**Augmented Reality and put a bracket (Quiz and Login Module)**

By

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Augmented Reality and put a bracket (Quiz and Login Module)

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Declaration

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Abstract

To be written.

Acknowledgement

This contains acknowledgement to those who have contributed directly or indirectly to the completion of the project. Usually the people to be acknowledged include the project supervisor(s), moderators, family, and those who have given assistance and supports to ensure the success of the project.

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Chapter 1

Introduction

# Introduction

The Fourth Industrial Revolution (IR 4.0) has had a significant impact on various industries in recent years, with the manufacturing sector experiencing significant technological advancements. Augmented Reality (AR), a key technology driving this revolution, integrates digital information into the user's real-world environment, enabling more intuitive and immersive interaction with machines and processes. AR has enormous potential in the manufacturing industry, as it has the potential to revolutionize product design, development, and manufacturing processes.

The goal of this project is to address these issues by creating an augmented reality application that assists Kian Joo Can Factory (KJCF), the biggest packaging company in the South-East Asia region [16] for their factory workers in comprehending and operating complex machinery. This app aims to improve training processes by providing an interactive and user-friendly solution that can run on any Android device. Besides, this project aims to contribute to the improvement of both security and effectiveness as well in the manufacturing industry by leveraging AR technology to enhance factory training. The methodology, development process, and evaluation methods used to create and assess the effectiveness of the proposed AR application will be discussed in the following sections.

## Objectives

The following session will be further expanded to discuss the objectives of this project and each part will be divided into sub-sections.

### Purpose of this system

1. Develop an Augmented Reality (AR) application prototype with a quiz module to enhance the training process at Kian Joo Can Factory (KJCF) by replacing traditional training methods with a more immersive and engaging approach.
2. Improve the interactivity and engagement levels of KJCF staff during training sessions by leveraging AR technology to provide a more hands-on and interactive learning experience.
3. Minimize the risk of injuries to KJCF staff during training by utilizing the AR application to simulate potentially hazardous scenarios and processes in a safe and controlled virtual environment.
4. Evaluate the effectiveness and usability of the AR application prototype in achieving the desired training outcomes and identify areas for further improvement and development.
5. Enable administrators to monitor staff progress and training outcomes through the AR application, facilitating real-time feedback and assessment, as well as allowing for easy uploading and updating of training materials to ensure continuous improvement and adaptability to changing industry needs.

### Functional Requirements

This application will allow staff to learn and familiarize the production machines via AR applications by interacting with them. After that, they should take a quiz test to test their familiarity and order to get into production. All staff within KJCF should pass the training session to get into can production, and before an administrator recognizes that staff’s progress, they are not allowed to get into can production.

1. AR Application Development
   1. The system shall provide an Augmented Reality (AR) application for Kian Joo Can Factory (KJCF) to be used in staff training.
   2. The AR application shall provide a learning list that machines should be learned by that staff in order to work on assigned task.
   3. The AR application shall allow users to interact with virtual training scenarios and objects, enhancing their learning experience and promoting active participation.
   4. The AR application shall be designed to reduce the risk of injuries during staff training by providing a safe and immersive learning environment.
   5. The AR application shall show the progress and assigned task that have given to the staff.
   6. The AR application shall be allowing users to take AR tests and quiz tests in order to test their understandings to a machine as well as measure their performance based on their marks.
2. Admin Monitoring and Management
   1. The system shall provide an administrator dashboard for monitoring staff progress, training outcomes, and providing real-time feedback and assessment.
   2. The system shall allow administrators to easily upload, update, and manage training materials within the AR application, ensuring continuous improvement and adaptability to changing industry needs.
   3. The system shall provide comprehensive reports on staff training progress and performance, allowing administrators to make data-driven decisions for training improvements and resource allocation.

### Non-functional Requirements

1. Usability: The AR application should be user-friendly and intuitive, allowing users with varying levels of technical expertise to easily navigate and interact with the training material. Besides, it should minimize the numbers of errors to prevent the injury accidents from happening as well as reduce the time required to familiar with the operating with machines.
2. Performance: The application should have minimal latency and load times, ensuring a smooth and responsive user experience during training sessions, the trainer can evaluate the worker’s performance based on their performance as well.
3. Scalability: The application should be designed to accommodate an increasing number of users and training materials as the company grows and expands its operations.
4. Compatibility: The AR application should be compatible with a wide range of Android devices, and AR technologies to ensure accessibility for all users.
5. Maintainability: The application should be easy to maintain and update, allowing for the addition of new training materials and improvements to existing content without significant downtime or disruption to users.
6. Customizability: The application should allow administrators to customize the training content to suit the specific needs and requirements of Kian Joo Can Factory.
7. Reliability: The application should be stable and reliable, minimizing the occurrence of technical issues or errors that could disrupt the training experience
8. Accessibility: The application should be designed with accessibility in mind, that provides multiple languages for local or foreign workers that have different background should be provided their mother tongue language to ensure that they understand the command or instructions on operating machines.

### Target Users

The targeted users for the AR application in Kian Joo Can Factory (KJCF) includes:

1. New Employees: The AR application aims to provide an engaging and efficient training experience for new employees joining the organization. By leveraging the interactive and immersive nature of AR, new employees can quickly learn the necessary skills and knowledge required for their roles.
2. Existing Employees: The AR application can be used to enhance the skillsets of existing employees, ensuring they stay up to date with industry advancements and best practices. Through continuous training and development, employees can maintain their expertise and contribute to the overall success of the organization.
3. Administrators: The AR application's administrator dashboard is designed for training administrators to monitor, manage, and assess staff training progress. By offering a centralized platform, administrators can efficiently oversee training activities and continuously optimize the training content to meet the organization's needs.

## Background and context

In recent years, the Fourth Industrial Revolution (IR 4.0) has brought about major technological advancements in manufacturing industries. One of the key technologies driving this revolution is Augmented Reality (AR), which combines the physical and digital worlds to create a new environment where real and virtual objects can coexist and interact in real time. [1] Besides, in the manufacturing industry, MR has the potential to revolutionize the way products are designed, developed, and manufactured by enabling engineers and designers to visualize and interact with virtual prototypes and assembly processes in a more intuitive and immersive way. Despite its potential, the adoption of MR in the manufacturing industry is still limited, and there are several challenges that need to be addressed to fully realize its benefits. Therefore, this section will be roughly explaining the Industrial Revolution (IR) and Augmented Reality (AR) and connecting both by giving some case studies out there and acceptance of people towards AR.

### Definitions of Industry 4.0

The term “Industry 4.0”, also as known as “Industrie 4.0” is being used interchangeably with the term “the Fourth Industrial Revolution”, but there are some key differences between those two terms. Industrial Revolution 4.0 refers to a broad range of technologies that changes the way of manufacturing and other industry works such as Artificial Intelligence, Big Data Analysis, the Internet of Things and Robotics, cloud computing, and analysis. [12][13][14] Industry 4.0 on the other hand refers to a vision of digital transformation for future production that involves modular and efficient manufacturing systems in which the product controls its process, such as integrating cyber-physical systems into the manufacturing process, which enables real-time data capturing and analysis for flexible and more efficient manufacturing. [11] [14] [15] In conclusion, Industry 4.0 has been seen as a key initiative within the fourth industrial revolution where it gives a vision where it can be integrated into the manufacturing process such as AI to improve efficiency. [14][15]

### Definitions of AR

Augmented Reality (AR) and Mixed Reality (MR) are closely related technologies that lie within the reality-virtuality continuum proposed by Milgram et al. [2][8]. The continuum represents a spectrum, ranging from a fully real environment to a fully virtual environment. Augmented Reality is positioned closer to the real environment side of the spectrum, where digital information and virtual objects are overlaid onto the user's real-world view. In contrast, Mixed Reality encompasses a broader range of experiences, blending various degrees of real and virtual environments, allowing real and virtual objects to coexist and interact in real time.

While AR and MR share similarities, they differ in the level of immersion and interaction with virtual elements. AR primarily enhances the real environment, while MR enables more advanced interactions between real and virtual objects. However, given the overlapping nature of AR and MR experiences, many use the terms interchangeably or consider AR to be a subset of MR.

### Implementations and potentials of AR in industries

The potential of AR can be immense, as it can be implemented across various sectors such as the military, manufacturing, medical, training, and education. [6][9][5][8] Besides, [9] also studied that there is multiple use case of AR to help the industry to simulate, assist and increase their productivity such as using AR to visualize and optimize assembly processes, using AR to train workers on complex tasks, using AR to provide real-time feedback on quality control as well as using AR for remote collaboration and maintenance tasks. For example, AR is used for accessing the interior design of a car by overlaying different car interiors in the automotive industry. [9]

One of the study cases using AR to simulate and assist is Gangabissoon, T., Bekaroo, G. and Moedeen, W. (2020) created an AR application for Cabin Crews to train them in Emergency Procedures Training (EPT). The main objective of this application is to enhance the motivation of the staff during the EPT Training. It has been said that the engagement of learners will determine the outcome. [5] Based on their outcome, interviewed the 45 participants which are working in the related field, such as Recurrent crew members, Senior Flight Pursers, and Flight Pursers, there’s 86.7% of the participants has given that they were able and strongly able to learn about safety equipment and its location and some crucial procedures with AR. In terms of the learning experience, there’s 95.6% of participants has given feedback that the 3D models and image used to display helps to improve their learning experience.

### Company’s background

Kian Joo Can Factory Berhad has established itself as a major player in the packaging industry, providing innovative packaging solutions that enhance product marketability and strengthen brand positions. With humble beginnings in 1956, the company has grown significantly, expanding its operations and acquiring other businesses. Kian Joo's achievements have been marked by significant milestones, such as the listing of its subsidiary, Box-Pak (Malaysia) Bhd, on the Main Market of Bursa Securities in 1996.

The company's journey has seen several major events, including the delisting from SES in 1988, the takeover by Can-One International Sdn. Bhd. in 2019, and the subsequent removal from the Official List of Bursa Securities. Today, Kian Joo is an indirect wholly-owned subsidiary of Can-One Berhad, a company listed on the main market of Bursa Securities.

Kian Joo Can Factory Berhad's legacy demonstrates the importance of adaptability, innovation, and resilience in a constantly evolving market. The company's continued success is a testament to its commitment to delivering high-quality packaging solutions that cater to the diverse needs of consumers and industries, contributing to its standing as a leading packaging giant in the region. [16]

The current training method employed at the facility involves having experienced staff members train new employees during actual operations. This approach presents a considerable risk for new staff, as they must exercise extreme caution to avoid potential injuries. Failing to do so could result in serious injuries that may significantly impact their lives.

## Advantage and Contributions

This section aims to discuss the advantages and contributions of the AR application for Kian Joo Can Factory (KJCF). By understanding these benefits, we can better justify the implementation of the AR application and set the foundation for its successful integration into the training process.

### Advantages

1. Enhanced Training Experience: The learning process will be more immersive and interactive compared to the current learning method, which uses PowerPoint presentations and quizzes to learn the theoretical part of the machines. This is because AR can provide interactivity that allows staff to interact with the machines when they are training. By touching it, the staff can know how that machine works when it is in production and what should they be cautious about.
2. Safer Work Environment: In terms of the practical side, the learning process will be safer, as the training method they are using currently is having experienced staff to guide the new staff, this may cause serious injury if the new staff is not being cautious. Therefore, implementing AR to train the new staff, can provide a safer work environment for them.
3. Monitoring and Progress Tracking: The administrators are able to monitor and track the learning progress of their staff. This allows them to plan the job division from the proficiency of the machine of each staff.

### Contributions

The AR application offers numerous advantages and significant contributions to Kian Joo Can Factory's training process. By enhancing the training experience, improving interactivity, promoting a safer work environment, and providing monitoring and progress tracking capabilities, the AR application has the potential to revolutionize the way KJCF trains its employees. Embracing this innovative technology can lead to more effective training outcomes and contribute to the overall success and growth of the organization.

## Teams and Organization

To develop this application, this team will consist of 2 persons, which is Me (Chong Tik Joe) and Chew Ying Ying. We are expected to create an AR application that consists of several modules, which are Login Module, Quizzes module, AR test module, learning module, and admin module. Which the division of modules will be shown as table 1 below.

Table 1: Project Team

|  |  |
| --- | --- |
| Team Member | Module |
| Chong Tik Joe | Login Module, Quizzes module |
| Chew Ying Ying | Admin Module, Learning Module and AR test module |

## Chapter Summary and Evaluation

In conclusion, this chapter has discussed the overview of proposed AR application prototype for Kian Joo Can Factory (KJCF). The AR app aims to revolutionize the training process at KJCF by enhancing intractability during training, reducing the risks of injury when training new staffs as well as providing a more engaging learning experience for staffs. Besides, this chapter has highlighted the objectives, backgrounds, the potential of implementing AR into manufacturing. This project will bring several benefits for KJCF such as improving training efficiency, increased employee’s satisfactory and reduce overall costs. The project also aims to showcase the potential of AR technology as an innovative tool for industrial training and knowledge transfer in the manufacturing sector.

The subsequent chapter will discuss deeper into the design, development, and evaluation of the AR application prototype which will include a detailed discussion of the methodologies and tools used, as well as an assessment of the project's overall effectiveness and impact on KJCF's training processes.

Chapter 2

Literature Review

# Literature Review

In recent years, there has been a lot of interest in the use of Augmented Reality (AR) in a variety of sectors, which has prompted the creation of numerous frameworks, pieces of hardware, and pieces of software to support its use. This literature analysis will examine several critical areas in order to acquire a thorough overview of the AR environment and its relation to the present research. We will first talk about the Vuforia Framework and how it works with the popular game engine Unity. Following that, we'll look at several AR application types, with a focus on Android platforms, as well as the hardware and software tools required for their creation, such as Unity, Vuforia SDK, and Java Developer Kit (JDK). We will also explore the fundamental ideas that underlie AR technology and the standards by which its performance is measured, such as error rate and time complexity. Also, the features of quiz applications on various platforms as well as the usefulness of AR glasses will be investigated. By going over these subjects, we hope to give readers a good foundation for comprehending the state of AR technology right now and some of its possible uses in the context of our research.

## Vuforia Framework and its integration with Unity

This subsection will be mainly discussed on Vuforia and its integration with Unity. We will delve into Vuforia's features, benefits, and its integration with Unity.

### Review on Vuforia

Vuforia is used to be an AR plug-in from Qualcomm, has been acquired by Parametric Technology(PTC), a leading industrial design software company. [J8] [19] Vuforia is a tool that provides support for SDKs (Software Development Kits) for iOS and Android mobile devices, allowing developers to easily create AR applications for mobile devices on different platforms. [18] [J8] [19]

[18] had concluded few benefits regarding using Vuforia SDK. Firstly, they stated that it provides developers to add virtual objects like 3D and multimedia to the app. This allows users to show a 3D modeled version of an object on a 2D screen, it improves interaction rendered camera images are previewed and displayed in the app, appearing as real images. [19] Virtual 3D objects are added to these real images, creating an immersive experience. Besides, they had review that there are four aspects that create good user experience by Vuforia SDK, which are:

1. Faster speed of local target recognition;
2. Supporting and use the technology that can recognize millions of targets;
3. Highly-robust target tracking that will not be affected easily by mobile devices;
4. More effective than other AR SDKs and supporting the recognition of low-light and partly-covered targets.

Additionally, [19] had reviewed and provided an additional view of how Vuforia SDK’s data stream work. The data stream in Vuforia SDK is divided into four modules: which are inputting, database, tracking, match and render output.

Although with the benefits above, [J8] mentioned that the numbers of maps provided is not enough for free version. If that is the case, developers purchase the add-on version according to each needs.

### Review on Unity and Integration of Vuforia into Unity

Unity 3D, developed by Unity Technologies, is a versatile and cross-platform game engine that enables the creation of immersive 3D games, interactive content, and Augmented Reality (AR) applications. The engine supports various platforms, including Windows, iOS, Android, and macOS, making it a popular choice for developers targeting multiple devices**.** [J8] [19] [10]

With its powerful development tools and AR-specific extensions such as Vuforia SDK, Unity 3D allows developers to overlay virtual elements onto real-world environments, enabling seamless human-computer interaction in AR applications. The engine also offers a comprehensive set of features, including terrain editing, audio integration, GUI customization, color grading, scripting, and more, which allows for the creation of rich and engaging experiences.[19]

### Use cases and examples of using Vuforia with Unity

[10] is developing an augmented reality-based application for character education using Unity with Vuforia SDK. The main goal of their research is to develop an AR system on a laptop that will improve the learning process of character education by helping the teacher to provide new interactive tools for teaching the students. They concluded that the AR application when the camera pointed towards to the marker, as it run successfully without any graphics, animations, and sound problem. Besides, they had provided three benefits of using Unity Engine combined with Vuforia SDK, such as:

1. The AR system could be made with minimal development cost by using Unity, which is cheaper (including a free version) than other engines. Additionally, assets can be created using Blender, which is also free, making the process almost cost-free.
2. Unity supports Ruby language, allowing for quick implementation and the ability to create complex transformations, such as an AR system with multiple 3D assets.
3. Using the Vuforia SDK, an AR system can be created that does not require a specific device, such as an HMD (Head Mounted Device), but can instead be used on any mobile device that supports AR. This makes the system usable in any educational environment, making it ideal for improving character education.

However, they have also pointed out that it will take a long period for the device to identify the marker, or the marker will not be identified at all. But still, this problem could be solved by restarting the application.

In another case study from [J8], a collaboration was established with K-SKY Technology Co., Ltd. to implement AR as a replacement for traditional training sessions related to machine maintenance. They utilized Vuforia to create identification cards at no cost. The study concluded that Vuforia offers quick, user-friendly, and advanced AR content development solutions that can assist industries in training their employees, particularly in the area of machine equipment maintenance.

## Review on AR

This subsection will mainly discuss AR, its applications in various industries, factors and impacts of its implementation, and challenges and principles of applying AR in industry settings.

### Applications of AR in industries

Numerous discussions regarding AR applications in industries exist. [J6] [J8] [8] However, [J8] provides a more comprehensive overview of different purposes within AR industries, such as AR Edutainment, Maintenance, and Training. Maintenance applications assist technicians in diagnosing factory equipment and offering easy guidance. [J3] [J10] [J6] [J8] This enables technicians to identify issues and fix them quickly, thereby increasing productivity. AR applications in training aim to train staff or replace traditional training methods. [J8] For instance, with the help of AR glasses, productivity can be significantly improved while reducing the risk of injury. [J8] demonstrated that by bringing the learning and working scenes infinitely closer, daily routines are accomplished by showing the step-by-step processes of troubleshooting. Lastly, AR Edutainment is another implementation of AR in the industry. [J6] [J8] This approach uses virtual 3D objects and presents them in real life. It is often employed for prototyping, allowing people to visualize the final product in a real-life setting. For example, [J1] reviewed the implementation of accessing interior design by overlaying different car mockups, an AR-based mock-up system for graphic design allowing designers to view the effects of each design, AR cockpit design from [J9], and prototyping a ceiling lamp from [J10].

### Factors and Impacts of Implementing AR

[J1] reviewed that one factor driving the implementation of AR into industries is addressing increasing equipment complexity. As mentioned in the previous subsection's case study, implementing AR can increase workers' productivity by showing a step-by-step guide of troubleshooting for workers to learn and enhance their experience during maintenance tasks. Additionally, [J1] and [J8] agree that a well-designed AR application can reduce operating costs. However, the amount of cost reduction may vary depending on the way AR applications are used in industries. For example, [J8] reviewed a maintenance application and concluded that it reduced costs by nearly 20%. Furthermore, AR enhances the interaction between systems and users by allowing users to interact and manipulate 3D objects naturally [J5], enabling better understanding of how they fit in real objects. [J1] Moreover, it also promises the numbers of error made by human mistakes. [8] [J1]

However, some drawbacks of implementing AR depend on the situation. [J9] reviewed that overreliance on the AR system may decrease workers' situational awareness. In their work, they reviewed a test involving two groups of surgeons: one group used an AR interface, and the other used a standard interface while performing an operation on a cadaver. The researchers measured how well the surgeons performed the surgery and whether they noticed a broken optic nerve and a small screw inserted into the surgical site. They discovered that only 7% of the AR group noticed the injured optic nerve, and none of them noticed the screw. In contrast, 46% of the other group noticed the nerve, and 41% noticed the screw. This finding suggests that AR may make workers less aware of their surroundings, which could lead to serious injuries when implemented in other dangerous sectors like the machinery industry.

Moreover, [J2] provided a comprehensive analysis of the factors influencing industries to adopt AR, including hardware and software characteristics [J1] [J5] [J9] [8], the attitude of company executives, and cybersickness. Firstly, [J2] reviewed case studies on hardware and software characteristics for industrial applications, such as battery life, connectivity, memory size, and wearability. Although [J5] concluded that the ergonomics of HMD devices, such as weight, resolution, and field of view, have improved compared to the past, both [J5] and [J2] agreed that HMD devices are still not ready to fulfill the requirements of industries for long-term implementation due to issues like small FoV, weight, the need for a stable Wi-Fi connection, battery life, and more. [J2] reviewed that some studies claim cybersecurity concerns should be taken into consideration during the adoption of AR in the industry. [8] Secondly, [J2] reviewed that the attitude of company executives toward digital innovations is another critical factor in whether an industry implements AR. In their work, they mentioned that the potential of AR can be realized if organizational and operational processes are changed. Lastly, cybersickness symptoms such as hallucinations, visual flashbacks, difficulty distinguishing reality from the reconstructed world, dizziness, and blurred vision are additional factors impacting industries' implementation of AR, as reviewed by [J2]. [J1]

### Challenges and Principles of applying AR into industry

There are multiple challenges to implementing AR within the industry. [J2] mentioned that no single AR system has yet been proven to be well-accepted by the industry. [J2] highlighted several typical factors that affect industry acceptance:

* 1. Over-expected outcomes from the industry: Companies may have high expectations for what AR can achieve, such as increased productivity, precision, and live feedback. However, if these expectations are not met due to insufficiently developed solutions or poor ease-of-use, acceptance of AR will suffer.
  2. Level of acceptance of workers: The attitude and predisposition toward the intention to use AR technologies are impacted by perceived usefulness and ease-of-use. If employees do not see the value in using AR or find it difficult to use, they may resist adopting it.
  3. Familiarity with digital technologies of companies: Companies unfamiliar with digital technologies may struggle with implementing AR. They may need to invest in training programs or hire new staff with relevant skills.
  4. Task-tech fit: If a task is too simple that people can solve it quickly, it could lead to workers refusing to adopt AR use, resulting in counter-productivity.

[J9] had provided a comprehensive overview towards multiple principles for applying AR in manufacturing. There are four principles provided, which are:

1. Develop AR technology that enhances human ability instead of replacing it. This principle emphasizes the importance of designing AR technology that works in harmony with human abilities and skills, rather than replacing or diminishing them. This means that AR should be used to enhance and support human performance, rather than replacing it entirely. For example, AR can be used to provide workers with real-time information and guidance during complex assembly tasks, but it should not replace the worker's ability to make decisions or perform tasks on their own. By creating AR technology that complements human ability, we can improve the efficiency and effectiveness of manufacturing processes while also empowering workers and enhancing their skills.
2. Simplify the information to avoid overwhelming the user or making them accustomed to the stimulus. This principle for designing AR implementations in manufacturing is to ensure that the technology is easy to use and understand. This means that AR interfaces should be intuitive and user-friendly, with clear instructions and feedback. The goal is to minimize the learning curve for workers and reduce the potential for errors or confusion. By making AR technology easy to use, we can increase adoption rates and improve overall productivity in manufacturing processes.
3. Customize the hardware to fit the specific instance where it will be used. This principle for designing AR implementations in manufacturing is to provide users with control over the technology. This means that workers should be able to customize and adjust AR interfaces to suit their individual needs and preferences. Additionally, workers should have the ability to turn off or disable AR technology if they feel it is interfering with their work or causing distractions. By giving users control over the technology, we can improve user satisfaction and reduce the potential for errors or accidents caused by technology that is not well-suited to a particular task or user.
4. Create instruction sequences that are responsive to the user's natural workflow, avoiding rigid structures that limit adaptability. This principle ensures that the technology is safe and reliable. This means that AR systems should be thoroughly tested and validated before being deployed in a manufacturing environment. Additionally, workers should be trained on how to use the technology safely and effectively, with clear guidelines and procedures in place for handling any issues or malfunctions. By prioritizing safety and reliability, we can minimize the risk of accidents or errors caused by faulty AR technology, while also improving overall productivity and efficiency in manufacturing processes.

These principles emphasize the importance of designing AR technology that works in harmony with human abilities and skills, making it easy to use and understand, providing users with control over the technology, and ensuring that the technology is safe and reliable.

## Feasibility Study

The purpose of this feasibility study is to determine the viability of implementing an Augmented Reality (AR) application for industrial training. This study will examine the potential benefits, drawbacks, and challenges of introducing AR technology into the training process, as well as the necessary hardware and software requirements.

### Technical Feasibility

Technical Feasibility assesses the project's available resources, including hardware, software, and necessary technology, as well as the technical expertise of the team. This analysis provides information on the availability of the required technologies and resources to develop the project. It also examines the viability of using existing technology, the ease of maintaining and upgrading the chosen technology, and other factors.

In this case, the primary development platform for the AR training solution will be Unity 3D, with the Vuforia SDK for AR integration. A database will also be developed to store all the data related to the system. The current development team is a group of interactive software development students proficient in the chosen tools and programming languages, ensuring a smooth development process and seamless integration of the new AR features into the existing system. The hardware specifications of the development team meet the requirements for developing the AR solution.

Considering the popularity of Unity 3D and Vuforia SDK, maintenance and future upgrades of the system are expected to be straightforward. The minimum hardware and software requirements for the development process are listed below:

* 1. Hardware Requirements:
     1. Laptop or Desktop with the following requirements:
        1. Intel Core i5-9th Generation, M1 or equivalent
        2. 8GB RAM
        3. 256 GB SSD
        4. Windows 10 64-bit or macOS
  2. Software
     1. Unity 3D
     2. Vuforia SDK
     3. 3D Modeling software (e.g., Blender, Maya)
     4. Android Studio or Xcode for platform-specific development (if required)

These specifications ensure that the development team has the necessary resources to successfully develop, implement, and maintain the AR training solution.

### Operational Feasibility

Operational feasibility examines how well a proposed AR training solution will meet the organization's needs and how easy it will be to use and maintain after deployment. Additionally, this assessment includes evaluating the product's usability, compatibility with existing systems, and the suitability of the development team's proposed solution.

Since the AR training solution will be developed using widely adopted tools and platforms like Unity and Vuforia, it is expected that it will be easy to maintain and use by the organization's staff. The user interface will be designed with simplicity in mind, ensuring that users can quickly learn and navigate through the system without extensive guidance. Moreover, the system can be maintained and used across various hardware and software configurations, as outlined below:

* 1. Hardware to operate and maintain the system
     1. Android Tablets (approximately 10 inches in size)
     2. Head-Mounted Displays (HMDs) or Smart Glasses (optional)
  2. Software to maintain and develop the system
     1. Unity and Vuforia for AR content creation
     2. 3D Modeling software such as Blender or Autodesk Maya
     3. Android Studio for mobile app development (if required)
  3. Software to operate the system
     1. Android OS for tablets or other compatible devices
     2. AR-enabled apps or web-based platforms for accessing AR content

The operational feasibility of the AR training solution is further enhanced by its compatibility with the organization's existing infrastructure and systems. By utilizing widely used software platforms and tools, the proposed solution can be easily integrated into the current workflow, minimizing disruptions to the organization's operations. Overall, the AR training solution presents a feasible and user-friendly option for improving industrial training processes.

### Economic Feasibility

In the economic feasibility study, the costs and benefits of implementing an AR training solution are analyzed. This entails conducting a detailed analysis of the costs associated with the project's development, which includes expenses for hardware and software resources, design and development costs, and operational costs. The analysis also evaluates whether the project will bring financial benefits to the organization.

The development cost for the AR training solution will likely be low, as the development team can use their own laptops, and software platforms such as Unity and Vuforia can be acquired at minimal or no cost. The design and development will be carried out by the development team, which may include students working on a final year project, further reducing costs. The operational costs to run the system include:

* 1. Hardware to operate and maintain the system
     1. Android Tablets
     2. Servers to host AR content and mobile application services
  2. Software to maintain and develop the system
     1. Unity and Vuforia for AR content creation
     2. 3D Modeling software such as
  3. Software to operate the system
     1. Android emulators of devices that supports features like camera and GPS etc.

Most of the required software can be used on a free version. Therefore, the only costs will be the factory on purchasing tablet devices as the PIC interviewed had shared about that they prefer an Android tablet that is physically sized around 10 inches.

## Review on Quizzing

### Benefits of Quizzing

[21] highlighted that tests can not only enhance students' existing knowledge but also stimulate their curiosity to explore new topics. An end-of-course test serves as a comprehensive evaluation, while mini-tests at the end of each section help review crucial points before introducing new material. Mini-tests are particularly useful in ensuring students have effectively grasped the information before progressing to the next section. Motivation, as the study points out, is the "why" or the reason behind learning, whereas engagement is typically the "what." To encourage student engagement, incorporating tests can be an effective approach, as they prompt students to actively interact with the content. During a test, students are required to think critically, delve deeper, and ultimately become proactive participants in the learning process.

## Chapter Summary and Evaluation

In conclusion, this chapter discussed the implementation of Augmented Reality (AR) in industries, focusing on its applications, factors and impacts, challenges and principles, and a feasibility study. The applications of AR span various industries, including maintenance, training, and edutainment. The factors and impacts of implementing AR were reviewed, with benefits such as increased productivity, reduced costs, and enhanced human-machine interaction. However, drawbacks like decreased situational awareness and technical challenges were also discussed. The challenges and principles of applying AR into the industry were highlighted, addressing the need for realistic expectations, worker acceptance, familiarity with digital technologies, and task-tech fit. A feasibility study was conducted to assess the technical, operational, and economic feasibility of implementing an AR application for industrial training, concluding that the proposed solution is a viable and user-friendly option for improving industrial training processes. Finally, the benefits of quizzing were briefly discussed, emphasizing its role in enhancing knowledge, stimulating curiosity, and promoting engagement.

Chapter 3

Methodology and Requirements Analysis

# Methodology and Requirements Analysis

A short introduction that describes what will be included in this chapter.

IMPORTANT NOTE TO STUDENTS: In this chapter, all requirements must be clearly spelt out, either in text or illustrations (diagrams / models).

## Sub-section 1 Heading

Sub-sections should be used to divide the chapter into logical parts.

### Sub-subsection Heading

Sub-section numbering should be limited to a maximum of 3 levels (e.g. 3.3.1) in order to avoid confusion.

## Sub-section 2 Heading

## Chapter Summary and Evaluation

*At the end of each chapter, evaluate the contents stated or discussed in the relevant sub-sections.*

Chapter 4

System Design

# System Design

A short introduction that describes what will be included in this chapter.

IMPORTANT NOTES TO STUDENTS:

* In this chapter, the design\* of the system must be illustrated/**updated according to what have been actually implemented.** (\*examples: use cases, flowcharts, class diagrams, state chart)
* For communication protocol and architecture: list the protocol used; illustrate the architecture among servers and clients
* MQTT Command List and Description (if applicable): List all the values used in the project, with descriptions. e.g. F016000001F017000001F018000003
* Algorithms: Explain the algorithms used in the program

## Sub-section 1 Heading

Sub-sections should be used to divide the chapter into logical parts.

### Sub-subsection Heading

Sub-section numbering should be limited to a maximum of 3 levels (e.g. 4.3.1) in order to avoid confusion.

## Sub-section 2 Heading

…

## Chapter Summary and Evaluation

*At the end of each chapter, evaluate the contents stated or discussed in the relevant sub-sections.*

Chapter 5

Implementation and Testing

# Implementation and Testing

A short introduction that describes what will be included in this chapter.

IMPORTANT NOTE TO STUDENTS: Include details about:

* **Implementation**

A detailed description of how you actually carried out the implementation (e.g., coding, etc.) of your system/prototype.

* Include code snippets and descriptions to show how the requirements of the application/prototype have been met –
  + For Smart Campus projects, code snippets of the MQTT protocol for both client side and server side has to be included with explanation.
* Include descriptions of important settings - Setting for server, network protocol, IP, database, security
* Note: this should **not** be a chronological account of the work you carried out.
* **Testing**

All test cases that have been carried out must be provided - To tabulate the test cases in tables

Note: Students may also opt to split Implementation and Testing into 2 separate chapters.

## Sub-section 1 Heading

Sub-sections should be used to divide the chapter into logical parts.

### Sub-subsection Heading

Sub-section numbering should be limited to a maximum of 3 levels (e.g. 5.3.1) in order to avoid confusion.

## Sub-section 2 Heading

## Sub-section 1 Heading

Sub-sections should be used to divide the chapter into logical parts.

### Sub-subsection Heading

Sub-section numbering should be limited to a maximum of 3 levels (e.g. 5.3.1) in order to avoid confusion.

## Sub-section 1 Heading

Sub-sections should be used to divide the chapter into logical parts.

### Sub-subsection Heading

Sub-section numbering should be limited to a maximum of 3 levels (e.g. 5.3.1) in order to avoid confusion.

## Chapter Summary and Evaluation

*At the end of each chapter, evaluate the contents stated or discussed in the relevant sub-sections.*

Chapter 6 *(if applicable)*

System Deployment

# System Deployment

This chapter would be applicable for students who have embarked on a real-life industrial project. Students in this case would need to describe how the deployment has been carried out. Some of implementation tasks which need to be described include: training, file conversion or creation, and changeovers.

## System Backup and Risk Management

Describe the procedures to backup the existing system for changeover purpose. Discuss the potential risk(s) for the changeovers and the solution.

## On-site Setup

Describe the preparations to be done prior to the setup of the new system on client’s site. Discuss the procedures to setup the new system, schedule, etc.

## Training Procedure

Describe the procedures on the training procedures, contents, schedule, etc.

## Follow-up

Describe the plan or procedures to follow up with the client (company) to verify the system reliability.

## Chapter Summary and Evaluation

*At the end of each chapter, evaluate the contents stated or discussed in the relevant sub-sections. For example,*

* Problems faced. Describe the various problems faced by students in the course of doing the project.
* Solutions. What have been done to solve the problems?
* What tools and techniques have been used and reasons for using them.

Chapter 7

Discussions and Conclusion

# Discussions and Conclusion

Each student is required to make an *evaluation of the project* he/she has embarked on. The project evaluation may include the following sections.

IMPORTANT NOTE TO STUDENTS: In this chapter, for problems related to code, hardware, internet connection, etc (where applicable):

* + List the technical problems faced and state how they were resolved
  + List the unsolved technical problems for future enhancement
  + List the achieved objectives/modules
  + List the incomplete parts for future enhancement - this is regardless the parts listed in the pre-determined scope. Suggestions for future improvement

## Summary

Summarize the project including the problem and proposed solutions, justification of the choice of tools, techniques and methodologies used in this project.

## Achievements

Students are required to evaluate the project’s achievement against project objectives, completion of the project, students’ view of the strengths and weaknesses of the work done.

## Contributions

Discuss the creativity, innovativeness, contribution of the proposed system. Explain why the proposed system is necessary. Describe the marketability of the system.

## Limitations and Future Improvements

Identify the limitations of the research or project. Provide suggestions for improvement or further development of the system or research in the future.

## Issues and Solutions

Students are required to describe the various problems faced by students during the project development and explain what has been done to solve the problems. The valuable experiences gained or lessons learnt through the project as a whole. The issues may include technical issues, project management issues, team dynamics problems, and other difficulties encountered and lessons learnt. How the issues are solved or can be solved to ensure the project can be completed on time or to be improved in the future.

# References

1. (2020) *NATIONAL FOURTH INDUSTRIAL REVOLUTION (4IR) POLICY*. ECONOMIC PLANNING UNIT, PRIME MINISTER’S DEPARTMENT OF MALAYSIA. Available at: https://www.epu.gov.my/sites/default/files/2021-07/National-4IR-Policy.pdf (Accessed: March 10, 2023).
2. Maximilian Speicher University of Michigan & C&A Europe *et al.* (2019) *What is mixed reality? Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, *ACM Conferences*. Available at: https://dl.acm.org/doi/10.1145/3290605.3300767 (Accessed: March 10, 2023).
3. *Mixed reality in education, entertainment, and training* (no date). Available at: https://www.researchgate.net/publication/7454465\_Mixed\_Reality\_in\_Education\_Entertainment\_and\_Training (Accessed: March 10, 2023).
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5. Gangabissoon, T., Bekaroo, G. and Moedeen, W. (2020) “Application of augmented reality in aviation,” *Proceedings of the 2nd International Conference on Intelligent and Innovative Computing Applications* [Preprint]. Available at: https://doi.org/10.1145/3415088.3415120.
6. Aziz, F.A. (no date) *Augmented reality: Capabilities and challenges in machining industry aligned with industry 4.0*, *Taylor & Francis*. Available at: https://www.tandfonline.com/doi/full/10.1080/2374068X.2020.1793269 (Accessed: March 12, 2023).
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13. <https://www.ibm.com/my-en/topics/industry-4-0>
14. <https://www.salesforce.com/blog/what-is-the-fourth-industrial-revolution-4ir/>
15. .
16. <https://kjcf.net/home-mobile/>

Appendices

In order to enhance better understanding of the project, students should as far as possible include all directly relevant materials, figures or diagrams in the **main body** rather than in the Appendix. The appendix is reserved only for items which may not directly be relevant or essential to enhance a reader’s understanding of the project, or which may interrupt the smooth reading of the project document (for example being too voluminous).

Appendices should only include supportive materials **directly referred** to in the writing and should be kept to a **minimum**, e.g. selected pages of an annual report, not the entire document. Examples of items included in Appendices are:

* Company’s report and documentation, such as sample invoice, purchase order form, etc.
* Project meeting documentation e.g. minutes of meetings, tracking documents, memos etc.
* Questionnaires and results, interview questions and results, pilot test and results, observation sheet and results, experiment test plan and results, etc.
* Analysis/design diagrams (only those not incorporated in the main body of the report).

If there is more than one appendix, they should be identified as A, B, etc (e.g. Appendix A). Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

IMPORTANT NOTE TO STUDENTS

**APPENDIX *n* User Guide**

* List the username and password of multiple roles (if applicable)
* Provide clear screen shots of each page, explain the functions of each button

As a rough guide, the user guide should include the following sections:

|  |
| --- |
| **System Document**  In this section, students should provide the following pieces of information:   * **System (hardware and software requirements)**. Students should describe the minimum hardware and software requirements to install the software application which has been developed by the students, for example, DBMS, OS, program development tools etc. * **Installation**. Under this section, students should create an ‘installation’ CD and provide a brief step-by-step guide on how a new user can install the software on a computer system. Students should indicate any special setup information, such as the specific location of placing the database files, the SQL statements to add tables, etc. Software source code should also be included in this CD. Students are not required to print out the software code.   **Operation Document**  Under this section, students are required to provide a brief step-by-step guide on how to use the installed software. The guides should teach the user how to run the software and use its major functions and features. For example, steps show guide the users on how to run the system, e.g. to use an executable file or to use the IDE. The login information such as username and password for each of the different users (or roles) must be provided. Some screen interfaces would be useful. |

**APPENDIX *n+1* Developer Guide\***

\*To be included for ***Smart Campus Projects*** and ***Real-Life Projects***. This section should include the following:

* List the necessary software, installer, API, library that must be installed
* List the authentication details, such as username and password for all security

**Other Appendices:**

* + Supporting documents
  + Non-disclosure agreement (if applicable)
  + Other detailed documentation, such as important references, interview results, survey results, etc.

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