Sparse: A Reservation and Computer Vision-Based Room Occupancy System for Malayan Colleges Laguna's Center for Learning and Information Resources

by

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DEFINITION OF TERMS

Algorithm	A set of steps, typically written as a program, that is followed to accomplish a task.
Capacity	Actual capacity of the CLIR
CLIR	Center for Learning and Information Resources. The equivalent of a library in Malayan Colleges laguna.
Computed Occupancy	Occupancy + Reserved Spots
Computer Vision	Is the field of Computer Science that aims to interpret the world similarly to the human visual system.
Computer Vision System	A part of the proposed system which includes the computer vision model and the web application.
Effective Capacity	Capacity set by the CLIR staff
Image Processing Techniques	Is the set of techniques that is used to extract information from an image.
MCL	Malayan Colleges Laguna. A college situated in the province of Laguna in the Philippines.
Occupancy	Number of people detected inside the CLIR
Prototype	Is a piece of software that simulates the core functionalities of the final software. It is usually built for demonstrating the feasibility of the concept.
Room Occupancy	The count of people inside a room.
Social Distancing	Is the practice of staying six (6) feet away from other people in order to prevent the spread of viruses.
Tambayan	Hangout Spot
Visitor	MCL's students, staff, and faculty members
Web Application	Is an application deployed over the internet that is accessible through a browser.

ABSTRACT

In this paper, the developers identified two problems the Center for Learning and Information Resources, or the library in other words, of Malayan Colleges Laguna faces. First, the CLIR is usually full and crowded. Therefore, it is common for visitors to go to the CLIR and find out that there are no more available seats. Second, its operations are affected by safety protocols amidst the pandemic. To help alleviate this problem, the developers propose a system called Sparse. Sparse is a computer vision-based room occupancy and reservation system. With this system, visitors would be able to use the CLIR for studying, waiting, or viewing reference materials without worrying whether or not they will be able to find a seat.

Keywords: room occupancy, reservation, people counting, computer vision, object detection

Chapter 1

INTRODUCTION

Background of the Study

In Malayan Colleges Laguna (MCL), the Center for Learning and Information Resources (CLIR), the term in MCL for the library, is one of the most important facilities of the college. It is a place where visitors may spend their time studying, waiting for their next class, or reading reference materials. However, there are two problems with using the CLIR.

First, visitors - MCL's students, staff, and faculty members - go to the CLIR but immediately leave because there are no vacant seats. This is a common experience among visitors of the CLIR. It is not only frustrating but is also a waste of time and energy.

Second, with the current COVID-19 pandemic, it has become imperative to avoid crowded places to minimize the spread of the virus. Because of this, the government has set policies to control the operational capacities of certain places (Department of Health, 2021). These policies include a reduction in the operational capacities of libraries. With limited seats available, it becomes harder for visitors to secure seats.

In order to solve these problems, the developers want a means for the visitors to know the room occupancy of the CLIR without going to the CLIR. The solution that the developers propose is a system named Sparse. Sparse has three primary functions. First, it determines room occupancy of the CLIR through a computer vision model. Second, it allows visitors to see the current room occupancy, and other useful information. Third, it allows visitors to reserve a spot in the CLIR. Due to COVID-19 restrictions, the visitors may only enter the CLIR if they have a reservation.

Statement of the Problem

In this study, the proposed computer vision based people counting and reservation system are developed to allow visitors to secure a seat and view the room occupancy of the CLIR. The following are the research questions that will be addressed in this study:

- What computer vision-based people counting algorithm would best identify the room occupancy of the CLIR?
- What features are needed to be implemented in the system?
- How useful would the features of the system be for users?

Objectives

The following are the objectives that will be addressed in this study:

1. To identify the most appropriate computer vision-based people counting algorithm for the system
2. To identify and implement features that would be useful for visitors and librarians
3. To evaluate the usefulness of each feature of the system

Significance of the Study

The developers believe that this is a significant problem to solve because the library is one of the schools' central areas of education. Allowing visitors of Malayan Colleges Laguna to secure a seat is essential to improve the experience of using the CLIR.

The CLIR is used by visitors for various reasons. Firstly, the CLIR contains reference materials that can be useful in research. Additionally, the CLIR is a quiet and air-conditioned location with minimal distractions. This provides visitors with the ideal environment for self-studying or reviewing. Aside from educational purposes, the CLIR also provides students a place to meet with friends and a place to stay in vacant periods. If a visitor could not secure a seat, the visitor would not be able to do any of the mentioned uses.

It is also common for visitors to go to the CLIR coming from another part of the campus. If the visitor were not able to secure a seat, their time and effort walking to the CLIR

are going to be wasted. This would lead to the visitor being frustrated, and, therefore, they may avoid using the CLIR in the future.

Additionally, the COVID-19 pandemic has shifted our way of living. For example, the government has mandated safety protocols that reduce the operational capacity of certain places. These measures are implemented in places where a lot of people gather in order to prevent the spread of the virus to other people. The CLIR would be one of the places that would operate with a limited capacity if it were to resume operations (Department of Health, 2021). With these restrictions in place, the proposed solution would allow the visitors to reserve a slot on a specific hour. The visitors may also view the current room occupancy of the CLIR and the reserved spots in order to know if there are spots available and what time is best suited for them.

The information presented by the system would also benefit the staff administrators in managing the operations of the CLIR. For example, the staff may use the information to determine the peak hours of CLIR. With this information, the staff may anticipate when they should do additional sanitary operations. This allows the CLIR to provide a safe environment for the visitors and to prevent the risk of spreading the virus.

Currently, Malayan Colleges Laguna has a prototype named Book-A-Seat made with Microsoft Booking. However, it lacks customization and some features that they want to implement. So the developers intend to create a system that will suit what the CLIR needs and could also be a reference when the college decides to implement the system in other areas of the school which is observed to have a significantly high room occupancy. (e.g. Cafeteria, Rizal Campus, etc.) Additionally, the developers also hope that the project could be a reference for future commercialization of similar systems.

This project will also play a huge role for the researchers in developing their abilities as future professionals, as this topic deals with computer vision and machine learning techniques, which is a prominent topic in the IT sector. Additionally, working with a group to accomplish the project would give a chance for the developers' to improve their soft skills.

Scope and Limitations

The scope of the project includes the development of a prototype of the target computer vision system and reservation system. This includes creating a computer vision model that identifies the current room occupancy of the CLIR, a web application that allows visitors to view the room occupancy of the CLIR, and a reservation system that allows the visitors to reserve a seat on a specific hour. Additional features suggested by users have also been implemented. However, due to time constraints, only essential features have been implemented.

Moreover, as the project is limited to creating a prototype, the project did not include the deployment to operational use and maintenance of the prototype. Also, the model that has been developed only counts the number of people in the CLIR. It does not determine the distance between the people in the room.

The project is also limited to the Center for Learning and Information Resources (CLIR) in Einstein Building of Malayan Colleges Laguna. The developers would be looking to implement the computer vision system in the other *tambayan* spots in MCL in the future, as they believe that this would benefit those students who frequent those locations as well.

Lastly, as the developers are not permitted to go to the MCL campus due to the pandemic, the developers are limited in testing the system. First, the developers cannot gather actual data for the model. Second, the developer cannot select the optimal camera position for the camera for the computer vision system. Lastly, the developers cannot conduct a pilot run of the system in the CLIR.

Conceptual Framework

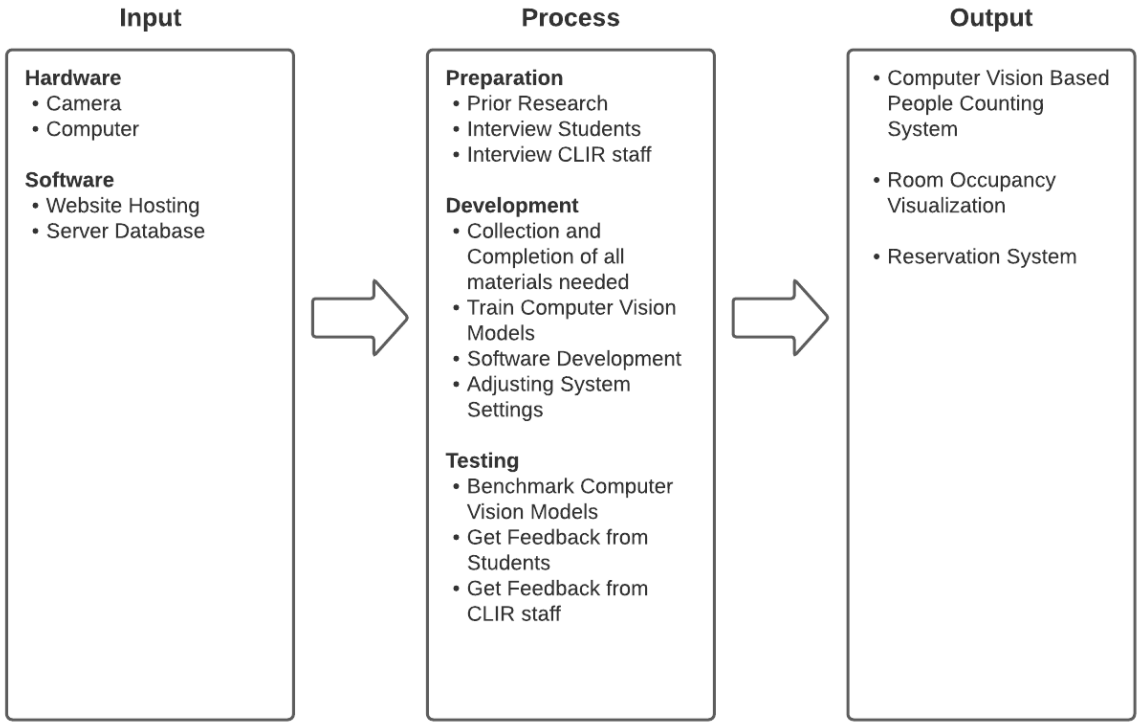

Figure 1. An Input-Process-Output diagram of the relevant variables for the project.

Figure 1. shows that for the input, the needed hardware is a camera and a computer. The camera would be used for capturing images in the CLIR. Meanwhile, the computer will store the computer vision model that will be processing the captured images. The needed software is a website hosting for the web applications and a server database for storing the data that the model has created and data of the reservation system.

The process includes preparation, requirements gathering, development, and testing. For the preparation, the developers needed to find prior research so that the developers could get an idea of how the system should be developed. After this, the developers interviewed students and the CLIR staff in order to elicit the needed requirements of the system. For development, the developers collected and completed all the needed materials previously stated in the input. Then the proposed system was developed which includes developing the computer vision model, the reservation system and the website application.

After the proposed system has been developed, the settings of the system have been adjusted as needed. For testing, the developers had benchmarked the model in determining

the room occupancy. The developers also took the feedback of the students and the CLIR staff to verify if the current state of the solution satisfies the needs of the users.

The output of the project is the proposed system. The proposed system is composed of three main modules. The first is the people counting system which uses computer vision techniques. The second is the room occupancy visualization which is accessible to both visitors and librarians. The third module is the reservation system.

Chapter 2

REVIEW OF RELATED LITERATURE

This chapter presents the concepts that inspired the development and implementation of the research study after thorough research about the use of Computer Vision for Room Occupancy Detection. There were several methods and algorithms considered since the usage of Computer Vision for counting people in specific places has been gaining popularity in the past few years with the widespread use of cameras and visually instrumented devices.

The discussion starts with an introduction to the concept of People Counting Systems, its applications, and techniques. Then, there will be a general overview of the concept of Computer Vision and its applications. Object Detection Algorithms that could be used in People Counting will also be presented and compared through a review of related studies. Lastly, the direction of this study will be discussed regarding the concepts that were presented.

2.1. People Counting System

People counting is one of the central processes that the proposed system is going to perform. Raghavachari et al. (2015) defined people counting as the task of determining the number of people in a given area.

People counting systems are typically composed of three components. The first component is the sensor which gathers information about a given area. This information is then sent to the second component. The second component is the algorithm that uses the information to determine the number of people in a given area. Lastly, the count is sent to the

third component which is the interface. This interface is viewed by the end-user to get information about room occupancy.

These systems are applied in a wide variety of situations which range from retail to public safety uses. Additionally, techniques for people counting have seen developments in the past few decades with each technique having its own sets of advantages and disadvantages. The following sections will discuss the applications and techniques of people counting and will discuss its relation with the proposed system.

2.1.1. Applications of People Counting System

People counting systems are applied in many different areas. Most commonly, it is applied in the areas of transportation, retail, public safety, and education.

In the area of transportation, people counting systems are used to determine the places where there are many passengers. One such system is the one proposed by Chen et al. (2008). Their system uses image processing techniques to count how many people get in and get out of a bus. With such information, transportation companies will be able to allocate more resources in places where there are more passengers, therefore, reducing costs.

In the area of retail, people counting systems could be used to monitor customer traffic such as the system proposed by Lacanlale et al. (2021). In their paper, they proposed a people counting system that makes use of CCTV footage. Their study hopes that the information from the system could be used to determine the position of producers, peak time, and scheduling of resources.

People counting systems have also seen uses in promoting safety in public places. With the COVID-19 pandemic, people have created systems that monitor whether or not people are practicing social distancing such as the system proposed by Punn et al. (2021).

Some systems use people counting in dense crows such as the system proposed by Arif et al. (2012). These systems could help authorities in the early prevention of exit blockages or even stampedes.

People counting systems could also be used in the area of education. As demonstrated by Castillo et al. (2018), it could be used for automatically generating class attendance. It could also be used to determine how busy a certain area is as demonstrated by Waitz Inc (2020). Waitz Inc's system also demonstrates the commercial feasibility of a people counting system as it has been deployed in numerous universities in the United States.

The system that the developers propose is similar to the system developed by Waitz Inc; A system that allows students to know the room occupancy of a certain area before going there. However, the system that the developers propose differs in the people counting technique used. Waitz uses a Network-Based people counting technique meanwhile the developers are proposing to use a Computer Vision-based technique. These techniques will be discussed in the next section.

2.1.2. Available Techniques for People Counting

The techniques available for counting people have evolved in the past few decades. These techniques include manual counting, infrared laser-based counters, thermal-based counters, network traffic-based counters, and computer vision-based counters. Each technique has its own set of advantages and disadvantages.

The oldest and simplest technique for people counting is manual counting. In this technique, a person will manually count how many people there are in the room. The person may use pen and paper to write down the tally or they employ a tool such as a handheld tally counter. This may be sufficient in scenarios where people need to be quickly counted only

once. However, when people need to be counted frequently, this technique may be unsuitable to be used.

One of the earliest ways to automatically count people is by using infrared beam counters (Beymer, 2000). These are simple tripwire counters that use infrared lasers to detect when someone passes through a certain area. However, this technique has two disadvantages. Firstly, it needs the area to be detected to have a definite entry point and exit point. This means this technique cannot be implemented in open areas. Second, if the sensor fails to detect people passing through the sensor, there is no way for the sensor to correct the room occupancy until someone resets the count.

Another early technique to determine room occupancy is to use thermal-based counters as demonstrated by Amin et al. (2008). Their paper uses infrared thermal cameras to capture the heat signatures of people in an area. Then, an algorithm is used to determine how many people there are. This technique of determining room occupancy is generally faster and more accurate as compared to other methods. However, the technique would require equipment, such as thermal cameras, that are not generally available.

A more recent way to perform people counting is to use network traffic-based techniques. One system that uses this technique is the system developed by Groba (2019). To determine how many people there are, their system detects the WiFi probe requests in an area. Some implementations, such as the system by Waitz Inc (2020), detect Bluetooth signals to improve the accuracy of the people counting technique. This technique has the benefit of being able to detect people even in rooms with complex layouts. However, the technique may give inaccurate counts as people often have more than one device with them, especially in the library.

The state of the art in counting people is using computer vision-based techniques. Computer vision techniques capture an image of the area to count the number of people.

Some variations of this technique use single cameras (Adriano et al., 2005), some use multiple cameras (Ma et al., 2012) but some also use specialized cameras (Coskun et al., 2015). After capturing an image, the system counts the number of people in the image by applying image processing techniques and other methods such as machine learning models.

Computer vision-based techniques have some disadvantages. First, the camera needs to be set up so that it sees everything in the area as noted by Castillo et al. (2018) and Xu et al. (2010). This means it will be difficult for this technique to be implemented in rooms with complex layouts. Additionally, since it uses image processing and other novel methods to count people, it may require more computing power compared to other techniques (Ngo et al., 2020; Lacanlale et al., 2021).

Despite these disadvantages, the advantages of computer vision-based techniques outweigh their negatives. First, cameras are common and are easy to install. Unlike other techniques, there is no need to buy specialized equipment such as thermal cameras or infrared beams to implement the technique. Second, the complexity of counting is centralized in detecting people. Once detection has been done, counting is usually straightforward (Raghavachari et al., 2015). Lastly, as compared to other techniques, computer vision techniques do not require real-time human intervention and therefore avoid human error.

It is for these reasons that the developers have selected a computer vision-based people counting system for the proposed project. However, computer vision is a broad field, and there are numerous computer vision algorithms available for people counting. The next section will discuss computer vision in greater detail and will compare the various computer vision-based methods available for people counting.

2.1.3. Tripwire and Object Detection Methods

Existing literature suggests that the methods of people counting techniques could be categorized into two methods. These two methods are the tripwire method and the object detection method.

Systems that use the tripwire method generally use simpler techniques in counting people. This is done by adding to the count of people when someone passes through the entrance. Then, when someone passes through the exit, the system deducts the count of people in the room.

On the other hand, the object detection method employs more complex techniques. Active counting systems gather information about the area where people are to be counted. Most commonly, this information is an image. Then, the system employs various processes to detect people with the given information. In some implementations, these processes may be machine learning algorithms. The number of people detected are then counted.

2.2. Computer Vision

Computer Vision is a field of artificial intelligence (AI) where computers process and analyze digital images, videos, and other visual inputs to get meaningful information, and possibly use this information to take actions or give recommendations. It allows a computer to have a human-like vision and understand what it sees (IBM, n.d.). Similar to a human vision system where the brain processes what the human sees from the eye, a computer vision system also processes images collected from an electronic camera (Nixon & Aguado, 2019).

The only requirements for a basic computer vision system are a camera, a camera interface, and a computer. With the recent technological developments, cameras are constantly becoming cheaper and more widely available, and aside from that, there is an enormous amount of computer memory and processing power, which makes computer vision become more widely used. Computer vision systems are being found useful in fields like

business, entertainment, transportation, healthcare, and everyday life. In routine industrial use, cameras are being utilized for food quality inspection. Forensic studies and biometrics also benefit from the automatic face recognition done by computers (Nixon & Aguado, 2019). Additionally, many researchers have also used computer vision systems to allow computers to count people that are currently present in a specific region of interest.

As mentioned in the previous section, a computer vision-based method is currently the outstanding option for a people counting system. Even if it consumes more computing power than other techniques and may not apply to certain complex layouts, cameras are still easy to install, and most facilities nowadays already utilize video surveillance. It does not require any other complicated and expensive equipment or sensors. Aside from that, this technique does not need real-time human intervention, and once detection is done, counting is usually straightforward for the computer.

2.3 Object Detection and People Counting

Object detection is the task of determining the identity of objects in an image given a set of known labels. By filtering the objects such that only people are detected, the number of people in an image could be detected. Traditionally, object detection is done through techniques such as HOG (Dalal & Triggs, 2005), SIFT (Lowe, 2004), and the Viola-Jones algorithm (Lowe & Jones, 2001). However, recent developments in deep learning and convolutional neural networks (CNNs) have led to high accuracy models such as Faster-RCNN, Single Shot Detection, and RetinaNet.

The Faster R-CNN model originated from Region-based Convolutional Neural Networks (R-CNN) which was proposed by Girshick et al. (2014). In the paper for the R-CNN, they proposed two stages in object detection. The first stage created region proposals which are boxes where there were possible objects. Meanwhile, the second stage applies

object classification for each region proposal. The R-CNN model was succeeded by the Fast R-CNN model by Girshick (2015). In the paper, they have identified that the bottleneck of R-CNN was that each object proposal needs to be processed individually in the second stage. To resolve this, they implemented spatial pyramid pooling networks. This method allowed the model to compute feature maps from an entire image only once instead of computing for each object proposal. The Fast R-CNN model was superseded by the Faster R-CNN model by Ren et al. (2017). In the paper, they have identified that the region proposal algorithm was bottlenecking the model. To solve this issue, they introduced a region proposal network (RPN). Compared to the old region proposal algorithm, the RPN is a fully convolutional network. RPNs have also allowed the model to be trained end to end. By introducing this method, they were able to achieve an average precision (AP) of 21.9 on the Microsoft Common Objects in Context (COCO) test-dev dataset with an average running time of 198ms per image.

The Single Shot Detector (SSD) proposed by Liu et al. (2016) is a single-stage detector. This means the SSD model detects objects in one stage, as compared to R-CNN which has a separate stage for region proposal and classification. SSD performs object detection first by dividing the image into S by S boxes. Then bounding boxes and confidence scores are generated for each grid cell. Lastly, non-maximum suppression is applied to each detection to select the best bounding box on repeated detections. On top of this, SSD also use multi-scale feature maps to improve detection. These feature maps progressively decrease in size, and each one is used in detection. These feature maps allow object detection at multiple scales. By implementing this, they were able to achieve an AP of 26.8 and an average FPS of 59.

RetinaNet proposed by Lin et al. (2017) is also another single-stage detector. In their paper, they have identified that the vast number of background examples in training causes

poor model accuracy. To address this issue, they have introduced the focal loss factor to the standard cross-entropy loss. The factor introduced by Focal loss decreases the loss for easy negatives like background while giving a high loss for hard negatives. This allows the model to focus on training on misclassifications. By applying this loss, RetinaNet was one of the first one-stage detectors to surpass the average procession of two-stage detectors at that time.

2.4 Summary

This chapter discussed an overview of related concepts and studies for developing a computer vision-based people counting system. It started by introducing people counting systems and their various uses. Then different techniques for counting people were discussed where it was identified that computer vision-based techniques are the state of the art in people counting. Lastly, the various object detection algorithms that could be used for people counting were discussed.

However, a few questions still remain unanswered. First, while the various uses of people counting systems were discussed, what features must be implemented to make the system useful for CLIR visitors and staff? Second, while different object detection algorithms were discussed, which among these is best suited for the people counting system? The next chapter discusses how the researchers are going to tackle these questions.

Chapter 3

METHODOLOGY

This chapter will be discussing how the developers solved the research problems and achieved the research objectives. These are going to be discussed in the four sections of the chapter.

The first section will discuss the development methodology the developers have taken in developing the system. The second section will discuss how the model for the people counting system has been selected which accomplishes the first research objective. Then, the third section will discuss how the system was developed. It will also discuss how the second and third research objectives were accomplished. Lastly, the fourth section will discuss how the team was structured in the development of the system and the selection of the model.

3.1 Development Methodology

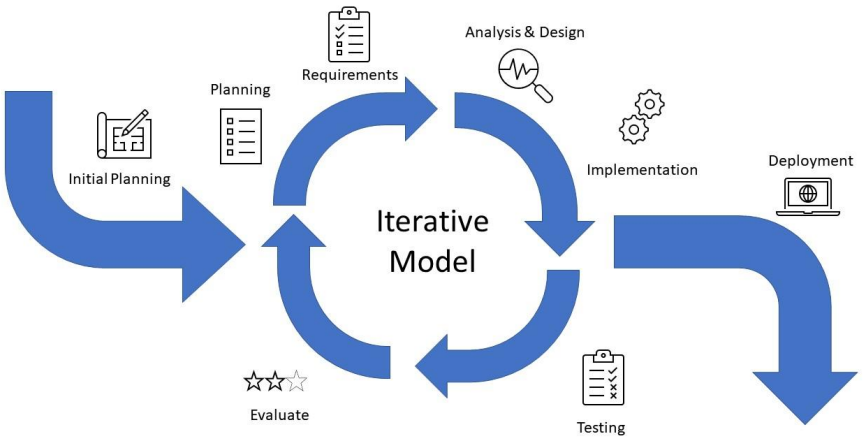

Figure 2. Iterative model

The methodology that the developers used is the iterative model as shown in Figure 2. It starts with basic requirements and focuses on a simple implementation which then will

gradually increase in complexity and features – called iteration – until the final system is completed and ready for deployment. Design, development, testing, and review are all included in each iteration. Each iteration is reviewed to assess if more features are needed or to enhance current features. Each iteration ends when the review phase is done. The next set of features is defined based on the results of the first iteration review. The next iteration design and development process begins once the updated requirements have been specified (SDLC Iterative Model, 2021; Rana, 2021).

The developers chose the iterative model for three primary reasons. First, the working system is deployed rapidly and frequently. Second, development is also more manageable as it is easier to test the system and manage risks in smaller iterations. This is related to the previous point which is that the developers are unfamiliar with how some requirements must be implemented. Because of these, the developers are given more breathing room for learning and experimentation. Moreover, this also allows developers to have the ability to quickly adjust to ever-changing needs.

Additionally, the developers decided to borrow techniques from the Scrum methodology. These techniques include sprints and sprint planning. According to West (2018), a sprint is a short and timed period during which a scrum team works to complete a specific amount of work. Meanwhile, sprint planning determines what goals can be accomplished and how they will be done for the next sprint while keeping the product backlog in mind. The scrum team as a whole collaborates on sprint planning.

With these, the developers implemented the combination of the two aforementioned methodologies.

3.2 Model Selection

3.2.1 Data

The dataset that was used is the SCUT Head dataset by Peng et al. (2018). The dataset contains 1443 images for training, 462 images for validation, and 500 images for testing. The distribution of the number of people per image is shown in figure 3.

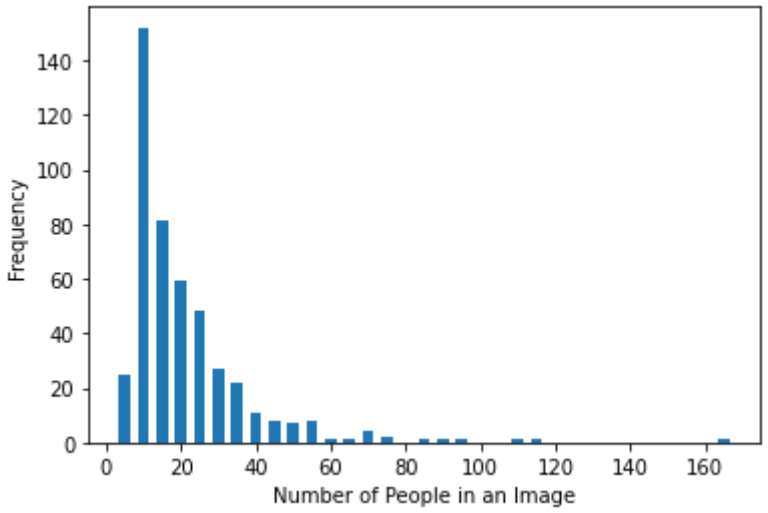

Figure 3. The frequency of the number of people in an image

The SCUT Head dataset was chosen over other full-body datasets for two reasons. First, it is expected that most images that would be taken from the CLIR will only contain the upper body as the lower body will be obstructed by tables. Second, the SCUT Head database mostly contains images taken from classrooms and libraries. These reasons make the dataset more representative of the environment where the model will be deployed.

3.2.2 Object Detection Models

The object detection models that were evaluated are the Faster R-CNN, SSD, and RetinaNet. These models used the implementations from the torchvision library. The Faster-RCNN and RetinaNet model has a ResNet FPN backbone and were pre-trained on the COCO dataset. On the other hand, The SSD model uses a Vgg16 backbone and has also been pretrained on the COCO database.

3.2.3 Model Evaluation

In order to determine which model is the most appropriate for the people counting system, the three mentioned models processed the test dataset of the SCUT Head dataset on Google Colaboratory. While processing the dataset, two metrics were collected and were used to compare the models.

$$\mathrm{T} = \frac{\sum_{i=1}^{N} X_i}{N}$$

Figure 4. The formula for Processing Time

The first metric that the developers considered is the processing time. Processing time is important to consider so that the system can deliver information promptly. As shown in Figure 4, the processing time is calculated by getting the average time it takes to process each data item in the dataset. Models with lower processing times will be considered better. The developers have arbitrarily selected 5 seconds as the threshold for acceptable processing time. If the model's processing time is more than 5 seconds, the model will be deemed unacceptable.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (i_i - y_i)^2}{N}}$$

Figure 5. The Root Mean Square Error Formula

Error is the measure of how far the predicted values of the model were from the actual values. This factor is important to consider because having low error would help users get better information about the room occupancy of the CLIR, and therefore allow them to make better decisions. To determine the error of a model, the developers are going to use the root mean square error metric. The formula can be seen in Figure 5. The root mean square error is

used to determine the average prediction error over all data values in the test set (Salkind, 2010). The lower the root mean squared error, the better the model has performed.

To determine the most appropriate computer vision model, the developers compared the average processing time and mean square error of each model. The model that provides the lowest error while being sufficiently fast was selected.

3.3 System Development

3.3.1 Requirements Gathering

To determine the requirements needed for the system, the developers have consulted one resource person per type of user. For visitors, the developers have consulted a third-year IT student who frequently uses the CLIR. For librarians, the developers consulted the Library Officer of the CLIR.

At the end of each sprint, the developers demonstrated the system to the resource persons. After demonstrating, the developers gathered feedback on the current features and suggestions on what additional features could be implemented. Then, these features were implemented in the next sprint.

3.3.2 System Testing

To make sure that the system is working as intended, the developers have created test cases for each feature of the system. Each test case contains preconditions, testing steps, and postconditions. If all expected system responses and postconditions were met, the test case will be considered as successful. Additionally, the test case also contains information about who has tested the system and when the test was executed. The system testing document template could be found in appendix A.

3.3.3 System Evaluation

To determine if the system is useful for users, the developers conducted a survey on 18 visitors and 2 librarians. The survey consists of three parts. The first part consists of profiling questions. In the second part, the users are going to evaluate the usefulness of each feature through a 5-point Likert scale. Lastly, the users will be asked what additional features they would like to be implemented in the future. The results of the survey will be discussed and analyzed in the next chapter. The survey questions for visitors and CLIR Staff could be found in appendix B, and C, respectively.

Additionally, the developers have created survey guidelines for the respondents. The survey guidelines contain all the necessary information the respondents need to know before answering the survey. It includes the objective of the survey, videos explaining each feature of the system, contact information of the developers in case the respondents have questions, and answers to frequently asked questions. The survey guidelines for Visitor, Librarian, and Head Librarian could be found in appendix D, E, and F, respectively.

3.4 Team Structure

3.4.1 Schedule and Timeline

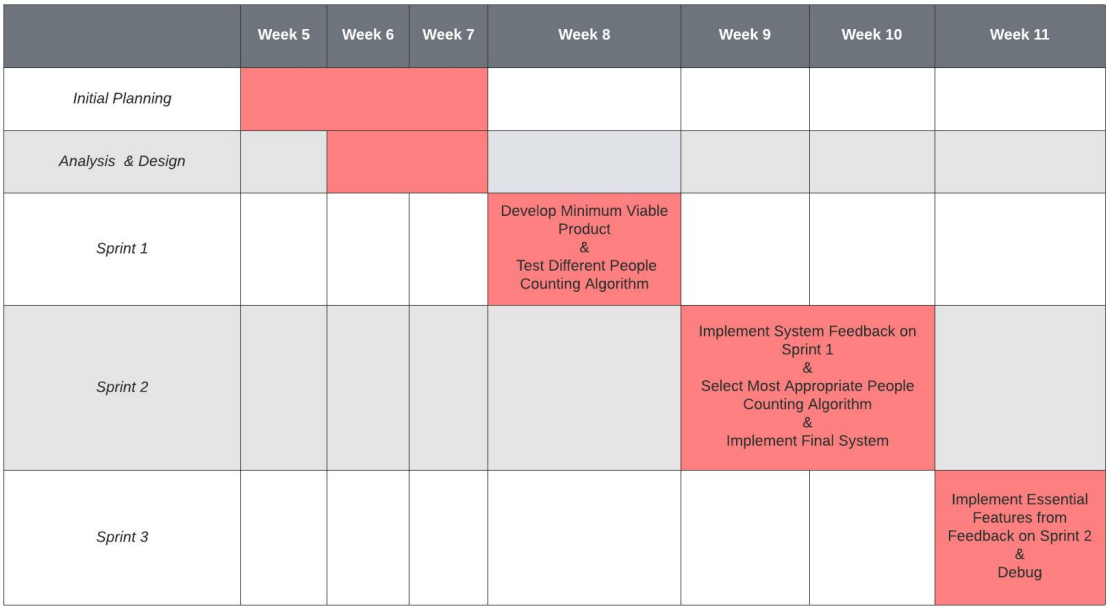

Figure 6. Gantt Chart of Schedule

Figure 6 shows the schedule for the proposed system. The week shown in the Gantt Chart is based on the schedule of the said semester. A semester is 12 weeks long excluding holiday breaks and health breaks. The semester started on November 24, 2021, and ends on March 8, 2022. Initial planning was done in weeks five to seven. While analysis and design took place from week six to seven. The first sprint was on week eight. The main objective of the first sprint is to develop a minimum viable product and to test different people counting algorithms. The minimum viable product is the first version of the system that only contains the essential features of the system. This version of the system was primarily used to gather feedback from the end-users. The second sprint took place from week nine to week ten, and it has three objectives. The first objective is to implement a system based on the feedback gathered from the first sprint. This may entail defining and implementing new use cases. The second is to select the most appropriate people counting algorithm. The third objective is to implement the final system. Lastly, the third sprint took place on week eleven, which has two

objectives. The first is to implement essential features from the feedback on sprint two and debugging of the system.

3.4.2 Project Teams and their Responsibilities

For the first iteration, the developers were divided into two teams. The members of the first team are Mark Anthony Mamauag and Job Lipat who focused on developing the computer vision model. They are in charge of gathering datasets, testing different people counting algorithms, and computation of room occupancy. The members of the second team are Charmaine Eunice Rabano and Madeline Isabel Galang who focused on developing the system. They are in charge of developing the database, designing the user interface, and performing various kinds of testing.

For the second iteration, the developers were assigned to each module. Job Lipat still focused on developing the computer vision model. Mark Anthony Mamauag was in charge of the visitor's module. Madeline Isabel Galang was in charge of the reservation system. Charmaine Eunice Rabano was in charge of the librarian module.

For the third iteration, Mark Anthony Mamauag was in charge of debugging and implementing essential features from feedback on the second iteration. While the rest were in charge of writing the documentation and preparing for the presentation.

3.4.3 Tools

The developers used various tools to develop the system. For the development of the reservation and room occupancy system, the developers used ASP.NET in Visual Studio 2019 with C# as the programming language and TailwindCSS as the CSS Framework. SQL Server Management Studio was also used to manage the database. For the development of the people counting model, the developers used Google Colaboratory with Python as the

programming language. In addition to this, the libraries that are used include PyTorch, Matplotlib, PIL, and others.

Along with this, GitHub is used for the project repository and version control. The repository was integrated with Azure which is used to host the website and database. Additionally, Trello is used for task keeping.

The tools for development that were mentioned are selected because of the familiarity of the developers with them. Moreover, the developers also prefer free tools as the project has no source of funding.

Chapter 4

RESULTS AND DISCUSSION

4.1 People Counting Model

4.1.1 Model Training

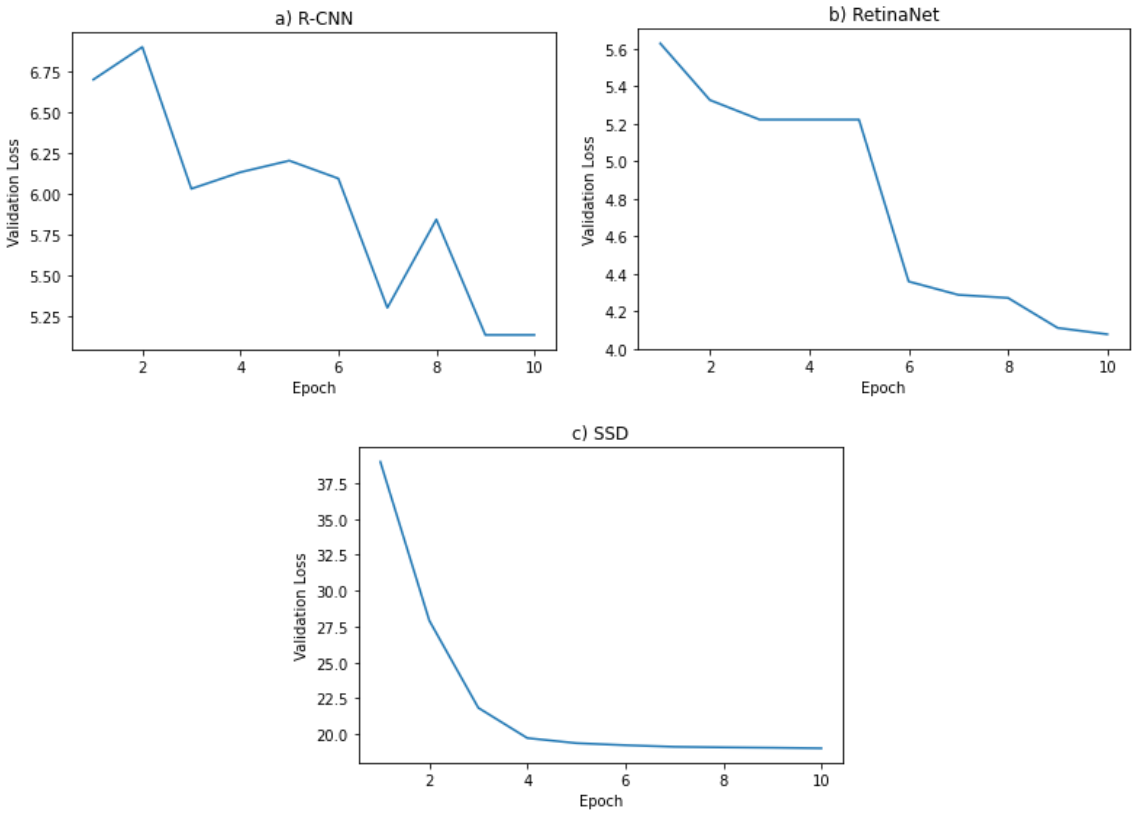

Figure 7. Validation loss per epoch of the a) Faster R-CNN, b) RetinaNet, and c) SSD models

Figure 7 shows the validation loss per epoch of the different models. As seen in the figure each model started with a high validation loss but gradually decreased as the epoch increased. The validation losses of the R-CNN are the most varied among the models. It could be seen that the loss increased at epochs 3 to 4 and epochs 6 to 7. This is because the learning rate of the model was set too high at those points. Because of this, the developers had to lower the learning rate in the next epoch to allow the validation loss to continue to decrease. The final validation loss of the R-CNN model is 5.135.

The learning rate of the RetinaNet model plateaued on the fifth epoch, but, after adjusting the learning rate, the loss significantly decreased. The final loss of the RetinaNet model is 4.077. Meanwhile, the validation loss of the SSD model had a sharp drop in validation loss in the first few epochs but plateaued on the latter epochs. The final loss of the SSD model is 19.022.

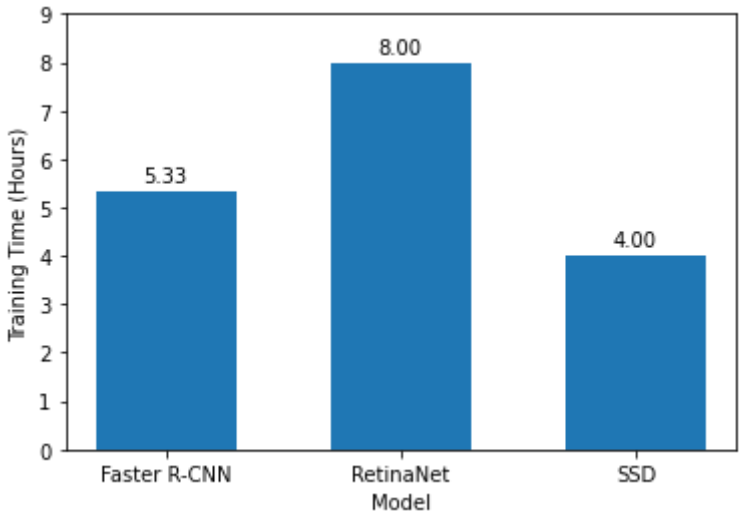

Figure 8. The total training time per model

Figure 8 shows the training time for each model. As it could be seen, the time it takes to train the model for only 10 epochs takes a significant amount of time. This is why the developers could only train the model for a few epochs. The Faster R-CNN took 5.33 hours to train. Meanwhile, the RetinaNet model took 8 hours to train. Lastly, it took 4 hours to train the SSD model. Google Colaboratory dynamically allocates resources depending on how many people are using the hardware. This may have affected the training time of the models.

4.1.2 Model Comparison

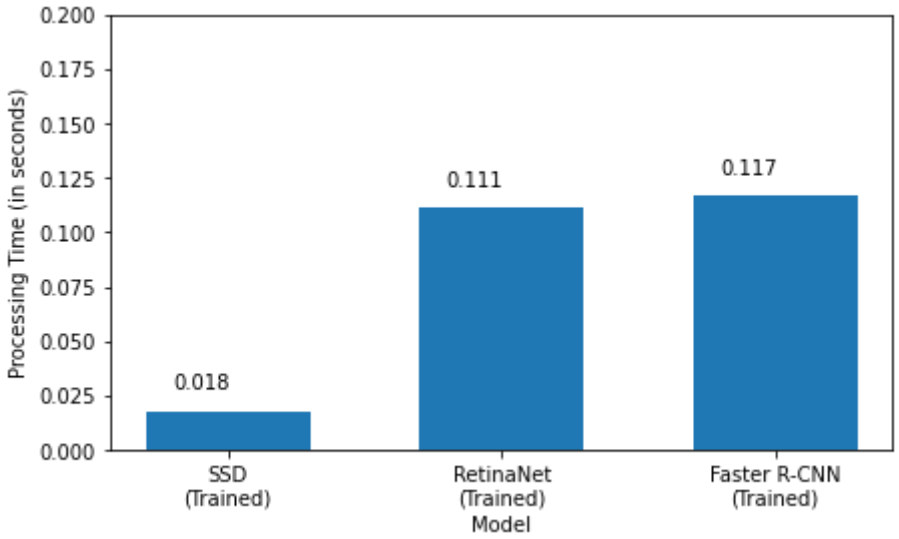

Figure 9. The average processing time of each model

As seen in figure 9, all the average processing times of the trained models fall within the acceptable range of processing time. The RetinaNet and Faster R-CNN models had similar processing times of 0.111 seconds and 0.117 seconds respectively. However, the processing time of the SSD model is significantly lower than the other models having an average processing time of 0.018 seconds. The SSD model may be more suitable if the model needs to be deployed in a computer with limited processing power.

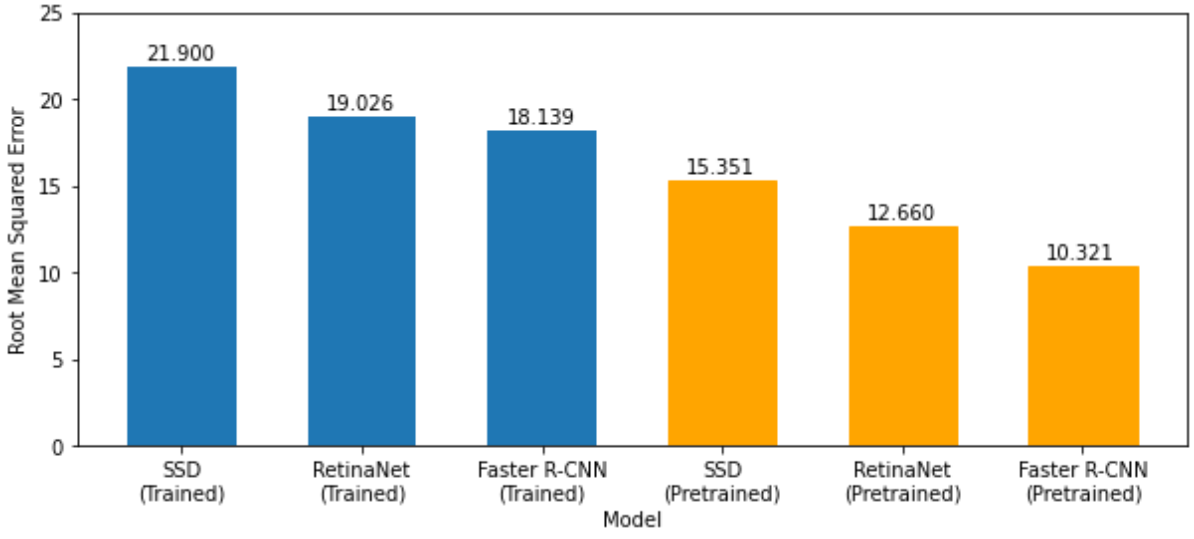

Figure 10. The root mean squared error of each model

As could be seen in figure 10, each model had a different root mean squared error. The models with the blue bars are the models trained by the developers, and the models with the orange bars are the pretrained models of PyTorch.

The results show that the models trained by the developers have, unfortunately, performed worse than the pretrained models. This may be because the pretrained models were only trained for a few epochs which resulted in the model underfitting the test dataset.

The model that performed the best was the pretrained Faster R-CNN model with a root mean square error of 10.31. Because of this, the Faster R-CNN model was integrated into the system.

4.2 Requirements Gathering

4.2.1 Use Cases

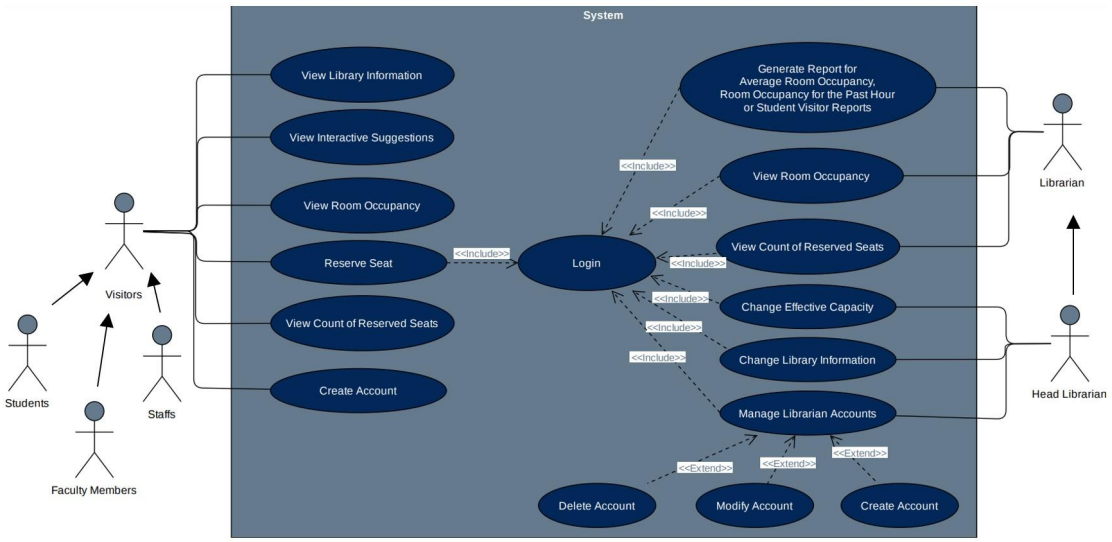

Figure 11. Use Case Diagram for Sparse

The diagram shown in Figure 11 shows the users' possible interaction with the system. As seen on the diagram, there are three users namely the visitors, the librarian, and the head librarian. The visitors may create an account and view library information,

interactive suggestions, room occupancy, and count of reserved seats. They may also reserve a seat - once they are logged in - which is needed to use the CLIR.

On the other hand, the librarian and head librarian must log in before doing any of their functions. After logging in, they may view room occupancy and count of reserved seats and as well as generate reports for average room occupancy, room occupancy for the past hour, and student visitor reports. The head librarian may also change the effective capacity and library information and as well as manage librarian accounts which include creation, modification, and deletion of accounts. The feature to change the effective capacity is important since room occupancy reduction should be practiced as a precaution to the current COVID-19 situation. The data regarding the seats and time is important so that they know what time the peak hours are and how often they should sanitize the CLIR.

4.2.2 Functional Requirements

From the use cases the developers have identified the functional requirements of the system. These are stated in table 1.

Table 1. The Functional Requirements of the System

Name	**Description**
Room Occupancy Information	Librarians and Visitors must be able to see the current room occupancy of the CLIR
Room Occupancy Status	Visitors must be able to see if the CLIR is not busy, busy, empty, normal, full, or closed
Interactive Suggestions	Visitors must be able to see suggestions about the CLIR. These include when the peak hours of the CLIR are, room occupancy compared to yesterday, and current room occupancy
Library Information	Visitors must be able to see basic information about the CLIR such as its opening and closing day and its opening and closing time
Visitor Registration	The visitor must be able to register to the website

Visitor Login	The visitor must be able to log in to the website using the credentials they have provided when they registered
Logout Visitor Account	Librarians must be able to log out of their account
Reserve Seat	Visitors must be able to reserve a seat
Accomplish Reservation	Visitors must be able to accomplish the reservation once they have reached the CLIR
Cancel Reservation	Visitors must be able to cancel their reservations to allow other visitors to reserve seats
Expire Reservation	If the visitor does not accomplish the reservation within 10 minutes, their reservation must be canceled
Librarian Login	The librarian must be able to log in to the website before doing any of their functions
Change Effective Capacity	The Head Librarian must be able to change the effective capacity of the CLIR
Library Information Management	Head Librarian must be able to edit the opening and closing time and day of the CLIR
Student Visitor Report Generation	Librarians must be able to create reports in Microsoft Excel format about the students who use the CLIR
Room Occupancy Report	Librarians must be able to create reports in Microsoft Excel format about the room occupancy of the CLIR
Summary of Reserved Spots	Visitors and Librarians must be able to see how many seats are reserved per hour
View Librarian Accounts	The Head Librarian must be able to see the list of librarian account
Delete Librarian Account	The Head Librarian must be able to delete librarian accounts
Create Librarian Account	The Head Librarian must be able to create librarian accounts
Logout Librarian Account	Librarians must be able to log out of their account
Record Room Occupancy	The system must be able to record the room occupancy at the current time

4.2.3 System Architecture

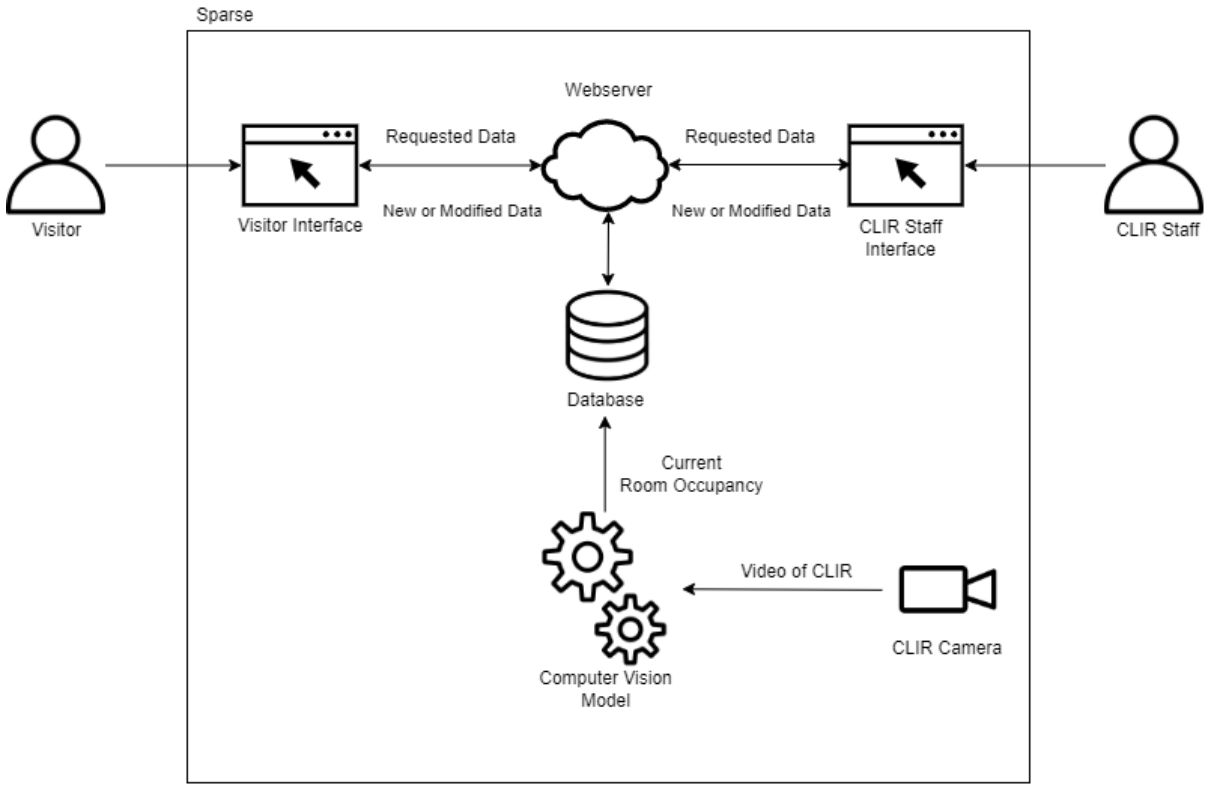

Figure 12. The system diagram of Sparse

The system diagram shown in Figure 12 shows the various components of the computer vision system. The system starts with the camera inside the CLIR. The video captured by the camera is sent to the computer vision model. From the video feed of the camera, the computer vision model calculates the current room occupancy and stores the calculated value inside the database. The web server queries the database to render the visitor or librarian interface with the requested data. This interface is then viewed by the visitor or librarian through a web browser.

System Requirements

The system is composed of a video camera, database, and a people counting model. A video camera is needed to get videos so that the computer vision model can calculate the current room occupancy. It must be capable of capturing videos that are clear enough to be

able to count the number of people; a video camera with a resolution of 720p will suffice. The camera must also be placed such that all the people in the room can be seen on the frame. The database is used to store data containing the room occupancy, reservation, library information and user accounts. It must be capable of storing a semester's worth of data. For the prototype with dummy data, a gigabyte will be sufficient. Meanwhile, the People Counting Model is going to count the number of people that can be seen on the video. The model must be able to satisfy the performance requirements stated in the non-functional requirements.

The visitor interface must be accessible through the internet and a web browser. This is done so that they can create a reservation regardless if they are on campus or not. While the librarian interface must be accessible through a web browser and in the network of MCL. However during the development, the librarian interface will be accessible through the internet.

4.3 Implementation of Features

4.3.1 Visitor Interface

Visitor Homepage

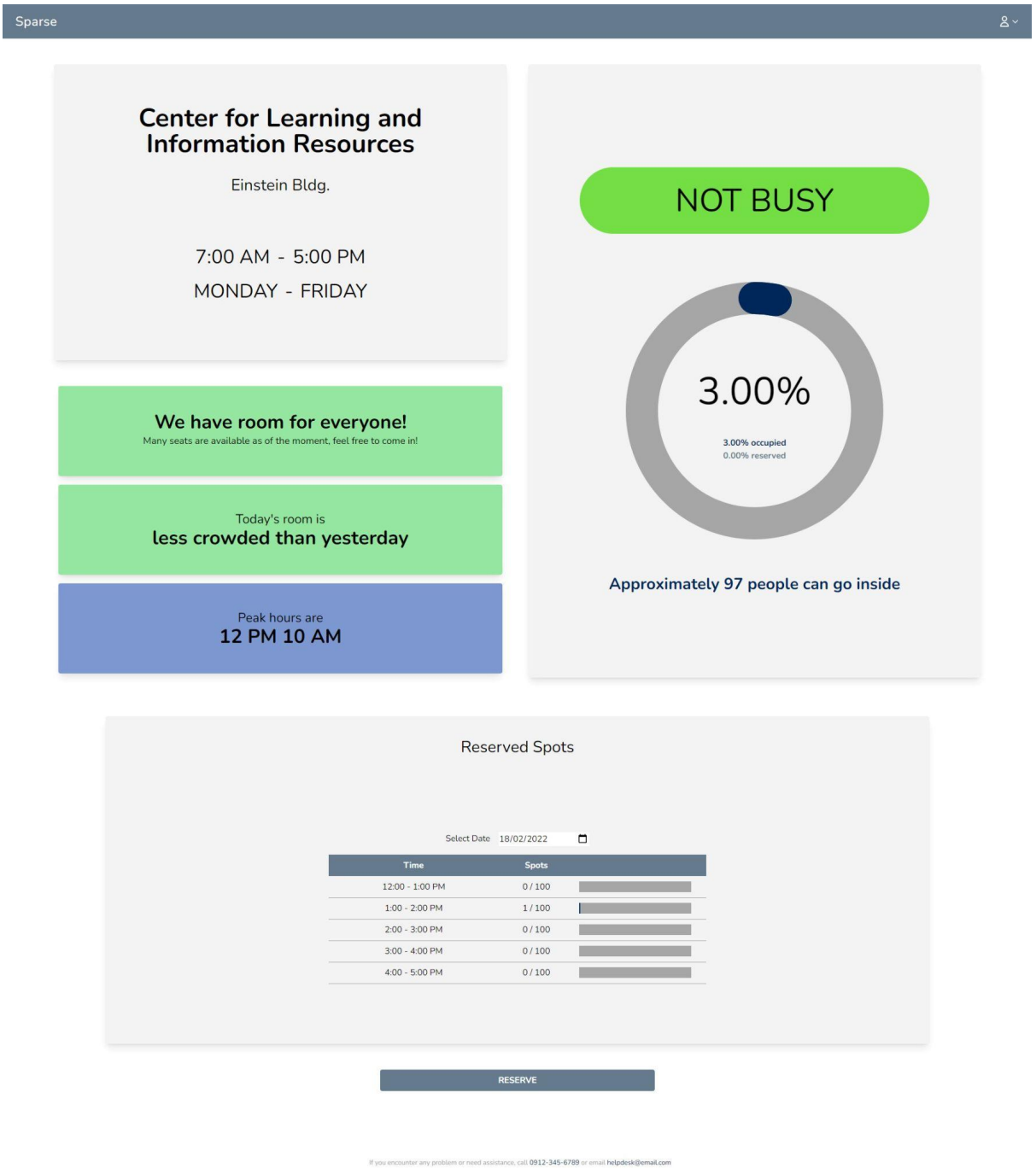

Figure 13. Visitor Home Page

Figure 13 shows the visitors' homepage. Features included here are current room occupancy, library information, interactive suggestions, count of reserved spots and button that links to the reservation page. The information in this page is updated every 5 minutes.

Room Occupancy Information and Status

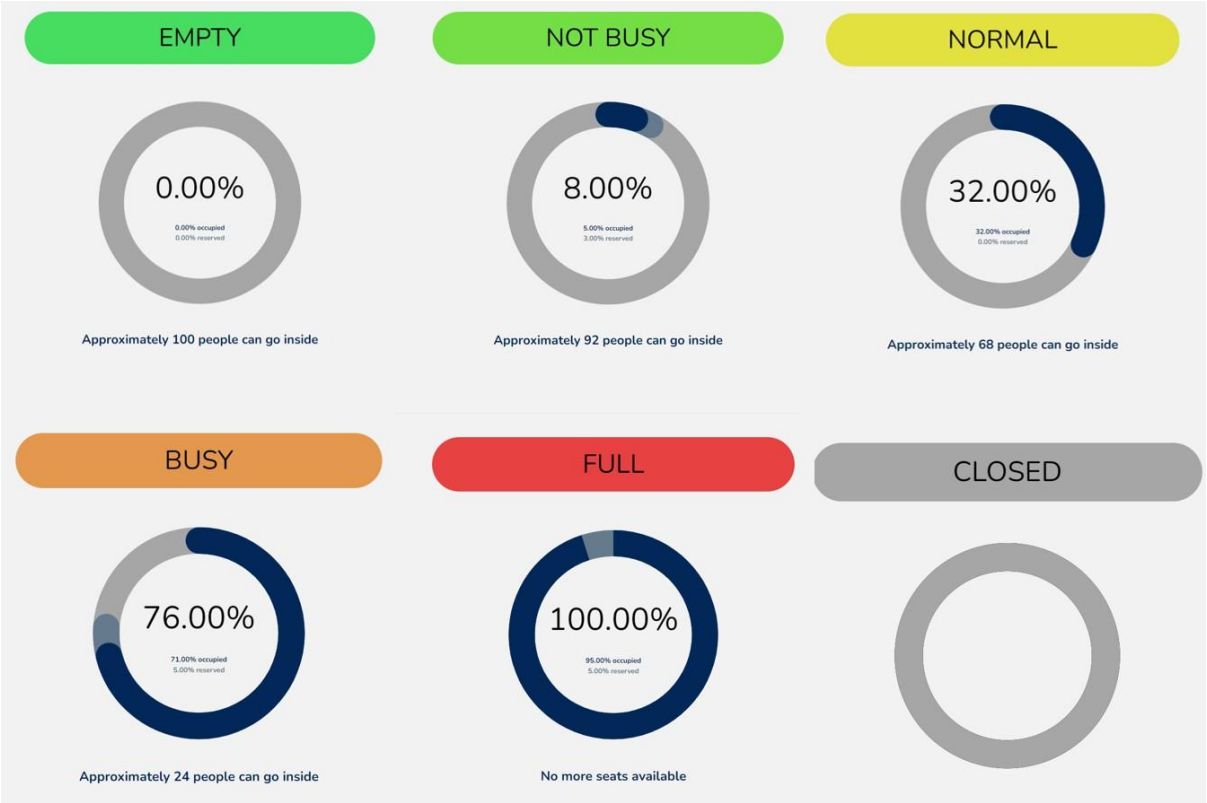

Figure 14. Room Occupancy Graph in Different Status

At the right side of the page in figure 13, visitors could see the Room Occupancy Graph feature. The computed occupancy shown in this graph is computed by adding the occupancy and reserved spots which are also displayed in the interface. The occupancy is calculated from the number detected by the computer vision model.

Additionally, the status of the current room occupancy will change based on its value. It may display "Empty", "Not Busy", "Normal", "Busy", "Full", or "Closed" which can be seen in Figure 14. It will display "Empty" if the computed occupancy is zero, "Not Busy" if

computed occupancy is one to thirty percent, “Normal” if computed occupancy is thirty-one to seventy percent, “Busy” if computed occupancy is seventy-one to ninety-nine percent, and “Full” if computed occupancy is one hundred.

Interactive Suggestions

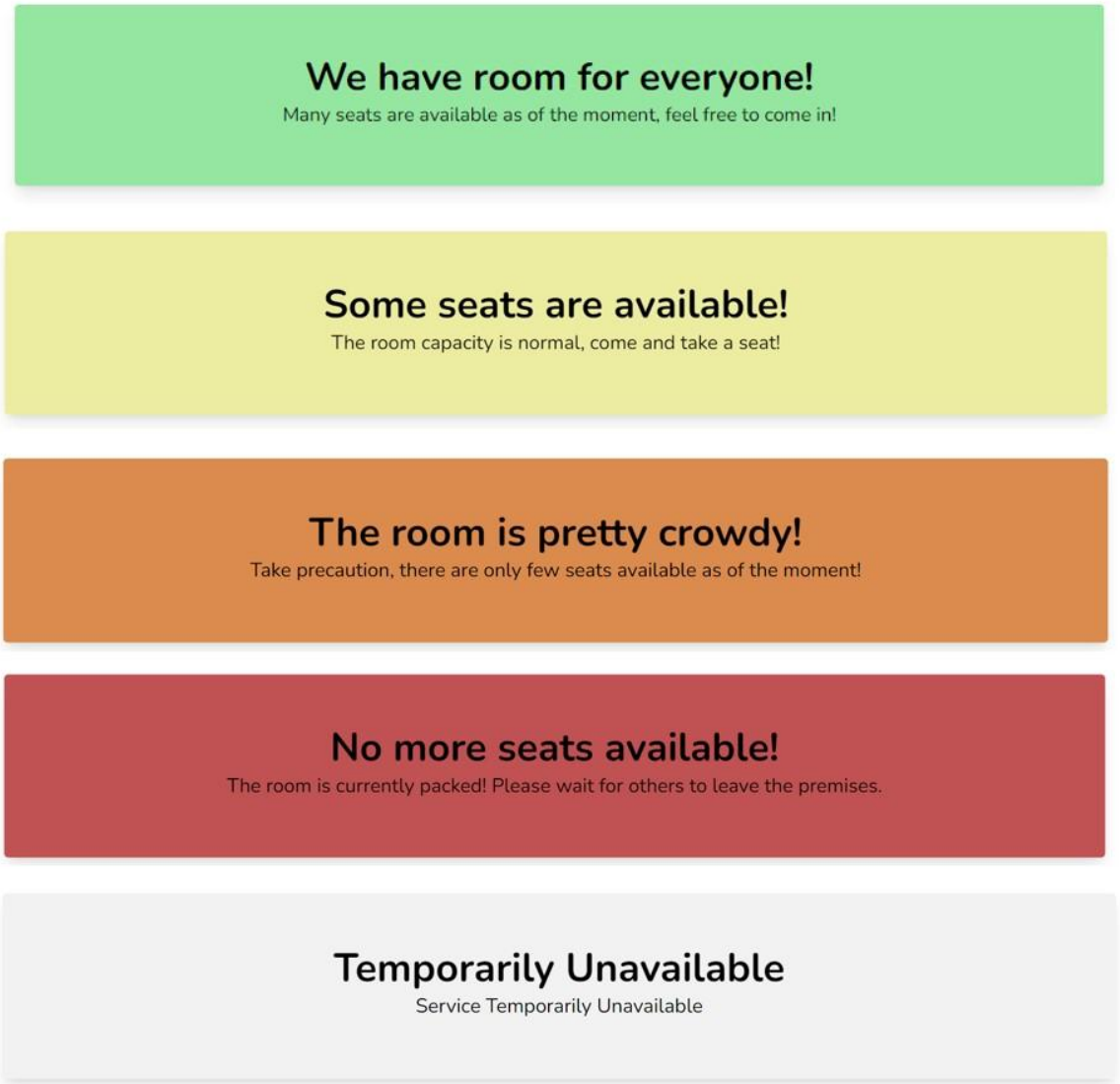

Figure 15. Seat Suggestion in Different Status

The three color-coded panels on the left side of the room occupancy graph is the Interactive Suggestions feature. The suggestions can help visitors decide if they want to go to the CLIR and at what time.

The uppermost panel will display action suggestions based on the current room occupancy status as can be seen in figure 15. It will display “we have room for everyone”, “some seats are available”, “the room is pretty crowded”, “no more seats available”, “temporarily unavailable” if the room status shown in the room occupancy graph is “empty” or “not busy”, “normal”, “busy”, “full”, and “closed”, respectively.

Figure 16. Crowd Comparison in Different Status

The middle panel displays a message about the comparison of today’s room occupancy to yesterday’s average room occupancy. It will display “today’s room is more crowded than yesterday” if the current occupancy is greater than yesterday’s average crowd, “today’s room is less crowded than yesterday” if the current occupancy is less than

yesterday's average crowd, "today's room is just as crowded than yesterday" if the current occupancy is equal to yesterday's average crowd, and "temporarily unavailable" if the CLIR is currently closed. The different status can be seen in figure 16.

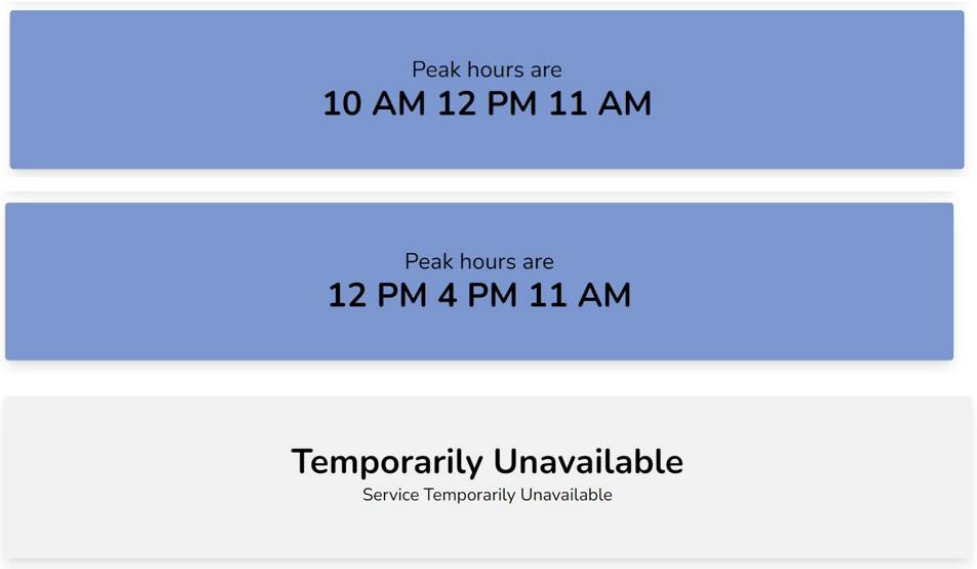

Figure 17. Peak Hours Panel

The lowermost panel, where its different status is shown in figure 17, displays the peak hours from past room occupancy records. If the CLIR is closed, it will display "temporarily unavailable".

Library Information

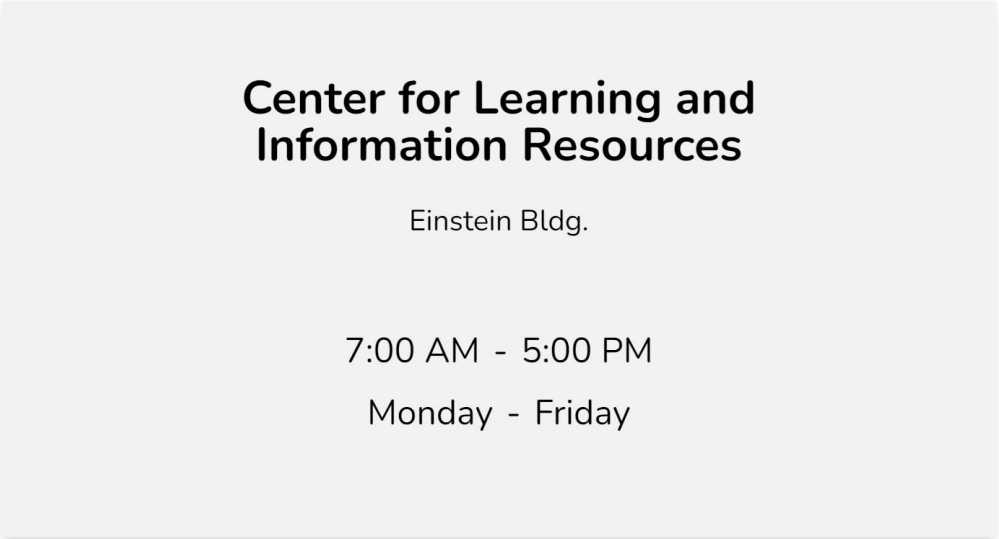

Figure 18. Library Information Panel

The library information panel, shown in figure 18, is located at the top of the interactive suggestions feature. This displays information about the library for the visitors' awareness. Information includes the schedule of the library, which consists of the opening and closing time, as well as the operational days of the library. The displayed schedule can also help visitors decide at what time they will go.

Visitor Login and Registration

Figure 19. Login Page

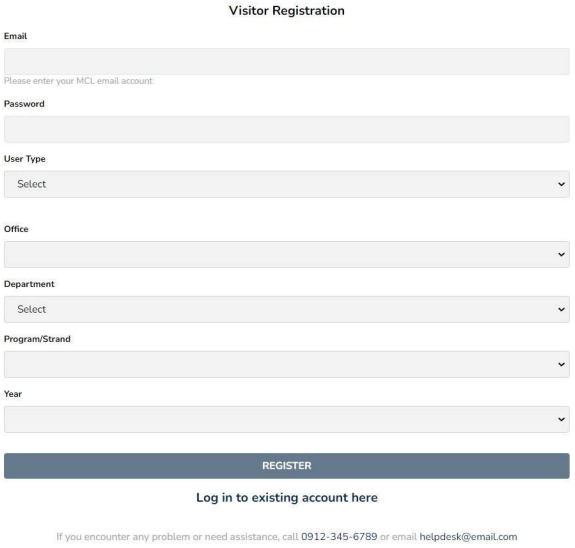

Figure 20. Registration Page

Figure 19 shows the login page of the website. In this page, the user must enter their email and password. If the user doesn't have an account, the user can create an account by pressing on the "Register" text button found on the bottom part of the login page. After that the user will be redirected to the register page shown in figure 20.

Reservation

The reservation feature of the website is suggested by the CLIR staff in accordance with the protocols that will be implemented when the CLIR has opened again. Based on the interview with the CLIR staff, the visitors may only enter the CLIR if they have a reservation. Additionally, the CLIR staff mentioned that a visitor is only allowed to stay an hour maximum and once a day.

Figure 21. Reserved Spots per Hour

Figure 22. Link to Reservation Page

Figure 21 shows the Reserved Spots per Hour panel which displays the number of reserved slots per hour in a day wherein the user can select a specific day to view. The visitor may only view future times and dates. This allows the visitors to check the slots to give more time to think before actually reserving.

The seat reservation feature is found on the bottom of the Reserved Spots per Hour panel, shown in figure 22. After clicking the button, the user will be redirected to the reservation page shown in figure 23 if the user has already logged in. If not, the visitor will be redirected to the login page.

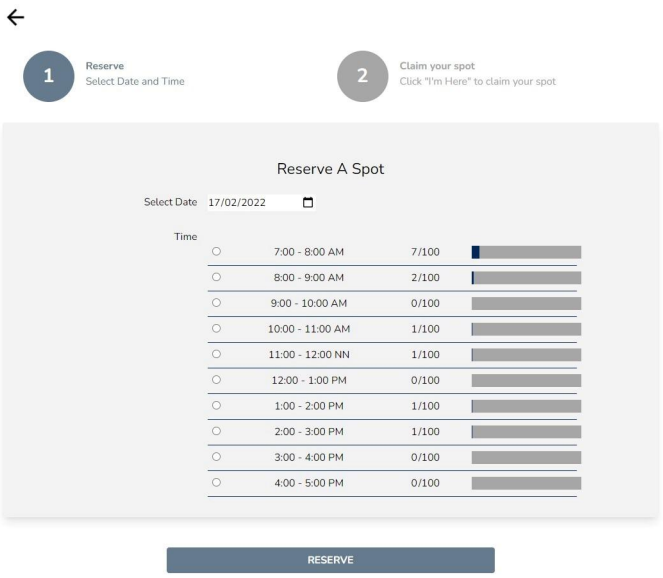

Figure 23. Reservation Page

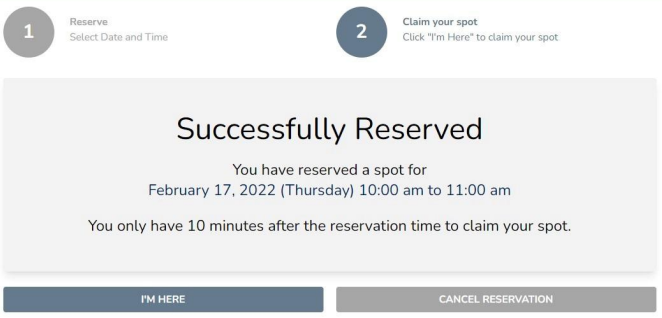

Figure 24. The interface for Successfully Reserved

Figure 25. The interface for Successfully Claimed Spot

In the reservation page, visitors can pick their desired date and time and can also see how many other visitors have reserved at each time After picking the desired date and time the user may now click the "Reserve" button. After reserving, the user will be redirected to

the Successfully Reserved page shown in figure 24. In this page, the reservation details are displayed and the user is informed that the user must claim the spot ten minutes after the reserved time. Once the user has arrived in the CLIR, the user must click the “I’m Here” button, to claim the reserved seat. If the seat has been claimed the user will be redirected to the Successfully Claimed Spot page shown in figure 25.

Figure 26. The interface for Successfully Canceled Reservation

Figure 27.The interface for Reservation Expired

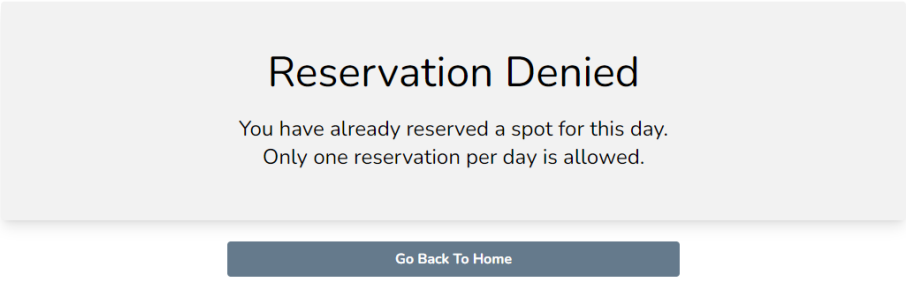

Figure 28. The interface for Reservation Denied

If the user changed his/her mind they may opt to cancel the reservation. After clicking the cancel button, they will be redirected to the Successfully Canceled Reservation page shown in figure 26. However, if the user fails to claim within ten minutes, the user will be redirected to the Reservation Expired page shown in figure 27. With this, the reservation will be marked as expired.

In the Successfully Claimed Spot, Successfully Canceled Reservation and Reservation Expired interfaces, a “Create New Reservation” is available if the user wants to create a new reservation.

As mentioned by the resource person for librarians, a visitor must only be able reserve a spot for at most one hour a day. Therefore, if the visitor has already reserved a seat for the day, the Reservation Denied page in figure 28 will be shown.

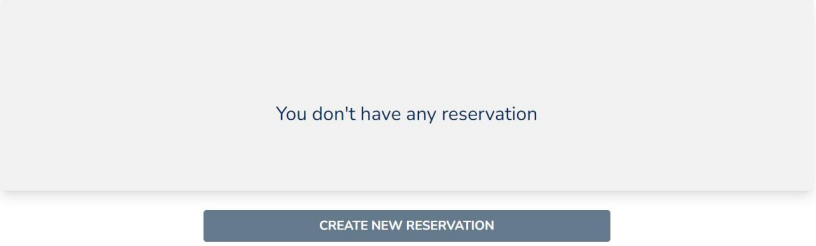

Figure 29. The interface for No Reservation

If the user has reserved days in advance, and has logged out after that. They may see their reservation again by clicking the “claim your spot” text. This is in the upper right corner as shown in figure 23. However, if the user doesn’t have any active reservation, and doesn’t have any past reservation, they will be redirect to the No Reservation page shown in figure 29. And if they have a past reservation, they will be redirected to the page Successfully Claimed Spot, Successfully Canceled Reservation or Reservation Expired depending on the status of the last reservation.

4.3.2 Librarian Interface

Figure 30. Librarian Interface

Figure 31. Head Librarian Interface

Figure 32. The interface for Librarian Login

Figure 30 shows the librarian interface, while figure 31 shows the head librarian interface. The librarian and head librarian must login first before they can access their respective interface. The Librarian login page is shown in figure 32. Features included in both interfaces are current room occupancy, effective capacity, count of reserved spots, and visualized data of the average room occupancy, room occupancy for the past hour, and student visitor reports of the current term. The data for the said graphs can be downloaded. Meanwhile features that are exclusive for the head librarian are changing the effective capacity, library information management, and librarian account management.

Room Occupancy Information

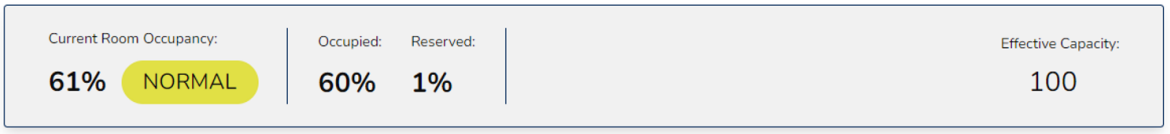

Figure 33. The interface for Current Room Occupancy and Effective Capacity

The room occupancy information is located at the left side of the first panel, as shown in figure 33. The computed occupancy shown in this panel is computed by adding the occupancy and reserved spots which are also displayed in the interface. The occupancy is calculated from the number detected by the computer vision model. Additionally, the status of the current room occupancy will change based on its value. It may display “Empty”, “Not

Busy", "Normal", "Busy", "Full", or "Closed". It will display "Empty" if the computed occupancy is zero, "Not Busy" if computed occupancy is one to thirty percent, "Normal" if computed occupancy is thirty-one to seventy percent, "Busy" if computed occupancy is seventy-one to ninety-nine percent, and "Full" if computed occupancy is one hundred. The room occupancy information is important so that the librarians will be aware of the current room situation and will be able to take any necessary actions.

Change Effective Capacity

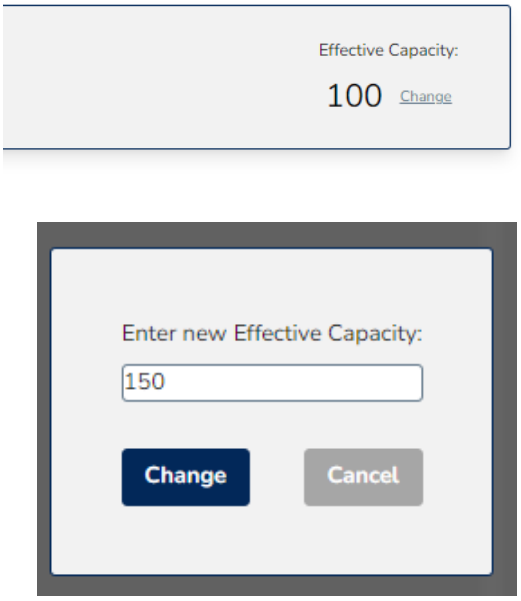

Figure 34. The interface for Change Effective Capacity

The effective capacity is located at the right side of the first panel. Librarians may only view the current capacity while head librarians may change the current effective capacity of the CLIR, interface is shown in figure 34. This is an important feature due to the current COVID-19 situation where the government implements a policy that reduces the operational capacities of certain places (Department of Health, 2021). This feature makes it possible to change the maximum number of visitors at a time according to changes in protocols. In changing the effective capacity, the number will directly reflect on the room

occupancy visualization on both visitors' and librarians' current room occupancy information.

Generate Reports

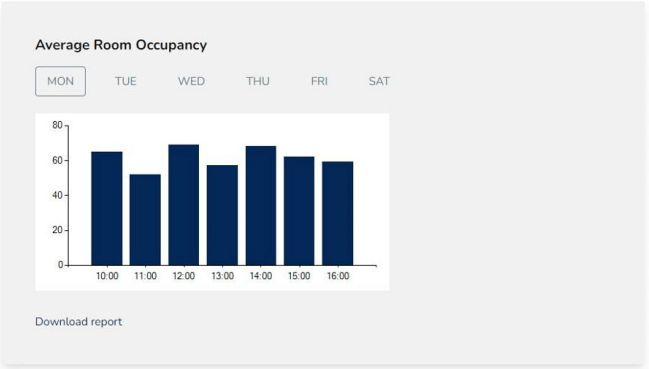

Figure 35. The interface for Average Room Occupancy

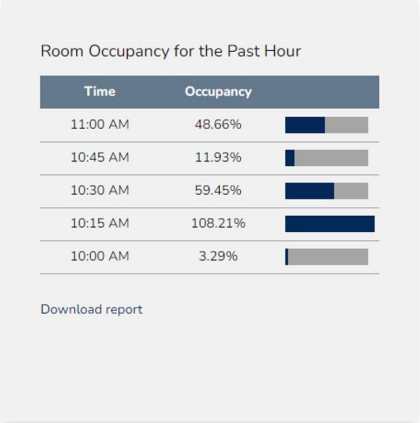

Figure 36. The interface for Room Occupancy for the Past Hour

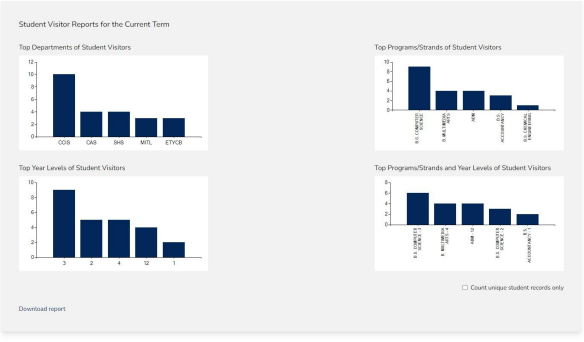

Figure 37. The interface for Student Visitor Reports

Another feature of the system is the Reports. This feature was suggested by the librarians as they mentioned that it would be useful for their daily operations. They have also suggested that the reports should be downloadable in Microsoft Excel format.

The reports include visualizations of the Average Room Occupancy shown in figure 35, Room Occupancy for the Past Hour shown in figure 36, and Student Visitor Reports shown in figure 37. Student Visitor Reports includes Top Departments of Student Visitors, Top Programs/Strands of Student Visitors, Top Year Levels of Student Visitors, and Top Programs/Strands and Year Levels of Student Visitors. The excel format of these reports could be downloaded by clicking the "Download report" button.

Reserved Spots per Hour

Figure 38. The interface for Reserved Spots per Hour

Figure 38 shows the Reserved Spots per Hour panel which displays the number of reserved slots per hour in a day wherein the user can select a specific day to view. The

librarian may only view future times and dates. This also allows the librarians to be informed of and anticipate the number of visitors for a certain time.

Library Information and Account Management

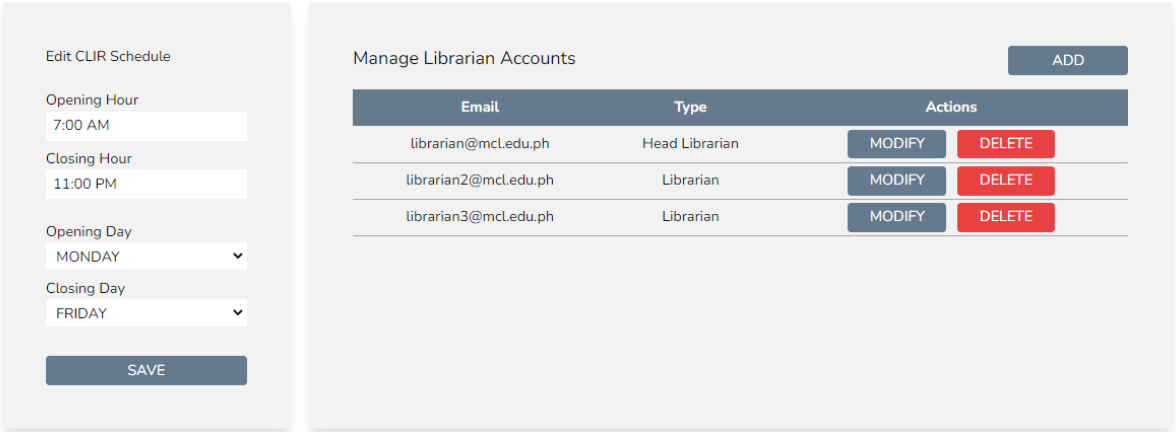

Figure 39. The interface for Library Information & Account Management

The next feature, shown on the left panel of figure 39, is accessible only to the head librarian. This allows the head librarian to change the opening and closing schedule of the CLIR according to changes in protocols. Once done, the librarian must press the "save" button to apply the changes. The changes made here will also reflect on the visitor's home page.

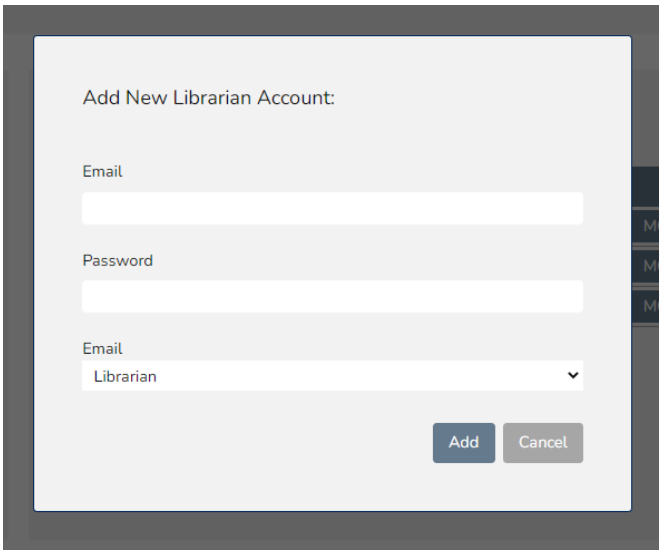

Figure 40. The interface for Adding Librarian Account

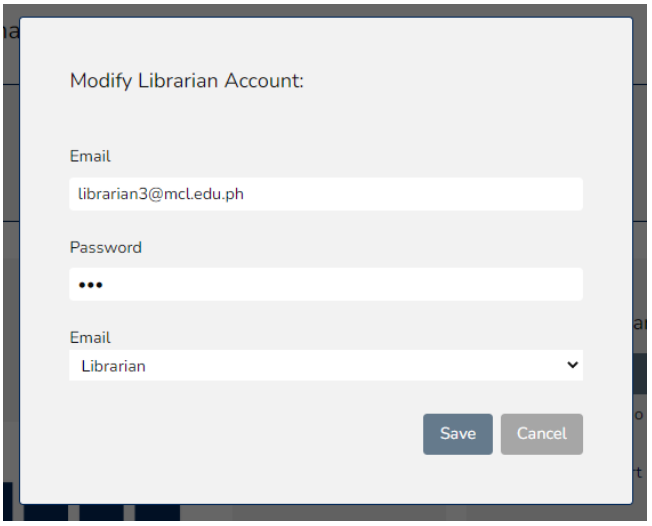

Figure 41. The interface for Modifying Librarian Account

The last feature, shown on the right panel of figure 39, is also accessible only to the head librarian. In this part the head librarian may manage the accounts of librarians. They may add (shown in figure 40), modify (shown in figure 41), and delete (red button shown in figure 39) the accounts of the librarian if needed. For account management, the accounts of the librarians and the head librarian are already given in the system.

4.3.3 System Testing

The developers executed the test cases they have created for each feature of the system. While executing each test case, the developer found bugs in the system. Whenever these bugs were found, the developer patched the bug and reran the test. At the end, the developers were successful in passing all test cases as shown in table 2. The full details of the test cases could be seen in appendix G.

Table 2. Summary of the test cases results

Test Case Name	Remarks
Reserve Spot	Pass
Claim Reservation Spot	Pass
Cancel Reservation	Pass
Reservation Expired	Pass
One Reservation Per Day	Pass
Notification	Pass
Room Occupancy Graph	Pass
Library Information Panel	Pass
Interactive Suggestions	Pass
Room Occupancy Information	Pass

Test Case Name	Remarks
Change Effective Capacity	Pass
Report Generation	Pass
Reserved Spots Per Hour	Pass
Library Information Management	Pass
Account Management	Pass
Visitor Account Login	Pass
Visitor Create Account	Pass
Librarian Account Login	Pass
Detect Room Occupancy	Pass

4.4 Evaluation of System Features

4.4.1 Survey Participants

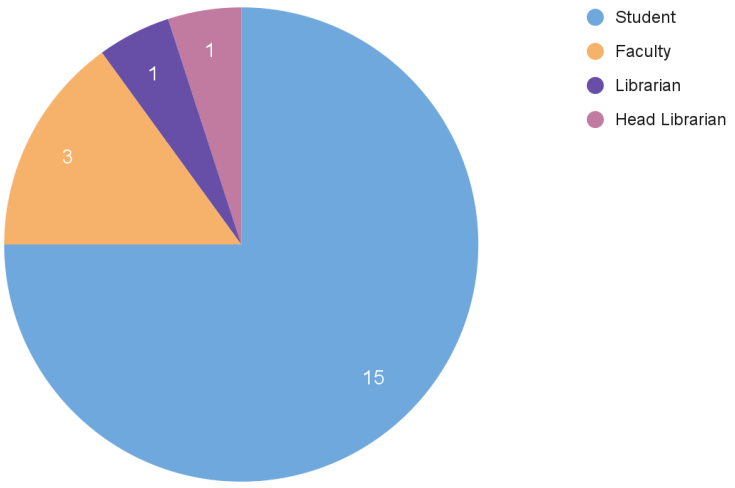

Figure 42. The number of respondents per type of user

As it could be seen in figure 42, the developers have surveyed 15 students, 3 faculty members, and 2 CLIR staff. The developers have used convenience sampling and selected a small sample size because of the limited time, the difficulty of finding students who have used the CLIR, and because there are no face-to-face classes.

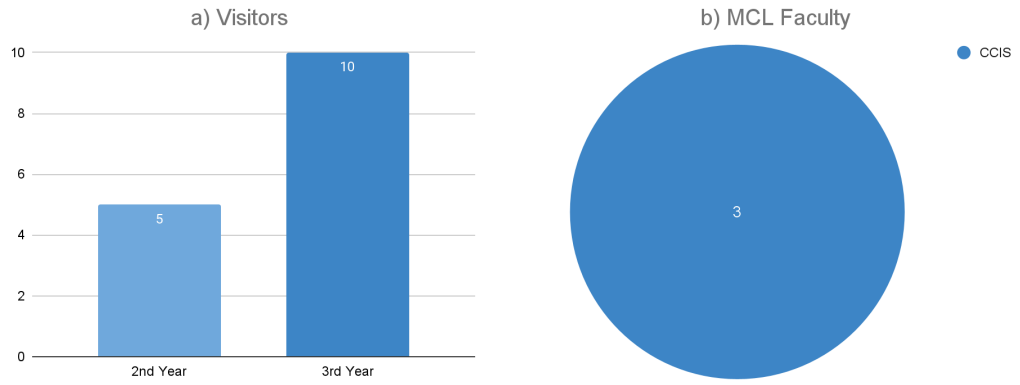

Figure 43. The (a) year levels of student and (b) department of faculty respondents

As seen in figure 43, the majority of the students surveyed were in their third year (66.7%) and a smaller proportion were in their second year (33.3%). Meanwhile, all faculty members that were surveyed were part of the CCIS department.

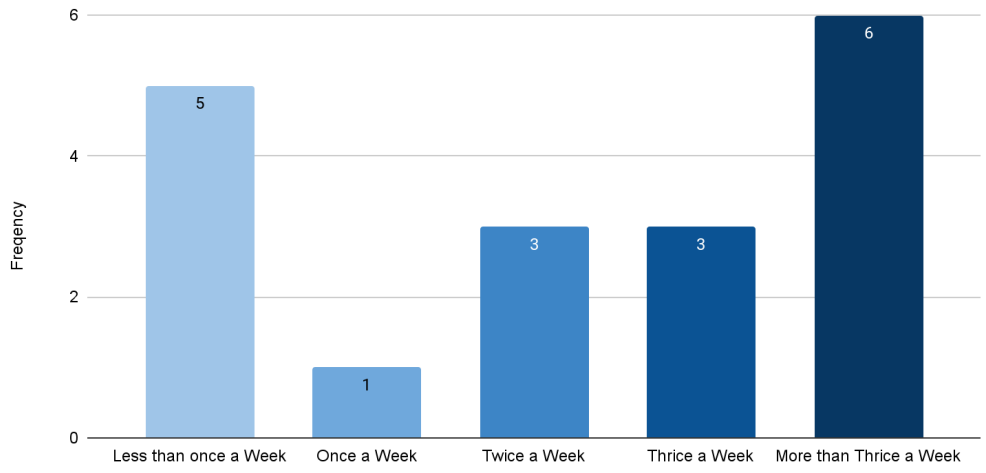

Figure 44. Number of Times per Week Visitors Use the CLIR Before Lockdown

Respondents varied in the number of times they used the CLIR before lockdown as seen in figure 44. The largest proportion, comprising 35.3% of the visitors, used the CLIR

more than thrice a week. The second-largest proportion, comprising 23.5%, used the CLIR less than once a week. The number of respondents who use the CLIR twice and thrice a week each comprise 17.6% of the samples. The smallest proportion, comprising 5.9% percent of the participants, uses the CLIR only once a week.

4.4.2 Usefulness of Features

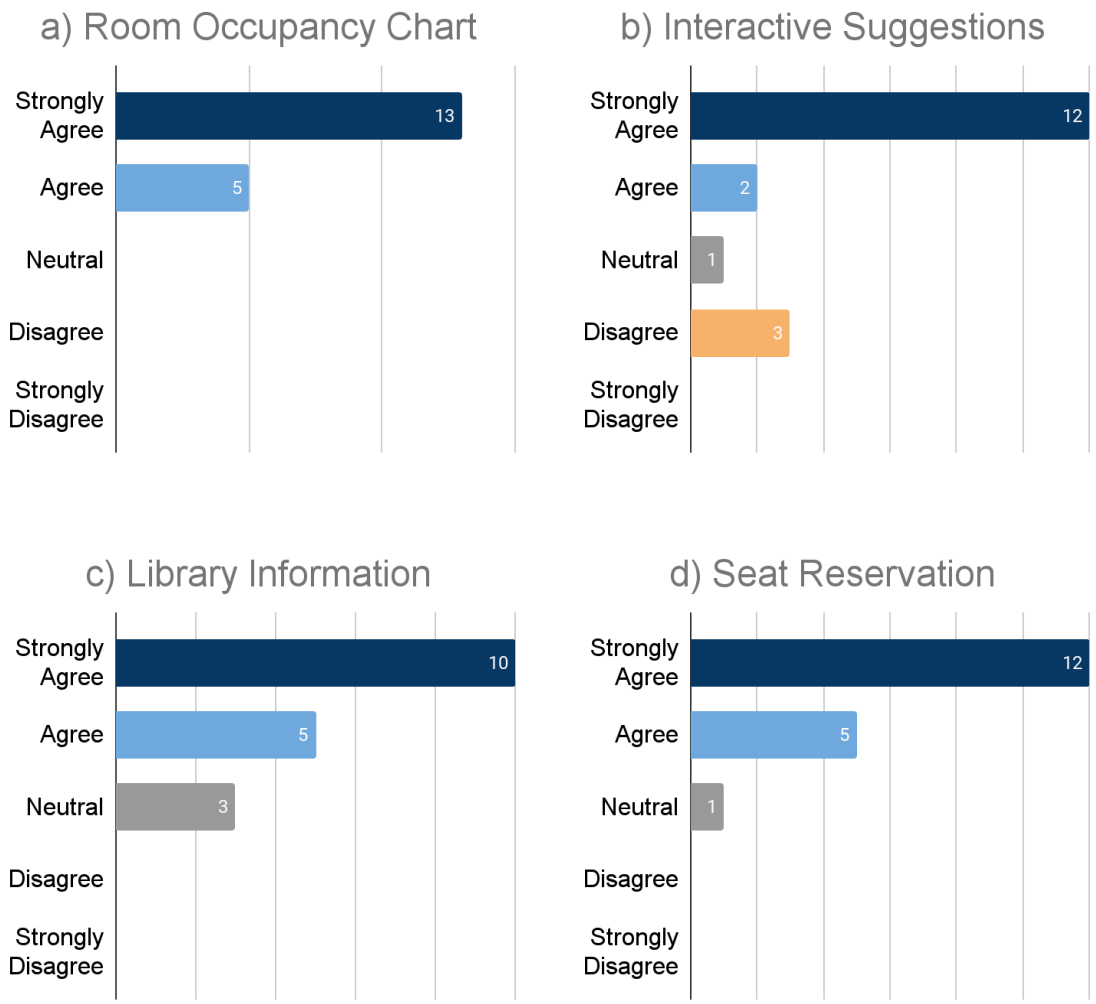

Figure 45. The distribution of visitor respondents' rating on each feature

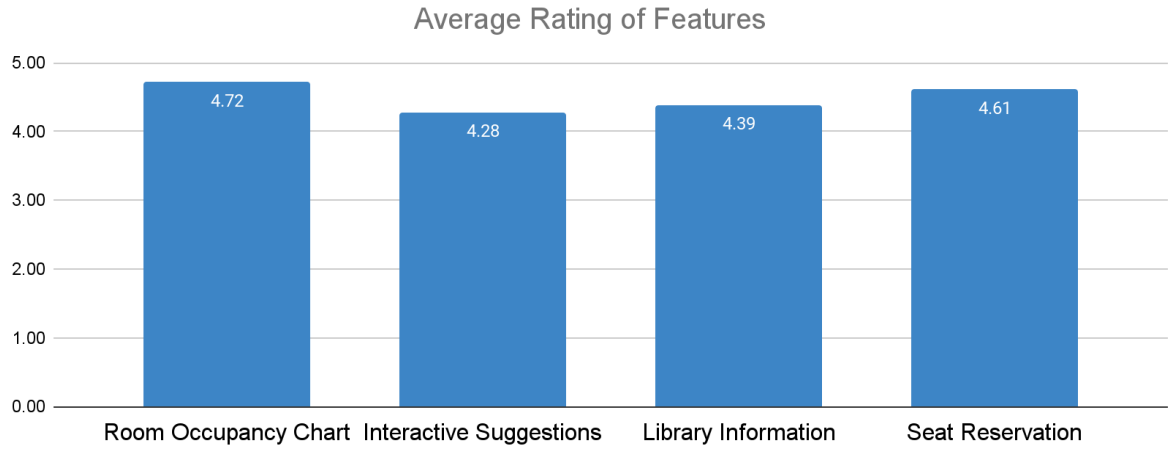

Figure 46. The average rating of each visitor feature

In the survey, the visitors have evaluated the usefulness of the Room Occupancy Chart, Interactive Suggestions, Library Information, and Seat Reservation features. As shown in figure 46, all features have an average rating above 4. The distribution of visitor respondents' rating on each feature is shown in figure 45. The feature with the highest score is the Room Occupancy Chart having an average score of 4.72. The seat reservation feature received the second highest average score of 4.61. There were also many respondents who mentioned ways to improve the reservation feature. On the other hand, the feature that received the second lowest score was the library information feature with 4.39. The feature with the lowest score is the Interactive Suggestions feature with an average score of 4.28. This is because some visitors found the information presented were too wordy or repetitive.

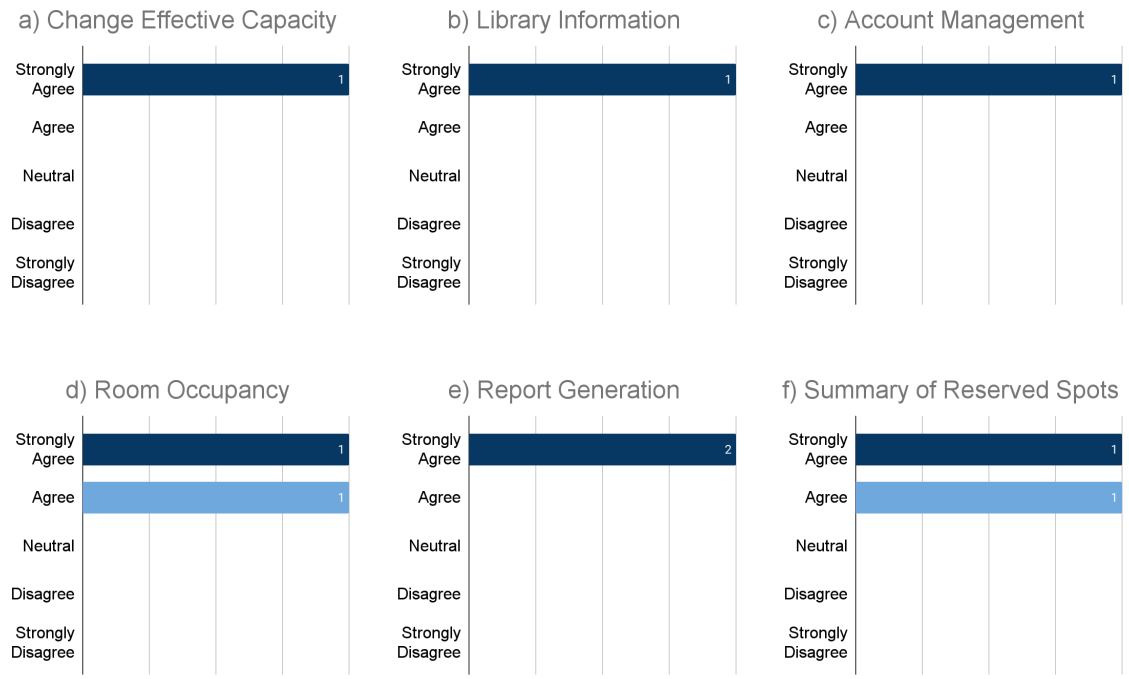

Figure 47. The distribution of librarian respondents' rating on each feature

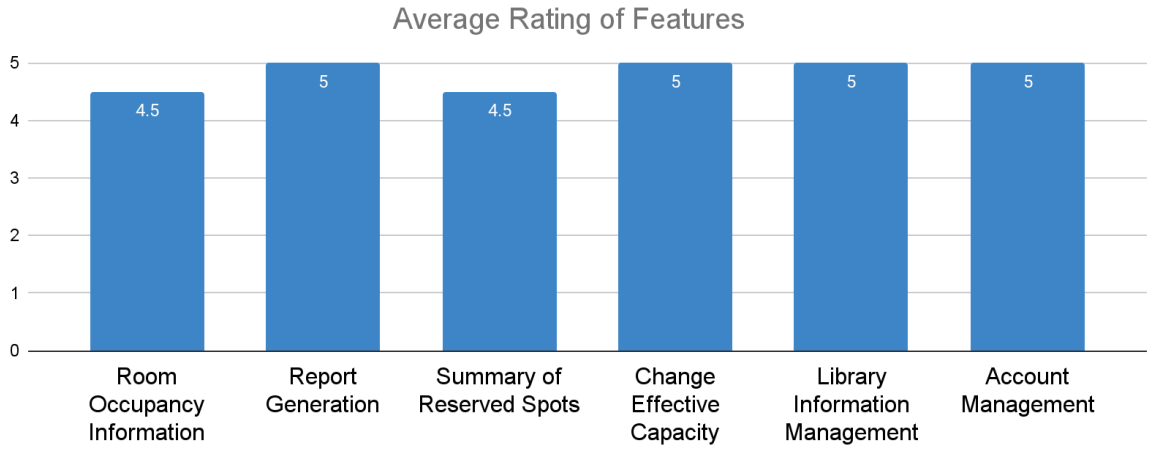

Figure 48. The average rating of each librarian feature

On the other hand, the librarians evaluated the usefulness of the Change Effective Capacity, Library Information Management, Account Management, Room Occupancy Information, Report Generation, and Summary of Reserved Spots features. All features have an average rating above 4, shown in figure 48. The distribution of librarian respondents' rating on each feature is shown in figure 47. The head librarian features have all received a rating of 5 because, as commented by the respondent, the system has complied with all of

their suggestions. The other librarian rated all the features 4 except for the report generation which the respondent has rated 5. The respondent found this feature particularly useful because, as mentioned in the comments, the respondent is in charge of reports and data generation.

4.4.3 Comments and Suggestions

Most suggestions of the respondents were about how to improve the reservation feature of the system. The most common suggestion on the reservation feature is to implement a seat map. Using this feature, visitors may visually select which particular seat they want to reserve. Some have also suggested allowing visitors to reserve library computers in particular. There was also a suggestion to allow visitors to reserve in groups so that visitors can use the CLIR for group studies.

There were also comments and suggestions about the interactive suggestions feature. One commented that the “peak hours” suggestion is very useful for them. However, there were some respondents who thought that some of the messages were redundant and wordy. There was also one respondent who suggested combining some aspects of the reservation feature to the interactive suggestions feature. For example, when the user forgot what time they reserved a spot, it could be viewed in the interactive suggestions.

Some respondents pointed out how to improve the user interface elements of the website. These include decreasing the size of UI elements, decreasing the font size, adding more graphics, and using the branding of MCL. Some respondents mentioned ways to improve the user experience. One respondent suggested fitting everything to the screen height of the device. Another mentioned moving the reservation button on top of the website where it could be easily found. One suggests that they want to be able to see all the information in the visitor home page while making a reservation.

The respondents also mentioned some comments on the system. Some participants wrote that they were satisfied with the website. Some also said that the website would be useful for library users.

Chapter 5

CONCLUSION

In this paper, the developers identified two problems the CLIR faces. First, students go to the CLIR just to find out that there are no more available seats. Second, its operations are affected by safety protocols amidst the pandemic. To help alleviate this problem, the developers propose a system called Sparse. Sparse is a computer vision-based room occupancy and reservation system. To develop the system, the developers first trained and benchmarked different object detection algorithms. From this, the developers were able to identify that the Faster-RCNN model is the most appropriate computer vision-based people counting algorithm for the system. Then, the developers have collaborated with visitor and librarian resource persons to identify the necessary features for visitors and librarians. The features that were identified for visitors were Room Occupancy Chart, Interactive Suggestions, Library Information, and Seat Reservation. For librarians, the features that were identified are Room Occupancy Information, Report Generation, Summary of Reserved Spots, Change Effective Capacity, Library Information Management, and Account Management. Lastly, the developers conducted a survey on students, faculty and librarians of MCL. The results of the survey show that the identified features were useful to users. Additionally, the survey has also gathered features that could be implemented in the future. With this system, visitors would be able to use the CLIR for studying, waiting, or viewing reference materials without worrying whether or not they will be able to find a seat.

Chapter 6

RECOMMENDATIONS

While the developers have shown that the Faster-RCNN model is the most appropriate computer vision-based people counting algorithm for the system, the developers think that the model could be improved. One problem that the developers faced is the lengthy training time of the models. Because of this, the developers could only train the models for 10 epochs. This led to the model underfitting the training dataset. The developers recommend future developers use more powerful hardware so that they could train the model for more epochs, and therefore get lower root mean square error.

The developers also recommend comparing different methods for people counting. Other object detection models such as YOLO, Mask R-CNN, and other variants of the models in the project could be compared to each other. Future developers could also test out the network-based people counting method that was mentioned in the review of related studies.

There are also multiple things that could be improved in the system. First, future developers must consider how they are going to manage data collected by the system. Even though the system only stores the current room occupancy and it's timestamp, the system stores these every five minutes. When the system is running every day, room occupancy data could occupy a lot of space in the database. Second, future developers must also consider possible concurrency issues as these were not considered in this project. Failing to consider this may lead to a sluggish system. Lastly, future developers must consider the synchronization points between the people counting and the reservation system. If the people counting were not synchronized properly with the reservation system, the reservation system may erroneously allow a visitor to make a reservation.

The developers were also able to collect features that were suggested by the users. However, the developers were not able to implement these suggestions due to the lack of time. The developers recommend implementing these features in future projects.

The developers also couldn't go to the campus of MCL to gather data and perform a pilot test of the system. The developers recommend future developers to gather actual data from the CLIR and test their system on the campus.

The developers also think that the method of surveying could be improved. First, the sample size of the survey is small. The developers recommend selecting a higher sample size to get better feedback. Second, the developers used convenience sampling because of the lack of time. Future researchers could use a better sampling technique to reduce bias.

The project has also primarily focused on the usefulness of the system. However, as seen in the suggestions of the users in the survey, users value the user interface and user experience. Therefore, the developers recommend future developers focus on the user interface and user experience of the system.

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APPENDIX A

Test Case Template

Test Case # X

Test Case #: 2 **System:** **Executed by:**	**Test Case Name:** **Subsystem:** **Design Date:** **Execution Date:**

Pre-conditions -

Step	Action	Expected System Response	Pass/Fail	Comment
-				

Post-conditions 1.

APPENDIX B

Survey Questions for Visitors

Sparse - Computer Vision System

Please read the data privacy notice before proceeding to answer the survey.

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Data Privacy Notice

The developers that are conducting this survey respects your right to privacy and is committed to protect the confidentiality of your personal information. It has adapted reasonable administrative, physical and technical measures to prevent loss, misuse and alteration of the information under our control. However, no method of transmission over the internet or method of electronic storage is 100% secure.

By filling up this form you are consenting to the collection, processing and use of the information in accordance to this privacy notice. The personal information that will be collected include:
- Full Name
- Program/Strand (For Students)
- Year/Grade Level (For Students)
- Department (For Faculty)

The information you have provided will be used to for the following:
- Basis for improvement of the system
- Data to support the accomplishment of the objective of the study

The information is collected and stored through Google. Google has its own Privacy Policy. Visit https://policies.google.com/privacy

The developers shall only retain the said information until it serves its purpose, after which it shall be securely disposed of.

If you have concerns or queries on Data Privacy, please e-mail lipatjj@live.mcl.edu.ph

After reading the Data Privacy Notice, please check the checkbox below. *

☐ I have read the Data Privacy Notice and I agree in its terms.

Susunod Page 1 ng 6 I-clear ang form

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Visitor Profile

Full Name (Last Name, First Name M.I.) *

Iyong sagot

Type of Visitor *

- ◯ Student
- ◯ Faculty

How often do you use the CLIR when MCL still had face to face classes? *

This includes using the CLIR to wait during vacant periods.

- ◯ Less than once a week
- ◯ Once a week
- ◯ Twice a week
- ◯ Thrice a week
- ◯ More than thrice a week

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Student Profile

Program/Strand *

e.g. CS, IT, IS, ICT, HUMSS

Iyong sagot

Kailangan ang tanong na ito

Year/Grade Level *

Pumili

Kailangan ang tanong na ito

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Rate Visitor Features

Note: The video explanations in each question are the same as the videos in the guidelines.

As a CLIR visitor, the "Room Occupancy Chart" feature of the website is useful *

Video Explanation: https://youtu.be/uusV3iEb_Ic

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

As a CLIR visitor, the "Interactive Suggestions" feature of the website is useful *

Video Explanation: https://youtu.be/db4YCXHH7cg

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

As a CLIR visitor, the "Library Information" feature of the website is useful *

Video Explanation: https://youtu.be/J3UtJHMjs0g

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

As a CLIR visitor, the "Seat Reservation" feature of the website is useful *

Video Explanation: https://youtu.be/N8vZKieTxrg

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Suggestions and Comments

What additional features or information would you like to see in the website? *

Iyong sagot

Which parts of the website do you think needs improvement? How do you think we can improve those parts? *

Iyong sagot

Do you have any additional comments?

Iyong sagot

Bumalik Submit

I-clear ang form

APPENDIX C

Survey Questions for CLIR Staff

Sparse - Computer Vision System

Please read the data privacy notice before proceeding to answer the survey.

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Data Privacy Notice

The developers that are conducting this survey respects your right to privacy and is committed to protect the confidentiality of your personal information. It has adapted reasonable administrative, physical and technical measures to prevent loss, misuse and alteration of the information under our control. However, no method of transmission over the internet or method of electronic storage is 100% secure.

By filling up this form you are consenting to the collection, processing and use of the information in accordance to this privacy notice. The personal information that will be collected include:
- Full Name

The information you have provided will be used to for the following:
- Basis for improvement of the system
- Data to support the accomplishment of the objective of the study

The information is collected and stored through Google. Google has its own Privacy Policy. Visit https://support.google.com/a/answer/9822731.

The developers shall only retain the said information until it serves its purpose, after which it shall be securely disposed of.

If you have concerns or queries on Data Privacy, please e-mail lipatjj@live.mcl.edu.ph

After reading the Data Privacy Notice, please check the checkbox below. *

☐ I have read the Data Privacy Notice and I agree in its terms.

Susunod

Page 1 ng 5

I-clear ang form

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

CLIR Staff Profile

Full Name (Last Name, First Name M.I.) *

Iyong sagot

Kailangan ang tanong na ito

Type of User *

Pumili

Kailangan ang tanong na ito

Bumalik Susunod Page 2 ng 5 I-clear ang form

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Rate Head Librarian Features

Note: The video explanations in each question are the same as the videos in the guidelines.

As the Head Librarian, the "Change Effective Capacity" feature of the website is useful *

Video Explanation: https://youtu.be/4gdpTG2B8ig

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

As the Head Librarian, the "Library Information Management" feature of the website is useful *

Video Explanation: https://youtu.be/BP3_dsFgOI4

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

As the Head Librarian, the "Account Management" feature of the website is useful *

Video Explanation: https://youtu.be/sS74SAytglo

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Rate Librarian Features

Note: The video explanations in each question are the same as the videos in the guidelines.

As a Librarian, the "Room Occupancy Information" feature of the website is useful *

Video Explanation: https://youtu.be/74UbGfo3x5M

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

As a Librarian, the "Report Generation" feature of the website is useful *

Video Explanation: https://youtu.be/fGIs98h4-wk

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

As a Librarian, the "Summary of Reserved Spots" feature of the website is useful *

Video Explanation: https://youtu.be/HEMr2RUKQXE

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Sparse - Computer Vision System

Mag-sign in sa Google para i-save ang iyong pag-usad. Matuto pa

*Kinakailangan

Suggestions and Comments

What additional features or information would you like to see in the website? *

Iyong sagot

Which parts of the website do you think needs improvement? How do you think we can improve those parts? *

Iyong sagot

Do you have any additional comments?

Iyong sagot

Bumalik Submit

I-clear ang form

APPENDIX D

Survey Guidelines for Visitors

Greetings,

Thank you so much for accepting the invitation to test our system. In this test, we would like to know **how useful** you think the features of our system are. The test will take around 15 to 30 minutes to complete.

To make the testing process easier, we have created this document to explain how you will be testing the system. We do not guarantee that our system will be bug/error-free. So, If you encounter any bugs/errors while testing the system, please do let us know so that we could fix them soon. Once you're done testing, kindly inform our group member who has contacted you. Once again, thanks for testing our system.

The following are what you have to do:

1. Watch the Introduction Video
    - Video Link: https://youtu.be/djygLXNPxTw

2. View the features of the website
    - Room Occupancy Chart
        - Video Link: https://youtu.be/uusV3iEb_Ic
    - Interactive Suggestions
        - Video Link: https://youtu.be/db4YCXHH7cg
    - Library Information Panel
        - Video Link: https://youtu.be/J3UtJHMjs0g
    - Seat Reservation
        - Video Link: https://youtu.be/N8vZKieTxrg

3. Explore the website
    - Website Link: https://sparse.azurewebsites.net/Visitor/Visitor.aspx
    - Note:
        - Please check the FAQ section below
        - Do not use your real password when creating an account

4. Answer the survey
    - Note:
        - The first part of the survey consists of questions about the participants' profile. The second part is the evaluation of the website features. The questions in the second part are in Likert scale, wherein 1 is equivalent to Strongly Disagree, 2 is equivalent to Disagree, 3 is equivalent to Neutral, 4 is equivalent to Agree, and 5 is equivalent to Strongly Agree. Lastly, the third part of the survey asks for comments and suggestions.

- Survey Link: https://forms.gle/VwR914gFJ8i6W15X7

If you have any questions, please feel free to message our group member who has contacted you. Alternatively, you may send an email or MS Teams message to lipatjj@live.mcl.edu.ph.

Best wishes,

Team Headlights

FAQ:

Q: What is our objective when testing the application?
A: Your objective is to evaluate the system in terms of **how useful** it is. Right now, the user interface/aesthetics of the system is not yet our main focus. But, if you have any comments about the user interface, please do tell us as we would highly appreciate them.

Q: What is a “computer vision model”, and how does it work?
A: In simple words, a computer vision model is something that accepts a picture and gathers information from that picture. It works similarly to our human vision where we see through our eyes and then our brain interprets what we see.

In our system, our computer vision model sees using a camera, and then it interprets how many people are in the picture using an algorithm called neural networks.

Q: I have encountered a bug/error in the website, what do I do?
A: Please report the bug to our group member who has contacted you.

Q: What happens if there is one more available seat in the CLIR, then I reserve that seat, and then someone who didn’t reserve walks in and takes that seat?
A: When the system is deployed, the assumption is that everyone who enters the CLIR must reserve first even though they “walk-in”. So, they will not be able to take that seat because the CLIR will be considered full, and therefore it cannot let in any more students except those who have already reserved a seat. We have thought of a couple of solutions on how the walk-in reservation could be streamlined, but, in the meantime, it is out of the scope of the project.

Q: Why are the opening and closing time and date of the CLIR on the website wrong?

A: For testing, we have set it to Sunday to Saturday from 7:00 AM to 11:00 PM so that you can test the website any time. If the status of the CLIR is closed on your end, please send us a message.

Q: Why is the room occupancy data in the system not updating?
A: The computer vision model is currently disabled for the testing

Q: If the computer vision model is disabled, where does the data in the website come from?
A: The room occupancy data on the website are randomly generated.

APPENDIX E

Survey Guidelines for Librarians

Greetings,

Thank you so much for accepting the invitation to test our system. In this test, we would like to know **how useful** you think the features of our system are. The test will take around 15 to 30 minutes to complete.

To make the testing process easier, we have created this document to explain how you will be testing the system. We do not guarantee that our system will be bug/error-free. So, If you encounter any bugs/errors while testing the system, please do let us know so that we could fix them soon. Once you're done testing, kindly inform our group member who has contacted you. Once again, thanks for testing our system.

The following are what you have to do:

1. Watch the Introduction Video
    a. Video Link: https://youtu.be/sRR-4k8rI_Y

2. View the features of the website
    a. Room Occupancy Information
        i. Video Link: https://youtu.be/74UbGfo3x5M
    b. Report Generation
        i. Video Link: https://youtu.be/fGIs98h4-wk
    c. Summary of Reserved Spots
        i. Video Link: https://youtu.be/HEMr2RUKQXE

3. Explore the website
    a. Website Link: https://sparse.azurewebsites.net/Librarian/Login.aspx
    b. Credentials
        - Email: librarian2@mcl.edu.ph
        - Password: qwerty

4. Answer the survey
    a. Note:
    The first part of the survey consists of questions about the participants' profile. The second part is the evaluation of the website features. The questions in the second part are in Likert scale, wherein 1 is equivalent to Strongly Disagree, 2 is equivalent to Disagree, 3 is equivalent to Neutral, 4 is equivalent to Agree, and 5 is equivalent to Strongly Agree. Lastly, the third part of the survey asks for comments and suggestions.
    b. Survey Link: https://forms.gle/CFisRLfdth5mph486

If you have any questions, please feel free to message our group member who has contacted you. Alternatively, you may send an email or MS Teams message to lipatjj@live.mcl.edu.ph.

Best wishes,
Team Headlights
FAQ:

Q: What is our objective when testing the application?
A: Your objective is to evaluate the system in terms of **how useful** it is. Right now, the user interface/aesthetics of the system is not yet our main focus. But, if you have any comments about the user interface, please do tell us as we would highly appreciate them.

Q: What is a “computer vision model”, and how does it work?
A: In simple words, a computer vision model is something that accepts a picture and gathers information from that picture. It works similarly to our human vision where we see through our eyes and then our brain interprets what we see.

In our system, our computer vision model sees using a camera, and then it interprets how many people are in the picture using an algorithm called neural networks.

Q: I have encountered a bug/error in the website, what do I do?
A: Please report the bug to our group member who has contacted you.

Q: What happens if there is one more available seat in the CLIR, then I reserve that seat, and then someone who didn’t reserve walks in and takes that seat?
A: When the system is deployed, the assumption is that everyone who enters the CLIR must reserve first even though they “walk-in”. So, they will not be able to take that seat because the CLIR will be considered full, and therefore it cannot let in any more students except those who have already reserved a seat. We have thought of a couple of solutions on how the walk-in reservation could be streamlined, but, in the meantime, it is out of the scope of the project.

Q: Why are the opening and closing time and date of the CLIR on the website wrong?
A: For testing, we have set it to Sunday to Saturday from 7:00 AM to 11:00 PM so that you can test the website any time. If the status of the CLIR is closed on your end, please send us a message.

Q: Why is the room occupancy data in the system not updating?
A: The computer vision model is currently disabled for the testing

Q: If the computer vision model is disabled, where does the data in the website come from?
A: The room occupancy data on the website are randomly generated.

APPENDIX F

Survey Guidelines for the Head Librarian

Greetings,

Thank you so much for accepting the invitation to test our system. In this test, we would like to know **how useful** you think the features of our system are. The test will take around 15 to 30 minutes to complete.

To make the testing process easier, we have created this document to explain how you will be testing the system. We do not guarantee that our system will be bug/error-free. So, If you encounter any bugs/errors while testing the system, please do let us know so that we could fix them soon. Once you're done testing, kindly inform our group member who has contacted you. Once again, thanks for testing our system.

The following are what you have to do:

1. Watch the Introduction Video
    a. Video Link: https://youtu.be/sRR-4k8rI_Y

2. View the features of the website
    a. Room Occupancy Information
        i. Video Link: https://youtu.be/74UbGfo3x5M
    b. Report Generation
        i. Video Link: https://youtu.be/fGIs98h4-wk
    c. Summary of Reserved Spots
        i. Video Link: https://youtu.be/HEMr2RUKQXE
    d. Change Effective Capacity
        i. Video Link: https://youtu.be/4gdpTG2B8ig
    e. Library Information Management Panel
        i. Video Link: https://youtu.be/BP3_dsFgOl4
    f. Account Management Panel
        i. Video Link: https://youtu.be/sS74SAytgIo

3. Explore the website
    a. Website Link: https://sparse.azurewebsites.net/Librarian/Login.aspx
    b. Credentials
        - Email: librarian@mcl.edu.ph
        - Password: qwerty
    c. Note: Do not use your real password when creating an account

4. Answer the survey
    a. Note:
    The first part of the survey consists of questions about the participants' profile. The second part is the evaluation of the website features. The questions in the second part are in Likert scale, wherein 1 is equivalent to Strongly Disagree, 2 is equivalent to Disagree, 3 is equivalent to Neutral, 4 is

equivalent to Agree, and 5 is equivalent to Strongly Agree. Lastly, the third part of the survey asks for comments and suggestions.

b. Survey Link: https://forms.gle/CFisRLfdth5mph486

If you have any questions or bugs that you want to report, please feel free to message our group member who has contacted you. Alternatively, you may send an email or MS Teams message to lipatjj@live.mcl.edu.ph.

Best wishes,
Team Headlights

FAQ:

Q: What is our objective when testing the application?
A: Your objective is to evaluate the system in terms of **how useful** it is. Right now, the user interface/aesthetics of the system is not yet our main focus. But, if you have any comments about the user interface, please do tell us as we would highly appreciate them.

Q: What is a “computer vision model”, and how does it work?
A: In simple words, a computer vision model is something that accepts a picture and gathers information from that picture. It works similarly to our human vision where we see through our eyes and then our brain interprets what we see.

In our system, our computer vision model sees using a camera, and then it interprets how many people are in the picture using an algorithm called neural networks.

Q: I have encountered a bug/error in the website, what do I do?
A: Please report the bug to our group member who has contacted you.

Q: What happens if there is one more available seat in the CLIR, then I reserve that seat, and then someone who didn’t reserve walks in and takes that seat?
A: When the system is deployed, the assumption is that everyone who enters the CLIR must reserve first even though they “walk-in”. So, they will not be able to take that seat because the CLIR will be considered full, and therefore it cannot let in any more students except those who have already reserved a seat. We have thought of a couple of solutions on how the walk-in reservation could be streamlined, but, in the meantime, it is out of the scope of the project.

Q: Why are the opening and closing time and date of the CLIR on the website wrong?
A: For testing, we have set it to Sunday to Saturday from 7:00 AM to 11:00 PM so that you can test the website any time. If the status of the CLIR is closed on your end, please send us a message.

Q: Why is the room occupancy data in the system not updating?
A: The computer vision model is currently disabled for the testing

Q: If the computer vision model is disabled, where does the data in the website come from?
A: The room occupancy data on the website are randomly generated.

APPENDIX G

Test Cases For the System

Test Case # 1

Test Case #: 1 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Reserve Spot **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Visitor must be logged into the Visitor Website
- Visitor must not have a reservation in the current day

Step	Action	Expected System Response	Pass/Fail	Comment
	View the Reservation Table in the Home Page	The table containing the available reservation periods and the amount of seats taken in the current time is displayed.	Pass	
-	Click the “Reserve Button in the Home Page	The “Reservation” Web Page loads	Pass	
	Select a reservation time	The visitor is able to select the wanted reservation time	Pass	
	Click the “Reserve” Button in the “Reservation” Page	The reservation is added and “Successfully Reserved” Webpage loads	Pass	

Post-conditions

2. Change are reflected to the database regarding reservation
3. The visitor may now claim the reserved time from the webpage

Test Case # 2

Test Case #: 2 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Claim Reservation Spot **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Visitor must be logged into the Visitor Website
- Visitor must only have one reservation per day
- Visitor must have an existing reservation in the current day

Step	Action	Expected System Response	Pass/Fail	Comment
-	Click the “Claim Reservation Button in the “Successfully Reserved” Page	Checks if the current time is equal to the reserved time. If not equal, the status will not be updated in the database and will display an error message. If equal, the status of the reservation will be updated to “Claimed” in the database and the “Reservation Result” Webpage loads	Pass	

Post-conditions

4. Change are reflected to the database regarding reservation status

Test Case # 3

Test Case #: 3 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Cancel Reservation **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Visitor must be logged into the Visitor Website
- Visitor must only have one reservation per day
- Visitor must have an existing reservation in the current day

Step	Action	Expected System Response	Pass/Fail	Comment
-	Click the “Cancel Reservation” Button in the “Successfully Reserved” Page	The status of the reservation will be updated to “Canceled” in the database and “Reservation Result” Webpage loads	Pass	

Post-conditions

5. Change are reflected to the database regarding reservation status

Test Case # 4

Test Case #: 4 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Reservation Expired **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Visitor must be logged into the Visitor Website
- Visitor must only have one reservation per day
- Visitor must have an existing reservation in the current day

Step	Action	Expected System Response	Pass/Fail	Comment
-	Click the “Claim your spot” Button in the “Reserve” Page	The “Successfully Reserved” Webpage loads	Pass	
	Click the “Claim Reservation Spot” Button in the “Successfully Reserved” Webpage	Check if the current reservation time exceeds 10 minutes. If so, the status of the reservation will be updated to “Expired” and the “Reservation Result” Webpage loads	Pass	

Post-conditions

6. Change are reflected to the database regarding reservation status

Test Case # 5

Test Case #: 5 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** One Reservation Per Day **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Visitor must already have a claimed reservation in the current day

Step	Action	Expected System Response	Pass/Fail	Comment
-	Click the “Reserve Button in the Home Page or the “Reserve” Page	Check the database if the visitor has already made a reservation today. If so, the “Reservation Denied” Webpage loads	Pass	
	Click “Go Back To Home Page”	The Home Page loads	Pass	

Post-conditions

7. None

Test Case # 6

Test Case #: 6 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Notification **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions
- Visitor must be logged into the Visitor Website
- Visitor's reservation is currently claimed

Step	Action	Expected System Response	Pass/Fail	Comment
-	Visit any of the pages in the Visitor Page Module (Home Page, "Reserve Page", "Successfully Reserved" Page, "Reservation Denied" Page)	The selected webpage will be refreshed every 5 minutes. After loading, it checks if the current time exceeded the reservation time. If so, the webpage notifies the user to leave the seats for the next occupants.	Pass	

Post-conditions
8. None

Test Case # 7

Test Case #: 7 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Room Occupancy Graph **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- None

Step	Action	Expected System Response	Pass/Fail	Comment
-	View the Room Occupancy Graph in the Home Page	Displays the current room occupancy and the currently reserved seats for the current time.	Pass	

Post-conditions

9. None

Test Case # 8

Test Case #: 8 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Library Information Panel **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- None

Step	Action	Expected System Response	Pass/Fail	Comment
-	View the Library Information Panel in the Home Page	Displays the schedule of the CLIR, including the opening and closing days, and the opening and closing hours.	Pass	

Post-conditions

10. None

Test Case # 9

Test Case #: 9 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Interactive Suggestions **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- None

Step	Action	Expected System Response	Pass/Fail	Comment
-	View the Interactive Suggestions in the Home Page	Displays suggestions for the user depending on the current occupancy status of the CLIR. Each suggestion is color-coded based on the status.	Pass	

Post-conditions

11. None

Test Case # 10

Test Case #: 10 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Room Occupancy Information **Subsystem:** Librarian Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Librarian/Head Librarian must be logged in

Step	Action	Expected System Response	Pass/Fail	Comment
-	View the Room Occupancy Information in the Librarian's Webpage	Displays the room occupancy, reserved seats, and the status of the CLIR for the current time.	Pass	

Post-conditions

12. None

Test Case # 11

Test Case #: 11 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Change Effective Capacity **Subsystem:** Librarian Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions
- Head Librarian must be logged in

Step	Action	Expected System Response	Pass/Fail	Comment
-	Click the “Change” Button	A window will be displayed, telling the librarian to enter a new effective capacity	Pass	
	Click the “Change” Button from the window pop-up	The effective capacity will be changed based on the entered input from the window	Pass	
	Click the “Cancel” Button from the window pop-up	Closes the window pop-up	Pass	

Post-conditions
13. None

Test Case # 12

Test Case #: 12 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Report Generation **Subsystem:** Librarian Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Head Librarian/Librarian must be logged in

Step	Action	Expected System Response	Pass/Fail	Comment
-	View the Average Room Occupancy	Displays a bar graph of the Average Room Occupancy	Pass	
	View the Room Occupancy for the Past Hour	Displays a table of the Room Occupancy for the past hour. If there is no occupancy for the past hour, the table is empty.	Pass	
	View Student Visitor Reports for the Current Term	Displays four bar graphs regarding the Student Visitor Reports of the current Term	Pass	

Post-conditions

14. None

Test Case # 13

Test Case #: 13 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Reserved Spots Per Hour **Subsystem:** Librarian Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Head Librarian/Librarian must be logged in

Step	Action	Expected System Response	Pass/Fail	Comment
	View the Reserved Spots Per Hour	Displays a table of the Reserved Spots Per Hour. If the CLIR is closed, the feature displays an empty table.	Pass	

Post-conditions

15. None

Test Case # 14

Test Case #: 14 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Library Information Management **Subsystem:** Librarian Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Head Librarian/Librarian must be logged in

Step	Action	Expected System Response	Pass/Fail	Comment
-	Enter new opening and closing hours through the Textbox	Librarian is able to enter new opening and closing hours	Pass	
	Choose new opening and closing days through the Dropdown List	Librarian is able to choose the new opening and closing days	Pass	
	Click the “Save” Button	Saves the current changes in the new schedule (opening/closing hours, opening/closing days) in the database	Pass	

Post-conditions

16. The Library Information Panel in the Visitor’s Page is updated with the new information

Test Case # 15

Test Case #: 15 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Account Management **Subsystem:** Librarian Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- Head Librarian must be logged in

Step	Action	Expected System Response	Pass/Fail	Comment
-	Click the “Add” Button	A window pop-up appears containing entry for Email, Password, and User Type	Pass	
	Click the “Add” button on the window pop-up	Adds the current entries for the new account into the database and displays the new account on the panel	Pass	
	Click the “Modify” Button	A window pop-up appears, containing entry for Password, and User Type	Pass	
	Click the “Save” Button	Saves the current changes in the entry by updating the database	Pass	
	Click the “Delete” Button	Deletes the account data from the database and the panel	Pass	

Post-conditions

17. The Account Management Panel is updated with the created/modified accounts if any

Test Case # 16

Test Case #: 14 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Visitor Account Login **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- None

Step	Action	Expected System Response	Pass/Fail	Comment
-	Enter the user's Email Address through the Text Box	Visitor is able to enter his/her Email Address with the following format (anycharacter@email.com)	Pass	
	Enter Password through the Text Box	Visitor is able to enter his/her password	Pass	
	Click the "Login" Button	Check the database if the entry for the account exists If so, the Visitor Home Page Loads	Pass	

Post-conditions

18. The Visitor is able to access the Reservation Feature

Test Case # 17

Test Case #: 15 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Visitor Create Account **Subsystem:** Visitor Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions
- None

Step	Action	Expected System Response	Pass/Fail	Comment
-	Click the “Register” Button on the Login Page	Displays the entries for Account Creation (Email, Password and User Type)	Pass	
	Choose a User Type by clicking on the User Type Dropdown List	Entries below the Dropdown List will be modified in accordance with the User Type	Pass	
	Click on the “Register” Button	Adds the entries as a new account into the database and the Login Page loads	Pass	
	Click “Log In to Existing Account Here”	The Login Page loads	Pass	

Post-conditions

19. The Visitor is able to access the Reservation Feature

Test Case # 18

Test Case #: 16 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Librarian Account Login **Subsystem:** Librarian Website Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions
- None

Step	Action	Expected System Response	Pass/Fail	Comment
-	Enter the Librarian/Head Librarian's Email Address through the Text Box	Librarian/Head Librarian is able to enter his/her Email Address with the following format (anycharacter@email.com)	Pass	
	Enter Password through the Text Box	Librarian/Head Librarian is able to enter his/her password	Pass	
	Click the "Login" Button	Check the database if the entry for the account exists If so, the Librarian Home Page Loads	Pass	

Post-conditions
20. The Librarian is able to access the Librarian Home Page

Test Case # 19

Test Case #: 17 **System:** Sparse **Executed by:** Mark Anthony Mamauag	**Test Case Name:** Detect Room Occupancy **Subsystem:** Computer Vision Model Module **Design Date:** 2/23/2022 **Execution Date:** 2/25/2022

Pre-conditions

- None

Step	Action	Expected System Response	Pass/Fail	Comment
-	Run the Python File	Python File is able to detect number of persons on the given picture, create records regarding room occupancy and insert the record in the Azure Database The processes happen every 5 minutes.	Pass	

Post-conditions

21. The table Room Occupancy is updated with a new record every 5 minutes