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Survey on Fall Detection System CNN based Fall Detection and Health Monitoring System using IOT

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Abstract: Falls are the common problem faced by elderly population. Fall may happen due to fainting. The reason for faint involves sudden changes in the heart rate. Falls are the common cause of traumatic brain injuries in elderly people and also cause severe injuries such as fracture of the hip. This kind of injuries can create negative impact on their quality of life. In most of the cases the elderly who lay on the floors for more than an hour after falls usually results in serious trauma, also leads to death of the individuals. There are some systems exist for detecting the falls of the elderly people. These ambient sensors involve video-based methods for fall detection using rule based and machine learning based methods. The wearable sensor mainly include accelerometer, gyroscope, barometric pressure sensor, infrared sensor and kinetic RGBD camera. The existing systems are based upon the ambient sensors faces some risks such as storage and processing of video is a complex task and it also affects the privacy of the people. It is necessary to propose a system that can overcome the above drawbacks. The system proposed involves capturing the motion of the elderly people using accelerometer sensors. Those captured data via sensors are processed using CNN, which involve steps such as convolution, it results in feature map then it has to be down sampled using the max pooling methods and based on the resultant layers, the captured motion can be determined whether it is a day to day activities or a fall. Once the fall is detected the information will be sent to the family members and neighbours. Additionally, it is provided with sensor to monitor the health conditions of the elderly people, when heart rate deteriorates, an alert message will be sent to neighbours and family members to provide medical assistance.

Keywords: Convolutional Neural Network (CNN), Internet of Things (IoT), Support Vector Machine (SVM).

I. INTRODUCTION

A convolutional neural network (CNN) is a type of artificial neural network, a machine learning algorithm for supervised learning, to analyse data. In deep learning, a convolutional neural network (CNN) is a class of deep neural networks, most commonly applied to analysing visual imagery. They are also called as shift invariant or space invariant artificial neural networks (SIANN), based on shared-weights architecture and translation in variance characteristics. Convolutional networks are inspired from biological processes in that the connectivity pattern between these neurons resembles the organization of the animal's visual cortex. Each individual cortical neuron responds to a stimulus only in a restricted region of the visual field known as the receptive field. The receptive fields of all the neurons partially overlap so that they can cover the entire visual field. CNN undergoes pre-processing compared to other image classification algorithms. The term convolutional neural network proves that it is a network employed with a mathematical operation called Convolution. Convolution is a special kind of linear operation. The convolutional neural network consists of input and output layer and multiple hidden layers. The hidden layers of a CNN consist of a series of convolutional layers that convolutes with multiplication. The activation function commonly used is RELU layer, and it is followed by other convolutions such as pooling layers, fully connected layers and normalization layers, considered as hidden layers because their inputs and outputs are masked by the activation function. The final convolution, mostly involves back propagation in order to accurately weight the end product. Though the layers are referred as convolutions. Mathematically, it is a sliding dot product or convolution. They have applications in natural language processing, recommend system, image and video recognition, image classification and medical image analysis.

IoT plays a major role in technology industry and most of the Social, economic engineered products are incorporated with this technology. The Internet is about 20 years old and more than 2 billion people are interconnected with it using computers, smartphones and tablets. The next Phase of the Internet has begun, that connects people to everyday devices (M2P) and everyday devices to each other (M2M). The number of IoT based devices which are active is expected to grow about 10 billion in the year 2020 and about 22 billion by 2025. The Internet of Things (IoT) is an interconnection of physical devices which can connect to a network and exchange data. Each smart device is a gadget embedded with electronics and software which can act as a sensor or actuator. Sensors are able to analyse the state of the real-world around them. IoT devices can deal with simple to complex tasks. IoT products includes smartphones, smart gadgets and autonomous vehicles the usage also increasing rapidly. IoT enabled devices impacts society in numerous ways. Smart homes, offices and cities have greatly reduced the energy consumption, one can take control of their environment, even when they are away from home or work and it offers better security by constant surveillance and taking action in case of any security breaches.

II. LITERATURE SURVEY

The works of various researchers and scholars are studied for survey and analysing the advantages and drawbacks in order to improve the system to function better.

Na Lu [1] et al discusses solution for fall detection systems based on video obtained through ambient camera. This system employs three-dimensional convolutional neural network (3D-CNN) based method as the feature extractor, which only uses video kinematic data and SVM as the classifier. In addition to locate the region of interest in each frame, a long short-term memory based spatial visual attention scheme is incorporated. The long short-term memory (LSTM) based attention mechanism can locate the most informative part of fall detection in the image. This system is applicable where multiple cameras fall dataset are used. Though this system provides better results, the computation complexity will increase accordingly, when the sampling interval between two consecutive clips increases and even some frames of fall event may get missed.

Maid Saleh [2] et al proposes a low cost, highly accurate and wearable system for fall detection. This system mounts a wearable device over the waist where the activity of the elderly is captured using 3-axial accelerometer. This system follows a two-segment feature extraction method that characterize falls as four phases that are pre fall, impact, body adjustment and post fall phases and an online method that calculates the features with low computational cost then the machine learning methods SVM are applied to proposed features that helps in classifying the activity between fall and daily activity. This System capable of functioning in both indoor and outdoor environments. The issues in the paper are slight increase in sampling frequency increases the power consumption and complexity of feature extraction.

Wala Saadeh [3] et al proposed an patient specific IoT based wearable fall detection and prevention system. This system comprises of single triaxial accelerometer sensor attached to thigh that records the activity of the patient and a Nonlinear Support Vector Machine (NLSVM) used to classify between a fall and ADL. The Fall incidence will trigger a notice to the concern health care providers via the Internet. This system operates in two modes, the fast mode and slow mode. The former one detects the fall about 300-700ms prior the occurrence of fall, whereas the later one detects the fall with one second latency. The NLSVM based fast mode is capable of extracting extracts seven different features for the pre-fall case to identify a fall risk event. The Slow mode Fall detection makes use of a Three-cascaded 1-sec sliding frames classification architecture provided with a linear -based offline training to identify the optional threshold of the patients. This system is capable of predicting a fall. Though it predicts fall, the time duration between fall prediction and fall occurrence is short.

Soon Bin Kwon [4] et al was able to classify five different types of falls using a wearable sensor located on the right side of the chest. This system used to classify the different types of falls using the Temporal Signal Angle Measurements (TSAM), Support Vector Machines, K-Nearest Neighbours (KNN) and random forest methods. Falls was recorded by using the IMU sensors with triaxial accelerometer and triaxial gyroscope which provides the temporal signals. This method record and classify the five types of fall using the machine learning algorithms and then the falls are determined using TSAM. Though this system was able to classify five different types of fall, the algorithms were validated while down sampling the signals at a rate of 10-20HZ in order to scale down CPU speed and to avoid power consumption which may lead to loss of accuracy in identifying falls.

Jin-Shvan [5] et al proposed a system to detect and predict falls using triaxial accelerometer present in smartphones by placing them in pant pocket. This system uses Support vector machines or Cascade-Ada boost classifier, Hidden Markov Model, Nearest Neighbour for Classification. In this fall are classified using support vector machines by identifying the situations, which rely on activities of daily living then fall is predicted and detected by Hidden Markov Model (HMM) triaxial accelerometer present in smartphone. In this system the user must install the mobile application, it calculates the three threshold values for the x, y, z direction. When a fall is detected by using activities of daily living an alert message is sent to the emergency centre. Though this system provides accuracy but has few constraints such as smartphone must be kept in their pant pocket only but elderly people cannot remember all the time to keep smartphones in their pant pocket, this method is not feasible for all smartphones. If a fall occurred, when the smartphone has shut down due to battery drain then an alarm cannot be sent to the emergency centre.

Fouzi Harrou [6] et al proposed an Integrated-vision based approach for human fall detection in home environment. This system uses camera which captures relevant pixels by variations in body shape by Generalized Likelihood Ratio (GLR) and then the falls are classified using support vector machine. The RGB camera does not record video but capture frames by analysing the variations in human postures and motion history and also considers the distance between the head and the floor. When the head position is abruptly close to the floor it generates an alarm. Though this system provides less false fall events than CNN-SVM, K-nearest neighbour-SVM, this system has several issues such as this approach is suitable only for home environments, affects privacy of the people creates false alarm when people simply lie down on the floor or while walking inside the home and when people picks up some things that are on the floor may generate a false alarm.

Soumen Moulik [7] et al proposed a system for fall detection and alarm generation in an IoT enabled environment. This system follows a Fall sense technique which uses Hidden Markov Model and it employs a fuzzy inference logic for precise decision making in case of fall

events. Hidden Markov Model get the input data from three sensors, infrared emitter, accelerometer and the ultrasonic sensor. These three sensors are controlled by three Arduino board. The Arduino provides the data and HMM checks for any speed movement of the human body and checks the fuzzy inference rules if it matches then an alarm is generated. This system main issues are it is restricted within a home environment and this system is done for a single person usage.

Ali Cheli [8] et al proposed a system for fall detection based on machine learning algorithms using IOT sensors. This system has used Ensemble bagged tree and Quadratic support vector machine algorithms for fall detection .It uses two important systems that are wearable device based system and context aware system .Wearable systems consists of watches and smartphones, whereas the context aware system is fixed to a particular environment where the activity of the person is continuously monitored. This system comprises of triaxial accelerometer and gyroscope to record those human activity, it uses a Chebyshev high pass filter to get a standardized acceleration and angular velocity values. Though this system performs fall detection it is fixed to the home environment only the privacy of the people is affected in context aware systems, it is impossible to detect when the person forgot to wear the watch or to take the smartphone.

Faisal Hussain [9] et al proposed a wearable sensor-based continuous fall monitoring system. The performance of the proposed model is investigated with the three machine learning algorithms k-nearest neighbours (KNNs), support vector machine, and random forest (RF). This system uses KNN for the fall detection and the falling activity recognition for the fall prevention. The proposed methodology, which consists of five major stages: data acquisition, pre-processing, feature extraction, fall detection, and falling activity recognition (FAR). The experiment is conducted to evaluate the performance of the proposed system of two stages fall detection and fall activity recognition. Each falling activity was comprised of fall pattern. Falling activity recognition rate is obtained using KNN classifier. Though this system used to detect falls processing is a complex task. It doesn't have a falling pattern.

Jian He Zihao Zhang [10] et al proposed a low power, strong network capacity fall detection system using FD-CNN. It records the activity of the person using a 3-axile accelerometer and angular velocity placed in a wearable vest. The cached data are mapped into an RGB bitmaps, then a fall detection convolutional neural network (FD-CNN) is trained using the dataset to determine the variation between falls from the activities of daily livings that corresponds to the bitmap. Once the fall is detected, notification message will be sent to concerned people. The system takes advantages of high accuracy in fall detection, low-power Consumption, therefore the system is much suitable for fall detection in elderly people. Though the system provides better accuracy the process of mapping RGB bitmaps is complicated

Table 1: Comparison of various methods used in fall detection

S.No	Paper	Technique	Result	Issues
1.	Deep Learning for Fall Detection:Three-Dimensional CNN Combined With LSTM on Video Kinematic Data	3D-CNN, SVM	The LSTM based attention mechanism can locate the most informative part of fall detection in the image and fall is detected based on output of SVM.	Though the system provides better results, the computational complexity increases when sampling interval between two consecutive clip increases, some frames of fall event may get missed.
2.	Elderly Fall Detection Using Wearable Sensors: A Low Cost Highly Accurate Algorithm	Two segment feature extraction method, SVM	Performs feature extraction and it detects the occurrence of an fall event based on SVM.	The issues in the paper are slighter increase in sampling frequency increases the power consumption and complexity of feature extraction.
3.	A Patient-Specific Single Sensor IoT-Based Wearable Fall Prediction and Detection System	NLSVM	The FMFP performs fall prediction and SMFD performs fall detection based on NLSVM.	Though it predicts fall, the time duration between fall prediction and fall occurrence is short.
4.	An Energy-Efficient Algorithms for Classification of Fall Types Using a Wearable Sensors	Temporal Signal Angle Measurements, Support Vector Machine	The TSAM performs fall prediction using temporal signals and the SVM classifies the fall type.	Efficiency can be achieved only when it is down sampled which affects accuracy.
5.	Development of an Enhanced Threshold-Based Fall Detection System Using Smartphones with Built-in Accelerometers	Hidden Markov Model, Support Vector Machines	The HMM performs fall prediction and the SVM performs fall detection by classifying the fall based on activities of daily living.	The smart phone must be kept in pant pocket only and the application is not flexible to all smartphones.
6.	An Integration Vision Based Approach for Efficient Human Fall Detection In Human Environment	Generalized Likelihood Ratio, Support Vector Machines	The RGB camera is used to capture the changes in the relevant pixels in frames and SVM acts as classifier.	This method is suitable only for the home environment and it affects the privacy of the user.
7.	Fall Sense: An Automatic Fall Detection And Alarm Generation System in IoT-Enabled Environment	HMM, Fuzzy Inference Rules	HMM analyses the data captured from sensors using Arduino and the fuzzy inference for decision making.	It is restricted in a environment, the Arduino board has to be placed on the wrist so the user may not fell comfortable with it.
8.	A Machine Learning Approach for Fall Detection and Daily Living Activity Recognition	Quadratic Support Vector Machine, Ensemble Bagged Tree	EBT checks for the fall and QSVM classifies fall types.	It is impossible to detect for the person who forgot to wear the watch or to take the smartphone.
9.	Activity Aware Fall Detection System Based on Wearable Sensors	KNN and Falling activity recognition	KNN classifies the fall type and Falling activity recognition is used to monitor the activities of daily living	There is no falling pattern is trained for the fall detection. Processing of KNN is complex
10.	A Low Power Fall Sensing Technology Based on FD-CNN	FD-CNN	It perform mapping of RGB bitmaps with respect to accelerometer values and process it using FD-CNN to classify between the activity and Fall.	The mapping of RGB bitmaps is a complex task.

III. CONCLUSION AND FUTUREWORK

Many systems are available in order to detect falls and provide an alert message when a fall occurs. From Table I it is understood that there is no system has analysed the reasons for elderly fall, that might prevent a fall. This proposed system provides a solution to detect falls in elderly people on analysing their activity and send alert to family and neighbours if a fall is sensed, it also governs the health conditions of the elderly people, when health condition deteriorates it provides an alert message to the concerned people in order to provide medical assistance to the elderly people, so it avoids falls caused due to fainting. This system takes actions to prevent fall before occurrence. In future, it can provide assurance to develops a comfortable wearable for the elders by minimizing the dimensions of the wearable sensors.

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