Design of Smart Campus System Based on Virtual Platform of Campus Card

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Abstract: Campus card is an important part of the construction of supporting facilities in colleges and universities, but there are widespread problems such as limited application scenarios, inability to meet the personalized needs of users, inability to realize remote business processing, and difficulties to carry out mobile payment. To solve the problems of campus card system in Beijing Institute of Technology, we design a campus card electronic payment platform to solve these problems. In this paper we first discuss the application scenarios and values of campus card electronic platform for student academic management, campus mobile payment and smart campus construction. Furthermore, relying on emerging technologies such as mobile-end micro-applications and face recognition technology, a reliable, convenient, extensible and highly integrated virtual campus card platform is built to realize a convenient campus era so as to shorten the waiting time for every payment scenario in school.

Keywords: Campus Card, Virtualization Platform, Smart Campus Construction

1. INTRODUCTION:

Campus card plays a critical role in the maintenance of students' authentication process and payments in school. With the development of mobile payment, many schools have built their own information management system to accomplish some basic functions and it have emerged as powerful platforms for campus services. Compared with the traditional campus card, virtual card provides users with a more secure and reliable application scenario as well as making services more convenient [1]. From a security perspective, personal information can be easily stolen as we have to carry the campus card all the time and without authentication it can be easily embezzled. From the perspective of convenience, studies of professor Xu from Zhejiang University have shown that most payments on campus only needs a single cellphone to realize [2-3]. It is also mentioned that teachers and students are fond of mobile payments better than the traditional way.

As the trend of mobile payment is becoming a necessity, some schools like Shandong university and East China Normal University have built their own campus card virtualization platform [4]. However, most studies in the field of smart campus system have only focused on convenience but ignored the importance of network security [5-6]. In this paper, we make a conception about building a smart campus system which can provide both security and convenience [7]. The system collects different types of information from its user and store them in databases. Once the information is required, the user have to get verified in several ways. Compared with the existing technology shown in Fig. 1, the new system is more secure as it supports a three-stage payment mode in which facial recognition, personal account of WeChat and student's school ID for authentication are included. As a contrast, the traditional payment mode can only support on-site payment, which is apparently less secure than the newly developed system.

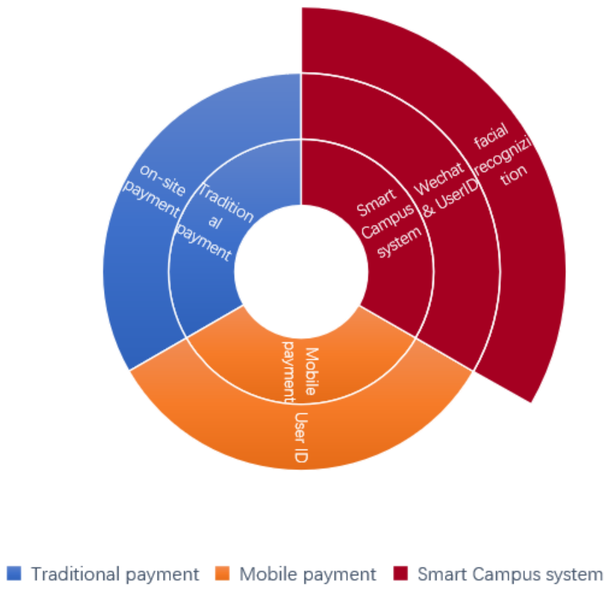

Fig. 1. Authentication under three circumstances

Our research is aiming at making contributions to a deeper understanding of smart campus as the system we design can accomplish both mobile payments and authentication process in a more flexible and secure way. In this paper, to enrich the functions of campus card system in Beijing Institute of Technology, a campus card electronic payment platform relying on face recognition technology and WeChat Applet is designed and established. Our group discusses the purpose and significance of the platform. At the meantime, we analyze the performance of the platform and compare it with other similar system. Our research has shown that the platform can shorten the waiting time as well as enhancing the security for payments in school.

2. METHOD

The traditional campus card is mainly designed as read-and-write ID card [8]. Once the users have completed the authentication process (entering password), personal information can soon be called for providing services. Although the traditional campus card has been widely used, it is still unavoidable to keep the card from getting lost. In 2017, Zhejiang University took the lead in launching the mobile payments system based on campus cards. The system is considered as an extension of the campus payments and quickly gain supports from users in school. Therefore, the establishment of virtual campus card system appears to be a timely supplement to the previous one. It provides the user with a new option and makes great improvements to the present payment system. Moreover, the introduction of facial recognition can guarantee the safety of personal information. With the new designed system, students on campus can enjoy a variety of services through their cellphone without paying attentions to worry about information being revealed. The two modes of payments complement each other and make up an integrated payment system. In this system, virtual card platform plays a significant role as a supplement to normal campus card. The figure below states the basic architecture of our program. The platform is mainly composed of two parts: the applet of WeChat and the server. User information is transferred from side to side and various functionalities are exposed. The following part of the article will analyze the overall architecture of the platform from the user's perspective.

2.1. Information Binding

For the first time of registration, the users have to send personal information and their images to the server. The image, after being processed by the facial recognition system, will be stored in the database together with the former. Up to this point, a new user has been successfully created and his campus account is bounded to facial features. The user can now call personal information through the face recognition module.

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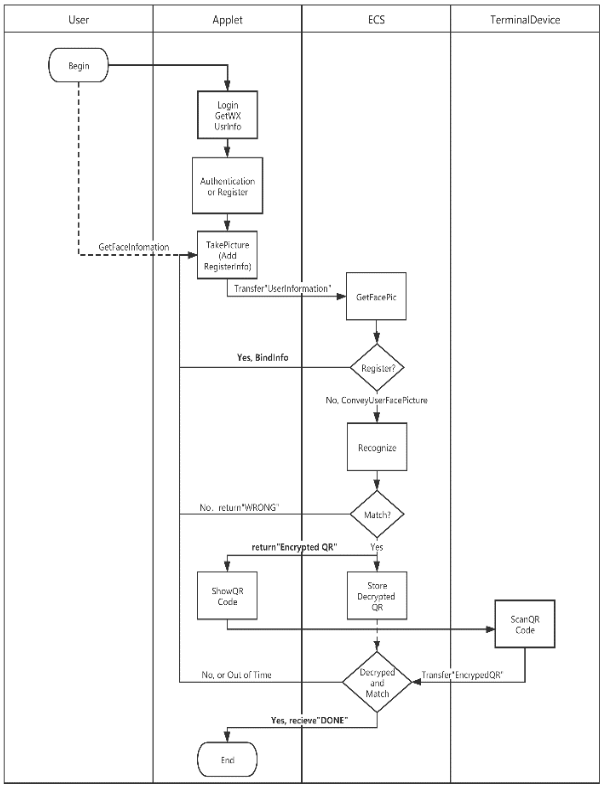

Fig. 2. The overall architecture of the program

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2.4. Information Matching

When information is required, the user has to send his image to server for facial recognition. Comparing the previously stored image with the latter, the recognition program has to decide whether the two features match each other and returns the final result to the server. If match, the server then returns an encrypted Quick Response (QR) code containing user information. Through this QR code, the user can enjoy a variety of services.

2.5. The Response of Remote Terminal Device

Once the remote terminal devices recognize the users' QR code, the decrypted messages will be sent to the server again. The server invokes the program to complete tasks on request, and returns information to the user once again. Thus, a closed loop is formed between the user and server.

3. TECHNIQUE REALIZATION

Technologically, our project mainly consists of four parts: a web framework which helps connect users with the server; an applet that provides users with high-quality services; a database system storing personal information and face recognition module using for authentication process.

3.1. Django

Django is a web framework developed in python. The framework is also known as MTV, which represents Model, Template and View [9-10]. Model is used for database management. The administrator can create customized graphs through Model. View can be loosely described as a controller. Most operations such as data processing and template-invocation are accomplished through it. As for Template system, it is mainly applied as a tool for website design [11]. Through setting the configuration file above, our group creates a server that can hold our students' information management system. From the Administrator account shown in Fig. 3. querying as well as modifying the personal information form the backend can be more convenient.

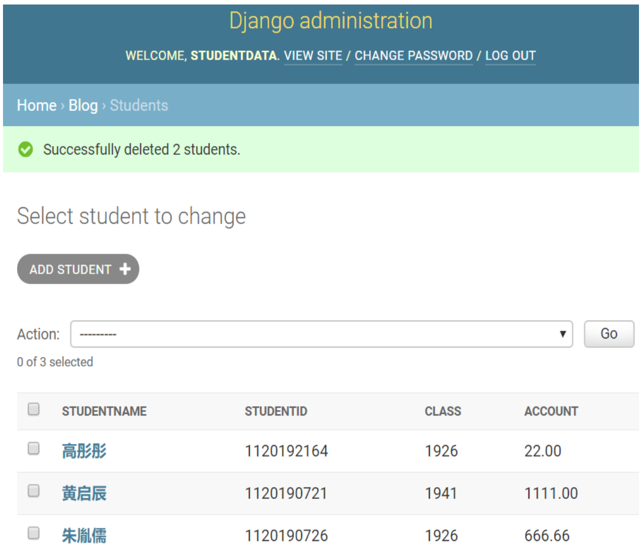

Fig. 3. The students' information management system

3.2. Applet

The emergence of applet provides a new way to connect the users with services, which can be easily acquired and distributed within WeChat while satisfying the user with a great experience. A lot of tools, such as WeChat applet development document and design guide, have been released to help developers exploit their applets simply and efficiently. From the perspective of the UI interface design, our team follows the principles of concise, clear and efficient and mainly divides it into several parts that are shown in figure 4: login, registration as well as the face recognition part.

When the user enters the app for the first time, the app will judge whether the user has registered on WeChat. If not, it will jump to the registration interface and users have to fill in their identity information for registration. While the user information is uploaded successfully [12], the applet will jump to the face recognition interface. In this interface, the applet will prompt the user to take a picture. After taking a photo, the applet will automatically upload the picture to the face recognition module for authentication process [13]. If matching, the server will return a QR code containing encrypted information which can be used for paying in campus [14].

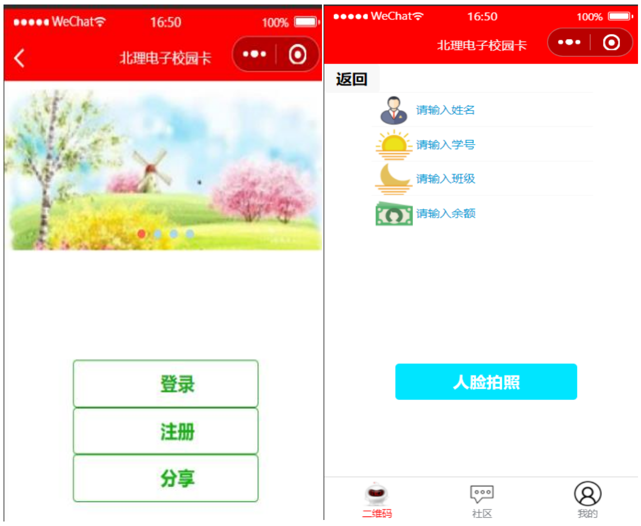

Fig. 4. The interface of WeChat applet

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3.3. Face Registration and Recognition

In this project, the face recognition module is used for authentication process, which mainly consists of two parts: face detection and feature extraction.

In the face detection part, we use the open source Libfacedetection Library [15] by Professor Shiqi Yu of Southern University of Science and Technology to obtain the coordinates of possible face boxes and the corresponding characteristic points (left eye, right eye, nose tip, left corner of mouth, right corner of mouth) on human face in the input image. Then we filter the above results and only retain the largest box and its corresponding feature points (when the input image only contains a single face, this process is ignored). The midpoint of the two corners of mouth is taken as the feature point of mouth, and other points remain unchanged; A quarter of the face box width is taken as the edge length of the feature region.

In the feature extraction part, we use the combination of neural network feature and LBP feature [16] as the final feature of the input image. For the former one, the Convolutional Neural Network(CNN) model we choose is the MobileFaceNet model [17] due to its high precision and good performance in mobile phones as well as embedded devices, which can provide us with 128 dimensional eigenvectors. For the latter, we scale the four feature regions of face detection part to 16*16, take the number of sampling points as 6 and the number of patterns as 32, then make histogram statistics for each region. In this way, we also get 128 dimensional eigenvectors of Local Binary Patterns (LBP) features, so the final feature vector is 256 dimensions. When implementing face registration function, the corresponding relationship between the feature vector obtained and the label will be set up and saved to the local model. After switching to face recognition function, the feature vector is used to calculate the cosine similarity with the feature vector in the model individually, then the label corresponding to the highest similarity vector will be taken as the matching result output. The module will return a parameter telling whether the two features match so that the server can make correct response immediately. When the number of registered faces is big enough, Extreme Learning Machine (ELM) [18] will be trained on the basis of the feature vectors stored in the existing model. At this time, for the input image data received in the face recognition mode, the module first obtains N candidates according to the ELM model output to narrow the target range, and then compares the features among them, which improve the recognition efficiency effectively.

4. RESULTS AND DISCUSSION

For the virtual platform our team constructs, in order to evaluate its performance, we have measured indicators from three different aspects and compared them with the existing modes of payment, which can help us test and verify the feasibility of our product.

4.1. The Response Time

Considering about the running speed of the platform, we calculate the response time of four payment methods and divide it into three parts: the time before payment, the response time during payment and the authentication process after payment. The data is shown in table 1. According to the table, traditional mode of payment is undoubtedly the optimal solution when response time is the only factor taken into account. However, the security of it cannot be ensured as no authentication process is applied. For the other three modes, Face Recognition Only mode seems to be faster than the other two but high cost as well as huge size of the equipment make it quite difficult for widely usage. In a more realistic situation, if students are lining up for lunch in the canteen, those equipped with our program can save more time as they can take advantage of the waiting time to accomplish previous preparation so that the payment process can proceed more efficiently.

4.2. Recognition Accuracy

In order to verify the recognition accuracy of face recognition module, our group has set up two experiments for comparative analysis. The FaceWarehouse data set was chosen for beta test, which includes a total of 3600 photos taken by 150 people. For each person, the first six photos are used to train the model while the remaining part are used for testing accuracy. In experiment 1 (EX1), three child Extreme Learning Machine (ELM) are set and the number of hidden layer nodes is 100. If we choose mobileFaceNet(MFN) as the final feature of the input image and test 10 times, the accuracy of the model can reach **0.96963**. As a contrast, the accuracy can reach **0.97863** when the combination of mobileFaceNet and LBP feature have been used for verifying. In experiment 2 (EX2), we keep the other variables the same and only change the nodes of hidden layer to 300. In this time, the recognition accuracy rises to **0.977111** and **0.9854482** separately. Through the results, we can confirm that the method of combining LBP feature into the final input image has better performance than others in recognition accuracy. The parameters above are listed in Table 2.

Table 1. The response time of different payments

Period t/s \ mode of payment	Preparation Time **t/s**	payment **t/s**	After payment **t/s**	Total **t/s**
Traditional	//	**1.24**	//	**1.24**
Payment Code only	**3.49**	**1.46**	**4.45**	**9.4**
Face recognition only	//	**4.35**	//	**4.35**
Virtual platform	**6.12**	**1.37**	//	**7.49**

Table 2. The accuracy of recognition module

	MFN	MFN&LBP
EX 1	**0.96963**	**0.97863**
EX 2	**0.977111**	**0.9854482**

4.3. User Carrying Capacity

The user capacity of our applet is obtained by analyzing the bandwidth of the cloud server, the maximum Input/Output Operations Per Second (IOPS) of Earth System Science Data (ESSD) cloud disk as well as the maximum throughput capacity of single disk. The cloud server ECS used in this applet is S6 / ECS.s6-C1m2.large (2vCPU 4GiB), the system disk is ESSD cloud disk 40GiB, PL0, and the current bandwidth is 1MB. Based on the parameter calculation formula of aliyun cloud disk, the maximum IOPS of a single disk is calculated as:

$$\mathrm{MaxIOPSperDisk} = \min\{1800 + 12 \times \mathrm{capacity}\} \,........ \quad (1)$$

The IOPS of this our applet is 2280; and the throughput capacity of single disk calculation formula (MB/s) is:

$$\text{MaxCapacityperDisk} = \min\{120 + 0.5 \times \text{capacity}\}. \ldots\ldots \quad (2)$$

In the use of our applet, users can mainly upload and download picture files, and several string, whose average size is 52.3KB. The maximum bearing capacity num_1 of broadband users can be calculated based on the conditions of broadband and the corresponding formula. In a complete process of being used, our applet needs to request the server for 5 times, with an average time of 7.49 seconds, and the average request to the server is 0.67 times per second. Based on the conditions of single-disk IOPS and the corresponding formula, num_2 can be calculated. In the process of using this applet, users need to call the face information and identity information stored in the cloud, whose average size is 1kB. Based on the maximum throughput capacity of single disk (MB/s) and the corresponding formula, num_3 can be calculated. The parameters above are listed in Table 3.

Table 3. The relevant parameters user carrying capacity

Main parameters	Applet Support	User Requirement	Carrying Capacity
Bandwidth(MB)	1	52.3KB	19.6
IOPS/disk	2280	0.67	3403
Throughput capacity /disk(MB/s)	120	2KB/s	61440

5. CONCLUSION

As information progresses in society while mobile payments are developing rapidly, the construction of smart campus has attracted quantities of colleges to participate in the project. In this paper, our research on smart campus system has shown that a virtual campus payment platform which is required to include both convenience and secure can be realizable and it can ensure user information security as well as facilitate students' campus life. Even though, the design of virtual platform is just considered to be a supplement of traditional payments and there are still a lot functions waiting for us to exploit. With the development of science and technology, the smart campus system will definitely meet user demands. By then, all users can enjoy convenient and safe campus services.

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