SDUMLA-HMT: A Multimodal Biometric Database

Yilong Yin, Lili Liu, and Xiwei Sun

School of Computer Science and Technology, Shandong University,
Jinan, 250101, China
ylyin@sdu.edu.cn, ll_liu@yahoo.com.cn, sun_xiwei@hotmail.com

Abstract. In this paper, the acquisition and content of a new homologous multimodal biometric database are presented. The SDUMLA-HMT database consists of face images from 7 view angles, finger vein images of 6 fingers, gait videos from 6 view angles, iris images from an iris sensor, and fingerprint images acquired with 5 different sensors. The database includes real multimodal data from 106 individuals. In addition to database description, we also present possible use of the database. The database is available to research community through http://mla.sdu.edu.cn/sdumla-hmt.html.

Keywords: Multi-modal, Homologous, Biometrics, Face, Finger vein, Gait, Iris, Fingerprint.

1 Introduction

The last decades has witnessed great advances in biometric recognition techniques. And lots of biometric traits have been used for identification authentication, such as fingerprint, face, iris, etc. Currently, biometric recognition system can reach very high accuracy when tested on the open biometric databases. However, due to inherent properties of biometric traits and the constraints of sensing technologies, the performance of individual biometric system is limited. Therefore, many researchers recently put their efforts to multimodal biometric fusion [1][2][3].

Multimodal biometric fusion, which combines two or more biometric traits, is an effective way to alleviate some of the limitations of single biometric system. It can improve the overall matching accuracy and make the biometric systems invulnerable to security threats. There are several approaches to study biometrics fusion. One approach is to use heterogeneous database [3], i.e., combine biometric trait (e.g. fingerprint) from a database with biometric trait (e.g. face) from another database. From the experiment point of view, these combined biometric traits belong to the same person. And the resultant person is called as *chimeric user*. Although this approach has been widely used in multimodal literature, it was questioned that whether this approach was reasonable during the 2003 Workshop on Multimodal User Authentication [4]. Poh et al. [5] studied this problem and showed that the performance measured with experiments carried out on *chimeric users* does not necessarily reflect the performance with true multimodal users. Obviously, the best way to study biometrics fusion is to use homologous multimodal biometric databases, which means the different biometric traits are truly come from the real same person.

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However, there are only a few multimodal biometric databases publicly available. And most of the existing multimodal databases are composed two modalities. BANCA [6] and XM2VTS [7] include face and voice; MYCT [8] includes fingerprint and signature. Besides, there are also several databases including more than two modalities, such as BIOMET [9] which includes face, voice, fingerprint, hand and signature, and BioSec [10] including fingerprint, face, iris and voice. These existing databases have several limitations, e.g., lack of import traits or lack of diversity of sensors/traits. Therefore, we build the SDUMLA-HMT database which is composed of homologous multimodal biometric traits, including face images from 7 view angles, finger vein images of 6 fingers, gait videos from 6 view angles, iris images from an iris sensor, and fingerprint images acquired with 5 different sensors. To the best of our knowledge, gait is the only biometric trait which can be recognized from a far distance, and finger vein is a kind of biometric traits which use information hidden inside of skin. Therefore, gait is non-invasive and it is difficult to conceal or disguise while finger vein cannot be damaged or forged easily. So, it is very profound to add gait and finger vein to the family of multimodal biometric database. The detailed characteristics of the SDUMLA-HMT database are described in Section 2; Section 3 gives conclusions.

2 SDUMLA-HTM Database

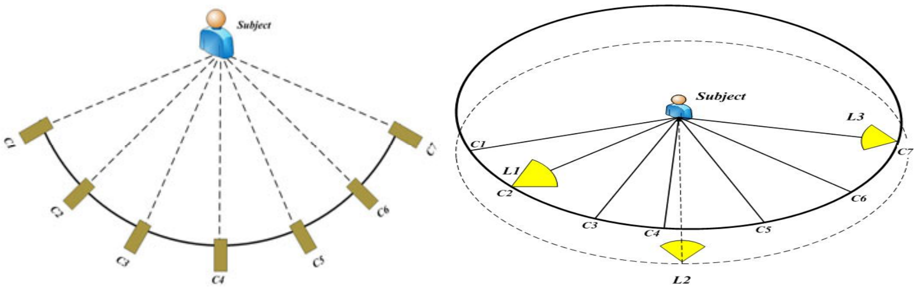
SDUMLA-HMT was collected during the summer of 2010 at Shandong University, Jinan, China. 106 subjects, including 61 males and 45 females with age between 17 and 31, participated in the data collecting process, in which all the 5 biometric traits – face, finger vein, gait, iris and fingerprint are collected for each subject. Consequently, there are 5 sub-databases included in SDUMLA-HMT, i.e., a face database, a finger vein database, a gait database, an iris database and a multi-sensor fingerprint database. It is to be noted that in the 5 sub-databases, all the biometric traits with the same person id are captured from the same subject. We will detail the 5 sub-databases in the next 5 subsections.

2.1 Face Database

Face recognition is a relatively mature technology in biometrics. The face database included in the SDUMLA-HMT is aiming at real-world face recognition. In order to simulate real-world settings, we capture faces with different poses, facial expressions, accessories and illuminations. Section 2.1.1 introduces the carefully designed simulate environment, followed by section 2.1.2 describing the database.

2.1.1 Environmental Setting

Camera Setting: We use 7 ordinary digital cameras to symmetrically capture both sides of the face. As shown in Fig. 1(a), all the cameras are fixed in a circle centered at the subject with radius 50 *cm* and angle interval 22.5°. And the subject was asked to sit towards the center camera *C4*. The height of the cameras is set to be 110 *cm* by tripods. All the 7 cameras work simultaneously.



(a) Camera Setting (b) Illumination Setting

Fig. 1. Environmental Setting

Illumination Setting: To simulate varying illumination condition, we design different illuminations using 3 lamps labeled as *L1*, *L2* and *L3*. As shown in Fig. 1(b), *L1* is nearby *C2, L3* is nearby *C7* and *L2* is under *C4*. It is to be noted that the direction of *L2* is from down to up to the subject. Each time only one lamp is on.

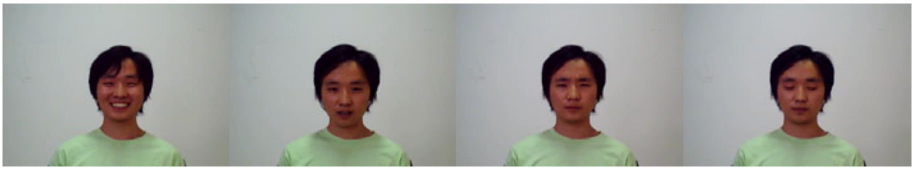
Accessories: To simulate the influences of different accessories, we prepared two common accessories -- a pair of glasses and a hat.

2.1.2 Database Description

Four variations, including poses, facial expressions, illuminations, and accessories, are considered in the face data acquisition process. Using normal illumination, i.e., no lamp is on, face images with 3 type of poses (look upward, forward, and downward), 4 type of expressions (smile, frown, surprise, and close eyes) and 2 type of accessories (glasses and hat) were captured in our face database. And each time with one lamp on, we captured face images with 3 types of illuminations. Sample images of our face database are shown in Fig. 2.

(a) Pose Variation

Fig. 2. Sample images in the face database



(b) Expression Variation

(c) Illumination Variation (d) Accessory Variation

Fig. 2. (*continued*)

The face database contains 7× (3+4+2+3) ×106=8,904 images. All images are 24 bit *"bmp"* files and the size of image is 640×480 pixels. The total size of the face database is 8.8G.

2.2 Finger Vein Database

Finger vein recognition is a recently developed research hotspot. We include in SDUMLA-HMT a finger vein database which, to the best of our knowledge, is the first open finger vein database.

The device used to capture finger vein images is designed by Joint Lab for Intelligent Computing and Intelligent Systems of Wuhan University. In the capturing process, each subject was asked to provide images of his/her index finger, middle finger and ring finger of both hands, and the collection for each of the 6 fingers is repeated for 6 times to obtain 6 finger vein images. Some sample images are shown in Fig. 3.

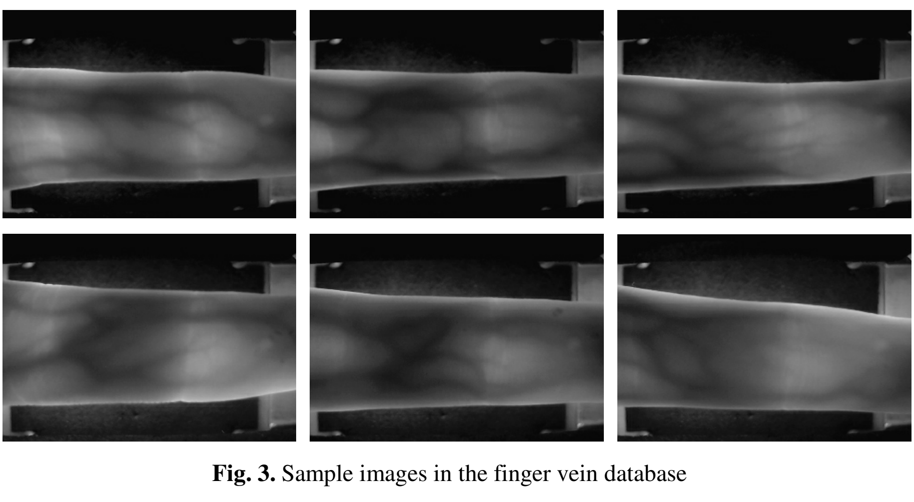


Fig. 3. Sample images in the finger vein database

The finger vein database is composed of 6×6×106=3,816 images. Every image is stored in *"bmp"* format with 320×240 pixels in size. The total size of our finger vein database is around 0.85G Bytes.

2.3 Gait Database

Gait recognition is a newly arisen research area in biometrics. So, there are few open gait databases. To the best of our knowledge, the gait database included in SDUMLA-HMT is one of the largest databases among the existing gait databases, and SDUMLA-HMT is the first multimodal biometric database which contains gait. As the gait capture process needs complicated environment, we first introduce environmental setting in Section 2.3.1, and then describe the details of the gait database in Section 2.3.2.

2.3.1 Environmental Setting

We capture gait data in a specially designed room. As shown in Fig. 4, we assigned 6 ordinary digital cameras labeled *C1* to *C6* along the right hand side of the subject, and all the cameras were fixed in a circle centered at the middle of walking road with radius 6 *m*. Here *C3* was set in the vertical direction of the walking path, and *C2* and *C1* (*C5* and *C4*) symmetrically spread around *C3* with angle interval 22.5°. *C6* was fixed along walking direction to capture the frontal view. To avoid reflection on the floor, we paved an 8*m* × 2*m* sized carpet along the walking path. Besides, a calibration tap with 10*cm* × 20*cm* white-yellow alternative blocks was placed to facilitate the reconstruction of geometry information, and the height of the tap is 2 *m*.

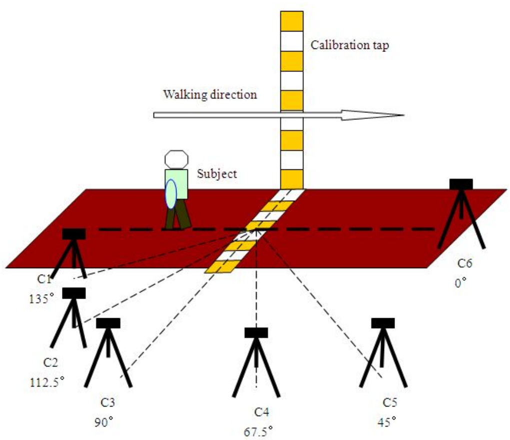


Fig. 4. Environmental setting for gait collection

2.3.2 Gait Database

Three variations, including view angle, accessory and motion type, are considered in the gait data acquisition process. For each subject, we first captured 6 background videos using the 6 cameras before his/her walking. Then the subject was asked to walk naturally along the walking direction for 6 times. After that, the subject was asked to carry a bag and walked twice again. The bag could be a knapsack, a satchel, or a handbag chosen according to the subject's preference. Furthermore, we also recorded twice of the subject's running videos. As a result, there are totally 66 videos recorded for the subject. Fig. 5 shows some sample snapshots of the gait videos.

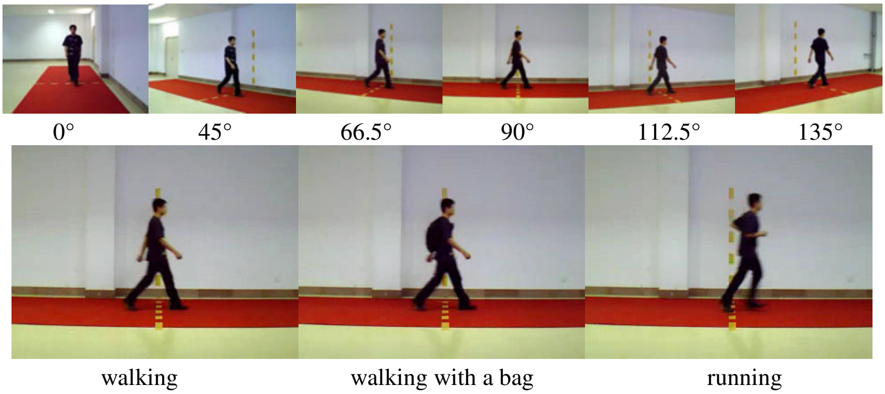


Fig. 5. Sample snapshots in the gait database

The gait database is composed of 6×11×106=6,996 videos in total and each video records about 2 to 3 gait cycles. All the videos are stored in *"avi"* format encoded with XviD codec. The frame size is 320×240 *pixels*, and the frame rate is 25 *frames per second*. The total size of the gait database is about 1.6G Bytes.

2.4 Iris Database

Iris recognition is a top research focus in recent years. Statistical tests made in [11] show that in all the biological characteristics, iris has the most reliable and most stable features. Therefore, we include in SDUMLA-HMT an iris database.

We collected the iris data with an intelligent iris capture device developed by University of Science and Technology of China under near infrared illumination. To avoid reflection, the subjects were asked to take off their glasses and to keep the distance between the eye and the device within 6*cm* to 32*cm*. Every subject provided 10 iris images, i.e., 5 images for each of the eyes. Fig. 6 provides 4 sample images in our iris database.

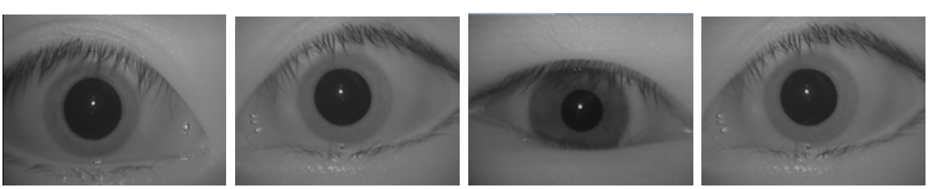


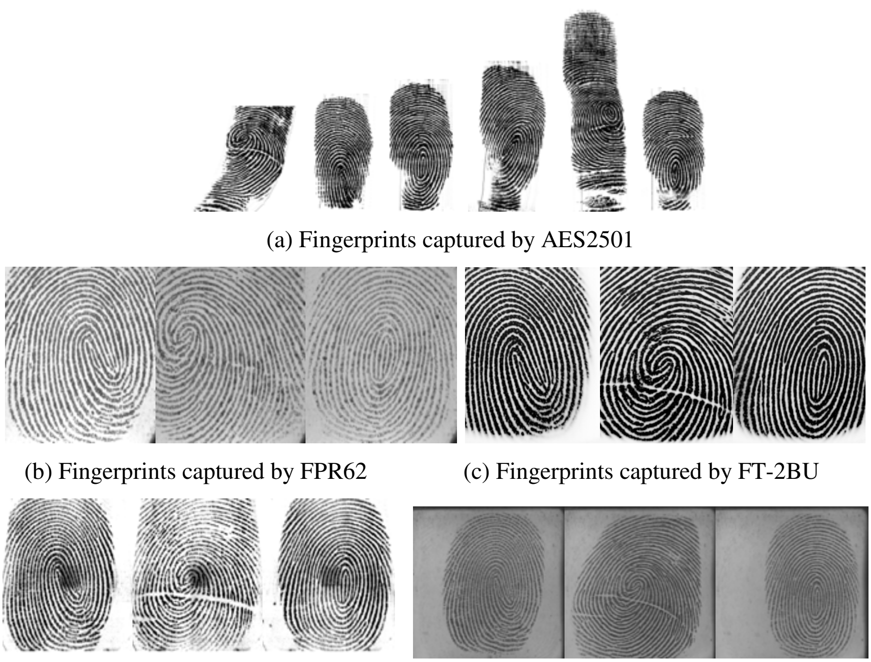
Fig. 6. Sample images in the iris database

The iris database is composed of 2×5×106=1,060 images. Every iris image is saved in 256 gray-level *"bmp"* format with 768 × 576 *pixels* in size. The total size of our iris database is about 0.5G Bytes.

2.5 Multi-sensor Fingerprint Database

Fingerprint is one of the most commonly used biometric traits in biometric authentication. Therefore, we include in a fingerprint database in SDUMLA-HMT. In addition, the fingerprint database acquired with 5 sensors will also enrich research on the sensor interoperability of fingerprint recognition which is a hotspot in fingerprint recognition recently.

Our fingerprint database includes fingerprint images captured from thumb finger, index finger and middle finger of both hands. In order to explore the sensor interoperability, we captured each of the 6 fingers with 5 different type of sensors, i.e., AES2501 swipe fingerprint scanner developed by Authentec Inc, FPR620 optical fingerprint scanner and FT-2BU Capacitive fingerprint scanner both developed by Zhongzheng Inc, URU4000 optical fingerprint scanner developed by Zhongkong Inc and ZY202-B optical fingerprint scanner developed by Changchun Institute of Optics, Fine Mechanics and Physics, China Academy of Sciences. It is to be noted that 8 impressions were captured for each of the 6 fingers using each of the 5 sensors. Some sample images of the fingerprint database are shown in Fig. 7.



(a) Fingerprints captured by AES2501

(b) Fingerprints captured by FPR62

(c) Fingerprints captured by FT-2BU

(d) Fingerprints captured by URU4000

(f) Fingerprints captured by ZY202-B

Fig. 7. Sample images in the fingerprint database

Our fingerprint database contains 6×5×8×106=25,440 fingerprint images in total. Every fingerprint image is saved in 256 gray-level *"bmp"* format but the size varies according to the capturing sensors. Table 1 lists the size of images captured by the 5 sensors. It is worth noting that AES2501 is a swipe fingerprint scanner and the image size varies in different swiping processes, which has been shown in Fig. 7(a). The total size of the interoperability-based fingerprint database is about 2.2G Bytes.

Table 1. Image size captured by the 5 sensors

Sensor	Image Size
AES2501 swipe fingerprint scanner	not fixed
FPR620 optical fingerprint scanner	256×304
FT-2BU capacitance fingerprint scanner	152×200
URU4000 optical fingerprint scanner	294×356
ZY202-B optical fingerprint scanner	400×400

3 Conclusions

In this paper, we describe a homologous multimodal biometric database — SDUMLA-HMT which contains 5 different biometric traits of 106 subjects. This database will be very useful to study different kind of biometric fusions, which is a profound research area of biometric recognition. And the database is available to research community through http://mla.sdu.edu.cn/sdumla-hmt.html.

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References

1. Kittler, J., Matas, G., Jonsson, K., Sanchez, M.: Combining evidence in personal identity verification systems. Pattern Recognition Letters 18(9), 845–852 (1997)
2. Snelick, R., Indovina, M., Yen, J., Mink, A.: Multimodal Biometrics: Issues in Design and Testing. In: Proc. of The 5th International Conference on Multimodal Interfaces (IMCI 2003), Vancouver, British Columbia, Canada (November 2003)
3. Ross, A., Jain, A.: Information fusion in biometrics. Pattern Recognition Letters 24, 2115–2125 (2003)
4. Dugelay, J.-L., Junqua, J.-C., Rose, K., Turk, M. (Organizers): In: Workshop on Multimodal User Authentication (MMUA 2003), Santa Barbara, CA (December 2003)

5. Poh, N., Bengio, S.: Can Chimeric Persons Be Used in Multimodal Biometric Authentication Experiments? In: Renals, S., Bengio, S. (eds.) MLMI 2005. LNCS, vol. 3869, pp. 87–100. Springer, Heidelberg (2006)
6. Bailly-Baillière, E., Bengio, S., Bimbot, F., Hamouz, M., Kittler, J., Mariéthoz, J., Matas, J., Messer, K., Popovici, V., Porée, F., Ruiz, B., Thiran, J.-P.: The BANCA Database and Evaluation Protocol. In: Kittler, J., Nixon, M.S. (eds.) AVBPA 2003. LNCS, vol. 2688, Springer, Heidelberg (2003)
7. Poh, N., Bengio, S.: Database, protocols and tools for evaluating score-level fusion algorithms in biometric authentication. Pattern Recognition 39, 223–233 (2006)
8. Ortega-Garcia, J., Fierrez-Aguilar, J., et al.: MCYT baseline corpus: a bimodal biometric database. IEEE Proc. Vis. Image Signal Process. 150, 395–401 (2003)
9. Garcia-Salicetti, S., Beumier, C., Chollet, G., et al.: BIOMET: a Multimodal Person Authentication Database Including Face, Voice, Fingerprint, Hand and Signature Modalities. In: Kittler, J., Nixon, M.S. (eds.) AVBPA 2003. LNCS, vol. 2688, pp. 845–853. Springer, Heidelberg (2003)
10. Fierrez, J., Ortega-Garcia, J., Toledano, D.T., Gonzalez-Rodriguez, J.: Biosec baseline corpus: A multimodal biometric database. Pattern Recognition 40, 1389–1392 (2007)
11. Mansfield, T., Kelly, G., Chandler, D., Kane, J.: Biometric product testing final report. Nat. Physical Lab., Middlesex, U.K (2001)