

Research on Facial Recognition Technology in Cashier-free Store to Improve Customer Relationship Management

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Abstract

The emergence of online retailers seriously challenged the brick-and-mortar models, though the whole retailing industry has grown these years steadily. Also, the severe competition between offline retailers threatens each participant's survival. In retailing, a customer determines the success or failure of a business. However, the current company still emphasizes the product-centric model to make a profit. The shopping experience is not satisfying enough for customers to choose more on-site purchases. These satisfaction problems can be classified into three domains: waiting for payment, low-quality employee service, and ineffective mass marketing. This paper studies facial recognition technology, one of the biometric technologies that could be used to tackle these problems in retailing. This research finds that, compared with other current technologies that could alleviate problems in SWOT Analysis, solutions supported by facial recognition technology could address these problems effectively. Facial payment, employee service empowered by emotion recognition analytics, and customized promotion offerings are superior and value-added for the customer to improve satisfaction and strengthen loyalty. Although some limitations still exist, facial recognition solutions are promising and fit the trend of future development.

Keywords

Facial Recognition; Retailing; Cashier-free Store; Customer Relationship Management.

1. Introduction

The cashier-free store has experienced rapid growth these years. For instance, the Amazon Go provided by Amazon.com is automated mainly by equipped with several cameras and other objects like types of sensors [1]. Customers do not have to pay at the checkout station after purchasing in this store. The store applies updated technologies, such as deep learning, sensor fusion, and computer vision to automate a retail transaction's shopping, checkout, and payment processes [2]. One of the necessary technologies used to realize cashier-free stores is the mature facial recognition in the biometric system.

The growing significance of human factors in cutting-edge technologies leads to a great demand for biometrics systems used for personal identification or verification. Some biometrics systems leverage static physiological factors like palm print, fingerprint, and iris. Others use behavioral features like facial dynamics, walking patterns, and signatures famous as soft biometrics [3].

The human face, as one of the primary biometric features, carries essential identity information about gender [4], age [5], race, and expressions that contain emotional and mental conditions behind [6]–[9]. Facial and behavioral analysis is an interdisciplinary study covering psychological, engineering, and neuroscientific areas [10].

Generally, facial recognition uses a person's face to identify or verify one's identity. It detects, analyzes, and matches features or patterns according to the details of facial information [11]. The history of facial recognition dates back to the middle of the 20th century, and the study of

automatic facial recognition started in the 1970s [12]. In these early researches, the distances of essential features on the face were used as measures to identify the human face [13]. Studies about facial recognition have thrived since the security-related applications increased with hardware developments in the early 1990s [10].

According to current literature, facial recognition can be separated into two essential parts: image-based and video-based approaches. The former uses physical appearances to recognize people, and meanwhile, the latter expand this method to include changes or dynamics of appearance and face over time [10].

The image-based facial recognition has progressed since the 1990s and has been generally classified into four development stages by Deng and Wang (2021). They are: a) Holistic or appearance-based approaches [15], [16]; b) Local-feature based face recognition methods that prevailed after 2000 [17], [18]; c) learning-based local descriptors methods that appeared after the 2010s [19], [20]; d) Deep Learning based methods which became popular after 2015 and provided a novel perspective for facial recognition [21].

For video-based techniques which are suggested for solving problems [22], particularly in cashier-free stores recently, are divided into three categories: Key frame-based methods which predict the identity of each track and select the best match [23], [24]; The temporal model-based methods that learn the temporal dynamics of a face from video [25]–[27]; Image-set matching based methods which models an image set of a face track [28].

Facial recognition has advantages such as convenience, directness, suitable interaction, friendliness, and no physical contact. In contrast to the traditional facial recognition mentioned above, the advanced one supported by deep learning could process the image on a vast scale. The accuracy of recognition, the ability of anti-interference, and the speediness of identification are enhanced significantly [1]. These advantages and abilities contribute to facial recognition applications in several contexts such as law enforcement, healthcare, social media, banking, and especially the retailing industry [11].

Retail sells goods or services through distribution channels to customers to gain a profit. A retail format could be a simple marketplace such as supermarkets and convenience stores at the primary level. However, this industry and market have a considerable scale. In 2018, the total retailing sales reached 23.6 trillion USD globally and increased to 24.8 trillion in 2019. Although COVID-19 challenged it, this market is still predicted to grow and peak at 26.7 trillion USD in 2022 [29]. Stimulated by technological progression, the annual online sales of products occupied one-fourth of the total market in 2020, which showed an unprecedented expansion of e-commerce [30], and this change will continue.

The prevalence of e-commerce platforms provides more choices for customers and encourages their demand for personalization and customization [31]. The retailing industry has become severely competitive, particularly for brick-and-mortar stores that compete with other offline shops in the same customer base and are challenged by online retail formats [32]. However, most brick-and-mortar retailers are still product-centric, focusing on product management and putting too many marketing and sales efforts into those profitable products [33]. Consequently, retailers' decisions depend on the past product profitability but fail to meet the future customer profitability. A customer-centric approach is needed to understand customers individually and personalize marketing strategies and the way of communication in order to improve customer satisfaction and build customer loyalty [32].

Concretely, problems that influence shopping experience and customer satisfaction could be identified in three main parts. The first is the long queue for checkout, which may hurt patience and, as a result, cause customer loss. The second is the unavailable or untimely consulting support that makes the customer feel abandoned and creates an unsatisfied impression [34].

The last issue is mass marketing, which could not attract customer interest and reduce customer loyalty in the long run [35].

The following section will be an extensive review that starts from a history of biometric systems and introduces the position of facial recognition. The central part will review the identified issues and technologies to address current problems based on professional literature and popular press articles.

2. Literature Review

2.1. Biometric Technologies and Facial Recognition

The term "biometrics" originates from the Greek words "bio" (life) and "metrics" (to measure). The idea of using essential biological characteristics such as the human face for recognition originally existed hundreds or even thousands of years ago. Although these historical applications are distinct from the current automated biometric system, they created this unique measurement approach which developed along with human history [36].

The current biometrics identifies and authenticates individual identity fast and reliably via distinctive biological characteristics (Thales, 2021). The proper biometric systems started to appear in the late 20th century with the emergence and development of computer systems. The primary field went through some related activities in the 1990s and began to emerge in daily applications after 2000 [36].

The basic timeline of key historical events in biometrics is presented below:

- In 1858, a systematic capture of hand images for distinguishing employees during paydays in India was recorded as the first biometrics used for identification [38].
- In 1870, anthropometrics, a method of using body measurements, photographs, and physical descriptions to identify individuals, was developed by Alphonse Bertillon [39].
- In 1892, Francis Galton studied and developed a new classification system using all ten fingerprints. These characteristics identified are still used today [40].
- In 1903, the New York state prison established the practice of fingerprinting to identify criminals [41].
- In 1936, an ophthalmologist, Frank Burch, proposed using iris patterns to identify an individual [42].
- In the 1960s, facial recognition was semi-automated and developed to locate and extract useable feature points [43].
- In 1960, Gunnar Fant created and published the first model of acoustic speech production [44].
- In 1965, the first automated signature recognition system was developed by North American Aviation [36].
- In 1970, Dr. Joseph Perkell expanded the previous acoustic speech production model to include behavioral and biological components of speech [45].
- In 1976, the prototype speaker recognition system was developed by Texas Instruments [46].
- In 1985, the patent for vascular pattern recognition that used the pattern of the subcutaneous blood vessel for recognition was awarded to Joseph Rice [47].
- In 1994, a palm system with palm and fingerprint identification technology embedded was benchmarked by American experts [48].

These events shaped the form of the current biometric system, and each type of technology continued developing and progressing along separate technological paths. The whole system of biometrics nowadays is presented below in Figure 1.

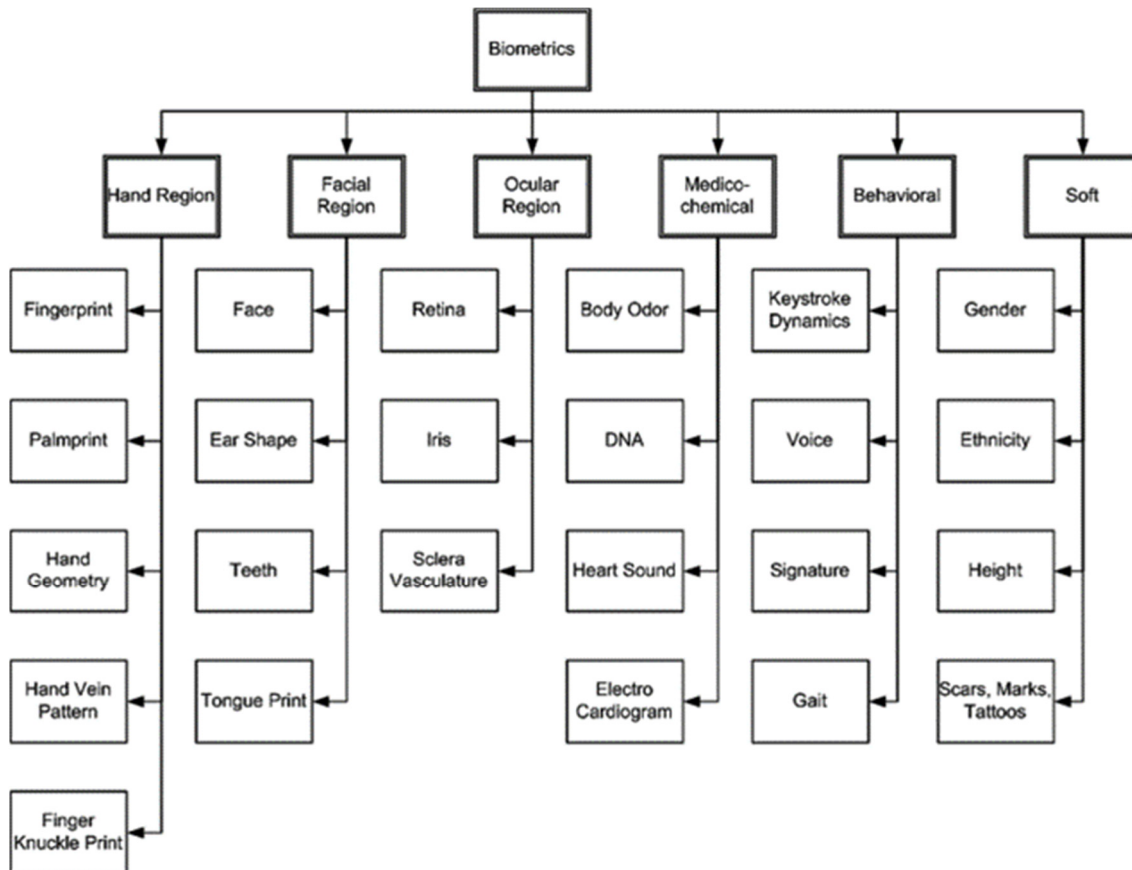


Figure 1. Classification of biometric modalities [49]

Hand region models using the human hand that carry plenty of texture information based on fingerprints laid the foundation for the early recognition systems. Besides fingerprints, other attributes such as palmprint, fingernail bed, and hand geometry are identified and tested as an extension to fingerprint technology [49]. In terms of face region models, as introduced initially, the automated facial recognition system is built to identify an individual by computing the 2D or 3D features [50], [51]. Other criteria such as ear, teeth, and tongue can also be qualified in this modality [52], [53]. Moreover, the ocular region model leverages the most accurate, well-protected, highly reliable, and stable biometric signatures such as iris, sclera vein pattern, and retina. However, the drawbacks, for instance, the high cost of sensors, sensitivity to illumination, and the need for higher subjects' cooperation are apparent in this modality [49].

In addition to those typical systems above, the medico-chemical biometrics, including Deoxyribonucleic Acid (DNA), Electrocardiogram (ECG), and heart sound, require special sensors to acquire data. However, the intrusive acquainting procedure, requirement of expert operators, and privacy issues are some restrictions [49]. Moreover, behavioral biometrics analyzes identity based on the way people do things, such as vocal characteristics, typing styles, walking styles, and signature dynamics [54]. However, verification accuracy could be easily limited by factors like noise, health conditions, and poor quality of devices. Furthermore, for the last soft biometrics, although these characteristics such as gender, ethnicity, height, and skin color [55], [56], lack permanence and distinctiveness, they are still used for data segmentation and improving accuracy for further identification procedure [49].

Table 1 below presents the tough accuracy comparison of majority biometrics, but an accurate comparison is difficult because of the variance in data gathered. Compared with other biometric technologies, facial recognition has a relatively high accuracy level and possesses a stable, non-physical contact, lower cooperation level, and lower intrusive identification procedure.

Table 1. The general accuracy of different biometric techniques[49]

Biometric Modality	Accuracy Level	Biometric Modality	Accuracy Level
Fingerprint	99.9%	Palmprint	>95%
Hand geometry	>95%	Vein pattern	99%
Face	95%	Ear	>95%
Signature	>90%	Iris	99.9%
Retina	99%	Voice	>90%
Keystroke dynamics	>90%	Gait	>90%

2.2. Business Problems in Brick-and-mortar Retailing

Analysts and industry associations highlighted the need for a customer-centric approach under the threat of e-commerce growth and severe competition from counterparts. Product-oriented firms should transform to achieve higher customer loyalty and performance with a substantial brand value [57]. The emphasis on customers is critical for retailers to drive customers and market as the core of their business [58]. Moreover, to pursue a proper customer-centric strategy, customer needs should be addressed, and retailers should provide customization and personalization by understanding customers' real-time needs at a high level [59].

From customers' perspective, their primary expectation is that quality products at reasonable prices in a pleasant environment could be provided by stores [60]. Thus, the shopping experience is one of three factors that will influence consumer satisfaction and the perception of stores. Moreover, supermarket executives considered shopping experience the most critical variable impacting their shopping behaviors [61]. Furthermore, three detailed domains can be found below for problems that could influence the shopping experience in current stores.

The dominant issue in a brick-and-mortar store is, waiting in a long queue when paying the bill. Generally, processing the payment takes 12 to 15 minutes [62]. Particularly on significant public events or promotion days, the seasonal congestion for payment is far more challenging and depressing [63]. Most customers choose to stop shopping from this store and shop online or somewhere else since time is the most significant aspect [62]. As a result, the store's sales will reduce, and the dissatisfaction will happen simultaneously.

Apart from the payment issue, many scholars [64]–[66] have studied that staff behaviors also impact the store attractiveness and customer satisfaction [67]. Moreover, the quality of service could significantly influence purchase intentions [68]–[71]. Although the self-service technology and culture have become more and more popular in the retail store business [72], many researchers [73]–[76] show that customers still think highly of personal interaction and expect good service experiences. Moreover, the sufficient number, professionalism, and skills of sales employees are essential and valuable for improving customer service [63].

Last but not least, customers became bored and resistant to retailing advertisements generated by mass marketing campaigns [77]. The attempt of mass marketing is going to be intrusive, adversarial, and even hostile to customers. As a result, this marketing is not evolving but devolving. It reflects that the communication is not efficient and the marketing department does not work together, and consequently, customers become overwhelmed and have to deal with repeating messages in conflict [35]. In the end, it could hurt satisfaction and long-term loyalty.

2.3. Current Technologies Used for Problems

For waiting in queue issues, self-service technologies mentioned above, such as self-checkout, could enable customers to directly process payments without employee involvement [78]. It minimizes the time customers should have spent waiting to pay [79] and protects the perceived personal privacy. Also, in this way, one employee can assist four to six customers in different checkout lanes, creating cost efficiency and improving staff use [80]. However, these new

machines are prevalent and suitable for specific customer groups [78]. Middle-aged and older people need support, and it may cost more time to operate a self-checkout machine.

Furthermore, for the other two problems, some updated interactive technologies have been applied to work [81]. These solutions could be categorized into three groups. The first is in-store technologies like robots, smart mirrors, and interactive displays, which could provide basic product information and customer consulting service within stores [82]–[84]. Moreover, the second type is out-store technologies such as interactive windows outside the store that act as an excellent advertisement to attract customers who get interested [85], [86]. The last one is omnichannel or pervasive technologies like store mobile App [87]–[90], by which customer could get product details during shopping, receive an electronic receipt for offline purchase. People could also order products online and accept promotions in the App.

However, these technologies are also regarded as new self-service methods. Moreover, they significantly changed the process of service delivery within the stores and removed the past human interactions [82], [91]. There is no doubt that, in the perspective of frequency and quantity of interpersonal contacts, interactive technologies modified the communication between humans (customers and employees) [92]. Furthermore, now the communication is mediated by a computer that creates a new retail context to influence consumers' behaviors. Moreover, traditional services are taken over by technologies and provided by automatic machines [93].

Although these brand-new tools provide a novel and fresh experience for consumers by increasing the interactions between different touchpoints [94], the actual demand of customers is not fulfilled completely. Interpersonal communication cannot be ignored since people still emphasize it [73]. Also, the automatic primary system is unable to catch emotion and intention inside people, and by contrast, the intelligent analytics could be embedded not only for employee service provided but also in targeting and promotion. Furthermore, the importance of the solutions suggested below is supported by facial recognition technology.

3. Research Plan

3.1. Research Questions

Q1: How to prevent waiting for payment in the queue via facial recognition?

Q2: How to improve customers' in-store shopping experience by providing better employee consulting service supported by facial recognition?

Q3: How to provide more effective promotions to customers via facial recognition?

3.2. Research Methodology

The solutions in this paper based on facial recognition will be explicitly described in the next section, and three other solutions using current technologies mentioned in the literature review are selected to make comparisons. According to each research question, a self-checkout machine is chosen for question 1, solving the queue issue. Moreover, robots from in-store technologies are selected for question 2, improving consulting service and customer shopping experience. For question 3, the mobile App from pervasive store is made to advertise and give promotion vouchers to specific customers.

A SWOT Analysis is conducted to evaluate each technology mentioned to make comparisons. Based on each research question, the strengths and weaknesses of selected technology and facial recognition solution will be analyzed and compared. Then, a comprehensive macro environment for facial recognition solutions will be described from the perspective of opportunity and threat, including trends in the economy, law, politics, and environment.

This research is primarily based on secondary data from several channels such as journal articles, interviews, databases, press articles, etc. The discussion, in the end, will produce implications for further study and the development of facial recognition and its applications.

3.3. Research Analysis

3.3.1. Solutions to Question 1

As mentioned in the literature review, the self-checkout machine is proposed for the customer to check items and pay the bill by themselves directly. People could get support from employees responsible for assisting the operation in four to six lanes simultaneously. Compared with a traditional payment method, it has the advantages of a shorter queue, faster checkout, labor cost reduction, and a novel experience provided. However, the initial up-front cost is inevitable, such as machine expenses and customer training. Moreover, the more people participated, the higher risk of shoplifting. Also, for customers, less human contact and communication could reduce their shop experience and make them disappointed [78]. Some customers like the old are likely to get confused and need time to learn how to operate, which may worsen the queue issue in some situations. At last, these vast machines may occupy too much room, mainly when the space in stores or supermarkets is much more valuable and needs to be profitable [95].

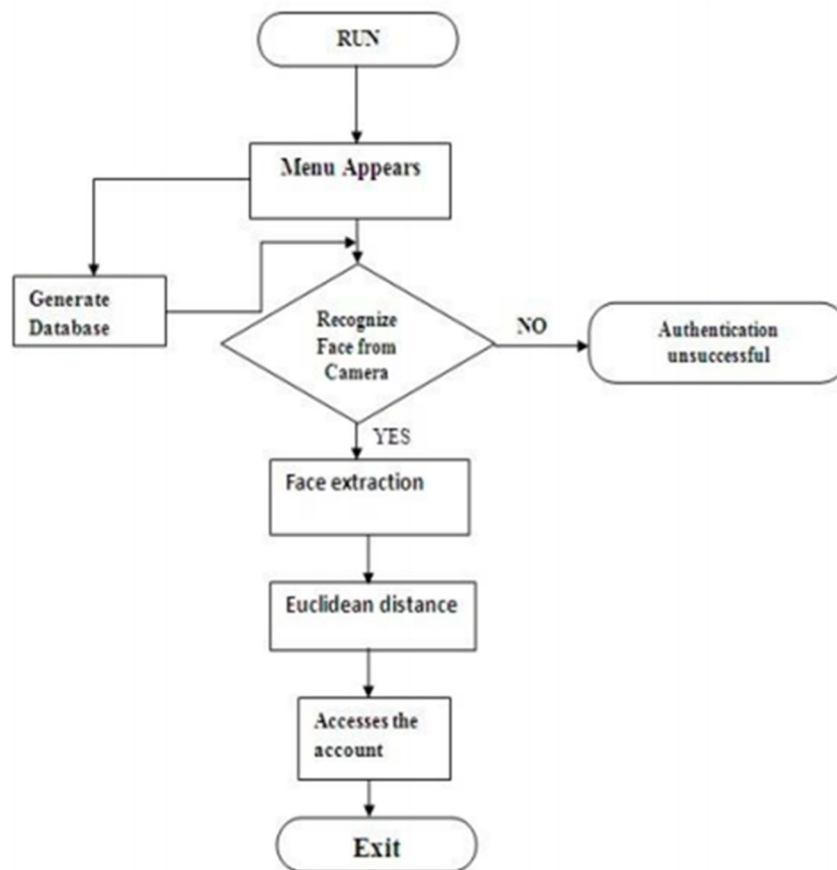


Figure 2. The Facial Recognition Payment System [96]

What is different, virtual payment supported by facial recognition technology could achieve a cashier-free operation. When a customer enters the store, the camera detects their face, and the system will authenticate their identity. Then their online account will be connected, and the real-time detection will work for every shopping behavior. What customers pick or withdraw will be recorded and presented automatically in their virtual cart. Furthermore, people do not

need to wait for payment after getting everything wanted. They could go and leave, and the payment will process online, and the purchase amount will be deducted directly from their account balance. Finally, customers will receive an electronic receipt with details on the phone. This kind of facial recognition system has been developed and proved to work. Gondkar (2018) has designed a safe and secured framework for this kind of payment, as shown below in Figure 2. The face will be extracted after camera detection, and the picture is transferred to compare with those in the database and authenticate the identity. The system could access the personal account if authenticating successfully. By using such technology, customers do not have to suffer from waiting for payment or waste time. It is more convenient and has no technical barriers for older people. However, the same disadvantage as the self-checkout machine could be the high start-up cost which is the camera and system expense in this case. Also, the construction and maintenance of such a vast database cost a lot, and a large amount of data risks a leak. Moreover, the maximum number of customers allowed in the cashier-free store is around seven due to detection and computing ability limitations. Furthermore, some specific issues can exist with factors such as glasses, color, gender, facial hair, and twins since the accuracy has variances for different targets.

3.3.2. Solutions to Question 2

Currently, large retailers use in-store robotics for warehouse and inventory management [97]. In terms of providing customer service, there is still a limited function that can help. The autonomous retail service robot called "LoweBot" could identify and find products in several languages and help guide customers to certain shelves effectively in stores. As an assistant to employees, LoweBot could answer simple questions and leave more critical issues to staff, who will spend more time addressing customers via expertise and specialty knowledge [98]. Moreover, another programmed robot called "Peppercorn" can not only give directions and answer questions but also play music and even take selfies with customers. It attracts more customers and contributes to good sales [99]. However, these robots have advantages of labor cost reduction, effective operation, and an engaging and exciting shopping experience for customers. Some disadvantages are apparent such as a high start-up cost, no ability to deal with emergent issues, only simple problems solved with customers, and no self-improvement out of vested rules without artificial intelligence technology [100].

By contrast, the real-time detection system in the cashier-free store could help employees realize and understand customers' emotions in time. The camera will detect customers' facial expressions or body language during shopping to analyze their emotions, intention, and behavior. If people are identified as confused, curious, or doubtful, the central system will deploy employees to communicate and help them out. Each customer will be classified into different groups, and each group will be assisted according to their emotion by other staff. Different cases may have different approaches to solve.

Many researchers have developed and proved this kind of emotion detection system [101]–[103]. Pantano's (2020) method, as shown in Figures 3 and 4 below, is precise in that face will be detected and extracted as the output image, and the facial expression analysis is based on the particular regions of the face. Then, the system will produce a result and send it to the central operator. It has strengths such as well-integrated human-machine cooperation, reduced labor cost due to less staff needed, and fulfilling the actual demand of customers. However, for weaknesses and those mentioned above, it requires high accuracy detection and identification. The size and quality of pictures still need to be progressed, particularly the image recognition and analysis technology should be prepared for further development. Under the COVID-19, the mask inevitably became the barrier to recognition and facial expression analysis.

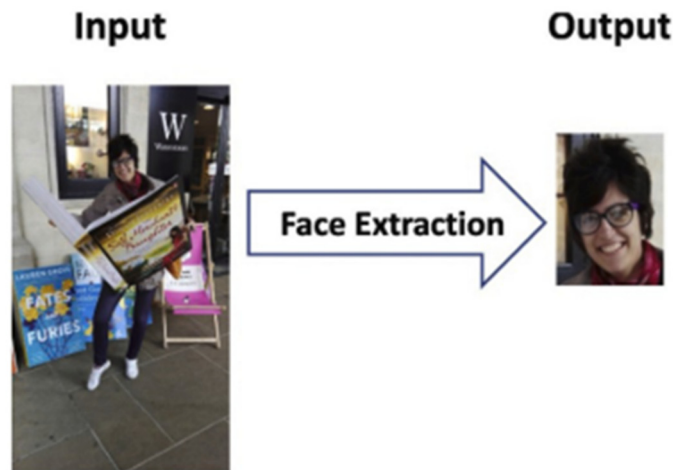


Figure 3. Face Extraction [93]



Figure 4. Special Feature Region in Face [93]

3.3.3. Solutions to Question 3

In terms of marketing, current store mobile Apps typically provide a discount message or notice to customers. These advertisements are primarily based on product-centric marketing and push people to buy in a particular discount season. Some promotions could be given to certain people, such as a birthday voucher. A few Apps can recommend related products according to customers' past shopping records to upsell or cross-sell [104]. It has strengths of a timely discount notice, customer firm brand awareness, and good marketing compared to traditional mass marketing methods. However, the weaknesses are that a product-centric advertisement is not changed, customization is still low, and the need for deep analytics of customer behaviors. What is different, a recommendation and promotion system powered by facial recognition will identify the customer first, and the past shopping experience, other personal profiles, and current emotions will be combined to analyze the most suitable product recommended for a particular person. Moreover, after shopping, apart from discount advertisements, the customized promotion offerings will be sent to people's accounts periodically according to their frequency and amount of purchases in the store to maintain valuable customers and keep loyalty.

This system could be built based on Wu, Zeng, & Shih’s [105] system, shown in Figure 5 below. The filtering could work according to the customer’s profile and behavior, and then the recommendation will be made for each person. The strengths of this system are that a more comprehensive and optimized approach could identify the actual demand of customers, and a personalized and targeted promotion is more effective in raising sales and improving customer satisfaction. However, for the drawbacks in addition to those mentioned above, this recommendation system needs more key access to customers' personal information, which may raise more concerns and worries. Also, security needs more improvements. On the one hand, attackers may create a fake face sample such as a forged 3D mask to fool the recognition system, called "spoofing attacks" [106]. On the other hand, a poisoning attack may happen when attackers use a sequence of designed fake templates to gradually update a customer's original template until it is replaced by an entirely different one[107].

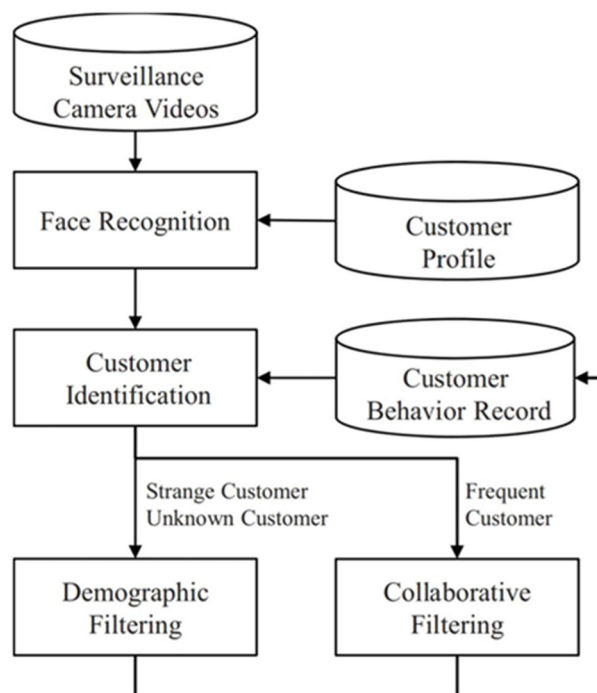


Figure 5. The Recommendation System[105]

3.3.4. Strengths and Weaknesses in Comparison and External Factors for Facial Recognition Solutions

Table 2. SWOT Analysis Comparison

Technological Solutions	Strengths	Weaknesses
Facial recognition Solutions	1. Less staff (Cost reduction) 2. Convenience and easy 3. Safer identity 4. Effective approach 5. Customer-centric 6. Human-machine cooperation 7. environmentally friendly	1. High start-up cost 2. Database related issues 3. Customer number limitation 4. Accuracy issues for different people groups 5. Immature image recognition technology 6. The mask issue 7. Security issue (positioning attack)
Self-checkout Machine	1. labor cost reduction 2. Faster checkout 3. New shopping experience	1. High initial cost 2. Risk of shoplifting 3. Space occupied

		4. Unfriendly operation for a specific people group
In-store Robotics	<ol style="list-style-type: none"> 1. labor cost reduction 2. Effective operation 3. Novel shopping experience 	<ol style="list-style-type: none"> 1. High up-front cost 2. Emergent issues 3. Simple problems solved only 4.No self-improvement
Store Mobile App	<ol style="list-style-type: none"> 1. Timely notice message 2. Brand awareness built 3. Relatively suitable customization 4. Relatively good marketing 	<ol style="list-style-type: none"> 1. Product-centric advertisement 2. Automatic promotion offerings 3. Lack of analytics

As shown in Table 2 of the comparison above, although facial recognition solutions have weaknesses, values such as a high level of convenience, safety, effectiveness, and human-machine interaction with cooperation are superior to other technologies. Also, unique factors like a customer-centric method and environmentally friendly approach are value-added and necessary under the macro environments mentioned below.

Table 3. Opportunities and Threats for Facial Recognition Solutions

Opportunities	Threats
<ol style="list-style-type: none"> 1. The trend toward password-less methods 2. The trend in environmental sustainability 3. Social distancing under Covid-19 	<ol style="list-style-type: none"> 1. Social concern about privacy 2. Immature law-related 3. The trend of online retailing 4. Prohibition in some fields

As listed in Table 3 above, in terms of threats that could hurt the application or development of facial recognition, people have become increasingly concerned with their privacy and are unwilling to share more information with companies. It definitely will affect the performance of the facial recognition system since a large amount of data should be obtained for analytics. Moreover, the different requirements in various law systems may hinder the expansion and further development of facial recognition. For example, China has regulations for personal information protection but excludes facial recognition technology. Moreover, the U.S. had passed the Biometric Information Privacy Act to regulate biometric applications. Also, The E.U. has a data protection law, but no facial recognition content is included [108]. Moreover, some cities such as San Francisco, Oakland, and Boston had banned facial recognition software for government use, and the business application was still under discussion [109]. Also, the challenge of online retailing has a substantial impact on brick-and-mortar stores, and it is still not sure whether these offline retailers could survive though equipped with advanced facial recognition technology.

Although there are many threats to the further related application, the trend for biometric technologies, particularly for facial recognition, is not stoppable. According to the history of biometrics, the future of authentication will be led by several password-less biometric approaches, and passwords may become a simple compliment [110]. Moreover, sustainability is emphasized and regarded as a heading trend of the future. The less paperwork and more digital formats of facial recognition match this tendency, and it is primarily based on the

Internet, which helps reduce non-necessary waste and eliminate potential pollution. Last but not least, during the pandemic era, significant social distancing is required to control the spread of the virus. The cashier-free store with a minor physical contact facial recognition system will be the ideal model for new retailers under pandemics.

To conclude, combining the comparisons and analysis above, the further development and expansion of facial recognition solutions are promising and could solve these significant problems faced by current offline retailers.

4. Discussion

For the further development of this technology, the primary issue should be solved or improved in some ways. The current accuracy has significant variance between people having different skin colors and gender. Furthermore, no single facial recognition software could work well across different countries. Moreover, the difficulty of distinguishing twins should also be addressed to prevent misuse. In terms of privacy issues, customers should be informed before accessing their personal information, and a more secured database could be built to avoid data leaks. Special attention to template poisoning and attack should be emphasized for further development.

For the application situation in the store, it is essential to develop a more mature system that could support more customers shopping at the same time, which is essential for the performance of retailers. Moreover, the database for customers should be built in advance, and the system needs time to train to keep an optimal condition. Under the pandemic, the face with a mask covered is challenging to identify, and related technology could develop in this direction to achieve recognition using fewer features of the face while maintaining acceptable accuracy. Also, in the future, the authentication system could mix several biometric technologies to achieve higher accuracy, and at the same time, the personal information will be well secured and hard to attack.

5. Conclusion

Although facing the challenge from online retailers and intense competition from other brick-and-mortar stores, offline retailers could consider transforming themselves from product-centric providers to customer-centric attractors by applying updated technologies.

This paper first identifies three main problems in brick-and-mortar retailers. In terms of customer satisfaction, people are bored waiting in queue for payment, and the shopping experience could be hurt when staff service is not timely and the actual demand is not fulfilled. At last, the mass marketing campaign used by retailers could annoy customers and reduce satisfaction or damage loyalty. A self-checkout machine could alleviate the slow payment issue, the in-store robot could guide customers and solve simple questions, and a store mobile App can contribute to a targeted advertisement compared with traditional mass marketing.

This paper suggests that facial recognition from biometric technologies can be used to solve those problems. Specifically, a facial payment could free cashiers and eliminate waiting queues. A real-time facial detection system could effectively support employees in assisting customers in need. Furthermore, the system can recommend products according to the past shopping experience and current profile. Also, further customized promotion offerings will be sent based on analytics.

Moreover, the SWOT Analysis is used to comparisons between facial recognition solutions with other technologies. Although there are some weaknesses of technology and threats from the external environment, facial recognition solutions have superior intellectual performance, value delivered, and fit the future application trend. There is no doubt that facial recognition

technology still has room to progress and develop. More and more valuable features may emerge in the future.

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