Fingerprint Recognition Out of Object's Surface Using Ordinary Cameras with the Aid of Magnifier

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Fingerprint Recognition Out of Object's Surface Using Ordinary Cameras with the Aid of Magnifier

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Abstract— **Detection and recognition have higher accuracy using learning-based methods but not the fastest. Template matching design is faster than leaning based design. Especially when there are no enough leaning data, there are no options except using matching methods. This paper tries to introduce a method for finger print recognition using few images per subject based on template matching techniques out of object's surface. Here there is just one sample as target and there might be few or even just one sample as input to match. The point here is the speed and mobile capability of the system but the most important part of this research is to using magnifier which is added to the capturing device which is an ordinary phone here. LG-K10 2017 smart phone is used in this research as main capturing device. Also, system is android based which with adding a magnifier could be a proper cheap field experiment tools in surveillance and security applications. To have better fingerprint recognition out of object's surface, proper preprocessing techniques helps to have higher accuracy which this paper employed this fact very well. Also, this research does not use any chemical material like powder to aid the recognition process which has cost and time advantages. experiments show that matching using magnifier and proper preprocessing techniques have 25% improvement versus normal capturing.**

Keywords- Template matching; Finger print recognition; object's surface; Smart phone; Magnifier; Surveillance and security

I. INTRODUCTION

The need to an instant finger print recognition system [13] out of object's surface always was an issue. This issue is possible to be fixed using fast approached like expensive ray-based sensors or using chemical powders which takes significant amount of time to reveal the finger print. First approach is fast but expensive and second approach is slow but less expensive. Proposed method is cheap, fast and portable. Our system uses ordinary cameras which a magnifier is attached to it to aid the recognition process. Using proper preprocessing techniques and having just one sample, it is possible to match the final template with the input template so fast in the proposed system. This type of system is applicable in surveillance and security specially in the crime scene which there are just few samples per person. Proposed research works best on images extracted out of glass, plastic and iron surface in the experiment field. The paper is consisting of V sections. Section I pays to introduction and materials. Section II explains some of the recent prior related researches. III section demonstrates the proposed method in details. Section IV belongs to experiment results and final V section consist of conclusion, discussion and future works.

A. Finger print recognition

One of the most famous identity recognition methods is finger print recognition [13]. There are other identity recognition methods such as face recognition [14], iris recognition [15], gesture recognition [16], voice recognition [17] and more, but the most usable and handy method is finger print recognition. Here we are talking about recognition, not detection. Detection is differentiating between two or more non similar objects like faces and fingers or even cars. Recognition is the differentiating between two or more similar objects like fingers of different persons or different person's faces or even cars. So, this research is about distinguishing different people finger prints which is called fingerprint recognition.

B. Different places of finger print marks

This research is not about usual learning based finger print recognition systems. These amounts of data almost not available and is repetitive research. So, there must be other ways to do this with lower amount of data, even two or three finger print sample per person. In such circumstances, learning based system is meaning less and matching based systems toke the lead. Actually, with having proper preprocessing techniques and just 75% of finger print, it is possible to have nice recognition accuracy per person. This research is about finger print recognition out of object's surface without touching it in real time and real experiment field. Finger print mark has long term effect of glass, iron, plastic and tape materials which also are exist almost everywhere. Figure 1 shows finger print marks on different objects and materials.

C. Template or pattern matching

The estimation between similarity of an image as template with another scene included same type of image inside of the scene is called template matching [18]. Here, finger print templates searches inside the output scene which included finger print marks and the one with the highest similarity

would be chosen. Figure 2 shows template matching using 2-dimensional correlation coefficients [19] as Equation (1) represents.

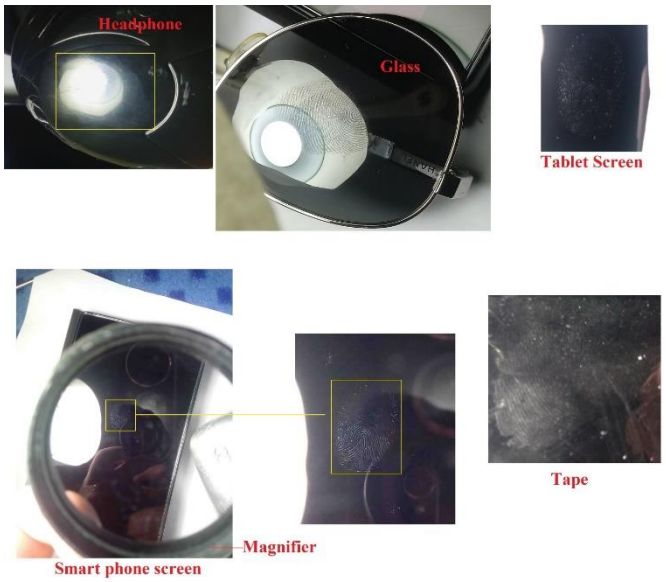

Figure 1. Finger print marks on different objects and materials

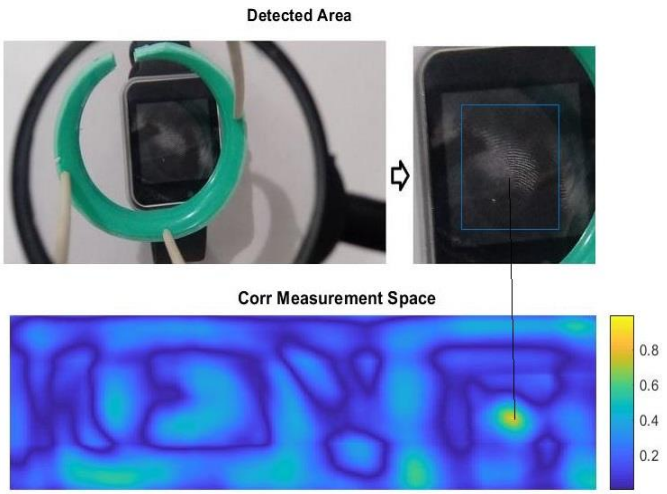

Figure 2. Template matching using 2- dimensional correlation coefficients

$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{(\sum_m \sum_n (A_{mn} - \bar{A})^2)(\sum_m \sum_n (B_{mn} - \bar{B})^2)}} \quad (1)$$

Where $\bar{A}$ = mean2 (A), and $\bar{B}$ = mean2 (B).

II. PRIOR RELATED RESEARCHES

Due to saving space and higher readability of the paper, the prior related researches on finger print recognition out of object's surface are presented in Table I. Some of the are learning based and some of them are matching based systems. As it is clear in Table I, they used different sensors for capturing their datasets which mostly are smart phones cameras. Also, number of subjects are different.

TABLE I. PRIOR RELATED RESEARCHES ON FINGER PRINT RECOGNITION OUT OF OBJECT'S SURFACE

Refs.	Capturing tool	Subjects	Year
[1]	Nokia N8 iPhone 4 Samsung S1	25	2008
[2]	Webcams from Apple, Microsoft, Philips	6	2009
[3]	Samsung Galaxy I, Nokia N8	25	2013
[4]	Canon PowerShot Pro1 (8 mp)	-	2007
[5]	Cannon PowerShot A75, resolution 110dpi	43	2009
[6]	Mobile phone camera	13	2015
[7]	Nokia 6700 classic (5 mp), HTC magic (3.5 mp)	13	2013
[8]	Webcam	12 images	2008
[9]	Apple iPhone5 (8 mp)	5100 images	2016
[10]	Samsung Nexus S, Galaxy Nexus	41	2012
[11]	Nokia N8, iPhone 4, Samsung Galaxy S	2100 images	2013
[12]	Samsung Note III	136	2018
OUR	LG - K10 2017	150	2019

III. PROPOSED METHOD

First a magnification system is made to capture more details from surfaces. It consists of magnifier, phone grabber, chop sticks and other necessary staffs. Figure 3 represents the structure of the proposed magnification capturing system. Also, Figure 4 shows proposed attachment gadget system in action. LG K-10 smart phone camera sensor is used in the research as main capturing device in High Definition (HD) mode. The proposed method starts in data acquisition and preprocessing [20], [21] stages. After receiving data in online or offline mode, the input image frames should convert to grayscale mode for faster computation. Then it is time to enhance the contrast to have more details. Third step is applying median filter followed with sharpening filter for clearer details. The final step of preprocessing is morphology erosion [22], [23] operation to remove unwanted pixels from finger print mark as Figure 5 shows these steps from a finger print mark out of smart watch glass. To make the system more applicable and handier, an android based version of it is made which works in online stream or recorded offline modes. As Figure 6 shows, it is possible to even make the templates and load them. After finger detection and recognition, recognition accuracy along with subject's number will returns as the output. System matches the template with all loaded templates and returns the higher accuracy and number of subjects belong to that finger print mark. Any recognition accuracy above 80 % consider to be a good match and above 90% is called perfect match. System performs on images extracted from glass, Iron and plastic very well. This system works with any android phone with operating system above 4.0 and it is so fast in real time computation. Proposed system uses simply based on 2-dimensional correlation coefficients [19].

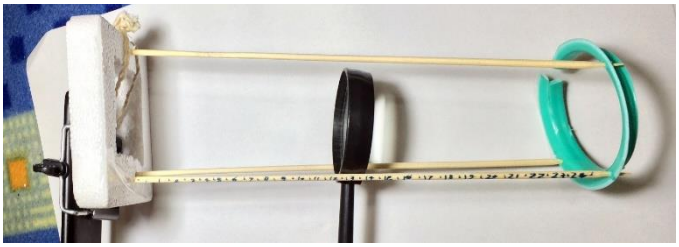

Figure 3. Proposed magnification capturing system

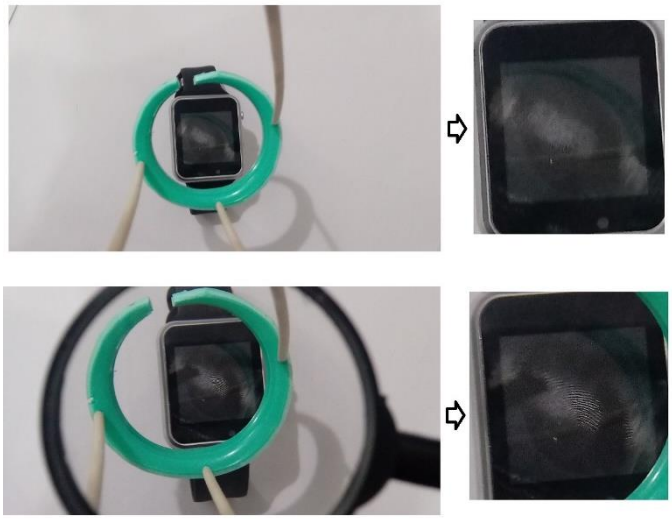

Figure 4. Proposed attachment gadget system in action (with and without magnification)

Figure 5. Employed steps for preprocessing

IV. VALIDATION AND RESULTS

System is tested with 15 subject's finger prints of five type of fingers. System matched the input images with the output image and returns the highest matching accuracy and its relative subject number. Also, sensitivity of the system in different thresholds of 30, 40, 50, 60 and 80 is consider for better understanding of system's performance. To have higher details on output, precision and recall [24] are calculated which their structure is demonstrated in Figure 7. The result of finger print recognition out of each material are shown in Tables II, III and IV which are glass, iron and plastic respectively. As it is clear in Tables II, III and IV, the higher accuracy is belonging to glass material and lowest to plastic. However, Iron placed in the middle. The results of Tables are calculated and averaged for all 15 subjects. Figure 8 presents graphical chart for proposed method's result using magnifier in five different thresholds. Also, Table V represents the acquired results from other methods versus proposed method's result.

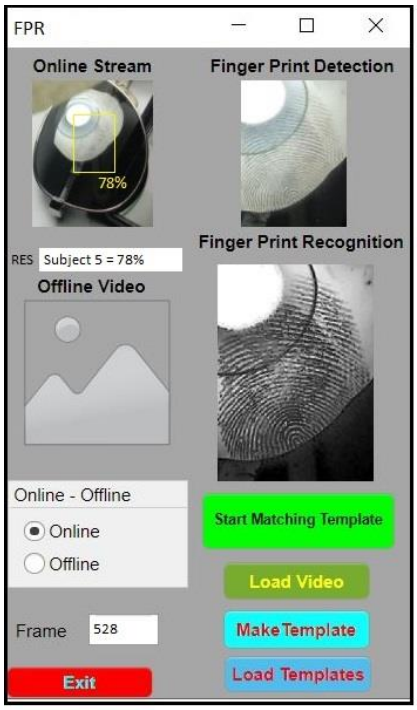

Figure 6. Proposed android GUI for proposed finger print recognition system out of object's surface

$$\text{Precision} = \frac{\text{True Positive}}{\text{Actual Results}} \quad \text{or} \quad \frac{\text{True Positive}}{\text{True Positive + False Positive}}$$

$$\text{Recall} = \frac{\text{True Positive}}{\text{Predicted Results}} \quad \text{or} \quad \frac{\text{True Positive}}{\text{True Positive + False Negative}}$$

$$\text{Accuracy} = \frac{\text{True Positive + True Negative}}{\text{Total}}$$

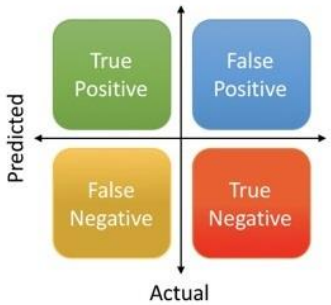

Figure 7. Precision, Recall and Accuracy

TABLE II. GLASS SURFACE RESULT

Threshold	Accuracy (with magnifier)	Precision (with magnifier)	Recall (with magnifier)	Accuracy (without magnifier)	Precision (without magnifier)	Recall (without magnifier)
30	89.6 %	88.3 %	87.1 %	84.2 %	85.1 %	84.6 %
40	90.6 %	90.3 %	90.2 %	86.7 %	86.7 %	86.9 %
50	91.8 %	91.7 %	91.8 %	87.1 %	87.5 %	88.4 %
60	90.9 %	90.7 %	89.6 %	85.3 %	85. 7%	85.3 %
80	87.3 %	87.9 %	88.1 %	81.8 %	82.8 %	82.4 %

TABLE III. IRON SURFACE RESULT

Threshold	Accuracy (with magnifier)	Precision (with magnifier)	Recall (with magnifier)	Accuracy (without magnifier)	Precision (without magnifier)	Recall (without magnifier)
30	86.3 %	86.3 %	86.6 %	80.6 %	81.7 %	81.5 %
40	86.4 %	87.5 %	87.2 %	82.2 %	81.7 %	82.6 %
50	87.8 %	88.4 %	87.7 %	83.3 %	81.5 %	82.4 %
60	85.5 %	85.7 %	86.8 %	80.3 %	80. 5%	80.3 %
80	84.5 %	85.4 %	85.3 %	79.6 %	78.8 %	80.8 %

TABLE IV. PLASTIC SURFACE RESULT

Threshold	Accuracy (with magnifier)	Precision (with magnifier)	Recall (with magnifier)	Accuracy (without magnifier)	Precision (without magnifier)	Recall (without magnifier)
30	83.1 %	82.2 %	83.1 %	79.1 %	79.8 %	79.5 %
40	84.2 %	84.5 %	83.3 %	79.3 %	79.5 %	78.6 %
50	82.4 %	82.4 %	84.5 %	78.7 %	79.8 %	77.9 %
60	79.2 %	78.1 %	78.8 %	75.5 %	74. 5%	75.4 %
80	77.4 %	76.4 %	76.9 %	73.8 %	73.7 %	74.3 %

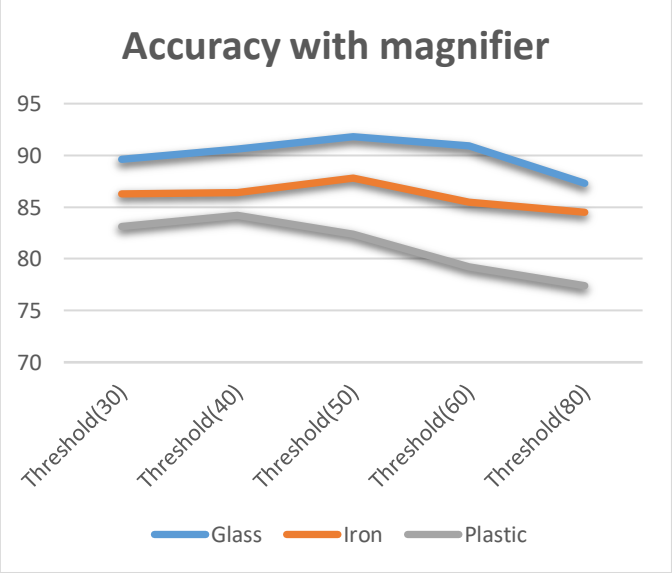

Figure 8. Proposed method's result (accuracy with magnifier)

V. CONCLUSION, DISCUSSION AND SUGGESTIONS

Proposed system showed decent performance on finger print recognition out of object's surface in comparison with other similar researches. Due to its matching mechanism it performs so fast but with less accuracy in comparison with learning-based systems. Mobility and handy feature of the system make it available to use in almost each circumstance. System showed that using magnifier increases the accuracy till 25% more. System could be modified for educational purposes as it has mobile capability. System uses correlation coefficients method to recognize which could be better with other recent algorithms. Stronger magnifier with higher magnification is recommended for future works.

TABLE V. ACQUIRED RESULTS FROM OTHER METHODS VERSUS PROPOSED METHOD'S RESULT

Refs.	Capturing tool	Performance	Subjects
[1]	Nokia N8 iPhone 4 Samsung S1	Accuracy = 97.4% Accuracy = 98.43% Accuracy = 97.25%	25
[2]	Webcams from Apple, Microsoft, Philips	FAR = 0.18% FRR = 10.29%	6
[3]	Samsung Galaxy I, Nokia N8	Highest EER 23.6%	25
[4]	Canon PowerShot Pro1 (8 mp)	Accuracy = 95.44%	-
[5]	Cannon PowerShot A75, resolution 110dpi	PCA 3.16% LDA 1.74%	43
[6]	Mobile phone camera	Controlled Environment Detection rate = 82.98% Uncontrolled Environment Detection rate = 78.21%	13
[7]	Nokia 6700 classic (5 mp), HTC magic (3.5 mp)	Accuracy = 77.95%	13
[8]	Webcam	FAR = 0.042% FRR = 3.92%	12 images
[9]	Apple iPhone5 (8 mp)	EER 3.10%	5100 images
[10]	Samsung Nexus S, Galaxy Nexus	EER < 20%	41
[11]	Nokia N8, iPhone 4, Samsung Galaxy S	Highest EER 35.3%	2100 images
[12]	Samsung Note III	Accuracy = 94.2%	136
Our	**LG K-10 2017**	**Accuracy (average)** **Glass = 90 %** **Iron = 86 %** **Plastic = 81 %**	**15**

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