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Novel contactless fingerprint scanner for Legal Enforcement Agencies

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Abstract

Biometric recognition systems integrated into mobile devices have gained acceptance during recent years. Authorities are particular interested on mobile contactless solutions due to many reasons: officers can acquire data wherever they are, solutions are generally easy to use, hygiene and no latent data is present. This paper presents a new mobile contactless fingerprint sensor which uses a liquid lens integrated with a TOF sensor. The device was used by the national police to acquire data of refugees. Matching results show promising results, while police officers expressed their satisfaction about the developed prototype.

1. Introduction

Contactless (CL) and mobile-embedded biometric recognition systems have made considerable progress and gained acceptance in recent years. Advantages of CL devices are high-user acceptance, no latent data is present in the acquisition device, hygienic reasons, less effort to acquire data, usability and speed. On the other hand, mobile devices also present many advantages: portability, more productivity and higher efficiency of the end-user, and the possibility to acquire data on different locations, i.e. unconstrained capturing environment. This paper presents a new mobile CL fingerprint (FP) sensor which uses a liquid lens integrated with a Time-of-Flight (TOF) sensor. A liquid lens substitutes a static optic glass lens and it has not any mechanical parts inside. Liquid lens are controlled cells containing a transparent fluid capsule. Changing the shape of the cells, the focal length is changed within milliseconds. Despite the advantages of liquid lens ((i) no moving parts inside the lens, (ii) one lens can deliver different focal lengths, (iii) good image quality, and (iv) speed), not much work was reported. Oku and Ishikawa [6] reported a high-speed liquid lens and its applications in different computer vision applications. Tsai et al. [10] used a liquid lens to acquire finger images. Their approach applied a strong illumination and a small distance between the lens and the fingertip to minimize environmental distortions. Recently, Jun and Won [4] used a liquid lens together with chromatic aberration to improve accuracy in depth-measurement of real 3D objects. The main contribution of this paper is the introduction of an operative mobile CL device aimed for police use. The device uses a liquid lens combined with a TOF sensor. The fully functional CL prototype is a mobile FP capturing tool aiming to optimize the process carried out by national police officers. To show the feasibility of the developed prototype, results of a matching comparison on real FP data are presented. This paper is organized as follows: Section 2 describes the developed prototype, the processing of the finger images and acquired data. Results are discussed in Section 3. Concluding remarks are summarised in Section 4.

2. Processing Chain

2.1. Developed device

We developed the capture device under various requirements: (i) to be mobile and contact-less, (ii) to record high quality images, (iii) easy to use, and (iv) the hardware costs should be as low as possible. Active illumination of the fingers during recording is a key feature to achieve a sufficiently strong contrast between the ridges and valleys of the fingertips. We use a daisy chain to connect 64 colour LEDs arranged in a U-shape with 45 degrees. The arrangement of the light emitting elements ensures a uniform illumination and provide sufficient illumination to all four fingers of a single hand. The camera sensor delivers grey-scale

Figure 1. Left image: contactless fingerprint capture device. Right image: device usage.

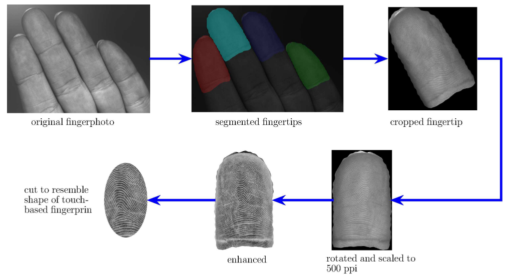

Figure 2. Overview of the processing pipeline.

images (3052×2015 pixels @ 10 fps). The sensor is connected via a USB3 interface to the processor. The minimum distance between the sensor and finger is 105 mm and the maximum is 175 mm. The camera sensor is supplemented by a TOF sensor to measure the distance of the fingers to the sensor. Thus, the most suitable focal plane can be targeted to capture sharp fingertips. We integrated a digital variable-focus liquid lens into the device which enables the acquisition of the fingers at pre-elected focal planes and within 5 ms a new focal plane can be reached. Fig. 1 shows the developed device. In order to capture images consisting of the detailed topology of the fingers we configured the camera in fast exposure modes with low apertures. In a pre-processing step, a flat-field correction [8] is carried out to cancel the effects of image artifacts caused by variations in the pixel-to-pixel sensitivity of the sensor, and the images are rectified to correct for lens distortions [11].

2.2. Image processing

The processing pipeline is depicted in Fig. 2. The fingertips are segmented using a Mask R-CNN [3], which is a two-stage pipeline for instance segmentation. Manually labeled fingertips images are used to fine tune the pre-trained model. Then, the images are cropped, rotated to a finger upright position, and scaled to 500 DPI (to be compliant to FBI-standards [2]). Because the device works with a small depth of field many images are blurred. Thus, we perform a sharpness evaluation based on edge pixels [1] and images with sufficient sharpness are enhanced to increase the con-

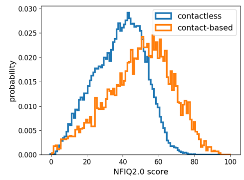

Figure 3. Probability density functions of NFIQ2.0 scores of contactless and contact-based fingerprints.

trast between ridges and valleys by applying a histogram equalization [7]. We use the well-established NFIQ2.0 [9] standard for quality estimation. NFIQ2.0 was developed for touch-based fingerprints and therefore likely not optimal for CL fingerprints.

3. Results

Data was acquired by national police officers using two devices: the developed prototype and a contact-based (CB) fingerprint device[1]. Data (all 10 fingers) of 481 people was acquired. Based on the sharpness value (at least 0.2) [5], the best 6 images of each finger were selected. To acquire 10 fingers the acquisition time is between 45 seconds and 120 seconds in case of the CB sensor, and between 8 seconds and 30 seconds in case of the CL prototype. Recording sessions took place in a national refugee registration center; thus, the dataset is diverse: people came from 4 different continents, and the gender distribution is 68.52% male, 31.32% female and 0.16% not indicated. In order to give an impression of the quality of the captured fingerprints, the distributions of NFIQ2.0 scores are shown in Fig. 3. The biometric performance is evaluated employing the ID-Kit SDK 8.0.1.50. We obtained equal error rates (EER) for different NFIQ2.0 thresholds in both cases, matching CL data against CL data (CL $\rightarrow$ CL) and CL data against CB data (CL $\rightarrow$ CB). When using a NFIQ threshold $>=$ 20, obtained EERs are CL $\rightarrow$ CL = 1.1e-04% and CL $\rightarrow$ CB = 2.7e-04% which are very good values in terms of performance recognition. The end user also expressed their satisfaction with the solution: it is very simple to use, the scanner turns on automatically when the hand is held over it and capturing data seems to be easier and better than using flatbed sensors.

4. Conclusion

This work presented a new mobile CL fingerprint sensor integrating a liquid lens and a TOF sensor, and its usability in a real setting scenario. Real fingerprint data was acquired by national police officers who expressed their satisfaction

[1]Optical fingerprint scanner IDEMIA TP 5300 scanner with 1000 DPI, https://www.idemia.com/palmprint-scanner

with the developed prototype. Acquired data was used to perform a fingerprint matching against data of an official database acquired using a CB device. Promising and encouraging results were obtained showing the feasibility of the prototype for operational police use.

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