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ScienceDirect

Procedia Engineering 87 (2014) 1338 – 1341

Procedia Engineering

www.elsevier.com/locate/procedia

EUROSENSORS 2014, the XXVIII edition of the conference series

An improved Ultrasound System for Biometric Recognition based on Hand Geometry and Palmprint

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Abstract

In this work, an improved ultrasound technique for biometric recognition is proposed. It allows to acquire simultaneously two biometric characteristics: 3D Hand Geometry and 3D Palmprint.
An open research platform is employed as ultrasound imaging system. A commercial high frequency probe is moved in the elevation direction over the region of interest by an automated scanning system based on numeric controlled pantograph.
Experimental results are presented and the advantages of the proposed technique are highlighted and discussed.

Peer-review under responsibility of the scientific committee of Eurosensors 2014
Keywords: Biometrics; Ultrasound system; Image processing; Hand Geometry; Palmprint

1. Introduction

Biometrics is being increasingly used for person recognition in a large number of civilian applications. Among the various biometrics characteristics, Hand Geometry [1] and Palmprint [2] are nowadays well established.

Ultrasound imaging has been experimented in biometric applications due to its intrinsic advantages like insensitivity to surface contaminations (stain, dirt, oil) and capability of providing information of the volume under the skin region.

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Peer-review under responsibility of the scientific committee of Eurosensors 2014
doi:10.1016/j.proeng.2014.11.709

Some of the authors have recently proposed an ultrasound technique, based on the investigation of the human hand, which could be exploited for biometric recognition purposes: a 3D image of the hand is acquired by mechanically shifting a linear array over the region of interest. The technique has been exploited for extracting and evaluating different biometric characteristics as Internal Hand Geometry [3], Palmprint [4] and Hand Vein Pattern [5].

Recently, improved performances have been achieved by exploiting the ULtrasound Advanced Open Platform (ULA-OP) [6] as ultrasound imaging system and a numeric controlled pantograph as scanning system [7]. Anyway, the method proposed in that works allows to acquire only a small Volume Of Interest (VOI), which is limited by the aperture of the array. In this work, the ultrasound technique has been improved to acquire a VOI sufficiently wide to include the whole human hand in a reasonable time.

2. Experimental setup

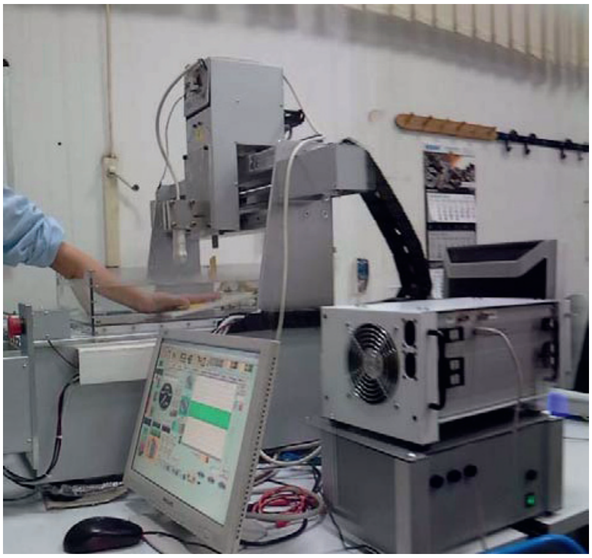

Fig. 1. A photo of the experimental set up.

Fig. 1 shows the experimental set up used for acquiring the 3D ultrasound images. The human hand under investigation is immerged in a basin filled with water and opportunely oriented by means of some pegs. The hand is illuminated by a commercial high frequency (12 MHz) ultrasound probe (LA435 by Esaote S.p.A.), which is immerged as well. As ultrasound imaging system, the ULtrasound Advanced Open Platform (ULA-OP) has been exploited [6]. In order to acquire a 3D ultrasound image of the hand, the probe is moved along the elevation direction by an automated mechanical scanning system based on a numeric controlled pantograph. Anyway, due to the small lateral dimension of the probe (slightly less than 40 mm), a single mechanical scan allows to acquire only a small Volume of Interest. In order to investigate and acquire ultrasound images of wider regions, several parallel mechanical scans have to be performed. A VOI sufficiently large to include the whole hand is acquired through five linear parallel scans. The adjacent scans are partially overlapped to guarantee an effective continuity. To make the acquisition process very fast (about 40 s), the whole VOI is acquired in a single record; the overlapped volumes are then realigned offline and fused using a convex combination, which weights follow a raised cosine law. This operation is necessary since the movement of the probe and the acquisition of the signals are completely asynchronous.

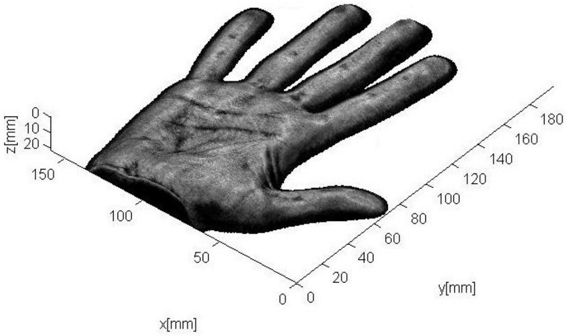

Fig. 2. 3D rendering of a human hand.

3. Results

An ad hoc software written in MATLAB code has been used to process the data provided by ULA OP. The software reconstructs the 3D matrix of pixels representing the acquired volume and is able to provide several 2D and 3D renderings of the human hand.

Fig. 2 shows a 3D rendering of the ultrasound image acquired from an user. It can be exploited to extract simultaneously 3D Hand Geometry and 3D Palmprint, which are expected to be more distinctive than the classical optical 2D ones.

Fig. 3. The ultrasound image with some of the measurements taken in the classical Hand Geometry recognition method.

Fig. 3 shows a 2D view of the ultrasound image. The quality of the image allows to take all the measurements used for the template definition in the 2D cases [1]. They could be increased by exploiting the 3D ultrasound information in order to improve the distinctiveness of the biometric characteristic.

Fig. 4 shows a frontal view of the ultrasound palmprint a) at the water-hand interface, b) 0.1 mm under the skin; the corresponding optical image c) is also reported for comparison. As can be seen, the principal lines and wrinkles can be clearly distinguished. The under skin images can be exploited to provide information of the depth of the various traits, which cannot be extracted with conventional methods.

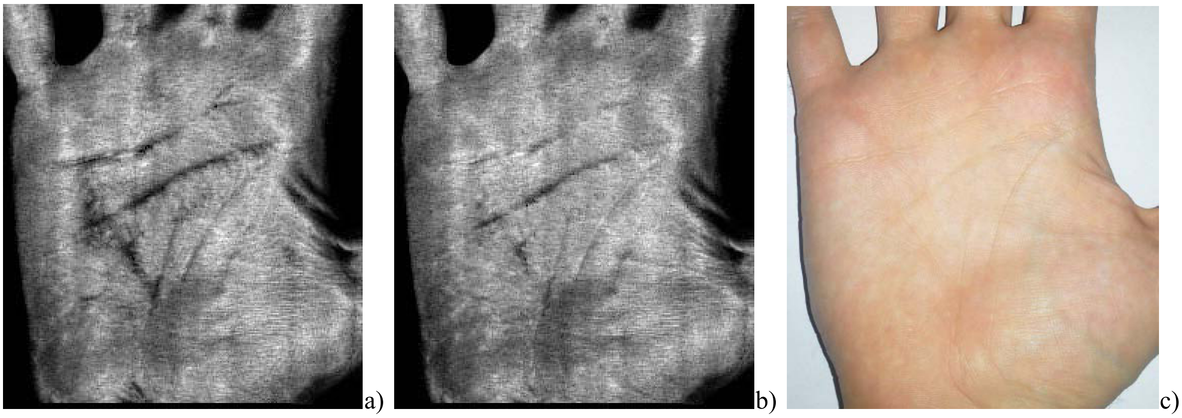

Fig. 3. A portion of the ultrasound image that can be exploited for 3D palmprint recognition; a) at the interface water-hand, b) 0.1 mm under the skin, c) optical palmprint.

4. Conclusion

An improved ultrasound technique for biometric recognition is proposed. It allows to acquire a volumetric image of the human hand by mechanically shifting a linear array over the region on interest. To cover the whole hand, five linear parallel scans have been performed; to contain the acquisition time, the ultrasound data acquisition and the mechanical scan were performed in an asynchronous way and realigned offline.

The method allows to acquire two biometric characteristics: 3D Hand Geometry and 3D Palmprint. These characteristics, if compared to the corresponding optical ones, have several potential advantages: 3D information, which can improve distinctiveness, insensitivity to certain surface contaminations. Furthermore, as they are acquired simultaneously, they are well suited for biometric fusion.

Acknowledgements

This work has been partially funded by the Italian Ministry of Education, University and Research (PRIN 10/11).

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