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Fall Detection System in the Elderly using IoT and AI

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Abstract: Artificial intelligence and deep learning methods are used in the suggested fall detection system for senior persons in order to reliably recognize falls in real-time. In contrast to conventional systems, which rely on Internet of Things (IoT) gadgets, this system uses wearable gadgets and sensors to collect data, which is then analyzed using AI algorithms. The device can tell the difference between falls and other movements with great accuracy, alerting caregivers or emergency personnel as needed. The system can continuously learn and increase its accuracy over time thanks to the application of AI and deep learning, which ensures accurate fall detection for senior people. As falls are a primary cause of injury and death in the aged population, fall detection systems are becoming more and more crucial. In order to detect falls and notify caretakers or emergency services, traditional fall detection systems rely on Internet of Things (IoT) devices, such as wearable sensors or smart home technologies. These systems, however, can be expensive and might not be available to everyone. In this study, we suggest an IoT-free fall detection system for older people that makes use of artificial intelligence (AI) and deep learning techniques. Our technology uses information from furniture found in most homes, including chairs, tables, and bed frames, to identify falls and notify caretakers. Our system accurately distinguishes falls from other movements and ascertains the fall severity using machine learning techniques.

Keywords: Fall detection system in aged population, IoT, Convolutional Neural Network model, Convolution Neural Network (CNN) architecture, You only look once version (YOLO), MobileNet, ResUNet and DeepUNet.

I. INTRODUCTION

We can precisely detect the incidence of a fall using a simple home security camera by employing deep learning computer vision algorithms. This alarm system may also reduce caregivers' and seniors' mental strain. When elderly patients in nursing homes display fall-prone behavior, our technology can notify caregivers in real time across the network. a few studies utilizing wearable sensors. Some sensors assess the rate of acceleration in order to detect falls. The bulk of commercial systems employ these techniques, which have some advantages in terms of the affordability and efficiency of embedded systems. The sensor's level of accuracy is constrained, and carrying it or charging it requires extra effort. Consequently, this technique has technological obstacles.[1] A deep learning and motion feature-based fall detection technique has been suggested. In order to identify whether a fall had occurred, our method integrated the deep properties acquired by CNN with the human motion aspects. You only look once version (YOLO) was used to identify human targets, a suitable algorithm was used to ensure the system's robustness, and auxiliary detection approaches were used to prevent missed detection. [2-4]

II. PROBLEM STATEMENT

To create a surveillance system for elderly people which includes monitoring, alert and buzzer system that alerts their family, neighbours and nearest hospital in the form of emergency message and call so that they can get assistance and help when they usually fall down, or in any emergency situations, using AI/ML and IoT.

III. EXISTING CNN MODELS

i. Inception V3: Szegedy et al proposed the Inception architecture in 2014. The original architecture was called GoogleLeNet. All the subsequent versions were called Inception Vn (n is the version number). Batch Normalization was added in Inception V2 as an improvement over Inception V1. In InceptionV3 model factorization methods were introduced as an improvement over V2.[4][5]

ii. ResNet50: In 2015 He et al proposed ResNet - The Residual Networks architecture. It has 50 convolutional layers with skip connections that help in improving the learning accuracy of the model. Also, it uses global averaging pooling instead of fully connected layers thereby reducing the model size.[6-7]

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iii. MobileNet: In 2017 another CNN architecture called MobileNet was proposed by Howard et al. In this separable convolution have been arranged depth-wise and they apply the convolution operation on each color channel separately instead of taking them as a whole. The cost of computation gets reduced in this architecture.[8-9]

iv. Xception: François Chollet developed Xception in 2017. This model can be considered as an improvised version of Inception as modules of Inception have been replaced with depth wise separable convolutions. This latest and accurate model scores upon speed and accuracy.[8]

IV. SOFTWARE REQUIREMENT SPECIFICATIONS (SRS)

i. Functional Requirements

- Device must be enabled at all the condition.
- Device should be able to read the change in state accurately from all the device connected
- Device should be able to display the state of a system.

ii. Non-Functional Requirements

- Usability: The system must be easy to learn for both users of the device and helpers who are the using the device.
- Reliability: The reliability of the device essentially depends on the software tools (Arduino IDE etc.) and hardware tools (NodeMCU, and other sensors) used for the system development.
- Performance: Noting the coordinate of the surrounding to send the location and Displaying Status.
- Flexibility: The system shall allow the system administrator to add additional features. The system needs to be cost-effective to maintain.
- Safety: In case of malfunction, system should shutdown itself and reboot.

V. SYSTEM ARCHITECTURE

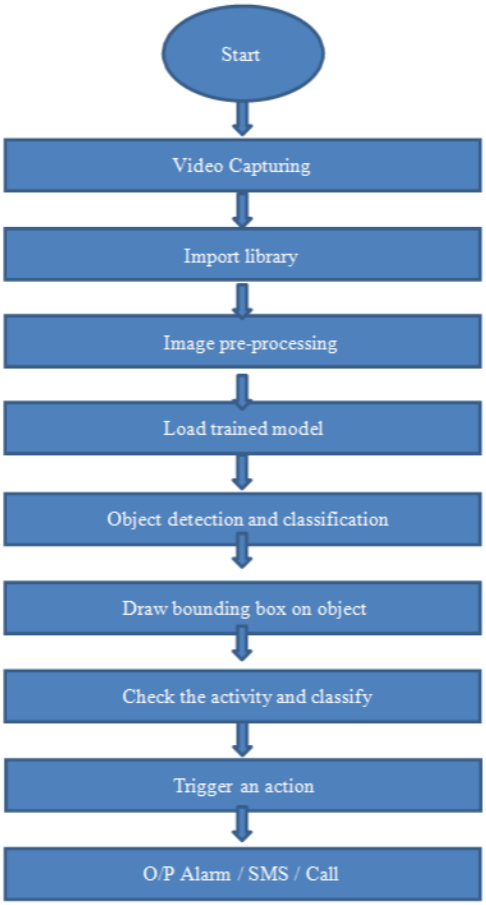

Figure 1 shows the system architecture of our proposed system

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i. **Video capturing**: The visual scene is captured at various sampling rates. Each and every frame is processed and checked (where a person is present) pre-processing of the image is done by the processor. Pre-pressing refers to giving color format (RGB or gray sale format), resize ratio, and reducing image resolution to a much smaller scale, this is because the object detection method can consume more CPU power and it lags a little bit.

ii. **Load-trained model**: Once preprocessing of the image is finished, the processor loads the trained model. Here, your (you only look once) algorithm is used, which is trained for detecting a person so that particular model file will be loaded The image that the user or admin gives will be bent to the trained model. This model checks in a given frame whether a person is present or not, if the person is identified then the representation of an object belonging to a class person is drawn using the bounding box values which is known as the bounding box of an object.

iii. **Object detection and clarification**: After the object detection, we have to classify the object, here the object class is a person. [10-13]

iv. **Draw a bounding box of an object**: Once classified, finally the bounding box for a particular object (person) is drawn from where, in this particular column, which particular row, to where X and Y values are going. X and Y values are needed to plot the bounding box. This is done from a visualization point of view.\

v. **Check the activity and classify**: Checking for the activity (whether the person is standing or fallen) is necessary.

vi. **Trigger Action**: For the case of fall down scenario, the height and width difference is checked and evaluated (height decreases and width increases) if this happens action is created or triggered.

vii. **Output**: Action can be SMS alert, call alert and email alert, which is viewed as the resulting output

VI. RESULTS

Figure 2 shows the normal sleeping posture of the subject.

Figure 3 shows the fall detected successfully of the subject.

A convolutional neural network (CNN or convnet) is a subset of machine learning. It is one of the various types of artificial neural networks which are used for different applications and data types. A CNN is a kind of network

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architecture for deep learning algorithms and is specifically used for image recognition and tasks that involve the processing of pixel data. There are other types of neural networks in deep learning, but for identifying and recognizing objects, CNNs are the network architecture of choice. This makes them highly suitable for computer vision (CV) tasks and for applications where object recognition is vital, such as fall detection and human movements. We have used YOLOv5 model for mapping fall detection in elderly people. Figure 2 shows the subject in normal position. Figure 3 shows the fall being detected of the subject during sleep. As in the figure, one can clearly make out the CNN algorithm detecting the fall during video streaming in realtime. Figure 4 shows an SMS alert being sent to the root/target user for care taking. Figure 5 shows an email being sent to the root/target user to alert them of the fall of their beloved family member or neighbour.

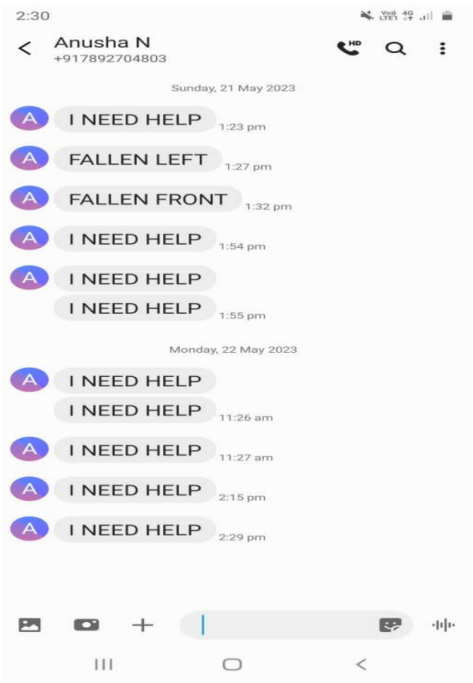

Figure 4 shows the SMS being sent to the target user

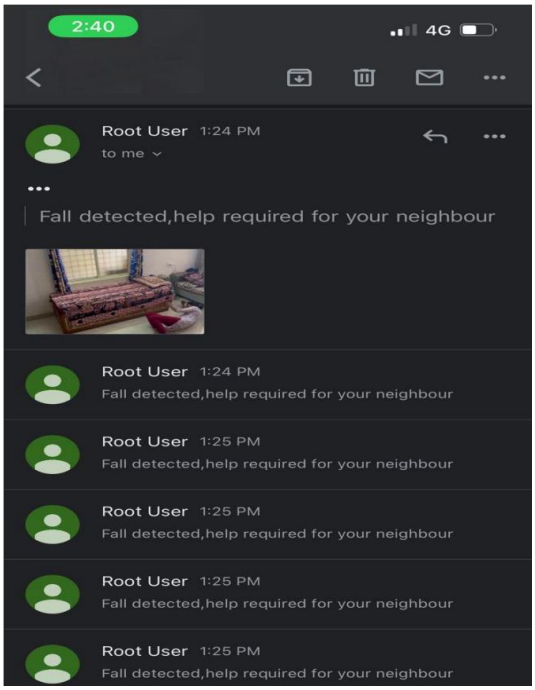

Figure 5 shows the email being sent to the target/root user

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VII. CONCLUSIONS

In this project, we proposed a fall detection system that uses a surveillance camera and deep learning algorithms to detect real-time fall scenarios in older persons. Deep learning algorithms for object (person) detection like YOLO v5 is used, and the model is pre-trained using the COCO dataset and based on the provided dataset, the CNN algorithm for image classification is used to distinguish between an old person falling and a man sleeping or lying on a bed or other surface. In addition to predicting the objects, object detection also determines their location in terms of bounding boxes.

The YOLO algorithm uses video image frames as its input and outputs bounding boxes for objects in the form of height, width, row, column, and class. Additionally, it establishes the object's class probability. It is only possible to consider the object with the highest class probability, which is known as non-max suppression. This system uses IoT to trigger the call or SMS to relevant parties using GSM module connected to a microcontroller, in fall case scenario. This system also includes a button that the elderly can press manually to declare no emergency or state that they need medical attention. As a result, the suggested algorithms can detect senior people's fall behavior with accuracy. Implementation of this system is user-friendly. Because we employ cameras instead of complicated gear, that the elderly person could easily use and he can be easily tracked by his family members.

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BIOGRAPHY

VISHESH S (BE(TCE), MBA(e-Business)) born on 13th June 1992 hails from Bangalore (Karnataka) and has completed B.E in Telecommunication Engineering from VTU, Belgaum, Karnataka in 2015. He also worked as an intern under Dr. Shivananju BN, former Research Scholar, Department of Instrumentation, IISc, Bangalore. His research interests include Embedded Systems, Wireless Communication, BAN and Medical Electronics. He is also the Founder and Managing Director of the corporate company Konigtronics Private Limited. He has guided over a thousand students/interns/professionals in their research work and projects. He is also the co-author of many

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International Research Papers. He has recently completed his MBA in e-Business and PG Diploma in International Business. Presently Konigtronics Private Limited has extended its services in the field of Software Engineering and Webpage Designing. Konigtronics also conducts technical and non-technical workshops on various topics. Real estate activities are also carried out under the guidance of Siddesh B S BE (civil). Vishesh S along with his father BS Siddesh has received various awards and applauses from the scientific and entrepreneurial society. He was appointed as the MD of Konigtronics Pvt Ltd (INC. on 9th Jan 2017) at an age of 23 years. His name is indexed in various leading newspapers, magazines, scientific journals and leading websites & entrepreneurial forums. He is also the guide for many international students pursuing their Masters.

