.

II. Literature Survey

Bor-Shing Lin et al... describe a system that is naturally driven to find unforeseen falls in real-time video sequences in [2]. In order to strengthen privacy protection, the system uses event-based temporal difference images across video sequences as input and extracts static properties from unobserved videos, such as aspect ratio and inclination angle of the human body silhouette. The necessary time difference is derived from the trials and confirmed by statistical findings because the time difference is a key aspect in differentiating between a fall occurrence and a lying down event. This technique offers a precise method to identify fall accidents using the KNearest Neighbor (KNN) classifier and the crucial time difference. In the trial, an average recognition rate of 86.11% was attained.

Jenny Ni et al... designed and implements an Android-based fall monitoring application for the elderly (Fall Guard) in [3]. The system combines existing fall detection devices and a cloud server. Model-View-Control (MVC) architecture and the OkHttp network request framework are used by Fall Guard. The fall detection device is linked to the mobile client in this study in order to gather user and device information, and OkHttp is utilized to send network requests to the cloud server. The information acquired, including device positioning, electronic fence information, fall alarm information, and motion tracking, is displayed on the user interface through JSON parsing. Multiple devices can be connected to a single login account. Fall Guard can receive a variety of fall alarm cues when an older person falls, including an alarm information list, a notification bar reminder, an SMS notice, device user status

bar information, and other prompts. Test findings demonstrate that Fall Guard has a high degree of monitoring precision and terminal compatibility.

Nor Asilah Saidin et al... system for detecting human falls in [8] has emerged as one of the most crucial components, particularly for use in indoor environments. The senior care industry and childcare facilities have both employed this technique. Any human fall is much easier to detect, and the carer will be informed of the incident. Due to its cost and capacity to scan and track people, the Kinect sensor can be utilized for detection. The skeleton-based technique, which detects human falls using Kinect, works by computing the distances between each joint and the floor plane and is one of the most popular algorithms in this field. The skeleton space coordinate system is used to find the joints. A fall is recognized when the floor plane is not visible and the Y-coordinate is less than the specified value. Due to its widespread use, it is necessary to examine its effectiveness in order to determine the optimal conditions that this algorithm can provide. Using Visual Studio as the interface, a few experiments were run to observe the performance of the chosen parameters. Due to its portability and potential for better indoor navigation in the future, a mobile-based Kinect is utilized in this work. Using this skeleton-based approach, the optimal parameter may be objectively identified in order to select the ideal setting for detecting human falls. The parameters include the human's distance from the Kinect, the light intensity, the duration of tracking the human, and the fall speed. The results show that the best circumstances would be at a distance of 3 to 3.5 meters, with a lighting of 1007 lux, and with 2 people present at the scene. When evaluating the usage of the algorithm for human fall detection using Kinect, these circumstances may be useful to others.

Roy Francis Navea et.al... shows the design and implementation of a human tracking CCTV using IP cameras in [13]. CCTV systems cannot evaluate the footage; they can only supply it. In this study, a proposed person-of-interest detection, recognition, and tracking CCTV system using IP cameras were made. Five IP cameras were first put up to record the subject's front and side views. These were also employed to indicate the heading. For face detection, the Haar feature-based cascade classifier was employed. For facial recognition, the Karhunen-Loeve transform was employed. Additionally, tracking that was developed in Processing utilized optical flow. The technology can discover and identify the person of interest with more than 81.0% accuracy, according to tests on gender, eye, and facial recognition. The average gender classification accuracy is 83%, especially when the subject of interest is a girl. When the subject of interest wears eyeglasses, accuracy is increased. Face recognition consistently works better when the subject is a female wearing glasses.

Jemai Bornia et.al... describes a method in [6] Detecting objects and people and tracking movements in a video using TensorFlow and deep learning. The goal of this research was to develop a technique for tracking individuals or objects in videos by combining detection and tracking techniques. For this purpose, we specifically used TensorFlow. A massive amount of data is produced every day as a result of the digital age and, more especially, videos, such as television archiving and video surveillance. It is obvious that algorithms with the ability to complete this task quickly and efficiently are required if we are to maintain control over this content and make use of it for analysis, classification, and a variety of other applications. The suggested method enables the analysis of video clips using TensorFlow and deep learning. The suggested method divides a movie into a collection of images, finds objects and entities present in these images, and records descriptions of these items and entities in a common XML file. We created an algorithm that allows us to track the movements of animated objects in video sequences. The goal of this research was to develop a technique for tracking individuals or objects in videos by combining detection and tracking techniques. For this purpose, we specifically used TensorFlow.

Vitoantonio Bevilacqua et.al... describes Fall Detection in an indoor environment with Kinect sensor in [7]. One of the main dangers to older people living alone at home is falls. Systems based on computer vision present a novel, affordable, and promising approach to fall detection. The fall detection technique presented in this paper is based on a readily available RGB-D camera. The suggested method can accurately identify a variety of falls by running an algorithm in real-time to determine whether a fall has actually occurred. The suggested method is based on measuring the speed at which the 3D human bounding box's width, height, and depth shrink and expand, as well as where it is located in space. With the only restriction being knowledge of the RGB-D camera position in the room, our technique does not necessitate prior scene knowledge. Additionally, the suggested method can eliminate false positives caused by actions like sitting, lying down, and picking up anything off the ground. The decision to utilize the Kalman filter as well as basic characteristics like speed and landmarks allows us to develop software that is more reliable and effective. In some situations, such as hospitals, senior leisure centers, and home settings, it is an excellent feature to employ to function in low-light conditions and to prevent rapid-downward-movement-misclassification. Finally, we note that the proposed algorithm is a component of a single module created for our Ambient Assisted Living (AAL) platform. This module consists of a voice commands recognizer that, in the case of a cognitively capable person, can also be used to confirm the occurrence of a fall and then to lessen the likelihood of false alarms from a functional standpoint.

Hadir Abdo et.al... falling is a significant health issue that can cause severe injuries and even death, especially in the elderly. Accidental deaths from falls are a risk for elderly adults over 75. The detection of human falls is made easier and more effective by methods based on computer vision. The study in [4] provided a system for fall detection that combines the RetinaNet and Mobilenet convolutional neural

networks with custom features. The performance of fall detection systems may be impacted by human shape distortion caused by conventional human detecting methods. In contrast to the conventional person detection approaches, the suggested framework relies on RetinaNet to recognize humans with a lower computation time and more accuracy. In order to represent the shape and motion characteristics of the detected human, the proposed framework uses handmade features. In order to generate the feature map, the suggested framework extracts the aspect ratio and head position of the identified human as form features and the motion history image as a motion feature. In order to categorize human motion as falling or not falling, the MobileNet network is trained using this feature map. The suggested framework is tested using the UR and FDD datasets, and the experimental findings showed that it is effective, attaining up to 98% accuracy when compared to state-of-the-art techniques.

Sara Usmani et all... discusses the most recent developments in machine learning (ML)-based fall detection and prevention systems [16]. It makes use of current research and examines datasets, age groups, ML algorithms, sensors, and geography. Additionally, it offers a thorough analysis of current fall detection and prevention system trends as well as potential future possibilities. By addressing the difficulties raised, this overview can assist researchers in better understanding the current systems and suggesting new techniques.

Arvind S Kapse et al... creates an Android application that can identify older people who may fall [17]. Android is an operating system that is free and open source. Anyone can easily construct their own application on an open-source platform. Families and medical experts are often concerned about older people falling. This is the rationale for the creation of a system for the elderly that can detect falls and alert the carer. The software keeps tabs on the person and notifies the carer if anything is wrong. This Android app's ability to send alarm messages to the carer with the necessary information is one of its important features. The application tracks the user and notifies the carer if anything unexpected occurs. This Android app's ability to send alarm messages to the carer with the necessary information is one of its important features. Important details like their geolocation and directions are included in the alert messages. The individual has the authority to put an end to a false alarm before taking any further action. The goal of this project is to help the elderly. Through a user-friendly interface, the smartphone application can spot possible falls and provide alerts to families, doctors, and other carers.

Chalavadi Vishnu et al... The technique of detecting falls is greatly aided by the representation of the spatiotemporal characteristics of the human body silhouette and the interaction of the ground with the human body. Therefore, utilizing the fall motion vector, they suggest a method for effectively modeling the spatiotemporal aspects in [18]. To implicitly capture motion attributes in both the fall and non-fall movies, we first build a Gaussian mixture model (GMM) termed the fall motion mixture model (FMMM) utilizing the histogram of optical flow and motion boundary histogram features. The FMMM has a high-dimensional representation since it has both fall and non-fall properties. They use factor analysis on FMMM to obtain a low dimensional representation known as the fall motion vector, which allows us to extract only the pertinent properties for specific fall or non-fall films. They can effectively recognize falls using a fall motion vector in a variety of situations, including those involving narrow-angle cameras (Le2i dataset), wide-angle cameras (URFall dataset), and numerous cameras (Montreal dataset). They demonstrate that the suggested fall motion vector outperforms the current approaches in each of these cases.

III. Methodology

This chapter discusses in detail the proposed implementation. As mentioned, the basic architecture consists of these parts:

1) Input: The system will accept input in the form of images or video feeds from various sources, such as CCTV cameras, smart cameras, or mobile devices.
2) Image Preprocessing: The input images or video frames will then be processed to improve their quality and reliability through noise reduction, color correction, grayscale conversion, and image enhancement algorithms.
3) Object Detection: The preprocessed images or video frames will be analyzed to detect and localize potential falls and use object detection algorithms. For our system, we will be using the VoLoV5 model.
4) Feature Extraction: After object detection, relevant features should be extracted from the detected objects to represent their characteristics and behaviors. These features include width to height ratio of the bounding box surrounding the human body and motion history images which show the direction of object movement
5) Classification: The extracted features should be used to classify the detected objects as falls using classification algorithms. For classification, classification algorithms such as Support Vector Machines (SVM) or Random Forests are used.
6) Alert Generation: The system should generate appropriate alerts or notifications based on the classified objects, such as through email, SMS, or push notifications.
7) User Interface: The system should have a user interface that allows users to view and respond to alerts.
8) Data Storage and Management: The system should store and manage the data generated by the fall detection algorithms, including input images or video, detected objects, extracted features, and classified results.
9) System Integration: The system should be integrated with appropriate hardware and software for real-time monitoring and alerting, such as CCTV cameras, smart cameras, or mobile devices.

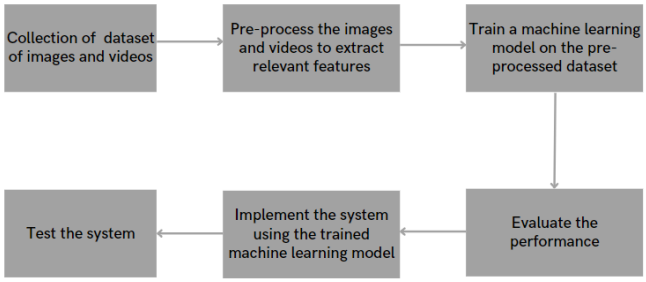

Fig. 1. Basic Working

IV. Framework

We aim to design a fall detection framework that uses YOLOV5 model to identify and classify falling motions in videos. The proposed framework consists of three stages: human detection, feature extraction, and classification.

1) Collecting the dataset: The first stage is to compile a dataset with pictures or videos of falling people. Images of individuals engaging in typical activities should also be included in this dataset so that the model can distinguish between these and fall patterns.
2) Preprocessing the dataset: Preprocessing the dataset is the next stage. The images or videos may be resized to a particular dimension, the pixel values may be normalized, and the dataset may be divided into training and testing sets.
3) Training the YOLOv5 model: The gathered dataset can be used to train the YOLOv5 algorithm. This entails giving the model training data and modifying the neural network's weights and biases to reduce the loss function.
4) Fine-tuning the model: It might be necessary to tweak the model after training it for improved performance. This might entail changing the model's hyperparameters, including the learning rate, group size, and the number of epochs.
5) Testing the model: The model can be evaluated on the testing dataset after it has been trained and adjusted to determine how well it performs. This entails computing various measures, including F1-score, recall, and precision.
6) Deploying the model: Deploying the model for practical applications is the last stage. Identifying falls in real-time, may entail integrating it with a camera system or a mobile device.

V. Datasets

Datasets are a crucial component of the framework because they are essential for the machine learning model's training and testing processes. We employ two distinct datasets for the detection of intruders and falls. We used a free, public dataset from Kaggle for the fall detection dataset. An online community of data scientists and machine learning experts can be found at Kaggle, a division of Google LLC.

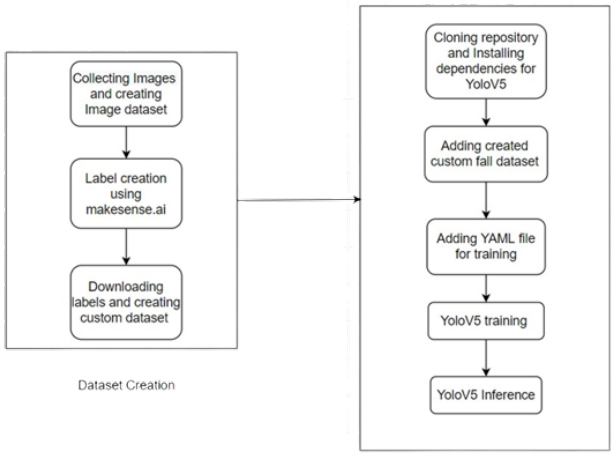

Fig. 2. Proposed Methodology

Two image and label directories make up the dataset. Within the images directory are two subdirectories: "train" and "Val," each of which has 111 photographs and is utilized for validation. "Train" comprises 374 images. "train" and "Val" are two additional subdirectories in the labels directory. The labels for each associated image are stored in text files in these locations. The Makesense.ai website was utilized to collect the labels for the photographs. There, the images were uploaded and labels (such as "Fall Detected," "Walking," and "Sitting") were made by creating bounding boxes around the human images and then giving the appropriate names to those boxes.

VI. Experimental Results

An experiment was conducted on the Kaggle public dataset to assess the effects of various improvement methods on the model's performance in the detection of elderly falling behavior. The results of the analysis of the effects of the various improvements are shown in the accuracy rate in fig. [3]

The YoLoV5 model gives a bounding box around the person on the screen and determines whether or not they have fallen using the fallen and not fallen dataset. When the box is colored pink, it is understood to be moving; when it is colored orange, it is understood to be seated; and when it is colored red, it is understood to be falling.

The fig. [4] shows that the YOLOv5 model has a strong detection effect for various objects and types of falls. The fig. [4] shows that in everyday activities, the improved model also achieves excellent detection results for non-falling behaviors whose postures are comparable to falling behaviors in various settings and lighting conditions.

We have created a flutter-based application named "FALL-E", through which the registered user will get a notification when a fall has been detected. The users are required to register in the application using their phone number and password after which they will receive notifications whenever falls have been detected in their area of surveillance.

Fig. 3. Dataset

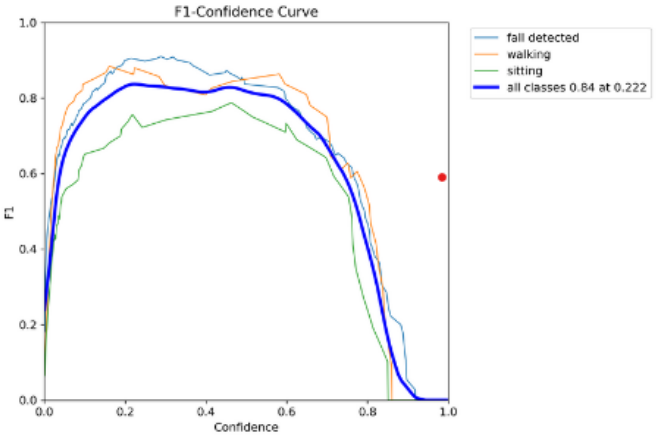

Fig. 4. Accuracy Rate

VII. Conclusion

An effective and dependable way to find and warn people about potential safety concerns is to use a fall detection system based on image processing. The technology can recognize instances of human falls by analyzing video feeds using image processing techniques. The system can warn the proper persons, such as the owner, to take action after a threat has been identified. This type of system is a useful tool for protecting people's safety in a variety of circumstances since it uses image processing, which enables a high level of precision and the capacity to detect threats in real time.

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