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Information Technologies

**ANOMALY DETECTION FOR VIDEO  
SURVEILLANCE IN CROWDED ENVIRONMENTS  
FOR POLICE**

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Master of Science

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The thesis titled “ANOMALY DETECTION FOR VIDEO SURVEILLANCE IN CROWDED ENVIRONMENTS FOR POLICE” prepared by “Bilal Fareed Abbas ALANI” and submitted on (22/10/2021) has been **accepted unanimously** for the degree of Master of Science Thesis in Information Technologies.

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## ABSTRACT

### ANOMALY DETECTION FOR VIDEO SURVEILLANCE IN CROWDED ENVIRONMENTS FOR POLICE

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Abnormality detection including human unusual movement, unusual traffic, crime sense, group violence, etc. is inspired by virtual data availability which is obtained from closed circuit television (CCTV). The logic of abnormality existence is made in assumption that most of the virtual data (surveillance data) is not included abnormal events with 100 % probability. The abnormal event is less probable than the normal one hence, appointing of people for surveillance who observe the data for long times is no longer appreciated due to the time and manpower wastage. Automatic abnormality detection is proposed in this work using deep learning technology to perform the detection and dispense manpower surveillance which ensures good performance is far less expensive budgets. Long short-term neural network (LSTM) is used for the same; LSTM performance is compared with the proposed state of the art e.g., Feed Forward Neural Network accompanied with K-nearest neighbor particle swarm optimization (KNN-PSO). The proposed state of the art is outperformed in abnormality detection accuracy, the maximum recognition accuracy was 99.18345128 percent.

**Keywords:** Abnormality Detection, Automatic, Neural Network, LSTM, Metrics, MAE.

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# 1. INTRODUCTION

## 1.1 PREFACE

Image processing technologies have been developed for many years and have become vital to human daily routine. Security related applications including data security is also begun new stage because of technology revelation and large extension of internet. Data amounts are dramatically increased after development of new generation mobile communication as users increased and internet with no obstacles e.g. (wires or speed) widely propagated [1][2].

The existence of strong security is required to protect web data as well as local server's data hence, the research activity on improvement of security applications as well as technologies is increased. The first attempt to protect the web-based data is using the passwords protection where authorized users are required to provide their password credential to gain access into that data [3][4].

With further development of technology, specially when internet and web application are being developed, passwords become stronger. Passwords become including alphabetical characters as well as special characters where more reliability is implemented so that prediction of passwords become more difficult. With development of technology and software application, a miscellaneous security crash attempts were seen. The passwords can always be predicted and penetrated so; it was required to develop another personal verification technology to tackle this problem [2].

Detection of abnormality in crowds (peoples gathering), traffic and environments have made big advancement in the recent year due to the popularity of virtual data. Such data can provide more features and information than that in numerical raw data and features. Thus, using of virtual data for unusual event detection in public human gathering is implemented in this thesis.

## 1.2 PROBLEM STATEMENT

Literature has shown large number of attempts to rely on biometrical features for abnormality detection, those features include facial recognition which is very much popular in this regard. System relies on cameras or CCTV in order to scan the clipped (segmented) video in order to detect the crime since or in other word to verify the presence of illegitimate candidates in the gatherings or in the public places. Other than that, several approaches were found in order to detect particular abnormality, the following challenges of the existing recognition technologies can be listed:

- a) Taking the voice recognition as example, technology is set to identify the gathering abnormality using the voice sense. It can be also applied to verify particular voice amongst many of voices, the most recent application is to identify the presence of illegitimate candidates by detection of their voice. Speaker identification might consider as one of outstanding technology of personal verification, speaker cannot be recognized in case of changing in his/her voice due to any reason such as cold effects or problem in the vocal cords.
- b) Face recognition is impacted by the age of candidate, by growing in age, face features will begin to fade off and change so, updating of dataset and retraining of the entire model is required.
- c) The straightforward recognition method is recognizing the candidate by his unique PIN number of passwords; however, such technology is suffering from guessing problem as many softwires are capable to predict the password and penetrate the system.

d) In normal conditions, face can be occluded with many objects such as hair growing, makeup, etc. these obstacles can largely impact the face recognition system performance and lead to error.

e) Updating of dataset (as growing by age) is practically not easy to do specially when the recognition system is including large number of candidates where each of them in different age group and hence changing of dataset might be required in daily basis which increase the cost and time.

### **1.3 OBJECTIVES**

The availability of CCTV data and wide spread of video surveillance had paved the road for other alternative in abnormality detection in the crowded environments. It is simply preferred since more information can be obtained from video data instead of other sources of recognition. In this work, abnormality detection is performed using video surveillance data, the same is made through the following steps:

- a) in order to detect the abnormality in video data firstly, all video (with normal sense and abnormal sense) is clipped in static format (images) where the interested senses can be seen.
- b) Labeling of normal senses and abnormal senses using K-nearest neighbor algorithm (KNN).
- c) KNN can be used in further (next) step for eliminating of unnecessary data (images) (some images that not included abnormality sense can be removed in order to mitigate the load on classification paradigm).
- d) Using of deep learning technologies for classification of the clipped images can increase the accuracy of abnormality detection/recognition.

## 1.4 THESIS ORGANIZATION

This dissertation report is included of five chapters used to demonstrate the abnormal image detection using deep learning approaches applied on clipped images from video data. The chapter-wise description is made available in the Table 1.1.

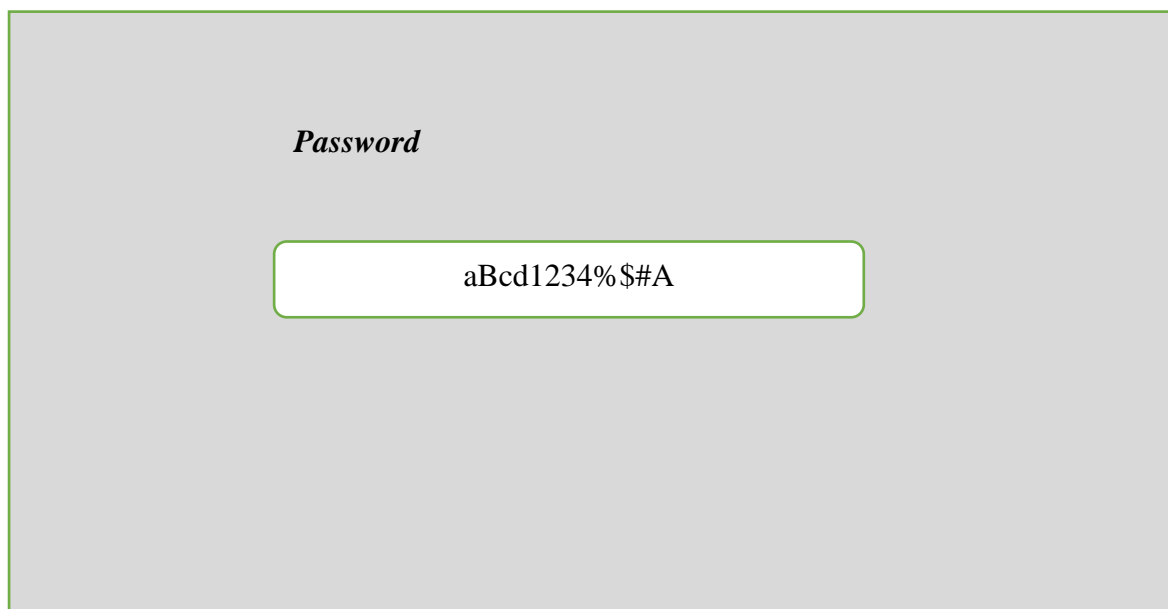
**Table 1.1:** Thesis Structure and Chapters Definition.

Chapter Title	Description
Chapter One “Introduction”	Involves the briefly made introduction about the technology and the problem statement as well as the research objectives.
Chapter Two “Literature Survey”	Demonstrates the previous research activity of the security systems and abnormality detection.
Chapter Three “Methodology”	Enlist the details of abnormality recognition and preprocessing method as well as description of the used database.
Chapter Four “Results Overview”	Reviewing the numerical and graphical results of the study.
Chapter Five “Conclusion”	Concludes the results and study findings.

## 2. LITERATURE SURVEY

At [1] [2], the techniques of security are begun using the mechanical locks openable with keys, the same is considered as first type of authentication techniques. Security methods impacted by technological revolution where no longer required to carry keys in order to verify personal authenticity for accessing some place. Passwords protected doors are established where user need to memorize a password which can be combination of numerical digits.

With further development of technology, spatially when internet and web application are being developed, passwords become stronger. Passwords become including alphabetical characters as well as special characters where more reliability is implemented so that prediction of passwords become more difficult as in Figure 2.1. With development of technology and software application, a miscellaneous security crash attempts were seen. The passwords can always be predicted and penetrated so; it was required to develop another personal verification technology to tackle this problem.



**Figure 2.1:** Password combined of char and special characters for more security requirement. [1]

At [3] [4], author stated that object recognition is the key feature of robust security enforcement techniques. Object recognition can yield permanent features from the object image, such features are constant and resistive to the time effects and age effects. Object image is recognized in this study using the essential lines and the wrinkles persist on the object surface. However, the wrinkles and, delta points are one of the richest sources of recognizable features of object as in Figure 2.2.

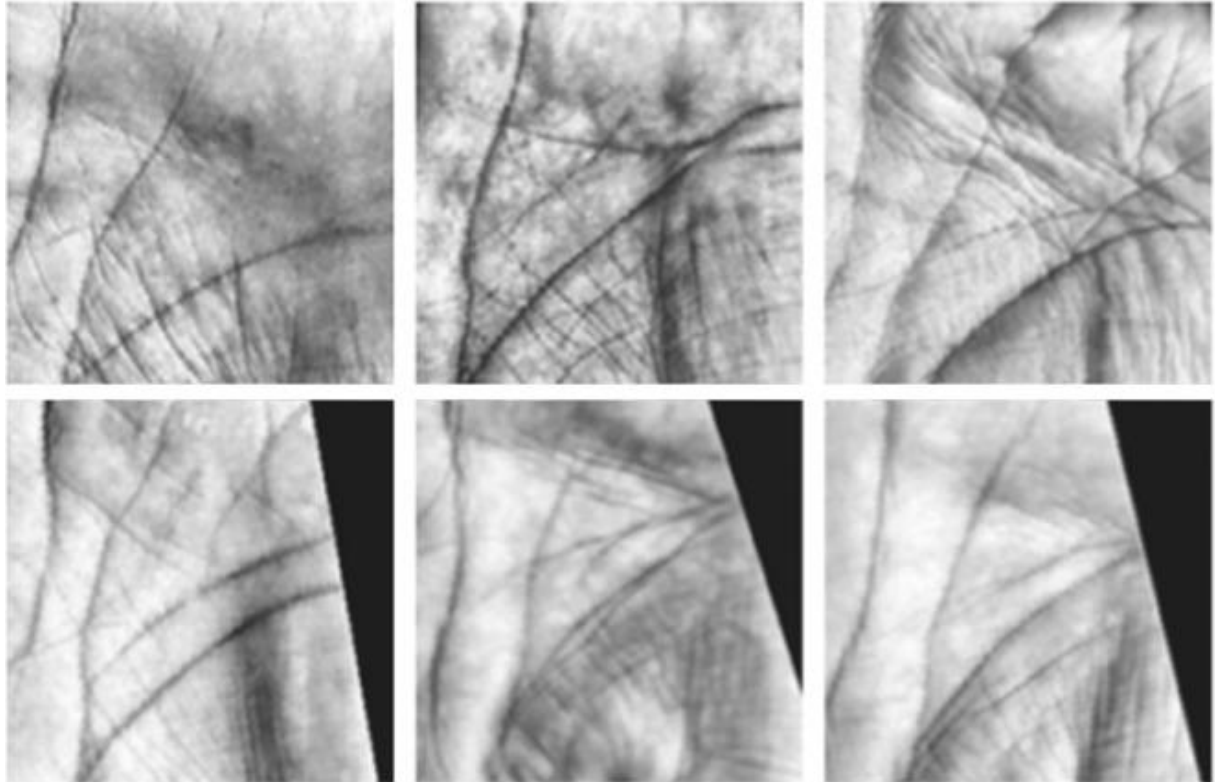
In this study, object recognition was deployed for security authentication in airports and other sensitive places. The designed system was used for inquiring the object image using scanner (same as this used for paper scanning). One of the steps that used for efficient data inquiry is differentiating between the object and the background object. For this, scanner lid is left opened so that the background object will appear black totally.



**Figure 2.2:** Object image front view [3].

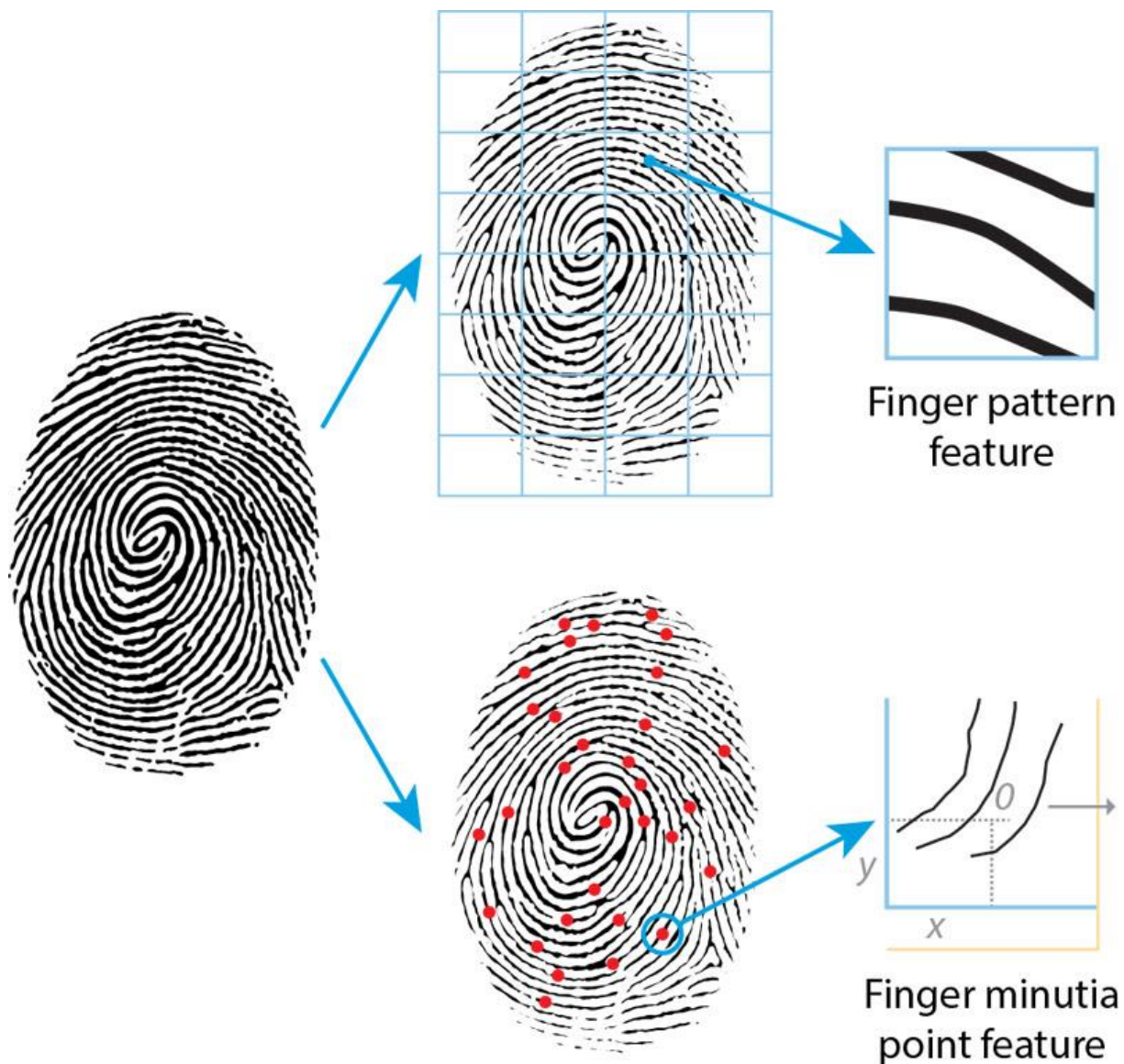
At [5], biometrical features are being used to enhance the security methods where those features cannot be cheated or penetrated as easily as passwords are; mentioned by the authors. However, biometrical features are unique for every person. One of the biometrical features is eye print, this have been used widely in personal identification systems. The features from eye can be detected and then applied into object classifiers for implementing of eye recognition system. Those system are being used in sensitive security missions where passwords and other features stands not enough. Author mentioned that cost of adaptation this technology is high more likely, eye image inquiry is to be taken using special camera which add more cost to the project.

From the other hand, eye can be impacted by the age problems where shape of eyeball can be varying according to the eye health and person age.



**Figure 2.3:** Sample of principle features at the object plane [5].

At [6], another approach of biometrical recognition is made over this study by utilizing fingerprint. Such biometrical features from fingers alike thumb are used for personal identification. Features from fingers are being extracted from the thumb image, this image is taken from the fingerprint scanner. Dataset of two hundred images is gathered from the two hundred candidates. Each image represents a fingerprint of the right-handed thumb with green colored background. Features alike circles and curved lines are recognize from each image using the pixel resolution values. Artificial neural network is used for classification of the image data for detection the character using the thumb features.



**Figure 2.4:** Fingerprint for personal identification features [7].

At [7] [8], occluded image recognition is another approach made in this study in the interest of personal identification. In most of the times, hand image is used for biometrical verification which proved a noticed performance in the security applications. One of the challenges raised in case of occluded hand object. The idea of recognizing the occluded image is based on some image features alike fingers width and the length and the minimum and maximum points (local maxima and local minima) of the hand. However, this approach can be applied when the biometrical features mentioned above are required for personal identification.

This approach is not applicable if the recognition process is based on other features like object veins and lines features. This study utilized the fact that the hand can be recognized using the geometrical features of the hand itself if the testing object image is occluded with gloves and the actual training data is not occluded with any object. So, in order to tackle this occlusion, all the dimensions are scaled down by some factor to recover the previous dimensions of the not occluded image.

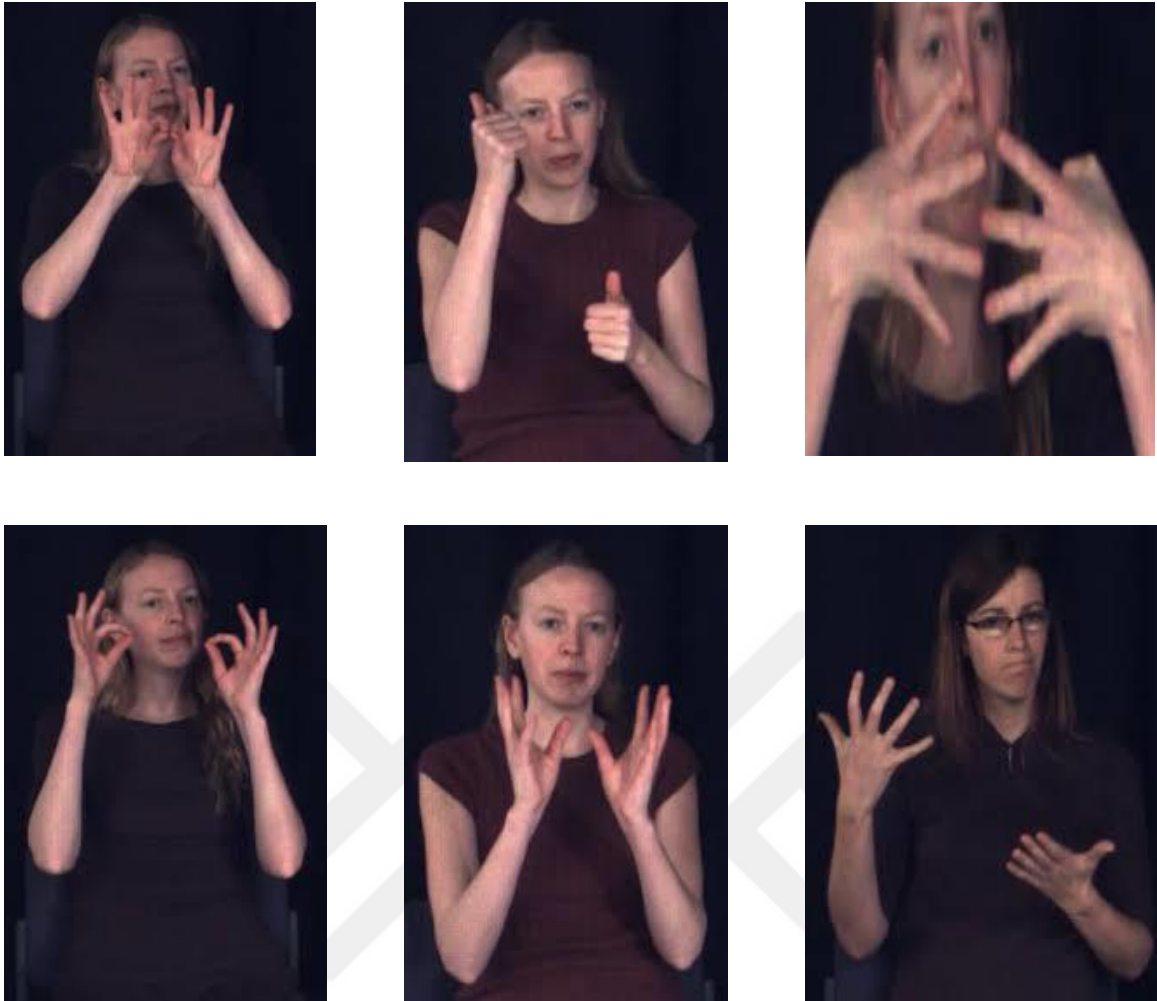
At [9], this study aimed to simulate the hand signs (Hamburg signs) that used for communication between the mute and deaf people. However, the approach is developed to detect the hand movement by a computer-based program and translated them into virtual (avatar) object that represents the hand signs language. Authors mentioned that hand movement is being detected using camera device from KINECT company which designed especially for hand movement detection.

In order to provide the MATLAB with the required hand movement image, another program is used provide a direct connectivity between the KINECT device and MATLAB. This device can provide a real time image decomposed into the three bands (green, red and blue). MATLAB program is made to detect the edges of each provided image and match the same with reference Hamburg image in order to return the appropriate avatar object.



※使用例

Figure 2.5: Object occluded with gloves [9].

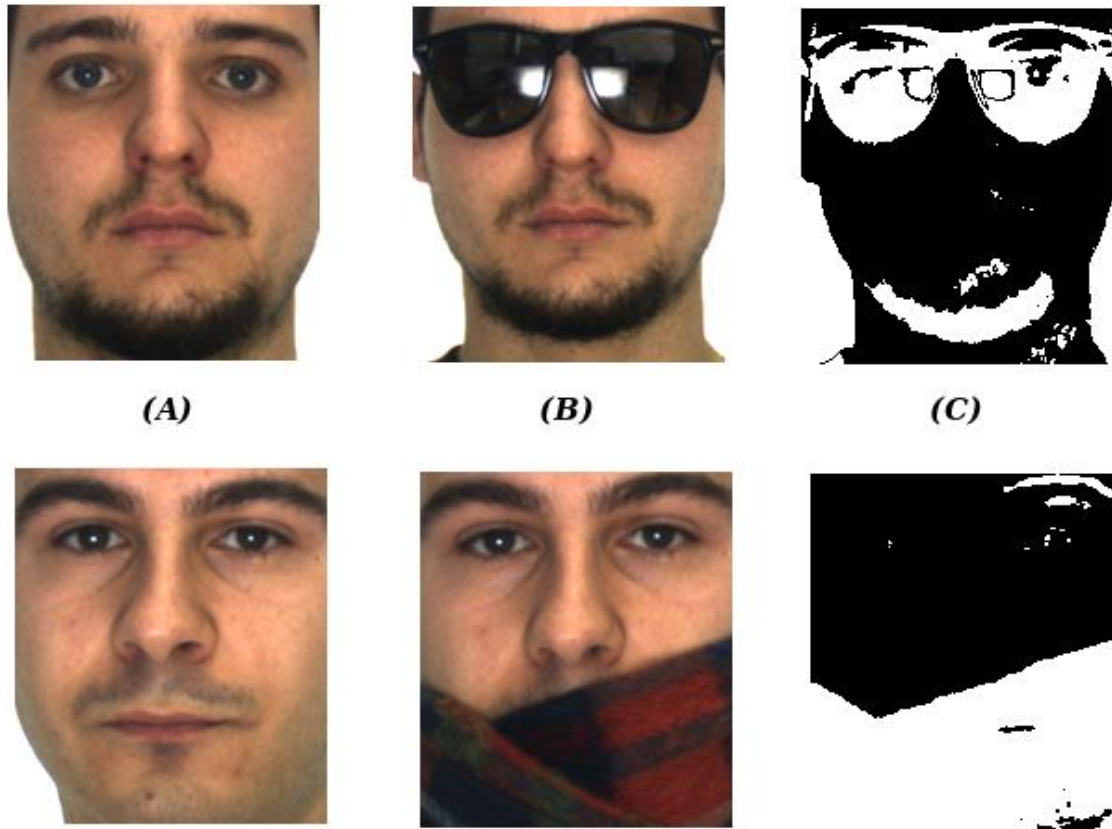


**Figure 2.6:** Mobile hand sign detection [9].

At [10], most of the advanced personal identification systems are based on human body organs biometrical recognition. Biometrical recognition involves face, hand object, fingerprint, and eye print recognition. Researchers aiming to enhance the performance of those recognition systems by defining new methods of recognitions. Problem raised when the data taken for face are relied for personal identification. This data is being pre-processed and used to train machine learning paradigm.

Face features data reliability cannot be garneted as permanent features to recognize the face. However, face is one of the human parts that impacted directly by the age effects. By growing

in age, face features changes and this is obvious as face during the childhood is changing while entering the youngster age and similarly while entering old age.

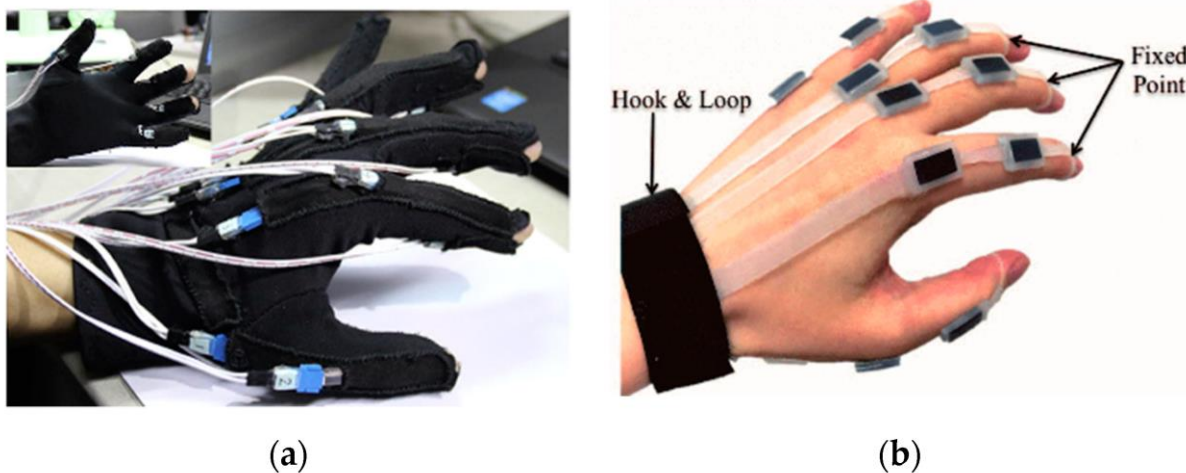


**Figure 2.7:** Occluded face recognition [10].

Face will be occluded with wrinkles and rashes due to growing in age, so the data of the face recognition system is to be upgraded periodically depending on the person age. Considering a big face recognition system involving a large number of candidates of different age groups; the updating of such data is not an easy task. The updating of face image data will be required both preprocessing and training stage updating which will increase the complexity and cost of the system. Figure 2.7 demonstrating the impact of occluded face on the recognition process.

At [11] [12], another approach is made to inquire the hand image while hand is moving. The detection of hand object while hand is not stable mode (capturing the hand image while person speaking and using hand action) is remained challengeable. One of the proposed approaches is

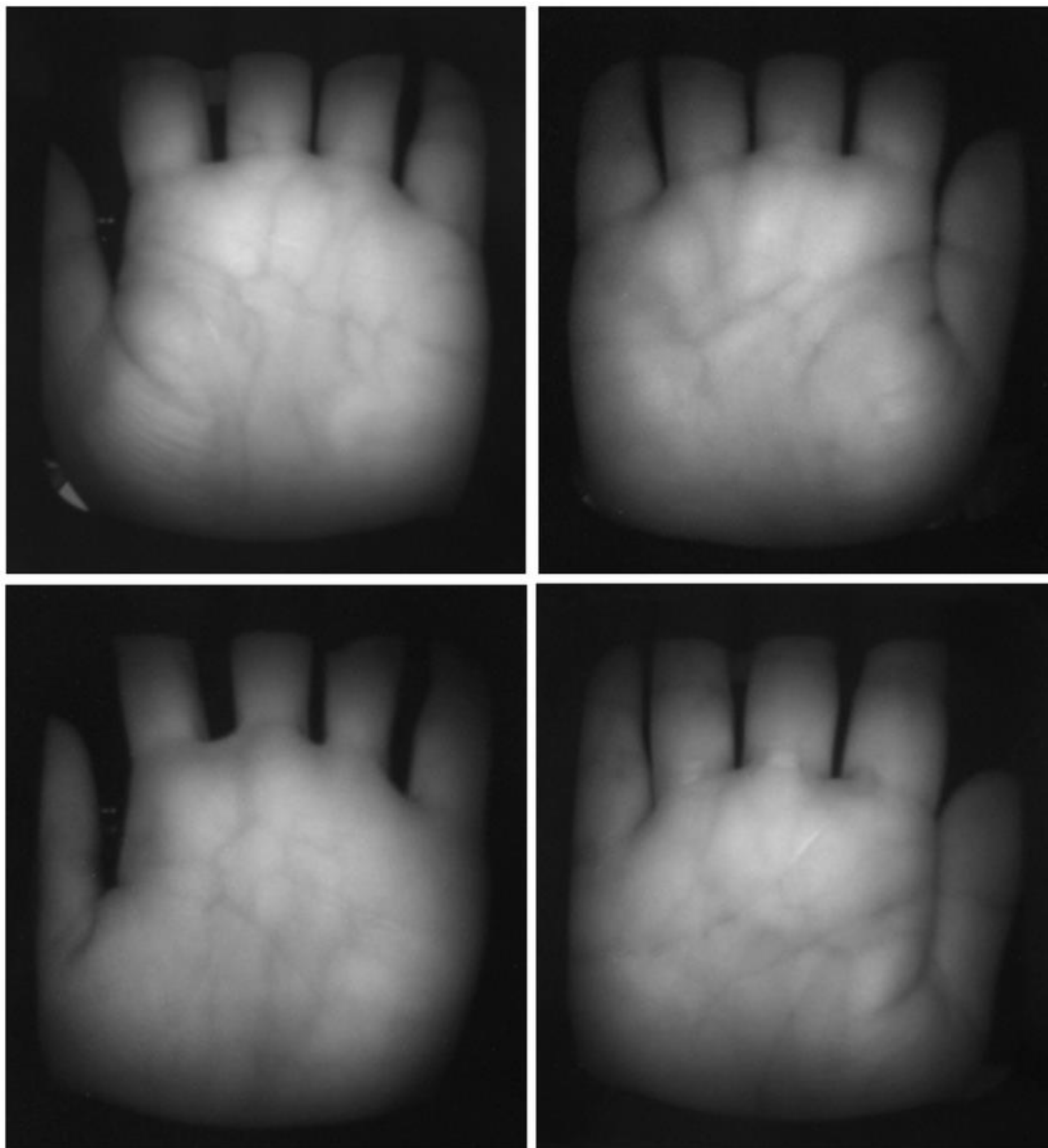
using gloves that are able to detect the hand while movement using infrared sensors. Author mentioned that, in order to capture the moving hand image, gloves can be worn in the hand, this glove are contained of infrared sources placed in between the fingers and the reflection of infrared light is being sensed using special camera placed at the finger top. One algorithm called as TTRPP is being used to capture the hand contour. A computer program is made using this algorithm (TTRPP) for detection of hand contour in real-time, the program is made using JAVA language.



**Figure 2.8:** Hand movement detection using wearable gloves [12].

At [13] [14], this approach has stated that object features are one of the best and reliable features for personal identification systems as compared to those of face and fingers impression. The reason is that finger dimensions can be changes and other factors such as wounds or finger wrinkles can occlude the features of fingers. Similar concept is applicable with face recognition, such features are highly affected by the age and hence it cannot be treated as reliable features for biometrical recognition. However, object is consisting of features that resistive for age impact and hence it has a good chance to be reliable of personal identification systems.

At [15], object image is being processed using four different masks where each mask will produce a different extension of the object image. However, each extension provided by the mask (filter) will be used to generate particular features. Features in each extension of those four will be generated by taking the standard deviation and variance of each extension. Those features are being used to recognize the object.

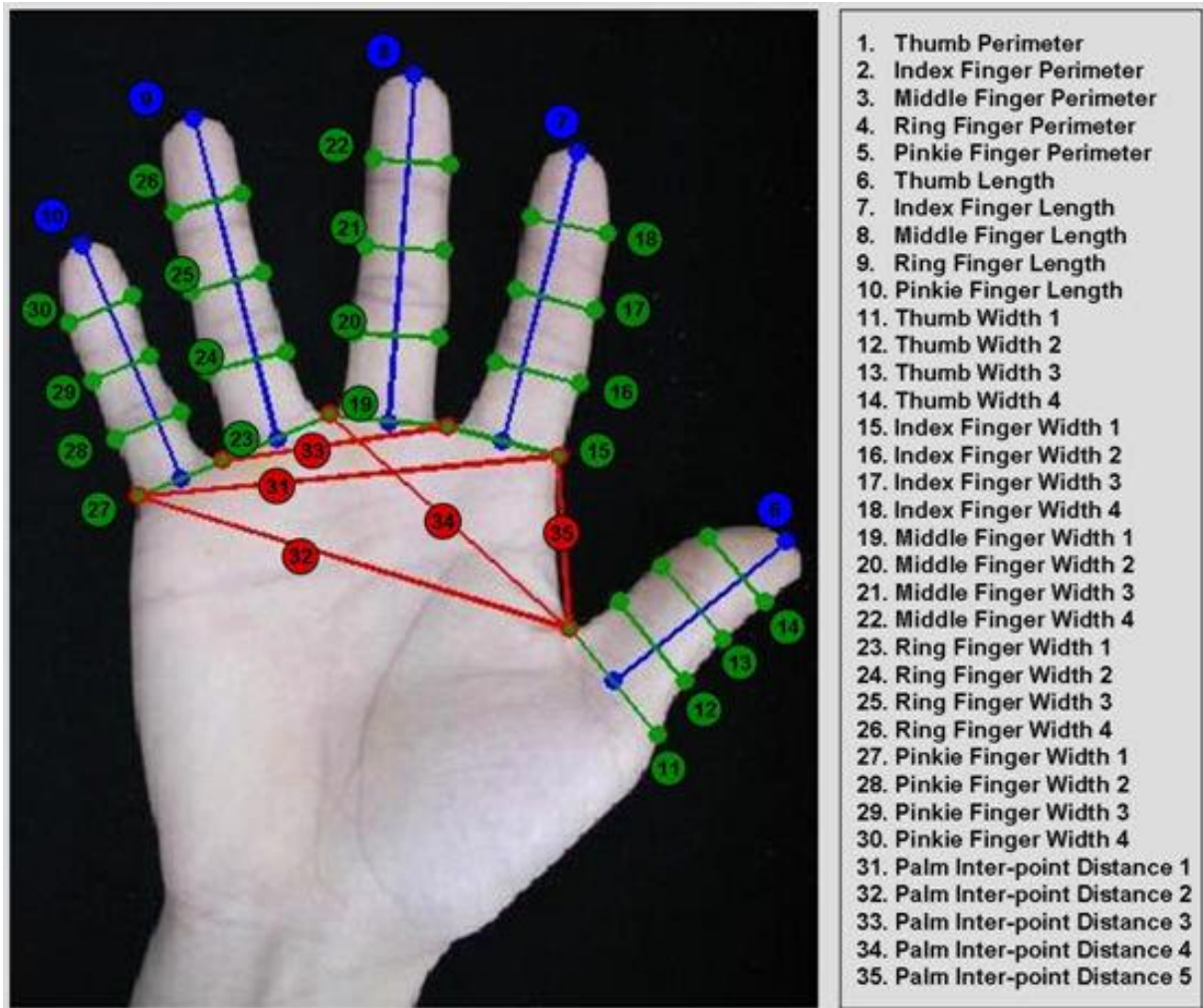


**Figure 2.9:** Object inner surface depict the blood veins [15].

Author is also mentioned that before all these must be robust procedure to crop the region of interest from the object image. It was also stated in this research that region of interest should be captured with enough accuracy so that the features extraction will be more reliable. Region of interest can be cropped using many methods alike radius method and centroid method. The main condition behind successful region of interest cropping is that: region of interest should be covering the same region (part) of the hand in all the dataset images and that is practically difficult. Figure 2.9 is depicting a sample of four filtered (masks) of the hand objects.

At [16], author mentioned that object can be recognized using several parameters related to the dimensions of object and its geometry. Hand object can be recognized with those features after performing of two starting stages namely image capturing and preprocessing. Author emphasized that image capturing must be performed with adequate device that ensures the required resolution as well as the uniformity amongst all the captured images. The images should preserve same content of the object more likely, same object orientation which make the objects appearing in similar snaps are required.

Authors used the following features to recognize every object: widths of all five fingers in the hand (which yields five features) and length of each finger in the hand (which yield five features as well). eventually ten statistical features are detected from each object which can be used for recognition process.



**Figure 2.10:** Object recognition using dimensions of fingers and distance between them [16].

At [17] [18], a new approach is proposed to recognize the object using the features of object blood veins. Authors stated that the recognizable features from the blood veins are robust than those features of face. The reason behind that is blood veins under the skin of the object can yield a feature that very resistive to the time and age (not impacted by the age of human) so, it is considered as permanent features.



**Figure 2.11:** Conversion object image into infrared band to extract the veins shape [18].

This study is applied on the old images that included object print on the tree leaf and kept inside those old caves in the area of Thailand. This technology is applied using a hardware (microchip) that involves the recognition program. Authors mentioned that deep learning algorithm can outperform for object recognition after good features extraction. However, performance metrics alike, training time, level of the recognition accuracy are evaluated and shown good results.

At [19] [20], one of the proposed methods to extract the features from the object image especially those images printed on ancient manuscripts e.g., tree leaf and caves; this method relies on the knowledge obtained from those images using spectrum domain analysis. However, spectrum domain information can be yielded from the pixel domain by using Fourier analysis. The frequency domain information is considered as good source of features from the faded images or old historical images which always can tell more about the objects associated in this image more than the spatial domain.

Soon after features extraction, authors stated that machine learning approaches such as Principal Component Analysis is used for object image classification. Authors stated that the

method in their proposal are resulted image classification with better performance than other available algorithms. Figure 2.12 demonstrates the hand object that printed on old cave.

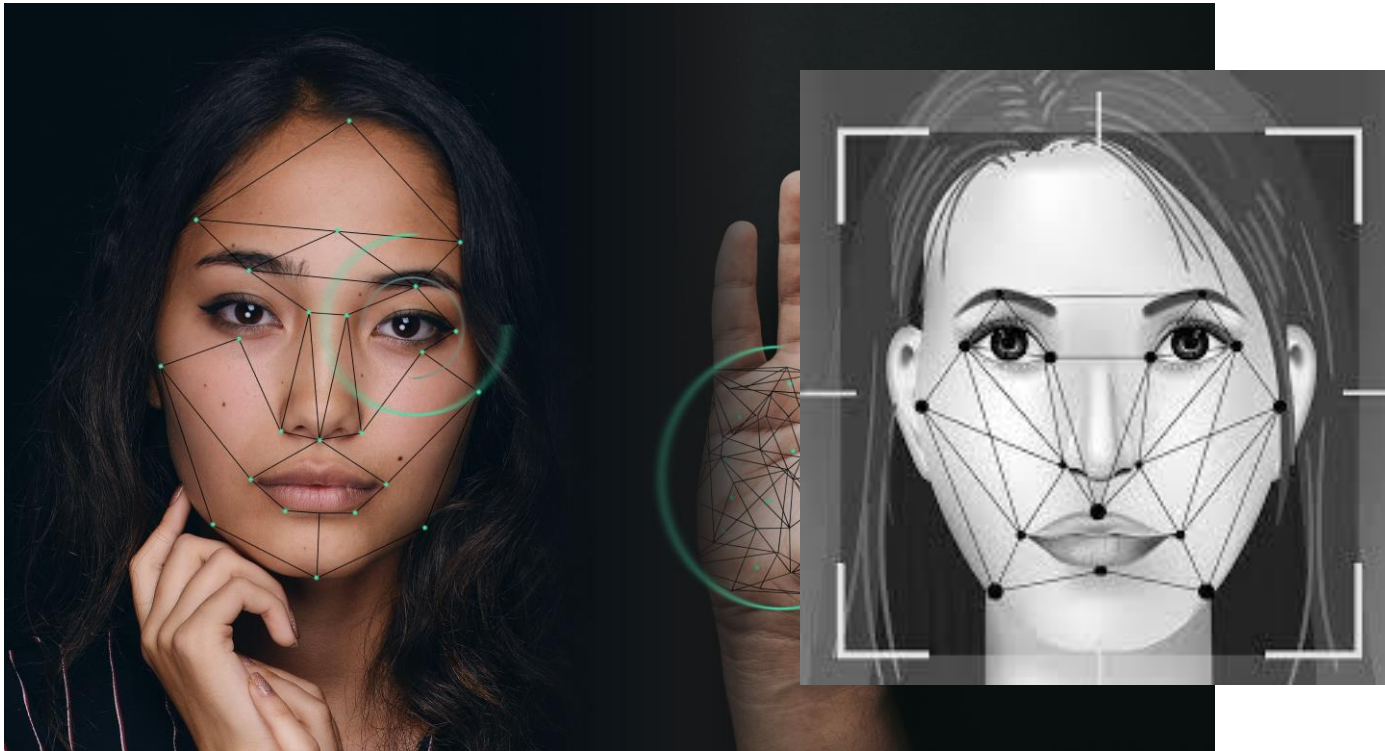


**Figure 2.12:** Recognition of old object print [19].

At [21] [22], authors of this study emphasized that object image is the richest available biometrical image that may provide features that not impacted by the natural effects such as hair growing (object is not witnessing any growing of hair unlike the face area) as well as not affected by the skin color fade by the sun light. Hence, object is one of the finest biometrical features sources that can participate the personal verification systems.

Within the object recognition context itself, many technologies are used to extract the object features. One of those technologies are the blood veins features. Author mentioned that blood veins features is mainly depending on the camera type and normal camera cannot be used for enquiring such images includes a veins feature. Veins features are extractable using infrared

rays' reflection from the blood cells (hemoglobin). So, first thing is to provide a camera which can produced a digital image with infrared band. Figure 2.13 demonstrates the difference between the visible parts of the face and object images.

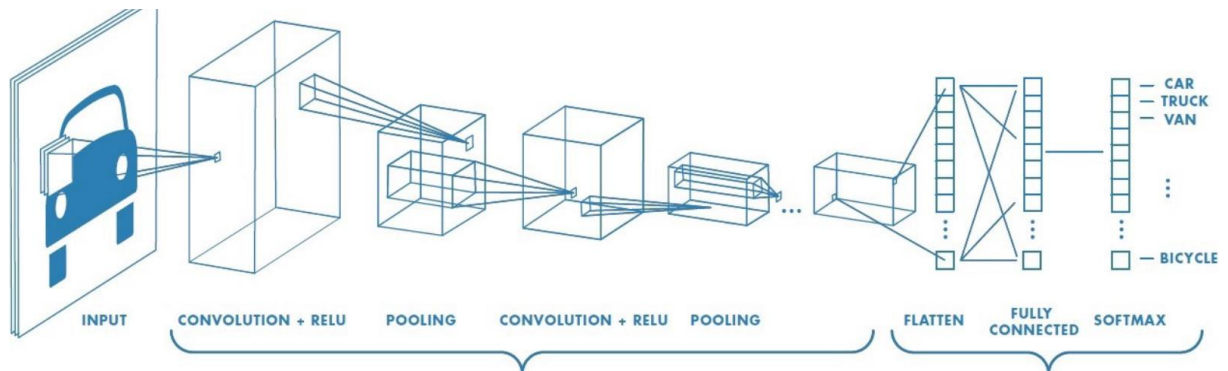


**Figure 2.13:** Demonstration of face and hand features difference [22].

At [23], another study is presented here which proposed using different kind of features combinations as multi-dimensional features vector. This vector involves features alike widths of all object fingers and length pf all object fingers as well as the skin color density (shad level). Those features are taken from each image and hence features matrix is formulated. The features matrix will be used for training a deep learning paradigm such as convolutional neural networks to predict the character base on the object features.

Convolutional neural network is trained using seventy five percent of the features available in features matrix. Performance is being measured using the percentage of correct decisions

during the neural network testing phase. Figure 2.14 is demonstrating the convolutional neural networks overview structure.



**Figure 2.14:** CNN neural network overview.

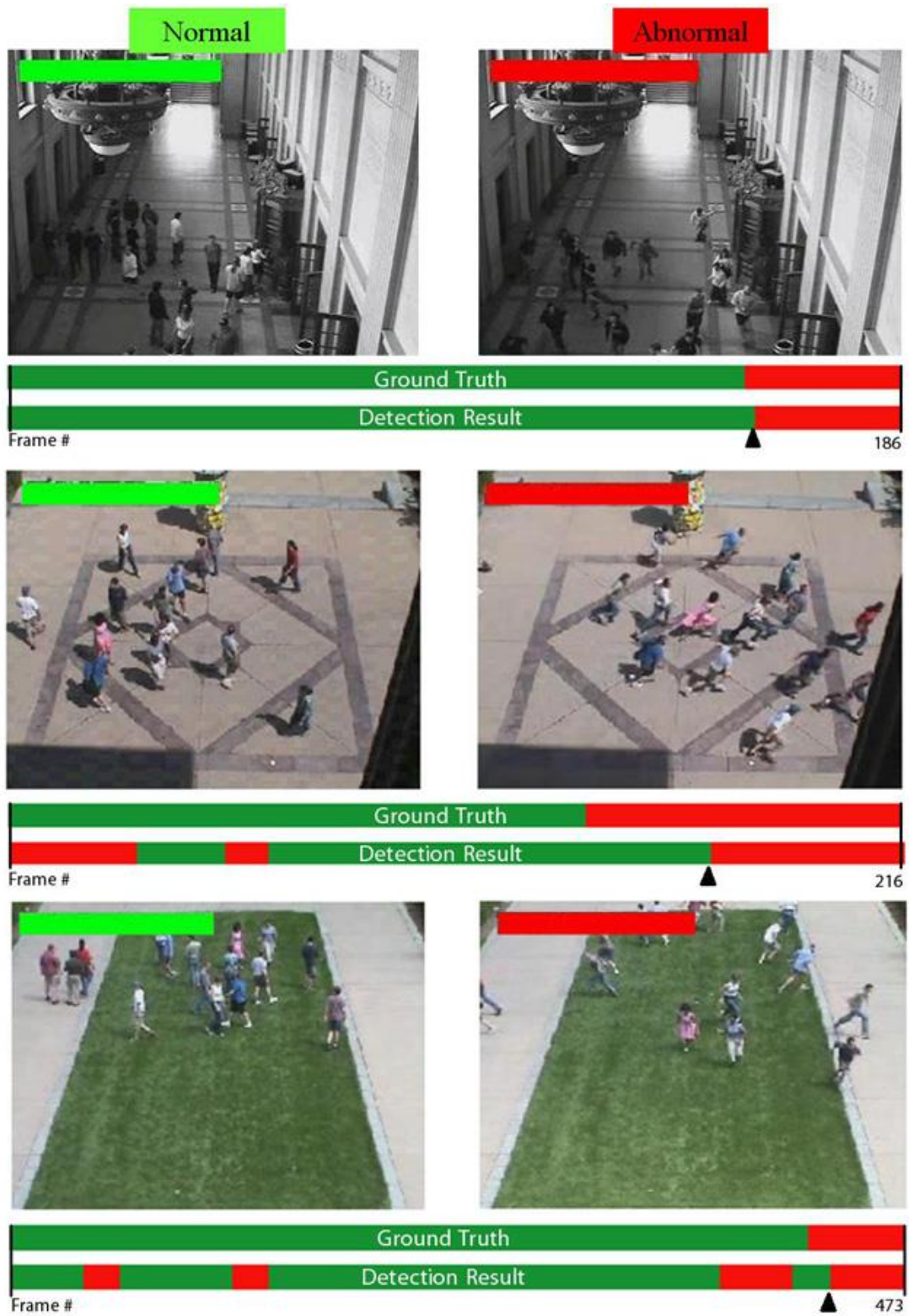
### **3. METHODOLOGY**

#### **3.1 DATABASE DESCRIPTION**

The context of image processing gained a lot of attention in the recent time; however, the project of this domain is very keen on data available. Data is important to accomplish the results in such projects and hence, data are available in two ways either open-source data which made by particular researcher and published in datasets banks (respiratory) or data might be collected from the society by calling a candidate to participate the research process.

However, utmost, researchers are preferring using published dataset which make the research process more feasible instead of making the data which takes a lot of efforts and time. In other word, if the application demands particular data, then data is to be gathered by calling field candidates to participate in the research and provide their data.

In this project, object data was required and hence, the most reliable dataset of this regard is UMN database that consisting of eleven video clips about ESCAPE event which stands for abnormality sense. Each video clip is having both normal sense and abnormal sense, the normal sense is incorporated at the beginning of each video while the abnormal sense is incorporated at the end of each video. Figure 3.1 is demonstrating the database video contains which depicts the normal and abnormal senses in the database.



**Figure 3.1:** A sample of UMN image database.

### 3.2 PROCESSING CHALLENGES

In order to use the above data efficiently, preprocessing is performed in initial stage in order to prepare the data for the next training and testing process. The following steps are made in the stage of the preprocessing:

- 1> Frames extraction: this is called framing which involves segregating the videos into several shoots called as clips. Program is made in MATLAB in order to snapshot each video in duration of TWO seconds. However, entire video can be divided into (X groups/images) with duration of TWO seconds.
- 2> Each image is then processed individually in order to correct the visibility of it and to enhance the pixel information (this is detailed in the next section).
- 3> Dividing the images into two groups using the labels information (i.e., normal and abnormal images). In order to do that efficiently, K-nearest neighbor is being used.
- 4> In order to mitigate the payload on the classifiers, two measures are made:
  - a. Data elimination: which is performed for the unnecessary data in the normal senses which is removed in order to reduce the processing time (training time).
  - b. Conversion of colored version of the images into grayscale image, this can be performed in order to reduce the load on the training model.

### 3.3 IMAGE CORRECTIONS

The previous section illustrated the challenges that virtually observed in the base, however, all the points mentioned above are important and need to be addressed properly.

a) MATLAB program is made to correct the images of objects (pre-processing) which works firstly by sourcing the images into the workstation directory using labeled loop that importing all the image one by one by looping through the image name. It is important to state that all the images are renamed in sequence so that the loop process will work systematically.

b) Image is smoothed out using smoothing filter to mitigate the impact of bad lighting and multiple objects presenting at the background. As demonstrating in Figure 3.2, image is converted into the binary format (black and white) in order to ease the process of contour detection of the object region only.

Hence after, image is passed through the MATLAB boundary function to detect the boundary of the image. However, while dealing with boundary function, multiple objects are seen in the image and the interested object is only the object which need to be detected. The other objects are however required to be neglected, in order to identify the object of interest, the sizes of all objects are compared and the one of the biggest sizes (largest number of pixels coordination points) is labeled as the object. In order to identify the objects existed on the image, function called REGIONGROUPS was used which yields each object with it centroid.

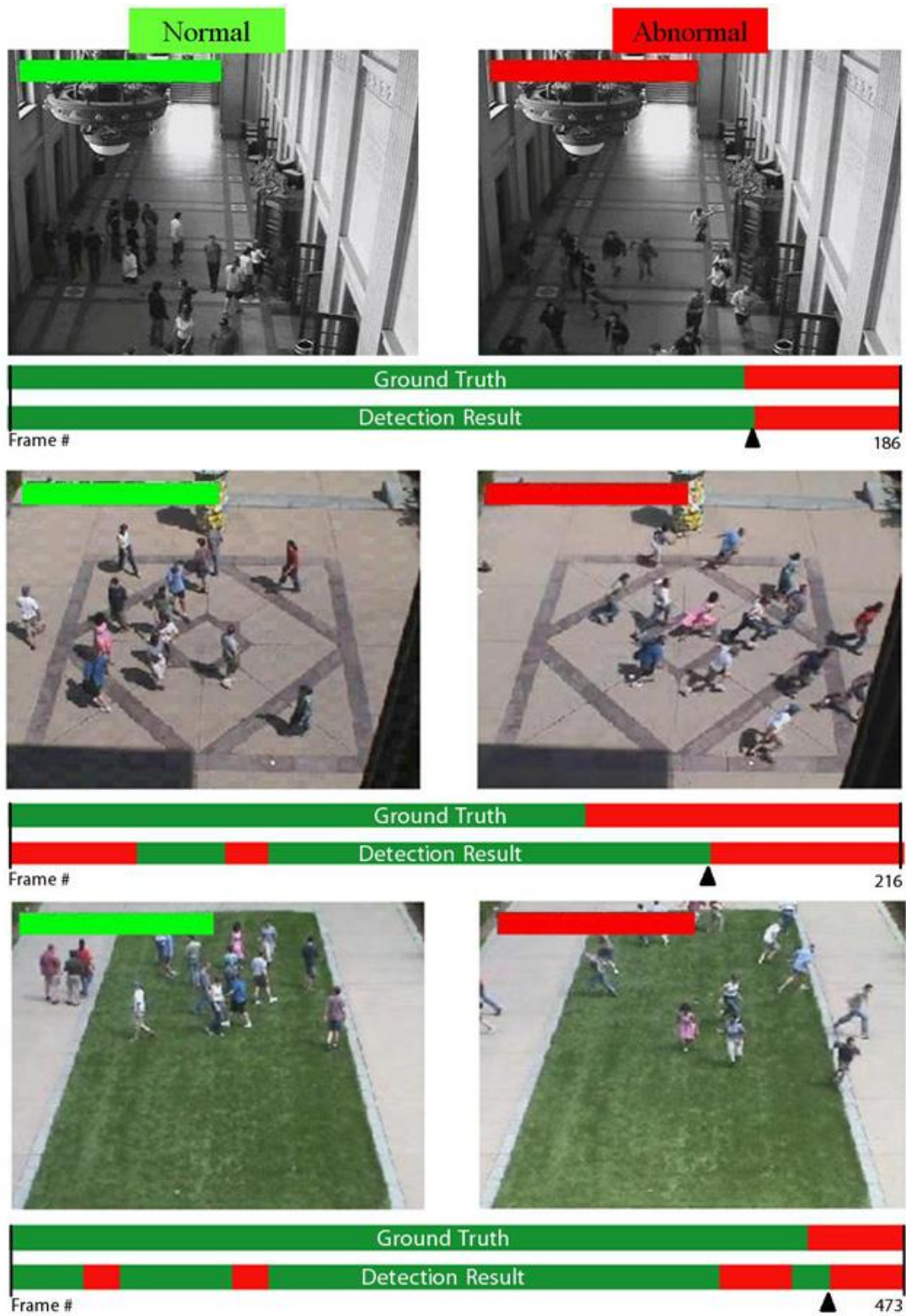


Figure 3.2: abnormality on object identification using the binary image format.

c) As soon as the images are treated in the pre-processing stage and the objects within the images are detected in each of it, each image is not produced with boundary (contour) points that yields each location in pixel format in point in the object boundary as well as the centroid that presents the middle point in the object image.

d) In order to finalize the pre-processing stage, image is to be rotated by some angle (either in clockwise or anti-clockwise) that make all the image in same orientation. In order to find the sway angle, three reference points are selected on the image plane.



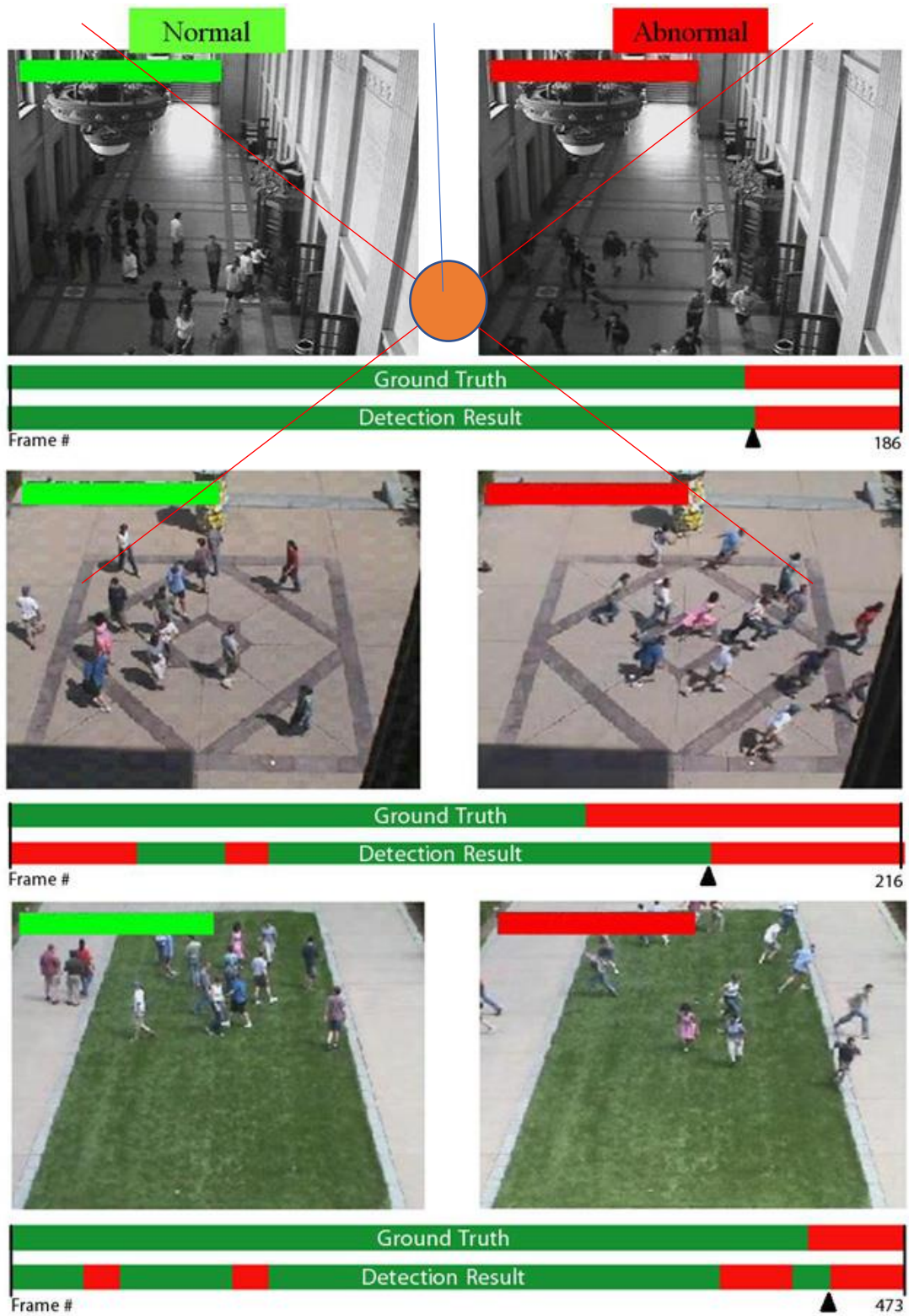


Figure 3.3: Object image orientation process.

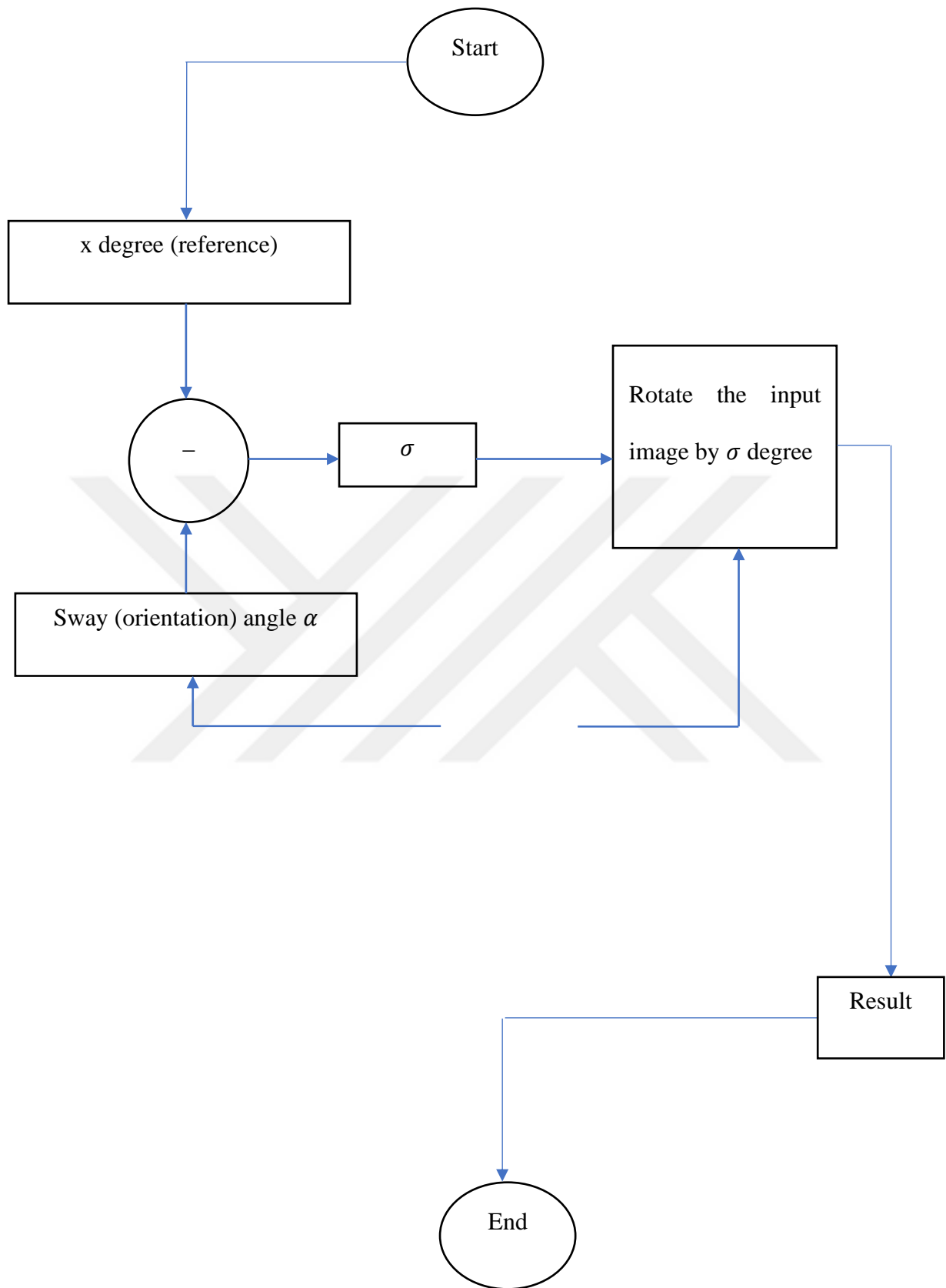
Let the red line length to be A, and the blue line length to be B and the green line length to be C. The angle that labeled by red circle can be admeasured by the following triangular formula.

$$\tan^{-1} \alpha = \frac{A}{B} \quad (1)$$

In order to current the orientation of the object image, it needs to be rotated by  $\sigma$  angle that producible in the following formula.

$$\sigma = x - \alpha \quad (2)$$

Where x is the reference angle that admeasured by passing the finest object image chose from the dataset into the preprocessing program and determining its orientation angle. This angle will act as reference angle and will be compared with all the other images angles so that each image rotation can be corrected as per the equation 2. The algorithm made to correct the image orientation is depicted in the Figure 3.4.



**Figure 3.4:** orientation angle correction algorithm.

### 3.4 DEEP LEARNING MODELS

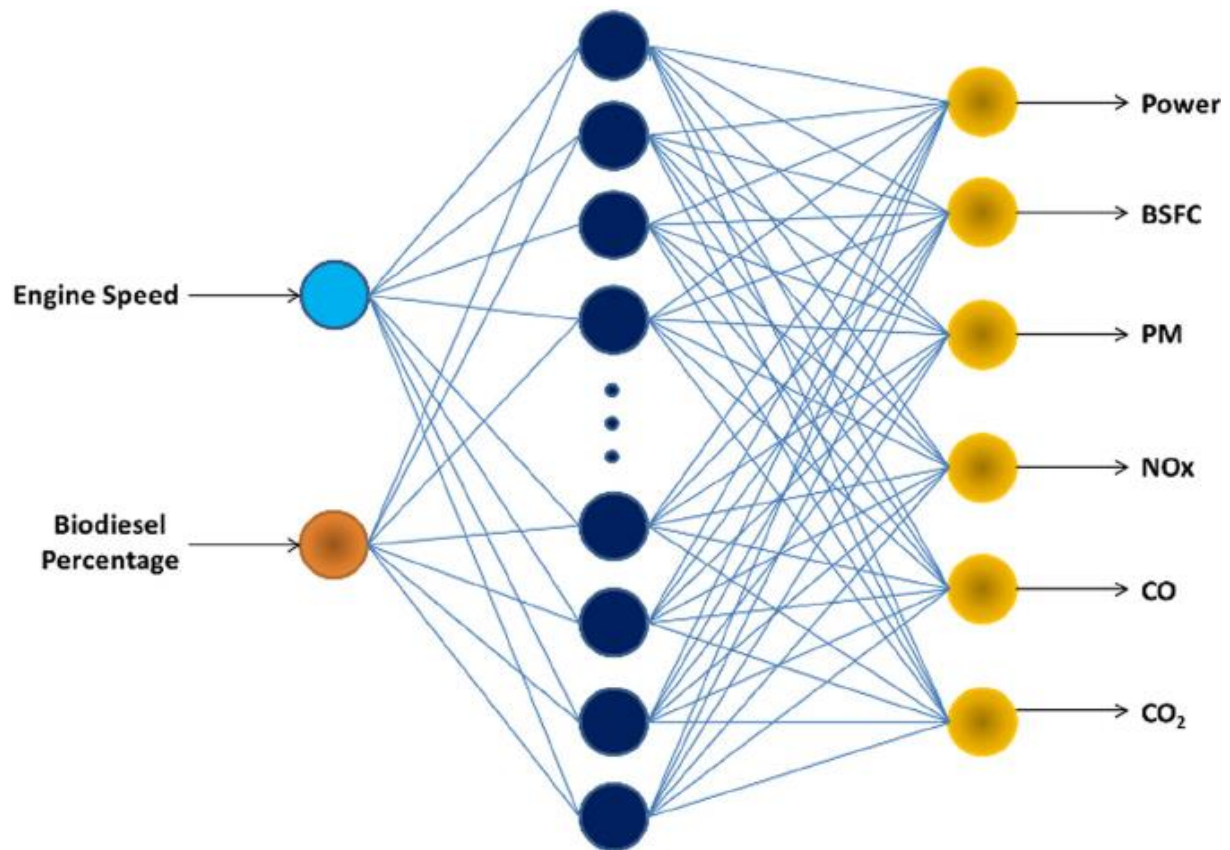
#### 3.4.1 Feed Forward Neural Network

As soon as object images are cropped and regions of interest are also detected from the object (abnormality object) image, the identification using the image information is to execute using advance deep learning methods. In this study, Feed Forward Neural network is implemented to predict the abnormality in image depending on the information of region of interest. The feed forward neural network is made for efficiently predicting the abnormal event by learning through the features of each image. All the object s features are to be referred from the regions of interest; feed forward neural network model will then use this data during learning stage. This method is called supervised learning where the features information as well as the target (image labels data) are both used during the learning stage. Feed forward neural network of the configuration mentioned in Table 3.1 are established using the MATLAB.

**Table 3.1:** Configuration parameters of the feed forward neural network.

Parameter	Description
Number of epochs	100
Total nodes per layer	Input layer: thirty
	Hidden layer: ten
	Output layer: one
Total layers	Three
Mean square error (target)	1 e-200
Algorithm of training	Levenberg–Marquardt

Feedforward neural network is using Levenberg–Marquardt algorithm for setting up the weight coefficients. Weight coefficients are vital for the accuracy level of prediction. However, Figure 3.5 demonstrating the structure of the feed forward neural network.



**Figure 3.5:** Feed forward neural network of single hidden layer.

### 3.4.2 K-Fold Validation

k-fold cross validation is technique to segregate big data into k groups (k-folds), every fold is further segregated into two parts namely training part and testing part. The algorithm of K-fold cross validation is running through following steps:

a> number of folds definition, i.e., let  $K=10$ , which has to be selected according to the number of rows on the dataset. However, K value is not being governed by any formula or method, it must be selected in accordance to the volume of elements of the features and under the

consideration that forecasting model need good amount of data for the training and lesser for testing.

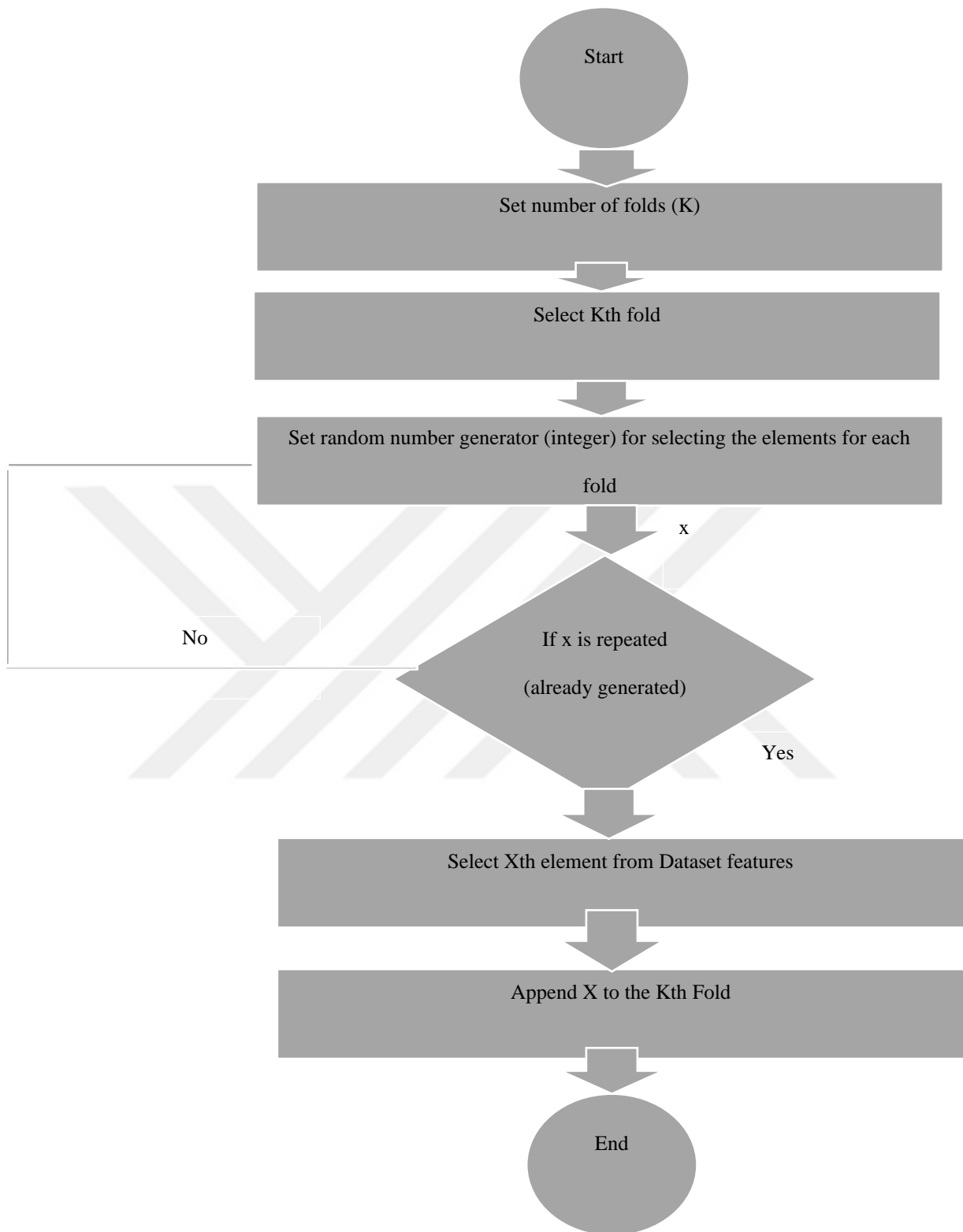
b> data features segregation using random labels (location selector/identifier) for training folds with the predefined number of folds.

c> target of those particular data points (elements) is also selected using the same location identifier (label) used in the previous operation.

d> data features segregation using random labels (location selector/identifier) for testing folds with the predefined number of folds.

e> target of those particular data points (elements) from data folds is also selected using the same location identifier (label) used in the previous operation.

f> within each fold along with its target, fold itself is segregated into training set and testing set. Training set is decided to be 80 percent of the total fold elements and testing set is decided to be 20 percent of it. Allotment of higher portion of fold's data to the training phase is must, the same gives more reliability and accuracy to the training process. Samples of data classes (lesser than training portion) is sufficient for testing purpose. Figure 3.6 is illustrating the procedure of the K-fold cross validation.



**Figure 3.6:** K-fold cross validation prototype.

### 3.4.3 PSO Algorithm

Particle Swarm Optimization (PSO) algorithm has a noteworthy performance in tackling the multidimensional problems in engineering and sciences. The heuristic approach of PSO algorithm is inspired by birds social and biological actions while they search food [17]. The standard PSO or SPSO works for evaluating best particle in swarm of particles by updating the position and velocity of particle in multiple iterations [19].

Let the swarm located at  $y_{axis}$  and composed by large number of particles ( $N$  particles).  $m_i$  is denoting the  $i^{th}$  particle in the swarm and hence,  $p_i$  denoted position of particle  $m_i$  in the swarm. So, particle position in the swarm moving on y-dimensional can be expressed as:

$$p_i = (p_{i1}, p_{i2}, p_{i3}, \dots, p_{iy}) \quad (3.2)$$

The particle  $m_i$  is varying its position by moving on the swarm domain by velocity  $s_i$  which is given as the following vector:

$$s_i = (s_{i1}, s_{i2}, s_{i3}, \dots, s_{iy}) \quad (3.3)$$

Hence, SPSO may attempt to evaluate best positions of particle  $m_i$  in swarm and yield that in a vector as in Eq. (3.4):

$$u_i = (u_{i1}, u_{i2}, u_{i3}, \dots, u_{iy}) \quad (3.4)$$

Some other terminologies are used in PSO more likely, the social and cognitive acceleration constants ( $c_2$  and  $c_1$ ) as well as weight of inertia ( $W$ ) [21]. In order to express the other PSO parameters mathematically, firstly weight of inertia is expressed as:

$$W = W_{min} + \left[ \frac{k}{K} \times r_3 \times (-W_{min} + W_{max}) \right] \quad (3.5)$$

$$s_{ix}^{k+1} = r_1^k c_1 (u_{iy} - p_{iy}^k) + r_2^k c_2 (u_{gy}^k - p_{iy}^k) + s_{iy}^k W \quad (3.6)$$

$$p_{iy}^{k+1} = p_{iy}^k + v_{iy}^{k+1} \quad (3.7)$$

Where,  $K$  is maximum iterations and  $r_1, r_2, r_3$  are random number having values in range of  $[0,1]$  [23]. PSO optimization may begin with swarm generation or population generation. In order to execute PSO algorithm; parameters such as number of populations (swarm) ( $N$ ), social and cognitive coefficients ( $c_1, c_2$ ), random distributed numbers  $e$  ( $r_1, r_2$ ), inertia weight coefficient ( $W$ ) as well as the global best ( $GP$ ) are required to be set [24].

PSO works for searching the weight (particle) ensuring best approximation of fitness function [25]. Hence, in abnormality-based prediction problem, PSO is used to search the best weight coefficients on feed forward neural network model that optimizes the accuracy/quality of abnormality forecasting. In our problem, we have enhanced the PSO performance by tuning up velocity coefficient using the K-nearest neighbor algorithm (KNN) as third party regressor [26] [27].

The number of velocities in PSO depends on number of positions of particle in swarm (solutions in search space). Velocity of  $i^{th}$  particle is to be updated using KNN in order to reach the best position. Let  $s^i$  is the velocity of  $i^{th}$  particle at  $t = t_0$ ; hence the velocity at  $t = t_1$  can be expressed in Eq. (3.7).

$$s_i^{t1} = W \times s_i^{t0} + c_1 \times R \times p_i^{diff} + c_2 \times R \times p_i^{diff} \quad (3.7)$$

$$p_{diff} = p_i - p_i^b \quad (3.8)$$

Where,  $R$  is random variable and  $p_i^b$  is best position of  $i^{th}$  particle. In order to find the best velocity, KNN is used for guessing the  $s_i^{t1}$ . KNN is used for selection the optimum random variables  $R_1$  and  $R_2$  in order to update the velocity, the configurations of SPSO algorithm are detailed in Table 3.1, Figure 3.8 depicts the process of SPSO.

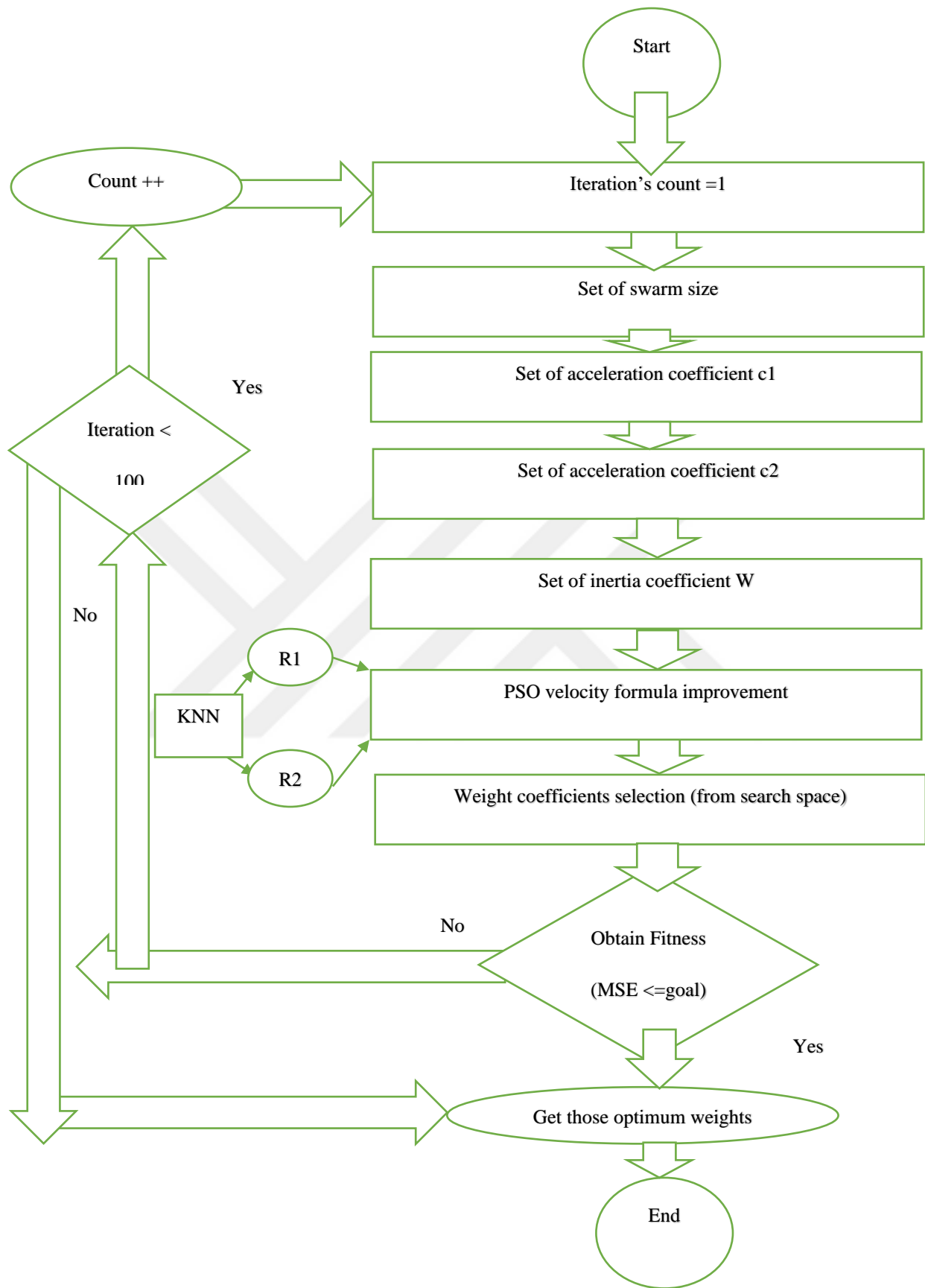


Figure 3.7: SPSO optimization flow diagram [19].

**Table 3.2:** SPSO configuration parameters details.

Parameter	Value
swarm size (S)	100
acceleration constants (c1)	2
acceleration constants (c2)	2
inertia weight (W)	1
number of iterations	100
Damping factor	0.5

The fitness function of the said SPSO is given by equation 3.9.

$$[Weight]_{FFNN} = arg_{\{R1,R2\}} [ R1, R2, \min \{ \frac{\sum_{i=1}^I (net(x[i]) - T)^2}{I} \} ] \dots (3.9)$$

Where:

I= total number of inputs vector.

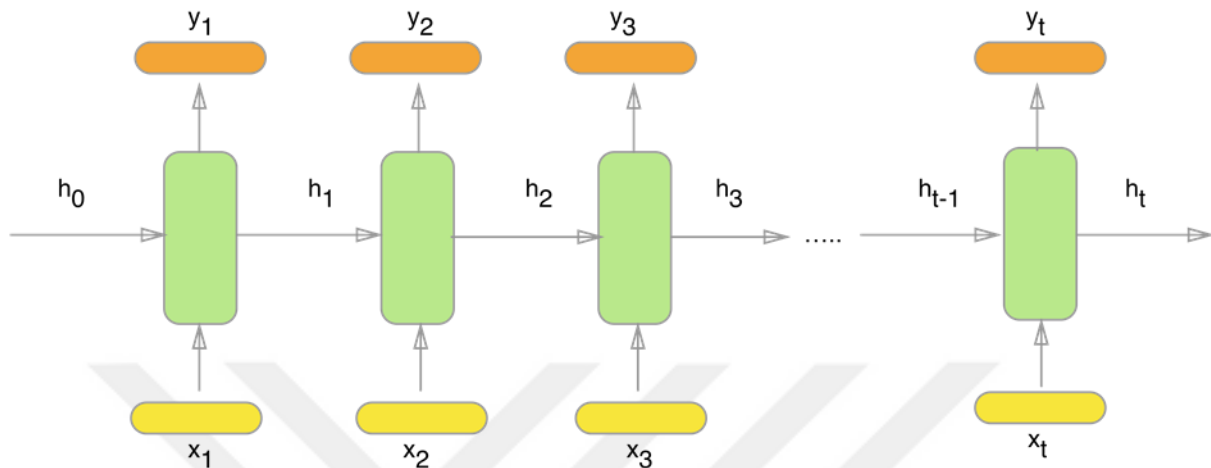
X(i)= i<sup>th</sup> input array.

T: Target of prediction

### 3.5 RNN-LSTM

Long short-term memory neural network is a popular type of neural network that depends on a backpropagation training mechanism. LSTM is basically constricted as a recurrent neural network, the prediction of the data in a recurrent neural network is depending on the previous

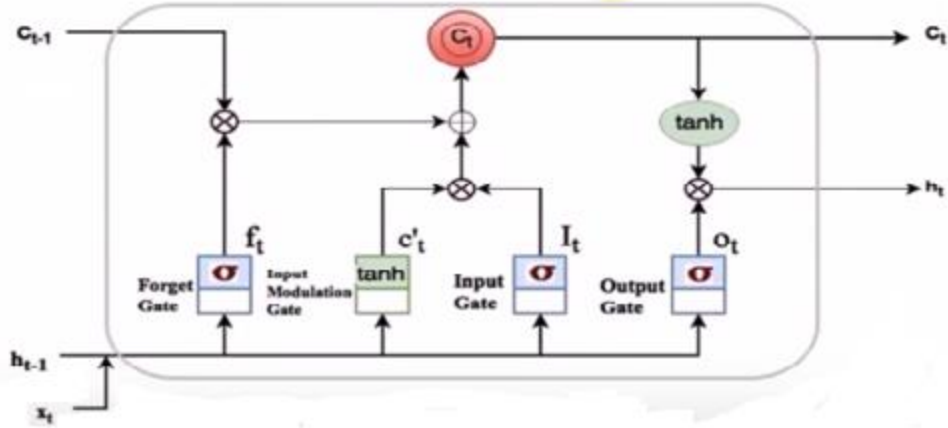
prediction of the same data, for example, prediction of the next word in the speech sequence (sentence) using the recurrent neural network is depending on the prediction of the previous work in the same sequence [28] [29].



**Figure 3.8:** Recurrent neural network structure [29].

Assuming the demonstration given in the Figure (3.12) above, a prediction of the next word in a spoken sentence contained of (t) number of words. Each word is represented as  $x_1, x_2, x_t$  as shown in the figure, the input words are feed into (t) number of training models (such as individual neural network) each neural network will be trained individually on the provided input and will produced the output as  $y_1, y_2, y_3, y_t$ . In the recurrent neural network, the next output prediction is depending on the previous output from the previous neural network which is updating the next model training procedure by producing coefficients alike  $h_1, h_2, h_3, h_t$ . Where J is the cross entropy [20][30].

Getting the required accuracy from the recurrent neural network is not as easy as required, the problem is the vanishing gradient problem which is acts against the accuracy of training the problem solved by modern type of RNN named long short-term memory neural network (LSTM) which designed to combat vanishing gradient through a gating mechanism as illustrated in Figure (3.13).



**Figure 3.9:** LSTM neural network internal structure (gated unite)

### 3.6 PERFORMANCE EVALUATION

In order to evaluate the performance level amongst the three proposed classifiers, the following performance metrics are to be calculated for each algorithm. Mean square error: which stands for the average of the square error after evaluating the error vector  $E$ . let the target vector to be  $T$  and the actual classifier's output to be  $O$ , then error  $E$  can be expressed by Equation 3.

$$E = T - O \quad (3)$$

However, the mean square error can be expressed as in Equation (4).

$$MSER = \frac{\sum_{i=1}^M E(i)^2}{M} \quad (4)$$

The other metric is called as root mean square error and can be given as in Equation (5).

$$RMSE = \sqrt{MSER} \quad (5)$$

Mean absolute error is given by (6) Equation (6).

$$MAER = \frac{\sum_{i=1}^M |E(i)|}{M} \quad (6)$$

Time and accuracy are also from the most important performance metrics; however, time is representing the number of seconds that classifier lasts to reach a decision. However, Accuracy measure is given by Equation (7).

$$AC = \frac{C}{R+C} * 100\% \quad (7)$$

Where, C is the number of right predictions and R is the number of wrong predictions, M number of total errors.

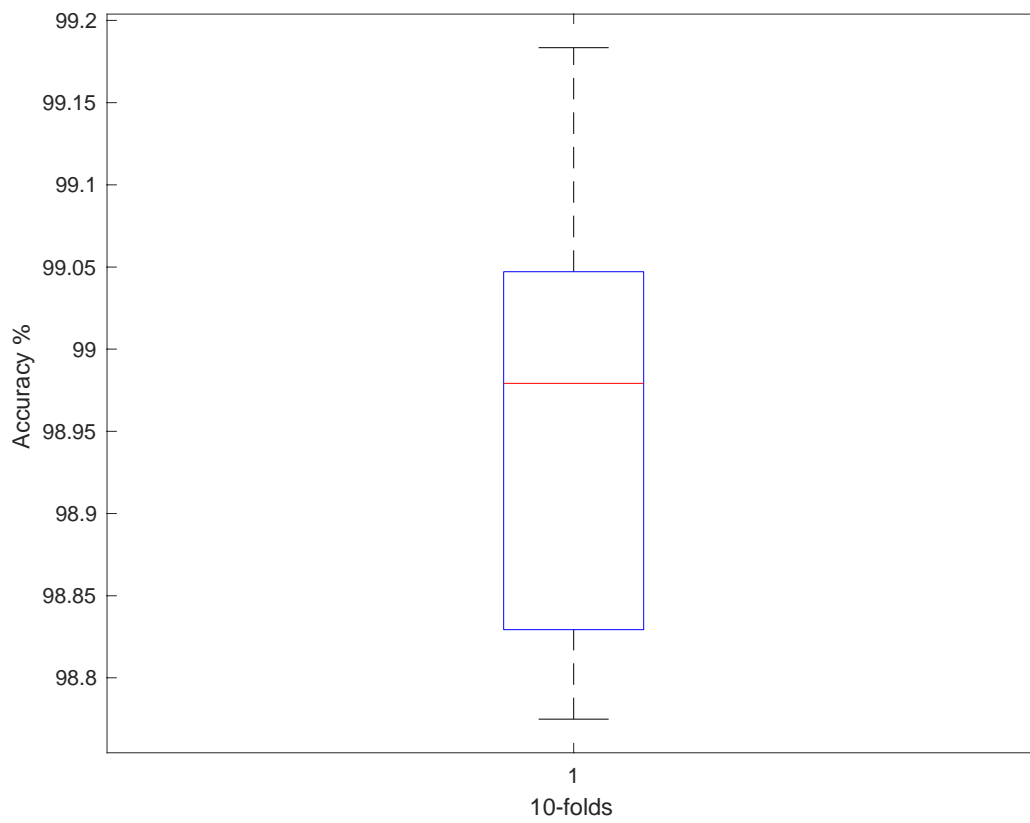


## 4. RESULTS OVERVIEW

Each algorithm mentioned in the preceding sections are tested properly using the performance metrics e.g. (MSE, MAE and AC). However, the performance metrics results are given in the Tables 4.1 through 4.4. the same is graphically demonstrated under each respected Table using the Figure 4.1 through 4.3.

**Table 4.1:** PSO-FFNN accuracy levels for 10 folds.

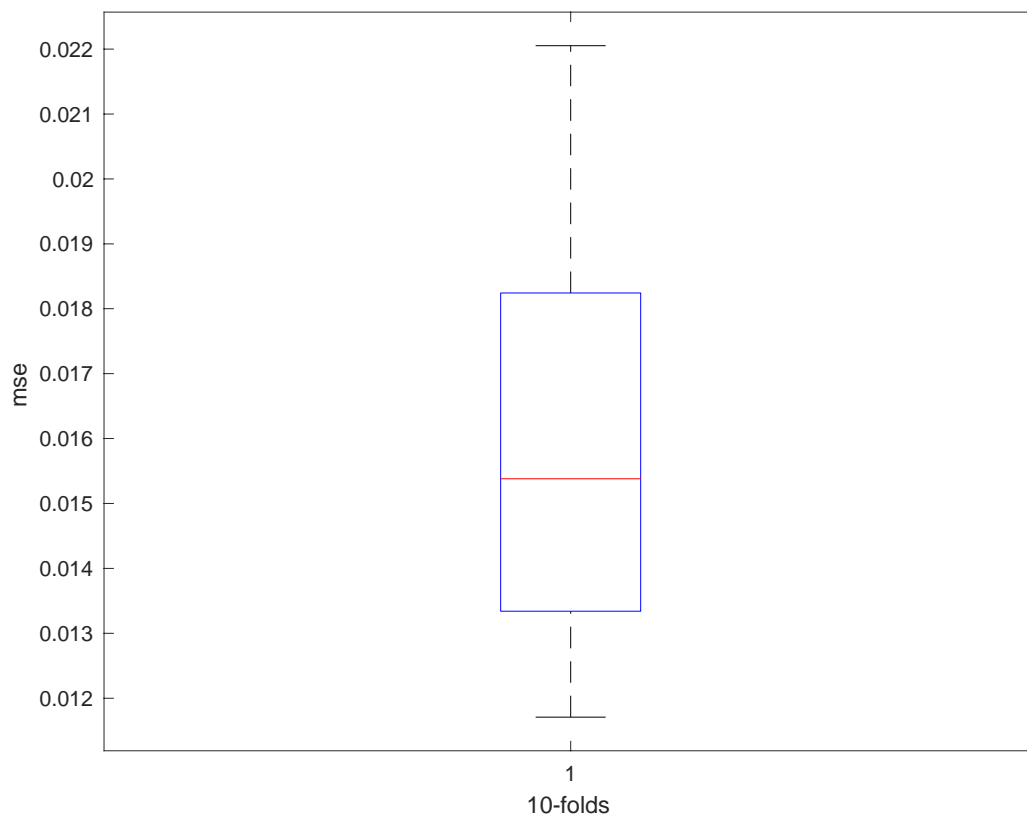
Fold number	Accuracy
1	98.7748435
2	99.0201415
3	99.1834513
4	98.9929232
5	98.8292949
6	98.9654234
7	98.8565206
8	99.0471005
9	98.7748435
10	99.1287776



**Figure 4.1:** PSO-FFNN accuracy for 10 folds.

**Table 4.2:** MSE of PSO-FFNN for 10 folds.

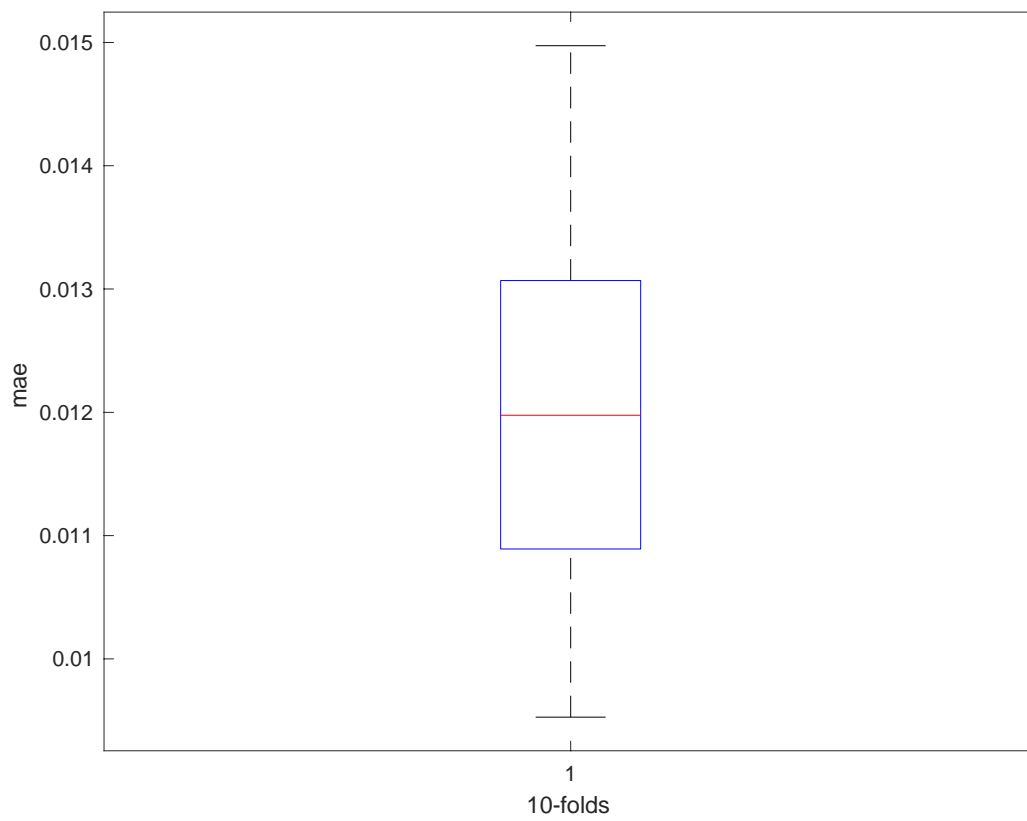
Fold number	MSE
1	0.01824122
2	0.01524224
3	0.01333696
4	0.0190528
5	0.01551865
6	0.01334059
7	0.01742445
8	0.01470188
9	0.02205282
10	0.01170705



**Figure 4.2:** PSO-FFNN MSE for 10 folds.

**Table 4.3:** MAE of PSO-FFNN for 10 folds.

Fold number	MAE
1	0.01388511
2	0.01143168
3	0.0095264
4	0.01252041
5	0.01279608
6	0.01116254
7	0.01306834
8	0.01089028
9	0.01497414
10	0.009529



**Figure 4.3:** PSO-FFNN MAE for 10 folds.

Comparing the best accuracy and mean absolute error with LSTM results is illustrated in Table below:

**Table 4.4:** LSTM VS PSO-FFNN performance comparison.

Algorithm	Accuracy	MAE
PSO-FFNN	99.18345128	0.009526402
LSTM	98.13789	0.129719



## **5. CONCLUSION AND FUTURE WORK**

### **5.1 CONCLUSION**

Large number of attempts to rely on biometrical features for abnormality detection, those features include facial recognition which is very much popular in this regard, and all reported with different disadvantage including (age impacted features such as facial recognition where features keep changing due to age or other obstacles such as masks, makeup, sunglasses, etc. System relies on cameras or CCTV in order to scan the clipped (segmented) video in order to detect the crime since or in other word to verify the presence of illegitimate candidates in the gatherings or in the public places. Other than that, several approaches were found in order to detect particular abnormality. In this work, Automatic abnormality detection is proposed in this work using deep learning technology to perform the detection and dispense manpower surveillance which ensures good performance is far less expensive budgets. Long short-term neural network (LSTM) is used for the same; LSTM performance is compared with the proposed state of the art e.g., Feed Forward Neural Network accompanied with K-nearest neighbor particle swarm optimization (KNN-PSO). The proposed state of the art is outperformed in abnormality detection accuracy, the maximum recognition accuracy was 99.18345128 percent. The performance of the proposed model is examined using tenfold validation and the above accuracy is the maximum one that produced in the first fold. Mean absolute error (MAE) is calculated for both algorithms and the results of the proposed state of the art are seen with the lowest MAE i.e., 0.009526402.

### **5.2 FUTURE WORK**

Much has already been done on this thesis, but there is surely always a lot to do I'm going to put up some useful extensions here. They're certainly not a word, but they're useful anyway.

In this thesis, data collection cost a lot of time and effort, so it is likely that in future work there will be the same problems and will be so Therefore, it would be very useful to have the data available and be available to everyone and free of charge. This will speed up future work while allowing comparisons to be made for different studies and algorithms.

There is another obvious extension that is useful for this work, which is the extension Experiments for more algorithms to see if there are algorithms available which work best. It would also be interesting to see how the difference affected the results.

This research can be developed into a program with graphical interfaces with the use of other algorithms in order to detect the anomalies in a direct, fast and high-performance way.

It is recommended to use other algorithms such as (**FCNT, CNNs, YOLO, Mask R-CNN** ) to test performance and accuracy with the amount of time spent

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## APPENDIX A

### CODES

- **Python Code**

```
from pandas import read_csv
from sklearn.decomposition import PCA
data='inputdata01.csv'
#data='inputdata11.csv'
dd = read_csv(data)
array = dd.values
X = array[:,:]
# Feature Extraction with PCA
print (X.shape)
import numpy
import pandas
import math
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import LSTM
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_squared_error
numpy.random.seed(7)
# load the dataset
dataset = X.astype('float32')
print (dataset[:,0:9].shape)
print (dataset[:, -1])
man= dataset[:,0:9]
data = man.reshape(1, 36732, 9)
tar=dataset[:, -1]
tar=tar.reshape(1,36732)
```

```

print (data.shape)
print (tar.shape)
# create and fit the LSTM network
# create and fit the LSTM network
model = Sequential()
model.add(LSTM(32, input_shape=(36732, 9)))
model.add(Dense(36732))
model.compile(loss='mean_squared_error', optimizer='adam')
model.fit(data, tar, epochs=30, batch_size=21, verbose=2)
res = model.predict(data)
from sklearn.metrics import accuracy_score
#print (res)
#print (tar)
#print (tar-res)
print (((36732-numpy.count_nonzero(numpy.round(tar-res)))/36732)*100)
print (mean_squared_error(res,tar))

```

- **MATLAB Code**

```

load ('INN.mat');
PP=INN;
n = length(PP(:,1))
c = cvpartition(n,'Kfold',10)
jdaTrain=cell(10,1);
jdaTest=cell(10,1);

for i=1:10
j1=training(c,i);
jj1=test(c,i);

```

```

jdaTrain{i}=PP(j1,:);
jdaTest{i}=PP(jj1,:);
end
load ('net_1_folds_PSO.mat');
% net_1_folds=cell(10,2);
accur1=[];
mse=[];
mae=[];
rmse=[];
cm=cell(10,1);
pr=cell(10,1);
recal=cell(10,1);
for i=1:10
% Create of Neural Network classifier
net1 = feedforwardnet([1]);
net1 = configure(net1, jdaTrain{i}(:,[2 4 5 6 7 8]),jdaTrain{i}(:,10));
% train net
net1.divideFcn='divideint';
net1.divideParam.trainRatio = 0.7; % training set [%]
net1.divideParam.valRatio = 0.2; % validation set [%]
net1.divideParam.testRatio = 0.1; % test set [%]
% train a neural network
net1.performFcn='mse';
net1.trainParam.showWindow= true;
net1.trainParam.showCommandLine= true;
net1.trainParam.show = NaN;

```

```

net1.trainParam.min_grad= 1e-101      %minimum gradance
net1.trainParam.max_fail=100;
net1.trainParam.goal= 1e-201 ;      %Minimum Performance Value
net1.trainParam.epochs= 22 ;      %Maximum Number of Training Epochs (Iterations)
net1.trainParam.time= 30;      %Maximum Training Time
[net1,tr] = trainlm(net1,jdaTrain{i}(:, [2 4 5 6 7 8]),jdaTrain{i}(:,10)');
net_1_folds{i,1}=net1;
net_1_folds{i,2}=tr;
output=round (net_1_folds{i,1} (jdaTest{i}(:,[2 4 5 6 7 8])));
    accur1(i)=length (find (((output-jdaTest{i}(:,10)')==0))/length (output) *100
cm{i}=confusionmat(jdaTest{i}(:,10)',output );
mp=[];
sp=[];
for m=1:length (cm{i}(1,:))
mp(m)=cm{i}(m,m)/sum(cm{i}(m,:));
sp(m)=cm{i}(m,m)/sum(cm{i}(:,m));
    end
error=(output-jdaTest{i}(:,10)');
mse(i)=mean(error.^2)
mae(i)=mean(abs(error))
rmse(i)=sqrt(mse(i))
indd=find(isnan(sp)==1);
sp(indd)=0;
pr{i}=mp;
recal{i}=sp;
end

```

```
figure;  
boxplot (accur1)  
ylabel("Accuracy %");  
xlabel("10-folds");
```

```
figure;  
boxplot (mse)  
ylabel("mse ");  
xlabel("10-folds");
```

```
figure;  
boxplot (mae)  
ylabel("mae ");  
xlabel("10-folds");
```

```
figure;  
boxplot (rmse)  
ylabel("rmse ");  
xlabel("10-folds");
```