

# ANALYSIS OF KINECT FALL DETECTION SYSTEM AND REHABILITATION GAMING EXERCISES USING AUGMENTED REALITY (AR) USER INTERFACE AND MULTI - PATH CONVOLUTIONAL NEURAL NETWORK (MP – CNN)

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## ABSTRACT

Among practically all nations, the occurrence of falls in the elderly is currently a big concern. Severe injuries occur as a result of the fall and sometimes even to mortality. Physiotherapy is an analysis of human joints and bodies, which gives remedy for any pains or injuries. Kinect Xbox One is a low – cost 3D camera which can be used for human motion tracking. The human movements are tracked in real time by using Kinect Xbox One and use the human exercises to calculate certain values in parameters. This paper contains, a Multi - Path convolutional Neural Network (MP – CNN) is recommended for doing rehabilitation exercises recognition using Kinect Xbox One sensor data. It contains two important components. They are a Dynamic - convolutional Neural Network (D – CNN) and a State transition probability convolutional Neural Network (S – CNN). Gaussian Mixture Regression (GMR) is used in D – CNN to record the sensor data's regarding the way the body moves at the time exercising for rehabilitation. The input signal and the GMR are appeared in various segments. In S – CNN we use Lossless Information Compression Encoder Algorithm (LICE) to take use of the hidden states of distinct motions' the transition probabilities. The combination of D – CNN and S – CNN creates the MP – CNN. We use Augmented Reality (AR) technique in this method. When comparing the results obtained from MP – CNN, KNN and Logistic Regression it is found that MP – CNN is better than Logistic Regression and KNN.

**Keywords:** *Healthcare, Kinect Xbox One, Rehabilitation Exercises, Recognition, Convolutional Neural Network.*

## 1. INTRODUCTION

In human being healthcare means development of health through the diagnosis, treatment and preventing diseases, mental and physical impairments. In developed countries there is tremendous development in the field of medical science. There has been severe health crisis in the undeveloped countries. Though there is advanced technological development they are rarely used in undeveloped countries. Healthcare is not given prime importance by majority of people. In order to counter the diseases, there are advanced instruments for motion tracking. There is necessity for self –

assessment of healthcare. The systems regarding artificial intelligence are trained and there by gained knowledge. This system solved all problems in healthcare. Researching technologies are started for developing healthcare system. To achieve this, we start with automated healthcare are by means of physical fitness or rehabilitation. For good health physical fitness is prime importance. The problems in human body are found out by means of human movements. Applications are developed and exercises are given to the user. Those exercises are done by the users, with the help of the system and the

movements those movements are analyzed with our algorithm through which distance and angles between joints and output values are verified.

Fall is quite common in the life of elderly people. People ageing more than nineties are mainly in the risk of fall. One – Third of people ageing more than 65 years old fall each year.

- 22 – 60% suffer injuries.
- 10 – 15% suffer serious injuries.
- 2 – 6% suffer fractures.
- 0.2 – 5% suffer hip fractures.
- Nearly 10 – 20% fall causes fractures.

Kinect is a collection of sensor that were originally designed as an input device for the Xbox 360 and Xbox one gaming console. It also has an infrared projector, IR camera which is utilized for obtaining exact depth maps, a RGB color camera, a four – microphone array and a motorized tilt. Developers may detect persons and follow their motions using the Kinect for windows SDK's skeletal tracking capability. It is more beneficial to undertake rehabilitative activities in a familiar setting. The system was designed in such a way that it is easily transportable from one location to another. It creates awareness in the minds of these people and making them aware of their surroundings and facilitate for an ability to do their individual life activities. These system consists of two types. They are

1. Gesture recognition system and
2. Voice processing system.

Rehabilitation is one of the main branches of health science. Rehabilitation is the main aim of every medical and ancillary service dealing with the care of patients. Fall and poor bone health are major causes of disability. Physiotherapy besides the therapy relevant visibility and there by the patients are advised to do the exercises under the supervision of physiotherapist. Physiotherapist do the physical examination including gait and balance, neurological and cognitive function, lower limb strength, visual acuity, feet and foot wear. A home exercise system is a type of rehabilitation programme in which a patient does a series of physical exercises at home.

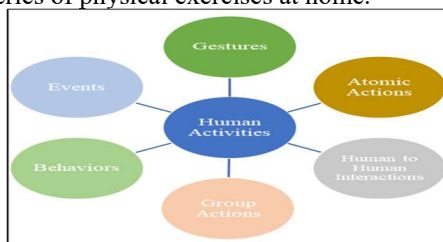


Figure1: Human Activities Decomposition

Deep learning algorithm is another name for machine learning algorithm. It is an area of research that demonstrates the ability of machines to comprehend data. It develops algorithm and it enables the computers to read the complex patterns and makes intelligent decisions based on that, at the time of learning there are numerous process. If the machine faces a problem, it alters its structural program me in order to improve future performance. Machine learning algorithm can be classified into

1. Supervised machine learning algorithm
2. Unsupervised machine learning algorithm and
3. Reinforcement machine learning algorithm.

The fall detection method is based on machine learning. Convolutional neural network algorithm which comes under supervised machine learning algorithm gives accurate result in the detection of fall. We propose sensor based action recognition method. There acquires a problem in this method. While using sensor data's, the data alignment problem acquires. The start and end point, as well as the speed, at the time of activity may differ totally. At the time of activity performance by different people the data contains noises and variations. In order to prevent this problem, a D – CNN is used. To collect the sensor data's hidden states, we use S – CNN by the odds of transition between states. The MP – CNN was created to classify rehabilitation exercises. Augmented Reality (AR) technique is used in this method. It is an enhanced version of the real physical world. AR is an achieved through the use of digital visual elements, sound or other sensory stimuli delivered via technology.

## 2. FALL IN ELDERS

Fall can be defined as an event which makes a person to rest on the ground or plane all of a sudden due to imbalance condition. There are many factors responsible for fall in elders. Some of the causes for fall are lower limb weakness, gait or balance disorders, functional and cognitive impairment, visual deficits, depression and poly – pharmacy. People have a lack of memory and learning challenges as they age, which might cause them to lose their balance.

Due to aging, fall is inevitable. Fall rate increases, because of change in the life style of the elders. There is more possibility of falling to the elders in the individual institutional residency. One of the major causes for fall in elders is balance and

posture control. Imbalance occurs due to interaction of musculoskeletal and sensory system. Fall can be categorized into four groups. They are

- Fall contributed to by external factors: These includes factors like wet floors, ice, ladders, unseen objects or poor lighting.
- Fall due to loss of consciousness: The factors responsible to this type of fall are myocardial ischemia, hypotension.
- Fall related with acute illness: It includes factors like stroke, infection, dehydration, interaction and facial impaction.
- Fall may be due to absence of serious illness: In the absence of serious illness may involve an external cause. It is usually hard to find distinct cause for them. Special attention must be given to this type of fall.

Environmental factors such as loose carpets, poorly constructed steps etc. are some of the other reasons for fall. The risk of falling is also by personal factors. Some of the diseases like changes in the neurological function, medications as well as diseases like hypertension, diabetes and chronic diseases are also causes fall. Fall causes in elders loss of confidence fear and anxiety occurs in the minds of elders due to repeated falling. Routine and social activities, loss of independence moving into aging residential or nursing care center are some of the social consequences. Fall threatens elders and it affects their mobility and independence. Many techniques are adopted for fall detection. Detection of fall must be accurate and reliable. It should be apart from bias.

Analysis Of Kinect Fall Detection System And Rehabilitation Gaming Exercises Using Augmented Reality (AR) User Interface And Multi - Path Convolutional Neural Network (MP – CNN)

### 2.1 Challenges Faced by the Fall Detectors

Some of the problems faced by fall detectors are

- Performance in real – life conditions: Fall detectors should be reliable and accurate. Robust fall detection system provides high sensitivity and specificity. Devices are designed and tested under controlled conditions.
- Usability: Fall detectors using smart phone attracts widely. It is due to the use of phone widely by majority of people including elders. It allows highly stereotypical parameter which gives accurate rating. Smartphones are used normally, without any

restrictions in relating with the position or functionalities.

- Acceptance: Acceptance of practicality and acceptability of the technology. Acceptance of elders is a major problem due to unfamiliarity of electronic devices. In order to overcome this, elders should be educated about the use of electronic devices. So that they can use them automatically without any intervention. Elders may operate smartphones both indoor and outdoor and integrate not only fall detection but also other healthcare applications.

### 2.2 Steps of fall Prevention in Elders

There are six steps to reduce their risk of fall

- List of steps to stay safe: Elderly peoples often afraid of falling but this would not happen to them. They were also not hurt if they had fallen in the past. They should be properly instructed by their health caretaker who can assess their risk and advised programs that could help them.
- Discussion of present health conditions: We should find out whether the elderly people experiences any health problem. We can also find out if there is any trouble for them in their medication. We should ensure whether the advantages of all the preventive benefits given under Medicare. Elders should be encouraged to speak frankly with their health caretaker.
- Interview about their eye checkup: If the elderly people were glasses, we should make sure whether they buy exact glass as prescribed by the doctor. We should remember that using color changing lenses can be risky while going from bright light to darkened homes. Elders should be properly advised to change their glasses every now and then as per the advice of the eye doctor.
- Observe whether they are holding onto the walls, furniture's or somebodies help while walking or finding difficult in walking: The physiotherapist help the elderly people to improve their balance, strength and gait through exercise. They also prescribed walking stick and proper guidance to use it. The risk of fall may also be prevented by using fit aids.
- Discussion about the elderly people medication: If there is any problem for elders regarding the track of medicine or facing any

side effects, we should encourage them to discuss with their physician. If any new prescription is prescribed to them the medication should be reviewed every time.

- Safety walking in home: Bright Light facilities must be facilitated in the home especially at the top and bottom of staircase ensured rails are provided in all stairs. Erection of grab bars in the tub/shower.



Figure2: Consequences of fall in Elders

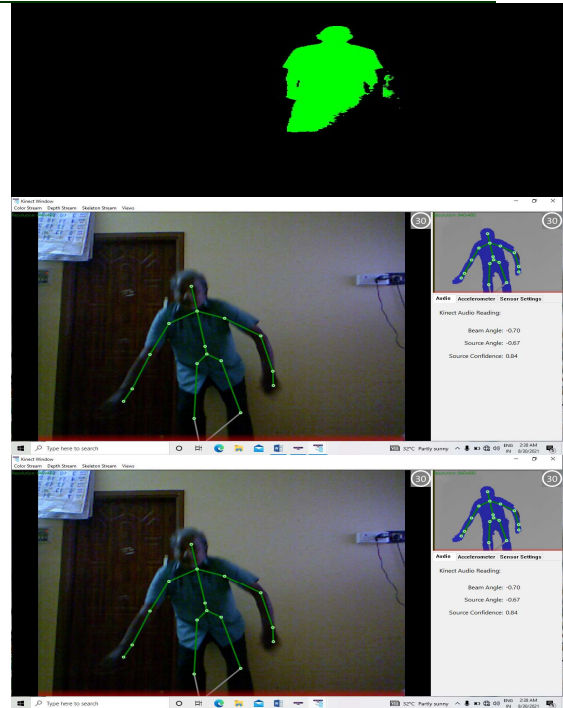
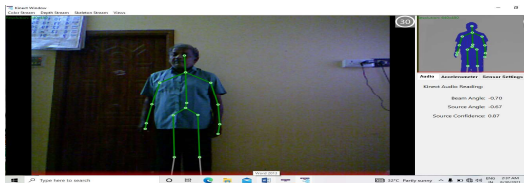


Figure3: Fall at the Time of Doing Exercises

```

public class KinectSensorItem : INotifyPropertyChanged
{
    private KinectStatus status;
    public KinectSensorItem(KinectSensor sensor, string id)
    {
        this.Sensor = sensor;
        this.Id = id;
    }

    public event PropertyChangedEventHandler PropertyChanged;
    public KinectSensor Sensor { get; private set; }

    public string Id { get; private set; }
    public KinectStatus Status
    {
        Get
        {
            return this.status;
        }
        Set
        {
            if (this.status != value)
            {
                this.status = value;
                if (null != this.Window)
                {
                    this.Window.StatusChanged(value);
                }
                this.NotifyPropertyChanged("Status");
            }
        }
    }

    private KinectWindow Window { get; set; }
    public void ShowWindow()
    {
        if (null == this.Window)
        {
            var kinectWindow = new KinectWindow();
            kinectWindow.Closed += this.KinectWindowOnClosed;
            this.Window = kinectWindow;
        }
        this.Window.KinectSensor = this.Sensor;
        this.Window.Show();
        this.Window.Activate();
    }
}
  
```

Table1. Procedure for Fall Detection

S.No	Position	Description
1.	Forward fall, finishing lying.	Individual is standing, forward fall and remains on the plane.
2.	Backward fall, finishing lying.	Individual is standing, backward fall and lying on the floor.
3.	Left side fall.	Individual is standing, but his left side has collapsed, and he is now lying on the ground.
4.	Right side fall.	Individual is standing, right side fall and lying on the floor.
5.	Pick up object from floor with bending.	Individual is standing, bends, pick up an object on the ground and then raise again.
6.	Sit and raise up from the chair.	Individual is standing, sit on a chair and then raise up again.
7.	Forward fall on the knees.	Individual is standing, forward fall and lying on the ground.

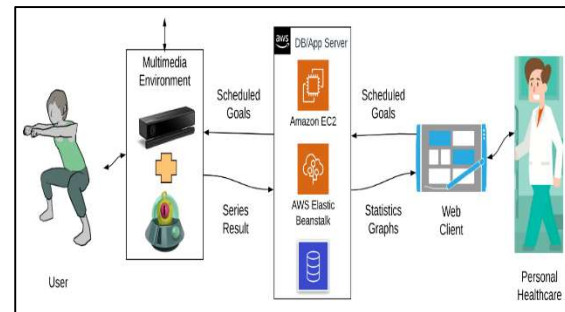


Figure4: Process of Kinect Rehabilitation

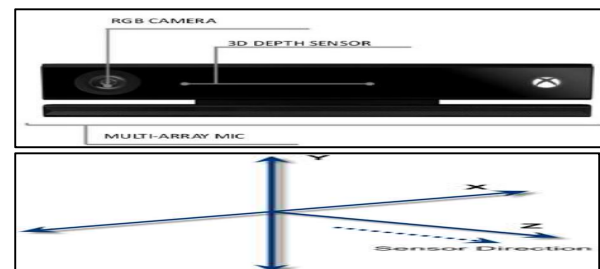


Figure5: Kinect Xbox One and Direction of Sensor

### 3. REHABILITATION

Rehabilitation, a branch in medical science gives treatment to gain lost abilities and thereby makes the individual more independent at the time of an individual in acute care. For many patients, it proceeds afterwards, as formal rehabilitation program or as individual rehabilitation program. The main aim of rehabilitation is to bring back the patient from bed to real active life. It is very important to have big team to achieve this challenge. The role of a physiotherapist in this team is vital. The medical team consists of following members. They are

- Medical members.
- Lay members.
- The relatives of the patient

#### 3.1 Kinect based Rehabilitation System in Homely Environment

Some patient suffers from certain injuries or disability in performing daily activities of their life. This type of people need rehabilitation process to monitor and exercise to make them to fit. The process of rehabilitation cost high in the rehabilitation centers. The main idea of this system is to give feedback to the user and correctness in exercises while performing by

visual aids and there by proves that Kinect can be used effectively in the stream of treatment program. Physical exercises play an important role in preventive and rehabilitative healthcare. The physiotherapist in the therapeutic center identifies the problem and needs of the patient. They designed exercise program for an individual patient and the patient is advised to perform the exercises daily. At the time of doing exercises the physiotherapist monitor two aspects. They are

- The body posture and
- The range of motions.

The patients are advised to perform the exercises as per the instruction of the therapist. As a result, people can avoid putting undue strain on their joints and muscles. This system includes a computer along with a Kinect Xbox one in homely environment. The patient must follows the instructions given by the physiotherapist strictly so that they can have safe effective and efficient rehabilitation care. The use of Kinect creates interest to the therapist and motivate the patient. Kinect is an inexpensive gadget, but it is very potential to give accuracy sufficient for clinical practice. Some of the advantages in these system are



- It allows the patient to read the exercises that are prescribed and so the therapist can read the patient session in detail.
- The physical rehabilitation system is utilized not only by the patient but also to the therapist.
- Exercises may be done at home, which is quite convenient for the patient.
- The Kinect – based rehabilitation is very convenient for the patient.

### 3.2 Kinect – based Rehabilitation Games

Physical and cognitive rehabilitation therapies are given to disabled. People using Kinect based rehabilitation games in the home environment. This type of games stimulates the body mobility. This type of games includes gesture interaction interfaces. This technology is a very useful tool in rehabilitation. This proposed system having different types of exercises provides a platform for the rehabilitants in several aspects like strength, aerobic or cognitive capacities. The structure of the system is designed in such a way that the presence of the physiotherapist is not required. The report of the sessions can be read offline by the therapist. He knows the performance of each session is carried out in a good way and if any modification is required to the performer it could be guided by the therapist. Rehabilitation procedure for Kinect based exercises are as follows

- Weeks 0 – 2: Breathing exercises, Upper limb pumping exercises, Shoulder flexion and up to 90°.
- Weeks 2 – 5: Kinect sports, Bowling (10 min, affected side), Boxing (10 min, affected side).
- Weeks 5 – 8: Table tennis (10 min, affected side), Walking 30 min 3 times a week.

Kinect based games are classified into two types. They are

- Aerobic games and
- Strength games.

#### 3.2.1 Aerobic Games

In this type of games, we can perform four different activities.

- Training of lower limb.
- Training of upper limb.
- Training of lower limb and upper limb simultaneously.
- Training of any one of the limb with a cognitive training in the same time.

Different landscapes are presented to the user. The landscape depends upon the kind

session suggested by the therapist. The device is placed before the patient. The patient is asked to make a number of different movements to detect of Kinect. The avatar's motions are moved to the terrain that was previously picked. The avatar's every motion is visible to the patient. The patient is requested to move sideways, elevating the legs and taking a slow stride to make the avatar travel around the landscape. When they are raised it is not the same. The parameter is configurable and the angle is configured by the therapist. If the pace is not maintained properly by the user, the therapist gets both visual and auditory feedback. In order to create awareness to the patient he needs the pace to be increased or decreased. The therapist explained the duration of time to point out the different landscape in the scene. The patient's speed in every session is triggered by the feedback and the session it will be shown etc.

#### 3.2.2 Strength Games

Exercises such as adduction/ abduction of shoulders, flexion of shoulders, extension of elbows, flexion of elbows, flexion of thigh, adduction/ abduction of hip, flexion/ extension of knees are prescribed in this kind. The platform is explained to him vividly. The patient is given specific directions regarding the kind of exercises he should perform, the amount of time he should relax, and the amount of weight he should lift. Patients are very much encouraged at the time of doing exercises. The therapist designed the strength therapy from the list of available exercises. Different exercises are designed to different patients. When the patient starts his performance, on the screen the system counts the number of series and repetitions, as well as the values of the counted increments. This can be possible because the system detects the movements correctly performed. If the patient fails in these regards, the system could identify it and it moves to the next exercise. The data's of every session is saved so that information can be gathered by the therapist.

## 4. TECHNOLOGY APPLIED IN KINECT XBOX ONE

The name Kinect is derived from the word "Kinetic". Its meaning is motion. Microsoft Company launched Kinect Xbox 360 in November 2010. An upgrade of V1 was done in November 2013. Kinect V2 is entirely different from V1 regarding Time of Flight (TOF) technology. The basic principle of Kinect V2 is an array of emitters send out a signal which is

modulated. It travels to the measured point, gets reflected and got back by the CCD of the sensor.

#### 4.1 Hardware Tools of Kinect Xbox One

Kinect is a black horizontal bar sensor and it appears as a webcam. Kinect Xbox one sensor consists of RGB camera, 3D depth sensor and multi – array mic. The RGB camera in V2 gives colorful pictures with resolution 1920 \* 1080 pixels. It contains 30 frames per seconds. The X direction is length of the Kinect sensor. The Y direction points vertically up and down. The Z direction measures depth by the sensors an infrared emitter and an infrared camera make up the three – dimensional (3D) depth sensor. The IR emitter generates a noisy pattern of build IR light. The projector along with the camera produce a depth image and permits the distance between the camera and an object. Kinect device sense is adjusted to a specified limit by depth sensor. It produces depth pictures with a resolution of 512 \* 424 pixels and a range of 0.4 ~ 4.5m. The frame rate of V2 is 30 per second. The V2 raised FOV to 70° (h) \* 60° (V). Four microphones are available for live communication. It can handle up to 16 bit audio streams at sample rate of 16KHZ. V2's hardware capabilities include full – body 3D motion capture, facial recognition and speech recognition. All of these features makes the Kinect extremely helpful in variety of applications, including object tracking and recognition.

- Recording and examination of the human skeleton.
- Analyzing hand gestures.
- 3D localization and mapping in the same time.
- Fall detection and other emergency occasion.

#### 4.2 Software Tools of Kinect Xbox One

Following the release of Kinect Xbox 360, business such as CL NUI platform, open Kinect\ Libfreenect, openNI and PCL provide unofficial free libraries and SDK for the Kinect. Microsoft introduced official tools, such as Kinect SDK 2.0, in 2011 to allow developers to create apps that enable speech and gesture detection. Application Programming Interfaces (APIs), device interfaces and code samples are also included. It also provides free tools for detecting and tracking a person's body skeleton and head. The majority of the approaches to fall detection are based on computer vision applications. Human Activity Recognition (HAR) uses skeleton tracking to detect human actions by

modeling body components as joints. They recognize that the body's characteristics are computed using a 3D skeleton, which leads to improved performance. Skeletal tracking is accomplished using tools such as the unofficial open NI (Open Natural Interaction) and various Kinect versions. We can utilize Kinect Xbox one to recognize and monitor up to six humans in real time, and it can detect up to 25 joints per person. The official Kinect SDK 2.0 is advised to track the user's skeletons for various reasons

- The SDK of Kinect is more advantage than other libraries at the time of skeleton tracking. It tracks the entire body.
- Kinect Xbox one detects 25 joints per people. It is flexible and options at the time of fall detection approach.
- It is more stable for the collection of quality of the original image and thereby the quality of the images brings out better performance.
- Details of occluded joints are processed by the SDK.

**4.3 Components of Skill Layer in Kinect Xbox One:** The components found in skill layer of Kinect Xbox One are as follows

- Gesture Recognition.
- Speech Recognition.
- Person Detection.
- Fall Detection.

##### 4.3.1 Gesture Recognition

The development of gesture recognition engine is based on comparison of joints positions and the deviation between the joints positions. We can recognize in two kinds of gestures. They are

- Start Following.
- Stop Following.

##### 4.3.1.1 Start Following

When the right hand is lifted over the right shoulder and the left hand is below the left hip, the start following motion is recognized. To reference point for this sort of gesture is the right shoulder joint position, whereas the target point right hand joint position.

##### 4.3.1.2 Stop Following:

When the left hand is above the left shoulder and the right hand is below the right hip, the stop following signal is recognized. The reference point for this sort of gesture is the position of the left shoulder joint, whereas the target point is the position of the left hand joint.

##### 4.3.2 Speech Recognition

The audio stream of the Kinect for windows software development kit (SDK) captures the

Kinect audio data. The speech recognition engine is built by Microsoft speech library. Three commands are recognized by speech recognition engine. They are

- Run: To start the fall monitoring system.
- Stop: To stop the fall monitoring system.
- Call: To make a call.

#### 4.3.3 Person Detection

Kinect uses the skeletal stream to recognize and track the individual. It logs the event so that it can listen for and follow the skeletal frame. After the person has been identified, the program examines the skeletal data.

#### 4.3.4 Fall Detection

The skeleton joint locations in reference to the ground are used to identify falls in this approach. The distance between the body joint locations and the ground – plane is calculated by the fall detection algorithm. The ground – aircraft has been identified. The Kinect for windows SDK gives a ground – clipping – plane vector estimates ground – plane equation. Calculate the distance between a point and the plane. By using this relation, the distance from the floor to each body joint point can be calculated. The fall is detected by thresholding the distance between the joint points and the ground.

### 5. MACHINE LEARNING ALGORITHM

An algorithm can be defined as a set of unambiguous finite steps that carries out to a given set of initial conditions, gives out corresponding output by terminating finite time. It can also be defined a finite, definite and strong procedure which gives out some output. There are number of steps which are developed to find solution to any problem. There are various kinds of algorithms for any problem. Machine learning is one of the branches of computer science. It is the study of pattern recognition and computational learning theory in artificial intelligence. Machine learning is having a close contact and frequently overlapping computational statistics. It is a discipline which has some special effect on prediction making. It has close contact with mathematical optimization and gives out methods, theory and application platform to the field. Machine learning is used in a frequency of computing tasks in which by designing and programming a detail and clear algorithms. Machine learning and recognition of pattern are seen as two sides of the same field. Some of the applications of machine learning algorithms are

- Search engines.
- Game playing.
- Classifying the sequences of DNA.
- Adaptive websites.
- Brain – machine interfaces.
- Natural language processing.
- Health monitoring.
- Computer vision, including object recognition.

#### 5.1 Supervised Machine Learning

We provided the computer with input as example and their desired outputs, is given by the master and the aim is to learn a general rule that matches inputs to outputs. Some of the supervised machine learning algorithms are KNN, SVM, CNN, DTT, LR, and LSM.

##### 5.1.1 K – Nearest Neighbor

The KNN algorithm saves all available examples and categorizes new ones based on comparable metrics [23]. It's employed in pattern recognition and statistical estimation. KNN may be used to solve classification and regression prediction issues. Because it does not have a separate training phase and uses all of the data for training while classifying. KNN is also known as a lazy learning algorithm or a non – parametric learning algorithm. This algorithm's several stages are as follows:

**Step-1:** Select the number K of the neighbours

**Step-2:** Calculate the Euclidean distance of K number of neighbours

**Step-3:** Take the K nearest neighbours as per the calculated Euclidean distance.

**Step-4:** Among these k neighbours, count the number of the data points in each category.

**Step-5:** Assign the new data points to that category for which the number of the neighbour is maximum.

**Step-6:** Our model is ready.

##### 5.1.2 Logistic Regression

Logistic regression is a classification and it is not a regression algorithm. It occupies its position in discrete values 0 or 1 on the basis of independent variables. So this algorithm is used widely for binary classification tasks. Logistic Regression model takes a linear equation as input and use logistic function and log odds to perform a binary classification task [24]. The different steps used in this algorithm are

**Step 1:** Data pre – processing step.

**Step 2:** Fitting logistic regression to the training set.

**Step 3:** Predicting the test result.

**Step 4:** Test accuracy of the result.



**Step 5:** Visualizing the test set result.

**5.1.3 Convolutional Neural Network:** The machine learning technique is described by a neural network architecture consists of many layers and each layer has neurons in their structure. Convolutional Neural Networks (CNN) is one of the most important machine learning neural networks used for image recognition. CNN is mainly used to identify displacement, Zoom and other forms of distorting invariance of two – dimensional graphics. The feature detection layer of CNN learns by training data, it avoids explicit feature extraction and implicitly learns from the training data when we use CNN. The different steps used in this algorithm are

**Step 1:** Choose a dataset.

**Step 2:** Prepare dataset for training.

**Step 3:** Create training data.

**Step 4:** Shuffle the dataset.

**Step 5:** Assigning labels and features.

**Step 6:** Normalizing X and converting labels to categorical data.

**Step 7:** Split X and Y for use in CNN.

**Step 8:** Define, compile and train the CNN model.

**Step 9:** Accuracy and score of model.

There are three types of layers used in this neural network. They are

- A convolutional layer.
- A pooling layer and
- A fully connected layer.

#### 5.1.2.1 Convolutional Layer

The feature maps of the input layer are convolutional by this layer. It comprises of a two – dimensional kernel that corresponds to the size of the convolution window. The advantages of the convolutional operation are twofold. They really are

- Reducing the number of parameters.
- The local connectivity obtained correlations among nearby pixels.

#### 5.1.2.2 Pooling Layer

Though this layer is fairly basic, it is frequently used after a convolutional layer to reduce the size of the feature maps. The pooling layer kernel size is 2x2, and it chooses the highest or average pixel for max – pooling or average pooling. We may simply conclude that max – pooling convergence is quicker than average pooling convergence. It allows maximum pooling to be employed in a variety of applications.

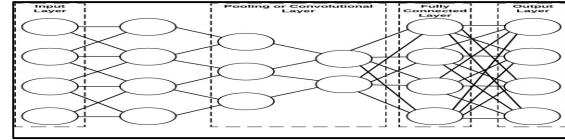


Figure6: Architecture of CNN

#### 5.1.2.3 Fully Connected Layer

This layer is used at the end of the CNN to modify the previous layer into one dimension. It includes 90% of the total parameters of the CNN and it is also responsible for most of the training computational cost. We tested three games for rehabilitation exercises. In the first game, combined training is done by two players. They were trained together with one neural network. In the second game, the individual player is trained with many neural networks. Each gesture is having one neural networks. In the third games, the individual is trained with four neural networks with one for each gesture.

#### 5.2 Multi – Path Convolutional Neural Network

Series of actions more than, one or many times is called rehabilitation movement. We are going to see in these paper a multi – path convolutional neural network to capture activity signals and thereby made classifications. There are two sub – networks in the MP – CNN. They are

- D – CNN
- S – CNN

A new evolution method is proposed to score rehabilitation exercises.

#### 5.2.1 D – CNN

When employing sensor data for human activity detection, the data alignment problem is considered a hurdle. The start and end times are different. Noises and variances arise throughout the performance of different people's activities. As a result, D – CNN is built using a Gaussian Mixture Regression (GMR) model. With the strategy of dynamic assignment, the GMR model is trained to fit the input signal. The dynamic assignment is divided into two tiers. Data partition and channel fitting are the two. The GMR model is trained to each well as the features activity class. The model as is partitioned into N parts in correspondence to the N channels in the D – CNN. By using channel fitting, features of identical model part go to the same channel in the D – CNN.

**Algorithm 1: Gaussian Mixture Regression**

```

1   Class: GMR
2   Parameters K: int X, Y, Z number of
   Gaussian distributions
3   d = X * shape [1]
4   labels = np * unique (prediction) self *
   initial means = np * zeros (self X)
5   d = Y * shape [2]
6   labels = np * unique (prediction) self *
   initial means = np * zeros (self Y)
7   d = Z * shape [3]
8   labels = np * unique (prediction) self *
   initial means = np * zeros (self Z)
9   Counter = 0
10  for label in labels: ids = np * where
   (prediction == label)
11  self * initial_pi [counter] = len (ids [0])
   X * shape [0]
12  self * initial_pi [counter] = len (ids [0])
   Y * shape [1]
13  self * initial_pi [counter] = len (ids [0])
   Z * shape [2]
14  counter += 1
15  assert np * sum (self * initial_pi == 1
16  return (self * initial_X, self * initial_Y,
   self * initial_Z)

```

**5.2.2 S – CNN**

Using probabilistic finite state automata (PFSA), transition probabilities may describe properties in between states (PFSA). The computational cost of the transition probabilities is found to be considerable while computing them. As a result, the CNN model is presented. For more discriminative feature representation, the links between input signals and transition probability states are examined. The PFSA code employs the Lossless Information Compression Encoder Algorithm (LICE) to represent sensor data and the PFSA to compute state transition probabilities between concealed states. There are three phases involved in this process

- Quantization.
- LICE coding.
- Construction of PFSA.

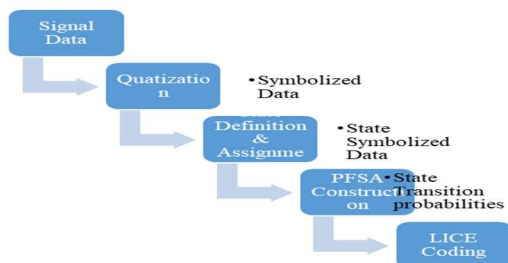


Figure7: Lossless Information Compression Coded Flowchart PFSA Approach

**Algorithm 2: Lossless Information Compression Encoder Algorithm**

```

1   Operation 1: Encoding the series W and
   determining Lossless information
   compression Kinect X, Y, Z
2   Initialize: Kinect X, Y, Z based on W
3   Check Code-C and Kinect X, Y, Z
4   Begin
5   If (X=A) - Character analysis (First
   variable)
6   Delete (w)
7   A=next input character in W
8   Else If Q+A is in Kinect X, Y, Z
9   Else
10  Add Q+A to the Kinect X, Y, Z
11  Q= A
12  End if
13  Check (Q)
14  End (w)
15  A=next input character in W
16  If Q+A is in Kinect X, Y, Z
17  Q = Q+A
18  Else
19  Output the code for Q
20  Q=A
21  End if
22  Output code for Q

```

MP – CNN consists of two models, a top CNN model and a bottom CNN model to increase the recognition accuracy. By using CNN model the gravity and body (GB) signals as input, named GB – CNN. The gravity path and the body path are combined in the GB – CNN model for common convolution and pooling operations to capture joint features. The two hidden layers called GB – CNN model depicted at the top and the S – CNN model is depicted at the bottom are consider to be the output. Both GB – CNN and S – CNN models combined to build the MP – CNN model.

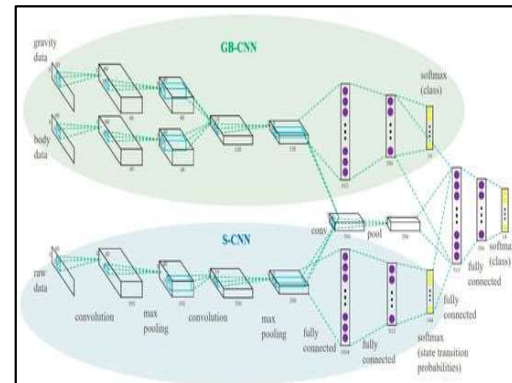


Figure8: Multipath CNN Model

**Algorithm 3: Combined MP – CNN****Task 1** : Learning S – CNN model.**Input** : Raw Sensor Signals.**Output** : State Transition Probabilities.**Step 1** : Quantization.**Step 2** : Symbolization.**Step 3** : LICE Coding.**Step 4** : PFSA Construction.**Step 5** : Obtain State Transition Probabilities.**Step 6** : S – CNN Model Training.**END****Task 2** : Learning D – CNN model.**Input** : Raw Sensor Signals.**Output** : Classification Results.**Step 1** : Feature Extraction, Gravity and Body Features.**Step 2** : GMR model learning.**Step 3** : Data Partition and Channel Fitting.**Step 4** : D – CNN Model Learning.**END****Task 3** : Learning MP – CNN.**Input** : Raw Sensor Signals.**Output** : Classification Results.**Step 1** : Kinect Model Setup.**Step 2** : Exploiting S – CNN and D – CNN as Pre – Train Exercises.**Step 3** : MP – CNN Training.**END****6. DIFFERENT TECHNIQUES USED TO SUPPORT IMPLEMENTATION OF AUGMENTED REALITY (AR) USER INTERFACES**

There are many games based upon Augmented Reality (AR) user interface. They are linked with many distributed system to a central server and database. The physiotherapist uses a web – based application to monitor and prescribe treatments regarding the progress of the user. A friendly and more enjoyable rehabilitation process is intended with suitable environment. Different gaming exercises are prescribed for different types of rehabilitation. It is with the help of potential games and Augmented Reality interfaces, the motor skills of the elderly peoples are improved. The following techniques are adopted in this regd.

**6.1 Natural Sensing Techniques**

In this technique, natural and intuitive interactions like gesture or voice recognition issued. In order to avoiding the difficulties faced by elderly people like buttons to change the screens.

**6.2 Loose Tolerance Margins**

In order to assess movement correction, at the time of executing exercises the limited motor skills of the elderly people are compensated.

**6.3 Gesture and Scripting – Based User Interface**

Natural and easy gestural inputs to interact with the system there to start the game or to play with it. The interface is reacting with the script – based game, by which the user has to follow step – by – step indications.

**6.4 Augmented Reality Environment**

A happy Augmented Reality environment that makes the user providing the real time feedback regarding the status of the current exercise.

**6.5 Rewarding Scheme**

A natural interactive environment is offered by playing games regarding the implementation of schemes to make the user's attention and the system is appealing. Thus, games are vital for the elders with poor skills of technology.

**6.6 Improved Graphic Elements**

Games and avatars are certain graphic elements, which contribute the system makes the elders more enjoyable and understandable.

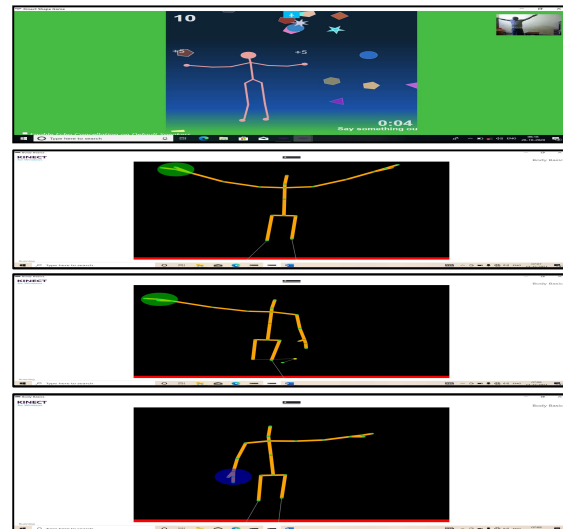


Figure9: Rehabilitation Games using MP – CNN

The exercises are designed in such a way that they are connected with a game and the two objectives such as

- Guiding the user.
- Maintaining the user's interest till the exercise is completed.

There are number of visual elements in the graphical user interface. They were designed to guide the user's at the time of exercises and also creates some feelings in the natural environment. The main example for the first objective is bouncing ball, which is designed in 3D animations to demonstrate the correct way to do exercises. To this exercise is dynamic, self – explanatory and appealing especially for the elders.

Feel of integration is the second objective, the components of Augmented Reality are dynamic and they are included in the games environment. The 3D coordinate with the ball. By doing bouncing ball gaming exercise, physiotherapy is given to four arms. Physiotherapist instructed the patient to strike a particular colorful ball to a particular direction. We obtained certain parametric values. We use these values to form UT – Kinect dataset. Each patient is asked to undergo three test. 3×3 confusion matrix method is utilize. Inter – quartile range is used to calculate TP, TN, FP and FN. Calculations and evaluations are done to find the parametric values of MP – CNN classifiers through which comparison is done with the classifiers of other machine learning algorithms like KNN and Logistic Regression.

This indicates the position to which the user. For multipath, we use the following classifiers: convolutional neural networks, logistic regression and KNN algorithms. To achieve the aim, participants should elevate their arm in a shoulder abduction exercise. The exercise's goal position is attained by striking the ball against the wall's point. The ball drops when the user has completed his exercise. The joints and muscles involved in the specific execution of this exercise are retrieved from the database, together with certain assessment guidelines based on the exercise's purpose and physical measures between the user's joints of interest.

$$\text{Accuracy} = \frac{TP+TN}{FP+FN} * 100$$

(1)

$$\text{Precision} = \frac{TP}{TN+FP} * 100$$

(2)

$$\text{Recall} = \frac{TN}{TN+FN} * 100$$

(3)

$$\text{True negative rate} = \frac{TN}{TP+} * 100$$

(4)

$$\text{True positive rate} = \frac{TP}{TP+FN} * 100 \quad (5)$$

$$\text{Sensitivity} = \frac{TP}{TP+FP} * 100 \quad (6)$$

$$\text{Specificity} = \frac{TN}{TP+FN} * 100$$

(7)

$$\text{Particularity} = \frac{TN}{FP+TN} * 100$$

(8)

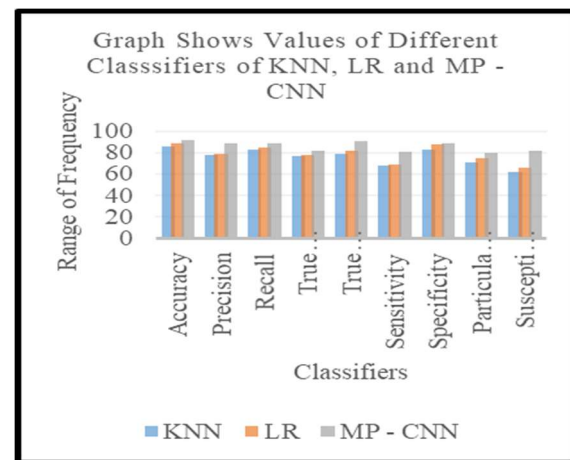
$$\text{Susceptibility} = \frac{TP}{TP+TN} * 100$$

(9)

Table 2: Aggregated Values of Different Classifiers of MP – CNN and LR Algorithms.

S.no	Classifiers	KNN	LR	MP – CNN
1.	Accuracy	86.15	88.35	91.5
2.	Precision	78.1	79.2	88.5
3.	Recall	83.1	84.5	88.2
4.	True negative rate	76.4	77.30	81.4
5.	True positive rate	78.3	81.5	90.45
6.	Sensitivity	68.1	69.3	80.50
7.	Specificity	82.41	87.45	89
8.	Particularity	70.8	74.9	79.5
9.	Susceptibility	62.3	65.5	81.5

## 7. RESULT & DISCUSSION



The graph shows summary of values acquired against the parameters of different classifiers of MP – CNN, LR and KNN algorithm. The accuracy of MP – CNN is 91.5, LR is 88.35 and KNN is 86.15. The precision value of MP – CNN is higher than LR and KNN. The recall value of LR and KNN is lesser than the value of MP – CNN. The true positive rate value of MP – CNN is higher than the values of LR and KNN. The true negative rate value of MP – CNN is higher than the values of LR and KNN. The sensitivity of MP – CNN is 80.50 whereas LR and KNN is 69.3 and 68.1. The specificity values of LR and KNN is lesser than the value of MP – CNN. The particularity value of MP – CNN is higher than the values of LR and KNN. The susceptibility values

of LR and KNN are lesser than the value of MP - CNN. Overall, MP – CNN has the highest value in all parameters. We can come to a conclusion that MP – CNN is better than logistic regression and KNN algorithm.

## 8. CONCLUSION

Fall is one of the major problems everywhere throughout the world. We should not ignore the fall caused to elders because it may result in various other problems in future. The growth of Internet – of – Things solves the great health disasters and thereby helps the people to lead a healthy life. Kinect Xbox one a new device is used for doing rehabilitation gaming exercises in the homely environment. Rehabilitation exercises are used to heal the disabilities. Rehabilitation exercises are given to elders within a stipulated time so that they can restore their lost abilities and they can come to normal life. MP – CNN algorithm is a computer program which gives accurate results in preventing fall events regarding elders. We use Augmented Reality method to eliminate unnecessary noise and other sensory stimuli.

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