Abstract  Patient registration is an essential process in every clinic and hospital before services are provided to patients. Usually, patient’s identity card or fingerprint (through a fingerprint scanner) will be requested for identity authentication in order to retrieve medical records of the patient. However, the current global health crisis of COVID-19 pandemic is raising concern on the hygiene and safety of sharing objects or touching surfaces. Same worry is also occurred towards the patient registration interaction process; further, hospitals and clinics are classified as high risk premises. Therefore, a contactless patient authentication for registration using face recognition technology is proposed in this work. In this system, a face is scanned and processed. If the face exists in the database indicating that the subject is an established patient, the patient’s records will be retrieved. Else, a new patient registration will be performed to register a new account. The efficiency of the system is assessed using our self-collected database. Empirical results show that the proposed system is able to attain 94% accuracy. But, an inferior performance is obtained, especially dealing with makeup variation.

Keywords  Contactless · Patient registration · Face recognition · Local binary pattern

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1 Introduction

Patient registration is essential to the bottom line of a medical practice. It is a complex process that collects a substantial amount of patient’s data, including demographic information, health payer coverage, health history, etc. Patient registration is the first step to generate medical record and personal information of the patient before healthcare services could be provided. It is a mandatory process in every clinic and hospital in order to provide services to the patient, as well as to keep a record of the services that has been availed by the patient. For an established patient, the patient is also required to perform registration at the clinic counter as the first step of each visit (revisit). Usually, it is done by just submitting his identity credential for identity authentication. Once the patient’s identity is verified, the registration is to confirm and update the patient's demographics and insurance information due to the frequently changes of circumstances, as well as retrieving the medical record of the patient which is crucial as a reference for medical officer’s diagnosis. Figure 1 illustrates

Fig. 1 Registration process of (a) new patients and (b) established patients
new and returning patient registration processes.

A patient is required to submit his identity card, coined as IC, to a clinic registration assistant for identity authentication. With holding the submitted IC, the clinic assistant will help the new patient for registration or retrieve the medical record of the established patient. This registration process has been practiced for years. Figure 2 illustrates the registration interaction between a patient and a clinic assistant.

In some healthcare institutes, on top of handling the IC, patients are required to scan their fingerprints via a fingerprint scanner for multimodal identity authentication. However, the recent global health crisis of COVID-19 pandemic, also known as coronavirus pandemic, is raising concern on the hygiene and safety of sharing objects or touching surfaces in public spaces. Same worry is also occurred towards the patient registration interaction process; further, hospitals and clinics are classified as high risk premises.

COVID-19 virus is transmitted between people through respiratory droplets and contact routes [1–5]. The virus remains suspended in droplets smaller than 5 micrometers, known as aerosols. It can stay suspended and live on surfaces from several hours to a few days [6–8]. These touching surfaces are paper, copper, cardboard, wood, cloth, plastic, glass, etc., which are common touching objects like door knobs, elevator buttons, shopping carts, public faucets, ATM screens/buttons, gas pumps, handrails, etc. Nevertheless, those fingerprint scanners used for patient registration can be likely contaminated. Possibly, the route of virus transmission begins from the carrier’s nose, eye or mouth and moves to his fingers, then to the fingerprint scanner. Since fingerprint scanner is a shared device, from there the virus transfers to another person. Handling a card is similar to touching any other surface. If the contaminated card is not sanitized, it can harbor germs and act as a virus transmission medium.

The sign of nervousness over touching surfaces has arisen. In viewing this, the current patient registration system should be revised to minimize the contact procedure. The hygiene distress raises the demand of touchless technology. In this work, a contactless patient registration system using face recognition technology is proposed. In literature, there are numerous deep learning approaches for highly accurate face
recognition [9–12]. With softmax and correlation loss supervision, the proposed deep correlation feature learning (DCFL) model learns deep features with the inter-class separability and the intra-class compactness [9]. This deep model shows highly discriminative capability for face verification. Further, a deep heterogeneous feature fusion network is also proposed [10]. In this network, different deep convolutional neural networks are constructed to generate complementary informative features for template-based face recognition. This approach fuses different deep features by learning the nonlinear projection of the deep features and producing a discriminative representation through preserving the inherent geometry of the deep features. Undoubtedly, the performance of deep learning approaches is great. However, deep learning is highly computational intensive [13]. A high-priced computer with high performance computing is required. This may cause limited potential markets since many panel clinics are hardly to invest such expensive machine just for patient registration purpose. Hence, a local feature descriptor is adopted as feature extraction technique in the face recognition system. Unlike those deep approaches, the implementation of the local feature descriptor is much computational efficient and a common home computer is sufficient to support the process.

2 Patient Registration System Using Face Recognition

This patient registration system is developed with the following coding environment:

- Microsoft Windows 10 (64bit)
- 8 GB RAM
- Intel Core i7-7700HQ
- NVIDIA GeForce GTX 1050
- NetBeans IDE
- MySQL database (database setup)
- XAMPP (database setup)
- Java Development Kit (JDK 8)
- OpenCV 2.4 (face recognition)
- JavaCV 1.5 (face recognition).

Figure 3 illustrates the flow diagram of a patient registration process. A face is scanned and processed. If the face exists in the database, this means that the subject is an established (existing) patient of the clinic, so the relevant records of the subject will be retrieved. On the other hand, if the face never exists in the database, a new patient registration will be performed to register a new account for the patient.

In this system, a real-time face detection and recognition is performed using Local Binary Pattern (LBP) on OpenCV and Java. LBP is a simple yet efficient feature descriptor with low computational complexity [13]. LBP encapsulates local constitute of face images by corresponding each pixel with its neighboring pixels. This makes the extracted features to be invariant to illumination variation. Hence, LBP is able to achieve a good performance in face recognition. Figure 4 shows
Fig. 3  Flow diagram of patient registration

Fig. 4  Facial feature extraction using LBP

Facial feature extraction using LBP. More details of LBP in face recognition could be referred in [14]. Figure 5 illustrates the overview of the face recognition process. A face is detected and captured. The preprocessed face region is further analyzed via LBP descriptor to extract informative features for representation. Then, the extracted feature representation template is classified for identity authentication.
3 Application of Patient Registration System

A database is setup to store the data of patients. The data includes patient’s personal data, medical records, appointment data as well as their enrolled facial template during the first registration, as shown in Fig. 6. For a returning registration, the newly captured facial data of a patient will be matched with all the facial templates stored in this database. If there is a match, the relevant data of the particular patient will be retrieved within seconds. Else, a new registration page will be prompted out for the new patient to register.

Figure 7 illustrates the pages of the application of patient registration system. Clinic registration assistant has two options to register an existing patient: (1) face
scanning and (2) IC, shown in Fig. 7a. During a new patient registration, personal data as well as medical records of the new patient will be captured and stored in the database, Fig. 7b. 25 facial photos are automatically captured continuously and processed into facial templates which then will be kept in the database for future matching purpose (Fig. 7c). For an existing patient registration, if option face scanning is selected, the system will automatically detect the face of the patient and perform face recognition, Fig. 7e. If the captured face is matched with the facial template in the database, the patient’s records will be retrieved within few seconds, Fig. 7f-h. Else, a new patient registration page will be prompted out.
4 System Performance Analysis Test and Discussion

In order to evaluate the efficiency of the proposed system, a system performance analysis test is conducted with 30 subjects with 25 photos per subject for system training purpose. Each subject is required to perform 5 attempts of testing and the average accuracy score is calculated. To better assess the efficacy of the system in dealing with the real world scenario, we introduce several intra-class variations between training and testing environments:

- Illumination—~40% illumination difference
- Makeup—without makeup during training and with makeup during testing
- Facial expression—no expression during training and different expressions during testing
- Camera-to-subject distance—~30 cm distance from camera during training and ~60 cm distance from camera during testing
- Facial details—without and with glasses.

From Fig. 8, we can observe that the proposed system is able to attain 94% accuracy in face recognition. This deduces that the local features encoded in LBP descriptor are well representing the facial data. However, the performance of the system is slightly inferior when dealing with illumination and facial details variations. The performance is degraded for 4% and 7% in the facial details and illumination variation conditions, respectively. Nevertheless, it is still able to obtain 90% and ~87% performance accuracy. On the other hand, when dealing with facial expression and camera-to-subject distance variations, the performance of our proposed system further drops. The accuracy rate is dropped with 17–20%. From the empirical results, we also observe that the system shows worst performance with makeup intra-class variation. The obtained accuracy result is merely 63%. The result reveals that facial makeup could alter the appearance of a person and degrade the performance of an
automated face recognition system. This finding is consistent to the literature studies that the performance of their proposed face recognition systems are also affected in the presence of makeup on face [15, 16].

5 Conclusion and Future Scope

This paper presents a contactless patient registration system by using face recognition technology. In this registration system, face of a patient is captured and processed into local feature template via Local Binary Pattern descriptor. The transformed feature template will be matched with the facial templates that enrolled earlier (during the new patient registration) in the database. If there is a match, this indicates that the detected patient is an existing patient of the clinic and hence his records will be retrieved. Else, he is required for new patient registration. Experimental results show that the system is able to obtain a promising performance in face recognition when the training and testing conditions are uniform. However, the performance is degraded, especially dealing with makeup variation. In our future work, we will explore a robust algorithm that can well handle intra-class variations, especially makeup variation.

References

1. Burke RM, Midgley CM, Dratch A, Fenstersheib M, Haupt T, Holshue M, Ghinai I, Jarashow MC, Lo J, McPherson TD, Rudman S, Scott S, Hall AJ, Fry AM, Rolfe MA (2020) Active monitoring of persons exposed to patients with confirmed COVID-19—United States, January-February 2020. MMWR Morb Mortal Wkly Rep 69:245–246
2. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T, Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Gao H, Guo L, Xie J, Wang G, Jiang R, Gao Z, Jin Q, Wang J, Cao B (2020) Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 395:497–506
3. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, Ren R, Leung KSM, Lau EHY, Wong JY, Xing X, Xiang N, Wu Y, Li C, Chen Q, Li D, Liu T, Zhao J, Liu M, Tu W, Chen C, Jin L, Yang R, Wang Q, Zhou S, Wang R, Liu H, Luo Y, Liu Y, Shao G, Li H, Tao Z, Yang Y, Deng Z, Liu B, Ma Z, Zhang Y, Shi G, Lam TTY, Wu JT, Gao GF, Cowling BJ, Yang B, Leung GM, Feng Z (2020) Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. N Engl J Med 382:1199–1207
4. Chan JFW, Yuan S, Kok KH, To KKW, Chu H, Yang J, Xing F, Liu J, Yip CCY, Poon RWS, Tsoi HW, Lo SKF, Chan KH, Poon VKM, Chan WM, Ip JD, Cai JP, Cheng VCC, Chen H, Hui CKM, Yuen KY (2020) A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet 395:514–523
5. Liu J, Liao X, Qian S, Yuan J, Wang F, Liu Y, Wang Z, Wang FS, Liu L, Zhang Z (2020) Community transmission of severe acute respiratory syndrome coronavirus 2, Shenzhen, China,. Emerg Infect Dis 26 (2020)
6. Study suggests new coronavirus may remain on surfaces for days—National Institutes of Health (NIH). https://www.nih.gov/news-events/nihs-research-matters/study-suggests-new-coronavirus-may-remain-surfaces-days. Accessed 24 May 2020
7. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, Tamir A, Harcourt JL, Thornburg NJ, Gerber SI, Lloyd-Smith JO, de Wit E, Munster VJ (2020) Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med 382(16):1564–1567
8. Reducing the spread of coronavirus starts with basic hygiene—Harvard Gazette, https://news.harvard.edu/gazette/story/2020/03/preventing-the-spread-of-coronavirus-starts-with-basic-hygiene/. Accessed 24 May 2020
9. Deng W, Chen B, Fang Y, Hu J (2017) Deep correlation feature learning for face verification in the wild. IEEE Sig Process Lett 24:1877–1881
10. Bodla N, Zheng J, Xu H, Chen J-C, Castillo C, Chellappa R (2017) Deep heterogeneous feature fusion for template-based face recognition. In: 2017 IEEE winter conference on applications of computer vision (WACV), pp 586–595
11. AbdAlmageed W, Wua Y, Rawlsa S, Harel S, Hassner T, Masi I, Choi J, Leksut JT, Kim J, Natarajan P, Nevatia R, Medioni G (2016) Face recognition using deep multi-pose representations. In: 2016 IEEE winter conference on applications of computer vision (WACV), pp 1–9
12. Guo G, Zhang N (2019) A survey on deep learning based face recognition. Comput Vis Image Underst 189:102805
13. Chen C, Zhang P, Zhang H, Dai J, Yi Y, Zhang H, Zhang Y, Khan MJ (2020) Deep learning on computational-resource-limited platforms: a survey. Mob Inf Syst (4):1–19
14. Ahonen T, Hadid A, Pietikäinen M (2004) Face recognition with local binary patterns. Lect Notes Comput Sci Lect Notes Artif Intell Lect Notes Bioinform 3021:469–481
15. Dantcheva A, Chen C, Ross A (2012) Can facial cosmetics affect the matching accuracy of face recognition systems? In: 2012 IEEE Fifth international conference on biometrics: theory, applications and systems (BTAS), pp 391–398
16. Kose N, Aprville L, Dugelay JL (2015) Facial makeup detection technique based on texture and shape analysis. In: 2015 11th IEEE international conference and workshops on automatic face and gesture recognition, FG 2015. Institute of Electrical and Electronics Engineers Inc