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Practical Considerations for Face Recognition System Implementation: Retail Business Use Case

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ABSTRACT

COVID-19 pandemic has proven experts' prediction which stated that traditional retail might not survive in the coming age. During the pandemic, many longstanding retail brands barely survived, and some of them even went out of business. To survive and thrive, implementation of digital technologies to drive a more convenient shopping experience and enhance customer experience has proven to be crucial in gaining customer loyalty. One of the use cases that is gaining popularity nowadays is the implementation of Face Recognition system. The purpose of this study is to propose the practical solutions to three underlying issues of Face Recognition implementation: the simple but effective choice of framework, the discreet but effective way to arrange camera locations, and the light but robust choice of algorithm that could deliver good accuracy with minimum resources. This study used explorative descriptive method, combining authors' direct experience with literature study. The result of this study is: proposed implementation framework, proposed camera arrangement, and proposed use of Neural Network algorithm with image augmentation. This study hopefully could give context to academics and fellow practitioners of the steps needed to implement Face Recognition to solve real world issues.

1. INTRODUCTION

Alibaba Group in 2017 responded to the e-commerce explosion that offline shopping will never be replaced by online shopping, however traditional retail shall not survive in the coming age[1]. This prediction was accelerated by COVID-19 pandemic, in which implementation of digital technologies has proven to be crucial to retail business survival [2], [3]. One of the potential implementations of digital technologies is Face Recognition system, that could both replace the traditional practice of customer membership and enhance shopping convenience. Aagja et al claimed that convenient transactions have proven to drive significant impact for retail customer experience [4].

One of the most crucial winning factors in a retail business' success is customer loyalty, which has proven vital in developing business profitability and resilience [5]. Hence it is required for a retail business to understand the loyalty factor and to use that knowledge to enhance relationships with customers. Retailers could use a truly customer-centric strategy to both retain and acquire loyal customers, which could be translated into membership program [6]. In such membership programs, consumers that joined as members would get special treatment from the retailer. Through this program hopefully the members will feel appreciated and needed, which in turn will improve their experience and satisfaction [7]. A membership program can increase the customer satisfaction index by 17% and increase consumer commitment in making purchases to 59.1%, compared to an absence of membership program [8]. More than that, it creates a comfortable environment which motivates consumers to create transactions with the same seller [9].

Concretely speaking, customer membership is usually done in the form of a member card, but there is also an ID number or a mobile phone-based application. The weakness of the existing system is that it is vulnerable to human errors such as loss, forgetting of passwords and the like. To solve the issue, Face Recognition-based customer membership is

predicted to be capable of answering the shortcomings in the traditional system such as membership cards, member identification number, or mobile-based applications [10].

On the other hand, from a retailer's point of view the implementation of Face Recognition could not only drive sales and provide business intelligence but also facilitate digitalized operation management. Potential benefits in the line of business intelligence might include tracking of customer footfall, conversion rate, customer demographics, traffic performance, or weather impact. Potential benefits in the line of digitalized operation management might include VIP customer identification, customer queue management, or human resource allocation.

However, developing and implementing Face Recognition systems in retail stores is not that simple. Most retail stores are controlled environments to display products, hence the room lighting and layout is not to display the customer's face but the products being sold. Camera placement should also be as discreet as possible so as not to obstruct the customer's shopping experience, i.e., cameras above instead of eye-level. However, in computer vision this situation introduced a reading distortion, since the customer face is visible from different angles than dataset. Hence, suitable hardware and correct layout for camera placement are vital for the success of Face Recognition system implementation in retail stores. We could then derive several underlying issues that need to be solved before the implementation, 1) how to implement Face Recognition system on retail stores? 2) how to arrange cameras effectively to enable Face Recognition system, without disrupting customer's comfort and shopping experience? And 3) how to train datasets to enhance similarity score of Face Recognition?

2. RESEARCH METHOD

This study is explorative descriptive research, using practical experience wisdom coupled with literature study to answer the underlying issues on Face Recognition implementation. Research conceptual model of this study is illustrated in Figure 2.

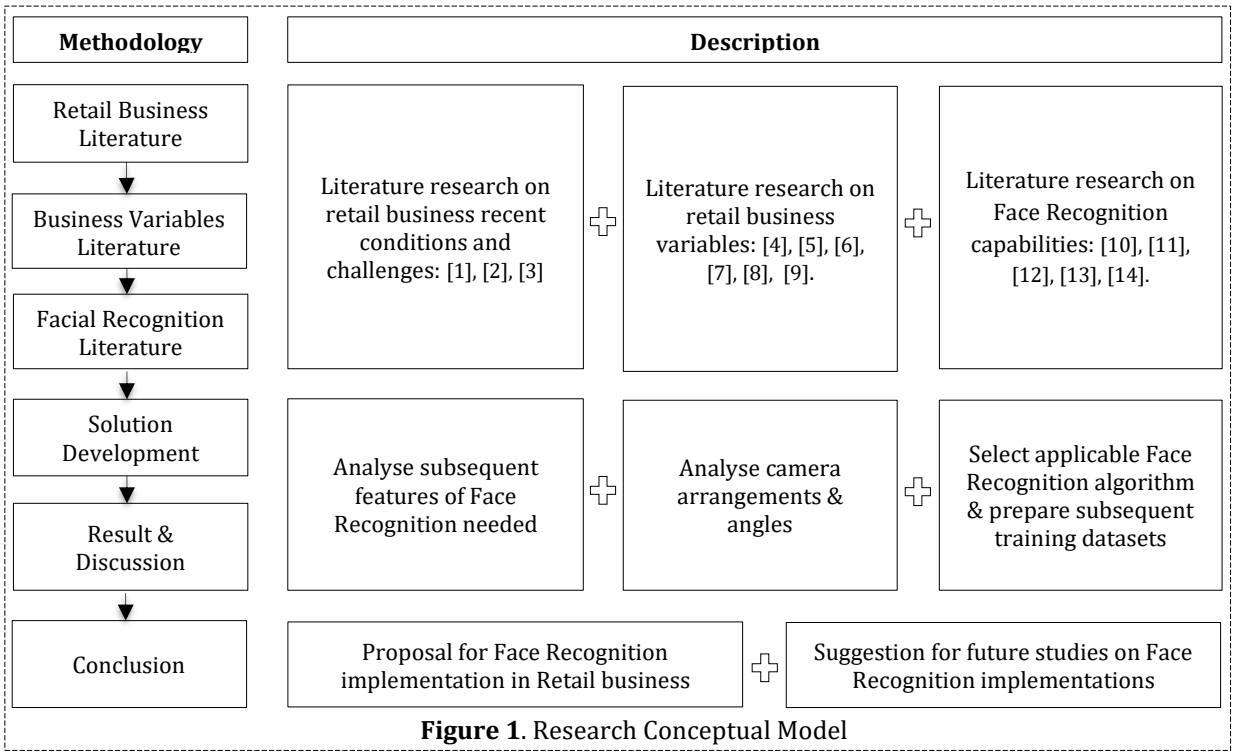

Figure 1. Research Conceptual Model

3. RESULT AND DISCUSSION

Biometric features to detect humans come in many forms such as iris, face, speech, fingerprint, palm print, gait, and signature. However, embedded with major issue that they require active cooperation of person for authentication, in contrast face recognition does not require so. Hence, Face Recognition is the most convenient form of biometrics authentication available. Face Recognition is the procedure of recognizing an already distinguished face. It can be known or unknown, in other words, it could be defined as recognizing the person who it is from our registered user database. Face Recognition has two important tasks: verification and identification. Face verification can be defined as mismatching a face image against databank's available face images which contain the person being matched. Face identification is a query of an image of a face against available images in a face database. Another case is also considered when a query face may or may not be in the available databank. In such cases, one can compute a similarity score and based on the highest similarity score found to be matched [11].

Face Recognition has always been evolving, such as for its accuracies that have just exceeded human accuracies on few benchmarks [12]. Especially the accuracies of open-source face recognition systems which have yet to attain a state-of-the-art. So, the firm answer to above question is no. Furthermore, problem in a real-world scenario, which should

simultaneously detect and identify [13]. Despite that, methods based on Deep Convolutional Neural Networks (DCNNs) have shown impressive performance improvements for object detection and recognition over the last 8 years [14].

Face Recognition system could be developed adopting the FaceNet's architecture which has incorporated pre-trained Convolutional Neural Network and Triplet Loss function as shown on Figure 1 [15]. Amos et al tested the system in mobile computing setting it has yielded impressive result and fast performance [16]. It shall have no problem when translated into stationary setting in a check-out counter of a store. Smart cameras as part of the IoT (Internet of Things) would be placed at the shop's entrance and at the checkout counter.

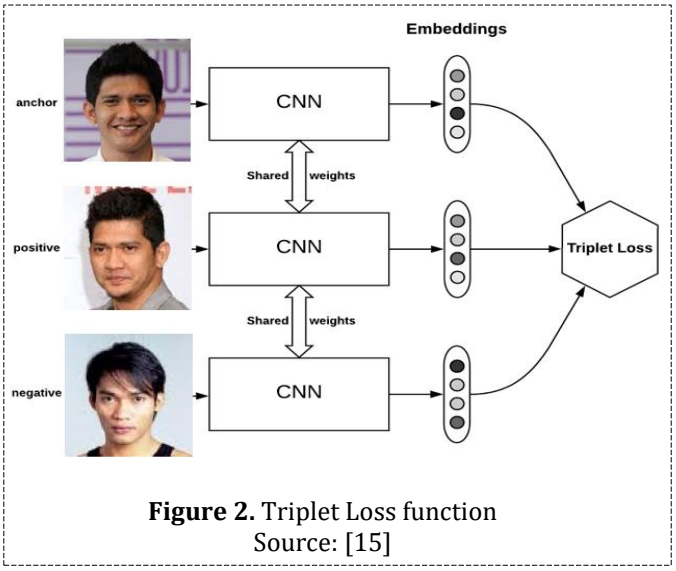

Figure 2. Triplet Loss function
Source: [15]

3.1 Face Detection and Verification

When a customer walks into the store, the camera detects the movement of the customer and locates the where the face is. The system then pre-processes the image and extracts feature of the face image and goes through matching process. If the query found its match from image database, the verification is successful, and the result will be notified to employees via store's computer. The simplified flow diagram of Face Recognition system can be illustrated in Figure 3.

Figure 3. Proposed flow diagram of Face Recognition system

3.2 Camera Arrangements

Several cameras are installed in designated areas which are then connected to the central computer system of the store. Each camera has a specific purpose, and the captured data should provide analytics about the business process and store performance. For the hardware selection, indoor smart cameras with IP connection, around 3MP resolution, adaptive IR, adaptive lens, with centralized data storage could be considered sufficient for use. The front camera is installed overhead by the entrance which will double as counter machine apart from face detection, as illustrated in Figure 4. This stationary camera will be counting people coming in and coming out, which could be compared to conversion rate of store sales at any given time of day, given day of week, given week of month and so on.

Figure 4. Proposed entrance camera
Sourced with changes from: [17], [18]

The second camera is installed facing the interior of the store, as illustrated in Figure 5 (left). Apart from shopper tracking and monitoring the security of the environment it also does job as hot spot monitor that provide data which aisles or which shelf customers tend to go in any given time. The last camera is installed in the checkout counter, as illustrated in Figure 5 (right). The main purpose is to identify whether a customer is a member of the store. If she is a member, the cashier will be notified via his monitor and given instructions on what to do and say to a store member. The camera installed here also works as queue line monitoring. If the line is too long, the computer system will notify the store manager to open another checkout counter or assign another staff to help the customer.

The face detection system is also able to detect a change of emotion in a customer's face. When a customer shows an unpleasant emotion, the face detection system will recognize such emotion and convey the finding to store manager's computer/ mobile device. The manager and employee can act on it first before the customer even starts to voice their uneasiness.

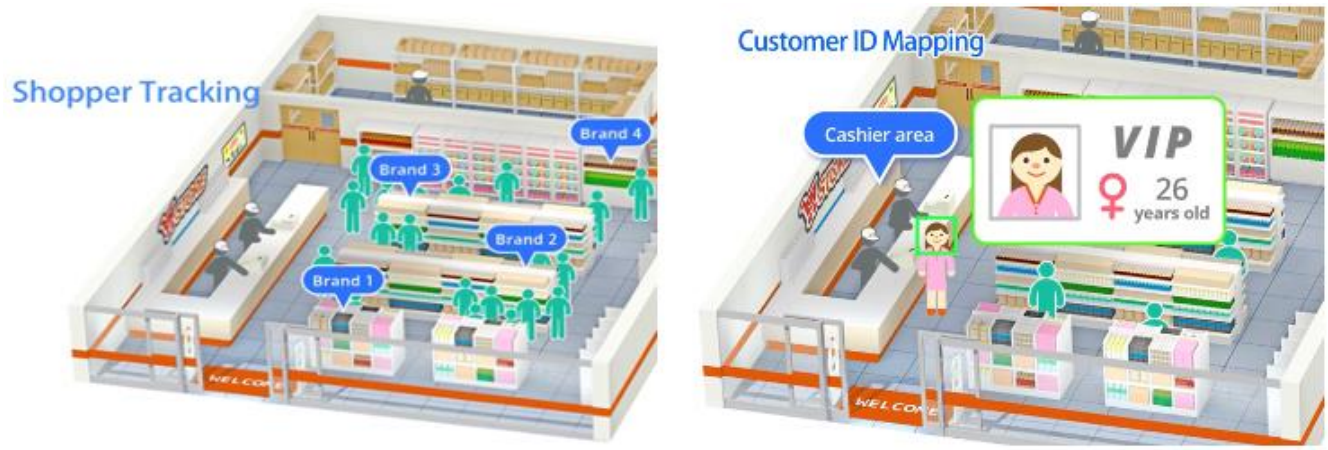

Figure 5. Proposed interior camera (left) and cashier camera (right)
Sourced with changes from: [17], [18]

3.3 Dataset Training

Unlike prior studies [15], [16], the Neural Network algorithm proposed will be trained using combination of datasets that covers face image of all ages, labeled based on age, and each image will be augmented into three copies as shown in Figure 6. The augmentations used for dataset training are flipped, rotated, and flattened, to give more context for real life situation of face detection inside the store.

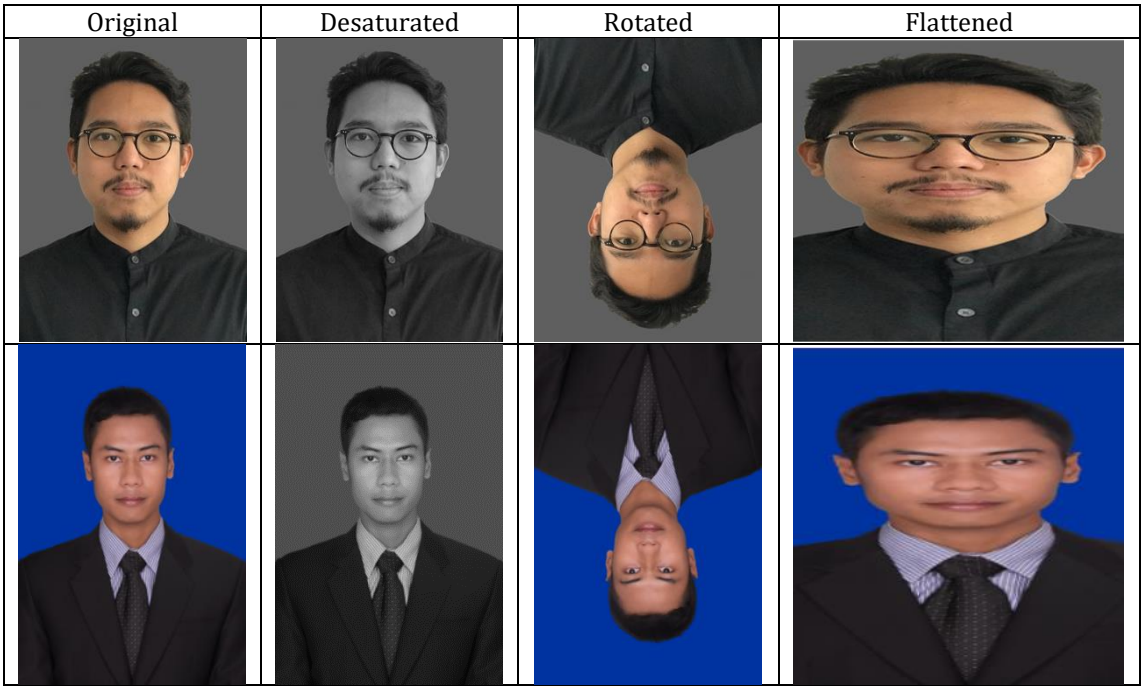

Figure 6. Proposed augmentation of image dataset

4. CONCLUSION

People are looking forward to a more convenient and sustainable lifestyle, that includes how they behave toward making expenses in routine daily life. A smart and intelligent environment provides exactly that. Face Recognition is an application of digitalization that previous research predicted to be capable of helping drive profitability and enhance customer experience in retail business. This study proposed solutions to several underlying issues which are: a simple but applicable framework of Face Recognition system implementation in retail stores, the effective but discreet camera arrangements, and the selection of Neural Network algorithm with image augmentation to give more context for real life situation inside the store.

This study hopefully could give context to academics and fellow practitioners of the steps needed to implement Face Recognition to solve real world issues. However, further studies and considerations are needed on these related technical issues before considering the implementation, such as: studying the required architecture development to enable data ETL (Extract, Transform, and Load) so the retailers could derive insight from data, architecting hardware arrangements to enable data capture and visualization, and developing a Machine Learning model to enable automated algorithm running.

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