LunchByte: A Facial Recognition-Based Payment System for Health-Conscious Elementary Student Meals

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Abstract **– A significant number of elementary school students experience challenges related to lunch, including forgetting lunch money, lacking awareness of their individual dietary needs, and the importance of balanced nutritional choices for their overall health. Numerous parents and guardians struggle to monitor their children at school, control their purchasing behaviors, and maintain their health. Therefore, this research aims to enhance the efficiency and monitoring of elementary school students' lunch choices. LunchByte, a face recognition system developed in this study assists elementary in monitoring lunch expenses concerning their dietary restrictions. The main feature of LunchByte is using a student's face print to generate a custom menu tailored to their allergies/diet restrictions and allowing them to pay with a prepaid balance added by their guardians. The evaluation of this system involves conducting model testing to assess the accuracy of facial recognition, integration testing to examine the interaction between different components of the system, and usability testing with end-users to evaluate the user experience. The results of these tests indicate that the system achieves high levels of accuracy and user satisfaction. The study is important because it has the potential to improve the overall health of young children.**

Keywords **– Artificial intelligence, face recognition, deep learning, school lunch, allergy.**

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1. Introduction

Children's school lunches are important since theyhave a significant impact on their diets and can improve their health, well-being, and academic performance in addition to lowering their risk of developing certain chronic diseases later in life [1]. While most schools have canteens where students can choose their meals from the menu and then pay, several issues warrant attention. What happens, for instance, if students forget their money or some students buy food that is not right for their diet? Young students frequently lose or misplace their lunch money, which causes them to skip meals during the school day. Some children need particular diets due to some health conditions like allergies, diabetes, obesity problems, etc., and, thus, eating inappropriate foods or even going without food might have a negative impact on them.

Midday meals like lunch increase blood sugar levels, giving children the extra energy, vitamins, and nutrition, they need to get through the rest of the day. A healthy balanced meal also helps children concentrate and focus better for the remainder of the afternoon. Numerous well-designed studies, including one from the University of California, Berkeley, have demonstrated an improvement in student performance in schools that worked with specific vendors of nutritious lunches [2]. Not only are the children having issues, but even the guardians find it difficult to keep an eye on what their children eat and how much money they spend at school. The school canteens also have other issues, such as minimizing food wastage [3], regulating the marketing of unhealthy foods, and providing access to safe and healthful food [4].

Therefore, LunchByte seeks to develop a solution to the students' forgetfulness/loss of lunch money while ensuring that every child has a suitable and balanced nutritious lunch, as well as improving the management of the canteens in the school using artificial intelligence (AI) techniques to develop easier and a more efficient and manageable lunch experience for elementary school students, guardians, and school canteen administrators. Artificial intelligence plays a crucial role in facilitating the process of digital transformation. By harnessing the potential of artificial intelligence in the field of education, it is possible to enhance the efficiency and effectiveness of the school systems. The primary objectives of this study are to create and implement a LunchByte smart system to facilitate the processes involved in the sale, purchase, and management of lunches for students, parents/legal guardians, and canteen administrators. Subsequently, assess the effectiveness of the proposed system through the utilization of functional and usability testing techniques with a focus on model evaluation that includes 14 pictures of real school students.

The waterfall methodology has been used as a software development process. It is a linear approach in software development, where each phase of the project is completed sequentially, with one phase leading to the next. Its phases include analysis, design, implementation, and testing and evaluation.

Three unique interfaces are offered by the LunchByte system to accommodate the requirements of guardians, students, and canteen management. Logging into their child's account, guardians can add money, set daily spending caps, and specify dietary restrictions. Students can then use the system and log in using their face print or ID. Then, they will see a special custom-catered menu for them. They can pick the food they want and pay for it using the money their guardians have deposited into their accounts. By awarding points for making nutrient-dense food choices, the system promotes healthy eating. Points can then be redeemed for savings on school lunches. When a child's balance is becoming low, the guardian will be notified, and they can access detailed transaction information. Guardians can get detailed purchase data about their children and will be notified when their children's balances are becoming low. Administrators of canteens can view analytics on the canteen on a dashboard. It will give them details about the most popular meals, the number of meals sold, and the average meal price. Administrators can use this information to make educated judgments regarding the meals they provide.

The remainder of this paper is structured as follows: The related research is covered in Section 2, and the system design and implementation are covered in Section 3 which is the research methodology, where system analysis, design, testing, and evaluation are illustrated in Section 4. The study's conclusions and future work are discussed in Section 5 at the end.

2. Related Work

Section 2 reviews the existing literature on facial recognition and its application, particularly in schools. It examines the effectiveness of deep learning models in facial recognition, explores the integration of this technology within school systems for both safety and administrative purposes, discusses the challenges of stakeholder acceptance and privacy concerns for children, and concludes with an examination of school meal payment solutions, setting the stage for the introduction of the LunchByte system.

2.1. Deep Learning Models for Facial Recognition

Deep learning models have revolutionized computer vision and, by extension, facial recognition. The models automatically learn hierarchical features from data, demonstrating exceptional accuracy in various image recognition tasks. Among these models, convolutional neural networks (CNN) are widely adopted across sectors ranging from healthcare to education and home security. For instance, [5] employed CNNs for an E-voting system, combining face recognition with blockchain technology and blind signature mechanisms to enhance the security of online voting. Also, [6] tackled the problem of fake accounts on online social networks using CNNs; [7] used CNNs for patient identification in hospitals; [8] used it in student attendance monitoring, and [9] used CNNs for face recognition in home security.

Beyond traditional CNN architectures, models such as VGGFace, FaceNet, and DeepFace have become pivotal in facial recognition research. VGG-Face is a widely recognized deep CNNs model for image recognition, developed by researchers from the Visual Geometry Group at the University of Oxford. The model underwent training using a dataset consisting of 2.6 million images, each depicting one of 2622 distinct individuals. The accuracy percentage achieved by this model on the Labeled Faces in the Wild (LFW) dataset was 97% [10]. FaceNet is another popular model developed by researchers at Google.

It is a type of neural network architecture known as a Siamese Network, that is designed to acquire the ability to discriminate between two distinct inputs. The model is trained directly using Euclidean distance, utilizing a dataset consisting of 8 million distinct identities and a total of 100-200 million photographs. According to [11], FaceNet has been documented to attain a remarkable accuracy of 99.63% on the LFW dataset, utilizing a mere 128 bytes per face. Finally, the DeepFace model, developed by researchers at Facebook, is a neural network model that utilizes deep learning techniques. The model was trained using a dataset consisting of 4 million images that were uploaded by 4000 users on the Facebook platform. This dataset was considered to be the largest of its kind at the time of its release in 2014. When tested on the LFW dataset, DeepFace demonstrated a level of accuracy of 97%, which is comparable to the performance of VGG-Face [11].

[12] and [13] employed the VGGFace model for age estimation, emphasizing the advantage of pre-trained models. Meanwhile, FaceNet, as highlighted by [14] and [15], has demonstrated its superior capabilities in recognizing faces under varied conditions and for attendance systems. In a broader application, [16] built a multi-camera surveillance system on the FaceNet model, showcasing its potential in efficient, automated surveillance solutions.

2.2. Facial Recognition in Schools

Facial recognition technology is rapidly being integrated into school systems, addressing both safety and administrative concerns. An example of its application for safety is seen in the school transportation system. [17] created a system for student tracking during their commute on school buses. Their face recognition model, when connected with IoT, recognizes students, tracks essential parameters like route adherence, and promptly sends updates via SMS to parents. This initiative aligns with the proposal of [18], which emphasized the need for a school bus subscription authentication system. They highlighted the drawbacks of conventional passenger management practices, proposing a face recognition solution using a cascade classifier and linear binary pattern histogram algorithms.

Within school premises, facial recognition extends to administrative functions as [19] developed an attendance system that leverages facial recognition. They emphasized the importance of positioning for imaging, noting that the system achieved 100% accuracy when students stood in a suitable position.

Further broadening the scope of applications, [20] integrated facial recognition into a student violation point system, allowing centralized recording of disciplinary actions in real-time using Android smartphones with the Fisherface method, achieving 90% accuracy.

Also, considering the diverse age groups within educational systems, [21] delved into the challenge of recognizing younger faces, spanning newborns to preschool children. The study built a CNN model that achieved an identification accuracy of 62.7% for single gallery newborn face recognition and 85.1% for single gallery toddler face recognition.

2.3. Stakeholder Acceptance and Children Privacy Concerns

The integration of facial recognition systems in schools necessitates the consideration of stakeholder acceptance. [22] explored this aspect by assessing the perceptions of elementary school parents in China. The research methodology incorporated two factors: technological innovativeness and dangerous beliefs in the virtual world (DBVW). Findings revealed that parents with a higher degree of technological innovativeness were more likely to perceive value in face recognition systems for schools. Conversely, those who have dangerous beliefs in the virtual world exhibited a reduced perceived value of such systems. Meanwhile, parents' perceived value played a pivotal role in determining continued support for the implementation of face recognition in schools.

However, alongside stakeholder acceptance, concerns regarding the privacy of children and the ethical implications of using their data for facial recognition have emerged. [23] highlighted the potential utilities of technology in schools, such as automated registration and campus security. However, the study cautioned that unchecked use could push schools towards authoritarian and oppressive practices. Meanwhile, [24] approached the topic from a design perspective, emphasizing the ethical challenges of facial recognition. Through the development of an educational web application, "Civil War Twin," the study underlined the need for transparency, inclusivity, and empathy in designing such tools. Similarly, [25] drew attention to the broader implications and potential pitfalls of facial recognition technologies, urging the global community to prioritize responsible development and usage.

2.4. School Meal Payment Solutions

School meals significantly influence a student's daily life.

Beyond being a source of nutrition in schools, they are essential for the well-being and academic performance of the student. However, issues such as equitable access have always been a challenge. [26] drew attention to the prevalent issue of unpaid meal debt, an unfortunate consequence of which is lunch shaming. This highlights the need for efficient and compassionate payment solutions to ensure every student can afford meals.

One considerable challenge faced by students and their guardians is the management of lunch expenses. Misplaced lunch money or simply forgetting it becomes an obstacle for students to get the nourishment they need. This leads not only to the immediate problem of hunger but could potentially result in students making sub-optimal food choices.

Furthermore, the increasing prevalence of specific dietary needs and health conditions among students elevates the importance of catering to these requirements during lunchtime. Meanwhile, current attempts to address these issues, however robust they might seem, have shortcomings. [27] analyzed the current school nutrition environment and found that while there are positive aspects to the reforms, challenges rooted in family home environments and larger socioeconomic factors remain.

Table 1 presents a comparison of the existing school meal payment solutions, including their features and shortcomings. Comparing these IT artifacts with the proposed solution, the LunchByte system would overcome the shortcomings presented in the table below which would assist in maintaining children's health in the elementary school.

Table 1. Comparison between existing school meal payment solutions

Solution	Feature	Platform	Shortcomings
Coupons and Cash	-	Real Life	Can be lost or forgotten and no supervision.
Bracelets	Smart bracelets that parents can transfer money to and can see what the child has bought. It is also connected to the child's health records.	Real Life	Can be lost or forgotten and can be expensive.
Prepay for Schools	Parents pre-pay the school and get a card or a unique pin for the child. Pupils then use the card to pay for lunch.	Application	Cannot set any restrictions to avoid allergy reactions or keep a special diet.
Lunchtime Software	Parents pay online and pre-plan each lunch meal at the beginning of every week.	Web-based or Windows Application	Children do not feel like they have personal choices and require a lot of parental interaction.
Smart Canteen	Application to order food and pay online. In Mumbai, they had a similar system but with an additional benefit, they can view if there were any free seats at the canteen.	Application	Difficult to implement with Children in primary schools.
Face Recognition Payments	Payments using face recognition, does not require any contact and students no longer need their identity cards or input their card's pin.	AI Software	Does not pay attention to allergies or special diets.

3. Research Method

The following section discusses the research method for the LunchByte system, starting with understanding user needs through surveys and interviews in Section 3.1.

Then, we discuss the system design in Section 3.2 and the implementation details, including the technology and dataset used in Section 3.3.

3.1. System Analysis

Two methods were used to understand users' needs: a legal guardian questionnaire and an interview with a few elementary school administration members.

The questionnaire was used to obtain insights from legal guardians about their thoughts and comments regarding the current lunch buying system which assisted in designing the proposed lunch system. Some of the questions that were asked are: (1) How many times does your child forget to take her/his lunch money? (2) and does your child have any allergies? if yes please list them.

The questionnaire received 188 responses, and the findings were used to refine the requirements for the proposed solution. The questionnaire revealed that knowing what a child eats for lunch is essential, with an overwhelming response of "yes" received. Legal guardians agreed that elementary students needed the most monitoring to avoid allergies and ensure a healthy and balanced meal, with 84% of respondents indicating so. The questionnaire also revealed that the primary payment method in most schools was cash, and many legal guardians had trouble procuring their children with money change every morning. Additionally, the questionnaire asked about the likelihood of children forgetting or losing their lunch money, with 62.2% of respondents indicating that their child was prone to this. The questionnaire also revealed that a significant percentage of children have allergies/special diets and have suffered from eating food products unsuitable for them at school, emphasizing the need for protective measures in the proposed system.

The interview conducted with the primary school's administration aimed to obtain insights into the lunch-buying process and the extent of legal guardians' involvement in their child's eating habits at school. The current system in place involves a simple menu displayed, a teller working a cash register, and children waiting in line to state which products they want to buy. The employees manually input sales and calculate profits, and legal guardians have no way of knowing what their children are buying or eating on school grounds. The administration believes that pocket money is easily forgotten or lost, especially among primary school students. If a child forgets or loses their lunch money, their name is written on a list by the cashier along with how much they owe, and a message is sent to the legal guardians.

The menu and food are supplied by a catering company, and the product quantity is determined by how much of each product has been selling the most concerning the number of students in school. Each teacher receives a list of children in their class and their respective allergies/health conditions, but legal guardians are not usually informed of what their child consumes. The administration suggested an automated dashboard for sales statistics and more parental involvement in their children's eating habits at school. They also suggested using student ID cards for verification before allowing them to purchase.

Based on the results from the questionnaire and the interview the LunchByte's system features were determined and finalized as follows:

1. The system would be designed to cater primarily to elementary schools, to ensure that the system caters to the needs of younger students who may require more monitoring and assistance with their lunch choices.
2. The system includes a feature that allows legal guardians to monitor their child's eating and purchases, it will provide the legal guardians with information on the food their child purchases, the quantity of food consumed, and the nutritional value of the food.
3. The system uses facial recognition as a payment option, as most schools currently use the cash method to meet the need for cash transactions and provide a more secure and efficient payment method.
4. The system would also allow legal guardians to customize their child's meal options based on their dietary preferences and restrictions, ensuring that they receive a balanced and healthy meal.
5. The system would use the student ID as an alternative approach if the facial recognition algorithm incorrectly identified the student's face.

3.2. System Design

In this second phase, two main diagrams were developed to get a full visualization of the system. The developed diagrams are use case and class diagrams. The use case diagram for the LunchByte system has been specified to understand the possible sequential interaction among the system and its actors [28]. As shown in Figure 1 the main actors are the student, the legal guardian, and the school.

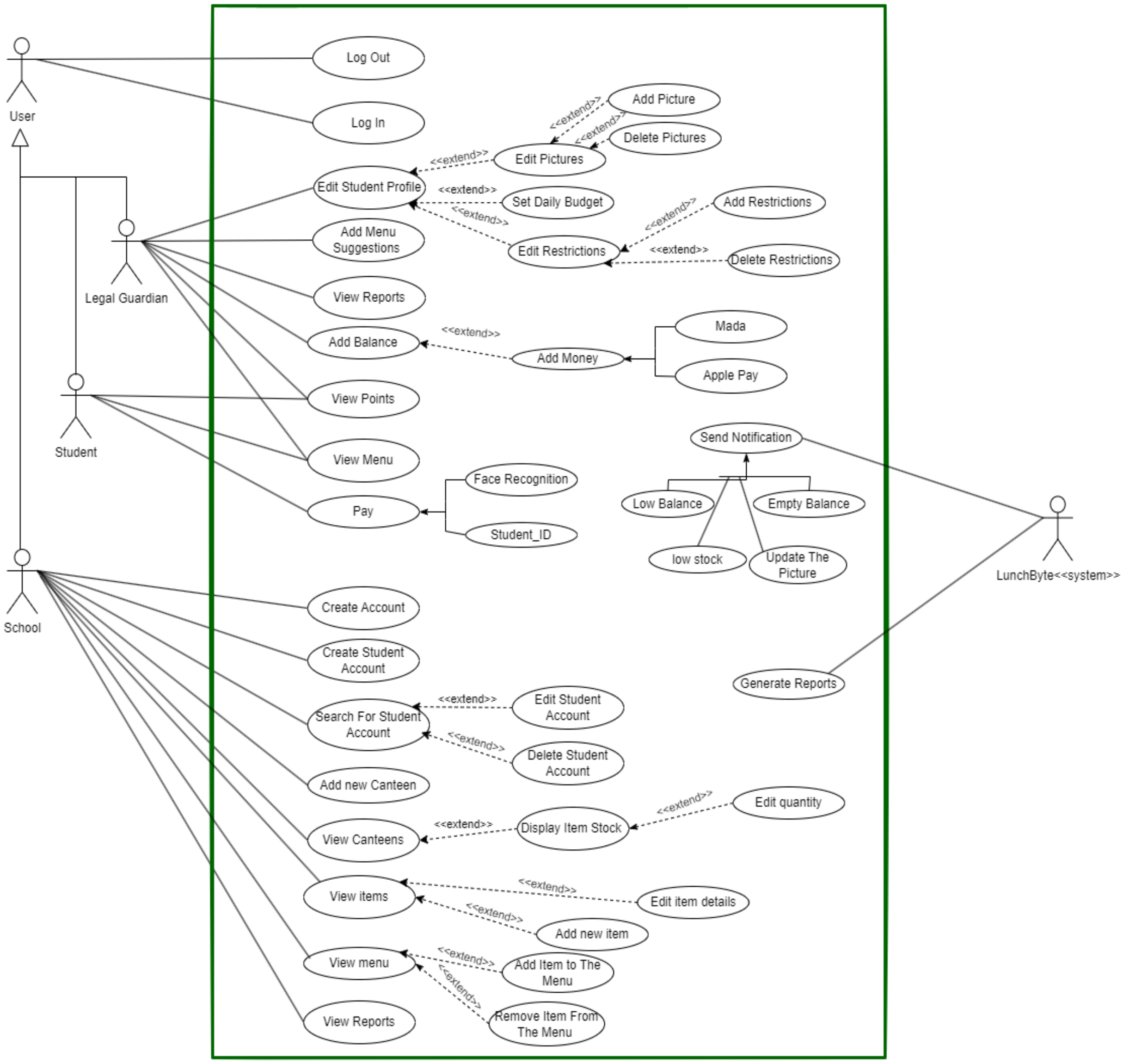


Figure 1. LunchByte's use case

To illustrate the relationships between the system's classes, the class diagram has also been developed that includes six classes: student, school, item, bill, balance, canteen, and restrictions. Figure 2 clarifies the relationships between these classes as well as all the details of each class, including its attributes and methods.

3.3. System Implementation

Several platforms, database management systems, programming languages, libraries, and models were used to develop LunchByte's system (Figure 3). For example, Python, Django, Google Colab, etc. More details are illustrated in the following subsections starting from section 3.3.1 database until 3.3.6 system integration.

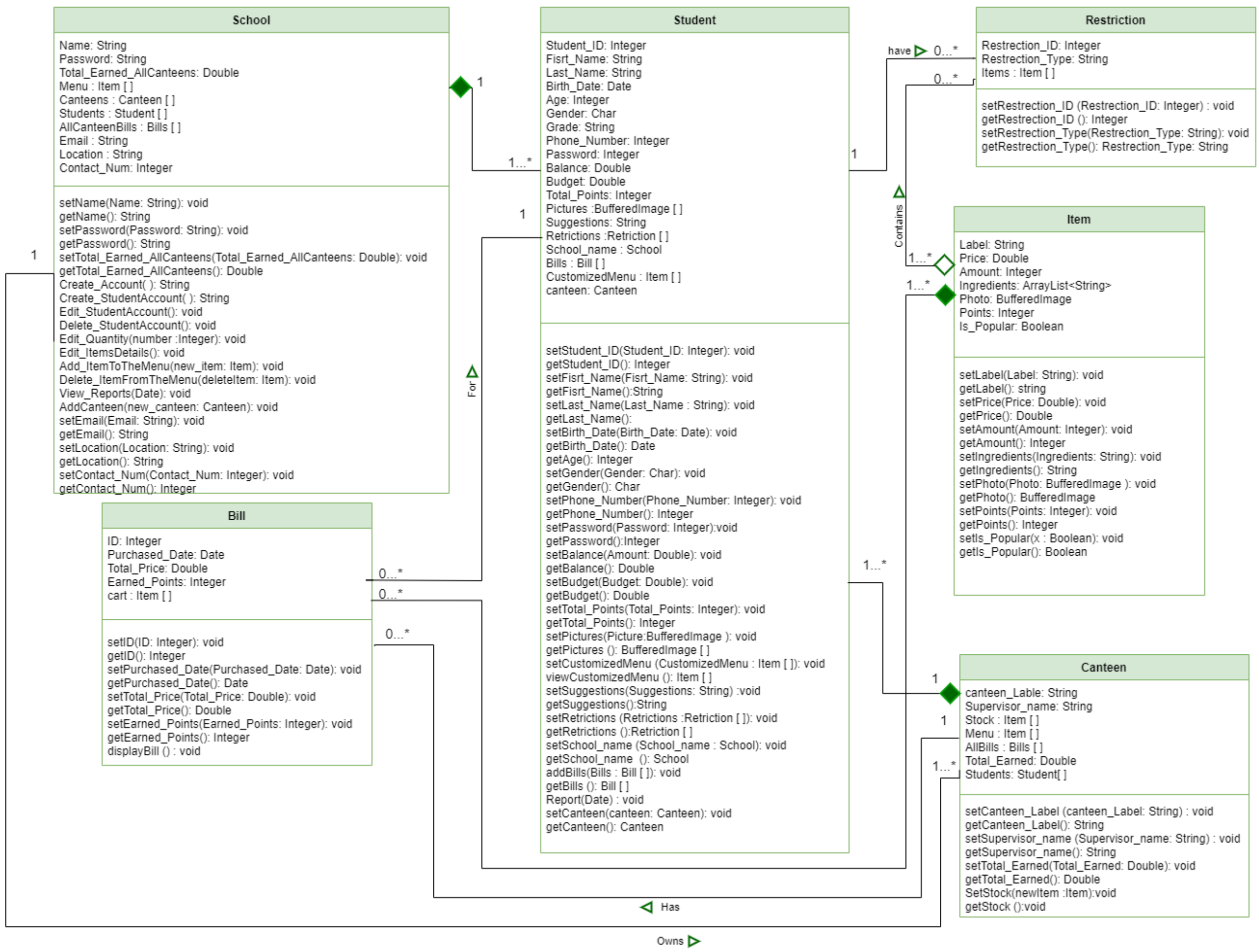


Figure 2. LunchByte's class diagram

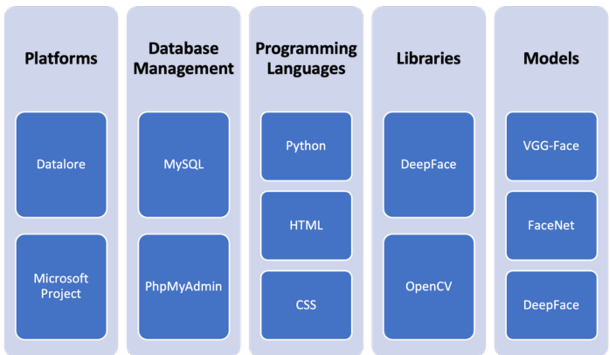


Figure 3. The software used in the LunchByte system implementation

3.3.1. Dataset

The primary source of novelty in the LunchByte system lies in its utilization of facial recognition techniques to streamline the lunch purchasing process. Consequently, the collection of children's images was imperative in order to select the most accurate model for our facial recognition system. The photographs of children were obtained from a cohort of students attending an elementary school located in Jeddah, Saudi Arabia.

A total of 60 images were gathered from a sample of 20 elementary school students. The collection of images was undertaken subsequent to obtaining the requisite authorization from the school administration as well as the guardians of the students.

3.3.2. Face Recognition Implementation and Model Selection

Modern face recognition pipeline is composed of 3 steps which are image pre-processing, feature extraction, and face recognition/classification [29]. In the first two phases, detecting and aligning faces are the most crucial early tasks in face recognition that represent the data pre-processing phase. [30] mentioned that foregoing them could worsen face recognition results by up to 1%. In our model, the DeepFace library [30] in Python was employed as a facial recognition tool. This library can be integrated with sophisticated computer vision libraries, such as OpenCV. One significant advantage of employing the OpenCV library is its utilization of haar-cascade algorithms for the purpose of facilitating image and video processing.

The OpenCV library initially identifies salient facial attributes, such as eyes, noses, and mouths, in order to establish the presence of a human face within the given photograph. The haar-cascade algorithm is then employed to perform image rotation by utilizing the angle between the two eyes as a reference point, resulting in the generation of a facial image that is centered.

During the phase of face recognition and classification, the DeepFace library is used to access the three facial recognition models, namely FacceNet, VGG-Face, and DeepFace. Each model takes different vector representation sizes as inputs and displays them as outputs of different sizes as well. When we import a model from the DeepFace library, we can easily resize the images to the sizes required by each model and output the vector representations. Then, Siamese neural networks use vector representations for each image rather than using the images themselves to run a comparison algorithm to determine image similarity. The Euclidean distance algorithm was selected to determine the difference between vector representations; the smaller the distance, the more similar the images are, with zero indicating that the images are exactly the same [31]. The performance of the three models was evaluated using the dataset that was collected. The results are presented in Table 2.

Upon conducting a thorough analysis and comparison of the outcomes yielded by various models, it is evident that FaceNet emerges as the most suitable model for the development of the LunchByte system. The rationale for selecting this particular model is predicated not only on its superior correct recognition score, but also on its minimal misclassification of only two individuals, specifically children. Despite achieving a comparable level of accuracy in recognition, VGG-Face exhibited a higher rate of misidentification by erroneously recognizing four individuals instead of the intended two. In fact, FaceNet's "No Result" is preferable to granting a child access to a false account. Additionally, DeepFace had the highest incorrect recognition score, indicating that it frequently failed to identify the faces of children.

Table 2. Comparative analysis of model testing results

Subject #	**FaceNet Result**	**VGG-Face Result**	**DeepFace Result**
1	Correct	Correct	Incorrect
2	Correct	Correct	Correct
3	Correct	Correct	Incorrect
4	Correct	Correct	Correct
5	Incorrect	Incorrect	No Result
6	Correct	Correct	Correct
7	No Result	Correct	Incorrect
8	No Result	Incorrect	Correct
9	Correct	Correct	Correct
10	Correct	Correct	Correct
11	Correct	Correct	Correct
12	Correct	Correct	Correct
13	Correct	Correct	Correct
14	Correct	Correct	Correct
15	Correct	Correct	Correct
16	Correct	Correct	Incorrect
17	Correct	Correct	Incorrect
18	Correct	Correct	Correct
19	Incorrect	Incorrect	Incorrect
20	Correct	Incorrect	Incorrect
Total (Correct)	16	16	12
Total (Incorrect)	2	4	7
Total (No Result)	2	-	1

3.3.3. Model Training to Build LunchByte System

Legal guardians can use their respective interfaces to upload, delete, or edit images of their children, and the images are uploaded and saved in a secure folder. Within that folder, there are subfolders for each child, each with their own image. When the images in this folder change, the last layer in the selected model is retrained with them. As a result, when asked to perform face recognition, the model can instantly recognize the child by comparing his or her current photo to the photos uploaded by their guardians [31]. Figure 4 depicts the LunchByte model training process.

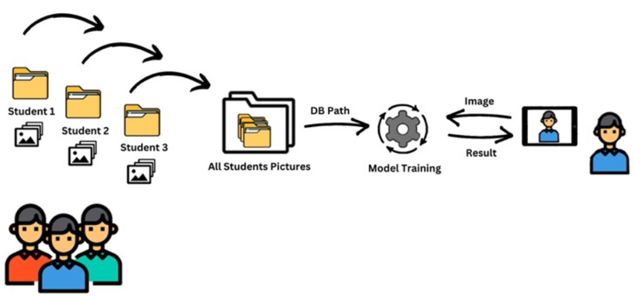


Figure 4. LunchByte model training working process

3.3.4. Database Implementation

The LunchByte database was implemented using SQLite, a widely utilized and user-friendly relational database management system.

The system includes ten tables: school, student, student pictures, canteen, canteen item, bill, items bill, item, restriction, and restriction item (Figure 5).

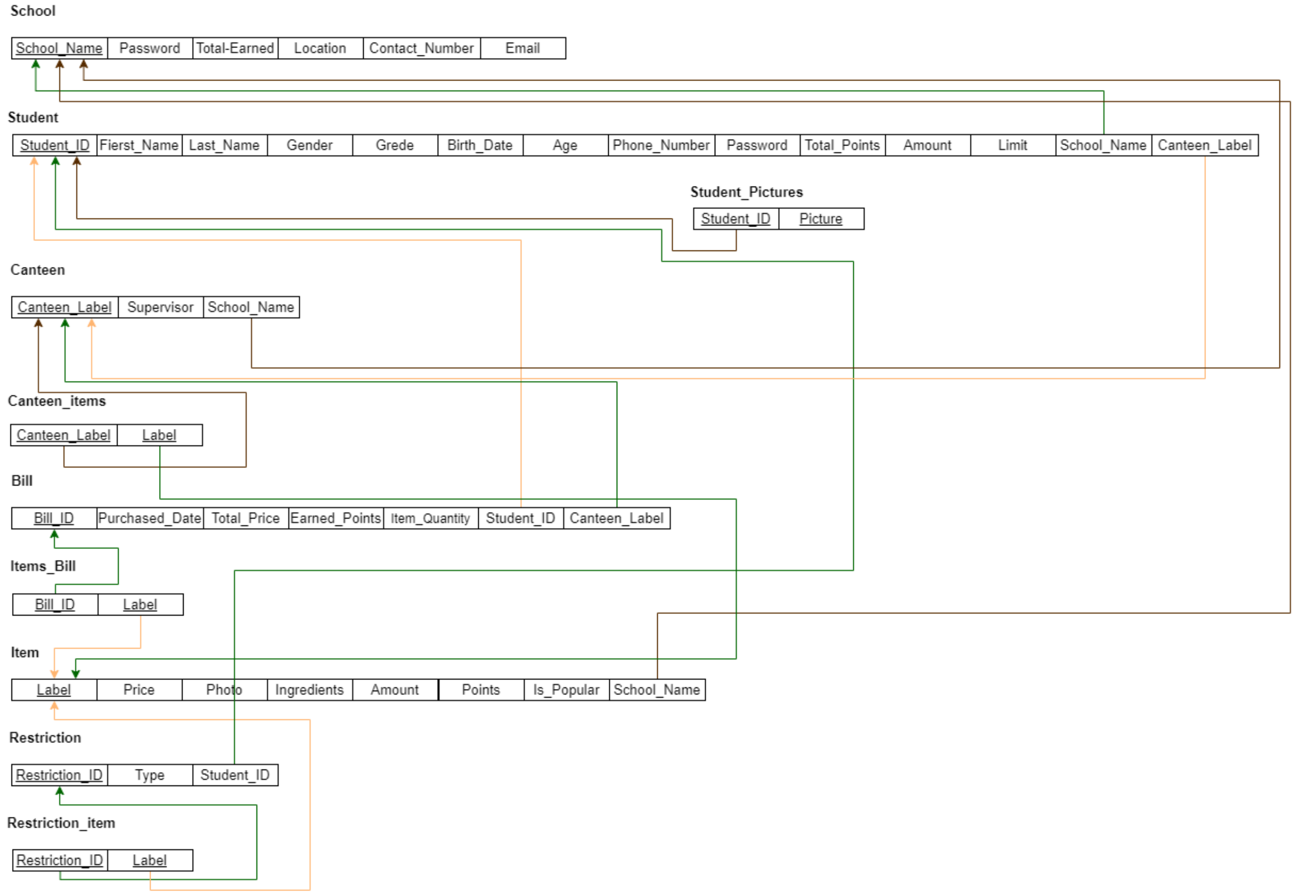
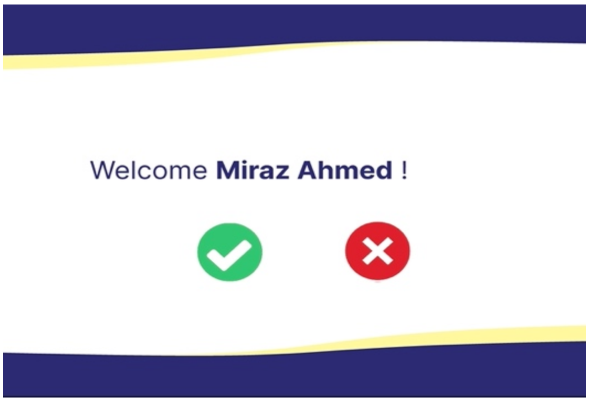


Figure 5. LunchByte's schema diagram

3.3.5. LunchByte's System Interfaces

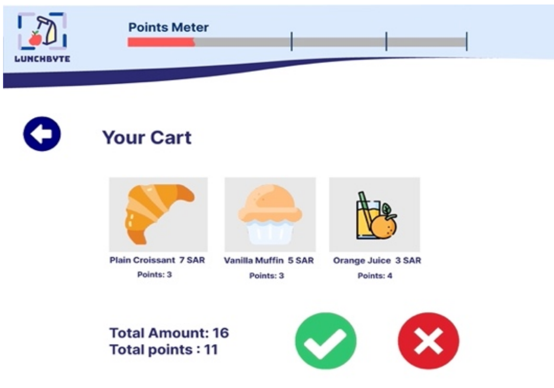
As previously stated, there are three main user categories, so this section describes some of the system interfaces for each user category. Figure 6 (a) shows the student's login page for the LunchByte system, where the student can log in using face recognition technology. Figure 6 (b) depicts the page that the student sees after the model has been detected. The student must confirm her/his identity before logging into the system, and then browse a custom menu tailored to the student's special diets and restrictions to maintain his/her health, as shown in Figure 6 (c). From there, the student can then choose the lunch items he or she wants and proceed to the checkout page, where the total cost of the items as well as the points earned after the purchase are displayed as in Figure 6 (d). The student will earn points for selecting healthy items from the menu, which will encourage healthy eating habits.

(a)



(b)

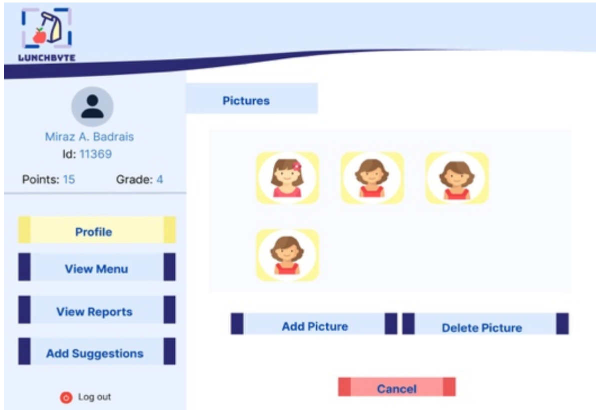
(c)



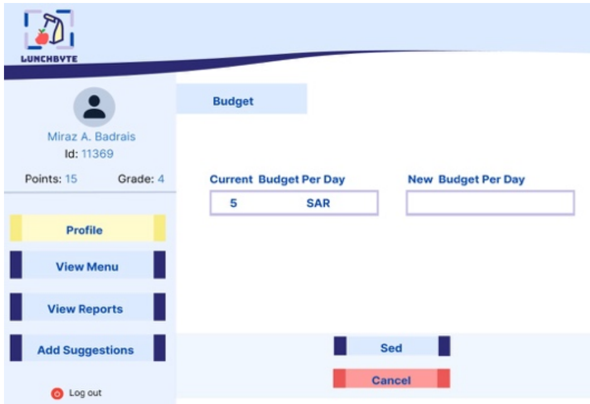
(d)

Figure 6. Interfaces of students in the LunchByte system

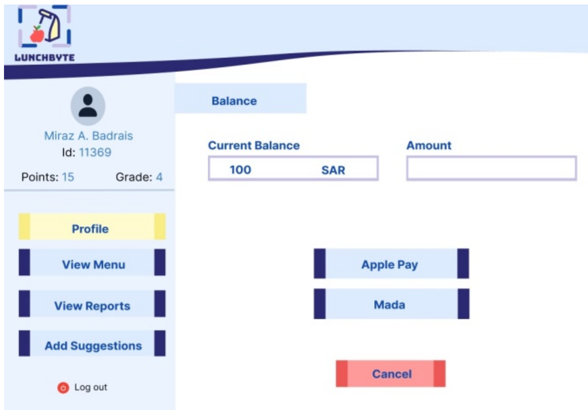
Figure 7 shows many legal guardian's interfaces that allow them to (a) add or delete a student's pictures, (b) set a student's daily budget, (c) add money to a student's account, and (d) obtain a student's purchasing report.



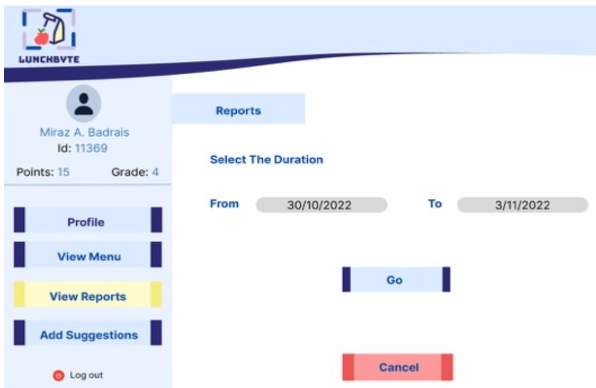
(a)



(b)



(c)



(d)

Figure 7. Interfaces of legal guardians' users in the LunchByte system

Figure 8 presents the interfaces for the canteen administrators that allow them to (a) manage the system by adding and removing students, and (b) display the analytical dashboard of the canteen to observe.

Figure 8. Interfaces of school administration users in the LunchByte system

4. System Testing and Evaluation

The section focuses on testing and evaluating the LunchByte system. Initially, we assess the model's effectiveness in student facial recognition, followed by a broader system evaluation covering functionality, usability, and user satisfaction.

4.1. Model Testing and Evaluation

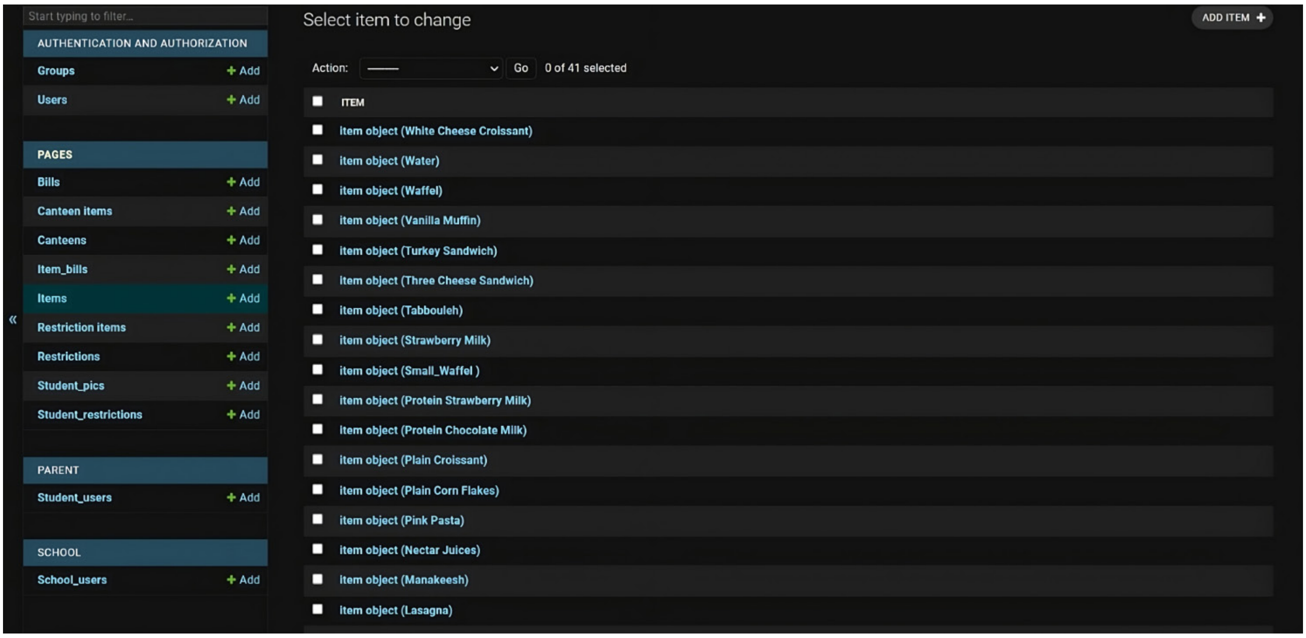
The effectiveness of the selected model was tested after getting the needed approval from the legal students' guardians. The goal is to ensure that students can log in using their faces, thus, the model works effectively without any issues. Euclidean distance was calculated to ensure the similarity between observations; the positivity indicates similarity. The total number of participants is 14 and, as shown in Table 3, 13 out of 14 are positively similar.

Table 3. Model testing results

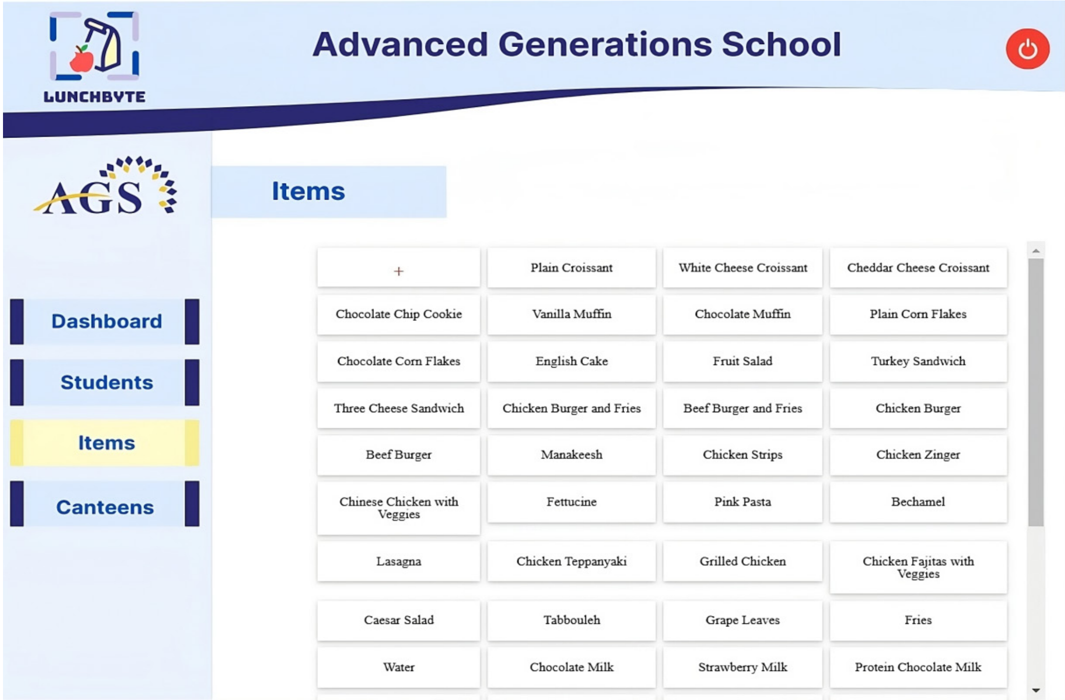
Subject #	Gender	Grade #	Detected?	Matched Image	Euclidean Distance
1	M	1	Yes	2	6.18
2	M	1	Yes	2	3.58
3	F	2	Yes	1	9.6
4	F	3	Yes	1	4.31
5	F	2	Yes	2	4.22
6	F	1	Yes	1	8.86
7	M	1	Yes	3	7.67
8	M	2	Yes	2	4.21
9	F	2	Yes	1	6.33
10	F	1	Yes	1	7.68
11	M	1	Yes	1	5.88
12	M	4	Yes	1	3.40
13	M	3	Yes	1	4.43
14	M	4	No	N/A	N/A

4.2. LunchByte System Testing and Evaluation

Several tests and evaluation techniques have been applied to ensure the system's integrity, functionality, and usability. First, integration testing was used to ensure the connection and information basing among the database and interfaces as displayed in Figure 9. Figure 9 (a) shows the added items in the database that match the items displayed in Figure 9 (b).



(a)



(b)

Figure 9. Integration testing

Second, several test case scenarios were performed to test and evaluate the system's functionality using different devices such as iPads, laptops, and iPhones. Thus, schools, legal guardians, and students were involved. Table 4 below illustrates some of the test case scenarios that were performed with results.

Table 4. Test case scenario results

User	Test Case Scenarios	Description	Results
School	Create Account	School admin can successfully create an account for the school.	Pass
	Login	School admin can successfully login after creating an account.	
	Add Item	School admin can successfully add items to the school canteen.	
	View Canteen	School admin can successfully view the canteen items.	
	Add Students	School admin can successfully add students to the system.	
	View Dashboard	School admin can successfully view the system dashboard and see the needed information.	
Legal Guardians	Login	Legal Guardians can successfully login to their account.	Pass
	Add Budget	Legal Guardians can successfully add money to their student ac- count.	
	Upload Student Picture	Legal Guardians can successfully upload a student picture to the system.	
	View Menu	Legal Guardians can successfully view the canteen's menu.	
Student	Login	Student can successfully access his or her accounts by using their faces.	Pass
	View Menu	Student can successfully view the menu that was customize by their legal Guardians.	
	Add Item	Student can successfully add items to the shopping cart.	
	Place Order	Student can successfully place the order after adding the items to the shopping cart.	
	Make Payment	Student can successfully make the payment if there is an item in the shopping cart.	

Third, a usability test was also executed to assess how well the end users performed the tasks. The focus was on four measures, which are: (1) the number of error clicks, (2) the duration taken to complete the task, (3) how many times the task has been repeated, and (4) the autonomy level that expressed on a three-level ordinal scale: 1 = "Not able to achieve the task independently" 2 = "Can achieve the task independently, with help" 3 =" Can achieve the task independently, without help". The number of participants for each end user/user category is as follows: Students = 14, legal guardians = 7, and the school administrator = 7. For example, the results of students exploring the menu showed that 57% of students reported being able to complete the tasks on their own, 35% reported requiring assistance, and 0.07% reported being unable to complete the tasks. For legal guardians performing the task of logging in, 87% reported task completion independently, while 13% reported task completion with assistance. Moving to the school administrators and during the task of adding a student, 57% reported task completion independently, while 43% reported task completion assistance. Table 5 is a snapshot of the usability test results that include all end users with one example of performed tasks.

Table 5. Snapshot of system usability results

Users	Preformed Task	Avg. # of Error Clicks	Avg. Duration to Complete Tasks	Avg. # of Repeated Tasks
Students	Explore Menu	0.2	1 minute	0.2
Legal Guardians	Login	0	11 seconds	014
School Administrators	Add Student	0.42	49 seconds	0.42

Finally, a short post-questionnaire was sent to school administration and legal guardians focusing on their satisfaction and the LunchByte system's simplicity. 14 responses were received where 71.4% strongly agreed on the simplicity of the system and 78.5% of the participants strongly agreed with the preference of using the system compared with the regular mechanism.

5. Conclusion and Future Work

The LunchByte system is designed to cater to the needs of elementary school students by assisting them in making informed choices regarding their dietary restrictions and allergies. It affords legal guardians the ability to add funds for the children's meals and as well as to control the children's purchases. Thus, it promotes guardians' involvement in monitoring their children's eating habits at school, which is very important in maintaining their health. Additionally, our system endeavors to optimize the services provided by canteens and enhance the efficiency of the purchasing process through the implementation of an automated dashboard for sales statistics which can eliminate the need for manual calculations. The dashboard also aims to effectively tackle the problem of food waste as it would enable canteen administrators to make informed decisions regarding the types and quantities of the purchases they make.

The implementation of facial recognition technology enhances our system and simplifies the purchasing process for students by eliminating the need for physical cards or cash to acquire their meals. This approach ensures a reliable means for students to obtain the necessary daily lunch meals. Moreover, the implementation of the interface that excludes allergenic or medically harmful foods alleviates guardians' concerns regarding the potential for their children to get ill from the consumption of such substances.

Despite not achieving perfect accuracy, FaceNet demonstrated a commendable performance by correctly identifying 16 out of 20 instances in our preliminary testing dataset and accurately recognizing 13 out of 14 students from the collaborative school. The interface proved to be comprehensible and user-friendly for all stakeholders, with certain design modifications implemented to align more effectively with the specific requirements of the educational institution. This research serves as a preliminary foundation for future investigations, and our intention is to continue conducting research until a solution with better accuracy is achieved.

To enhance the LunchByte system in the future, numerous beneficial features can be added. These features include expanding the size of the dataset used to build the model to increase the accuracy of our algorithms, adding a notification mechanism to alert guardians when a student's balance is low, and supporting multiple languages. Additionally, adding a reward badge to students who collect a certain number of points will be useful to maintain their healthy eating habits.

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