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Study and Analysis of Environmental Noise and Its Impact on Fingerprint Image

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***Abstract*— In this digital era, biometric traits are used extensively in person authentication system (PAS) due to their uniqueness and permanence. The task of achieving accurate and reliable fingerprint identification is very challenging and depends heavily on the quality of the fingerprint images which in turn depends on the type and amount of noise present. The biometric data collected during registration or identification stage is subjected to various environmental conditions. This variation degrades the performance of Biometric Authentication System. To address this issue a study has been conducted to analyze the impact of environmental variations on biometric trait.**

***Index Terms* – Biometric traits, Fingerprint identification, FRR, Gaussian noise, MSE and PSNR .**

I. INTRODUCTION

Person authentication refers to associating a particular individual with an identity. Every individual has set of unique features(traits) or personal attributes which can be used to distinguish a person. Some of the commonly used biometric traits are, fingerprint, the pattern of a retina, and voice characteristics. This unique feature helps to address many questions such as, Is this the individual who he or she claims to be?, Should this person be given access to carry out this transaction? Is this person authorized to access this system? etc. So, it is very important to have highly accurate automatic personal authentication systems to either determine or confirm the identity of individuals requesting their services. The main purpose of such systems is to ensure that the rendered services are accessed by a legitimate user, and not anyone else. These systems are helpful in ensuring that only legitimate users are allowed to access the rendered services, and not anyone else.

Traditional approaches like knowledge-based security systems (passwords) and token-based security systems have a number of disadvantages as they are not based on any inherent features or attributes of an individual. Simple passwords may be guessed by illegitimate users. Difficult passwords are hard to recollect and may be forgotten by legitimate users. ID cards may be lost, stolen or misplaced. Therefore they are unable to satisfy the security requirements of our electronically interconnected information. The outgrowth of biometric authentication systems has addressed the problems present in traditional verification schemes. Biometrics is a more reliable indicator of identity than traditional systems based on passwords and PINs.

Among various biometric technologies, fingerprints have high reliability and have been extensively used by forensic experts in criminal investigations. There are several factors which influence the quality of a fingerprint image, such as, acquisition device conditions (e.g. dirtiness, sensor and time), individual artifacts (e.g. skin environment, age, skin disease, and pressure), etc.

The main objective of this work is to analyze the effect of environmental variations on fingerprint recognition systems. The analysis helps us to understand how the fingerprint image quality is affected in low temperature environment.

The paper is prepared into 5 sections such that: section 2 describes off-line analysis, section 3 describes finger print image quality analysis in off-line analysis, section 4 describes real-time analysis, section 5 describes investigational results and finally section 6 presents conclusion.

II. OFF-LINE ANALYSIS

In the off-line analysis reference fingerprint images are captured from different subjects. Different types of digital image noise are added to each reference image and the resulting noisy or degraded images are stored in a database. Fingerprint matching score is computed between reference fingerprint image and noisy images stored in the database. From literature [1], it is clear that Gaussian noise is caused by natural sources such as thermal vibration of atoms and discrete nature of radiation of warm objects. So, Gaussian noise model is more application for the present work.

A. *Algorithm used in off-line analysis*

Step 1: Capturing Reference fingerprint image of size M*N.
Step 2: Adding Gaussian noise with zero mean and different variances then storing the resulting noisy images in a database.
Step 3: Compute Matching Score with respect to Reference image.
Step 4: Compute MSE & PSNR values of all the noisy images stored in the database.

Two of the error metrics used to compare noisy images with its respective reference images are, the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. The result obtained is as shown in Table 1. The mathematical formulae for the two are,

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2 \quad (1)$$

$$PSNR = 10 * \log_{10}\left(\frac{255}{\sqrt{MSE}}\right) \quad (2)$$

Where *I(x,y)* is the original image(clear fingerprint image), *I'(x,y)* is the approximated version (noisy fingerprint image) and *M, N* are the dimensions of the images. A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR.

Noisy fingerprint images	***Variance used***	***Matching score***	***MSE***	***PSNR In dB***
Reference image	-		0	99
1.	0.1	10000	9401	12.40
2.	0.2	8724	11169	10.00
3.	0.3	4777	12532	8.82
4.	0.4	3356	13590	8.13
5.	0.5	893	14454	7.64
6.	0.6	583	15108	7.26
7.	0.7	92	15722	6.95
8.	0.8	0	16176	6.75
9.	0.9	124	16552	6.58
10.	1.0	0	16917	6.45

Table 1: Image quality metrics computed for a reference image in the off-line analysis

III. Real-time analysis

From the literature [6], it is observed that most of the fingerprint devices have an issue of FRR during winter or rainy season. This may be because of the reason that skin becomes hard and dry during winter and during rainy season. To find the impact of cold environment on fingerprint images an experiment is conducted by pouring crushed ice inside the container and the subjects were asked to place their finger in the finger inserting section. As the cold temperature of ice passes through the local area of finger inserted, the finger ridges starts becoming stiff. The experiment was carried out between 1°C to 20ºC and the images were captured for everyone degree raise in temperature. The ridge thickness or brightness is varied in the cold environment as shown in Figure 2.

Figure 2: Image a, c represents reference images of subject 1 and subject 2 captured at room temperature (28ºC). b, d are the degraded images of subject 1 & 2 captured at 2°C and 11°C.

IV. Results

The database consists of fingerprint images acquired from 5 subjects (22 samples/subject, total 110 samples) using optical fingerprint scanner. From the database, 2sample/subject is used as reference image and 20 fingerprint images captured at different temperatures are used for testing and to demonstrate recognition performance of fingerprint recognition system in cold environment. False rejection ratio defined as number of false rejections divided by number of identification attempts is calculated. Table 2 indicates the false rejection ratio at different temperatures analyzed by the results obtained for 5 subjects.

Temperature In ºC	1-10	11-13	14-16	17	18	19-20
FRR In %	100	80	75	60	20	0

Table 2: FRR for images captured during cold environment

V. Conclusion

A study based on the impact of cold environmental condition on fingerprint images has been made in this paper. It is evident from the experimental results that the fingerprint images captured at low temperature (between 1-15ºC) are degraded resulting in increase in the FRR. From the image quality metrics such as MSE, PSNR it is clear that the degraded images are due to the presence of Gaussian noise.

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