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Comparing the Quality of Fingerprint Images by Two Different Sensors

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Introduction

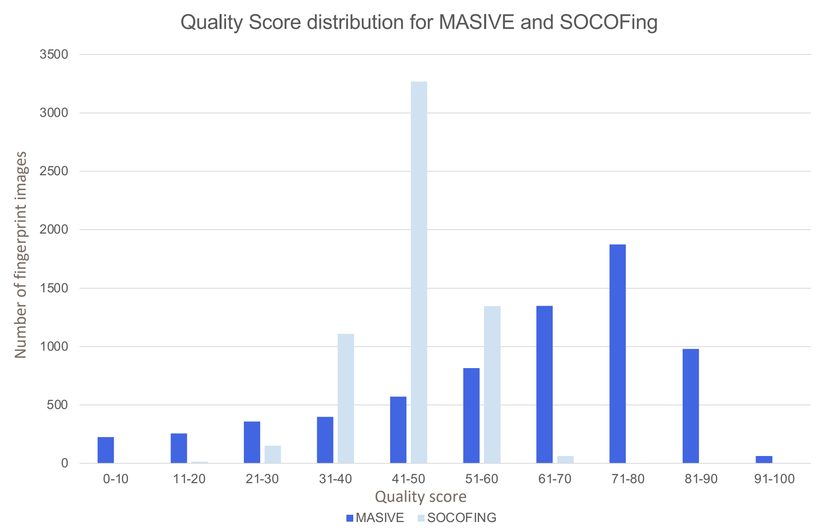
In the world of biometric security, fingerprint recognition is considered a backbone, playing an important role in identification and authentication systems across the world. The effectiveness of these systems mainly depends upon the accuracy and reliability of fingerprint image acquisition, a process promoted by the availability of an array of sensor technologies such as optical, light-emitting, capacitive and many more. Given the crucial nature of fingerprint-based authentication, the quality of the captured fingerprint images is important. High-quality images increase the chances of accurate matches in recognition algorithms, which leads to higher security and efficiency of biometric authentication systems.

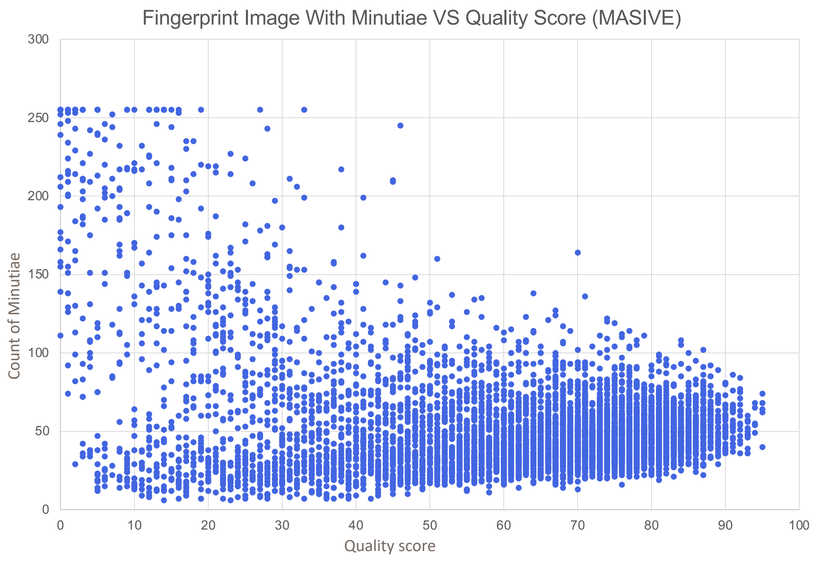
This project aims to contribute to this field of research by conducting a comparative analysis of fingerprint images obtained from two different sensors: optical sensors and light-emitting sensors. Using two existing fingerprint datasets such as MASIVE[2] collected using a light-emitting sensor and SOCOFing[3] collected using an Optical sensor, this analysis will focus on assessing the quality of images based on relevant metadata such as gender, hand and finger type shared by both datasets and address challenges with image resolution and propose a practical solutions to enhance fingerprint image quality. The quality assessment of fingerprint images will be performed using the NFIQ2.

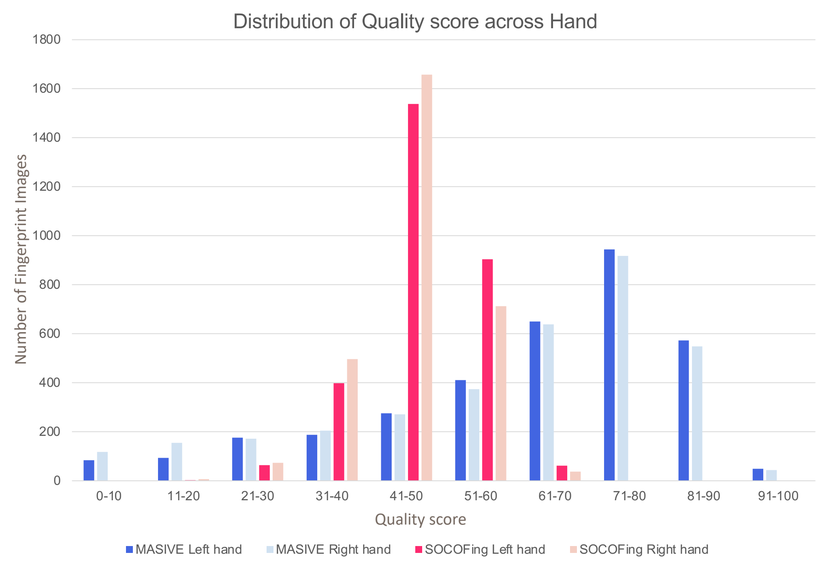
DATASETS

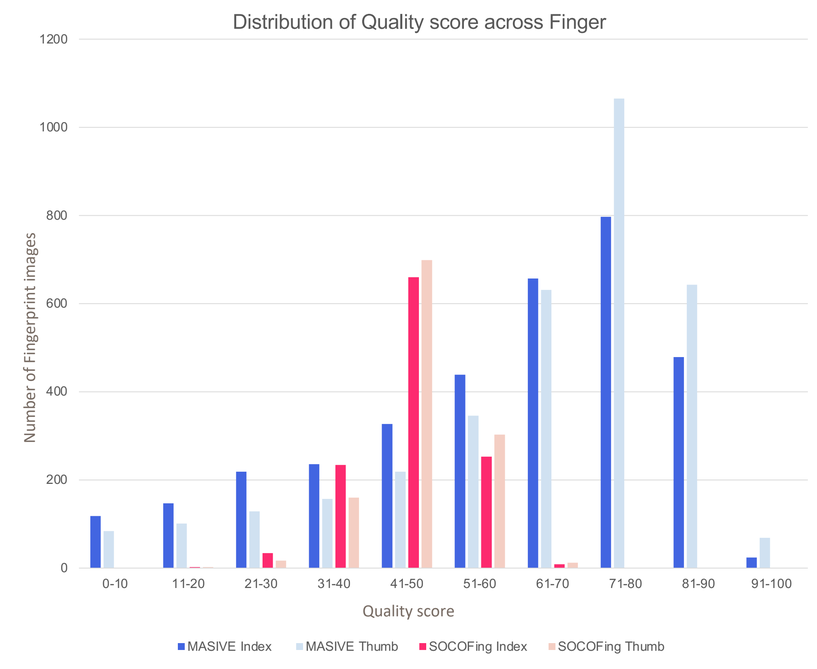
MASIVE	SOCOFing
This dataset contains fingerprint images of Nigerian volunteers, collected in Nigeria in operational settings that are similar to those of the National elections which are conducted outdoors	Sokoto Coventry Fingerprint Dataset (SOCOFing) is a biometric fingerprint database designed for academic research purposes.
Dataset collected using Light-emitting sensor(LES) technology.	Dataset collected using Optical Sensor technology.
Scanner Used: Integrated Biometrics' Columbo 500 PPI single fingerprint scanner	Scanner Used: Hamster Plus (HSDU03PTM) and SecuGen SDU03PTM sensor scanner
The age of participants 18 (inclusive) to 99 years.	The age participants are 18 years and more.
Metadata includes gender, hand, age, finger type, occupation, physical condition of dingers, and environmental factors like humidity and temperature.	Metadata includes gender, hand and finger type.
For all participants, the fingerprint images collected were the index fingers and thumbs of both hands.	There are 10 fingerprints per participant which include little, ring, middle, index and thumb of left and right hand
Total 288 participants	Total 600 participants.
12,000+ fingerprint images	6,000 fingerprint images
Unpublished dataset	Published dataset
Available with University of Dundee	Available at Kaggle.com

Analysis









Methodology

- **Data Collection:** SOCOFing- Publicly available on Kaggle and MASIVE is an unpublished dataset with the University of Dundee.
- NFIQ2 Tool is used to extract Quality scores and features of fingerprint images.
- **Data Preparation:** Fingerprint images need to be prepared as an Input to a standardized format for NFIQ2. Images should be grayscale, 500 PPI and acceptable fingerprint extensions such as BMP and PNG.
- The MASIVE dataset was already in an acceptable format. SOCOFing images had to be improvised as they have 72 PPI and also they had different colour scales.
- **Data Processing:** A script was used to automate the processing of the image dataset through NFIQ 2.0, generating scores for each image. This script is capable of handling batch input to streamline the assessment of large datasets.
- **Data Analysis**: Data Analysis is performed using Python, pandas, and the Tableau tool. Statistical Analysis, comparative analysis and correlation analysis are performed to summarise dataset quality, identify significant differences in image quality across sensor types and metadata.

Discussion or conclusions

- The light-emitting sensors are better at capturing high-resolution images which helps in high-quality scores compared to optical sensors.
- Fingerprint images from SOCOFing Dataset need a lot of refinishing to be accepted by NFIQ2 quality standards.
- For both sensors, the Left-Hand shows a higher quality score compared to the right hand.
- Fingerprint minutiae are the minute characteristics of friction ridge skin that make the forensic use of fingerprint identification possible. But a higher minutiae count does not mean the quality score will be high as well.
- Thumb Fingerprints have high-quality scores in both datasets compared to other fingers.

Future work:

- Gather more metadata related to fingerprint images by optical sensors so they can be compared for environmental conditions as well.
- Enhance fingerprint image quality by changing image characteristics using Gabor filters or deep learning models.

References

[1] National Institute of Standards and Technology. "NIST Fingerprint Image Quality (NFIQ) 2.0" Internet: https://www.nist.gov/services-resources/software/nfiq-2, [12 November 2021]

[2] O. Samuel, I. Martin and L. Magerand, "Verification Failures: Assessing the Sample Quality of Fingerprints collected in an African Election Setting," *2022 International Conference of the Biometrics Special Interest Group (BIOSIG)*, Darmstadt, Germany, 2022, pp. 1-4, doi: 10.1109/BIOSIG55365.2022.9896973.

[3] Shehu, Y.I., Ruiz-Garcia, A., Palade, V., James, A. (2018) "Detection of Fingerprint Alterations Using Deep Convolutional Neural Networks" in Proceedings of the International Conference on Artificial Neural Networks (ICANN 2018), Rhodes – Greece, 5th - 7th October 2018. Springer-Verlag Lecture Notes in Computer Science.