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Low Resolution Fingerprint Image Verification using CNN Filter and LSTM Classifier

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Abstract*: A biometric system is an evolving technology that is used in various fields like forensics, secured area and security system. One of the main biometric system is fingerprint recognition system. The reduced rate of performance of fingerprint verification system is due to many reasons such as displacement of finger during scanning, moisture on scanner, etc. The result and accuracy of fingerprint recognition depends on the presence of valid minutiae. According to literature several Fingerprint Recognition System are designed that uses various techniques in order to reduce false detection rate and to enhance the performance of the system. A comparative study of different recognition technique along with their limitations is also summarized and optimum approach is proposed which may enhance the performance of the system. This research work is focused on designing of fingerprint verification/classification including feature extraction methods and learning models for proper classification to label different fingerprints. In order to gain above mentioned objectives, FVC2002 dataset is taken for training and testing. In this dataset there are approx. 72 images which are used for testing purpose. In this dataset there are some blur, distorted as well as partial images also which are considered for recognition. Convolution Neural Network (CNN) and Long Short Term Memory (LSTM) is used for recognition of fingerprint. The result analysis shows approx. 3% enhancement over existing work.

Keywords* : Fingerprint Identification, Image Enhancement, Segmentation, Convolutional Neural Network, LSTM, TDR.

I. INTRODUCTION

In today's computer era, one of the most commonly used biometric systems id fingerprint which is used for personal identification as well as verification among all other biometric system. Throughout the world, it is one of the most acceptable biometric system due to it fast, secure and cost efficient method for personal identification [1]. The components required for biometric generation as well as identification are discussed as below:

Fingerprint Sensor: It is a device that is used to extract the input data of the finger. With respect to functionality and application different optical sensors are used.

Feature Extraction: Different algorithms are used for feature extraction out of the captured fingerprint data.

Database: All the extracted features are stored in a database in particular format. This database is used for fingerprint verification as well identification.

Decision Making: Finally, decision making algorithms are used for feature matching from the database.

Fingerprint is the most interesting and oldest human identity used for recognition of individual. In the early twentieth century, fingerprint was formally accepted as valid signs of identity by law-enforcement agencies. The criminal identification activities faces a series of photographic challenges to the crime scenes. These images can also be extremely fragile so hard to see. The background color or texture can easily overlap thin details. Curved, reflective or irregular surfaces may appear resist attempts to record all the details in one show. After all, pieces that need proof can often be difficult, if not impossible. In most cases under these circumstances, conventional photographic techniques have been successfully used to record such evidence discovered on the scene. Figure 1 shows the sample taken from criminal scene.

Fig. 1. Fingerprint Image from Crime Scene

One of the most important application of fingerprint identification on crime scene. The image obtained from crime spot are of two types, one is patent fingerprint samples and latent fingerprint samples. Among them, patent fingerprints are visible by our naked eye. In latent fingerprint image the extracted images are invisible and very difficult to perceive. Many research works have been done to extract fingerprint accurately but still there are some drawbacks that should be eliminated. Many image enhancements. The crime scene fingerprint is somehow noisy or partial and very difficult to identify.

II. RELATED WORK

Pavithra [1] proposed an algorithm for crime scene fingerprint image detection by using Convolutional Neural Network (CNN). Images acquire from crime scene is complex in physical appearance. So, image pre-processing and feature extraction is used are fed into the CNN and accuracy of 80% is achieved. B.

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Wenxuan [2] proposed an algorithm which is focused on feature extraction by the edges of the fingerprint obtained. For this purpose clustering with neighboring points. O. I. Abiodun [3] focused using artificial neural network (ANN) for feature extraction from the fingerprint images and identification purpose. The experimental result of the proposed algorithm with some existing algorithms such as GAN, SAE, DBN, RBM, RNN, RBFN, PNN, CNN, SLP, MLP, MLNN. Serafim [4] proposed an algorithm which is used to segment region of interest in fingerprint image using convolutional neural networks (CNN) without pre-processing steps.

Han [5] proposed fingerprint image enhancement technique termed as adaptive median filter which is used to remove impulse noise. Its performance is measured with existing median filter and it outperforms better with respect to traditional method.

III. METHODOLOGY

In order to gain above mentioned objectives, FVC2002 dataset is taken for training and testing. In this dataset there are approx. 72 images which are used for testing purpose. In this dataset there are some blur, distorted as well as partial images also which are considered for recognition. The algorithm is designed to match with given training dataset that gives matching result in probability. The fingerprint with highest probability is considered as matched fingerprint.

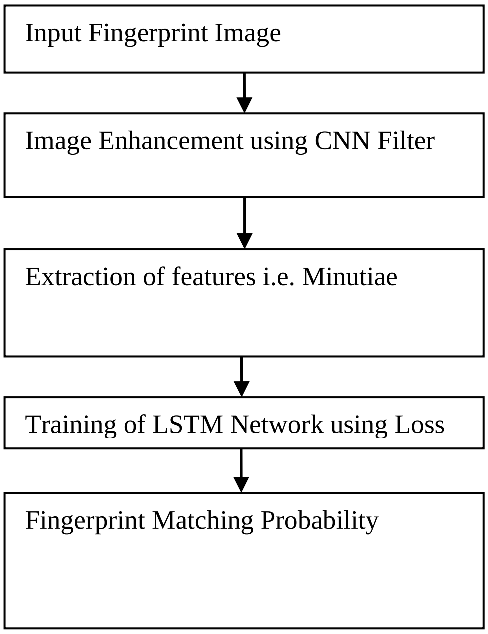

Fig. 2. Flowchart of Proposed Methodology

The flowchart of the proposed methodology is discussed as below:

Step 1: Input fingerprint image

Step 2: CNN Filter is used to enhance image in case of blur or distorted image.

Step 3: Extraction of features i.e. minutiae is performed which is ridge endpoints and bifurcation on a fingerprint.

Step 4: Training the proposed LSTM network and classify the fingerprint.

Step 5: Evaluation of Performance Parameters such as True Detection Rate as well as False Detection rate along with PSNR value.

The details of all the steps are described as follows:

A. Data Collection

In order to design robust and efficient fingerprint recognition technique, it is required to collect input images from specific condition dataset. In this research work, FVC2002 dataset is used [31]. Four different databases (DB1, DB2, DB3 and DB4) were collected by using the following sensors/technologies:

- DB1: optical sensor "TouchView II" by Identix
- DB2: optical sensor "FX2000" by Biometrika
- DB3: capacitive sensor "100 SC" by Precise Biometrics
- DB4: synthetic fingerprint generation

Each database is 110 fingers. Fingers from 101 to 110 (set B) have been made available publicly. So, in this research work performance is evaluated using set B dataset.

B. CNN Filter and Feature Extractor

In this paper, a CNN filter as well as feature extractor is designed to find the equalization function among pixels of the input fingerprint image, I(x, y). Information from the image is extracted using convolution function. This function is used to refine the image pixel properties such as for sharpening of pixels values, deblurring or enhancing the edges. Then LSTM network is used to train the network for fingerprint verification or identification.

The proposed CNN has 5 convolutional layers and 3 fully connected layer as:

Conv with 96 filters of size 11*11 with strides 4 are used to generate 96 feature maps

For nonlinearity in network, ReLU (Rectified Linear Unit) is applied.

Max Pooling with 3*3 with stride 2

Conv with 256 filters of size 5*5 with 1 stride that generate 256 feature maps

For nonlinearity in network, ReLU (Rectified Linear Unit) is applied.

Max Pooling with 3*3 with stride 2

Conv with 384 filters of size 3*3 with 1 stride that generate 384 feature maps

For nonlinearity in network, ReLU (Rectified Linear Unit) is applied.

Max Pooling with 3*3 with stride 2

Conv with 384 filters of size 3*3 with 1 stride that generate 384 feature maps

For nonlinearity in network, ReLU (Rectified Linear Unit) is applied.

Conv with 256 filters of size 3*3 with 1 stride that generate 256 feature maps

For nonlinearity in network, ReLU (Rectified Linear Unit) is applied.

Max Pooling with 3*3 with stride 2

Fully connected layer with 4096 neurons each for adding the operation that is used to attach the feature maps.

By using the weight updation using CNN features the proposed methodology is used for enhancing the luminance values of the pixels of the low contrast image.

As the input images is low-contrast that contains both dark as well as bright pixel values. By using the CNN network, the low contrast image is enhanced to high contrast image by shifting the color intensity value.

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Therefore, the proposed methodology enhances the image and introduce CNN filter to refine it to the respective level.

Further features are extracted through activations, which will pull the features learned from the CNN up to that point in the architecture.

C. Long Short-Term Memory (LSTM) Classification

Long short-term memory (LSTM) is a deep learning approach of recurrent network type. It consists of basically four main units termed as memory cell, input unit, output unit and forget unit. The LSTM deep network is used for classification process.

IV. RESULT ANALYSIS

The simulation scenario is created and simulated for performance evaluation of proposed fingerprint identification algorithm using CNN and LSTM network. In order to evaluate the performance of proposed algorithm scheme, the proposed algorithm is simulated in following configuration:

Pentium Core I5-2430M CPU @ 2.40 GHz
4GB RAM
64-bit Operating System
MATLAB Platform

A. Performance Parameters

True Detection Rate (TDR)/ Accuracy

True Detection Rate (TDR) or accuracy is one of the important parameters that determines the performance of the fingerprint recognition. TDR represents the total percentage of correct classification out of all given input values. TDR is evaluated as in equation 4.8:

(TP+TN)/(Total number of Features) (1)

Where,

TP stands the number of true positive samples which determines that true pores of the test data and classifier also predict it same.

TN stands the number of true negative samples which determines that false pores and classifier predicts it same.

Error Rate Detection (ERD)

Error rate detection is evaluated as in equation 4.9.

1-TDR (2)

Peak Signal to Noise Ratio (PSNR)

PSNR represents the degradation between two images. It is expressed as a decibel scale. Higher the value of PSNR higher the quality of image. PSNR is represented as in equation 4.10.

$$PSNR = 10log10(\frac{(X*Y)}{MSE} \quad (3)$$

Where, X and Y are height and width respectively of the image.

MSE= Mean Square Error between images

B. Result Analysis

In this section, result of different fingerprints are shown in below table I for performance evaluation of the proposed methodology.

Table I. Result Analysis of Proposed Methodology

Input Image	TDR	ERD	PSNR
	1	0	10.75
	0.55	0.45	11.79
	0.87	0.13	11.299
	1	0	12.86
	1	0	13.536
	0.91	0.09	10.94
	0.69	0.31	10.94

Table II represents the comparative performance evaluation with respect to existing work.

Table II: Comparative Performance Evaluation

Techniques	CNN [1]	CNN-LSTM (Proposed)
Accuracy	80%	83%
ERD	20%	17%
PSNR	10.52	11.84

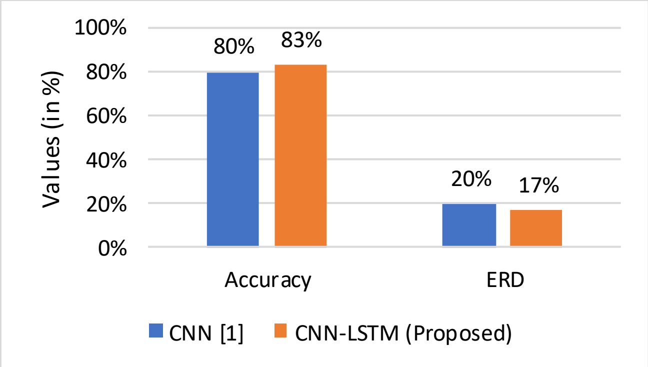

Fig. 3. Comparative Performance Evaluation

Figure 3 represents the comparative performance evaluation of proposed CNN filter and feature extractor-based LSTM classifier with respect to existing work for fingerprint recognition.

V. CONCLUSION

In this paper, the work is focused for development of fingerprint identification as well as recognition system. The proposed methodology is performed in two steps basically as image processing and recognition. In this work dataset is used here is FVC2002 dataset. Further input images are enhanced in the image processing stage by convolution neural network. After the image has been processed, minutiae features and CNN features are extracted and fed into the LSTM classifier in order to train the network. After training, the LSTM network is ready to perform the identification or recognition operations. Specifically, this algorithm is designed to recognize pores in a small image block. Taking advantage of the CNN features, learning capability of LSTM classifier, the proposed method would be able to achieve an efficient detection rate for partial fingerprint also. The result analysis is performed using three parameters i.e. Accuracy, Error detection rate and PSNR value. The evaluation of accuracy is approx. 83% which is 3% enhancement over existing work. The future work is to develop a high-resolution fingerprint recognition framework that better utilizes the CNN features. In future, work will be focused on enhanced of accuracy rate for partial fingerprint images.

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