DESIGN AND DEVELOPMENT OF INEXPENSIVE AUTOMATIC PASSENGER COUNTING SYSTEM FOR INTERCITY BUS IN PENINSULAR

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in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled “Design And Development Of Inexpensive Automatic Passenger Counting System For Intercity Bus In Peninsular ” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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APPROVAL

I hereby declare that I have cheked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature :

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Date : 17 / 1 / 2024

DEDICATION

I would like to dedicate this thesis to my parents, whose unconditional love and unwavering support have been the foundation of my academic journey. Their constant encouragement, sacrifices, and belief in my abilities have been my guiding light. This accomplishment is a testament to their dedication and belief in my potential. I am forever grateful for their guidance, sacrifices, and endless encouragement. I also extend my heartfelt dedication to my family, whose support has been a constant source of motivation. To my supervisor, thank you for your invaluable guidance, mentorship, and expertise throughout this research journey. Your unwavering support and belief in my abilities have been instrumental in my growth as a researcher. Lastly, I express my deepest gratitude to all the participants who generously contributed their time and insights, making this study possible. Your involvement and contributions have been invaluable.

ABSTRACT

Bus passenger counting is a critical part of public transportation, and it is an effective way of collecting data on passenger demands and improving the quality of transportations. This research paper aims to provide an in-depth analysis of bus passenger counting technologies, including their advantages, limitations, and potential applications. The paper will review the existing bus operators' methods for counting passengers and their experiences with these systems, both from technical and operational perspectives. This paper will also evaluate the potential benefits of a bus passenger count system, including improved passenger safety, increased operational efficiency, and better data for planning and analysis. The study will also highlight the effectiveness of integrating an infrared sensor with an Automatic Passenger Counter (APC) and offers a practical and affordable option. This study lays the way for the implementation of APC systems in public transportation networks that are more effective and precise, enabling better passenger counts and wise decision-making in transportation operations.

ABSTRAK

Pengiraan penumpang bas merupakan sebahagian penting dalam pengangkutan awam, dan ia merupakan cara yang berkesan untuk mengumpul data mengenai permintaan penumpang serta meningkatkan kualiti pengangkutan. Kertas penyelidikan ini bertujuan untuk menyediakan analisis mendalam mengenai teknologi pengiraan penumpang bas, termasuk kelebihan, kelemahan, dan aplikasi berpotensi. Kertas ini akan menilai kaedah pengiraan penumpang semasa oleh operator bas yang sedia ada dan pengalaman mereka dengan sistem ini, dari segi teknikal dan operasi. Kertas ini juga akan menilai manfaat potensi sistem pengiraan penumpang bas, termasuk peningkatan keselamatan penumpang, peningkatan kecekapan operasi, dan data yang lebih baik untuk perancangan dan analisis. Kajian ini juga akan menonjolkan keberkesanan pengintegrasian sensor inframerah dengan Kaunter Penumpang Automatik (APC) dan menawarkan pilihan yang praktikal dan berpatutan. Kajian ini membuka jalan bagi pelaksanaan sistem APC dalam rangkaian pengangkutan awam yang lebih berkesan dan tepat, membolehkan pengiraan penumpang yang lebih baik dan membuat keputusan yang bijak dalam operasi pengangkutan awam.

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Last but not least, I would like to extend my heartfelt gratitude to my family for their unwavering love, encouragement, and understanding throughout my academic journey. Their constant support and belief in my abilities have been a driving force behind my accomplishments. They have been a pillar of strength, providing me with the necessary motivation and reassurance during challenging times. Their sacrifices, understanding, and unwavering faith in me have been instrumental in my pursuit of higher education. I am truly blessed to have such a loving and supportive family, and I am forever grateful for their presence in my life. Thank you for being my source of inspiration and for always standing by my side.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter

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CHAPTER 1

INTRODUCTION

1.1 Background

Dependable and affordable public transportations have always been the essential need of the people worldwide. Due to the high reliance of public transportations, the services and quality must be improved from time to time to ensure that the people are provided with the best facility. In order for transportation industry to develop, public transport passengers' demand data is a crucial component to identify the discrepancies in the existing services to enable further improvement and enhancement to be carried out. In most of developed and developing countries, people are relying on public buses to commute from one place to another for day-to-day activities, thus it is significant to collect data of the number of people boarding and disembarking buses for research purposes.

The collection of data were obtained from the present automated systems that apply sensors or cameras to count the number of passengers that are getting on and off a bus. These systems provide real-time data on passenger demands, hence allowing operators to make further improvements of the current resources, service plannings, and customer services.

The purpose of this research paper is to provide an in-depth analysis of bus passenger counters system, including their advantages, limitations, and potential applications. This study intends to explore the current state-of-the-art in passenger counting technologies and identify any emerging trends or promising innovations.

The paper will review the existing bus operators' methods for counting passengers and their experiences with these systems, both from technical and operational perspectives. It will also investigate regulatory requirements related to passenger counting, such as those related to safety, privacy, and data protection.

This research paper will also evaluate the potential benefits of a bus passenger counting system, including improved passenger safety, increased operational efficiency, and better data for planning and analysis. It will identify any potential trade-offs or risks associated with implementation and provide recommendations for bus operators looking to implement a passenger counting system.

Overall, this research paper will provide valuable insights into the use of bus passenger counters as a means of collecting data on passenger demands and improving the quality of public transportations.

1.2 Problem Statement

This project will address the issues on mismatched passengers head counts during boarding until arriving to their respective destinations. Typically, head counts discrepancy happen during short pit stop at public Rest and Relax areas (R&R). According to the standard procedure, bus drivers are required to conduct head counts before resuming the journey. However, in most cases, bus drivers tend to skip head counts and neglect to update passenger list to confirm exact head count. Furthermore, the current standard procedure is fully dependent on human which contributes to the problem. Possibility of human error whether intended or unintended actions are very likely to happen due to various reason. The innovation on the now day make the system in the world become more advance and accoding to this the Automatic Passenger Counter has been produce to prevent the miss count number of passenger.

The reliance on short-term memory during manual passenger counting by bus operators poses a risk of miscounts, with the duration of short-term memory lasting only 15 to 30 seconds, as highlighted in a 1971 report on memory control. This constraint becomes especially problematic in fast-paced boarding scenarios, where operators must swiftly recall and update counts amid continuous passenger movement. Interruptions further exacerbate the challenge, increasing the likelihood of errors. The conventional manual counting method, centered on human memory, is inherently susceptible to inaccuracies. To address this, Automatic Passenger Counters (APCs) offer a technology-driven alternative, automating the counting process and reducing dependence on short-term memory. Supplementary measures, such as cross-checks, provide an extra layer of verification, collectively improving the accuracy of passenger counts in public transportation systems.

Ultimately. the miscommunication among bus drivers, especially during driver changes, can lead to errors in passenger counts. When the incoming driver receives information from the departing driver, there's a risk of misunderstandings. This reliance on potentially inaccurate information not only affects immediate passenger tracking but also impacts overall work quality in the transportation system (Yolanda et al., 2021). The consequences of such miscommunication go beyond passenger counts, influencing resource allocation, scheduling, and customer satisfaction. To address this, Yolanda et al. (2021) emphasizes the need for clear communication protocols during driver transitions. Establishing guidelines and standardized procedures, along with training programs, can improve the accuracy of information transfer and enhance the efficiency of passenger counting processes in public transportation systems.

Lastly, it is essential to decrease dependence on manual ride inspections in public transportation for several different reasons. Manual counts take a lot of time, are prone to mistakes, and regularly need for specialized staff, which makes frequent turnover a problem. Operations delays and inefficiencies can result from manual checks (Siebert & Ellenberger, 2020). On the other hand, implementing Automated Passenger Counters (APCs) simplifies the procedure and offers precise, up-to-date passenger counts without requiring a lot of manual labor. This shift raises overall service quality and increases operational efficiency, allowing for better resource allocation. Additionally, automation provides an effective response to issues related to staff resignations, providing accurate and constant passenger counts in the constantly shifting public transit industry.

1.3 Research Objective

This thesis aims to design and develop an Automatic Passenger Counter (APC) system for buses that utilizes a new method which is to prevent the misscount the number of passenger from the conventional method of manually counting passengers. The system is intended to enhance the features of the bus work system by providing reliable data for passenger counts, which can be used to optimize service routes, schedules, and capacity planning. There are several specific objectives that will be pursued in this study, including:

a. To develop a reliable and accurate APC system for transportation with inexpensive component.
b. Enabling the operational deployment of the APC.
c. To optimize the functionality of the APC.

1.4 Scope of Research

a. Implement automatic passenger counter for single level intercity or express bus with the single door entrence.

b. The proposed automatic passenger counting system for buses is designed to operate independently, contactless with passenger except for operator monitoring APC.

1.5 Limitation

In any study or implementation of an automatic passenger counter system, it is crucial to acknowledge and discuss the limitations that may affect the accuracy and generalizability of the findings. By addressing these limitations, it can provide a comprehensive understanding of the system's capabilities and potential areas for improvement.

One significant limitation to consider is the occurrence of occlusions. Occlusions refer to situations where the sensors line of sight is obstructed, leading to potential inaccuracies in passenger counting. For example, passengers standing very close together or carrying large bags may partially or fully block the sensors, resulting in missed or false readings. These occlusions can affect the system's ability to detect and count passengers accurately, particularly in crowded or congested environments.

Another limitation to address is the possibility of system failures or technical issues. Like any technology, automatic passenger counter systems may encounter malfunctions, glitches, or unexpected errors that could affect their operation and data collection. For instance, connectivity issues, sensor malfunctions, or software bugs may result in inaccurate readings or data loss. It is important to acknowledge these potential system failures and their implications for the accuracy and reliability of the collected data.

Additionally, it is essential to consider the specific context and conditions under which the automatic passenger counter system was evaluated or implemented. Factors such as varying bus types, passenger behaviors, or environmental conditions may introduce certain limitations that affect the generalizability of the findings. For instance, if the system was tested on a specific bus model or in a particular geographical region, the results may not be directly applicable to other bus models or locations with different passenger characteristics.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A greater need for precise and effective passenger counting systems has emerged in recent years across a variety of cases, particularly in the sector of bus transportation. The implementation of automatic passenger counters has become more crucial for optimizing the operation in ability to track and count the number of passengers in the bus while giving positive feedback on improved resource allocation and security measures. Due to the significant amount of interest in automatic passenger counting on buses, new solutions have been developed to fulfill the increasing demand and encourage continual growth in this field of technology. According to(Nitti et al., 2020a) it is offering new perspectives and creative methods for the study of A Wi-Fi-Based Automatic Bus Passenger Counting System (iABACUS) by shedding light on a different viewpoint. Research has mostly concentrated on identifying travel modes using sensor data from accelerometers and Global Positioning System/Geographic Information System (GPS/GIS). Many methods also rely on users having installed particular smartphone applications, which limits the applicability of crowd-counting concepts to them. It overcomes the issue of Media Access Control (MAC) address randomization and provides a system that monitors passengers' devices from boarding to alighting. By utilizing the IoT, iABACUS is able to precisely count the number of gadgets, which is comparable to the number of passengers on the bus. The installation of apps or connecting devices to an access point is not necessary for iABACUS, nor are any actions on the part of passengers. With the use of this functionality, Public Transport Companies (PTCs) may observe and analyse urban movement to support short- and long-term planning.

Other than that, by extending our review to (Sojol et al., 2018)we have access to a broad collection of papers and analyses that enhance our comprehension of Smart Bus: An Automated Passenger Counting System. The introduction of the paper discusses the transportation issues faced by the people of Dhaka, Bangladesh, due to the high travel fare in taxi cabs, CNG, and UBER. As a result, people choose local bus services as their preferred mode of transport, but corruption is a major problem in this sector. The paper proposes an automated passenger counting system called Smart Bus, which uses hardware and mobile-based applications to count the number of passengers sitting on the bus seats and display it on a real-time monitor.

Moreover, the influential study that was published(Jain, 2019). System which has significantly advanced the area, to widen our understanding of Intelligent Bus Tracking and Passenger Counting. The setting of India's increasing urbanisation and its impact on transportation systems particularly in major cities where there is a rise in rural-urban migration. The study suggests the construction of an intelligent bus tracking and passenger counting system to address the problems caused by this expanding demand. The suggested system intends to deliver real-time information on the location of the bus and an approximation of the number of passengers on board by utilising GPS and IR sensors. Additionally, based on passenger demand, the system's passenger counting component can help transportation authorities manage and optimise bus routes and frequencies.

Furthermore, it is critical to look at the insights offered in a recent journal paper titled Automatic passenger counting system for bus based on RGB-D videos we delve into the research around it and impact in the realm of transportation. The (Li et al., 2017)highlights the value of real-time bus passenger flow data inside a smart bus system, as it empowers bus firms to improve scheduling flexibility and optimize bus line arrangements while allowing passengers to optimise their routes. Although it is important to precisely determine the number of people boarding or getting off buses at each station, the current data collection techniques are still in their development. The research suggests an automated approach of people counting for buses utilising RGB-D video technology. This technique has the ability to significantly increase the effectiveness and efficiency of bus systems by offering a rapid and reliable solution.

Last but not least, this study aims to contribute significantly to the body of knowledge by thoroughly reviewing the literature on automatic passenger counters. It provides practitioners and scholars with insightful information that will help improve this important topic. The results of this research could help with the creation of improved passenger counting systems that are more accurate, efficient, and intelligent, which would have a big impact on transportation management, customer satisfaction, and public safety.

2.2 Current Finding

The development and justification of an idea or conduct research are one of the primary objectives of the topic. The method or product forms the basis of the study, and it must be functional in order to respond to the stated issue or research question. A clear and concise summary is necessary to clarify the beginning of the method's operation. In line with previous studies (Nitti et al., 2020), the paper proposes iABACUS, a Wi-Fi-based automated bus passenger counting system that tracks people during their travel on public transport vehicles using sensors installed on board the vehicles. The foundation of iABACUS is the recognition of Wi-Fi signatures originating from any gadget with an active Wi-Fi interface, including mobile phones, tablets, and other gadgets. A bus has an on-board unit fitted, as seen in Figure 2.1 Due to the presence of a sniffer, it is responsible for gathering MAC addresses from the on-board devices, storing information, and providing a preliminary analysis of the information the de-randomization of the MAC addresses. Then, using a mobile connection while travelling or a Wi-Fi connection at the bus station, data are sent to the cloud where they are further analysed to determine the precise number of devices on the bus.

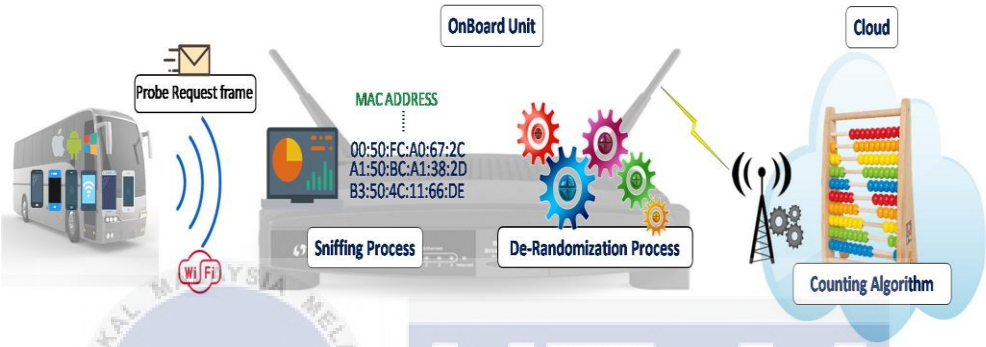


Figure 2.1 ABACUS (Journal iABACUS)

A Wi-Fi device has to know which AP to access each time it needs to send a message. The idea of association, which is a required but insufficient activity to allow the connectivity of the devices, gives this information to the devices. In fact, prior to a gadget being. It must first associate with the AP in order to deliver a data message via the Arithmetic Progression (AP). In order to identify nearby APs, the device transmits Probe Request frames, or messages, frequently from any active Wi-Fi interface. The basic component of the proposed system is a Wi-Fi sniffer that gathers and examines the Probe Request frames. These frames contain data that can be clearly connected to the device that provided them, allowing for identification and counting of that device.

The system counts the number of Wi-Fi-enabled devices and evaluates urban mobility. The de-randomization approach was put to the test in the trials using a static environment. Due to its independence from both telecom operators and passenger consent, the system outperforms large-scale mobile phone and smartphone app systems. Passengers can be tracked using the system in an anonymous manner.

Furthermore, in exploring alternative approaches to passenger counting, one method that shows promise involves the use of pressure pads. According to (Sojol et al., 2018) propose that another way the implemented approach differs from previous ones is by using the Arduino Uno microcontroller as the main processing unit for collecting information and analysis, enabling for the development of the Smart Bus system. The system's hardware consists of an Arduino Uno, a Bluetooth HC-05 module, pressure pads, and potentiometers. For accurate and dependable passenger counts, the design involves smoothly integrating these elements. Software modules like the Arduino IDE and Bluetooth terminal HC-05 are used to simplify data collection and communication between the hardware elements and the main system. The pressure pads' voltage signals can be transformed into digital signals (0 or 1) using the Arduino IDE. Wireless communication between the Arduino microcontroller and the Android mobile platform is made possible by the Bluetooth terminal HC-05. Each seat has a pressure pad that, when not in use, intentionally generates an open circuit. As shown in Figure 2.2 the pressure pad recognizes the change when people sit on the seats and closes the circuit, allowing voltage to enter the circuit. The technology can precisely detect and count the number of passengers on board thanks to this process.

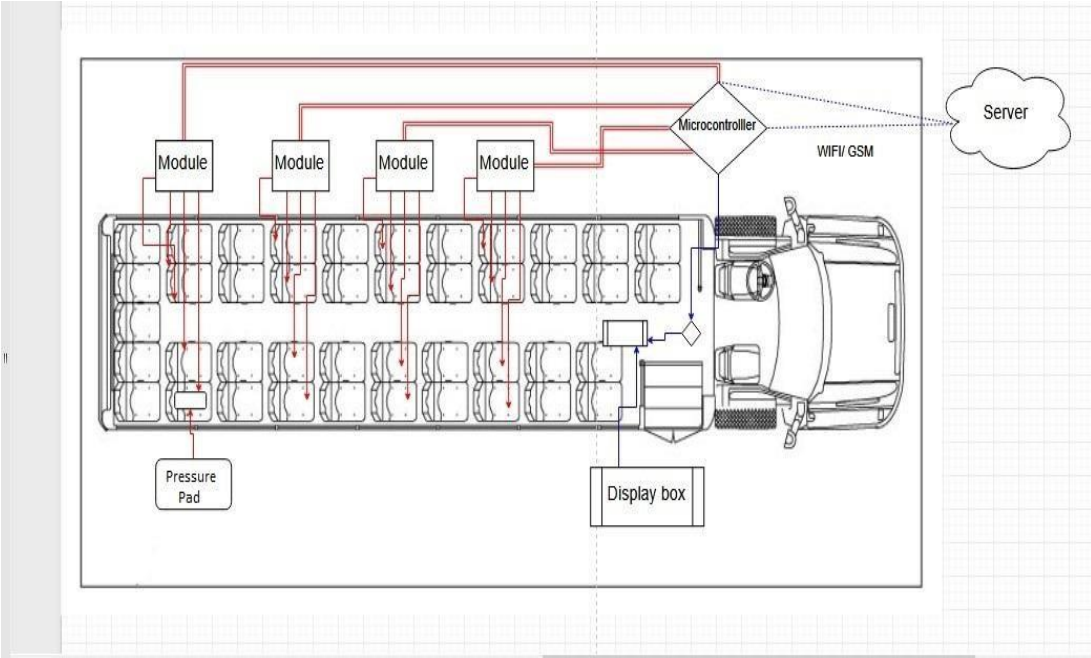


Figure 2.2 Smart Bus System (Journal Smart Bus)

Moreover, With the aid of cutting-edge computer vision technology, an automatic passenger counter camera can precisely count the number of passengers getting exiting of and entering of transport. The camera has the ability to count passengers in real-time by analysing human presence using methods of image processing. A lot of transit systems utilise this technology to improve operational effectiveness and make passenger flow analysis easier. As per the journal finding in (Li et al., 2017) the study proposes an RGB-D video-based method for freely counting passengers on buses. In order to record passenger flow, a camera is positioned above the bus door. As shown in Figure 2.3 the technique precisely detects passenger heads by combining RGB and depth pictures. It suggests a special tracking method that combines mean shift algorithms and feature re-based tracking to ensure reliable tracking. The elongated shape of the ellipse and the circle degree are employed as characteristics to match the detected heads with their intended targets. In order to discover the appropriate area in the depth map, the approach additionally identifies the head region in the foreground image and uses its form. With better scheduling and resource management for bus firms, this method provides an effective option for real-time passenger counts on buses.

Figure 2.3 RGB image

Ultimately, the solution developed to precisely count the number of people entering and exiting a vehicle is the automatic passenger counter using infrared sensors. By strategically placing infrared sensors close to the entrance and exit points, this system makes use of the concepts of infrared radiation detection. Passengers are recognized and registered as they move within the field of the sensor, allowing for precise and real-time passenger counting. This engineering breakthrough provides useful information for improving operational effectiveness, optimizing resource allocation, and permitting thorough passenger flow analysis inside transportation networks. Base on the study of automatic passenger counter using infrared radiation detection (Jain, 2019). The system for an intelligent bus tracking and passenger counting system developed in this study is a two-module system. The bus tracking module is the initial component, and it uses GPS technology to give passengers real-time location data on their mobile devices. This makes it possible for customers to track the bus through a specific route and get an estimated arrival time. The second module as shown in Figure 2.4 known as the passenger counting module, counts the number of passengers by using infrared sensors installed inside the bus. Passengers can use this information to decide whether the bus is crowded and how to plan their travel using this information.

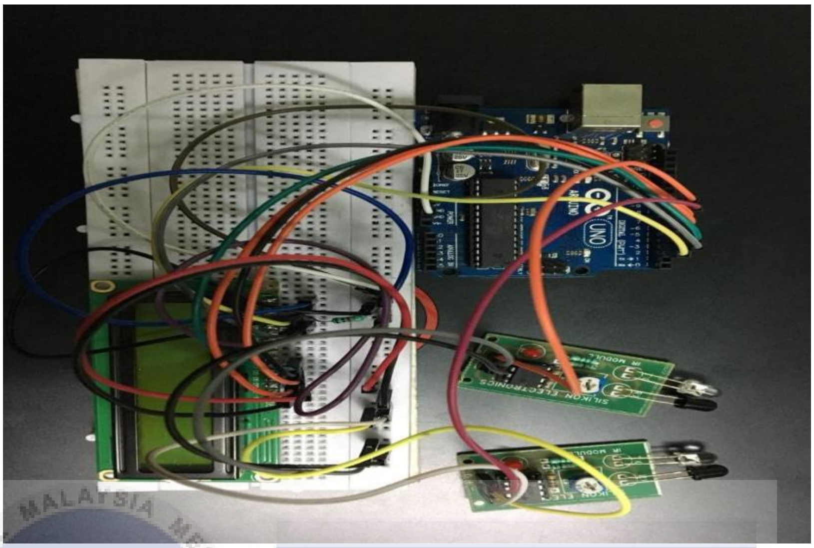


Figure 2.4 Passenger counting module (Journal Intelligent Bus Tracking and Passenger Counting System)

2.3 Finding Outcome

The accuracy of the various automatic passenger counting techniques differs. The precision with which a method counts the number of passengers is referred to as accuracy. The accuracy is affected by a number of variables, including sensor type, sensor placement, and data processing methods. The method chosen will rely on the precise needs of the transportation system and the desired level of accuracy. The best approach for obtaining accurate passenger count data must take into consideration the trade-off between accuracy, functionity, and practicality. The findings of the experiments performed to evaluate the iABACUS system are presented in the publication (Nitti et al., 2020) . With an accuracy of 100% in the static situation and roughly 94% in the dynamic case, the system effectively counts the number of devices with an active Wi-Fi interface. The latter situation involves a random fault that only shows itself when two bus stops are quite near to one another. The study finds that because the iABACUS system doesn't rely on telecom operators or passenger agreement, it operates better than large-scale mobile phone and smartphone app systems. Passengers can be tracked using the system in an anonymous manner.

Next, the other result that obtain in the paper (Sojol et al., 2018) presents the results of testing the Smart Bus automated passenger counting system that using the pressure pad for three consecutive seats to compare the results. The researchers checked several functionalities, including the pressure pad and display screen. When pressure was applied to a seat, the display turned red, indicating that the seat was occupied. The proposed passenger counting system has been tested as a working prototype, which has been detecting 3 seats with an accuracy rate of 90%. Additional testing includes loading the seat with varying weights. Weights under 20 kg were shown to have no effect on the pressure pad's reaction. However, the outcome showed a value of 1, indicating that the seat was occupied, when a weight of 20 kg was placed on it. This demonstrated that the pressure pad could detect a weight of at least 20 kg. The greatest weight tested was 89 kg in order to assess the pressure pad's detecting capacity's upper limit. The fact that the technology was able to detect this weight suggests that the pressure pad may support even larger loads.

Besides that, the results obtained from the research study (Li et al., 2017) provide further evidence to support the findings. The research highlights that the suggested method exhibits a high level of accuracy in identifying the head region from video footage and precisely counting the number of people who board and get off a bus. The technology managed an outstanding accuracy rate of 95.4%, according to studies done in a busy bus queue during rush hour in Shenzhen, China. In tests using an i5-4590 processor and 8GB RAM, the system's processing performance hit 15 frames per second (fps), while the video was taken at 10 fps, meeting the real-time criteria. The experiment covered several time periods, which gave important information about the stability and resilience of the approach. The test findings showed that the suggested strategy consistently produced reliable outcomes, keeping its accuracy and stability over a range of durations.

A thorough examination reveals that the journal (Jain, 2019) lacks in-depth experimental results. The publication (Moser et al., 2019) reports findings about the usage of infrared sensors, in contrast. According to the article, the use of 3D infrared sensing produced findings that were generally comparable to those of video-based techniques, with particularly reliable outcomes for precisely counting entering passengers. The performance did show a considerable reduction when counting passengers leaving through the doors, though. This decreased performance is most probably caused by both difficulties with occlusions and a lack of experience in identifying passengers approaching from behind. The situation made it difficult for the system to precisely tally the number of passengers getting off the bus.

2.4 Finding Gaps

The study explores the outcomes of a live trial that assessed four modern Automatic Passenger Counting (APC) technology alternatives: video-based, WiFi sensing, pressure pad sensor, and 3D Infrared. The participants in this research were actual passengers who were transported on public transport buses. The study presents a thorough, two-phase methodology created for the assessment of APC technologies in the context of public transit. Additionally, the live trial's implementation served to validate the methodology in and of itself.

The trial results were analysed, and the study draws the conclusion that the technique suggested is quite successful in comparing the various technological possibilities in a true-to-life operational context. It is a useful tool for evaluating each technological option's performance and capabilities as an effective APC solution. The study's results are useful for the development of APC technology as a whole since they offer important information that will help each technological option be improved and advanced in the future. In the end, this research lays the way for the implementation of APC systems in public transportation networks that are more effective and precise, enabling better passenger counts and wise decision-making in transportation operations.

The passenger counting process in transportation networks has been transformed by automatic passenger counters (APC), however there are still problems and possibilities for technological advancement. The difficulty of occlusion and detection is a significant gap. APC systems may have trouble effectively detecting passengers during busy times, which could lead to an undercount or incorrect classification. Additionally, it might be difficult to accurately count people who are getting out of the transport because it can be difficult to tell who is getting out and who is staying. For accurate statistics, exit counting must be precise. APC systems' capture and storage of personal data raises privacy issues as well, calling for a compromise between precise counting and privacy protection.

The ability to integrate APC systems with other transportation management tools is another area of issue. To maximize the effectiveness of APC technology, seamless interaction with fare collection or scheduling systems is essential. Interoperability can be facilitated, and system performance can be improved by standardizing protocols and interfaces. Another consideration is price, as installing APC systems can be costly. It's crucial to find economical solutions without sacrificing precision and dependability. In order to guarantee long-term performance, APC systems must also be maintained and serviced. Analyzing data in real-time is also another thing that needs improvement. Although APC systems offer data on passenger counts, it can be difficult to obtain analytical understanding and useful data in the present. Operators may be able to make quick, informed decisions and optimize transportation operations because of improvements in data analysis methods and procedures.

The accuracy, dependability, and usability of APC systems in different transportation scenarios will improve when these gaps are closed. APC technology can increase passenger counting in the transportation sector by enhancing occlusion handling, exit counting accuracy, privacy protection, integration capabilities, cost-effectiveness, maintenance procedures, and real-time data analysis.

Table 2.1 Literature Review

Automatic Passenger Counter (APC) Technology	Author	Type of Counting	Accuracy	Finding Gaps
1. iABACUS	(Nitti et al., 2020)	WIFI base	100%(static case) 94%(dynamic case)	-Must have a smart phone, tablet or other gadjet to count the number of passenger.
2. SMART BUS	(Sojol et al., 2018)	Pressure Pad	90 %	- Can detect at certain of the weight - Complex installation

3. RGB-D Video	(Li et al., 2017)	Camera	95.4 %	- Cost of instllation and maintenance expensive - Complex installation
4. Intelligent Bus	(Jain, 2019)	Infrared sensor	≥ 95.4 %	- Sensitive to vibration - Need to install more than one sensor

CHAPTER 3

METHODOLOGY

3.1 Introduction

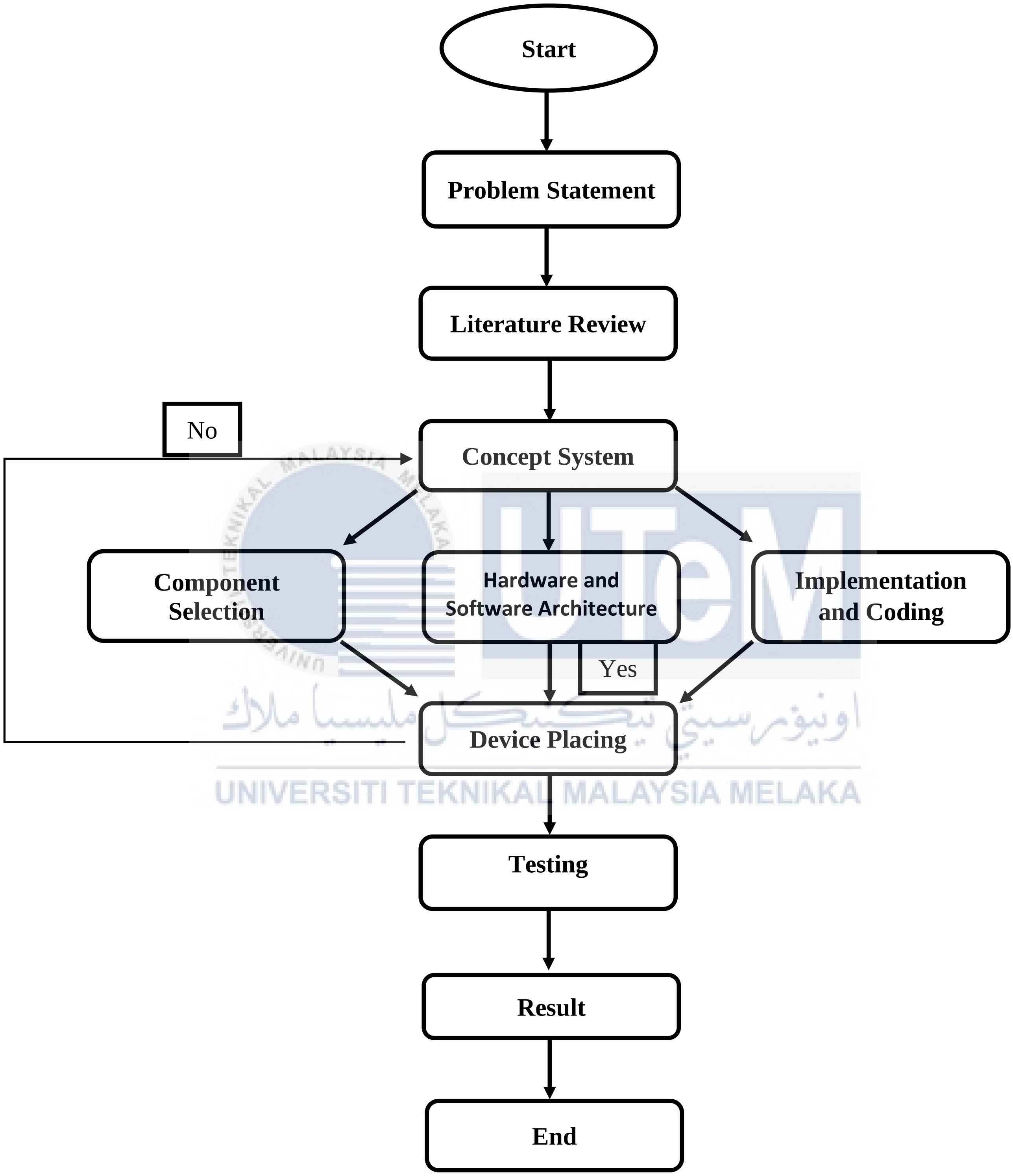
This methodology of research studies outlines the methods that are used to evaluate the efficiency and precision of Automatic Passenger Counter (APC) system in transportation. In this methodology section, it is essential to understand the process of development, steps used to collect data and methods used to analyze performance and functionality.

The methodology section also describes the data collection techniques used for this research. The installation of APC system on various platforms in the public transportation industry, specifically bus, may apply these data collection techniques. The data collected enable to assist in choosing suitable types of APC, operating mechanism of control units and select the effective area to install the APC.

This section also explains the data gathering procedure, which may involve counting passengers over a defined length of time. It covers the methods employed to ensure counting accuracy, taking into account elements like cabin space constraint, variations in passenger movement, and design constraint due to various type of buses cabin layout.

The methodology will uphold the research in terms of transparency and reproducibility. This research paper can be used as a basic assist future researcher of interest parties to be achieved intended result.

3.2 Flow Chart



Flow Chart 1 Flowchart Methadology

3.3 Concept System

The concept for creating an automatic passenger counter system has been selected based on important factors after conducting an extensive literature review. The best possible development of the system shall be considered. Four separate concept ideas have been tabled out as practical choices from considerable research which are WiFi-based systems, pressure pad sensors, camera technologies, and infrared sensors. In order to meet the core requirements of the automatic passenger counter, these concepts were assessed. The automatic passenger counter's basic building blocks were assessed based on reading accuracy, material cost, power efficiency, and design durability.

Table 3.1 Sensor Selection

Feature	**Infrared Sensors**	**Pressure Pads**	**Cameras**	**WiFi Base**
Reading Accuracy	2	1	3	2
Cost	3	2	1	2
Power Efficiency	3	1	1	1
Durability	3	3	2	3
Total marks	11/12	7/12	7/12	8/12

In the analysis presented in Table 3.1, the selection of sensor types for the concept of the system is decided based on the highest score assigned to specific characteristics. In terms of reading accuracy, cost, power efficiency and durability, which were evaluated on a scale of 1 to 3, achieving the highest score of 3 indicates excellent evaluation results.

Based on the observations derived from Table 3.1, it can be concluded that the best concept for the system is utilizing the infrared sensor. Following closely in second place is the Wi-Fi-based concept, while the camera-based concept and the pressure pad concept takes the last place in the concept selection. These findings provide valuable insights for the development and implementation of the system, highlighting the outstanding type of sensor for concept realization. However, the type of sensor used in the system must be accurate and cost-effective for system the main factors development automatic passenger counter.

3.4 Component Selection and Specification

The accurate of passenger count is dependent on several components. The core that must have in the system is infrared sensor which the control unit use to detects motion and the presence of passengers, is an essential component. Then it connected to hardware which is Arduino board that processes the sensor signals. When Arduino processing all the data, it also performs algorithms and fit the output to display. Next, this system was powered up by electricity to ensure stable operation and continues power supply. In order, operators can easily view and interact with the system through a screen display, serving as the primary interface. The APC will construct with a body frame protecting core component.

3.4.1 Main Component

3.4.1.1 Sensor

Infrared sensors as shown in Figure 3.4.1 are a commonly technology used in APC due to their effectiveness in detecting passenger movements. These sensors operate by emitting infrared beams, which are invisible to the human eye, and able detecting changes in the reflected or interrupted beams. The infrared sensors able to monitor the presence of passengers entering or exiting the point placement area which is near bus doorways or entry points,. When a passenger obstructs the emitted infrared beams, the sensor's receiver will detects the change and triggers a signal to the APC system, indicating movement of passengers entry or exit the bus. This technology enables the identification of passengers through advanced detection methods, utilizing touchless systems that require no direct access or interaction from the passenger.

Figure 3.1 Infrared sensor

The infrared sensor in the Figure 3.1 can provide a high level of accuracy when properly calibrated, positioned, and maintained. These sensors have been extensively used in various applications, specifically in transportation systems, due to the technology reliability and effectiveness. According to (Moser et al., 2019) “Infrared Sensing achieved similar results to video-based overall” which is have same accuracy with the video APC and the advantages of this sensor technology is very cost-effectiveness, provide high accuracy, high adaptability to various bus layout and contactless. For optimal performance of APC system to ensure accurate passenger counting in real time is it crucial to have proper device placement, sensor aligment and calibration.

The infrared sensor placement to achieve affective sensing range can significantly depend on sensor sensitivity and range. The infrared sensors are engineered for various applications, and their sensing ranges can ranging from a few centimeters to several meters. To develop an APC for buses, the primary focus is to provide detect passenger movement accurately detecting passenger movements at the bus door. According to (*PANDUAN PEMERIKSAAN KENDERAAN BAS*, n.d.) the standard dimension area of entrance bus door is 53.4cm. Therefore, the infrared sensor shall at least able to detect distance of 53.4cm

3.4.1.2 Arduino Uno

The Arduino board functions in the passenger counter system by serving as the main hardware. It processes the input data infrared sensors to detect the presence of passengers. The Arduino board then utilizes its programming logic to increment or decrement the passenger count based on the sensor readings. It also interfaces with other components, such as the display unit or communication modules, to provide real-time updates or transmit data. Additionally, the Arduino may store and analyze passenger headcount. Arduino plays a critical role in the accurate and automation counting of passengers.. However, the Arduino Uno board as shown in Figure 3.2 stands out as an effective choice when considering the overall requirements of such a system.

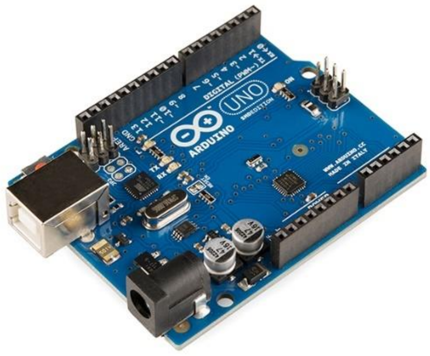


Figure 3.2 Arduino Uno

The Arduino Uno built-in analog-to-digital converter is what the ADC parameters refer to. These options control the reference voltage that is applied during the transformation of analogue signals into digital values. The precision of the conversion procedure is determined by the resolution, which on the Uno is typically 10 bits. Timing and precision of the analog-to-digital conversion are controlled by conversion parameters, such as the ADC clock speed. Power parameters cover every aspect of the Arduino Uno's power supply and control. These settings include choosing the proper power source determining the supply voltage (often 5V or 3.3V), setting current restrictions to safeguard the board and attached components, and more.

Due to its adaptability, affordability, and user-friendliness, the Arduino Uno board is highly demand. It has a 20 number of input and output (I/O) pins which is 14 can be used as digital input/output pins, and 6 are dedicated solely as analog input pins that enabling smooth interaction and interface with the essential infrared sensors and other key elements of the passenger counter system. The Arduino Uno makes development and troubleshooting easier and speeds up project development because to its continues after sale support, widely micro industries usage and have many references platform such as video tutorials.

3.4.1.3 Baterry

The rechargeable lithium-ion (Li-ion) battery as shown in Figure 3.3 is a suitable choice compare to Alkaline, Nickel Metal Hydride (NiMH) in comman. The. Li-ion batteries provide high energy density, long cycle life, lightweight, reliable and portable power for the APC system that operating in log hour. Base on the (*Food Living Outside Play Technology Workshop Powering Arduino with a Battery*, n.d.) board can run on a 6 to 20 volt with external source. However, the supply pin at may deliver less than five volts if supplied with less than 7 volts, and the board may become unstable. The voltage regulator could overheat and harm the board if more than 12V is used. The suggested range for battery that can be use is between 7 and 12 volts.

The information provided in the Table 3.2 is based on general knowledge about alkaline, NiMH, and lithium-ion batteries that is widely available in the website.

Table 3.2. Battery Specification

	Alkaline Battery	NiMH Battery	Lithium-ion Battery
No Memory Effect	3	2	3
Cycle Life	1	2	3
Low Environmental Impact	2	2	3
Low Cost	3	2	1
Typical Applications	Remote controls, flashlights	Cordless, digital cameras	Smartphones, laptops
Total marks	9/11	8/11	10/11

Figure 3.3 Lithium-Ion Battery

The battery's capacity required to provide power to the infrared sensors and other components, and the duration the automatic passenger counter system is in operation, are just a few of the factors that affect the battery's lifespan. The system can calculate the average current draw, considering the power requirements of the infrared sensors, to determine the battery lifetime. To estimate the runtime, divide the battery's capacity (measured in milliampere-hours, or mAh) by the average current draw.

For example, if the infrared sensors and other components have an average current draw of 100mA and the battery capacity is 10000 mAh, the estimated runtime would be:

Runtime = Battery Capacity / Average Current Draw

Runtime = 10000mAh / 50mA

Runtime = 200 hours

3.5 Hardware

Infrared sensors are used in the system to sense the motion and put in place a circuit for an automatic passenger counter in public transportation networks. Creating a independable and precise system as tracking public transport is the aim of this study. The proposed circuit design consist of Arduino, signal conditioning components, infrared proximity sensors to identify and count passengers. In-depth testing and validation for are used in the thesis to evaluate the circuit's performance and effectiveness.

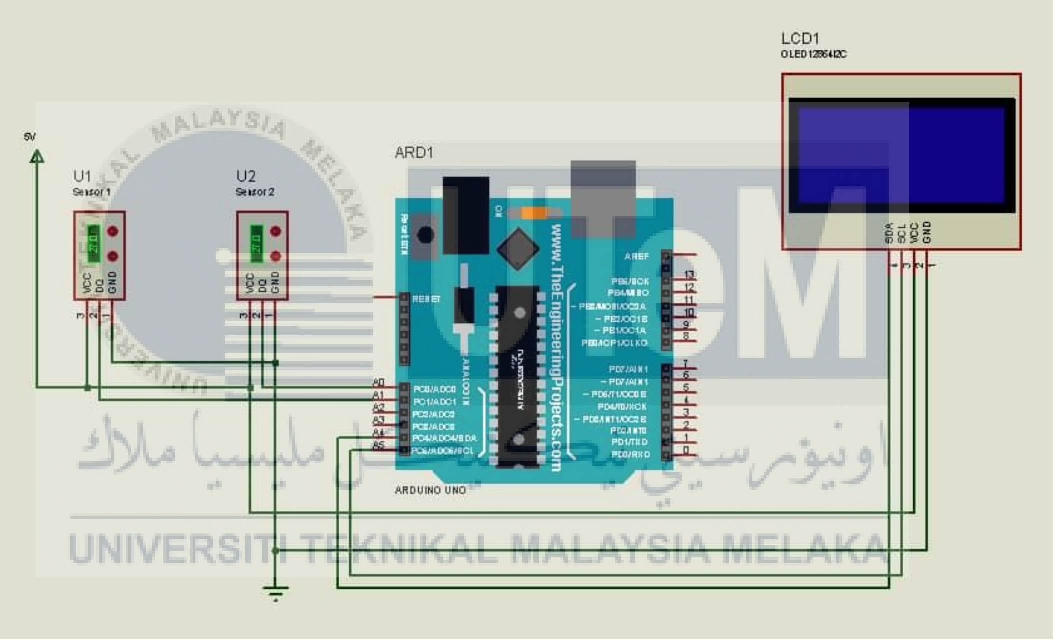


Figure 3.4 Circuit design

In this thesis, the Proteus 8 as shown in Figure 3.4 programme was used to make it construct the circuit to test the system functionality. The user-friendly interface of Proteus 8 and provide component library in the software, which for uncommon components that not available in this sofware it can easily to intsall by browsing the component in the internet. Proteus 8's user-friendly interface provides a clean, organised layout that makes it simple to explore and properly build the circuit components. This software was essential for developing APC since it made it possible to build and test circuits effectively.

The pair of infrared sensors will be interfaced with the Arduino. To initiate the counting process, both sensors, sensor 1 and sensor 2, need to be triggered simultaneously. If sensor 1 detects motion first, it will register the entrance count, and the count will be completed once the motion passes sensor 2. Conversely, if sensor 2 detects motion first, it will initiate the counting process, and the count will be finalized upon the motion passing sensor 1. The LCD screen will be linked to the Arduino to display real-time passenger numbers once the sensors complete the motion detection sequence. Powering the system involves utilizing a pair of lithium-ion batteries Figure 3.5, supplying a stable 7.4 volts. These batteries boast a 10000 mAh capacity, ensuring sustained energy for prolonged circuit operation, especially during extended periods of passenger counting.

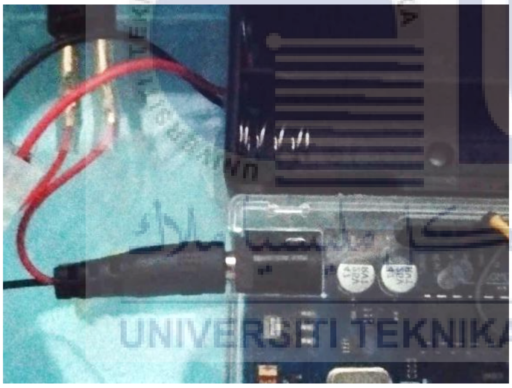


Figure 3.6 External power supply connect with batteries

Figure 3.5 lithium-ion batteries

From the Figure 3.5 and Figure 3.6 it show the external power supply connector links to the battery, distributing power to various components through wires connected to the ground and 5V pins in Figure 3.7. The infrared sensors, each equipped with three wires (power, ground, and signal), interface with the Arduino Uno's analog pins (A0 for sensor 1, A1 for sensor 2) in Figure 3.7. The I2C Figure connection between the LCD and Arduino minimizes wiring complexity, ensuring easy installation. The LCD connects using two wires Figure for power and ground, along with SDA and SCL connections.

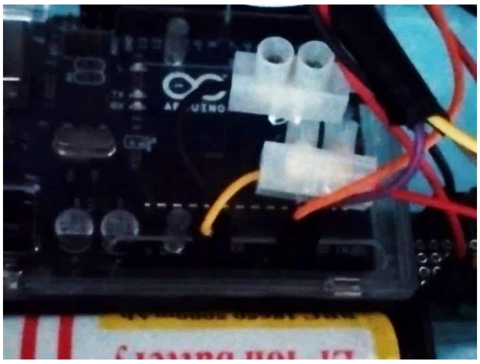


Figure 3.8 Ground and 5V pins /Infrared sensor connect pin A0 and A1

Figure 3.7 I2C Figure connect with LCD

The on/off button in Figure is positioned between the battery port and the external power supply connector. Additionally, a reset button is grounded and connected to pin 7. The Arduino Uno in Figure, powered by the ATmega328P microcontroller, incorporates EEPROM, a type of rewritable memory capable of preserving stored data persistently, even when the system is not powered,the characteristic referred to as non-volatile memory.

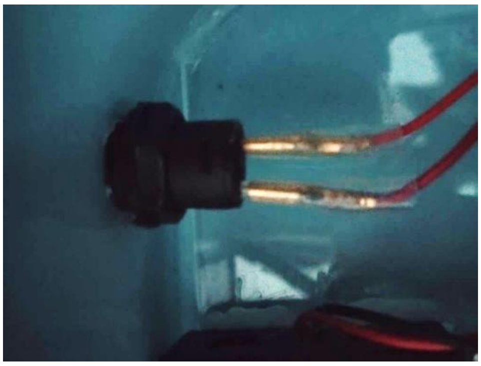


Figure 3.10 On/Off button

Figure 3.9 Reset wire pin and SLC with SDA wire

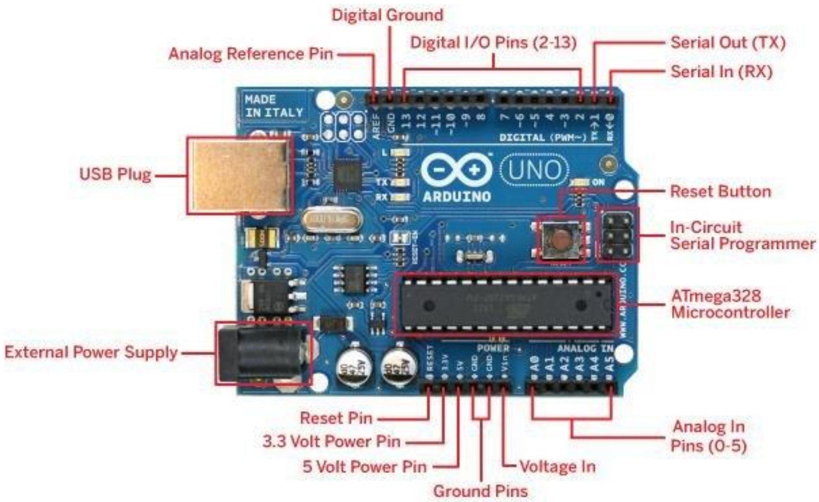
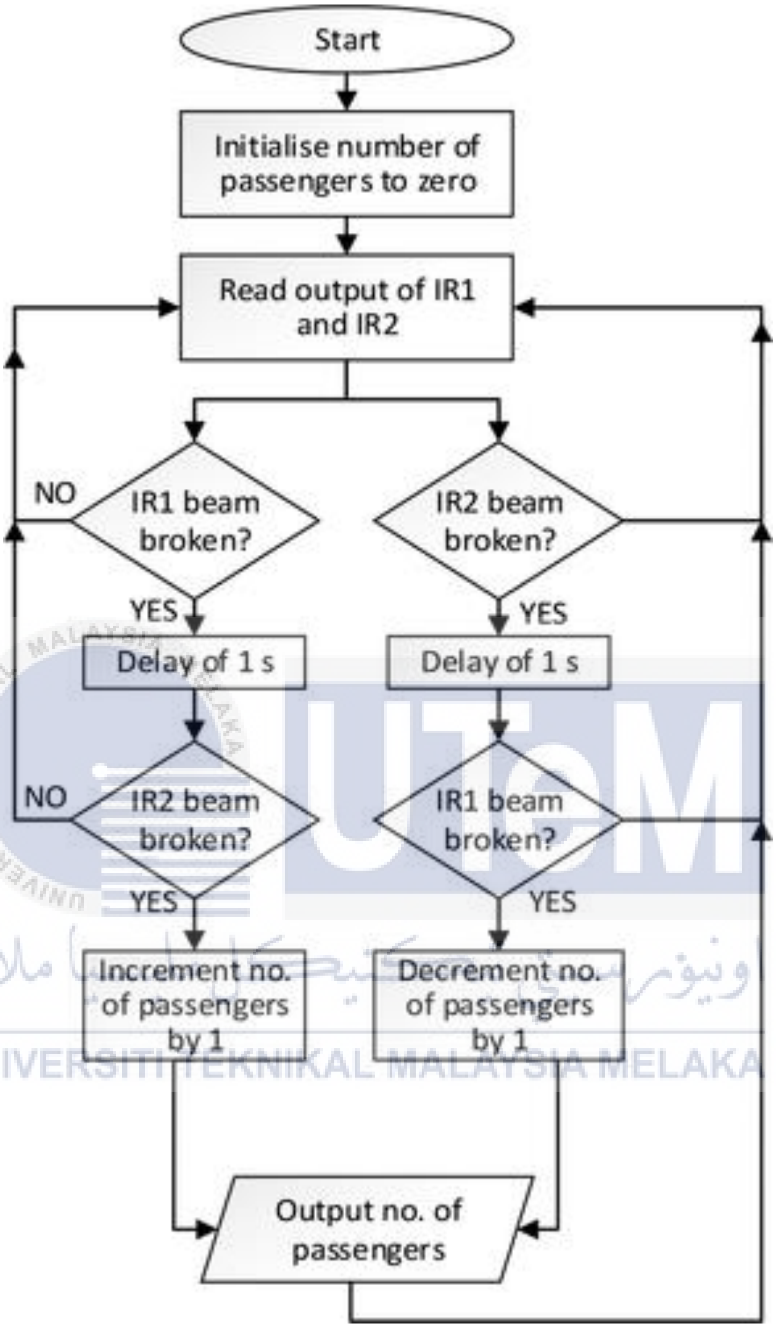


Figure 3.11 Arduino Uno Atmega 328p

3.6 Software

The APC system it counting the number of passenger by using pair of infrared sensor which it act as the control unit. At the first the arduino act as the hardware which receive the signal from the infrared sensor in analog signal due the detection of passenger pass throught the pair of sensor. Then Arduino act as sofware in sysnthesis the algorithm and do calculation to decision-making in increament or decreament based on which one of the sensor detect the movement of the passenger whether first or sencond sensor. After that, the Arduino send the digital signal to screen display to show the increament of decrement of number passanger. The Figure 3.8.1 will show flow chart the process of APC function.


Start
Initialise number of passengers to zero
Read output of IR1 and IR2
IR1 beam broken?
NO
YES
IR2 beam broken?
YES
Delay of 1 s
Delay of 1 s
IR2 beam broken?
NO
YES
IR1 beam broken?
YES
Increment no. of passengers by 1
Decrement no. of passengers by 1
Output no. of passengers

Flow Chart 2

3.7 Implemanting and Coding

The coding discussed in this paper aims to demonstrate the implementation of a system by using C++ that effectively senses motion and captures data from passengers. Specifically designed for use in buses, the system utilizes sensors to detect the presence of passengers and intelligently counts them based on their direction of movement entering or exiting the bus.

The primary function of the system focuses on its motion sensing ability. The sensors quickly catch up any motions made by passengers getting on or off the bus. These signals are carefully interpreted by the code, and then it handles the data appropriately. The system keeps track of the number of passengers who board the bus. On the other hand, the bus records an exit count when a passenger is detected to be leaving.

3.7.1 Initialization set up variables to track entry and exit counts

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <EEPROM.h>

int one, two;
int incounter;
int outcounter;
unsigned long lastTimeOne = 0;
unsigned long lastTimeTwo = 0;
const int debounceDelay = 50;  // Adjust this value as needed
const int countDelay = 50;    // Adjust this value as needed
const int detectionDelay = 50;  // Adjust this value as needed (1 second)
const int lcdUpdateInterval = 300;  // Update LCD every 300 milliseconds (0.3second)
unsigned long lastLcdUpdateTime = 0;
const int warningThreshold = 30;
int eepromAddress = 0;  // Choose an EEPROM address to store data
const int resetPin = 7;  // Pin to trigger the reset

```

Figure 3.12 Variable

Table 3.3 Variable function

Variable	Function
int one , two;	It declare variable of the pair of infrered sensor.The declaration is to store the digital reading from the the infrared sesnor.
int encounter,outcounter;	Variables to track the counts of passengers entering and exiting. Which it store the infromation after complete cycle of the detection motion from the two infrared sensor.
unsigned long lastTimeOne, lastTimeTwo;	The varible to store the last time that the infrared sensor has been triggered by the motion.
Const int debounceDelay, countDelay, detectionDelay, lcdUpdateInterval;	This varible to imporve the timing of the lcd which have stable in changing the display while the passenger enter and out from the bus.
unsigned long lastLcdUpdateTime;	It store the last time lcd was updated.

const int warningThreshold;	This is warning sign if the number of passenger more than 30.
int eepromAddress = 0;	The is the Electrically Erasable Programmable Read-Only Memory wish store the address.
LiquidCrystal_I2C lcd(0x27, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE)	This variable to make the connection between the I2C and the lcd can be read by the Arduino.

From the Table 3.3 it have two thing to be more spesification which the EEPROM in this coding was implement to be the the ways to prevent the lost of data while it operating that cause by many factor. By using this function even when it off the last memory before it off do not disappear it to prevent from loss the data number of passenger.

Next the lcd use the I2C for interaction between the Arduino and lcd which to reduce the wire connection between the arduino and the lcd which only using four wire it is 2 wire for power up the lcd . The another two is serial data line (SDA) and and a serial clock line (SCL) for communicating to display the data.

```
22  void setup() {
23    Serial.begin(9600);
24    lcd.begin(16, 2);
25    lcd.backlight();
26    lcd.setCursor(0, 0);
27    lcd.print("PASSENGER");
28    lcd.setCursor(0, 1);
29    lcd.print("COUNTER");
30
31    pinMode(A0, INPUT);
32    pinMode(A1, INPUT);
33    pinMode(resetPin, INPUT_PULLUP);  // Set resetPin as input with internal pull-up resistor
34
35    // Read data from EEPROM
36    EEPROM.get(eepromAddress, incounter);
37    EEPROM.get(eepromAddress + sizeof(incounter), outcounter);
38  }
```

Figure 3.13 Void setup

The Figure 3.13 illustrates the void setup section, where lines 23 to 29 of the code are dedicated to initializing the LCD screen. Upon pressing the button, the display presents "PASSENGER COUNTER." The coordinates for "PASSENGER" (0,0) signify it begins in row one, column one. Similarly, for "Counter," the coordinates (0,1) indicate a start at row one, column two.

Pin declarations A0 and A1 are set as inputs to facilitate system execution. The reset button is also defined as an input, triggering a passenger count reset when pressed. In the void loop, EEPROM is declared to function within this loop, restoring the passenger count from the stored data. This stored data persists even when the system is turned off and resumes when it is powered on again.

```
40 void loop() {
41   one = digitalRead(A0);
42   two = digitalRead(A1);
43
44   // Check if resetPin is pressed (input is LOW due to pull-up)
45   if (digitalRead(resetPin) == LOW) {
46     incounter = 0;  // Reset the incounter to zero
47     outcounter = 0;  // Reset the outcounter to zero
48     delay(1000);  // Optional: Debounce or add a delay to avoid multiple resets with a single press
49   }
```

Figure 3.14 Void loop

In this Figure 3.14, sensor one is defined to be connected to pin A0, while sensor two is linked to pin A1. In lines 45 to 48, the conditions for the reset button are established. If the reset button is pressed, it transitions to a low state, triggering a reset of the passenger count for both entries and exits in the EEPROM. The one second delay applied to the reset button serves the purpose of preventing multiple resets within a short timeframe.

3.7.2 Entry and Exit Handling: .

```
52  if (one == 0 && (millis() - lastTimeOne) > debounceDelay) {
53    Serial.println("Start");
54
55    while (two == 1 && (millis() - lastTimeOne) > debounceDelay) {
56      two = digitalRead(A1);
57      Serial.println("waiting");
58      delay(100);
59
60      if (millis() - lastTimeOne>Timereset){
61
62       lastTimeOne = millis();
63        return 42;
64
65
66      }
67    }
68
69    while (two == 0) {
70      two = digitalRead(A1);
71      delay(countDelay);
72      Serial.println("In Count +");
73
74      lastTimeOne = millis();
75    }
76    incounter++;
77    outcounter--;
78  }
```

Figure 3.15 Condition counting

Based on coding Figure 3.15 this loop for sensor detection condition where if the sensor one and the time of sensor one is bigger than bounce delay it will starting cycle in the loop. At line 55 until 66, if no detection at sensor two it will waiting with the timing 2 second and will return back to line 42. If detect the motion continues by sensor two , the calculation will be created and the number of passenger in will be increase while number out of the bus will be decrement by 1. This condition same as if the detection of motion capture by sensor two at first point at line 69 until 93 ,but in this codition only different which the number of passenger out of bus will be increse while the number of passenger in the bus will be decrese.

```
106
107    if (incounter <= 0) {
108      incounter = 0;
109    }
110
111    if (outcounter <= 0) {
112      outcounter = 0;
113    }
114
115    if (millis() - lastLcdUpdateTime >= lcdUpdateInterval) {
116      lcd.clear();
117      lcd.setCursor(0, 0);
118      lcd.print("In: ");
119      lcd.print(incounter);
120      lcd.print("  Out: ");
121      lcd.print(outcounter);
122    }
123
124    if (incounter > 30) {
125      lcd.setCursor(0, 1);
126      lcd.print("Warning: Excess ");
127    }
128
129    // Write data to EEPROM
130    EEPROM.put(eepromAddress, incounter);
131    EEPROM.put(eepromAddress + sizeof(incounter), outcounter);
132
133    lastLcdUpdateTime = millis();
134  }
```

Figure 3.16 lcd , EEPROM

At line 107 until 113 show in Figure 3.16 that condition that number of counter if same or less than zero it will be zero to prevent the number of count become negative. For line 115 until 121 this condition for lcd where the lcd will show out the number of passenger in and out real time. Then line, 124 until 127 it for alert information if the number pessanger more than 30 it will give alert and lastly the line 130 until 134 show the functio of the EEPROM to store the last information of detection system process.

3.8 The Structure

The structural framework of this project employs a purpose-designed enclosure, effectively serving as a protective housing for the system components. This enclosure is meticulously crafted to house and safeguard the integral elements of the passenger counting system. Its design not only ensures the secure installation of components but also facilitates easy access for observations pertaining to functionality and the accuracy of the infrared sensor in counting passengers within the bus.

The infrared sensors, crucial to the system's operation, are strategically positioned at the bottom of the front view of the box. This specific placement is chosen to enable them to efficiently sense the motion of passengers as they enter or exit the bus. The distance between the paired infrared sensors is precisely set at 12.5 cm. This intentional separation is critical in determining the sequence of motion detection between the two sensors. This setup allows the system to make informed decisions, discerning whether a passenger is entering or exiting the bus based on which sensor is triggered first. This deliberate configuration enhances the system's accuracy and responsiveness to passenger movements

Figure 3.17 Front view

Then the lcd also have place at the fornt of the box to appear the number of the passenger. It place at the top of front view between the infrared sensor. At the right side of the front view that the reset button was palced in reset . The infrared sensor, lcd screen and the reset button was place at the front view that show in Figure 3.17.

The system's brain, an Arduino Uno, is located the inside the box. It is an essential part that is mounted firmly and integrates in with the box's the layout. The system is powered by a lithium-ion battery, that also mounted in the box with the Arduino Uno that show in Figure 3.18. The on/off button was place on top view of the box that show in Figure 3.19 and the final appearnce is show in Figure 3.20.

Figure 3.19 Arduino Uno with Battery in the box storage

Figure 3.18 Top view with on/off button

Figure 3.20 Final implement system in the box

3.9 APC Placement

Alignment of the sensors is equally important to optimizes detection range, and ensures sensors are correctly oriented towards the target. The sensors should be strategically placed in locations where they can effectively capture passenger movements. Typically, these sensors are positioned near the bus doors as shown in Figure 3.17 to ensure accurate counting. This method was implimented on (Jahn & Siebert, 2022) place the automatic passenger counter mounted above the door and following by (Li et al., 2017) the sensor at door area. Proper alignment ensures that the sensors have an optimal field of view to detect passengers movement as they board or alight from the bus. Careful positioning and alignment of the sensors help minimize blind spots and improve the system's ability to capture passenger data accurately. The red line in the Figure 3.17 is the detection line when passenger crossing red line.

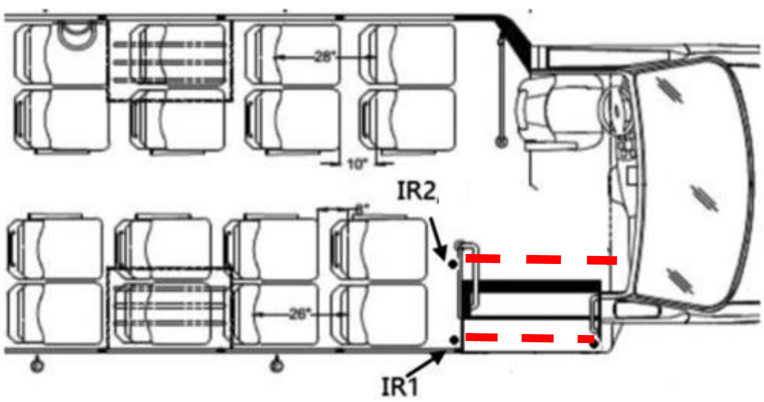


Figure 3.21 Position of Device

According to the standards set by (*PANDUAN PEMERIKSAAN KENDERAAN BAS*, n.d.), the width of the bus door should be equal to or less than 53.4 cm as shown in Figure 3.18. This dimension serves as the basis for ensuring the proper fit and functionality of the automatic passenger counter system. Additionally, during the demonstration phase, a house door with a width below 80 cm is used to simulate real-world scenarios and test the system's effectiveness in a wider range of door sizes.

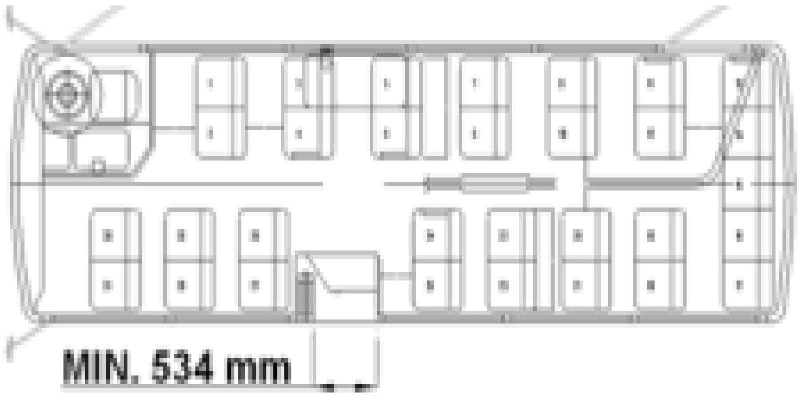


Figure 3.22 Bus Door Dimension (PUSPAKOM)

Thorough testing should be conducted to verify the functionality and accuracy of the system after installation. This may involve testing with known passenger counts and performing validation tests in controlled environments. In the experiment conducted for this thesis, a specially constructed simulation that install the device at the bus to assess how well the APC system had been implemented in the transport sector. It were specifically chosen to be identical to those of a normal bus door.

3.10 Testing and Evaluation Scenario

In order to evaluate the function and effectiveness of the APC system in identifying and counting passengers, the testing was conducted with counting the number of passenger by install it at the bus. The testing was conducted at the Melaka Central with the permission of the bus driver with company Panorama Melaka to implement the APC at the bus to get the data of number of passenger in and out from the bus.

Throughout the testing, the functionality, reliability, and accuracy of the APC system were closely observed. The results obtained from these scenarios provided valuable insights into the system's performance and its capability to accurately count passengers during various stages of a bus journey.

The conduction of test used in this thesis can assist the assessment APC system's performance in a bus daily routine. The findings from this study help to varify the system's capabilities and provide helpful recommendations for future advancements in the APC.

By emphasizing the importance of proper equipment setup, including calibration and alignment, it give confident that the automatic passenger counter system can operates at optimally, providing accurate reading and reliable data for managing bases operator daily planning. Performing convertional passenger counts on selected bus trips as a reference for comparison with the APC system's counts. During testing activity, an observer was assigned to record the number of passengers boarding and departing at specific stops or intervals during each trip. There testing to be conducted to prove APC system functinality and performance.

3.11 Summary

The methodology for developing the Automatic Passenger Counter (APC) involved several key steps, including concept selection, component selection and specification, APC circuit design, the hardware and software architecture, implementing and coding, APC placement, APC functionality and testing.

In the concept seletion phase, the overall concept and requirements of the APC system were established. This included identifying the purpose, functionality, and desired outcomes of the system.Component selection and specification involved choosing the appropriate components for the APC system. Factors such as sensor accuracy, reliability, compatibility, and cost were considered when selecting the components.

The APC circuit design focused on creating the circuitry that would enable accurate passenger counting. This included designing the circuit layout, determining the wiring connections, and ensuring compatibility with the selected components.APC placement involved determining the optimal locations for installing the sensors within the transportation vehicle. Factors such as passenger flow, visibility, and accessibility were considered to ensure accurate counting.

APC functionality encompassed the development and implementation of the necessary software and algorithms to enable accurate and real-time passenger counting. This involved programming the APC system to detect and count passengers as they enter and exit the vehicle.Testing and evaluation scenarios were conducted to assess the performance and accuracy of the APC system. Various test scenarios were created to simulate different passenger scenarios and evaluate the system's ability to accurately count passengers in different conditions.

Throughout the methodology, process consideration was given to the concept, selection, and implementation of components to ensure the functionality and reliability of the APC system. The testing and evaluation phase allowed for adjustments and refinements to be made based on the system's performance.

By following this methodology, an effective and reliable Automatic Passenger Counter system was developed, capable of accurately counting passengers in transportation vehicles and providing valuable data for analysis and decision-making.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Intoduction

The APC system's testing gave important results which proved its progressive benefit for public transportation passenger counts. The results, which are the outcome of extensive testing and development, provide strong proof of the system's abilities. This chapter explores the system's operation in detail, highlighting its accuracy, stability, and overall effectiveness in improving public transit.

4.2 Functionality

The success of the Automatic Passenger Counter (APC) project can be related to its patient creation, patient coding, and simple installation. As a consequence, the system boots up without any problems. The infrared sensor functions well, sending signals to the Arduino, and the LCD, Arduino, and sensor all work together properly.

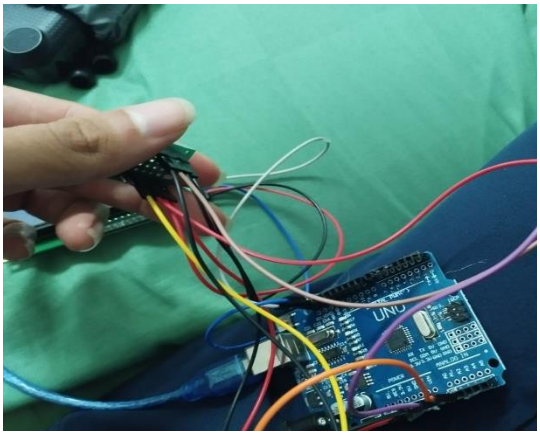


Figure 4.1 Assemble part

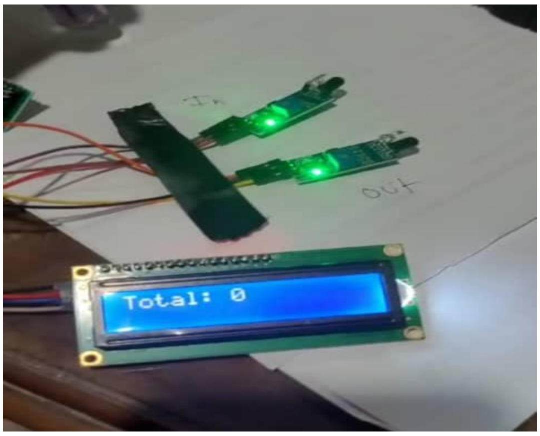


Figure 4.2 Funtionality after assemble

As seen in Figure 4.1, the APC components undergo step-by-step assembly to form a single unit. The formation of the electronic core is depicted in Figure 4.2, illustrating the connection of the LCD, Arduino, and infrared sensor. The subsequent step involves coding, where full instructions control continuous passenger recognition, counting, and information transfer.

Figure 4.3 The detection of sensor

The project's success is demonstrated by the infrared sensor's excellent performance as shown in Figure 4.3 , which reliably provides the Arduino with precise signals. Precise control over passenger counting is ensured by the comprehensive codes written during the coding phase. This method makes the APC system dependable and seamless, which makes it a useful choice for passenger counting in public transit.

4.3 Stability

At the first assembly the system is not stabilize even the connection and the condition of infrared sensor was good interaction. The stabilization result can show from the starting testing where the system was implemented in bus for the detection of the number passenger in the bus. While it running through the process in static condition it well running smooth. In the condition the bus have movement and the APC has lost stability while it shaking when the bus bumping and make the lcd become boxes and also lost the data as shown in Figure 4.4. The first testing was failed without the data that can provide as the result .

Figure 4.4 Boxes lcd

From the failure at the first test because of the sensitive connection while it bumping or shaking, the improvement on the coding has been done in protecting the data and also make it more stable on the situasion uneven road condition. The result can obtain for the second testing and it show in picture that it count properly that prove in Figure 4.5.

Figure 4.5 Second testing

The third testing was carried out the result same as the second testing where the system is in good condition without any issues. The lcd and the system also in good condition even in the third bus road route more bumping and uneven condition where it will messing the data for count the number of passenger. The result obtain in the Figure as the prove that the APC in good condition can display the number out and in passenger with real time.

Figure 4.6 Third testing

4.4 Accuracy

The accuracy of the outcomes was assessed during the second and third rounds of testing. The objective of these tests was to evaluate the accuracy of the Automated Passenger Counter (APC) in tallying the number of passengers. It's worth noting that ordinary buses, rather than express buses, were utilized in this phase. This data serves to validate the accuracy and implementation of the system, specifically designed for express buses. However, due to the extended travel time associated with express buses, ordinary buses were employed to observe the system's performance in counting passengers.

Figure 4.7 APC installation

Thus, the collected data not only serves to substantiate the accuracy of the APC but also provides valuable insights into its functionality under varied operational circumstances. The decision to employ ordinary buses, despite the ultimate target being express buses, was a strategic approach aimed at comprehensively assessing the system's ability to accurately count passengers in diverse transit settings. The installation has been made as show in Figure 4.7. The Figure 4.8 show the number of passenger at the first station and Figure 4.9 show the number of passenger in last station.

Figure 4.8 Station 1

Figure 4.9 Station 5

Table 4.1 Second testing

Station	Number of Passenger In and Out		APC Display		Direction of Movement Passenger
	In	Out	In	Out	
1	3	0	3	0	Passenger going in first
2	1	1	3	0	Passenger going out first
3	6	1	8	1	Passenger going in first
4	0	4	4	5	Passenger going out first
5	0	4	0	9	Passenger going out first

The data accurately documents the passenger movements at every bus pit stop in Table 4.1. The movements in the number of passengers as they board or exit at each stop are captured in the second column. Notable observations in the table provide the essential objective of ensuring the precision of the Automated Passenger Counter (APC) system. By serving as a guide, these remarks ensure accurate passenger counts and enable the APC system to offer a true picture of the passenger capacity.

Understanding the order in which passengers are moving that is, whether they are getting on or off the bus first is essential to this procedure. The difference is important because, when comparing manual counts without taking into account the changing conditions of the passengers, the counting sequence may produce different results. To demonstrate, consider the case at station 3, where the recorded data reveals 8 passengers boarding and 1 disembarking. By using notes, you can be confident that the computation begins with the right assumption in this example, 8 passengers were entering and 1 leaving. This avoids a possible calculation error where an incorrect count of eight passengers in the bus and zero number of passenger getting off .

That can be proven strongly with the conducting third testing. The third testing only have 3 station and it suitable for situation like the express bus operation. The result has been collected and it also show the accuracy in counting the number of passenger in Table 4.2.

Table 4.2 Third testing

Station	Number of Passenger In and Out		APC Display		Direction of Movement Passenger
	In	Out	In	Out	
1	14	0	14	0	Passenger going in first
2	0	9	5	9	Passenger going out first
3	0	5	0	14	Passenger going out first

The table 4.2 represents a journey which includes three stations. Fourteen people boarded the bus at the first station, heading towards station 3, the last stop on the trip. The bus stopped at destination 2 along the way, and when a manual count was carried out there, it was discovered that 9 people got off. Five passengers were effectively recognized as still being on the bus at the same time by the Automated Passenger Counter (APC).

By the time the bus arrived at the last station, every passenger had got off, making a total of 14 people off by the time the trip was over. The APC counted passengers accurately and dependably for the whole trip, as evidenced by the consistency in the number of passengers recorded from station 1 to station 3.

Figure 4.10 for the first station, Figure 4.11 for the second station, and Figure 4.12 for the last station show the results graphically. These values illustrate the real passenger counts at each station graphically, highlighting the accuracy with which the APC tracks passenger counts over the course of the full trip path.

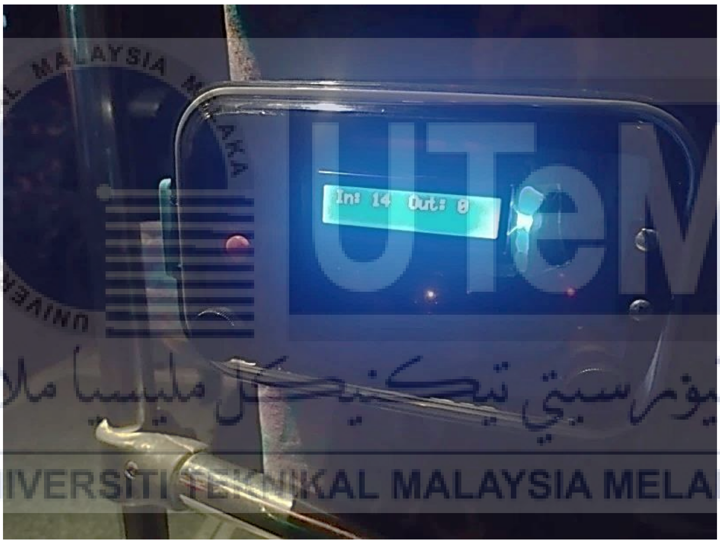


Figure 4.10 Station 1 third test

Figure 4.11 Station 2 third test

Figure 4.12 Station 3 third test

4.5 Discussion

The discussion delves into the root cause of the failure, attributing it to the sensitivity of connections between components, particularly affected by vibrations or bumps encountered during the bus trip. The statement goes on to explain the specific impact of these external factors, highlighting how they lead to issues such as the disconnection of the LCD, resulting in the display of box characters on the screen.

The problem was handle by code optimization which the software code handle the distruption . Code optimization often involves improving resource utilization to enhance performance. This may include reducing memory consumption, optimizing algorithms, and minimizing unnecessary computations.

The impact of vibrations extends to data loss, particularly in the passenger count. When the LCD loses connection due to vibrations, the screen fails to display the passenger count. To restore functionality, a system reset is required, involving turning off and then on the system. However, this reset action results in the loss of passenger count data accumulated during operation. To mitigate this data loss during resets, the coding includes a crucial element powering up the EEPROM to store the latest passenger count information before system shutdown. This ensures that the last updated count is preserved.

The incorporation of EEPROM in the system introduces the advantage of continuous counting, preventing the reset of passenger count to zero. To enable intentional resets for new trips with different destinations, a designated trigger button becomes essential. This button serves as the mechanism to reset the passenger count, facilitating accurate tracking for each trip passenger data.

The Automatic Passenger Counter (APC) system's implemented code enhances passenger counting's efficiency and accuracy while resolving a number of problems with conventional methods. To improve accuracy, the code includes analogue sensors such as and buttonPinTwo, paired with a thorough debouncing process (debounceDelay). By ensuring steady button presses, reduces the possibility of mistakes brought on by electrical noise or button bouncing. The handleButtonPress feature improves counting even further by constantly tracking state changes and reducing the possibility of counting errors caused on by unclear passenger movements.

By using millis( ) for timing, the code employs non-blocking programming techniques to increase efficiency. This design decision enables the system to smoothly perform various activities, refresh the LCD display at regular intervals (lcdUpdateInterval), and monitor button inputs continuously. Transit operations are more efficient overall because of the LCD's immediateness and real-time updates. Enhancing the system's efficiency is the instant reset mechanism (resetCounters function), which makes quick resets possible at the start of new routes .

The code uses EEPROM storage (EEPROM.put) to store passenger count data persistently for operational continuity. This functionality provides that the APC system maintains its accuracy even in situations requiring system resets or power cycling, which is crucial for keeping accurate passenger records during bus trips. In summary, the code is an excellent instance of an APC system that effectively handles the problems of efficiency and accuracy in passenger counts. The use of analogue sensors, effective coding steps, and features like LCD updates and EEPROM storage all work together to provide an advanced and dependable public transportation system that supports the main objective of improving accuracy and automating operations.

CHAPTER 5

CONCLUSION

In summary up, this research highlights the effectiveness of integrating an infrared sensor with an Automatic Passenger Counter (APC) system and offers a practical and affordable option. Remarkable results show that the passenger count collected by this technology closely matches the manual count, providing an easier solution than traditional methods. The importance of proper coding alignment with the desired outcomes must be emphasized to ensure the smooth integration of this feature in express buses.

The project's performance depends on the efficient integration of coding and system operations, which is essential to obtaining precise passenger counts. In terms of technology, maximizing the performance of the collected data results depends critically on the correct selection of components, as demonstrated by the usage of the original Arduino Uno.

The objectives have been successfully fulfilled. These goals were to build a working device for accurate passenger counting and then apply it on express buses. In addition to accomplishing the primary purpose of showing passenger counts on an LCD screen, this device also achieves its secondary objective of providing a dependable method for accurate passenger counting in public transportation.

This finding has significant implications for how technology is developing. This solution fulfills an important gap by delivering a device that optimizes public transportation management and eliminates away with the errors that come with conventional headcount systems. As a result, this device makes a substantial contribution to improving the accuracy of passenger count statistics in the public transportation industry.

However, it's important to recognize certain limitations. Due to limitations on time during the automated passenger counter's development, further work must be done in the future to thoroughly examine its behavior and resolve any possible problems. Furthermore, the depth of our study is limited by variances in bus layouts, leading to the need for more study in the future.

Lastly, in order to improve accessibility and management, future work should focus on developing a specialized independent device that can be easily installed in buses, adding a battery life indicator for better usability, and investigating potential IoT-based data connectivity options. These factors will surely aid in the ongoing development and useful application of our automated passenger counting system.

REFERENCES

Food Living Outside Play Technology Workshop Powering Arduino with a Battery. (n.d.). http://www.instructables.com/id/Powering-Arduino-with-a-Battery/

Jahn, N., & Siebert, M. (2022). Engineering the Neural Automatic Passenger Counter. *Engineering Applications of Artificial Intelligence*, *114*. https://doi.org/10.1016/j.engappai.2022.105148

Jain, B. (2019). *Intelligent Bus Tracking and Passenger Counting System* (Vol. 6). JETIR. www.jetir.org

Khan, S. H., Yousaf, M. H., Murtaza, F., & Velastin, S. (2020). PASSENGER DETECTION AND COUNTING FOR PUBLIC TRANSPORT SYSTEM. *NED University Journal of Research*, *XVII*(2), 35–46. https://doi.org/10.35453/nedjr-ascn-2019-0016

Li, F., Yang, F., Liang, H., & Yang, W. (2017). *Automatic passenger counting system for bus based on RGB-D video*.

Moser, I., McCarthy, C., Prakash Jayaraman, P., Ghaderi, H., Dia, H., Li, R., Simmons, M., Mehmood, U., Ming Tan, A., Weizman, Y., Yavari, A., Georgakopoulos, D., & Konstantin Fuss, F. (2019). *Australasian Transport Research Forum*. http://www.atrf.info

Nitti, M., Pinna, F., Pintor, L., Pilloni, V., & Barabino, B. (2020a). Iabacus: A Wi-Fi-based automatic bus passenger counting system. *Energies*, *13*(6). https://doi.org/10.3390/en13061446

Nitti, M., Pinna, F., Pintor, L., Pilloni, V., & Barabino, B. (2020b). Iabacus: A Wi-Fi-based automatic bus passenger counting system. *Energies*, *13*(6). https://doi.org/10.3390/en13061446

PANDUAN PEMERIKSAAN KENDERAAN BAS. (n.d.).

Professor, A. (n.d.). *DETECTION AND WARNING OF PASSENGER COUNT IN BUSES USING ARDUINO*. http://www.acadpubl.eu/hub/

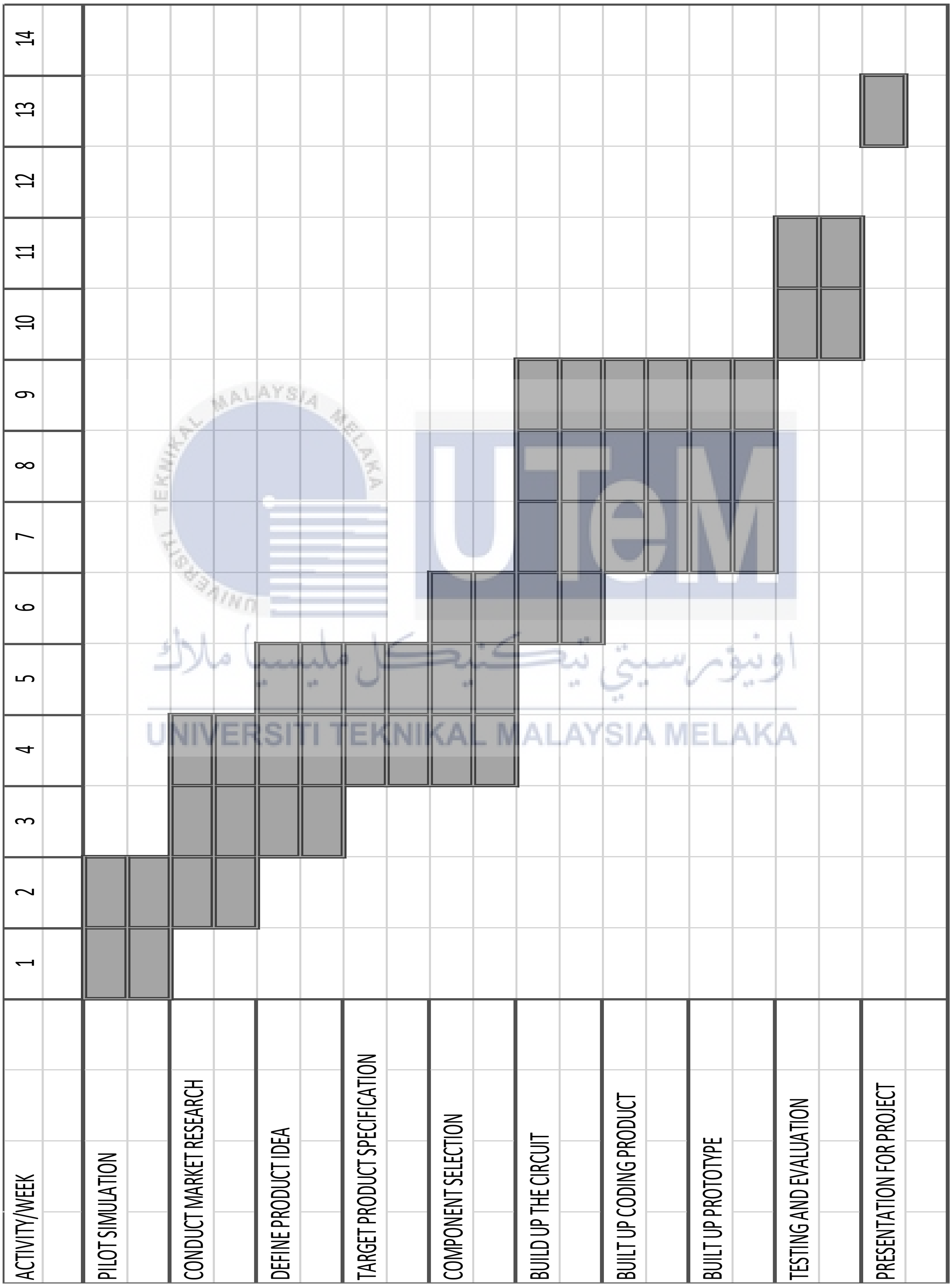
Săvescu, C., Nechifor, C., Vasile, M. L., Lale, D., Borzea, C., Gogoneață, S., Vasile, M., & Niculescu, F. (2021). Passengers Monitoring System with Infrared Sensors and Microcontroller. In *TURBO: Vol. VIII* (Issue 2). https://www.researchgate.net/publication/357180151

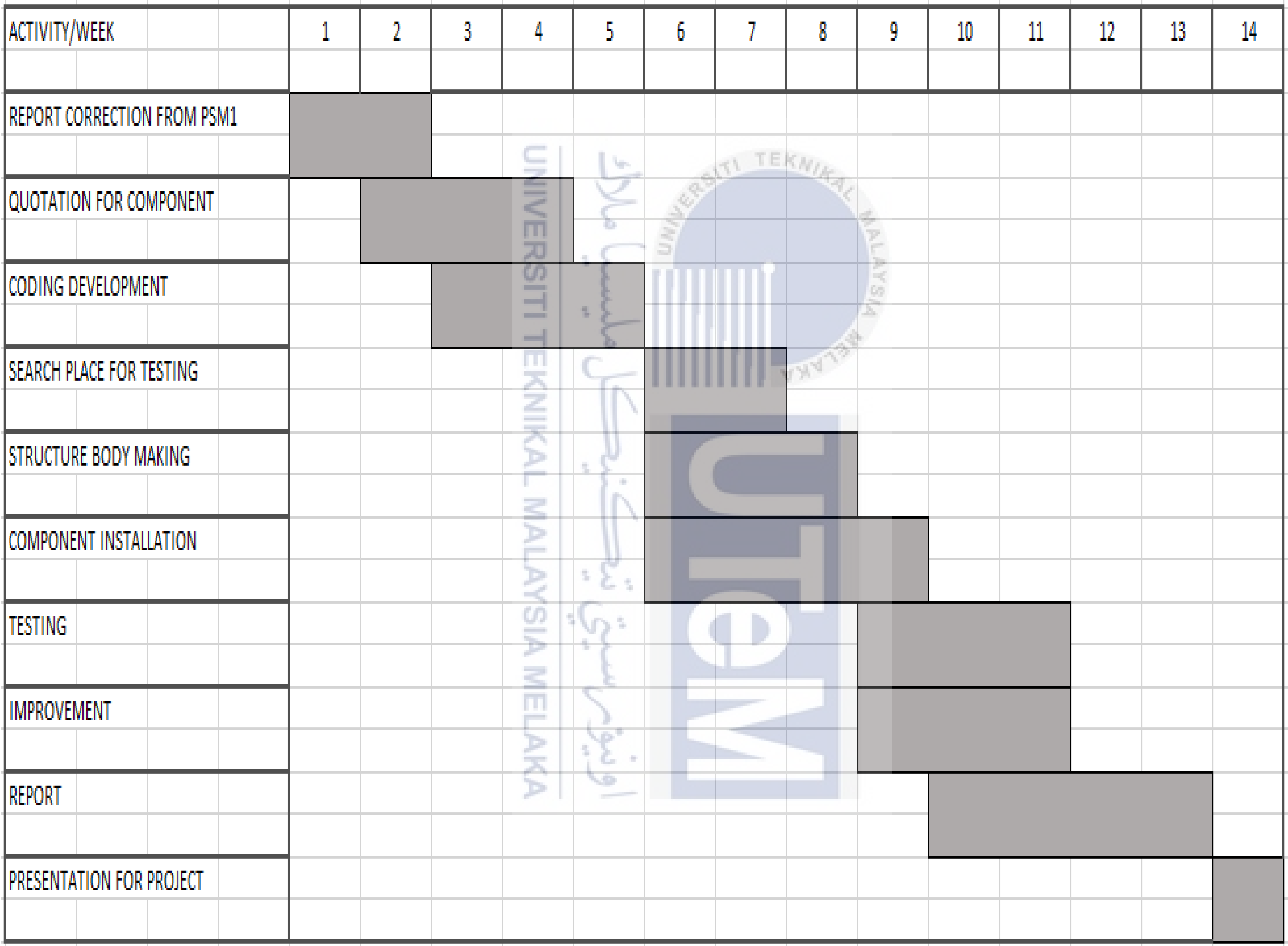
Siebert, M., & Ellenberger, D. (2020). Validation of automatic passenger counting: introducing the t-test-induced equivalence test. *Transportation*, *47*(6), 3031–3045. https://doi.org/10.1007/s11116-019-09991-9

Sojol, J. I., Ferdous, N., Motahar, T., Ferdous Piya, N., & Sadman, S. (2018). *Smart Bus: An Automated Passenger Counting System Human Computer Interaction View project PROHORI: Smart Surveillance System for Security Purpose Based on RFID and Color Code Detection View project Smart Bus: An Automated Passenger Counting System 1*. https://www.researchgate.net/publication/323027620

APPENDICES

APPENDIX A Gantt Chart




ACTIVITY/WEEK
1
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REPORT CORRECTION FROM PSM1
QUOTATION FOR COMPONENT
CODING DEVELOPMENT
SEARCH PLACE FOR TESTING
STRUCTURE BODY MAKING
COMPONENT INSTALLATION
TESTING
IMPROVEMENT
REPORT
PRESENTATION FOR PROJECT

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

TAJUK: DESIGN AND DEVELOPMENT OF INEXPENSIVE AUTOMATIC PASSENGER COUNTING SYSTEM FOR INTERCITY BUS IN PENINSULAR

SESI PENGAJIAN: **2023/24 Semester 1**

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