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A survey of Face detection and Recognition system

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ABSTRACT

In recent days, our world has entered the age of advanced digital systems, which means humans has to interact with technology in all scopes of live, this leads too as a result to another main concept, security. There are many security technologies that was developed to keep user information save. for example, there are several technologies used to let just the accurate user to log into devices like fingerprint, face recognition, or any another type of these systems. These technologies are in continuous development and are still suffering from accuracy, so several studies were performed to get the best accuracy for any of these systems.

Computer vision was developed to give the devices the ability to see and recognize objects in an image or a video scene. It is a science that aims to build an intelligent application that are able to understand the content inside images as humans can do. To create a system like this, first step is to make Data acquisition, this task is done by cameras which gives us a sequence of frames when we record a video. After that, this data is analyzed and studied to extract important features from it. This feature will allow us to re-construct the description of the outer world in a manner that can understood by computer system.

Face recognition systems are used on a wide range in mobile applications, banks, and military sites, police stations to make a recognition of the criminals, even in covid19 situations the face recognition was used too.

Our proposed method aims to increase the accuracy a face recognition system using deep learning models, the system proposed is able to work on any platform compiled with python which is the application was used in our study. The model performed gives a high accuracy with a very speed result.

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1. INTRODUCTION

Computer vision is a new age system that aims to build an intelligent application has the ability to understand the content inside images like human's dose. It mainly depends on separating the pixels inside the image using edge detection and regions of interest. Data acquisition task is done by cameras which can give us single pictures or a sequence of images in frame per second rate. Data resulted is then analyzed, studied to extract main features. These features can allow us to re-construct a description about the outer world in a manner like humans does to make it understood by computer system [1]-[3].

There are many applications of computer vision which can used in:

- An application able to recognize objects or people in an image.
- Automated control applications (e.g.: Auto Vehicles).
- Re-construction of models (e.g.: Analyze of medical images).

- Application for tracking a moving object in a video.
- Re-construction of 3D images from 2D images.

2. RECOGNITION IN IMAGE PROCESSING

Recognition is a part of image processing where we can define people in an image. This can be done easily by humans. But this problem still unsolved in computer vision system. This works by finding the best solution in a group of geometric shapes, people face, printed or written characters, and the position of a background object in an image[5].

There are 2 types of recognition:

- Recognition: define objects in an image from different angles.
- Selection and Investigation: it aims to select a special feature for a special object like a car plate. It aims too to search in an image to find an object (e.g., finding a sick cells or finding a car on a highway).

3. TYPES OF COMPUTER VISION SYSTEMS

Computer vision systems are different and are divided between small systems for small missions, and a very complicated systems which can define and recognize large an several objects in an image in the same time.

Any computer vision system must run in number of steps[6],[7]:

- Image Acquisition: here we get an image by using one or more image sensors (which can be light sensor cameras, distance sensors, x-Ray machines, Radars, ultrasonic cameras). The resulted image may be a 2D or 3D image or a sequence of images.
- Pre-processing: before we can use a computer vision algorithm on an image, it is important to made a group of pre-processing operations to make sure that the data achieves some hypothesis in the algorithm. This pre-processing can contain changing the image accuracy decrease to emphasis the image coordinate system and decreasing the noise to emphasis that the sensor does not sending wrong data, increasing contrast to became sure that the required information can be got successfully.
- Image features extraction: in this step we will get a multiple level of resolution from the same image, these landmarks are divided into global landmarks like colors and shapes, and local landmarks like corners and spots. We can also get a more complicated landmarks in the image.
- Image fragmentation: consists of a group of important operations, like choosing a group of landscapes, or image splitting to get the region of interest of the object searching for.
- Hight level operations: the data entered in this stage will be a small group of the total data, like the range in the image which we can find the searched object in.

2. RELATED WORKS

Wenming et al [8] proposed a DPSRC approach to recognize the face in an image, instead of using all the parts in an image which is time consuming and needs a large amount of memory we need to select just important patches and by using the Bagging greedy search to use the selected patches in the image and a series of local optimums. Xavier et al [9] study the uncontrolled environment states that can affect on the accuracy of face recognition system like varying of face orientation as example, for face recognition the author uses Robust Spares Coding algorithm which uses a weight matrix W to increase the system performance. He examines the system on LFWA database.

Young Zhu et al [10] study the effect of illumination on face recognition system, all previous studies did not take the spectral wavelength in interest which leads for less accuracy. So, the author gives a new algorithm called Logarithm Gradient Histogram which takes the three important parts of to solve the illumination problem which are direction, magnitude, and spectral wavelength for all lighting conditions. This logarithmic algorithm depends on a bank pass filter which must be multi-scaled to remove the illumination effect which affecting on the image. This algorithm was examined on Yale B database.

Ding et al. [11] introduced an HPN method which can use two- and three-dimensional methods and provides three tasks for FIER. This algorithm can avoid losing of semantic information. Also, Vigneau et al [12] focused on problems produced by the conditions caused by the environments so he found that the temporal variation conditions, to avoid that effect the author uses two thermal face databases that got in real static and variable conditions.

4. METRICES USED TO IDENTIFY THE ACTIVITY OF FACE RECOGNITION SYSTEMS

There are several metrics can used to verify if the face recognition system is working fine, these methods can define in [1]-[5], False Accept rate (FAR) which calculates the probability that the system was incorrectly matches with the input image to non-matching pattern in the database. It gives as an output the percentage of invalid inputs that are incorrectly accepted. Second metric is False Reject Rate FRR which means that the system has fails to detect any matching between the input image and the templates in the database, it gives the percentage of right inputs which are rejected incorrectly.

Another metric used which is Receiver Operating Characteristic or ROC plot which gives a trade-off between FAR and FRR. The last metric is Equal Error Rate (EER) which is the rate of equality between accepted and rejected errors and can obtained from ROC. Less ROC values means that the system is more accurate.

5. USAGE OF FACE RECOGNITION SYSTEM

There are many applications for face recognition systems which are can shows in this scope. First important application in face recognition system is accessing to the ATM, here we can collect all the customers images in a database and where the customer enters the bank the system takes an image for him using a high-resolution camera and compare it with the database data. When we got a match with special percentage, we can allow the user to access.

Another use of this system is identification of a person and was used on a large scale globally after 11 September to identify and catch terrorists all around the world. It is used too by police stations to identify criminals in the station or by CCTV cameras.Table 1 shows the developed algorithms and their results.

Table 1. Some developed algorithms and their accuracy.

Author	Extraction	Classification	Database	Recognition Rate
MinMoon a al. [13]	CNN	Euclidian Distance	IPES-1280 Face database	88.9%
Hameed a a.,[14]	DWT	Hidden Markm-Model	ORL Yale	100% 100%
Jahya et al, [15]	PCA	Euclidian Distance	Yak B	96%
Regina a at. [16]	PCA	K•Nearest Neighbor	Cropped Yale Own database	76.68% 75.19%
Decheng a al. [17]	SIFT and HOG	Euclidian Distance	e•PRIP	70.1±5.94
Yang et al., [18]	CNN	SRC	AR	95.83%

6. FACE RECOGNITION SYSTEM

Face recognition system is defined as a part of biometric systems, which might consist face scan, fingerprint, foot print, hand scan, iris, etc. Face recognition depends on face biometric features like eyes position, lips position and size…etc. So, we can first identify the existence of the face inside the image and its position, and then recognize it. This task can be done easily by human brain, but it needs training in a computer system. Figure 1 shows the different types of biometric systems:

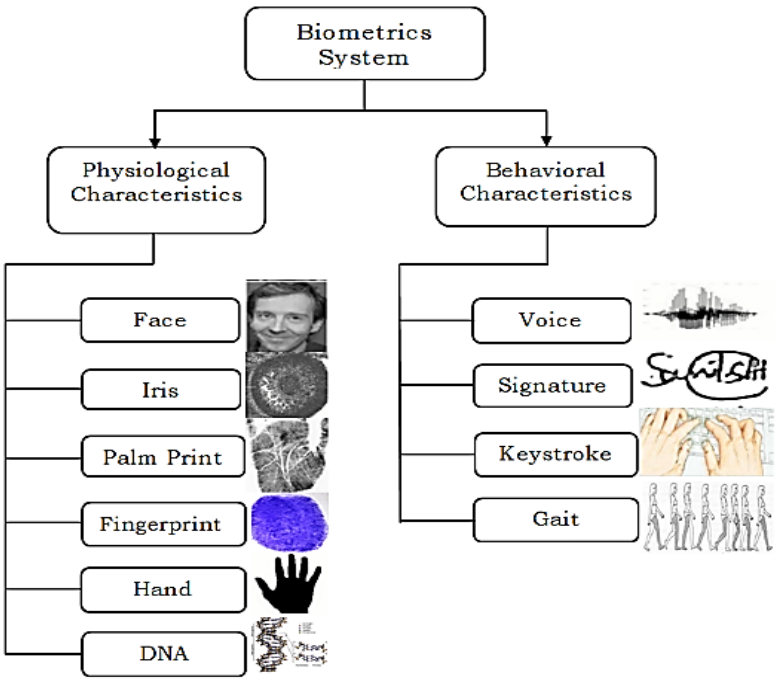

Figure 1. the different types of biometric systems

Biometric systems work in different manners. So, when the target is to identify a special object in an image, we must first create a dataset of features for all the data available for us and then compare it with the newly entered data. For example, here we can use template matching algorithm of correlation task. Here we need just to find an object in the image.

In another hand, in verification task, we need the verify that, for example, the face in the image belongs for a specific person we are searching for or not. This is done when we validate the collected features with pre-stored one. 2 and figure 3 defines these tasks. In figure 2 we want to make a matching between two images to give a result if the person is the same, so the result is yes or no. in figure 3, we are comparing the person image with several images in the dataset and then returns all the data saved about it.

Figure 2. one-to-one face matching and identification

Figure 3 one-to-N face matching and identification

7. CHALLENGES IN FACE RECOGNITION SYSTEM

In recent days, Face recognition systems are growing fast in usage in many applications, and becomes the most important verification task in mobile security applications. In addition to the importance of this system, this technology is facing a large number of challenges, at the top of this challenge is, for example, the illumination changing in image when the environmental conditions changes, in addition to aging which makes a problem for the system to give an accurate recognition.

The main problem about detecting and recognition of faces is that human face is not a rigid object, that means an image structure could change if the illumination is changed, or the face pose changes too, aging can effect on the face, even we can get problems if the capturing device has a low accuracy [8-11].

2.1. Challenge of illumination change

It is clear that the image of the face can affected in light or dark, this change in light condition can cause a change in illumination in the image. In addition, too, not all the cameras' lenses give the same result of illumination. This poor response in illumination can cause poor recognition result. Recent application studies the face recognition tasks under special conditions. The problem here that the darkness cause hiding some face textures where high illumination cause mixing these textures, booth will reduce the accuracy of the all system. Figure 4 gives example about this effect

Figure 4. challenge of illumination change

2.2. Resolution of the camera

If the resolution of the camera decreases, some of the textures in the image will be lost. And the size of the image might decrease too. That means we will build a system that works under any resolutions and sizes which is absolutely a bad choice. Figure 5. Shows the effect of resolution on the image.

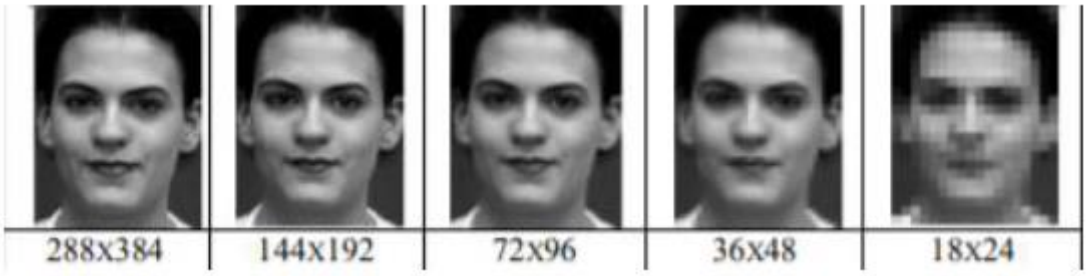

Figure5. challenge of resolution change

2.3. Pose of the face

Any changes in face pose can cause the system to became less in accuracy, all face data available are not covering all face positions in the image. To avoid this problem, we have two solutions. first, the face dataset must contain all positions of the user face, which means a huge size dataset. Or we must align the faces using preprocessing task in a special alignment before recognition. If we have a large dataset, that means the necessary of a large memory which cause an additional cost too.

2.4. Effect of aging

When we collect a dataset of a person, the data might collect in young age, after a time, aging can affect on the person texture, then on images. All of that can affect on the accuracy of the system. It is impossible to collect a dataset for a person in all ages, so the accuracy of the system will be degraded see figure 6 and figure 7.

Figure 6. challenge of face pose

Figure 7. challenge of aging

2.5. Facial expressions

images can vary in facial style and hairstyle. for example, makeup can affect the recognition task. expressions like smiling, anger, can cause changing the accuracy of all the system. Here we might save all the expressions types in the dataset, which can be time consuming see figure 8.

Figure 8. Challenge of face expressions

2.6. Effects of occlusion

Another effect on the images can caused by additional objects like clothes and glasses. The person in the image can have a bread or a mustache but they were not in the dataset. Figure 9 shows the effect of occlusion on an image and as we can see it might be hard to confirm that all the images are for the same person.

Figure 9. Challenge of occlusion

2.7. Locating the face position

When we create a face recognition system, first we must locate the face position. It could be different if we have a still image or a video sequence. It might be difficult to isolate face image from background in poor images.

Figure 10 shows a face with low accuracy and with a rotation which causes loosing of face landmarks decreasing the accuracy of recognition task.

Figure10 challenge of face position

2.8. Similarity of faces:

In some cases, two persons may be similar too much so the recognition result might be wrong see figure 11.

Figure (11) challenge of face similarity

3. FACE RECOGNITION SYSTEM TASKS

3.1. Detect the face in the image

When we talk about face recognition system, It is really easy task for humans, but it is difficult for computer system, because the system we build must decide if the pixel belongs to a face or not.

3.2. Normalization step

After we became able to isolate face image from the background, we will normalize it. it is an operation we will use to standardize the image with respect to pose, size, and illumination.

To normalize a face image, the face landmarks must be located carefully and accurately. So, we must do some pre-processing steps which contains:

- Histogram Equalization: in image histogram all the values which are equal in probability remains constant with equal distribution, mathematically we can write it $P(i) = {}^{n_i}/_{N}$ (1)

  where N the total number of pixels in an image.
- Adaptive Histogram Equalization: here we can compute the histogram of a local image centered with the given pixel towards the mapped value of the pixel so we can enhance the resolution of the image.
- Computing the gradient: we can compute this value for its importance to extract some properties of the face in the image like the surface geometry.
- Gamma correction: it is a conversation of an image calculated to brighten or darken the image using equation

  $$M(x,y) = N(x,y)^{1/\gamma} \quad (2)$$

  where $N(x,y)$ is the input image and $M(x,y)$ the output image and gamma the correction constant. When gamma>1 the image will be darker and when gamma<1 the image will be brighter.
- LOG correction: this is a logarithmic equation used on grayscale images, this transformation uses equation(3):

  $$S = C * \log(1 + r) \quad (3)\ ,$$

c is a constant, and r is the input pixel added to 1 to make sure the log not be zero, where S is the output pixel. This transform is used to enhance low gray levels and compress high ones[12],[13].see figure 12 and figure 13.

Figure (12) transforms on face images

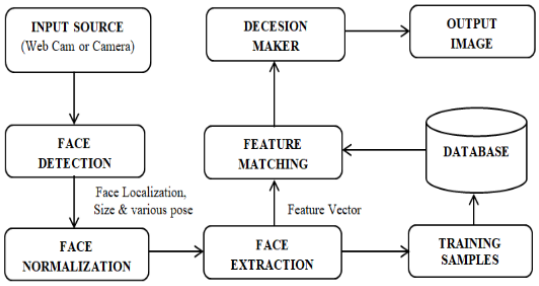

Figure (13) tasks performed in face recognition system

3.3. Features Extraction

This step creates a template called a biometric reference, this reference is stored in the database, many algorithms are used for this task, like Gabor filter or LBP filter. Features can be extracted using PCA (Principal component analysis) transformation too which can decrease the features space dimensions. We use these feature extraction methods to increase the speed of computation task and decrease the size of the dataset.

4. ALGORITHMS USED IN FEATURE EXTRACTION

- Eigen faces: this feature depends on PCA(Principal Component Analysis) method where we can decrease the dimensional space and then lower dimensionality of image. This algorithm is fast and has a large learning capability. Figure (14) gives a chart of all methods used in feature extraction.
- Gabor Filter: this filter depends on wavelet transform which can represent the frequency and orientation of the filter like how humans can see the space around. This algorithm can extract features for just aligned faces on particular orientations.
- Local Binary Pattern (LBP): it is a method used for textures analysis and classification. This method is can avoid light effects. It will divide face image into large number of blocks and features.
- Speed Up Robust Features (SURF): this method is used to detect local features which can find the points of interest in the facial image. This algorithm uses Hessian blob detector computed with three integer operations.
- Scale Invariant Feature Transform (SIFT): here we calculate the image pyramid using different scales which can give us much more performance under face changing geometries.
- Conventional neural networks (CNN): it is a deep learning and machine learning algorithm used in a large type of data specially images, it is an active technology in 2D datatypes. This network consists of a number of layers different in a structure from normal neural networks and shares it in input, output, hidden layers and neurons.

- Fisher Faces: is one of the popular algorithms used in face recognition, and is widely believed to be superior to other techniques, such as eigenface because of the effort to maximize the separation between classes in the training process see figure 14 .

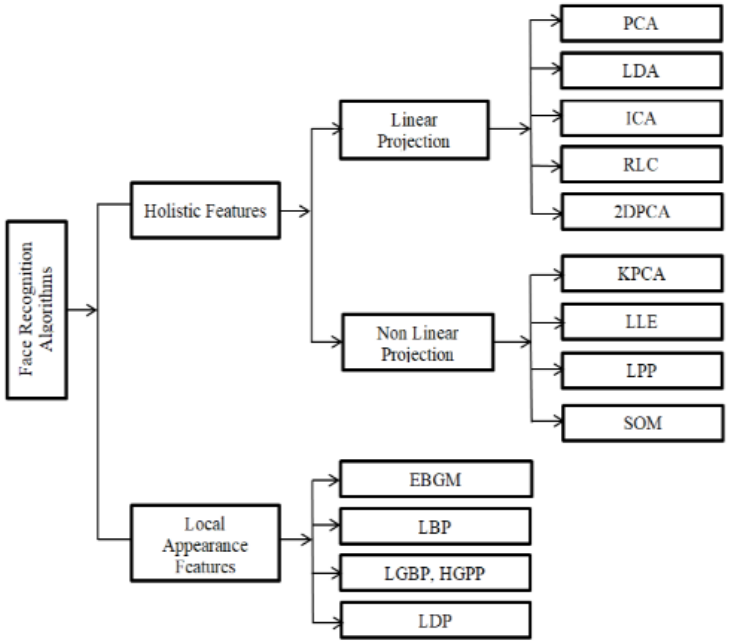

Figure (14) traditional face recognition algorithms

5. Metrices used to identify the activity of face recognition systems

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8. CONVENTIONAL NEURAL NETWORKS

Neural networks are one of the modern technologies that gives high accuracy in classification and prediction tasks. High speed, combability with many science scopes makes neural networks one of the most widely used techniques. There are different types of neural networks, such like forward neural network (FNN), recurrent neural networks (RNN), and conventional neural networks (CNN), these networks are shared in term of having neurons and an input and output layers with one or several hidden layers, and are different in terms of the tasks performed by these layers.

Interconnected networks (CNN) carry out classification operations, whether with the presence or absence of a supervisor. Training is used with a supervisor by providing a number of corresponding inputs and outputs, and the system learns to connect them and predicate the output. In case of learning without a supervisor, the values of known inputs are used here, and the system tries to link these values with the distribution of available output data. The following figure (15) shows the supervisor training method for an image classification system. In the beginning, the input images are entered and a number of their properties such as edges and gradients are calculated in the main layer. In the middle stage, a number of features are extracted from the previous stage, and then in the last stage the features are extracted, which in turn can be passed for the classifier[16].

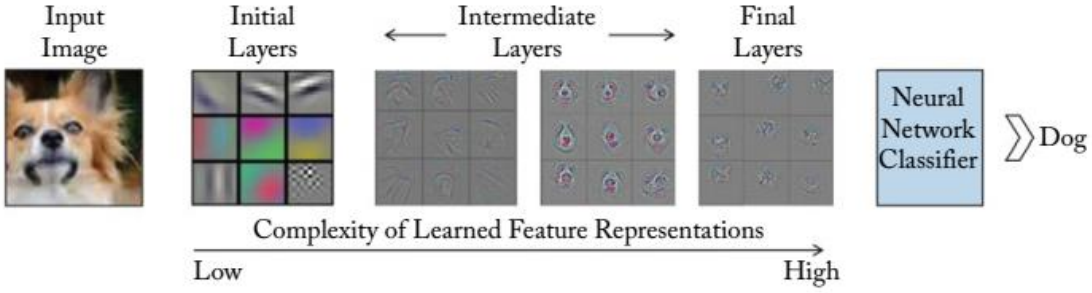

Figure (15) traditional face recognition algorithms

The network links the attributes extracted features from the images and the classification they follow, where the attributes are extracted according to a sequence from the simplest to the more complex features and then used these attributes to train the network to predict other values.

This network consists of a number of successive layers, each of them performs a set of tasks, before we can feed the data to the neural network, we must start with a preprocessing stage which consists of

- Mean subtraction: we enter the train and test data and then we center it around zero value by subtracting the average in each training group to get N training image by using equations

$$x' = x - \hat{x}, \quad (4)$$

$$\hat{x} = \frac{1}{N}\sum_{i=1}^{N} x_i \quad (5).$$

- Normalization: in this stage we take the standard deviation for all training data group to squeeze the standard deviation range using the equation (6):

$$x'' = \frac{x'}{\sqrt{\frac{\sum_{i=1}^{N}(x_i - \hat{x})^2}{N-1}}} \quad (6).$$

- PCA Whitening: this stage aims to decrease the interconnection rate between different data dimensions, here we can find the convolution matrix which can encode the interconnection between data dimensions and then apply the SVD (Singular Value Decomposition) to get the eigen vectors which can divide into groups represent the special values of images features.
- Local Contrast Normalization: aims to get more of high constraint features, here we will create the neighbors of each pixel then calculate the average of these pixels for centering and then taking the standard deviation for all pixels which must be more than one**CNN Layers**

9. CONVOLUTIONAL LAYER

A CNN neural network consists of a number of layers which are[17],[18]:

9.1. Convolutional layer

the most important layer in conventional Neural Network, it contains a collection of filters (known as Convolutional Kernels too). It convolves these filters with the desired input to get the output has best connection with the input features. The filter itself is a connected layer or a network of discrete numbers like the filter shown in figure 16.

2	0
-1	3

Figure 16. conventional neural network

The filter weights changes by training, these weights starts with random numbers and changes with every input-output pair fed to the network, these pairs are a series of training tasks. Conventional task can define as showed in figure 17. the filter passed on image pixels and multiply each value with its opposite, resulting the sum in discrete pixel. The different between convolution and correlation shown in figure 18.

This task is named also the subsampling because the image suffers decreasing of the samples size. Here we need also to add zero pixels (padding) on image edges to make sure that the filter moves on edges too.

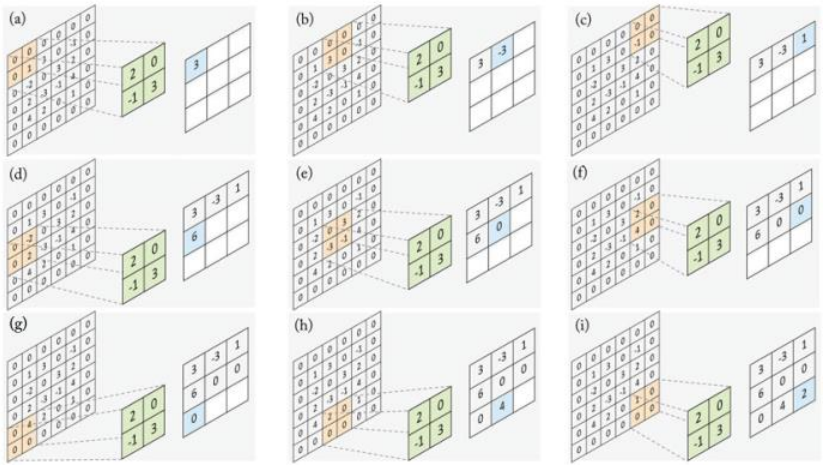

Figure 17. Convolution task with padding

Figure 18. Convolution vs correlation

This filter will be resized in every loop and on several levels.

9.2.Pooling layer

This layer elects a pixel of each mask which could be the average or the maximum pixel, we need to select the area we elect from it as shown in figure 19.

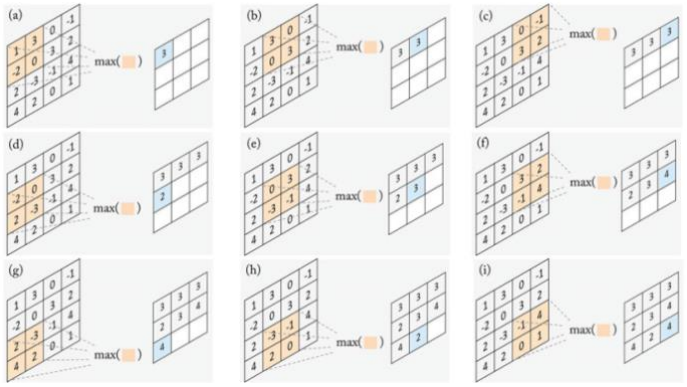

Figure19. pooling task in neural network

9.3. Activation function

Here we define all the levels where the neurons activate the output using several functions, they define the threshold when the neuron fires the output, see figure 20 and figure 21 shows an example for the most used functions.

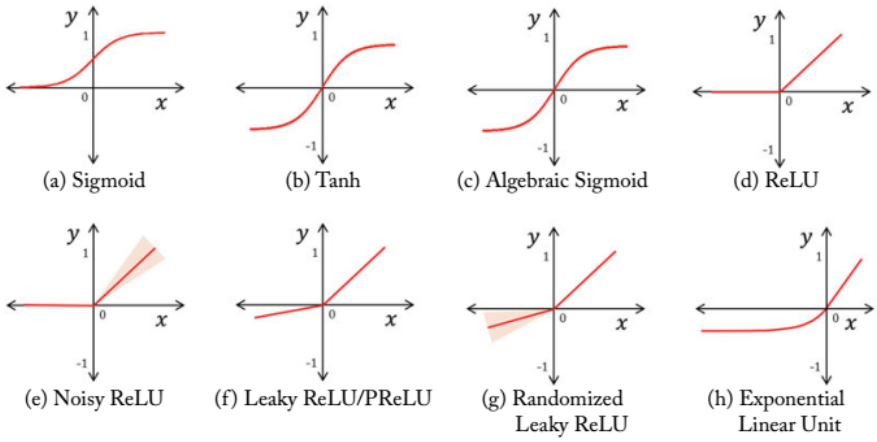

Figure 20. activating function

Then we can define the regions of interest and train the network on it.

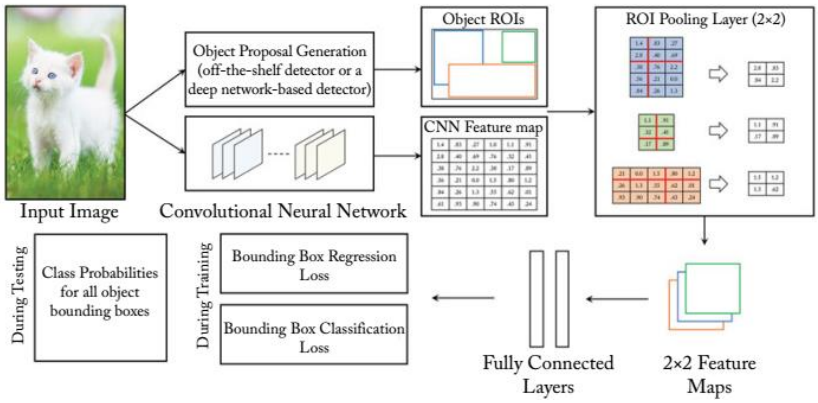

Figure 21. full neural network system

Then the data will be ready to enter the neural network.

10 .RESULTS AND RECOMMENDATIONS

In our research we proposed a new method for face recognition using conventional neural networks, we have used a dataset consists of 10 persons with 300 images of each person, then splits this dataset into training and testing groups. The accuracy of the system was so far better than traditional methods and reached to 99.3% with no negative impacts. The only problem we have faced when training the neural network on a huge dataset was time consumption and needing for large amount of memory.

The PCA face recognition system reaches an accuracy of 75.2% and the LBPH was 78.1%, when the KNN reaches 71.4% which mean our proposed method was far better in face recognition performance depending on classifiers.

We recommend using face recognition system in all automatic lock systems. This system can developed to recognize even sick situations. Here, after the recognition of the face we can analyze the color of the face and by using the color degree we can define if the person is sick or not.

In criminal's situation we need to use a high accuracy camera in streets and when we want to recognize the face of the criminal, we can send an alarm of the presence of the person with GPS signal of the camera position to the closest police station.

10. CONCLUSIONS

We found that we can use several methods to improve the recognition performance, first of all we must use a large number of images of the person (at least 75 images). Images must be collected in multiple poses of faces with different light conditions and angles. We can use colored images instead of gray scale images with edge detection to increase the neural network accuracy.

Using noise remove technique plays an important rule too to give a good feature extraction method. the dataset can be increased by using traditional image processing techniques like mirroring, scaling, and resizing too, which can increase the performance of the neural network.

We must keep in mind that increasing dataset size needs more processing power and memory to build a good feature extraction model required for face recognition system.

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