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Research Article

Fingerprint Image Recognition for Crime Detection

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Abstract: Fingerprint images play an important role in solving serial crime cases. The main objective of this paper is to provide a complete fingerprint identification analysis of crime scenes using deep machine learning which a class of Convolutional Neural Network is. Images taken as a database are generally insufficient and are difficult to classify. Therefore we use appropriate enhancement techniques for pre-processing the fingerprints which we have taken from the database. Minutiae are uprooted from the fingerprint images with the process of minutiae extraction. The preprocessed data is given as input to the CNN for training and testing. It further goes with the similarity checks. The experimental results demonstrated on the database using Matlab show high accuracy. Fingerprint images are important tools for finding culprits at the scene of the crime. Thus, the identification of the suspect using the fingerprints will be more quick and accurate. And we came up with an algorithm of deep learning architecture called Alexnet. This technology shows that it is feasible to get accurate results to identify the artifacts that we generally use in the actual scenario. This procedure offers up to 99 percent accuracy with much less than 6 seconds of classification time.

Keywords: CNN (Convolution Neural Network), Database, Image Skeletonization, Matlab, Minutiae, Otsu Segmentation.

1. Introduction

Crime scene images (CSI) are those images that are collected from the crime location. When a crime happens, the investigator gathers both latent and patent samples of fingerprints. The fingerprints which are visible by the naked eye are called patent fingerprints, so they are simply taken as photos [6]. But we can't see the latent fingerprints so these are tough to detect. These samples are often lifted through different methods. With the help of cyanoacrylate vapors that stick to prints and make them clear to see in the presence of normal light. This process is way difficult, so generally, in crime scenes, the investigators make use of a fine dusting powder on the surface where fingerprints are to be extracted. The dust will stick to the fingerprint after which they use clear tape to extract the fingerprints. After the extraction of the fingerprints, they are scanned and saved in the form of a digital image. The fingerprints taken from the crime scene are accidentally created and these images are noisy or partial prints and are tough to spot.

Machine Learning (ML) is the study of algorithms and statistical models that can be used to perform a specific task without using outright instructions, relying on patterns instead of that [9]. Machine Learning algorithms have widely emerged in the security imaging field as a part of artificial intelligence [6]. It can be mainly divided into two categories, supervised and unsupervised. In supervised techniques, an algorithm is used to seek out a mapping function of input variables and their related output labels to predict new subject labels.

Deep Learning (DL) is a subdivision of Machine Learning that is based on learning data representations and feature learning. DL algorithms utilize arrays of various layers of nonlinear processing identities for feature extraction. The output of every sequential layer is that the input of the subsequent one, which helps in data abstraction as we go far within the network [15]. Convolutional Neural Network is a class of Deep Learning and generally used in analyzing visual images and drafted to have less preprocessing [16].

It is inspired by biological processes in the human brain and is utilized to handle data that is available in multiple arrays. MATLAB software acts as a good image processing toolbox, digital fingerprint images are often analyzed using MATLAB.

2. Literature survey

Anil K. Jain et.al [1] proposed a system for matching latent fingerprints with rolled fingerprints. The

matching procedure consists of minutiae matching, orientation field matching, and skeleton matching to check the proposed system, 258 latent fingerprints in NIST SD27 were matched against a background database consisting of 29, 257 rolled fingerprints from three different NIST databases. The identification rate of 34.9 percent of the baseline minutiae matcher was improved to 74 percent when singularity, ridge quality map, ridge flow map, ridge wavelength map, and skeleton were incrementally used. The importance of varied extended features has also been studied and therefore the experimental results are the foremost effective features in improving the accuracy.

Mohammad Mogharen Askarin et.al [2] mentioned thatFingerprint is that the filter constant is the most well-known and successfully implemented advantage by using easy process, proven use, acceptableness, and high recognition. One variety of fingerprints is automatic fingerprint. Given its delicate presence, the automatically latent fingerprint is widely left everywhere, including hot tap, gate handle, lift button, and glass. The traditional solution requiring the method of reapplying sunscreen and filming will permanently damage the latent fingerprint to remove such latent fingerprints. And a decreased form of touch is preferable. This study focuses on the latent fingerprints left on flat surfaces like a water tap, doorknob, and flasks of water. By seething the latent fingerprint is exposed (i.e. rendered visible), and a camera catches the result.

Tripti rani boroh et.al[12] described a fingerprint-based biometric identification system where the ANN forms a critical decision support system. The best thing about the work is related to the fact that if the ANN is configured correctly it can tackle the differences in the fingerprint and that gives the perceptions for developing a system that needs these samples as inputs for verification and permissions. A system designed to supply authentication call victimization these inputs is a reliable suggestion of verification as has been discovered from experimental results. Further, the system's overall performance can be enhanced by the use of statistical and hybrid systems together with ANN-based blocks.

Hamsa A. Abdullah [11] presented a paper on automatic person recognition of biometric systems is based on behavioral and physiological characteristics. The fingerprint-based systems are tested to be effective in protecting data and resources during a massive space of applications. The fingerprint options are simply non - heritable by the scanners and measured for the process solely within the presence of someone. So, these systems are tested as extremely confidential laptops based mostly on security systems with higher rates of accuracy.

B. Gour et.al [17] showed Fingerprint Feature Extraction Using the Midpoint ridge Contour method and Neural Network. In this paper he presented the minutiae extraction approach by using the midpoint ridge contours and the output of this method takes very little time and does not detect any false minutiae which are a very good advantage.

A. Chatterjee et.al [18] presented Fingerprint Identification and Verification System by Minutiae Extraction Using Artificial Neural Network. This method suggests a replacement method for fingerprint identification technology by minutiae feature extraction using a back-propagation algorithm. For an input image, the local ridge orientation is identified and the region of interest is located. For the identification of fingerprints, the authentication part of the system recognizes the fingerprint based on the training performance of the network. This paper presents the execution of Artificial Neural Networks to give an efficient matching algorithm for fingerprint identification. Using the Back-Propagation technique, the algorithm works to match twelve fingerprint parameters and compare them to a unique number provided for each authorized user.

3. Software and hardware requirement

3.1 Software:

MATLAB R2018a or above

3.2 Hardware:

3.2.1 Operating Systems:

Windows 10, Windows 7 Service Pack 1, Windows Server 2019, Windows Server 2016

3.2.2 Processors:

Minimum: Any Intel or AMD x86-64 processor

Recommended: Any Intel or AMD x86-64 processor with four logical cores and AVX2 instruction set support

3.2.3 Disk:

Minimum: 2.9 GB of HDD space for MATLAB only, 5-GB for a typical installation

Recommended: An SSD is recommended A full installation of all Math Works products may take up to 29 GBof disk space

3.2.4 RAM:

Minimum: 4 GB

Recommended: 8 GB

4. Block diagram

The proposed methodology is as shown in Fig.4.1, the fingerprints of the crime scene are taken from the crime location and are converted into digital form. The finger print images of both crime and non-crime person together forms the dataset. Image pre-processing step is included to remove noises present in the images. This enhances the quality of images in the dataset. As a part of enhancement, Otsu thresholding is used, which converts greyscale image in to binary image.

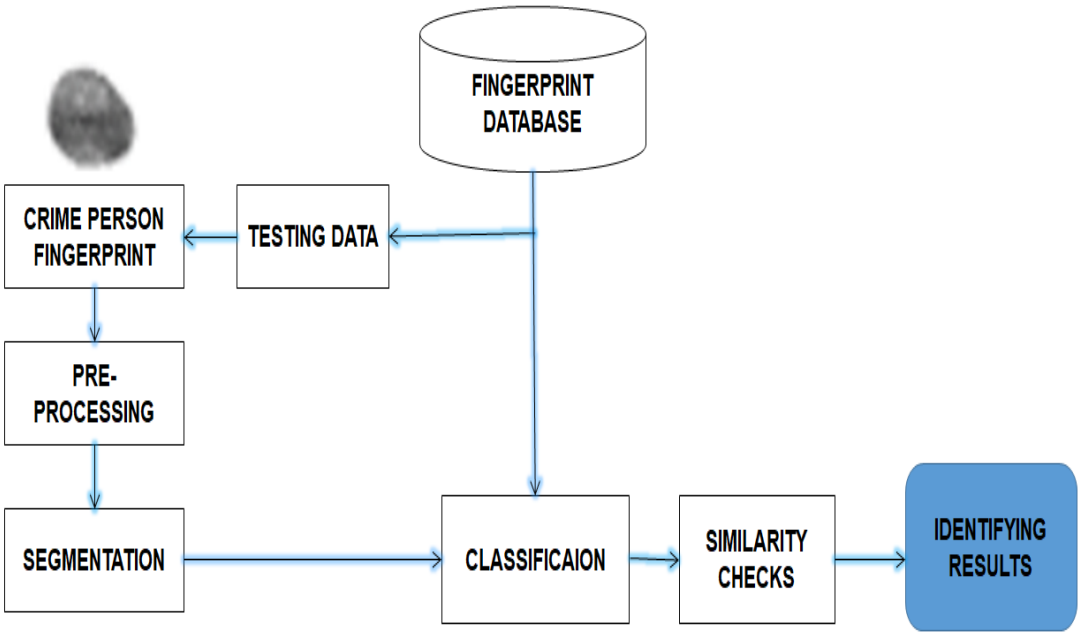

Fig.4.1 Block Diagram of Proposed Methodology

Segmentation is a process of segmenting a precise or trivial detail of the fingerprints which extract the minutiae marking from the dataset. By applying the image thinning operation region of interest (ROI) is extracted. The filtered ROI images are given as input to the Convolutional Neural Network. The dataset is divided into training and testing sets. Then the model will be trained as per our requisition. At the last step, we use Matlab software to identify the suspect fingerprint match with the fingerprint in the dataset or not. If the fingerprint matches, the system identifies the criminal and gives the output as a person is a crime person or not.

5. Proposed methodology

The flowchart of the proposed system is shown in Fig5.1.The detailexplanation of flowchart is as below.

5.1 INPUT IMAGE

The input image is taken from the database of the crime scene. The total dataset consists of 3000 images, where 2500 images are non-crime person and 500 images are from crime person. All these data as been collected from kegel website.

5.2 IMAGE ENHANCEMENT

In the process of image enhancement the input image which is taken from the dataset is converted from RGB to grayscale image so that the result images are used for further image analysis. Each pixel has similar characteristics in a distinct region. Input image is noisy image, global thresholding for the value of 127 applied in the first step. We applied a 5x5 Gaussian kernel to the filtered image to remove the noise. The Gaussian kernel is explained in 1-D, 2D and N-D respectively as

$$G_{1D}(x;\sigma) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-\frac{x^2}{2\sigma^2}},\ G_{2D}(x,y;\sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}},\ G_{ND}(\vec{x};\sigma) = \frac{1}{(\sqrt{2\pi}\,\sigma)^N} e^{-\frac{|\vec{x}|^2}{2\sigma^2}}$$

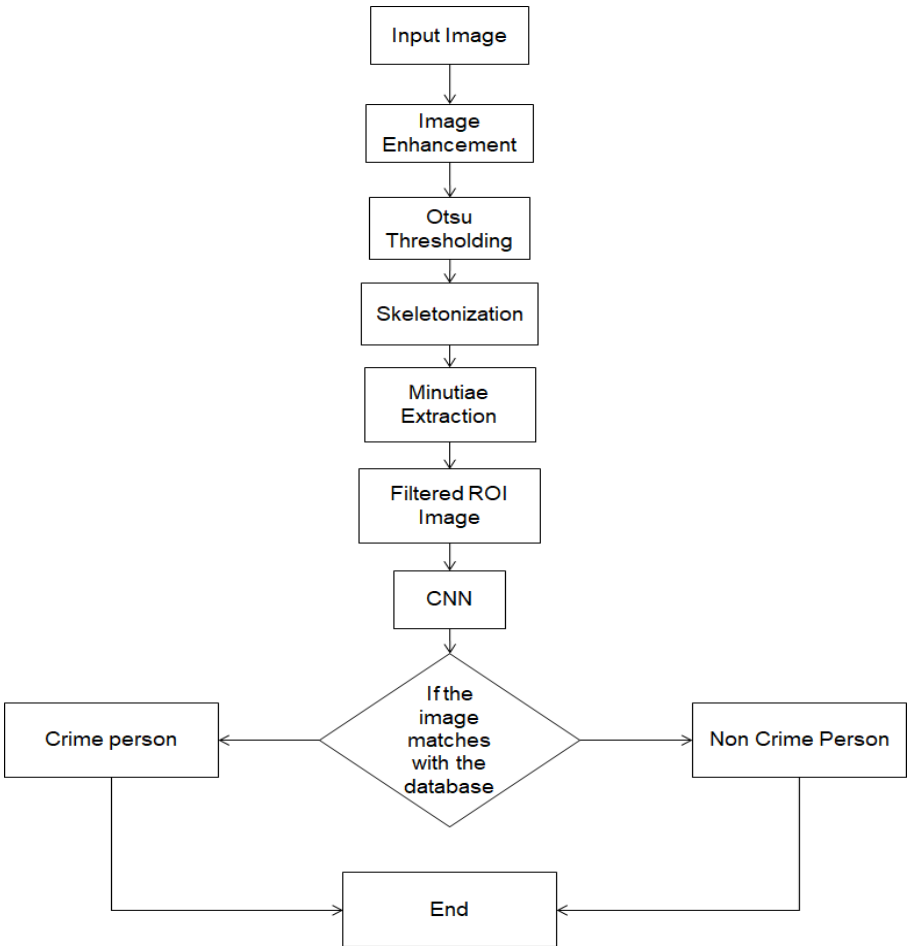

Fig.5.1 Flowchart of the proposed system

5.3 OTSU THRESHOLDING

As a part of preprocessing Otsu thresholding is used. Otsu thresholding involves calculating a measure of spread for the pixel levels on each side of the threshold and iterating through all the possible threshold values. i.e., the pixel that either falls in the forefront or background. In the second step, we directly applied the Otsu method thresholding.The threshold value (t) was found by the Otsu algorithm which minimizes the weighted within-class variance given by the relation:

$$\sigma_\omega^2(t) = q_1(t)^2\sigma_1^2(t) + q_2(t)^2\sigma_2^2(t)$$

5.4 IMAGE SKELETONIZATION

Fingerprint Image Skeletonization is used to reduce ridges and the foreground regions until one pixel wide to a skeletal image. A binary image comprises l's and 0's and is acquired with a display of all the points in the image where its gradient is more than the value of the threshold. In image skeletonization, a thinned image is formed from the binary image.

5.5 MINUTIAE EXTRACTION

Identifying the important features from the thinned image fingerprint is called minutiae. It is very tough to choose for the projecting and accurate demonstration of input images for fingerprints in crime scenes. A valid demonstration of the fingerprint is the pattern of the minutiae details of the fingerprint. The 150 various local characteristics called minutiae details have been identified. Only the two most prominent types of minutiae details are used; they are bifurcation and ridge ending because of their stability and robustness. Bifurcation is where a ridge divides from a single path to two paths, and ridge endings are the points where the ridge curve will end. The Cross-Number (CN) concept is the most commonly used method of minutiae extraction.

5.6 FILTERED ROI IMAGE

The ROI (Region of interest) is extracted using open and close operation by removing the image areas without effective ridges and terminates. The remaining effective area is divided into two areas, to determine the white area used and to represent the inner area the gray area used.

5.7 CNN ARCHITECTURE

There are different ways to perform a convolution, it may be a particular convolution like image processing, FFT (Fast Fourier Transform), or a convolution using GEMM (General Matrix Multiply) as well as other advanced algorithms like Winograd.Our proposed model deploys Alexnet CNN in which the initial convolutional layer presents convolution and max-pooling with Local Response Normalization where 96 different filters are used that are 11×11 in size. We perform max pooling operations with 3×3 filters using a stride size 2. Similar operations are done in the preceding layer with 5×5 filters.

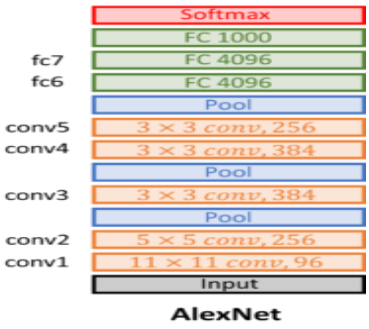

Fig.5.2 Alexnet architecture

Two fully connected layers (FC) ought to be utilized with dropout and a Softmax layer at the first. For a system like this, two systems with ideas associated and an equal quantity of practicality, maps are trained in parallel. Local Response Normalization and dropout are the two additional principles implemented.CNN's main component is the convolution layer. Convolution refers to a mathematical procedure for combining two knowledge sets. For generating a feature map, the convolution is joined to the incoming data with the use of a convolution operator. Many words are often used in the process.

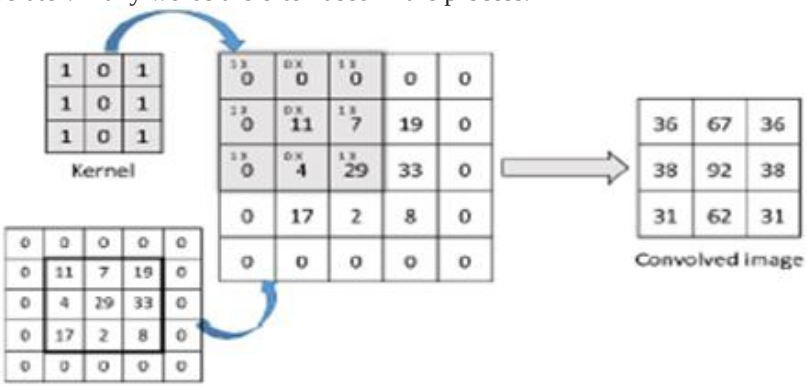

Fig.5.3 Convolution using zero padding

Pooling is carried out after convolution procedure to decline the dimensionality. This helps us to decrease the number of parameters which reduces both training time and battle for similarities. The suitable type of pooling is max pooling which takes the highest value in the pooling window.The common perspective of regularization is dropout which is used to stop overfitting into neural networks. The perspective simply gives up classes as per the ideal probability in a neural network. A preferred value of 0.5 is an ideal choice to check off.

The activation function shows the structure to be nonlinear. Rectified Linear Unit (ReLU) typically fixes well against the convent. There are many substitutes like sigmoid, tanh, and other task-deepening activation functions.Then CNN matching takes place. The image obtained is compared with both crime and non-crime fingerprint images.

6. Results

The input image shown in Fig.6.1 taken from the database is enhanced to a grayscale image to get the enhanced image shown in Fig.6.2. This undergoes otsu thresholding shown in Fig.6.3. Then the binary image as shown in Fig.6.4 is formed and then converted to a thinned image shown in Fig.6.5. After minutiae matching we get Fig.6.6. Then ROI extraction takes place as shown in Fig.6.7.

After Obtaining the ROI filtered image training progress takes placc, when the iterations increase accuracy also increases as depicted in Fig.6.8 which helps to give the precise output. The Alexnet CNN compares the original image from the database and the obtained image to give the popup output as Crime person or non-crime person as shown in Fig.6.9 and Fig.6.10.

Fig.6.1 Input image
Fig.6.2 Enhanced image

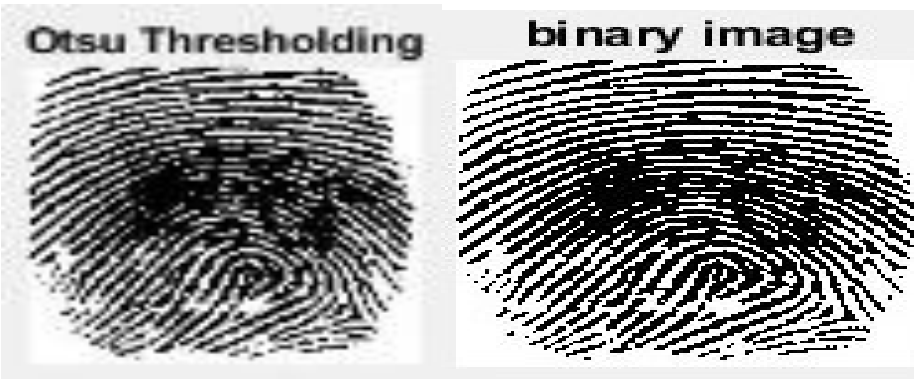

Fig.6.3 Otsu thresholding
Fig.6.4 Binary image

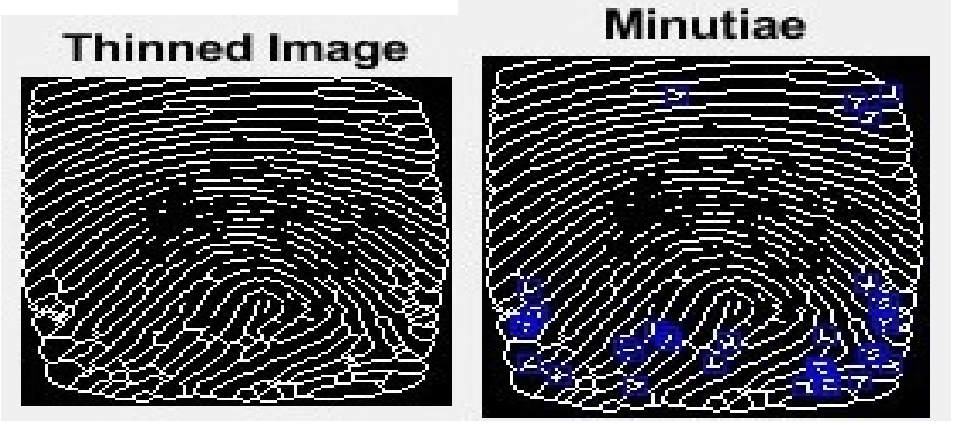

Fig.6.5 Thinned image

Fig.6.6 Minutiae

Fig.6.7 Filtered ROI image

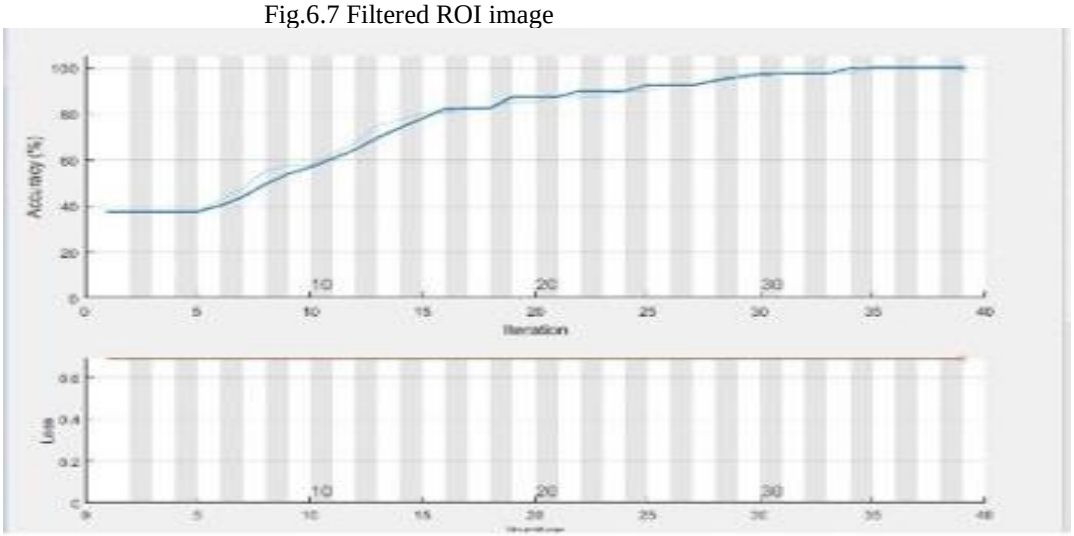

Fig.6.8 Training Progress

Fig.6.9 Crime person popup window Fig.6.10 Non Crime person popup window

7. Conclusion

Fingerprint identification system used to identify the given fingerprint as a crime person or non-crime person. Pre-processing was executed with Otsu thresholding, fingerprint thinning, and minutiae extraction is executed with the Cross-Number method. A CNN classifier called Alexnet performs the Feature Extraction. The identification of fingerprints is a significant technique for various types of security authentication. Hence, we have advanced outlines to make the identification process simpler and accurate using deep learning methods. The experimental output clearly says that, as compared to other methods, this method gives better performance. MATLAB software is used for training and testing of the data to get accurate result.

8. Future Scope

Fingerprint identification systems face two kinds of problems i.e. false match and false mismatch. To get more precise matching, the dataset can be increased. For instance, the government will have the fingerprint database of all the citizens of the country as they collect fingerprints for Aadhar identity. Using a larger database can give better results and the probability of finding the criminal also increases. CNN classifier acts as a best to give high accuracy results.

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