



**Sentiment Analysis of Product Reviews using Machine Learning**

**By**

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## ABSTRACT

Sentiment analysis, also referred to as opinion mining, is a process of analyzing text data to extract subjective information hidden within the data, such as emotions, opinions, and attitudes, from text data. Currently, it is a popular area of research in Natural Language Processing (NLP) and has numerous practical applications, including the analysis of customer reviews for products. In this project, a machine learning technique called DistilBERT, distilled version of Bidirectional Encoder Representations from Transformers, was fine-tuned with an Amazon dataset of product reviews to develop a sentiment analysis model. The developed model will then be embedded in a proposed product review web application to perform sentiment analysis on the existing customer's reviews and show the analysis results to users. This project will provide insights into the effectiveness of the machine learning approach for sentiment analysis and may be helpful for businesses seeking to gauge the public perception of their products and potential customers looking for a product with better quality and seller services.

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## CHAPTER 1: INTRODUCTION TO THE STUDY

### 1.1 Background to the Project

The digital revolution and the growth of the Internet have changed the way of purchasing items. Online shopping has become the latest trend bringing up the e-commerce business and creating a new worldwide electronic commerce (e-commerce) market, mainly targeting the younger generation. The transformation from physical cash to online transactions also stimulates the development of online shopping platforms. The number of online shopping users keeps increasing year by year, as well as e-commerce sales. Statista Research Department (2022) states that the United States had 256 million online shopping users in 2020, estimated to reach 291.2 million in 2025.

Since the advent of e-commerce, the market has been completely transformed, making it easier to discover and purchase products from around the globe. Compared to the physical store, the online shopping platform provides massive commodity information, assisting customers in making comparisons among different sellers. For example, the famous footwear manufacturing companies Nike and Skechers have their official online stores on the Lazada online shopping platform. Customers can browse the shoes on Lazada and compare these two companies instead of visiting the physical retail shops a few distances from their living places. They can enjoy the comfort and convenience of online shopping as the courier will send their purchased shoes from door to door.

E-commerce keeps growing because people nowadays tend to seek faster speed and higher quality in every aspect. Hence, product reviews play an essential role in ensuring product quality. The product review will summarize the clients' opinions of their purchase experience, including the evaluation of products according to their characteristics. A product with high ratings consists of many favorable comments that the buyers express their satisfaction with the product quality. On the other hand, the clients provide negative feedback for the low-quality product resulting in low user experience ratings posted on online shopping platforms. Product reviews help provide better insight into the product, and the potential customer can expect the product quality they will get. As a result, a good reputation from the product reviews will bring more customers to visit their stores and check out their products.

Besides, the product review feature is able to prevent digital criminal activities, called cybercrime. Currently, criminal activities also undergo digital transformation, transforming

into the virtual environment and conning buyers out of their savings. New Straits Times reported that Malaysians had lost about RM58 million due to online shopping scams in 2021 (Kalbana Perimbanayagam, 2021). The scammer pretended to be a legitimate seller on the online shopping platform and delivered products that were different from the customer's expectations, or customers would receive nothing after they paid. The product review function provides opportunities for customers to comment on the product and give their ratings after using it. With this insightful information, potential customers will be able to make better buying decisions and avoid getting into online shopping scams by checking out user feedback.

From the business perspective, product reviews also assist e-commerce businesses in building their reputation as positive feedback from clients will attract other potential customers to choose their products. The positive online reviews offer a business the advantages a simple marketing campaign cannot provide. They are more to the micro-marketing campaign that continues to work long when the customer feedback has been posted online, being a constant source of brand awareness to present a positive image to potential customers (Marketou, 2018).

Apart from that, e-commerce businesses are able to gain a better insight into their products by analyzing product reviews. The analysis result will help businesses better understand the customer requirements and preferences to develop a strategic business plan for the upcoming project. By collecting and evaluating the client satisfaction data, businesses can also improve their customer service as they will realize the issues customers encounter and rapidly resolve the problems (Marketou, 2018). Therefore, the sentiment analysis of the product reviews is vital in tailoring products and services to meet the client's needs. Sentiment analysis, a subcategory of Natural Language Processing (NLP), is implemented to conduct analysis on textual data and classify the data into positive, neutral, or negative statements. In this project, the sentiment analysis machine learning model will be embedded in the proposed product review analysis system to analyze customer feedback automatically.

When more and more clients buy the products and share their experiences, there comes a problem that the feedback will overflow the product review page resulting in online platform users feeling bewildered by the sheer variety of customer reviews. Hence, the proposed product review analysis system will also help categorize the extensive product reviews.

## 1.2 Problem Statements

One of the main reasons that affect the customers' online product purchase decisions is the opinions of other customers (Kumar et al., 2018). The product review is able to help potential customers decrease the purchase risk and the search cost while making decisions (Wang et al., 2020). A lack of product reviews will cause an "unknown" for the specific product. Without the other customer's evaluation, it would be challenging for potential customers to build trust towards the product. Today's customers tend to make purchase decisions based on the review score information given by the current users instead of the product descriptions offered by the sellers (Camilleri, 2020). Hence, it is crucial to provide a platform including the product feedback features for e-commerce businesses and their customers.

According to the research by Xun Xu (2021), the increasing number of product reviews will encourage customers' behaviors regarding leaving their own feedback. Day after day, it generates an enormous amount of publicly available data that leads to cluttered information of the product reviews. However, the existing literature on online reviews has highlighted that variants of product reviews could confuse customers in decision-making as it is hard to distinguish the product attributes according to customers' preferences (Wang & Wang, 2020). Categorizing the messy user feedback according to the product features can assist the customer in finding their preferences directly and ease the process of comparing with other brands. For example, a customer looking for a longer-lasting smartphone can filter the user feedback to show only the comments relevant to the battery life.

Millions of online reviews are posted daily to represent the latest consumer preference trends. Most prospective buyers will view the product reviews related to product quality and its ease-of-use regarded with the consumer emotions or attitudes before making the purchase decisions (Jang et al., 2021). Zablocki (2019) and his research team found that emotional feedback has a more significant effect on determining customer preference than informational feedback. Positive emotional comments, such as excitement and happiness, considerably improve the general attitude about a product (Zablocki et al., 2019). Sentiment analysis distinguishing the comments into positive, negative, or neutral words is a natural language processing (NLP) technique to better understand customer preferences (Birjali et al., 2021). Analyzing and displaying the polarity of user emotions towards the products will increase the potential customer's confidence during their purchase.

From the business perspective, manually analyzing the product reviews requires human resources, which are limited and easily prone to human error. Besides, a human may make conflicting decisions while processing large amounts of data, leading to inaccurate analysis results. In contrast, these repetitive tasks can be performed by Artificial Intelligence that achieves low management cost and short analyzing time compared to human beings (Bhbosale et al., 2020; Pallathadka et al., 2021). Through implementing sentiment analysis in an online shopping platform, it will provide a business with better insight into their products by classifying the polarity of the product reviews (Ireland & Liu, 2018).

### 1.3 Rationale

Compounding with the problem context, the proposed end product will be a web-based Product Review Analysis System offering two primary usages and advantages. First and foremost, the system will be a platform for connecting e-commerce businesses with their customers. Businesses can collect customer feedback to help develop a strategic business plan for improving their products and services. Besides, they can improve their brand reputation and credibility of reliable services when more customers positively review their products and services. As a result, customer satisfaction will be achieved to maintain the business's competitive advantage. From the customer perspective, they can make their voices heard by the businesses and potential customers by telling them about their user experience through the product review feature. Classifying the comments into different categories allows potential customers to focus on the topic that they are concerning. By having the feedback from existing customers, the potential customer is able to make their purchase decision confidently and precisely.

Secondly, the embedded sentiment analysis model accepts the paragraphs or sentences as input. The input will go through the data pre-processing and will be broken into pieces of words. Each word will be proceeded with the sentiment analysis algorithm and return the polarity score as the output. The result will then be visualized as a graphical representation of the insightful information. Apart from product reviews on online shopping platforms, the designed sentiment analysis model can also accept different datasets as input for analyzing user behavior, such as opinions shared on social media, ideas shared on forums, and articles posted in newspapers. By feeding suitable datasets for training the classifier, it can contribute to various fields of application: from the stock market to tourism; from healthcare to the election (Abualigah et al., 2019; Bansal & Srivastava, 2018; Mohan et al., 2019; Zvarevashe & Olugbara, 2018). By utilizing sentiment analysis, it will avoid the wastage of human resources for classifying the large quantity of data and reduce human error while performing the monotonous, repetitive, time-consuming tasks in order to produce a more accurate finding effectively (Kaličanin et al., 2019). Compared with lexicon-based sentiment analysis techniques, the machine learning algorithm can achieve higher accuracy and eliminate the shortcomings of manually labeling a few documents (Britzolakis et al., 2020).

## 1.4 Potential Benefits

The primary goal of the proposed system is to analyse the sentiment analysis of the product reviews and display the graphical representation of the insightful information. The advantages of this project are divided into two main categories, tangible and intangible benefits, which are described as the following:

### 1.4.1 Tangible Benefits

- Reduction of business employees' workload as the system can deliver the result of sentiment analysis automatically.
- Eliminate human error caused by traditional, manual analytical methods.
- Increase the product sales as the positive reviews will bring more customers to purchase the item.
- Resource cost saving by minimizing the needs of business analyst team in analyzing the product reviews due to natural language processing technique adoption.
- Savings on analyzing time where employees do not have to label the massive amount of data as a positive, neutral, or negative comment.
- Cutting losses of customers since the online shopping scams will be decreased.

### 1.4.2 Intangible Benefits

- Increase customer satisfaction by providing a platform for expressing their feedback to the e-commerce business.
- Improve user experience where the product reviews are classified and labeled as positive, neutral, or negative feedback.
- Bolster customers' confidence in the decision-making process while comparing the products from different online retailers.
- Facilitate the development of a strategic business plan according to sentiment analysis results on product reviews.

## 1.5 Target Users

The primary users of the proposed product review analysis system will be targeted e-commerce businesses and shoppers on the online shopping platform. However, the embedded sentiment analysis machine learning model is suitable for any individual who wants to analyze the sentiments from the product reviews, especially from the aspects of data sciences, sales and marketing, and customer service. E-commerce businesses can utilize the product review analysis system to optimize the decision-making when proposing a new product, designing a marketing campaign, and communicating with customers. The proposed system is also helpful for data analysts and scientists who desire to research online shopper user behavior.

## 1.6 Scope and Objectives

### 1.6.1 Aim

To develop a product review analysis system that is able to extract the information from words, sentences, or paragraphs by existing customers and classify the polarity of the information, which would provide e-commerce businesses with better insight into their products and optimize potential customers' decision-making.

### 1.6.2 Objectives

1. To investigate and compare the existing machine learning algorithms implemented for developing a sentiment analysis model.
2. To apply text analysis technique in data pre-processing to transform the raw data into the correct format.
3. To propose rules for determining sentiments of product reviews according to the product characteristics.
4. To integrate a machine learning model into a web application for analyzing the customer reviews and rating the products.

### 1.6.3 Deliverables

The proposed Product Review Analysis System will be a web application that enables current product users to review the product, assists potential customers in decision-making, and helps businesses enhance their products and customer services. The application will include a pre-trained sentiment analysis model using the Amazon product review dataset to classify the product reviews according to their polarity.

The target users of the Product Review Analysis System are:

1. E-commerce businesses
2. Customers

The business-end Product Review Analysis System will include the following functions:

- Allow businesses to register themselves as a business
- Allow businesses to login the system with the correct email and password
- Allow businesses to logout from the system

- Allow businesses to add, edit, and delete the product on their pages
- Allow businesses to manage the review tags for the product
- Allow businesses to view product feedback provided by existing customers
- Allow businesses to filter the product reviews based on the review tags
- Allow businesses to view the bar chart showing the proportion of positive, neutral, and negative feedback based on the chosen product review tag

The customer-end Product Review Analysis System will include the following functions:

- Allow customers to register themselves as a customer
- Allow customers to login the system with the correct email and password
- Allow customers to logout from the system
- Allow customers to search for a product based on its name or the company name
- Allow customers to comment on the product and choose tags for their comments
- Allow customers to view product feedback provided by existing customers
- Allow customers to filter the product reviews based on the review tags
- Allow customers to view the bar chart showing the proportion of positive, neutral, and negative feedback based on the chosen product review tag

The following deliverables are the extra features of the Product Review Analysis System that will be developed if time permits:

- Allow customers to upvote or downvote the product reviews
- Allow businesses to reply to the product reviews

#### 1.6.4 Nature of Challenges

While developing the proposed system, the developer will encounter a series of challenges that are required to be solved in order to produce satisfactory system quality, achieve the project objectives, and satisfy the end-user requirements. By defining the factors that may affect the project's success at the early stage, the project failure risk will be decreased, and the success rate will be increased. First and foremost, developing a sentiment-based product review analysis system would be a new challenge for the developer. Having intermediate programming skills is not enough to complete the project. The developer ought to enhance the programming level by continuously practicing self-learning with the correct learning goals and appropriate resources throughout the system development process. The required knowledge for building a web application is Java, while Python is the necessary technique for developing a sentiment analysis model. The integration of multiple programming languages is needed to be carried out to meet the proposed system scope.

Apart from the coding skill, the developer has to encounter the complex machine learning algorithm and Natural Language Processing libraries. Due to the lack of exploring the sentiment analysis technique, it will be a new experience for the developer to build a model with high accuracy, low bias, and acceptable levels of variances. Therefore, the developer must conduct massive research when choosing the suitable dataset and implementing the appropriate machine learning algorithm in the proposed system.

Besides, word ambiguity is one of the challenges in sentiment analysis when classifying the sentence's polarity. A single word can have multiple meanings depending on its usage in the sentence and the domain area. For example, the term 'return' in the banking industry might mean the amount of made profit that leads to a positive label. Conversely, from the retail sector, 'return' means giving back something interpreting a damaged product to the seller resulting in a negative label. Without the appropriate context, the machine learning model will face obstacles while performing sentiment analysis in product reviews that contribute to incorrect language interpretation.

Furthermore, some customers will provide their feedback with sarcastic remarks. From the sentence's literal meaning, the trained sentiment analysis model will not get the impression that the customer was being ironical. For example, the statement "the bed is super comfortable that I feel like lying on the floor" will provide a false impression resulting in positive feedback

as the phrase "super comfortable" on the surface seems that the customer was leaving a good review. However, by connecting with the context "I feel like lying on the floor," the user is obviously expressing frustration about the product quality using sarcasm. This type of comment makes the sentiment analysing process more challenging to label the polarity of the sentence.

## 1.7 Overview of This Report

This Final Year Project (FYP) report is divided into 11 chapters, including deep research conducted intensively by the developer. Each chapter represents the essential elements and information required during the project development phase. A detailed overview of the seven chapters is provided as the following:

### **Chapter 1: Introduction to Study**

It is the beginning of the report that introduces the overall project in terms of background information, problem statements, justification of chosen solution, potential benefits, system target users, project aim and objectives, system functionality, and the possible challenges during the project development.

### **Chapter 2: Literature Review**

This section will investigate various earlier works of other researchers related to the proposed system in this FYP report. The literature review is divided into domain research and similar systems. Domain research will include the impact of the problem statement, the importance of sentiment analysis, and the algorithms used for performing sentiment analysis. The developer will also conduct a literature review on the market available systems that are similar to the proposed system.

### **Chapter 3: Technical Research**

A developer must first prepare the tools and techniques if he wishes to develop a successful system. Technical research is the chapter that defines the technical resources that are currently accessible on the market and choose the best resource that suits developer the most after comparing their characteristics.

### **Chapter 4: System Development Methodology**

Every Information Technology (IT) project comes with a system development methodology to monitor the project development and delivery processes. In this chapter, the researcher will compare different methodologies in terms of their mechanism and characteristics. One of them will be chosen as the proposed system development methodology for the second half of FYP, which is the project's implementation stage.

## **Chapter 5: Research Methods**

This chapter will carry out the data collection technique that the developer implemented to gather the project's end-user requirements. The question designs will also be included in this section, along with the justification of each question's intended usage.

## **Chapter 6: Requirements Validation**

The developer will analyze and evaluate the responses according to the selected data collection approach defined in Chapter 5. This chapter's primary purpose is to define the project's requirements from the end-user side clearly.

## **Chapter 7: System Architecture**

This chapter will contain planned system architecture, including system, database, and user interface design, with various diagrams, such as a use case diagram, class diagram, entity relationship diagram, and others.

## **Chapter 8: Project Plan**

Release plan details and project test plan templates will be included in this chapter as project plans. After releasing the final version of the system, the developer will conduct the test plan and provide the test results in Chapter 10.

## **Chapter 9: Implementation**

The developer will provide the source code explanation in this chapter. Besides, an overview of the connection and integration among the web application, database, and machine learning model will be explained.

## **Chapter 10: System Validation**

The system validation chapter consists of the test results of unit testing, model performance testing, and user acceptance test planned in Chapter 8.

## **Chapter 11: Conclusion and Reflections**

This is the final section that includes the summary and evaluation of the Final Year Project. Besides, it also consists of the limitations of the research and the possible improvement in the future.

## 1.8 Project Plan

| SEMESTER 1 PROJECT PLAN |  |          |            |           |           |
|-------------------------|--|----------|------------|-----------|-----------|
| TASK ID                 | TASK NAME  | DURATION | START DATE | END DATE  | STATUS    |
| WBS-C1                  | Project Proposal Form (PPF)                      | 12-days  | 23-May-22  | 3-Jun-22  | Completed |
| WBS-C2                  | Project Specification Form (PSF)                 | 27-days  | 6-Jun-22   | 2-Jul-22  | Completed |
| WBS-C3                  | Investigation Report (IR)                        | 38-days  | 4-Jul-22   | 9-Aug-22  | Completed |
| WBS-C3-1                | Chapter 1: Introduction to the Study             | 5-days   | 4-Jul-22   | 8-Jul-22  | Completed |
| WBS-C3-1-1              | Background to the project                        | 4-hours  | 4-Jul-22   | 4-Jul-22  | Completed |
| WBS-C3-1-2              | Problem statements                               | 4-hours  | 4-Jul-22   | 4-Jul-22  | Completed |
| WBS-C3-1-3              | Rationale  | 3-hours  | 5-Jul-22   | 5-Jul-22  | Completed |
| WBS-C3-1-4              | Tangible Benefits                                | 2-hours  | 5-Jul-22   | 5-Jul-22  | Completed |
| WBS-C3-1-5              | Intangible Benefits                              | 2-hours  | 5-Jul-22   | 5-Jul-22  | Completed |
| WBS-C3-1-6              | Target Users                                     | 1-hour   | 6-Jul-22   | 6-Jul-22  | Completed |
| WBS-C3-1-7              | Aim  | 1-hour   | 6-Jul-22   | 6-Jul-22  | Completed |
| WBS-C3-1-8              | Objectives                                       | 1-hour   | 6-Jul-22   | 6-Jul-22  | Completed |
| WBS-C3-1-9              | Deliverables                                     | 4-hours  | 6-Jul-22   | 6-Jul-22  | Completed |
| WBS-C3-1-10             | Nature of Challenge                              | 1-day    | 7-Jul-22   | 8-Jul-22  | Completed |
| WBS-C3-1-11             | Overview of Investigation Report                 | 1-hours  | 8-Jul-22   | 8-Jul-22  | Completed |
| WBS-C3-1-12             | Project Plan                                     | 2-hours  | 8-Jul-22   | 8-Jul-22  | Completed |
| WBS-C3-2                | Chapter 2: Literature Review                     | 12-days  | 9-Jul-22   | 20-Jul-22 | Completed |
| WBS-C3-2-1              | Introduction                                     | 1-day    | 9-Jul-22   | 9-Jul-22  | Completed |
| WBS-C3-2-2              | Domian Research                                  | 5-days   | 10-Jul-22  | 14-Jul-22 | Completed |
| WBS-C3-2-3              | Similar Systems                                  | 5-days   | 15-Jul-22  | 19-Jul-22 | Completed |
| WBS-C3-2-4              | Summary  | 1-day    | 20-Jul-22  | 20-Jul-22 | Completed |
| WBS-C3-3                | Chapter 3: Technical Research                    | 5-days   | 21-Jul-22  | 25-Jul-22 | Completed |
| WBS-C3-3-1              | Programming Language Chosen                      | 1-day    | 21-Jul-22  | 21-Jul-22 | Completed |
| WBS-C3-3-2              | IDE (Interactive Development Environment) Chosen | 4-hours  | 22-Jul-22  | 22-Jul-22 | Completed |
| WBS-C3-3-3              | Libraries Chosen / Tools Chosen                  | 3-hours  | 22-Jul-22  | 22-Jul-22 | Completed |
| WBS-C3-3-4              | Database Management System Chosen                | 5-hours  | 23-Jul-22  | 23-Jul-22 | Completed |
| WBS-C3-3-5              | Operating System Chosen                          | 2-hours  | 23-Jul-22  | 23-Jul-22 | Completed |
| WBS-C3-3-6              | Web Server Chosen                                | 1-day    | 24-Jul-22  | 24-Jul-22 | Completed |
| WBS-C3-3-7              | Web Browser Chosen                               | 3-hours  | 25-Jul-22  | 25-Jul-22 | Completed |
| WBS-C3-3-8              | Summary  | 1-hour   | 25-Jul-22  | 25-Jul-22 | Completed |
| WBS-C3-4                | Chapter 4: System Development Methodology        | 4-days   | 26-Jul-22  | 29-Jul-22 | Completed |
| WBS-C3-4-1              | Comparison of Methodology                        | 5-hours  | 26-Jul-22  | 26-Jul-22 | Completed |
| WBS-C3-4-2              | Justification                                    | 3-hours  | 26-Jul-22  | 26-Jul-22 | Completed |
| WBS-C3-4-3              | Description of SCRUM Methodology                 | 1-day    | 27-Jul-22  | 27-Jul-22 | Completed |
| WBS-C3-4-4              | Project Overview with SCRUM Methodology          | 2-days   | 28-Jul-22  | 29-Jul-22 | Completed |
| WBS-C3-5                | Chapter 5: Research Methods                      | 4-days   | 30-Jul-22  | 2-Aug-22  | Completed |
| WBS-C3-5-1              | Introduction                                     | 1-day    | 30-Jul-22  | 30-Jul-22 | Completed |
| WBS-C3-5-2              | Design   | 2-days   | 31-Jul-22  | 1-Aug-22  | Completed |
| WBS-C3-5-3              | Summary  | 1-day    | 2-Aug-22   | 2-Aug-22  | Completed |
| WBS-C3-6                | Chapter 6: Requirements Validation               | 5-days   | 3-Aug-22   | 7-Aug-22  | Completed |
| WBS-C3-6-1              | Analysis of Data Collected through Questionnaire | 4-days   | 3-Aug-22   | 6-Aug-22  | Completed |
| WBS-C3-6-2              | Summary  | 1-day    | 6-Aug-22   | 7-Aug-22  | Completed |
| WBS-C3-7                | Chapter 7: Conclusion and Reflections            | 1-day    | 8-Aug-22   | 9-Aug-22  | Completed |
| WBS-C3-7-1              | Conclusion and Reflections                       | 1-day    | 8-Aug-22   | 9-Aug-22  | Completed |

Figure 1 Project Plan Part 1

| WBS-C4      | Final Year Project (FYP)               | 102-days | 26-Sep-22 | 6-Jan-23  | Completed |
|-------------|--|----------|-----------|-----------|-----------|
| WBS-C4-7    | Chapter 7: System Architecture         | 12-days  | 26-Sep-22 | 6-Oct-22  | Completed |
| WBS-C4-7-1  | Introduction                           | 2-days   | 26-Sep-22 | 27-Sep-22 | Completed |
| WBS-C4-7-2  | Abstract Architecture                  | 10-days  | 28-Sep-22 | 6-Oct-22  | Completed |
| WBS-C4-8    | Chapter 8: Project Plan                | 6-days   | 7-Oct-22  | 13-Oct-22 | Completed |
| WBS-C4-8-1  | Release Plan                           | 2-days   | 7-Oct-22  | 9-Oct-22  | Completed |
| WBS-C4-8-2  | Test Plan                              | 4-days   | 10-Oct-22 | 13-Oct-22 | Completed |
| WBS-C4-9    | Chapter 9: Implementation              | 67-days  | 13-Oct-22 | 19-Dec-22 | Completed |
| WBS-C4-9-1  | Sentiment Analysis Model Development   | 28-days  | 13-Oct-22 | 10-Nov-22 | Completed |
| WBS-C4-9-2  | Web Application Development            | 39-days  | 11-Nov-22 | 19-Dec-22 | Completed |
| WBS-C4-10   | Chapter 10: System Validation          | 14-days  | 20-Dec-22 | 3-Jan-23  | Completed |
| WBS-C4-10-1 | Unit Testing Result                    | 6-days   | 20-Dec-22 | 26-Dec-22 | Completed |
| WBS-C4-10-2 | User Acceptance Testing Result         | 7-days   | 27-Dec-22 | 2-Jan-23  | Completed |
| WBS-C4-10-3 | Summary                                | 1-day    | 3-Jan-23  | 3-Jan-23  | Completed |
| WBS-C4-11   | Chapter 11: Conclusion and Reflections | 3-days   | 4-Jan-23  | 6-Jan-23  | Completed |
| WBS-C4-11-1 | Critical Evaluation                    | 2-days   | 4-Jan-23  | 5-Jan-23  | Completed |
| WBS-C4-11-2 | Conclusion                             | 1-day    | 6-Jan-23  | 6-Jan-23  | Completed |

Figure 2 Project Plan Part 2

## 1.9 Summary

During the introduction section, the developer clearly illustrates the problem background, solution, proposed system's description, advantages, and challenges. The developer is going to develop a product review analysis system embedded with a machine learning model. This system will be capable of performing sentiment analysis on customer feedback and classifying them into positive, neutral, or negative statements. The results will then be displayed to the system users in the graphical representation to provide them with better insight and assist them in decision making. As a result, e-commerce businesses can increase product sales and customer satisfaction, while online shoppers will be more confident when making purchase decisions. During the system development, the developer will encounter the challenges of programming skills, complex machine learning algorithms, and model accuracy as the developer is a beginner in the IT field. Hence, the developer should be hardworking to upskill himself in order to produce an excellent FYP.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 Introduction

This chapter is designed to discuss the literature reviews conducted by the developer. Until today, the research on sentiment analysis has been carried on, and more and more findings have been published. Understanding the available research would allow the developer to understand the pros and cons of each implemented technique, which is essential for the developer to gain insight into the available options for developing the proposed system in order to achieve the highest accuracy and precision. The following sections will discuss several journal papers, academic publications, conference proceedings, books, and online reliable academic resources related to product review analysis features, sentiment classification techniques, and machine learning algorithms.

### 2.2 Domain Research

#### 2.2.1 Impact of Product Reviews on Online Shopping Platforms

Oliveira and his research team (2021) indicate that customer-provided feedback is a method to express their good or bad user experience and the purchase decisions they will make in the future. Accepting customer feedback is one of the marketing strategies to attract online shoppers to browse their web pages and increase the probability of purchasing their products. By establishing interaction with customers, e-commerce businesses can understand customers' needs and handle their complaints to retain the existing customers and attract more potential customers (Oliveira et al., 2021).

According to another research conducted by Wang and his team (2020), online reviews can support product improvement strategies by measuring customer opinions and preferences, which are significant components of customer relationship management. As a result, it benefits manufacturers to fine-tune the existing product problem and satisfy customer requirements through the product's next release. Other than that, the research also mentioned that customer feedback can aids the marketing department in making advertising decisions. Positive reviews that emphasize the product's features and performance will attract customers' attention and improve the company's brand image (Wang et al., 2020).

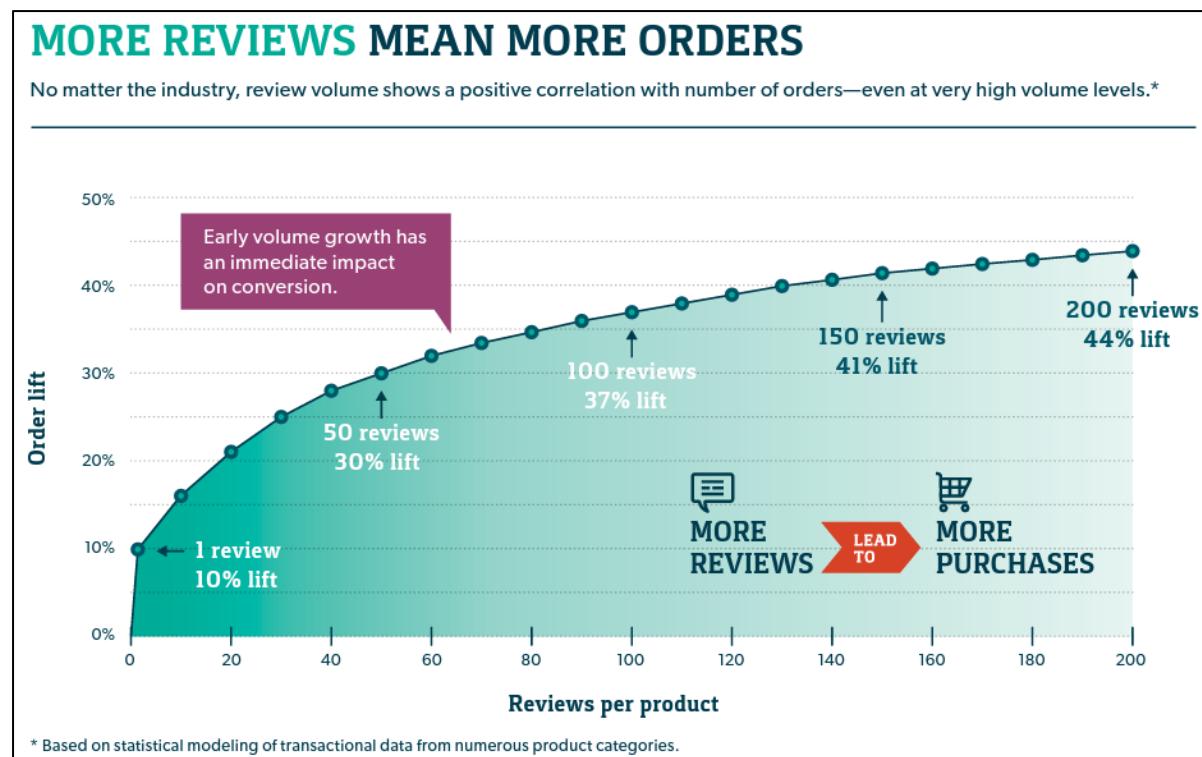


Figure 3 Relationship between Review Volume and Number of Orders (Rodriguez, 2022)

The diagram above indicates that the number of reviews will positively affect the number of purchase orders. For example, a single review will increase sales by 10%. However, there is only a slight rise in the number of orders when the number of reviews is getting higher and higher. It is because the number of reviews is not the only factor affecting the increase in order lift. The findings of Zhao and his research team's (2020) study show that online promotional marketing, seller guarantees, and review system curation also play significant roles in determining online product sales. They also emphasize the importance of product information from existing customer reviews that potential customers pay the most attention to (Zhao et al., 2020).

To break online reviews into deeper, the main factors affecting product sales include the number of feedback, star ratings, rating's standard deviation, helpful votes, review length, reviewer's reputation, and reviewer emotion. Other than review length, all the mentioned factors have positive relationship expectations with the product sales performance (Li et al., 2020). It is proven by the research from Fernandes and his team members (2022), stating the importance of product review source's reliability, the number of ratings and feedback, commented language, and content quality. These factors seriously affected the reputation of the e-commerce businesses. Hence, businesses should lay great stress on their product reviews

and their relationship with customers in order to develop appropriate marketing strategies and maximize company interests.

### **2.2.2 Importance of Sentiment Analysis**

Sentiment Analysis, also referred to as Opinion Mining, is a subcategory of Natural Language Processing (NLP) implemented to recognize and classify opinions expressed in textual format into positive, neutral, or negative statements. Its ultimate goal is to gather insight about the general public and assist people in making decisions. Currently, sentiment analysis is a growing research area that investigates its usage in various applications, such as the healthcare industry, tourist industry, service industry, entertainment industry, and others (Birjali et al., 2021). For instance, sentiment analysis in healthcare can allow researchers to expect insights into the opinions regarding the medications and treatments patients receive, the patient's feelings about their illnesses, and the patient's satisfaction with the hospitals and clinics (Ramírez-Tinoco et al., 2019).

Internet, with fast-paced growth, has made the web become an essential source of publicly accessible digital data, containing structured, semi-structured, and unstructured formats. Hence, the existing research is able to perform sentiment analysis and build a customized machine learning model using different data types, including hotel reviews, movie reviews, tweets, Facebook posts, news and articles, and others (Jagdale et al., 2018). For example, Twitter is a social media platform with 336 million active users, and around 500 million tweets are generated daily. Through the Application Programming Interfaces (APIs) provided by Twitter itself, the researcher and policymaker can easily collect the tweets and profile information for further analysis on the trending topics. As a result, the researcher and policymaker will be able to understand the effect of humans' feelings and opinions on their behaviors and decision makings (Karami et al., 2020).

From the electronic commerce (e-commerce) aspect, the most visited online shopping platforms in Malaysia are Shopee, Lazada, and Lelong (Kiong, 2019). According to the Statista report by Hirschmann (2022), the number of Shopee's web visits has increased from 13.77 million per month in 2018 Quarter 1 to 54.93 million per month in 2022 Quarter 1. The shocking number is far above the Malaysian population, which is only 32.7 million in 2022 (Mohd Yusrizal Ab Razak, 2022). Hence, the massive amount of data generated in e-commerce

daily is enough for e-commerce businesses and researchers to analyze customers' sentiments and understand their behaviors and preferences while shopping online.

The collected data from e-commerce platforms include product descriptions, customer feedback, user complaints, and profile information. However, sentiment analysis will only proceed with the data in textual format and will primarily be implemented in product reviews by classifying them into positive, negative, and neutral feedback. Review analysis can assist e-commerce businesses and researchers in tapping into the customer base and understanding their requirements and expectations of the desired products. E-commerce businesses also can gain ideas for business strategies, assisting them in maintaining product quality and fulfilling customer requirements (Vanaja & Belwal, 2018). Furthermore, the e-commerce marketing team can improve their marketing strategies and policies, helping the company to expand the customer base and reach more potential customers (Jabbar et al., 2019). Enhancing both business and marketing strategies will bring more revenue and increase sales, leading to growing and expanding the business.

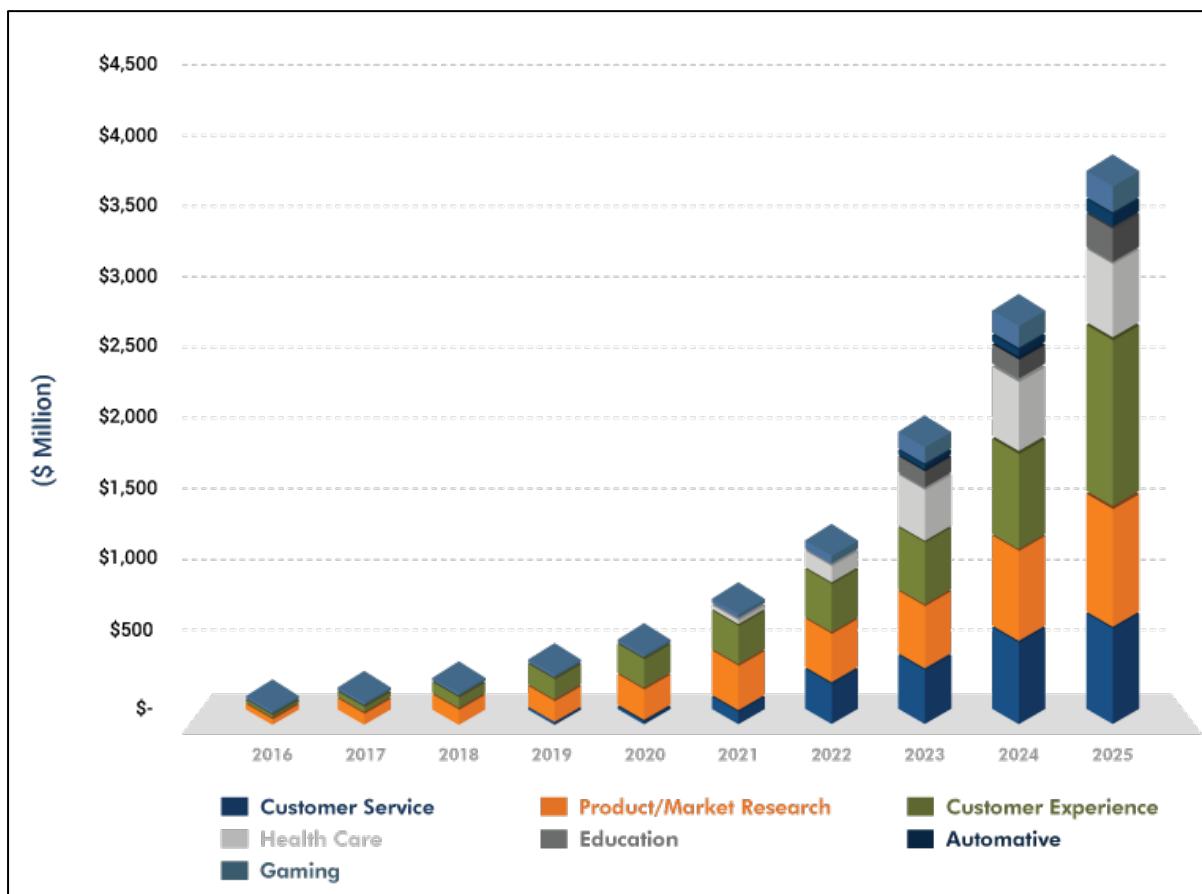


Figure 4 Sentiment Analysis-based Software Revenue by Use Case Category (QASource, 2019)

From the diagram above, it is obvious to know the growing trends of sentiment and emotion analysis-based software. The profits provided by this software keep increasing year by year, and it is expected to reach 3.8 billion U.S. dollars by the year 2025 (QASource, 2019). Therefore, sentiment analysis-based products have great potential in the current market, especially in the customer experience and product/market research aspects, as both of these fields bring the most revenue to the companies providing sentiment analysis services. As a result, the expanding sentiment analysis market not only brings revenue to the software companies but also helps their clients increase sales by achieving higher customer satisfaction with improved products based on the analysis results.

Currently, many IT companies are providing the sentiment analysis tools, such as Google, Amazon, Microsoft, MonkeyLearn, Lexalytics, and others. A detailed description and comparison among several sentiment analysis service providers will be discussed in the next section, “Similar Systems.” Overall, sentiment analysis can be implemented by e-commerce businesses to understand customers' attitudes, viewpoints, and behavior toward their products. By utilizing the sentiment analysis results, a business can develop a strategic business or marketing plan and improve its products to achieve higher sales performance and attract more customers.

### **2.2.3 Sentiment Analysis Approaches**

Sentiment analysis that categorizes the textual input data into positive, neutral, or negative statements is usually broken into three levels: document stage, sentence stage, and aspect stage (Vanaja & Belwal, 2018).

Document-level sentiment analysis accepts an entire document that consists of multiple paragraphs and various sentences with different lengths as input, performs analysis at a time, and comes out with an analysis result representing the document's overall sentiment. This type of sentiment analysis can implement both supervised and unsupervised classification algorithms to develop the machine learning model (Vanaja & Belwal, 2018). Selvadurai and Raviya (2022) have introduced a hybrid CNN-SVM model to perform document-based sentiment analysis. In the proposed model, Convolutional Neural Network (CNN) technique serves as an automated feature learner, while the Support Vector Machine (SVM) technique is implemented to classify the input document's sentiment based on the CNN output (Selvadurai & Raviya, 2022).

Sentence-level sentiment analysis utilizes the sentence input, which is broken down from a document to perform classification. This sentiment analysis type consists of two steps. Firstly, the process of sentence segmentation and clustering within a document is called subjectivity classification aiming to filter out the sentences expressing factual information (objective sentences) and keep the sentences expressing emotions (subjective sentences). During the second step of sentence-level sentiment analysis, each subjective sentence will be the only input, analyzed at a time, and classified into positive or negative categories. Then, to get the overall document's sentiment, the sentiment output of each subjective sentence will be gathered and summed up (Vanaja & Belwal, 2018). The main challenge of this sentiment analysis type is the subjectivity classification process that will affect the model accuracy as the misclassified objective sentences may carry opinions (Behdenna et al., 2018). Compared to document-level, sentence-level sentiment analysis is more complicated. However, the analysis result may be more accurate than the document-level analysis as it investigates the sentiment more deeply.

In aspect-level sentiment analysis, the primary objective is to discover and extract the object features according to the target entity attributes. This sentiment analysis type concentrates on the data input's sentiments instead of the language structures. Besides, aspect-level analysis is able to accept multiple contents from different sources as input, such as comments, feedback, complaint, reviews, and others, instead of being limited to a single document (Behdenna et al., 2018). Hence, the applications of the mentioned sentiment analysis consist of multiple fields, including restaurant, hotel, and product reviews (Vanaja & Belwal, 2018). The proposed project is specified for aspect-level sentiment analysis. Hence, the techniques to carry out aspect-level sentiment analysis will be focused on in the following discussions. Basically, these sentiment analysis approaches can be broken into two types: lexicon-based and machine learning-based methods.

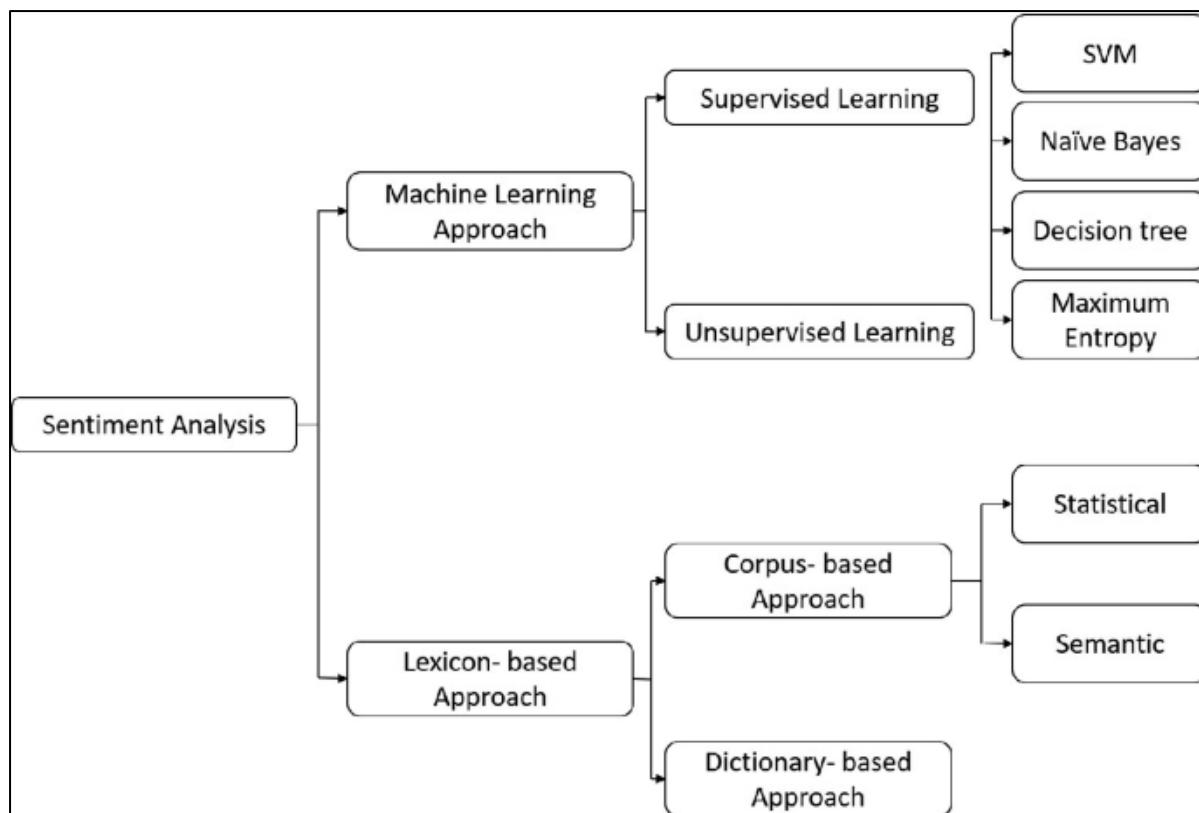


Figure 5 Types of Sentiment Analysis Technique (Abualigah et al., 2019)

### 2.2.3.1 Lexicon-based Approach

Lexicon-based sentiment analysis determines the input data's polarity according to the predefined opinion lexicon containing the positive and negative labels for words or phrases. The output analysis will compare the total number of positively connotated words with the total number of negatively connotated words. For example, if a sentence consists of data with positive connotations more than negative connotations, the sentence will be assigned a positive sentiment score (Kumar et al., 2019). The lexicon-based method can be divided into the corpus-based and the dictionary-based approach.

The corpus-based approach makes use of huge, existent corpora to identify the words' syntactic and semantic patterns. This approach requires massive prelabelled datasets with specific context to build a complete sentiment lexicon. When implementing the corpus-based method, the seed word set is spread over a huge text corpus, and additional words are added to the sentiment lexicon by looking for syntactic and semantic patterns discovered between terms (Chathuranga et al., 2019).

The dictionary-based approach uses dictionaries containing predefined words with their sentiments to perform sentiment analysis. Besides, the dictionaries also include synonyms and

antonyms for every word in order to link the sentiment together. This method is the most straightforward sentiment analysis. Currently, there are various publicly accessible sentiment dictionaries, including SentiWordNet and SentiStrength, which are the most complete dictionaries having comprehensive coverage in the general domain (Alharbi & Alhalabi, 2020). For example, SentiWordNet contains 147306 synsets annotated with positive, negative, or neutral sentiment scores (Bonta et al., 2019).

Apart from the mentioned dictionaries tools, Bonta and his research team (2019) have evaluated several lexicon-based sentiment analysis tools, such as NLTK, TextBlob, and VADER. Among these tools and techniques, VADER performs the best sentiment analysis for microblog text as it follows syntactical and grammatical conventions and has the shortest processing time (Bonta et al., 2019).

The main advantage of the lexicon-based method is its simplicity and ease of use compared to the complicated machine-learning methods. However, manual maintenance is required to be carried out by human beings in several processes of the lexicon-based approaches, leading to high maintenance costs (Yang et al., 2020). Besides, according to the research by Khattak and his team (2021), the lexicon-based approach has limited sentiment word coverage that leads to inaccurate analysis results. Due to the mentioned reasons, the machine learning-based approach will be a better choice for the developer to perform sentiment analysis as it will reduce the number of manual interventions and automatically extract the sentiment features leading to the wide coverage of sentiment words in multiple domains areas.

### **2.2.3.2 Machine Learning-based Approach**

Machine learning-based sentiment analysis automatically defines the input data's polarity (positive, neutral, or negative) based on the machine learning model built with a single or multiple algorithms by feature selection and trained with training datasets. This sentiment analysis type can be divided into supervised and unsupervised learning approaches. Supervised machine learning requires the labeled data to train the model in order to make predictions about future data, while unsupervised machine learning deals with unlabeled data to find the hidden structure in the input data (Hasan et al., 2018).

Usually, the supervised machine learning technique breaks its input dataset into two parts: training and testing. The training dataset consists of labeled data which allows machine learning to learn from the attributes of texts. On the other hand, the testing dataset consists of

raw data without labels to measure the machine learning's performance and accuracy (Hasan et al., 2018). Examples of several supervised learning algorithms include Support Vector Machines (SVM), Naïve Bayes Classifiers, Decision Trees, and Maximum Entropy Classifiers (Abualigah et al., 2019).

Naïve Bayes, one of the easiest algorithms in the AI field, follows the Bayes Theorem, which is a formula to describe an event's probability. Despite its simplicity, Naïve Bayes is still able to produce an excellent result as it employs the concepts of mixture models to carry out the classifier and utilizes feature distribution while calculating the posterior probability (Rahat et al., 2019). Figure 5 shows the equation of the Naïve Bayes Classifier, where  $P(H|E)$  is the analysis output containing the posterior probability of a class. q

$$P(H|E) = \frac{P(E|H) * P(H)}{P(E)}$$

*Likelihood of the Evidence given that the Hypothesis is True*

*Prior Probability of the Hypothesis*

*Posterior Probability of the Hypothesis given that the Evidence is True*

*Prior Probability that the evidence is True*

Figure 6 Naive Bayes Classifier Formula (ZeMing, 2021)

SVM is a two-classification supervised machine learning model based on the Vapnik – Cherenenkov (VC) theory. From the sentiment analysis aspect, SVM defined the data input as vector space and the output as either positive or negative. By feeding a textual dataset, SVM will identify the optimal compromise between data's complexity and learning ability to obtain the best generalization capability. SVM is known as the best method to deal with high-dimensional spaces and the relationship of data with an apparent boundary of separation (Chen & Zhang, 2018).

Rahat and his research team (2019) have compared the performance of Naïve Bayes and SVM algorithms in sentiment analysis on airline reviews. As a result, SVM is able to produce 82.48% accuracy, higher than the accuracy brought by Naïve Bayes, with 76.59% (Rahat et al., 2019). The result is proven by the research conducted by Dey and his team members (2020) concluded that SVM with 84% accuracy is better than Naïve Bayes with 82.875% accuracy while categorizing Amazon product review sentiment.

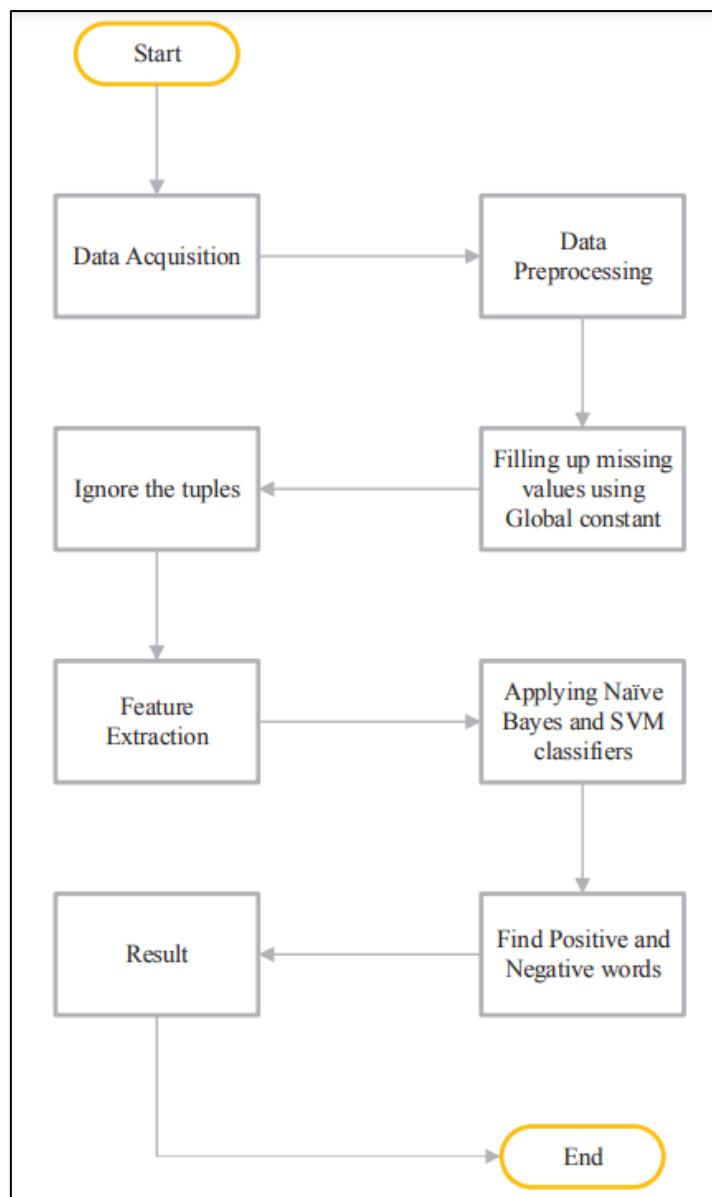


Figure 7 Machine Learning System Architecture Workflow (Dey et al., 2020)

The diagram above shows the workflow of the machine learning system architecture by implementing Naïve Bayes and SVM classifiers. Generally, a machine learning approach will consist of data acquisition, preprocessing, feature extraction, model training, and model evaluation. After getting the data, the data preprocessor is responsible for cleaning and formatting the data, filling in missing values, and scaling the data to a suitable range. After that, feature extraction will extract relevant features from raw data to create a more useful representation of the data for a machine learning model. Once the model has been selected, it must be trained on the training data in order to learn the relationships between the input data and the output labels. Lastly, the model will be evaluated on a separate testing dataset to assess its performance (Dey et al., 2020).

Being a part of machine learning technique, the transformer-based approach stands out in these few years, driving a new wave of advances in machine learning. Machine learning methods and techniques enable devices to learn from data without being explicitly programmed. Transformer-based models are a type of machine learning technique that has been developed to effectively deal with sequential input, such as time series data or natural language text. The following section will explain in more detail on transformers-based approach.

### 2.2.3.3 Transformers-based Approach

Transformer, developed by Hugging Face, is a deep learning model aiming at solving Natural Language Processing (NLP) tasks, like language translation, text classification, and language generation (Vaswani et al., 2017). The diagram below outlines the general architecture of a transformer-based model.

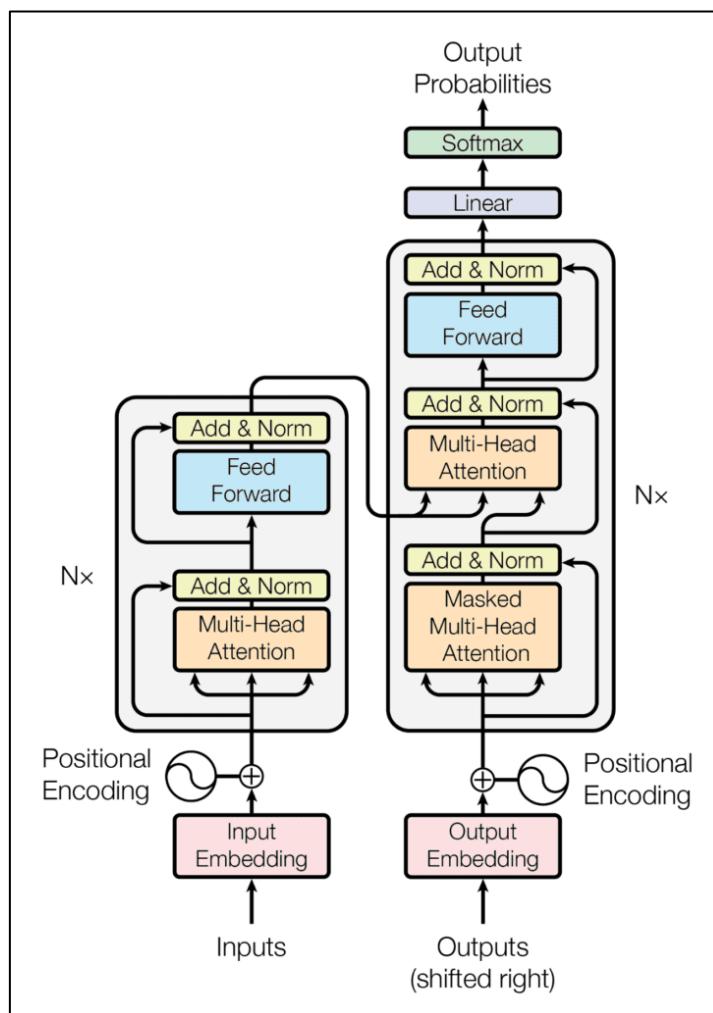


Figure 8 Transformer-based Model Architecture (Vaswani et al., 2017)

A transformer-based model mainly has two blocks, which are the encoder and decoder. Before feeding and retrieving the data into and from both blocks, a pre-processing stage is required for the input and output embedding, including tokenization, padding, and masking. Tokenization will split the input into individual tokens and assign unique IDs based on their position in the vocabulary, while padding will add special tokens to the beginning and end of the input to ensure that all sequences have the same length. Lastly, masking involves adding special tokens to the input text to indicate which parts of the text should be masked during training (Ashis Kumar Panda, 2021).

The Transformer encoder block is responsible for processing the input and extracting useful features from it. It consists of a series of Transformer layers (typically six layers, according to the original paper), each consisting of a multi-head attention mechanism and a fully-connected feed-forward network. The multi-head self-attention layer allows the encoder to consider the context of the entire input text and extract features based on this context, while the feed-forward neural network extracts more complex features from the attention vector (Ashis Kumar Panda, 2021; Vaswani et al., 2017).

The Transformer decoder block is responsible for making predictions based on the features extracted by the encoder. It also consists of a series of Transformer layers (also six layers) and uses a self-attention mechanism to take into account the context of the entire input text. The decoder is trained to recognize patterns in the input data and make predictions based on these patterns (Cristina, 2022; Vaswani et al., 2017).

Compared to traditional machine learning approaches, the transformer model is able to realize state-of-the-art performance in completing NLP tasks and is considered to be more powerful and accurate. It is because transformer models use a combination of self-attention mechanisms and feed-forward neural networks to process input text and make predictions. From the aspect of data processing, Transformer models can process sequential data in parallel, which allows them to take into account the context of the entire input text. On the other hand, traditional machine learning approaches, such as linear regression, decision trees, and SVM, typically process data sequentially and may not be able to consider the context of the entire input text (González-Carvajal & Garrido-Merchán, 2021; Ontoum & Chan, 2022; Wolf et al., 2019).

According to the research by González-Carvajal and Garrido-Merchán (2021), they conducted model performance testing on sentiment analysis for both transformers-based models and traditional machine learning approaches using the IMDB movie review datasets available on Tensorflow. The dataset containing only positive and negative reviews, two types of sentiment, was split into 25000 training data and 25000 testing data. As a result, the fine-tuned Bidirectional Encoder Representations from Transformers (BERT) model achieved the highest accuracy, which is 93.87%, while the logistic regression and linear SVC were only able to score 89.49% and 89.89% accuracy respectively (González-Carvajal & Garrido-Merchán, 2021). Hence, the transformer-based deep learning model will be a more suitable choice for the developer to include in this project for achieving higher accuracy in performing sentiment analysis of product reviews.

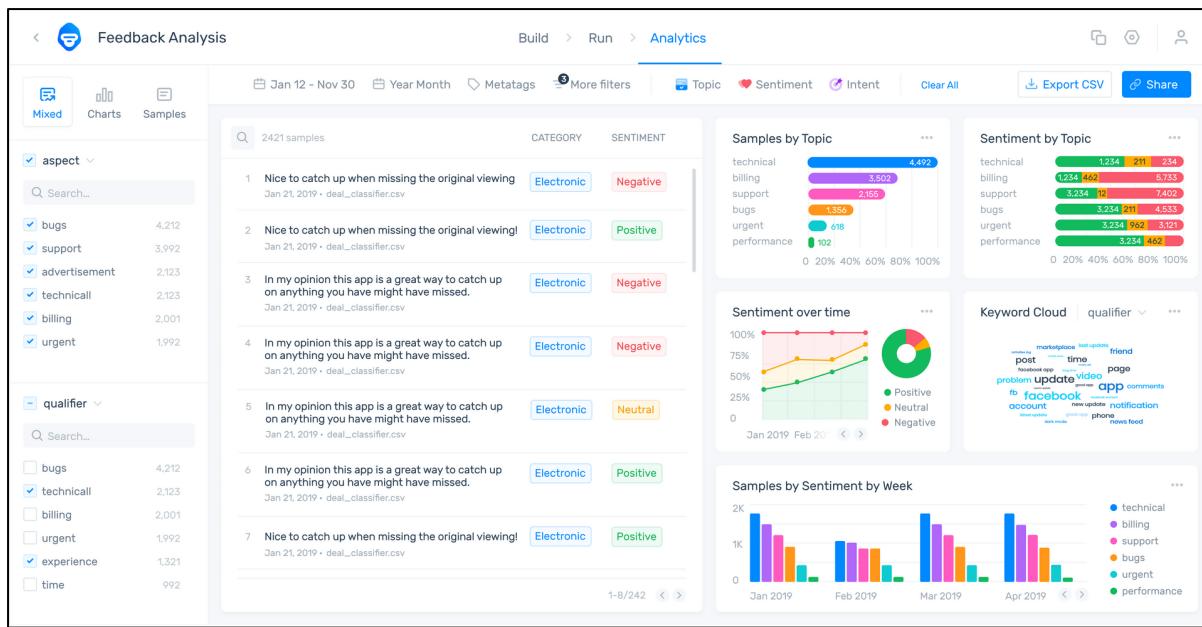
Hugging Face provides a collection of tools and resources for developers to work with the Transformer model, including pre-trained models that can be fine-tuned for specific tasks and a platform for training and deploying custom models. Examples of transformer-based models include GPT-3 by OpenAI, BERT by Google, DistilBERT by Hugging Face, and others (Sun et al., 2019; Wolf et al., 2019). A more detailed explanation and comparison of these models will be provided in Chapter 3, Technical Research.

## 2.3 Similar Systems

### 2.2.1 MonkeyLearn

MonkeyLearn is a no-coding web application that provides text mining and analysis tools for businesses to analyze structured and unstructured data. It allows users to interact with a graphical user interface (GUI) instead of coding to perform text analysis with Machine Learning, suitable for users from a non-IT background, such as marketing, sales, customer service, and others. MonkeyLearn is able to accept various types of data input from different resources. It can extract actionable information from raw texts, including online reviews, support tickets, social media conversations, email communication, text documentation, spreadsheets, and survey responses. MonkeyLearn can easily integrate platforms with Microsoft Outlook, Google Play Review, Google Sheets, Rapidminer, Twitter, Survey Monkey, Slack, LinkedIn, and many more (Das, 2022; McFarland, 2022).

The main functionality of MonkeyLearn is implemented to automate business workflow and extract valuable insights into collected data, resulting in time-saving and better decision-making. Besides sentiment analysis, MonkeyLearn offers text mining, keyword extraction, language detection, email classification, Net Promoter Score (NPS) analysis, and others. The cloud computing platform is also adopted by MonkeyLearn for training and running the machine learning models. Moreover, users can integrate MonkeyLearn into any software application via Application Programming Interface (API) and Software Development Kits (SDKs), regardless of programming language. With attractive AI features and extensive documentation, MonkeyLearn has gained the trust of several well-known companies, including Dell, Freshly, Archer, and Devex (Das, 2022; Garreta, 2022).



*Figure 9 MonkeyLearn Dashboard (MonkeyLearn, 2022)*

The diagram above shows the user interface of MonkeyLearn to analyse the sentiment according to the user input. It can categorize the analyses based on topic, keyword, tag, frequency, and timeline. Its GUI is simple and attractive, having a logical structure and differentiating the categories and tags with various colors. For example, for the positive sentiment, MonkeyLearn labels it with a green color tag; for the negative sentiment, MonkeyLearn labels it with a red color tag; for the neutral sentiment, MonkeyLearn labels it with a tangerine color tag. By tagging with bright colors, users will be able to notice the types of sentiment they want to focus on it. Apart from that, MonkeyLearn shows the analyses in impressive graphical representations, such as line graphs, bar graphs, word clouds, and tables. These data visualization methods will simplify the data to give users a better understanding and reduce literacy barriers.

Another outstanding advantage of MonkeyLearn is its flexibility of offering an option for the user to train their own Machine Learning model by feeding with particular data according to their business domain. This feature provides its customers with highly accurate text sentiment analysis thanks to its sophisticated machine learning algorithms and Natural Language Processing (NLP) technique. It is proven by research from Sadriu and his team members (2022) that compare MonkeyLearn and TextBlob automated models in performing sentiment analysis of students' feedback.

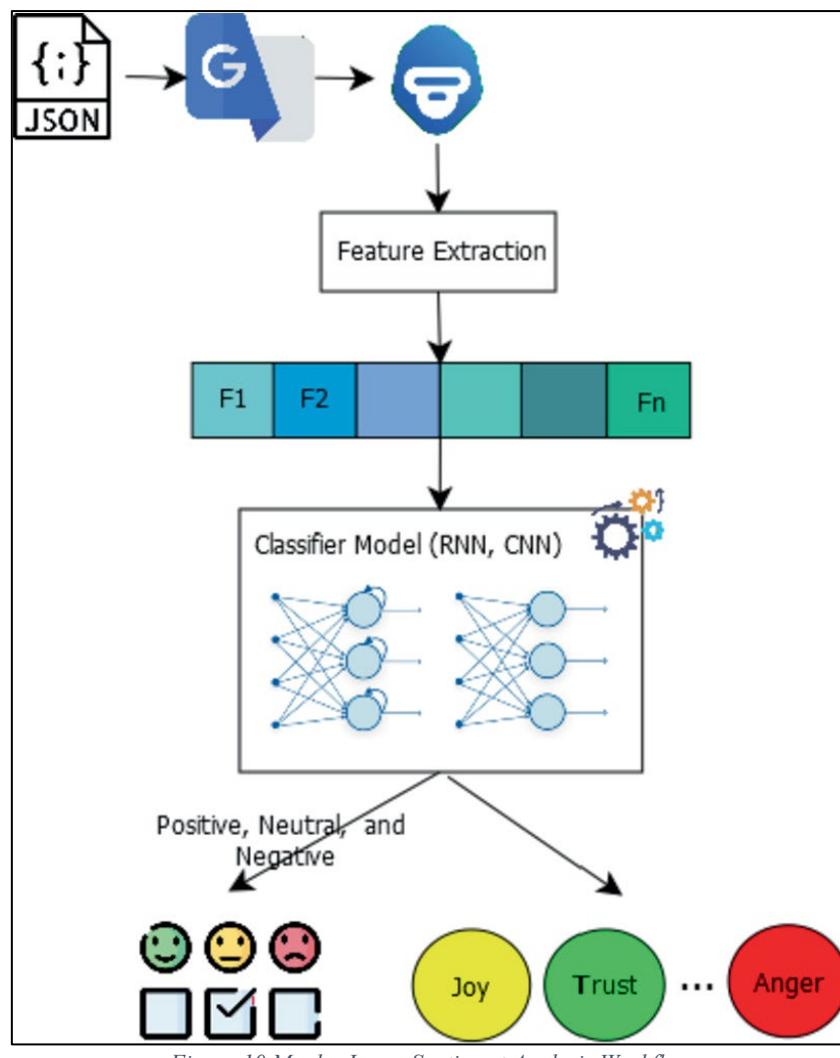


Figure 10 MonkeyLearn Sentiment Analysis Workflow

From the above diagram, the researcher implemented Recurrent Neural Network (RNN) and Convolutional Neural Network (CNN) to classify the feedback into three classes of sentiment, which are positive, negative, and neutral, and seven types of emotional labelings, which are love, joy, surprise, anger, sadness, fear, and neutral. As a result, MonkeyLearn API is able to achieve 72.12% classification accuracy, higher than TextBlob API with 50.48% accuracy (Sadriu et al., 2022).

In addition, the unsupervised classification algorithm offered by MonkeyLearn is able to perform sentiment analysis at the tweet level to assess the earthquake impact instead of traditionally time-consuming fieldwork. The researcher collected the data from Twitter written in various languages, such as English, Albanian, French, German, Icelandic, and others. Before processing MonkeyLearn's unsupervised classification, the data was pre-proceeded by eliminating the hyperlinks and translating them into English. In the end, a 0.63 overall accuracy matrix was obtained (Contreras et al., 2022).

### 2.2.2 Google Cloud AutoML

Google, one of the leading companies in the AI industry, has carried out several significant AI projects, including TensorFlow, DeepMind Lab, Bullet Physics, Cloud AI, CoLaboratory, and others (Sanyal, 2021). From the sentiment analysis perspective, Google has provided two solutions on the Google Cloud Platform (GCP):

- Natural Language API: Allow developers to perform sentiment analysis with a prebuilt Machine Learning model.
- AutoML Natural Language: Allow developers to train their own Machine Learning model with a more specific domain in order to achieve higher accuracy (White & Rege, 2020).

To measure the differences in ML model performance between Natural Language API and AutoML, White and Rege (2020) conducted a toxic comments classification using the Kaggle dataset consisting of over 1.5 million samples of labelled data. As a result, Natural Language API achieved only 57% accuracy, while AutoML attained 90% accuracy (White & Rege, 2020). Research from Mahima and his research team (2021) also proved that AutoML could achieve high accuracy in classifying 8500 samples of spam message datasets using Random Forest Classification with 93.4%. Hence, it is crucial to include a specific use case or knowledge domain while performing sentiment analysis.

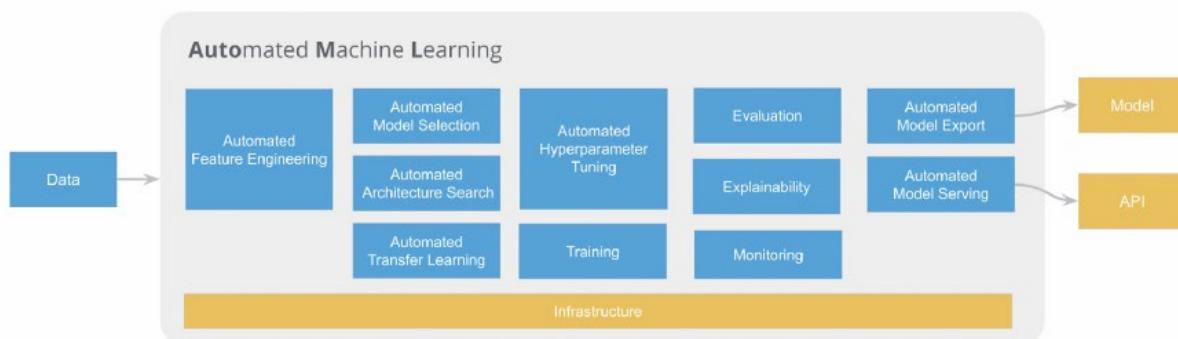


Figure 11 AutoML Sentiment Analysis Workflow (Heyer, 2021)

An AutoML requires users to provide a domain-specific dataset for training the machine learning model. Automated Feature Engineering, which is the first step of AutoML, transforms the raw data into features by selecting the relevant input variables and eliminating the data noises. Through Model Selection, the users will be able to implement the best candidate model for sentiment classification. The parameters required to pass to the machine learning model are chosen while conducting the Automated Hyperparameter Tuning. Training

and evaluating the machine learning model is a must before deploying it to examine its performance in terms of accuracy and precision. In the end, the user only needs to include the API endpoints produced by AutoML in the projects for analysing the sentiment analysis (Heyer, 2021). All the complicated processes of developing a machine learning model are automated using Google Cloud AutoML, resulting in higher efficiency, better performance, improved accessibility, and cost savings. Currently, AutoML sentiment analysis supports 20 languages, including English, Chinese, French, German, Korean, and others (Google Cloud, 2022).

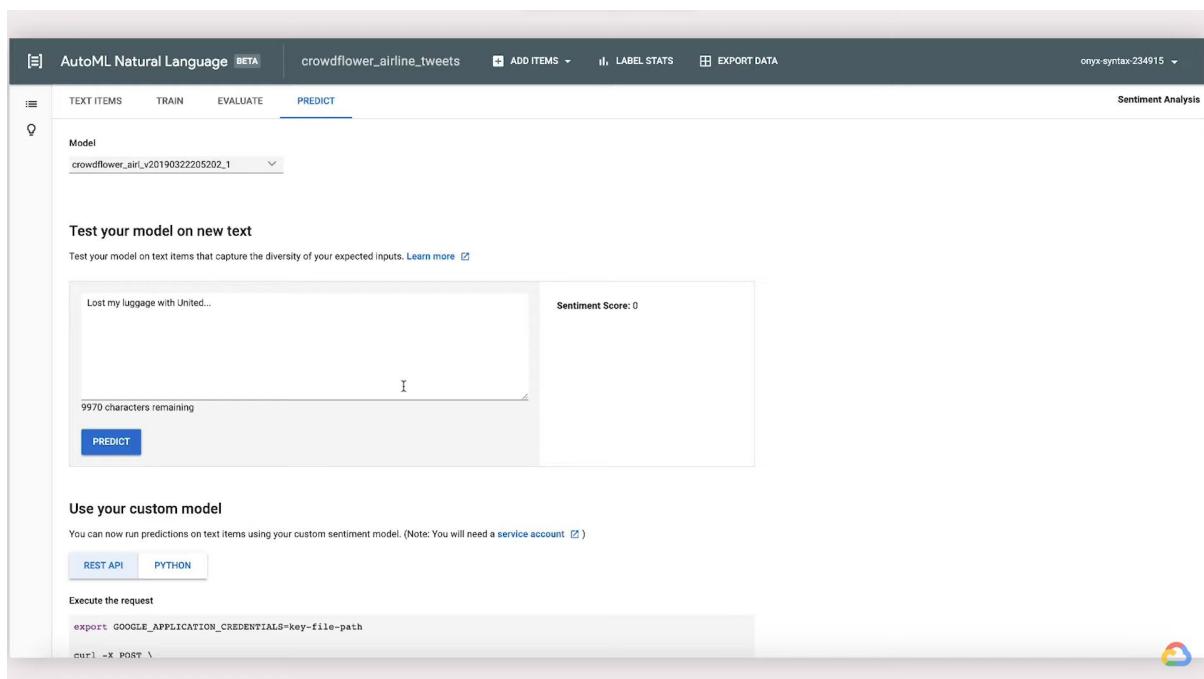


Figure 12 AutoML Natural Language Console User Interface (Google Cloud Tech, 2020)

Similar to MonkeyLearn, AutoML Natural Language provides sentiment analysis without coding for users from non-IT backgrounds through the Google Cloud console. However, if users pursue the goal of automating the machine learning development processes and embedding them into their products, AutoML Natural Language is able to support various common programming languages, such as Python, Java, Go, PHP, C#, and others (Hopf, 2019).

Moreover, Google AutoML also provides developers with solutions to perform text classification, entity extraction, vision object detection, video intelligence object tracking, and others. Google Cloud Platform is one of the best choices for implementing sentiment analysis and is currently chosen by famous companies, such as PayPal, Twitter, Airbus, Carrefour, King, and others (Google Cloud, 2022).

### 2.2.3 Amazon Comprehend

Another commercial sentiment analysis tool is Amazon Comprehend, provided by Amazon Web Services (AWS), which enables developers to use its NLP services to find relationships and insights into blocks of text using machine learning algorithms. Amazon Comprehend provides API operations to detect the sentiment within documents, paragraphs, and texts. Hence, it is more suitable for users with little programming knowledge to deal with an API endpoint (Amazon, 2022).

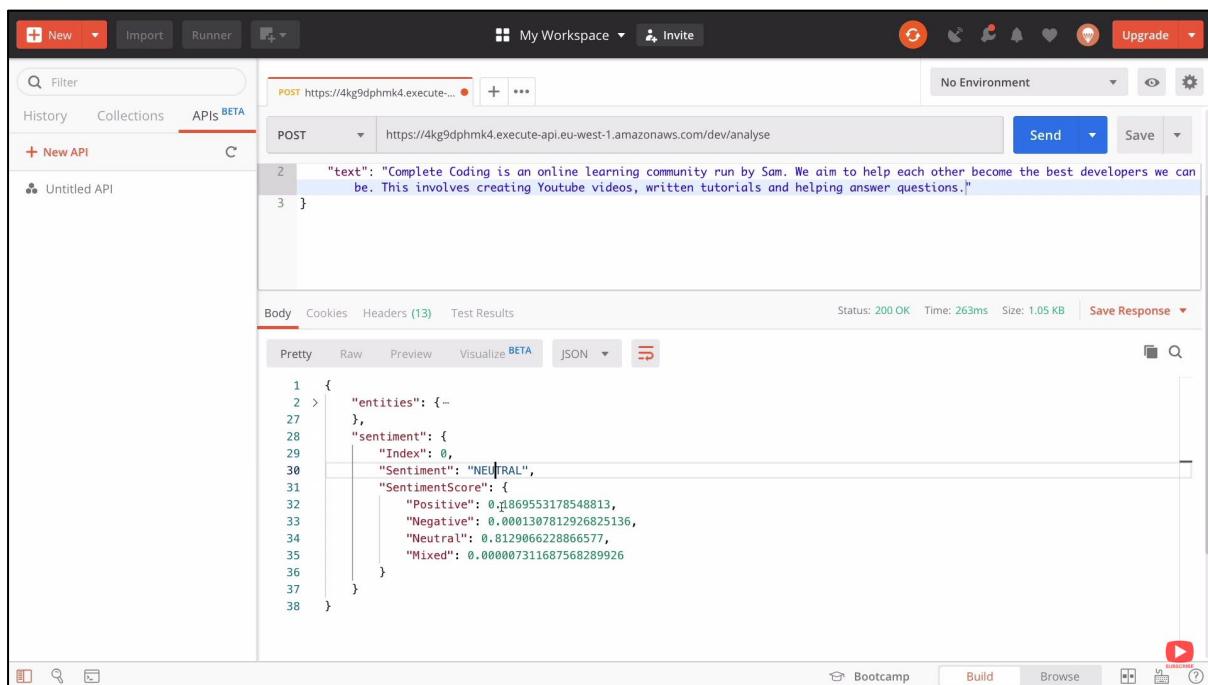
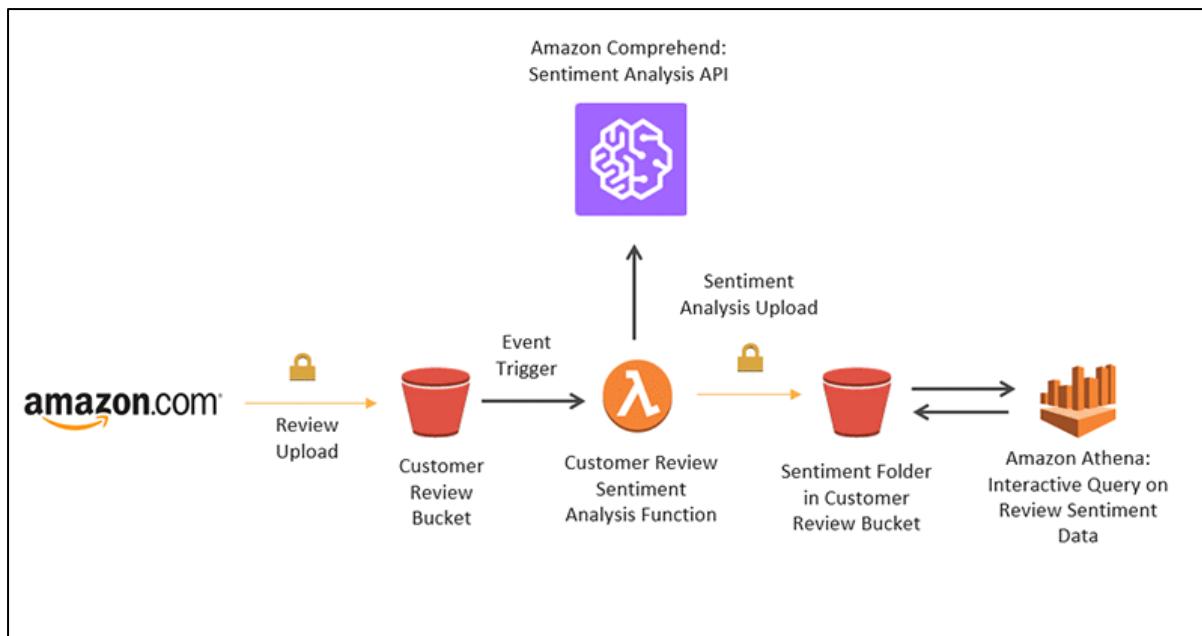


Figure 13 Postman API Platform with Amazon Comprehend (Complete Coding, 2020)

The diagram above is a Postman tool that implements the Amazon Comprehend service to analyse the sentiment of the input messages. By sending a JSON POST request to the server, it will return a “200” response encapsulating entities and sentiment scores based on the input messages. According to the received scores, the message was labelled as a neutral sentiment as it gained the highest neutral sentiment score with 81.29%. The additional mixed sentiment score is the main difference from other sentiment analysis-based products that usually provide only three sentiment classes, which are positive, negative, and neutral. Mixed sentiment determination means the input possesses both positive and negative sentiments at opposite poles of neutral sentiment.



*Figure 14 Sentiment Analysis Solution Architecture on Customer Review using Amazon Comprehend*

Amazon is popular with its online shopping platform producing massive amounts of data consisting of thousands of client feedback. Hence, Amazon Comprehend can be easily integrated with Amazon.com gaining continuous data flow in order to train the machine learning model by retraining against new data to catch up with the language evolution. The diagram above shows the solution architecture of sentiment analysis brought by Amazon Comprehend. Firstly, the review uploaded by the customer will act as an Amazon S3 event and trigger the sentiment analysis function to perform text analysis with the data using Amazon Comprehend. Then, the output results containing the sentiment (positive, negative, mixed, neutral) confidence scores will be stored in a CSV file inside a sentiment folder. Finally, Amazon Athena will query the data along with its findings within the sentiment folder, focusing on the negative sentiment that assists businesses in addressing their customers' issues (Escalona, 2018).

Regarding the Machine Learning algorithm's accuracy, Amazon Comprehend is able to achieve 72.7% accuracy from 10380 tweets while performing sentiment analysis on U.S. airline issues, which is rated third place, losing to IBM NLU and Google Natural Language. However, through analysing sentiment on 3240 Facebook posts about Starbucks' public page, Amazon Comprehend can attain 76.3% accuracy in the comparison among IBM NLU, Microsoft Text Analytics, Google Natural Language, and Bag of Words (Carvalho & Harris, 2020).

Besides sentiment analysis, Amazon Comprehend offers other NLP techniques, including language detection, syntax analysis, topic modelling, entity recognition, and key phrase extraction. Due to its high reliability, scalability, and cheap cloud computing services, Amazon Comprehend is used by many famous companies worldwide, including Chisel AI, Assent, SuccessKPI, Gallup, ExxonMobil, and others (Amazon, 2022; Mohanta, 2021).

#### 2.2.4 Comparison of Similar Systems

| Similar Systems      | MonkeyLearn  | Google Cloud AutoML   | Amazon Comprehend   |
|----------------------|--|---|---|
| Application Type     | Web Application & REST API<br>(Supported Programming Language) <ul style="list-style-type: none"> <li>• Python</li> <li>• Ruby</li> <li>• PHP</li> <li>• Java</li> <li>• Javascript</li> </ul>   | Web Application & REST API<br>(Supported Programming Language) <ul style="list-style-type: none"> <li>• C#</li> <li>• Go</li> <li>• Java</li> <li>• Node.js</li> <li>• PHP</li> <li>• Python</li> <li>• Ruby</li> </ul> | Web Application & RESTful API<br>(Supported Programming Language) <ul style="list-style-type: none"> <li>• Java</li> <li>• Python</li> <li>• .NET</li> <li>• C++</li> <li>• PHP</li> <li>• Kotlin</li> <li>• JavaScript</li> <li>• Node.js</li> </ul> |
| Core Functionalities | <ul style="list-style-type: none"> <li>• Sentiment Analysis</li> <li>• Text Mining</li> <li>• Keyword Extraction</li> <li>• Language Detection</li> <li>• Email Classification</li> <li>• Net Promoter Score (NPS) analysis</li> </ul> | <ul style="list-style-type: none"> <li>• Sentiment Analysis</li> <li>• Text Classification</li> <li>• Entity Extraction</li> <li>• Syntax Analysis</li> </ul>   | <ul style="list-style-type: none"> <li>• Sentiment Analysis</li> <li>• Language Detection</li> <li>• Syntax Analysis</li> <li>• Event Detection</li> <li>• Topic Modelling</li> <li>• Entity Recognition</li> <li>• Key Phrase Extraction</li> </ul>  |
| Sentiment Analysis   | Machine Learning-based Approach  | Machine Learning-based Approach   | Machine Learning-based Approach   |

| Supported Language | 18 Languages  | 20 Languages   | 12 Languages   |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
|--------------------|---|--|--|-------|-----------|------|----------|----------|------------|-------|------------|------|------------|--------------|--|---------|-------|-------|------|---------|----------------|---------|-----------------|---------------|------------------|
| Top User Companies | <ul style="list-style-type: none"> <li>Dell</li> <li>Freshly</li> <li>Promoter.io</li> <li>Devex</li> <li>Archer</li> </ul>   | <ul style="list-style-type: none"> <li>PayPal</li> <li>Twitter</li> <li>Marks &amp; Spencer</li> <li>AES Corporation</li> <li>Imagia</li> </ul>  | <ul style="list-style-type: none"> <li>Assent</li> <li>Chisel AI</li> <li>SuccessKPI</li> <li>Gallup</li> <li>TeraDact</li> </ul>  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| Pricing            | \$299/month<br>(10k queries/month)  | <p>Pay as you go</p> <table border="1"> <thead> <tr> <th>Training</th> <th>Price</th> </tr> </thead> <tbody> <tr> <td>0-2 hours</td> <td>Free</td> </tr> <tr> <td>2+ hours</td> <td>\$3/hour</td> </tr> </tbody> </table><br><table border="1"> <thead> <tr> <th>Prediction</th> <th>Price</th> </tr> </thead> <tbody> <tr> <td>1-30K text</td> <td>Free</td> </tr> <tr> <td>30-5M text</td> <td>\$5/1K texts</td> </tr> </tbody> </table> | Training   | Price | 0-2 hours | Free | 2+ hours | \$3/hour | Prediction | Price | 1-30K text | Free | 30-5M text | \$5/1K texts | <p>Pay as you go</p> <table border="1"> <thead> <tr> <th>Feature</th> <th>Price</th> </tr> </thead> <tbody> <tr> <td>0-50K</td> <td>Free</td> </tr> <tr> <td>50K-10M</td> <td>\$0.0001 /unit</td> </tr> <tr> <td>10M-50M</td> <td>\$0.00005 /unit</td> </tr> <tr> <td>50M and above</td> <td>\$0.000025 /unit</td> </tr> </tbody> </table> <p>(1unit = 100 characters)</p> | Feature | Price | 0-50K | Free | 50K-10M | \$0.0001 /unit | 10M-50M | \$0.00005 /unit | 50M and above | \$0.000025 /unit |
| Training           | Price   |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 0-2 hours          | Free  |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 2+ hours           | \$3/hour  |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| Prediction         | Price   |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 1-30K text         | Free  |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 30-5M text         | \$5/1K texts  |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| Feature            | Price   |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 0-50K              | Free  |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 50K-10M            | \$0.0001 /unit  |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 10M-50M            | \$0.00005 /unit   |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| 50M and above      | \$0.000025 /unit  |  |  |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| Advantages         | <ul style="list-style-type: none"> <li>Attractive user interface with graphical analysis representation</li> <li>User-friendly navigation to clean, organize, and visualize data in a simple method</li> <li>Able to build a customized machine learning model</li> </ul> | <ul style="list-style-type: none"> <li>Support the most amounts of languages</li> <li>Able to build a customized machine learning model</li> <li>Able to handle large amounts of complex data</li> </ul>   | <ul style="list-style-type: none"> <li>Offer “mixed” sentiment classes</li> <li>Able to handle large amounts of complex data</li> <li>Provide Amazon Comprehend Medical Feature that focuses on health data</li> </ul> |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |
| Disadvantages      | <ul style="list-style-type: none"> <li>High price and not offering a free trial</li> <li>Limited number of queries</li> </ul>   | <ul style="list-style-type: none"> <li>Costly for large dataset</li> </ul>   | <ul style="list-style-type: none"> <li>Support the least amounts of languages</li> </ul>   |       |           |      |          |          |            |       |            |      |            |              |  |         |       |       |      |         |                |         |                 |               |                  |

Table 1 Comparison among MonkeyLearn, Google Cloud AutoML, and Amazon Comprehend

## 2.4 Summary

In a nutshell, the developer has provided evidence of the product review's impact and the importance of sentiment analysis from the literature carried out by other researchers. Besides, the developer has discussed several sentiment analysis approaches, including lexicon-based, machine learning-based, and transformer-based approaches. As the transformer-based model provides higher accuracy than other methods, it will be a more suitable machine learning technique for aspect-based sentiment analysis to discover and extract emotional information expressed towards specific aspects or features of a product or service. Hence, the developer will fine-tune a pre-trained transformer-based model customized to fit sentiment analysis using the Amazon product review dataset in the proposed project.

Besides the domain research, the developer also introduced the market available sentiment analysis-based tools, which are MonkeyLearn, Google Cloud AutoML, and Amazon Comprehend, and compared their characteristics. By investigating similar systems, the developer can learn from their implemented techniques and expect the proposed project's outputs. To summarize, the literature review is an essential stage in any software development. It is because this section can guarantee that the developer will be able to comprehend the project topics thoroughly and have a better knowledge of the required techniques integrated with the proposed system in order to achieve better results and system performance.

## CHAPTER 3: TECHNICAL RESEARCH

### 3.1 Programming language Chosen

Programming language is the central core for any information technology development projects, such as mobile applications, websites, artificial intelligence algorithms, and others. It acts as a computer language that enables the programmer to communicate with the computer/system. Currently, there are hundreds of different programming languages available in the market. Each programming language has different characteristics and available frameworks, modules, and libraries, resulting in different processing times, difficulty, and modularity. These factors will affect the end product of software development in terms of efficiency, usability, and effectiveness. Hence, it is crucial for the developer to choose the correct programming language by considering the application types, objectives, complexity, performance, and maintainability. As the proposed machine learning algorithm and product review analysis system are Artificial Intelligence applications, the most popular programming languages, Python and Java, will be compared based on their advantages and disadvantages.

Python is one of the easiest programming languages associated with elegant syntax and straightforward English keywords. It is highly readable and easy to understand. Python programming languages can be used in both front and backend software development. However, compared with traditional programming languages, such as Java or C, it requires more processing time and resource allocation for runtime while interpreting the variables due to its high-level nature. Python is more prone to runtime errors and needs to carry out more testing during the development process. From the perspective of Artificial Intelligence (AI) application, Python has a list of powerful libraries and modules to deal with AI algorithms and large datasets. For example, Scikit-learn embedded in Python is able to cope with classification and regression algorithms, NLTK library can handle natural language processing, and TensorFlow is capable of dealing with deep learning applications. By utilizing these Python-available open-source libraries and modules, the AI end product can be easily streamlined and developed to meet the goal of flexibility, cost efficiency, and ease of use (Atha, 2022).

As one of the most widely used programming languages, Java enables object-oriented development that only requires writing the code once and implementing it in multiple functions. Java is mainly implemented for mobile apps, desktop apps, and website development. Its significant advantages include short processing time and quick execution,

empowering the AI application that relies on fast and accurate performance. Java provides advanced authentication and access control functionalities that help to increase the overall software application security. A malicious attack can be easily prevented on a website built with Java programming language. Regarding AI development, Java also offers various tools and libraries. For instance, Massive Online Analysis (MOA) can be used for developing classification, clustering, and linear regression algorithms, RapidMiner works closely with the data science lifecycle from the data mining to the model deployment, and Weka focuses on the data mining and data analytics technique (Atha, 2022; Slesar, n.d.).

| Characteristics                 | Python   | Java  |
|---------------------------------|--|---|
| Syntax                          | Simple   | Complex   |
| Difficulty                      | Easy   | Hard  |
| Readability                     | High   | Low   |
| Processing Time                 | Long   | Short   |
| Security                        | Less secure  | More secure   |
| Frameworks                      | 1. Django<br>2. Flask<br>3. Bottle<br>4. Web2Py                                | 1. Spring<br>2. Struts<br>3. Hibernate<br>4. JSF                                      |
| Libraries<br>(Machine Learning) | 1. TensorFlow<br>2. Scipy<br>3. Scikit-learn<br>4. PyTorch<br>5. NLTK          | 1. Weka<br>2. RapidMiner<br>3. MOA<br>4. MALLET<br>5. JSAT                            |
| Popular Applications            | 1. AI and machine learning<br>2. Data analytics<br>3. Data visualization       | 1. Mobile application<br>2. Web application<br>3. Desktop GUI application             |
| Top Developed Software          | 1. Google<br>2. Instagram<br>3. YouTube<br>4. Dropbox<br>5. Reddit<br>6. Quora | 1. Spotify<br>2. Twitter<br>3. Opera Mini<br>4. ThinkFree Office<br>5. NASA WorldWind |

Table 2 Comparison between Python and Java

The above tables show the main comparison between Python and Java according to the research from Anderson (2022), Atha (2022), Brewster (2022), Christian (2020), Kumar (2022), Shankar (2022), Singh (2022), and Slesar (n.d.). After considering the functionalities and features of both Python and Java, the developer had a deep understanding and decided to select Python as the primary programming language for developing the proposed project. It is because Python provides lots of AI-based libraries, especially the Natural Language Tool Kit (NLTK), which supports the developer's research area in analyzing linguistics and cognitive science. NLTK offers the kernel content in natural language processing and machine translation. It assists the developer in meeting the goal of the project by producing a set of rules to determine the sentiment of product reviews.

Additionally, Python is easily implemented by both novices and experts while developing an AI application because of its simplicity and flexibility. Functions produced using Python require fewer lines of code than Java programming language written with complex syntax. Python has a flourishing community due to its ease of use and higher productivity, enabling developers to concentrate more on fixing complex core structures instead of the coding process. Besides, Python also possesses the object-oriented structure, one of Java's characteristics. The developer can easily reuse similar classes and objects while developing new functionalities in the system. It arranges the Python code by eliminating the redundant parts, leading to the enhancement of readability. Moreover, Python also supports web applications by integrating with the Python framework, such as Django and Flask. It allows the developer to build a website for the product review analysis system embedded with the sentiment analysis machine learning algorithm.

### 3.2 IDE (Interactive Development Environment) Chosen

Interactive Development Environment (IDE) provides a graphical user interface (GUI) for developers to integrate multiple common software development tools for developing an application. It acts as a code editor and compiler to transform the developer's written source code into binary code that is executable by the computer. IDE also runs automated tests internally before showing the output to the developers (Arora, 2022). In section 3.2, the developer decided to use Python programming language to develop the proposed system. Hence, the most popular Python IDEs, including Interactive Development and Learning Environment (IDLE), PyCharm, and Visual Studio Code, will be compared in this section.

| IDE                        | IDLE   | PyCharm   | Visual Studio Code  |
|----------------------------|--|---|---|
| Company                    | Python Software Foundation   | JetBrains   | Microsoft   |
| Price                      | Free   | US \$89/year<br>(Professional)  | Free  |
| Supported Operating System | 1. Windows<br>2. macOS<br>3. Linux   | 1. Windows<br>2. macOS<br>3. Linux  | 1. Windows<br>2. macOS<br>3. Linux  |
| Version Control            | -  | 1. Git<br>2. Subversion<br>3. Mercurial<br>4. Perforce  | 1. Git<br>2. Subversion<br>3. Mercurial<br>4. Perforce  |
| Characteristics            | 1. Ability to explore multiple files<br>2. Syntax highlighting<br>3. Suitable for beginner<br>4. Ease of use | 1. Git integration<br>2. Syntax highlighting<br>3. Potential error highlighting<br>4. Ability to install various plugins<br>5. Database integration<br>6. Intelligent code navigation<br>7. Code safety refactoring | 1. Ability to use multiple programming languages<br>2. Git integration<br>3. Lightweight memory consumption<br>4. Ability to install various extensions<br>5. Terminal emulator<br>6. Smart code navigation |

Table 3 Comparison among IDLE, PyCharm, and Visual Studio Code

The above table shows the difference of Python IDE among IDLE, PyCharm, and Visual Studio Code after carrying out the investigation by Awosan (2021), Gupta (2022), and Pedamkar (2022). The proposed IDE for writing the Python web application source code in this project is Microsoft Visual Studio Code (VS Code). It is because VS Code is able to integrate Python with frameworks and other programming languages effortlessly, which is necessary for this project. The proposed end products require a connection between the frontend, that is the web application, and the backend, which is the machine learning algorithm. Implementing Django or Flask framework is essential to creating complicated and database-driven web applications using the Python programming language. However, this function is only available in PyCharm Professional, which requires the developer to pay instead of the free version of PyCharm Community. Hence, VS Code is a better choice when considering the financial status of the developer.

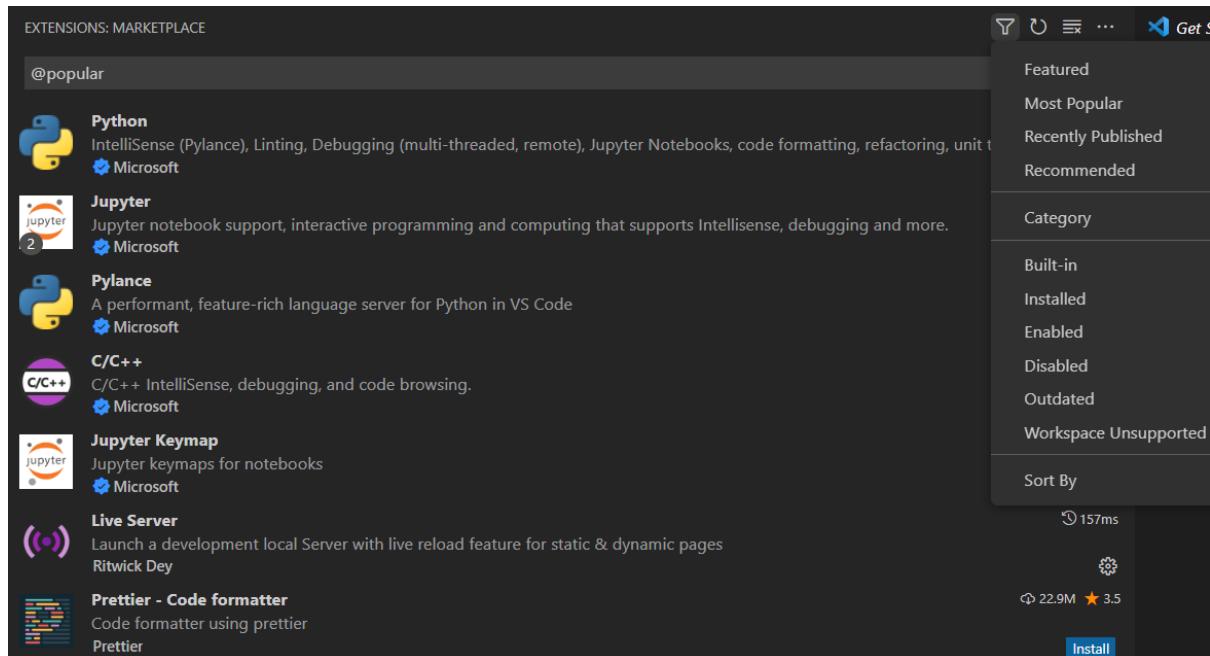


Figure 15 VS Code Extension Marketplace

Besides, VS Code enables the developer to install various extensions through the extension marketplace shown in the above figure. Some popular extensions include Live Server, which provides real-time update functions for static or dynamic web pages, Error Lens, which highlights the possible error and warning messages, Bracket Pair Colorizer, which matches the relevant brackets with the same colors, and other valuable tools and techniques (Fawcett, 2022). Although PyCharm also provides plugins to extend its core features, VS Code has a decided advantage in offering more extensions, and developers even can create their own extensions.



Figure 16 VS Code Terminal Emulator

Compared to IDLE and PyCharm, VS Code offers a terminal emulator that allows the developer to switch between different shells installed on the developer's system without exiting the application. As shown in the figure above, it enables script writing for Windows commands, Git commands, PowerShell commands, and others. Moreover, VS Code is exceptionally versatile and lightweight in contrast to PyCharm, which consumes a lot of memory and processing when in use (Awosan, 2021; Pedamkar, 2022). VS Code is one of the best IDE not only for Python project development but also for different types of programming languages in software development.

For developing the machine learning model, the researcher decided to use Google Colaboratory (Colab) as the IDE to train and test the model. Google Colab provides a free online IDE platform for users to build and run their Python scripts in the cloud without installing and maintaining software locally. Currently, it is widely used in the aspects of data science, data analytics, and machine learning fields as it offers developers access to powerful computing resources, such as GPUs and TPUs, and a wide range of tools and libraries for realizing data analysis. The free GPU and paid TPU computing resources can help to accelerate the model training and inference for a machine learning model, while the pre-installed tools and libraries, including NumPy, Pandas, Matplotlib, and others, can save users time and effort to set up these tools themselves, increasing their productivity (Van Den Reym, 2020).

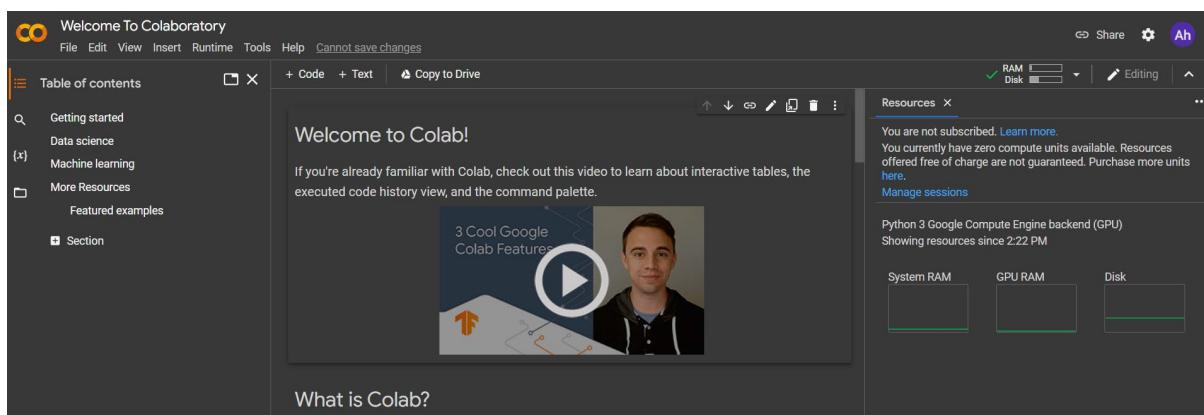


Figure 17 Google Colab User Interface

Apart from that, Google Colab is designed to be easy to use with a user-friendly interface, helping users or beginners get started quickly. It uses Jupyter-style notebooks, which allows users to mix code, text, and multimedia in a single document and to execute code and view the results directly in the notebook. The notebook can then be saved to and accessed from Google Drive, allowing users to easily store and share their work. By sharing the notebook, Google Colab makes it an ideal platform for team-based projects with collaboration in real-time (Yalçın, 2020).

Overall, the interactive development environments (IDEs) chosen for this project are Visual Studio Code and Google Colab. Visual Studio Code for developing web applications with Python Flask provides powerful debugging tools and a wide range of extensions for developers to work efficiently, while Google Colab for developing machine learning models with Jupyter notebook offers free high-performance computing resources, making it an attractive option for the developer to work more productively.

### 3.3 Libraries Chosen / Tools Chosen

A programming library contributed by other developers contains a collection of prewritten code that lessens the developer's burden while developing a project (Ryan, 2020). The proposed project includes a sentiment analysis system that is an Artificial Intelligence (AI) application under the Natural Language Processing (NLP) category. In order to develop the machine learning model for analyzing the product review sentiment, the developer is required to figure out the beneficial libraries and tools associated with the Python programming language to optimize the tasks during the coding process. The proposed Python libraries in this project include NumPy, Matplotlib, NLTK, and Scikit Learn. A detailed explanation of each library will be conducted as follows:

#### 3.3.1 NumPy

NumPy is an open-source project designed by Travis Oliphant in the year 2005. Its primary feature is dealing with the array that contains the same data type value in Python. Besides, it is also implemented in the area of linear algebra, matrices, and Fourier transform. Machine learning algorithm involves numerous operations on array functions. By utilizing NumPy, the developer does not need to loop through each value one at a time for large datasets, which is a challenging and time-consuming process. Compared to the traditional list function, the NumPy array can boost the processing speed and reduce the execution time while vectorizing the mathematical operations ("Introduction to NumPy," n.d.; Ryan, 2020). Hence, the developer will use the NumPy library to pre-process, model, and analyze data using array data types.

#### 3.3.2 Matplotlib

Matplotlib, a cross-platform library in Python, was introduced by John D. Hunter in 2003. It is usually used for data science projects as it helps developers visualize and plot with various graphing formats to produce an effective data chart. With the Matplotlib library, the developer can produce a bar chart, pie chart, histogram, correlogram, time series plot, and other graphs according to the input variables. Matplotlib is usually utilized with NumPy to assist with the datasets. NumPy allows the creation of an array to store the data, while Matplotlib accepts the array as x and y values to show the relationship between them (Kumar, 2021; Ryan, 2020). In the proposed project, the developer will implement Matplotlib to perform data visualization for the sentiment analysis result to evaluate the model performance.

### 3.3.3 Tensorflow

As an open-source library, Tensorflow is developed by Google for the use of machine learning and numerical computation. The wide range of tools and resources available in Tensorflow helps developers build and train machine learning models in a variety of applications, such as Natural Language Processing (NLP), image and video recognition, speech recognition, robotics, and others (Yegulalp, 2022). Moreover, one of the key features of Tensorflow is its support for working with datasets. Tensorflow has lots of datasets accessible to the public, such as MNIST (handwritten digits dataset), IMDB (movie reviews dataset), UCI Machine Learning Repository (datasets for classification, regression, and clustering), and others. These datasets can be imported to any project with Tensorflow's tools and functions for accessing, loading, and manipulating them and preparing data for training a machine learning model ("TensorFlow Datasets," 2022). In the proposed project, the developer decided to utilize the Amazon product reviews dataset from Tensorflow to train and test the sentiment analysis model. Once the dataset is loaded into the project, the developer will use Tensorflow's built-in functions and transformers to manipulate and pre-process the data.

### 3.3.4 Scikit-learn

Another essential machine learning library, Scikit-learn, is an open-source project providing supervised and unsupervised learning methods. It has the functionality for classification, clustering, and regression technique as it is built on SciPy, offering algorithms for signal processing, statistics, optimization, and other machine-learning problems. Some examples of classical machine learning algorithms, such as K-Means, Random Forest, and Support Vector Machines, are handled by Scikit-learn, and the developer can access them easily by importing the relevant libraries. For evaluating the model performance, Scikit-learn also provides tools and resources, such as a confusion matrix, to compare a classification model's true and false predictions in order to calculate the accuracy, precision, misclassification rate, and other measurement standards. Currently, Scikit-learn is popular and implemented by many famous companies, including Spotify, OkCupid, and others, as it is easy to use, quick, and offers a user-friendly API (Kanade, 2022). The built-in tools of Scikit-learn for training and testing the machine learning model make it simpler for the developer to develop the algorithm. Hence, the developer will utilize Scikit-learn to evaluate the machine learning model performance in the proposed project.

### 3.3.5 Transformers

The Transformers library is introduced by Hugging Face to support the transformer-based model, such as BERT, GPT-2, XLNet, RoBERTa, and many more. Currently, it is widely used in NLP tasks, including language translation, text classification, and question answering. One of its key features is the integration with popular deep learning frameworks like PyTorch and TensorFlow. Besides, it also provides functions for word tokenization and data preprocessing according to the chosen machine learning model (Jwalapuram, 2021). As the proposed machine learning is planned to fine-tune the DistilBert model, the Transformers library is able to help the developer import and load the model.

### 3.3.6 Flask

Flask is a useful Python library for building web applications and APIs. It is a microweb framework designed for lightweight websites with a small footprint and minimal dependencies. Compared with Django, Flask is less complicated and easier to get started with and deploy. A more detailed comparison between Django and Flask will be discussed in Chapter 3.6. By importing its library, a range of tools and resources will be provided for building and serving web applications, including routing, templates, and support for a variety of request methods and protocols. Besides, the developer also can integrate Flask with third-party libraries and extensions, such as Flask-WTF, to create forms. Due to its simplicity, flexibility and ease of use, the developer will use Flask while developing the web-based product review analysis system.

### 3.3.7 Flask-WTF

Flask-WTF is an extension for Flask that integrates the WTForms library, which is a framework for building and validating forms in web applications. Flask-WTF provides a range of tools and resources for working with forms in a Flask application, including form classes, validation, and rendering of form elements in templates. It simplifies the process of building and working with forms in a Flask application, making it easy to create and process form submissions (“Flask WTF - Javatpoint,” 2021). Hence, the developer will utilize this library for creating web application forms, such as login, registration, and add product forms.

### 3.4 Database Management System Chosen

Database Management System (DBMS) is a place for the developer to store and deliver the application data for the project. Although there is a wide variety of databases to pick from, it is advised to choose one of them according to the data structure. Databases are typically divided into two groups: relational or Structured Query Language (SQL) structure and non-relational or NoSQL structure. SQL database arranges the structured data into relations in the form of rows and columns in table format and outlines the relationship between the tables. In contrast, NoSQL database utilizes storage models, such as document store, wide-column store, key-value store, and graph database, which benefit unstructured and semi-structured data (Pattinson, 2020). The following table will have a clear side-by-side comparison between SQL databases and NoSQL databases after conducting the research by Pattinson (2020), Sheldon (2021), and Smallcombe (2021).

| Database Type  | SQL   | NoSQL   |
|----------------|---|---|
| Data Structure | Highly structured   | Unstructured or semi-structured   |
| Format         | SQL language (Table-base)   | JSON, XML, BSON<br><br>(Document, graph, key-value, column-oriented)                  |
| Schema         | Predefined schema   | Dynamic schema  |
| Flexibility    | Rigid architecture as adding a new property may need schema alteration                      | Dynamic and flexible architecture as stored data may not have the same properties     |
| Scalability    | Vertical scaling with more server resources   | Horizontal scaling with data divided to span servers                                  |
| Performance    | 1. Problematic update as entity information is scattered<br>2. Easy to select and read data | 1. Easy update as entity information is gathered<br>2. Easy to insert and update data |
| Example        | 1. PostgreSQL<br>2. Microsoft SQL Server<br>3. Oracle Database<br>4. MySQL                  | 1. MongoDB<br>2. Amazon DynamoDB<br>3. Cloudera<br>4. Apache CouchDB                  |

Table 4 Comparison between SQL and NoSQL

Traditionally, most enterprises will choose SQL database due to its capability to secure the data and guarantee its integrity. However, the data proliferation brought by the emergence of the Internet and cloud technologies has led many businesses to choose NoSQL databases as they have well performance in managing the massive amount of unstructured and semi-structured data (Sheldon, 2021). Hence, the developer proposes implementing a NoSQL database in this project as the data needed to be displayed on and collected from the product review analysis web application will be unstructured. It includes the textual and graphical product descriptions posted by the e-commerce business. Besides, the schema-less ability of the NoSQL database allows the developer to store, query, and retrieve data with greater flexibility over the data types. The dataset used to proceed with the machine learning model may include various messy data, and the NoSQL database will be a better choice. Compared to SQL database, schema-less NoSQL database avoids data truncation as the data is saved in separate documents with partial schemas, and the raw information is untouched.

After narrowing the database category, the popular NoSQL databases, MongoDB and Google Cloud Firestore, will be compared in terms of their functionality, service, and pricing. MongoDB is an open-source database developed in 2009, while Cloud Firestore is a commercial database owned by Google Inc and founded in 2011 (Aneesha, 2021). The following tables will show the research result from Aneesha (2021), Barot (2021), Bohbot (2022), Dengis (2021), and Tareq (2021), comparing their strengths and weaknesses.

| NoSQL Database                  | MongoDB  | Cloud Firestore   |
|---------------------------------|--|---|
| Application                     | Large-scale application  | Small-scale application   |
| Data Model                      | Collection of JSON documents where are referred to with an object ID<br>Maximum: 16 MB | Collection of documents which are referred to with a REST-like resource path<br>Maximum: 1 MB |
| Server Operating System         | Hosted server  | Windows, Linux, Solaris, FreeBSD, OS X  |
| Replication Method              | Master-slave replication   | No replication  |
| Supported Programming Languages | Python, C#, Go, JavaScript, PHP, Ruby, and many others                                 | Java, JavaScript, C++, Swift, Objective-C   |
| Security                        | High   | Low   |

| Realtime Support | No   | Yes   |      |       |       |         |     |           |        |         |             |       |         |             |         |         |             |
|------------------|--|---|------|-------|-------|---------|-----|-----------|--------|---------|-------------|-------|---------|-------------|---------|---------|-------------|
| Pricing          | 1. Community Edition: Free<br>2. Enterprise Edition:<br>US \$6k - \$13k/year                                   | 1. Spark Plan: Free<br>2. Blaze Plan: Pay as you go <table border="1"> <thead> <tr> <th>Plan</th><th>Spark</th><th>Blaze</th></tr> </thead> <tbody> <tr> <td>Storage</td><td>1GB</td><td>\$0.18/GB</td></tr> <tr> <td>Writes</td><td>20K/day</td><td>\$0.18/100K</td></tr> <tr> <td>Reads</td><td>50K/day</td><td>\$0.06/100K</td></tr> <tr> <td>Deletes</td><td>20K/day</td><td>\$0.02/100K</td></tr> </tbody> </table> | Plan | Spark | Blaze | Storage | 1GB | \$0.18/GB | Writes | 20K/day | \$0.18/100K | Reads | 50K/day | \$0.06/100K | Deletes | 20K/day | \$0.02/100K |
| Plan             | Spark  | Blaze   |      |       |       |         |     |           |        |         |             |       |         |             |         |         |             |
| Storage          | 1GB  | \$0.18/GB   |      |       |       |         |     |           |        |         |             |       |         |             |         |         |             |
| Writes           | 20K/day  | \$0.18/100K   |      |       |       |         |     |           |        |         |             |       |         |             |         |         |             |
| Reads            | 50K/day  | \$0.06/100K   |      |       |       |         |     |           |        |         |             |       |         |             |         |         |             |
| Deletes          | 20K/day  | \$0.02/100K   |      |       |       |         |     |           |        |         |             |       |         |             |         |         |             |
| Top User Company | <ul style="list-style-type: none"> <li>• Uber</li> <li>• Lyft</li> <li>• Stack</li> <li>• Accenture</li> </ul> | <ul style="list-style-type: none"> <li>• PayPal</li> <li>• Alibaba Travels</li> <li>• Twitch</li> <li>• Instacart</li> </ul>  |      |       |       |         |     |           |        |         |             |       |         |             |         |         |             |

Table 5 Comparison between MongoDB and Cloud Firestore

Based on the comparison analysis from the above table, the developer decided to utilize Google Cloud Firestore as the database management system. The primary consideration is the short development time as the Firebase is designed for a small-scale application suitable for the newbie programmer. Compared to Cloud Firestore, MongoDB has a better performance when complicated data queries and aggregations are needed due to its maturity. Cloud Firestore has query restrictions that make some queries unfeasible, but it also possesses query scaling capability that is enough for this project. Besides, the developer is able to scale up the web application effortlessly and frequently with the implementation of Cloud Firestore.

The end product of this project is not designed for commercial purposes. Hence, the data flow and required storage are small, allowing the developer to use Cloud Firestore in the free version. Furthermore, Cloud Firestore supports real-time synchronization between devices. As there are two user roles, e-commerce business and customer, in this project, it is necessary to share the data in real-time for different users. For example, when a business has updated their product in the web application, the customers should be able to find the specific product on the product page using their devices simultaneously.

### 3.5 Operating System Chosen

The developer is using Windows 11 version 21H2 provided by Microsoft as the operating system to develop the proposed project. This latest version of Windows has a better performance in terms of security, customization, and compatibility compared to earlier versions of Windows. The chosen operating system is able to support the installation of Visual Studio Code and the Flask framework. Besides, multitasking can be easy to achieve with Windows 11 as it provides multiple desktops on a single monitor that allows the developer to open various applications or programs on different desktops and select a specific desktop to perform the corresponding tasks (Kourafalos, 2022).

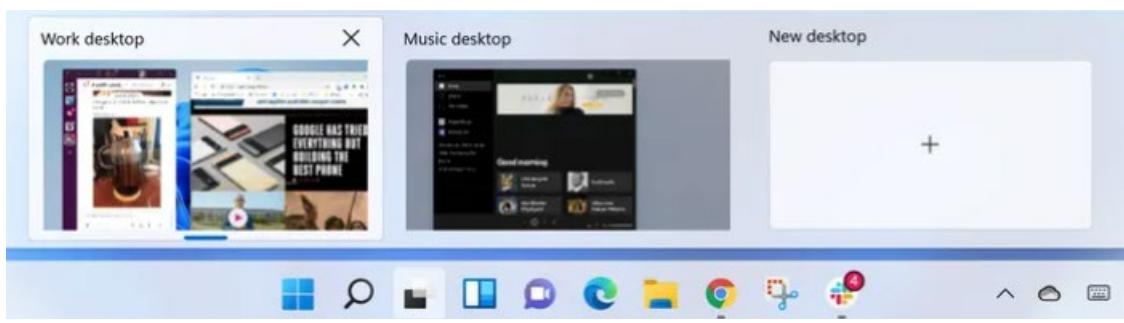


Figure 18 Windows 11 Multiple desktops (Krasnoff, 2021)

Additionally, snap layouts and groups offered by Windows 11 are easily accessible in the taskbar. Snap group can be used to launch multiple applications on a single screen by dividing their proportion. The developer can resize each proportion of the application according to his preference (Kourafalos, 2022).

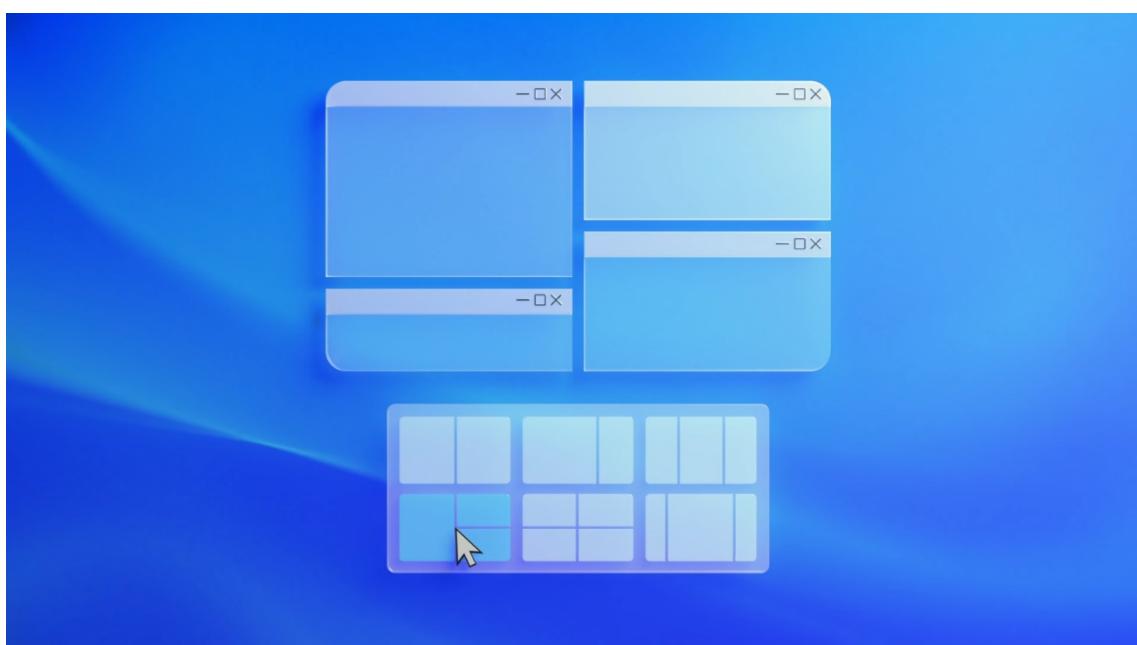


Figure 19 Windows 11 Snap Layouts and Groups (Parmar, 2021)

### 3.6 Web Server Chosen

A web server, one of the components in a client-server architecture, typically provides functions and services to a network of clients via the Internet. It mainly uses Hypertext Transfer Protocol (HTTP) and other internet protocols to communicate with web browsers and answer the requests made over the World Wide Web (WWW) from the client-side with required files. These presented contents may include HTML format, which is the text or media displayed on the website, or JSON format, which is the applications (Shankar, 2022). Web framework offers a standardized set of design and methods for creating and deploying web applications on the Internet, leading to cost efficiency and time saving as it lessens the developer's burden on the initial web development work. For example, a web framework is able to help developers apply a consistent design for the text, buttons, and tables on similar web pages and handle the default browser settings and file structures (An, 2021). As the developer has chosen Python as the primary programming language in this project, the comparison between the most popular Python web frameworks, Django and Flask, will be conducted in the following research.

Django is a full-stack framework providing one-stop solutions, including template engines, bootstrapping tools, and form generators, that are useful while developing a secure and maintainable web application. It follows the classical "Don't Repeat Yourself" (DRY) rule that seeks consistency, prevents code duplication, and avoids pattern repetition. Django offers the Model-View-Template (MVT) architecture to integrate the different components parallelly, achieving simpler and faster data communication over the Internet. The built-in Object-Relational Mapper (ORM) system allows the data transmission between an interactive database and application model, making the project more portable as it replaces the traditional SQL database queries. Django supports various database management systems, including PostgreSQL, SQLite, and MySQL, resulting in effortless database schema migration. Besides, Django provides URL routing and robust authentication systems and protocols to ensure the security of web applications preventing itself from clickjacking (Campbell, 2022; Singh, 2022).

On the other hand, Flask is a microframework suitable for minimalistic and lightweight web applications as it only offers the basic functionalities and features with little or no external libraries and dependencies. Unlike Django, Flask is less complex and easier to implement for a simple website, creating a beginner-friendly framework. Both Pocoo projects, which are the Werkzeug WSGI toolkit and Jinja2 templating engine, form the foundation of Flask. Its key features include a quick visual debugger, restful request handling, simple and adaptable

configurations, and coherent API, leading to high flexibility, scalability, and compatibility with modern technology. Moreover, Flask offers customization methods and gives developers complete control over the choices made to develop the web application (Semik & Stempniak, n.d.; Singh, 2022).

| <b>Web Framework</b>            | <b>Django</b>        | <b>Flask</b>              |
|---------------------------------|----------------------|---------------------------|
| Type                            | Full-stack framework | Microframework            |
| Project Size                    | Large and monolithic | Small and extensible      |
| Project Layout                  | Conventional         | Arbitrary                 |
| Design                          | Batteries-included   | Minimalistic design       |
| Object-Relational Mapping (ORM) | Built-in ORM         | SQLAlchemy as SQL toolkit |
| More Suitable Database Type     | SQL                  | NoSQL                     |
| Working Method                  | Monolithic           | Diversified               |
| API Support                     | No                   | Yes                       |
| Difficulty                      | Hard                 | Easy                      |
| Flexibility                     | Low                  | High                      |
| Security                        | High                 | Low                       |
| Performance                     | Low                  | High                      |

*Table 6 Comparison between Django and Flask*

The summary information shown in the above table is summarized from the research of Campbell (2022), Semik & Stempniak (n.d.), and Singh (2022). The developer decided to implement Flask as the proposed product review analysis system is a lightweight and extensible website. Besides, the developer is a novice web application developer, and the Flask application is less complex, easy to understand, and suitable for beginners compared to the heavier Django framework. Flask also provides flexibility to the developer to accept the changing requirements that meet the proposed agile system development methodology. Furthermore, Flask is capable of using NoSQL effectively, which suits the proposed project as the chosen database in section 3.4 is Cloud Firestore.

With Flask, the developer can create an HTML file for a webpage and utilize CSS techniques to beautify the webpage. HTML and CSS are then the primary programming language to develop the frontend of the web application, while Python will be used to build the backend.

### 3.7 Web Browser Chosen

The battle between Google Chrome and Microsoft Edge has been going on since 2019 to win the title of “The Best Browser.” Google Chrome was first released in 2008 and embedded in Windows XP, while Microsoft Edge, developed on Chromium source code, was introduced in 2019 and is available on Windows and macOS operating systems. Nowadays, Google Chrome continues its lead at the top of the desktop browser, having a 66.58% market share. However, the new released Chromium-based Microsoft Edge is becoming more competitive in the browser market, from 8.03% market share in March 2021 to 10.07% market share in March 2022, overtook Apple’s Safari and became the world’s second most commonly used browser (Duò, 2022; Mearian, 2022).

Google Chrome and Microsoft Edge have similar features, such as extensions, password managers, horizontal tabs, synchronization across multiple devices, and others. However, there are slightly different characteristics possessed by each browser in terms of the user interface, performance, and privacy. Google Chrome is using Google search engine by default, and Microsoft Edge’s default search engine is Bing. While Google is more concerned with expertise, authority, and trust (E.A.T.), Microsoft Bing focuses more on on-page optimization. Microsoft Edge has provided an immersive reader feature that converts web pages into simple eBook-based designs in order to increase readability. Within the immersive reader, one of the valuable features, read alone, enables a virtual reader to read the texts on the web pages in a human-sounding voice integrating variations of tone and pace. Moreover, Microsoft Edge has offered the user the option to choose a row of horizontal or vertical tabs that Google Chrome requires extensions for changing to vertical tabs (Burton, 2021; Duò, 2022).

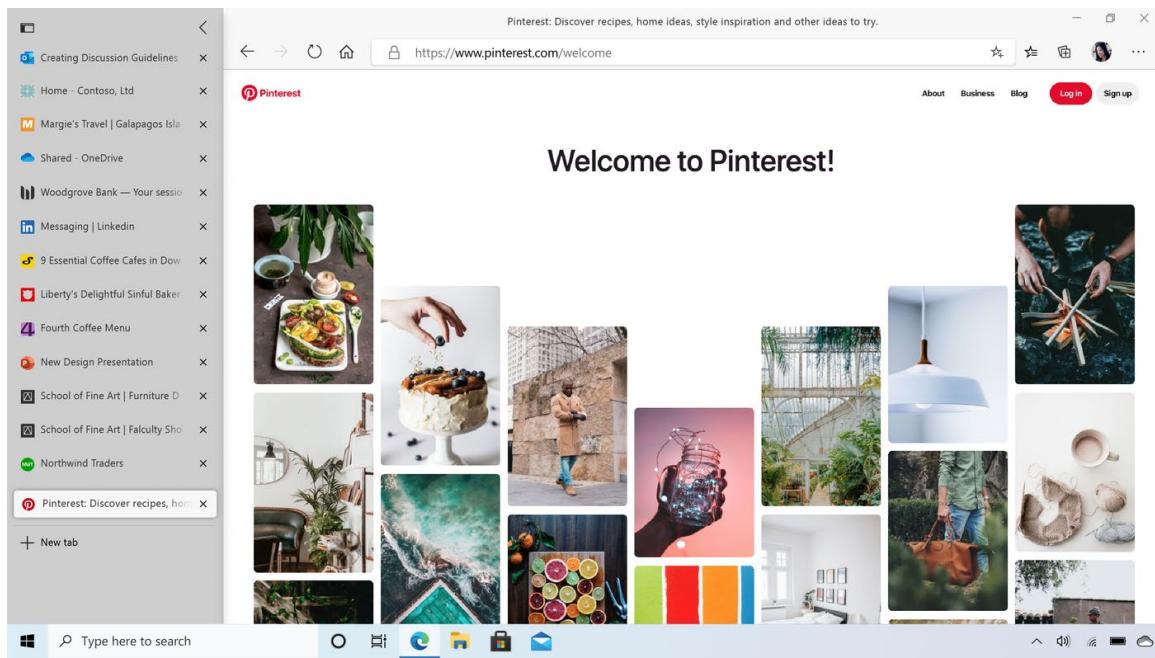


Figure 20 Microsoft Edge Vertical Tabs (Warren, 2020)

The most significant advantage of choosing Microsoft Edge over Google Chrome is its performance, which requires less memory allocation and resource consumption. Duò (2022) found that Microsoft Edge is 112% faster than Google Chrome in loading and response times. Although both Google Chrome and Microsoft Edge did not provide security and privacy as tight as privacy-focused browsers, such as the Tor browser and Brave browser, Microsoft Edge allows users to select from three different levels of tracking prevention to limit trackers from several sites (Coppock, 2022).

### Tracking prevention

Websites use trackers to collect info about your browsing. Websites may use this info to improve sites and show you content like personalized ads. Some trackers collect and send your info to sites you haven't visited. [Learn more](#)

The image shows the 'Tracking prevention' settings in Microsoft Edge. It features three options: 'Basic' (disabled), 'Balanced' (selected and recommended), and 'Strict'. Each option has a list of pros and cons. A large blue toggle switch is at the top right. Below the settings are sections for 'Blocked trackers' and 'Exceptions'.

| Level    | Description   | Status                              |
|----------|---|-------------------------------------|
| Basic    | Allows most trackers across all sites<br>Content and ads will likely be personalized<br>Sites will work as expected<br>Blocks known harmful trackers                                | <input type="checkbox"/>            |
| Balanced | (Recommended)<br>Blocks trackers from sites you haven't visited<br>Content and ads will likely be less personalized<br>Sites will work as expected<br>Blocks known harmful trackers | <input checked="" type="checkbox"/> |
| Strict   | Blocks a majority of trackers from all sites<br>Content and ads will likely have minimal personalization<br>Parts of sites might not work<br>Blocks known harmful trackers          | <input type="checkbox"/>            |

**Blocked trackers**  
View the sites that we've blocked from tracking you >

**Exceptions**  
Allow all trackers on sites you choose >

Figure 21 Microsoft Edge Tracking Prevention Levels (Microsoft, 2022)

Furthermore, Windows Defender SmartScreen embedded in Microsoft Edge is able to protect the developer against malware, phishing, and shady downloads. On the other hand, Google Chrome has its own built-in anti-malware functions to get a strong level of security protection (Coppock, 2022; Duò, 2022).

| <b>Web Browser</b> | <b>Microsoft Edge</b>           | <b>Google Chrome</b>  |
|--------------------|---------------------------------|-----------------------|
| Search engine      | Bing                            | Google                |
| Tabs               | Horizontal and vertical tabs    | Horizontal tabs       |
| Immersive reader   | Yes                             | No                    |
| Read aloud         | Yes                             | No                    |
| Extensions         | Few                             | Many                  |
| Performance        | High                            | Low                   |
| Security           | Windows Defender<br>SmartScreen | Built-in anti-malware |

*Table 7 Comparison between Microsoft Edge and Google Chrome*

All in all, the advantages of using Microsoft Edge outweigh the benefits provided by Google Chrome. Hence, the developer decided to choose Microsoft Edge as the web browser to accomplish research and interact with the web server while developing the proposed project.

### 3.8 Machine Learning Technique Chosen

After conducting research on machine learning approaches for performing sentiment analysis in Chapter 2, the developer has decided to implement a transformer-based model as its ability to process sequential data in parallel, achieving higher accuracy in performing sentiment analysis of product reviews. Besides, it uses a combination of self-attention mechanisms and feed-forward neural networks to process customer reviews as input text and make predictions. With the tools and resources provided by Hugging Face, fine-tuning a pre-trained transformer-based model for analyzing customer feedback can ensure that the deployed custom model performs better when embedded in the proposed system.

Currently, the popular pre-trained models suitable for sentiment analysis include GPT-3, BERT, DistilBERT, and others. These models are based on transformer architecture consisting of a series of Transformer layers stacked on top of each other, with each layer using a self-attention mechanism and a feed-forward neural network to process the input text and make predictions (NLPiation, 2021).

GPT-3 is known for the largest number of trainable parameters at around 175 billion. It is an autoregressive and unidirectional language model, which generates text one word at a time in a single direction, either from right to left or left to right. At each step, the model considers the previous words in the sequence and uses this context to predict the next word. This process continues until the end of the sequence is reached or a stop token is encountered. As a result, GPT-3 becomes simpler and faster to train and inference than bidirectional models, as it only needs to consider the context in one direction. However, it may become one of the weaknesses and not be as effective as bidirectional models on tasks that require understanding the context in which a word is used, such as natural language understanding, translation, and text summarization (360DigiTMG Group, 2021; Symbl, 2022).

Relying on the decoder segment of Transformer architecture, GPT-3 is primarily used for language generation tasks, such as text completion and machine translation. Due to its vast training data, it has achieved strong performance on a wide range of tasks, especially in generating coherent and natural-sounding text. It can generate text in a variety of styles, including news articles, poems, and stories. Hence, GPT-3 is typically embedded in chatbots or code generators to perform language translation, question answering, and text summarization (NLPiation, 2021).

Unlike GPT-3, BERT allows the model to use the context in both directions. It pre-trains on a bidirectional context by considering the input data in both the left and right directions when processing the input data. This makes BERT particularly well-suited for tasks that involve understanding the context in which a word is used, such as natural language understanding, translation, and text summarization. However, BERT is not as effective at generating human-like text as GPT-3, which is specifically designed for language generation tasks (Sousa et al., 2019).

BERT replies more on the Transformer structure's encoder instead of the decoder part for the task downstream. Developers are able to add new trainable layers on the top of the encoder in order to fine-tune for specific tasks, allowing it to be customized for different applications. Therefore, the BERT model performs well in domain-specific tasks, such as answering questions and sentiment analysis (Symbl, 2022). According to the research by Zhang (2019), BERT has set new benchmarks for Stanford Question Answering Dataset (SQuAD), achieving 93% accuracy.

DistilBERT (Distilled BERT) is a smaller, faster version of BERT developed by Hugging Face. The model developed using DistilBERT is able to retain 97% of BERT's performance with 60% faster and 40% smaller in size. It is based on the same transformer architecture and self-attention mechanisms as BERT, but has fewer parameters and encoder blocks. Hence, DistilBERT is faster to train and inference. Like BERT, it is pre-trained on a bidirectional context and can be fine-tuned for specific tasks (Kotamraju, 2022; NLPiation, 2021).

The table below shows the comparison among GPT-3, BERT, and DistilBERT according to the research conducted by Kotamraju (2022), NLPiation (2021), and Symbl (2022).

| <b>Transformer-based Model</b> | <b>GPT-3</b>   | <b>BERT</b>     | <b>DistilBERT</b> |
|--------------------------------|----------------|-----------------|-------------------|
| Company                        | OpenAI         | Google Research | Hugging Face      |
| Parameter Size                 | 175 billion    | 110 million     | 66 million        |
| Pre-training                   | Unidirectional | Bidirectional   | Bidirectional     |

| Focus<br>Transformer<br>Architecture Parts | Decoder  | Encoder   | Encoder   |
|--|--|---|---|
| Focus Tasks                                | Language Generation  | Language<br>Understanding   | Language<br>Understanding   |
| Performance                                | Strong   | Strong  | Strong (Smaller and<br>faster than BERT)  |
| Main<br>Applications                       | <ul style="list-style-type: none"> <li>• Machine Learning</li> <li>Code Generator</li> <li>• Chatbots</li> <li>• Text</li> <li>Summarization</li> <li>• Article and Story</li> <li>Writer</li> </ul> | <ul style="list-style-type: none"> <li>• Text</li> <li>Classification</li> <li>• Sentiment</li> <li>Analysis</li> <li>• Machine</li> <li>Translation</li> <li>System</li> </ul> | <ul style="list-style-type: none"> <li>• Text</li> <li>Classification</li> <li>• Sentiment</li> <li>Analysis</li> <li>• Machine</li> <li>Translation</li> <li>System</li> </ul> |

Table 8 Comparison among GPT-3, BERT, and DistilBERT

All the mentioned transformer-based model has their own strengths and weaknesses. GPT-3 has been trained with a vast amount of data, having a strong ability to generate coherent and natural-sounding text. However, due to its large number of parameters, GPT-3 model requires more computation and memory than BERT and DistilBERT. Besides, it may require more fine-tuning to achieve good results on specific tasks, as it is primarily designed for language generation tasks and is pre-trained in a unidirectional context. On the other hand, both BERT and DistilBERT can complement GPT-3 by being pre-trained in a bidirectional context, allowing them to understand the context in which a word is used. They can easily be fine-tuned for specific tasks and customized for different applications.

Compared to BERT, DistilBERT requires fewer computational resources to train and fine-tune the model, avoiding time-consuming processes. In exchange, DistilBERT may not perform as well as BERT on some tasks due to its smaller size.

In a nutshell, the developer decided to choose DistilBERT as the machine learning model to be fine-tuned for performing sentiment analysis. It is because the proposed project is a small-scale application and needs to be developed in a limited timeline. A better model performance with higher accuracy and lower misclassification rate may also be achieved using DistilBERT instead of GPT-3 due to the bidirectional transformer.

### 3.9 Summary

In short, the developer has researched several technical requirements, including programming language, interactive development environment (IDE), libraries, database management system, operating system, web server, and web browser. The table below will show the overview of the tools and technique and their version that will be used during the project implementation stage. However, there is the possibility that the mentioned tools and techniques might be replaced to cope with the faced barriers and the changing requirements.

| Category                                  | Tools and Techniques  | Version   |
|---|---|---|
| Programming Language (Backend)            | Python  | 3.10.5  |
| Programming Language (Frontend)           | <ul style="list-style-type: none"> <li>• HTML</li> <li>• CSS</li> </ul> (Enabled by Flask)  | <ul style="list-style-type: none"> <li>• HTML 5</li> <li>• W3.CSS 4.15</li> </ul>   |
| Interactive Development Environment (IDE) | <ul style="list-style-type: none"> <li>• Visual Studio Code (Web Application)</li> <li>• Google Colaboratory (Machine Learning Model)</li> </ul>  | <ul style="list-style-type: none"> <li>• 1.69.2</li> <li>• -</li> </ul>   |
| Libraries and Tools                       | <u>Machine Learning Model</u> <ul style="list-style-type: none"> <li>• NumPy</li> <li>• Matplotlib</li> <li>• Tensorflow</li> <li>• Scikit-learn</li> <li>• Transformers</li> </ul> <u>Web Application</u> <ul style="list-style-type: none"> <li>• Flask</li> <li>• Flask-WTF</li> </ul> | <ul style="list-style-type: none"> <li>• 1.22.4</li> <li>• 3.5.2</li> <li>• 2.9.2</li> <li>• 1.2.0</li> <li>• 4.25.1</li> </ul> |
| Database Management System (DBMS)         | Google Cloud Firestore  | -   |
| Operating System                          | Windows 11  | 21H2  |
| Web Server                                | Flask   | 1.1.1   |
| Web Browser                               | Google Chrome   | 103.0.5060.134  |

|                      |          |  |   |
|----------------------|----------|--|---|
| Machine<br>Technique | Learning | DistilBERT Model (Transformer-based model) | - |
|----------------------|----------|--|---|

*Table 9 Technical Research Summary*

## CHAPTER 4: SYSTEM DEVELOPMENT METHODOLOGY

### 4.1 Comparison of Methodology

System development methodology (SDM) ensures that the high-quality, maintainable software will be developed within a reasonable time frame by providing a logical and systematic procedure from the system planning to the deployment. Within the information technology (IT) aspect, every project must come with a system development methodology, especially for large, complex projects, such as large-scale programming where many developers are involved. It will help identify a set of standard communication channels, including the shared objectives and concepts, for the development team in order to convert their ideas into a practical project (C. K. Wong & S. L. Lee, 2018).

Nowadays, these diverse methodologies have been classified into two main categories, traditional and agile system development methodology, to make it easier to choose the most appropriate one. Examples of traditional approaches include Waterfall, V-model, Structured Systems Analysis and Design Method (SSADM), and others, while agile methods consist of Rapid Application Development (RAD), Feature Driven Development (FDD), Kanban, Extreme Programming (XP), and others (Shaikh & Abro, 2019). The comparison of two representative approaches from traditional and agile system development methodology, which are SCRUM and Waterfall, will be analyzed in the below table:

| Methodology | SCRUM  | Waterfall  |
|-------------|--|--|
| Process     | Iterative development<br>Each iterative includes:<br>1. Sprint planning<br>2. Daily SCRUM meeting<br>3. Sprint review<br>4. Sprint retrospective | Sequential development<br>The overall process includes:<br>1. Requirement gathering and analysis<br>2. System design<br>3. Implementation<br>4. Integration and testing<br>5. Deployment<br>6. Maintenance |
| Focus on    | Frequent product delivery and customer satisfaction  | Good documentation and error-free product  |

|                           |   |   |
|---------------------------|---|---|
| Project Requirement       | Requirement remains unclear as it allows changing requirements during the system development                                    | All the requirements are needed to identify at the beginning of the system development  |
| Flexibility               | High  | Low   |
| Client Involvement        | High  | Low   |
| System Testing            | System testing is conducted throughout the process rather than leaving it for the end   | System testing is conducted at the end of the system development  |
| Product Delivery          | There will be at least one deliverable presented to the customers at the end of each iterative                                  | The end product will only be delivered after completed all the phases   |
| Risk                      | Low   | High  |
| Informative Documentation | Not compulsory  | Compulsory  |
| Client Feedback           | There will be a product review section at the end of each iterative for collecting client's opinions                            | The development team only considers the feedback related to the initial requirement after completing all the phases                               |
| Development Time          | Short   | Long  |
| Project Size              | Small-scale project   | Large-scale project   |
| Team Size                 | Small. The team members are flexible and can be increased or decreased according to the task carried out in each sprint         | Huge. The development team consists of members who are fixed to this project  |
| Developer Skill           | Multi-talented and experienced specialists are required   | A combination of junior and senior developers is accepted   |
| Team Roles                | <ol style="list-style-type: none"> <li>1. Product owner</li> <li>2. Scrum master</li> <li>3. Development team member</li> </ol> | <ol style="list-style-type: none"> <li>1. Developer</li> <li>2. System tester</li> <li>3. Business analyst</li> <li>4. Project manager</li> </ol> |

Table 10 Comparison between SCRUM and Waterfall

The cross-analysis table above is completed by the developer after carrying out the research by Chandana (2022), Codegiant (2020), Coursera (2022), Koelblen (2019), and Petrova (2021).

## 4.2 Justification

After weighing the advantages and disadvantages of both SCRUM and Waterfall system development methodology, the developer has decided to choose SCRUM for developing the proposed project. The primary reason is its short development time. The entire project development duration for Final Year Project (FYP) is around three months. SCRUM enables fast-paced development by breaking the entire project requirement into small, manageable tasks carried out during each sprint. Compared to the Waterfall method, SCRUM accepts the changing requirements even during the late project development. It is crucial for the developer who faces the challenges of uncertainty about the proposed project. If something untoward happens, the developer can quickly conduct changes to cope with the difficulties, such as insufficient development time, unfamiliar tools and techniques, and others.

Besides, system testing is conducted at the end of each sprint. It assists the developer in checking the performance of the developed features at an early stage instead of carrying them out at the end of the system development. As a result, the project failure risk will be reduced. Frequent project delivery enabled by SCRUM will enhance the confidence level of the developer by successfully developing a few system functionalities. After completing each sprint, the developer can request feedback from his lecturers and friends to gain insight into the end product regarding the actual system expectation and user satisfaction.

Using the SCRUM development methodology ensures that the developer can manage his workflow and boost productivity. Although SCRUM is designed for a development team with a high degree of skill, it also can be applied to an individual project as the agile technique is helpful in providing guidelines for finishing the project in a short development time. For example, task prioritization and scaling optimize the development process and allow the developer to focus on the core feature of the proposed system.

Overall, the SCRUM methodology will be helpful for the developer in producing the end product on schedule with a high level of quality. Additionally, thanks to the feasibility offered by SCRUM, the developer will develop some additional features to the system if time allows.

### 4.3 Overview and Application of SCRUM Methodology

Scrum system development methodology was first implemented in 1993 by Jeff Sutherland, who referenced a Harvard Business Review study named “The New Product Development Game.” It is an agile methodology that follows the 12 agile principles considering customer satisfaction, development teamwork, fast project development, and high product quality. Scrum methodology separates the entire system development lifecycle into multiple standalone phases, called sprint. Multiple iterative and incremental sprints make up the entire Scrum development process (Ageling, 2019; Anguelov, 2019).



Figure 22 SCRUM Workflow ("Scrum vs Waterfall vs Agile vs Lean vs Kanban," n.d.)

In the proposed project, the developer will be the only member who builds the system from the sketch until the system deployment. Hence, the following description of the Scrum methodology will exclude the Scrum roles (product owner, Scrum master, Scrum team members). Instead, the developer will customize the Scrum system development methodology and focus on individual responsibility while developing the proposed system.

Figure 19 shows the operational flow of Scrum, from identifying the project vision to the sprint iteration that starts with the planning stage and ends with the retrospective stage. First and foremost, a clear project vision and business goals should be identified by understanding the market's needs and discovering the challenges and possible solutions in order to design the proposed projects (Anna, 2020). After finalizing the business goals and defining the use cases toward the goals, epics are created according to the prioritized use cases. An epic is then

segmented into numerous smaller, specific user stories, which are informal documents describing the product or software features using the natural language from the end-user perspective. The product backlog, including the project goals and a list of product characteristics, is usually done before the first sprint according to the user stories. The item order inside the product backlog is prioritized based on its importance and can be modified when a new requirement is added to the list (Hema et al., 2020; Rehkopf, 2022).

After the product backlog is identified, it will start looping the sprint to complete all the items listed in the product backlog. Every iterative sprint is an increment of product quality. Usually, each sprint takes up to one to four weeks. In every sprint, the developer is required to complete the tasks listed in the sprint backlog during the sprint planning conference. Sprint backlog acts as a subset of product backlog that includes prioritized dynamic requirements, which are the project's detailed features and characteristics determined by the developer (Hema et al., 2020).

### **Sprint planning:**

Each sprint is started with the sprint planning meeting. The developer will be the only meeting participant as the proposed project is an individual project. The purpose of the meeting is to have a clear understanding of the sprint goals and the tasks that will be carried out during the sprint (Hema et al., 2020). During the planning phase, the developer should break down the project backlog into individual, standalone tasks for sprint backlog and assign them with a timeline. Besides, the precise goals and objectives of the sprint should be determined by the developer to guide him throughout the entire sprint. When the sprint backlog is determined, it indicates the beginning of the sprint development.

### **Sprint Implementation:**

During the implementation phase, the developer should focus on the to-do list created based on the sprint backlog. A daily Scrum, which is usually less than 15 minutes, will be conducted on a day-to-day basis. The fundamental purposes of the daily start-up are to review the progress of scheduled tasks, list out the task the developer is going to accomplish on the current day, and identify the issue arising throughout the development. Two essential techniques, impediment logs and burndown chart, are required during the sprint implementation. A Burndown chart illustrates the amount of work completed and the remaining

task in a sprint, while the impediment log keeps track of the obstacles and barricades that prevent the team from completing the tasks (Canty, 2018; Hema et al., 2020; Rehkopf, 2022).

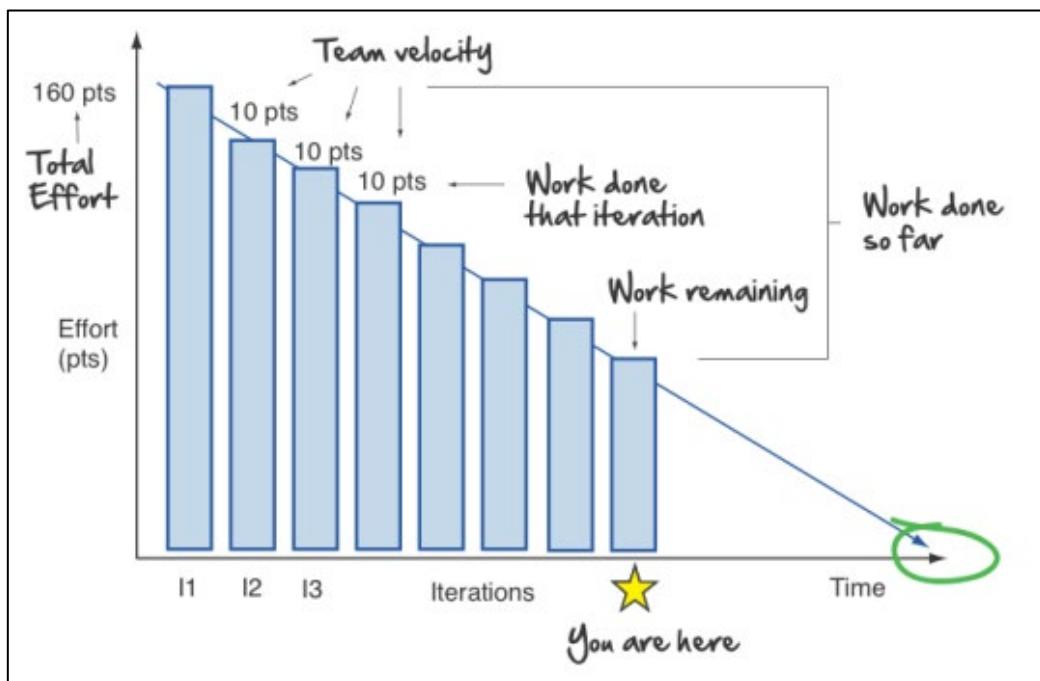


Figure 23 Burndown Chart Template (Gonçalves, 2021)

| Impediment  | Description | Importance | Status      | Action |
|---|-------------|------------|-------------|--------|
| Outdated software version                         |             | Blocker    | Resolved    |        |
| The machine learning model is not functioning     |             | Critical   | In Progress |        |
| Not enough memory allocated for the kernel buffer |             | Minor      | Open        |        |

Table 11 Impediments Log Template

In addition, the developer should carry out test cases at the end of the implementation stage. Several types of testing can be conducted by the developer, such as unit testing, integration testing, system testing, and others. Each testing assists the developer in checking the performance of the developed features at an early stage and reducing the risk of project failure.

### Sprint Review:

After completing all the tasks listed in the sprint backlog, a sprint review meeting will be conducted. The developer can review the conducted sprint alone or invite his supervisor, lecturers, family members, or friends to review the sprint together. During the sprint review meeting, the developer needs to carry out the demonstration of the developed product that

includes the latest features and key increments in order to request feedback from the attendees (supervisor, lecturers, family members, and friends). The attendees can express their doubts about the product features and suggest new requirements. The developer should note down the discussions, including the modified product backlog and refer to them during the upcoming sprint planning meeting (Hema et al., 2020).

### **Sprint Retrospective:**

At the end of the sprint, a sprint retrospective that reflects on the process of the current sprint and the possible improvement for the following sprint should be carried out to discover new opportunities of success for the proposed project (Hema et al., 2020). During the sprint retrospective, the developer should have a critical self-reflection and record the good and bad throughout the sprint process. It is helpful for the developer to improve himself in terms of productivity, attitudes, discipline, and other personal development.

The following detailed plans are the initially planned sprint backlog designed for each sprint in order to develop the proposed system:

#### **Sprint 1:**

- This sprint is planned to spend three weeks.
- The first cycle will concentrate on the fundamental feature of the web-based product review analysis system.
  - User register (E-commerce business and Customer)
  - User login and logout (E-commerce business and Customer)
  - Add, remove, and modify product (E-commerce business)
  - Add, remove, and modify tags for product review titles (E-commerce business)
  - Graphical User Interface (GUI) design of web application

#### **Sprint 2:**

- This sprint is planned to spend four weeks.
- This loop will focus on the rest of the interactive user interface for the web application.
  - Search for business's product (Customer)
  - Provide product review and choose a title for the comment (Customer)
  - Filter product reviews based on the titles (E-commerce business and Customer)
  - View feedback provided by existing customers (E-commerce business and Customer)
  - Graphical User Interface (GUI) design of web application

#### **Sprint 3:**

- This sprint is planned to spend four weeks.

- This increment will concentrate on developing the machine learning algorithm and training the sentiment analysis model.
  - Input data
  - Data pre-processing (Sentence segmentation, word segmentation, punctuation and symbols removal, stop words deletion)
  - Split train data and test data
  - Model selection
  - Model training
  - Classify the polarity of the product review
  - Data visualization

**Sprint 4:**

- This sprint is planned to spend three weeks.
- The last sprint will focus on integrating the sentiment analysis machine learning model and web-based product review analysis system.
  - Integrate the machine learning model with the web application
  - View bar chart showing the proportion of the product review polarity
  - Graphical User Interface (GUI) design of web application
  - Upvoting and downvoting the other customer's product reviews (Customer) (Extra feature)
  - Reply to customer review (E-commerce business) (Extra feature)

#### 4.4 Summary

Scrum system development methodology was chosen as a guideline for developing the proposed system instead of the traditional Waterfall methodology as it benefits the small project that requires the developer to complete in a short timeline. In addition, the proposed product review analysis system will be developed by the developer alone. Hence, the developer customizes the Scrum methodology by ignoring the Scrum roles and shouldering all the responsibilities individually. For the sprint review stage, the developer will choose to include his supervisor, lecturers, family members, and friends to request their feedback referred to improve the end product during the upcoming sprints. In the end, the developer outlines a sprint backlog draft utilized for the proposed project during the implementation stage, the FYP second phase.

## CHAPTER 5: RESEARCH METHODS

### 5.1 Introduction

Although the developer has conducted intensive research on various literature in Chapter 2, it is essential to gather the opinions of the public, who represent the proposed system's end-users. There is a wide variety of data collection methods available in the current market. However, these methods can be categorized into two types of research: quantitative and qualitative. Each of them has its own unique properties and techniques for data gathering.

#### **Qualitative research:**

Qualitative research method aids in understanding an individual's ideas, experiences, concepts, feelings, and behaviors towards the research topic. It allows the researcher to gather in-depth insight into what and why a person subjectively comprehends and provides insights into his/her social reality. This research aims to discover how and why things happened, analyze events, and define activities concerning the research topic. The result of qualitative research is usually described in words and considered as non-numerical data that can be analyzed using thematic analysis or established theory. Examples of qualitative research approaches are observations, interviews, focus groups, literature reviews, and others (Jordan, 2021; Mcleod, 2019; Streefkerk, 2019).

#### **Quantitative research:**

Quantitative research method includes the process of objectively gathering and analyzing the numerical data. The purpose of this research is to define, forecast, control interest variables, and generalize the research topic by systematically identifying the patterns and relationships among the collected data. Quantitative research is able to establish how often, how much, how many, or to what extent someone needs or something happens. The gathered quantitative data is commonly expressed in graphs, tables or numbers and counted as numerical data, which can be analyzed using statistical analysis. Examples of quantitative research approaches are surveys and questionnaires, polls, experiments, observations, and others (Jordan, 2021; Mcleod, 2019; Streefkerk, 2019).

The developer has chosen questionnaire as the research method to collect the data from the public. A questionnaire has numerous advantages that are listed as the following:

### **1. Speedy Data Collection without Geographical Limitation**

The most significant advantage of the questionnaire is its various methods for distributing the survey. The developer can share his survey through a public forum, online communication platform, and social media sites, such as WhatsApp, WeChat, Facebook, Instagram, Microsoft Teams, Twitter, and many others. Even if the respondents are dispersed over different countries, states, or cities, the developer can easily send the questionnaire over the Internet within seconds. Besides, the short project timeframe allocated to the FYP Report requires the developer to reach out to the questionnaire participants in the most effective method in order to complete the research within the planned timeline.

### **2. Cost Saving**

To conduct the questionnaire, the developer will use the free survey tool, Google Form, to collect the responses without any cost. Compared to an online questionnaire, an interview conducted face-to-face, over the phone, or by mail may require labor, paper, printing, or transportation expenses resulting in high costs that burden the developer. A questionnaire can be sent through social media or email that requires no cost. As the resources are limited for this project, the online survey is the best choice for the developer. However, the developer needs to target effectively to increase the response rates and receive accurate results.

### **3. Scalability**

An online survey offers the developer the advantage of changing the sample size of the questionnaire to include more participants by simply extending the survey timeframe and sending the link to more respondents. If the developer finds that there is a typo inside the questionnaire, it is effortless to correct it and provide the participants with the latest survey using the survey link. Scalability provides ease for the developer to decide on the number of responses. By gathering more data, the developer is able to uncover more accurate patterns and trends in order to support his arguments and empower him to make informed decisions to proceed with further development.

#### **4. Flexibility for Participants**

As the term “sentiment analysis” might be foreign to many participants, they may require more time to research this area in order to answer the questions better. By considering this situation, a questionnaire can provide flexibility to its respondents to fill out the survey anytime and anywhere. On the other hand, some methods, including face-to-face interviews and focus groups, require the participants to respond immediately to the question. It might put the participants who are weak at reacting on the spot at an unfair disadvantage leading to inaccurate collected data. Conversely, an online survey gives respondents extra time to complete the survey and even the option to start and finish it. Hence, the respondents are able to participate in the survey in the best condition resulting in increased response rates and more accurate data collected by the developer.

#### **5. Anonymity**

Last but not least, the other significant advantage provided by the questionnaire is its ability to offer anonymity, especially for the survey conducting sensitive topics. When respondents remain anonymous, it provides a comfortable environment to share their thoughts or ideas, tallying with a vital ethical factor for any data collection process. The questionnaire also put respondents at ease and encouraged them to provide more honest answers without making them feel criticized, allowing the developer to collect more accurate data.

The proposed product review analysis system requires the facts, numbers, and statistics of online shopping user experience and behavior analysis. A questionnaire can assist the developer in gaining insight into an individual’s opinions, knowledge, and behaviors. This questionnaire combines quantitative and qualitative research to generalize the results to broader populations and investigate an individual’s perception in depth. An example of quantitative questions included in this questionnaire is asking participants about their age range. By analyzing the pie chart of the age group, the developer can indicate the average age of online shopping users. On the other hand, an example of qualitative questions included in this questionnaire is questioning participants about the categories they will consider while providing product reviews. Besides the pre-determined options, the developer has included the “other” choice for participants to fill in their creative thoughts, providing the developer with an opportunity to identify a new possibility.

## 5.2 Design

The structure of the designed questionnaire is all closed-ended questions that include a combination of qualitative and quantitative research. It is divided into three sections: project description and acknowledgment, demographic profile, and online shopping experience. There are 1 question in **Section 1**, 6 questions in **Section 2**, and 11 questions in **Section 3**, a total of 18 questions. The questionnaire design of this research will be shown below:

The screenshot shows a survey interface. At the top left, a purple button says "Section 1 of 3". The title "Survey: Sentiment Analysis of Product Reviews using Machine Learning" is centered at the top. To the right of the title are two small icons: a close button (X) and a more options button (three dots). Below the title, the text reads:

Dear Participants,

My name is Lew Jun Long, currently pursuing a bachelor's degree in Computer Science (Intelligent Systems) at Asia Pacific University of Technology and Innovation (APU). I am conducting a questionnaire survey as one of the data collection methods for my Final Year Project (FYP) entitled "Sentiment Analysis of Product Reviews using Machine Learning". The purpose of this survey is to have an understanding of online shopping users' behaviours and attitudes toward customer feedback and how the product reviews affect their purchase decision.

Sentiment analysis is a natural language processing (NLP) technique that is performed on textual data to identify the writer's emotions. It will classify the data (paragraph, sentence, phrase, word) into a positive, neutral, or negative statement. By implementing sentiment analysis in product review, the electronic commerce business is able to understand the customer needs in order to tailor their products and improve their customer service. It will also optimize potential customers' decision-making process while purchasing a product through an online shopping platform.

**Disclaimer:**  
All participant information will be kept confidential and anonymous. Your corporation in filling out the questions with utmost honesty, truthfully, and faithfully will be highly appreciated. Please be informed that participating in this survey has no consequences or known risks. Your participation is voluntary, and this research is only conducted for academic purposes.

This survey will only take around 5-10 minutes of your time to be completed.  
If you have problems or concerns regarding this research, please feel free to contact the researcher through an email as provided below.

Thank you for your corporation.

Sincerely,  
Lew Jun Long  
tp059638@mail.apu.edu.my

I hereby acknowledge that I fully understand and agree to the terms stated above. \*

Agree

**Objective:**

- The introduction aims to inform participants regarding the characteristics of the proposed system as well as its general knowledge and benefits.
- The purpose of a disclaimer is to clarify the obligations to the participants and to protect the researcher from liability.
- By clicking the “Agree” button, the researcher is able to get evidence that the participants are willing to participate in this survey.

Section 2 of 3

**Section A Demographic Profile**

To keep your data anonymous, questions such as name or contact details will not be asked.

Gender \*

Male

Female

Prefer not to say

Other...

**Objective:**

- To identify the gender group of the participants and their relationship with the online shopping user.

**Age \***

- 18 - 25
- 26 - 34
- 35 - 44
- Above 44

**Objective:**

- To identify the age group of the participants and their relationship with the online shopping user.

## In terms of your current working area, how would you categorize yourself? \*

- IT/Data Sciences
- Media/Entertainment
- Sales/Marketing
- Education/Training
- Customer Service
- Healthcare
- Other...

**Objective:**

- To identify the participants' occupation and their relationship with the online shopping user. Also, to determine which occupation has the most interest in sentiment analysis-based products. The result may assist the researcher in concentrating on the correct target markets.

Have you ever shop online? \*

- Yes
- No

**Objective:**

- To define whether the participants have an online shopping experience and whether there is a market for the proposed system.

Which of the following shopping apps have you used before? \*

- Shopee
- Lazada
- Taobao
- Amazon
- Facebook Marketplace
- Other...

**Objective:**

- To determine the participant's preferences and the popularity of each online shopping platform. The result may affect the researcher's decision on the partnerships company for performing real-world system testing in the future for further improvement.

How often do you buy products online? \*

- Once in a week
- More than twice times in a week
- Once in a month
- Twice to five times in a month
- Once in a year
- Never

### Objective:

- To determine the frequency of participants purchasing items using the online shopping platform.

#### Section 3 of 3

#### Section B Online Shopping Experience



This section composes of questions designed to capture the behaviours and attitudes toward product reviews.

How often do you review a product on an online shopping platform after experiencing it? \*

- Extremely often
- Quite often
- Moderately often
- Slightly often
- Not at all often

### Objective:

- To define the frequency of participants expressing their opinion and feedback on products on online shopping platforms. The result indicates the amount of data and the size of dataset input to the sentiment analysis model.

Which category/categories will you include when providing feedback on online shopping platform? \*

- Product quality
- Value for money
- Delivery service
- Customer support
- Other...

**Objective:**

- To determine the categories that the participants were concerned about while offering product reviews. The result may affect the developer's design of the product review title tag.

You are always affected by your emotions (joy, sadness, anger, surprise) while providing product reviews. \*

**Objective:**

- To demonstrate whether there is any sentimental and emotional element within the product reviews answered by the participants. The result may affect the performance of the proposed product review analysis system.

How do you find information about your desired product (e.g. electronic device, fashion item)? \*

- Social Media
- Friends and Family
- Search Engine (e.g. Google, Baidu)
- Online forum reviews
- TV and Newspaper
- Other...

**Objective:**

- To define the methods and resources participants usually used to research the products. Also, to indicate the importance of the feedback and opinions provided by various users on different platforms. The researcher is able to decide on the possible platforms to embed the sentiment analysis model based on this research result in the coming future.

Select the top 3 attributes that will affect your purchase decision the most? \*

Product Textua... Product Graphi... Seller Rating Seller Chat Res... Product Review

|                   |                       |                       |                       |                       |                       |
|-------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| First to consider | <input type="radio"/> |
| Second to con...  | <input type="radio"/> |
| Third to consider | <input type="radio"/> |

**Objective:**

- To define the factors that influence the participant's decision-making the most. Also, to identify the importance of the product review before paying for an item. The result may determine the significant effect of the proposed system and its helpfulness to the public.

You rely on user feedback to make purchase decision? \*

1      2      3      4      5

Strongly disagree

Strongly agree

### Objective:

- To determine the importance of the product reviews. If the results show an average of participants who choose to agree with the statement, it means the researcher is heading in the correct research direction.

Would you prefer to buy a product that has lots of reviews but more expensive rather than the \* cheaper product but less reviews?

Yes

No

Maybe

### Objective:

- To determine the importance of the product reviews and their weight compared to the product price. The result will give the researcher a better insight into the impact of product review and price on the participant's purchasing decision-making.

Do you think that some positive product reviews available on online shopping platform are \* fake or posted by company itself?

Yes

No

Maybe

**Objective:**

- To indicate the confidence level of the participants towards the veracity of the product reviews. If the result is prone to “Yes,” the researcher should consider the need for a product review verification feature before showing it to the customers.

Would you be interested in sentiment analysis tool to gain a better insight into the real emotion behind the messages? \*

- Yes
- No
- Maybe

**Objective:**

- To determine whether the public show interest in the proposed system and if there is a potential market for the proposed system. The result, which is prone to “Yes,” may indicate the researcher is heading in the correct research direction, and the system should be introduced in the coming future in order to realize their expectations.

Have you ever used a sentiment analysis or similar tool before? \*

- Yes
- No
- Maybe

**Objective:**

- To define the popularity of the sentiment analysis-based product and the users' experience level. The result may affect the user-friendliness of the proposed product review analysis system. If most participants are novices or beginners in using the sentiment analysis-based product, the researcher should include guidance for the users to navigate the system.

(If your response to previous question was No, you may skip this question) The sentiment analysis tool that you have used before, is able to produce accurate result despite the complexity of the data.

- Yes
- No
- Sometimes
- Maybe

**Objective:**

- To find out the efficiency and trustworthiness of the current market available sentiment analysis product. Also, to determine the participant's confidence level in using the sentiment analysis tool. The result, which is prone to "No," may require the researcher's high concentration on the accuracy and performance of the sentiment analysis machine learning model.

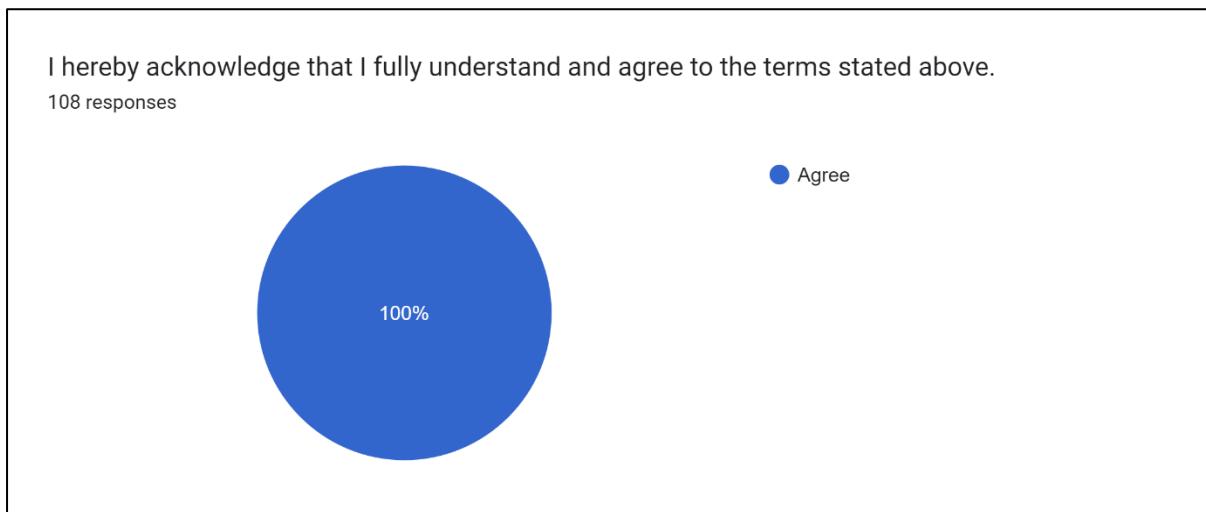
### 5.3 Summary

The result of this research method might affect the goals and deliverables of the proposed project as well as the direction of further research and improvement. Customer satisfaction is an essential element in Scrum agile system development methodology. In order to provide the highest software quality, it is necessary for the developer to solicit user involvement and opinions for the designed project. As a result, every feedback, whether critical or supportive, will be taken into account while developing the proposed system. This questionnaire aims to collect respondents' thoughts from different work areas, genders, and ages on how the sentiment analysis might assist in making purchase decisions. Additionally, respondents can also gain knowledge of how the sentiment analysis might be beneficial to them.

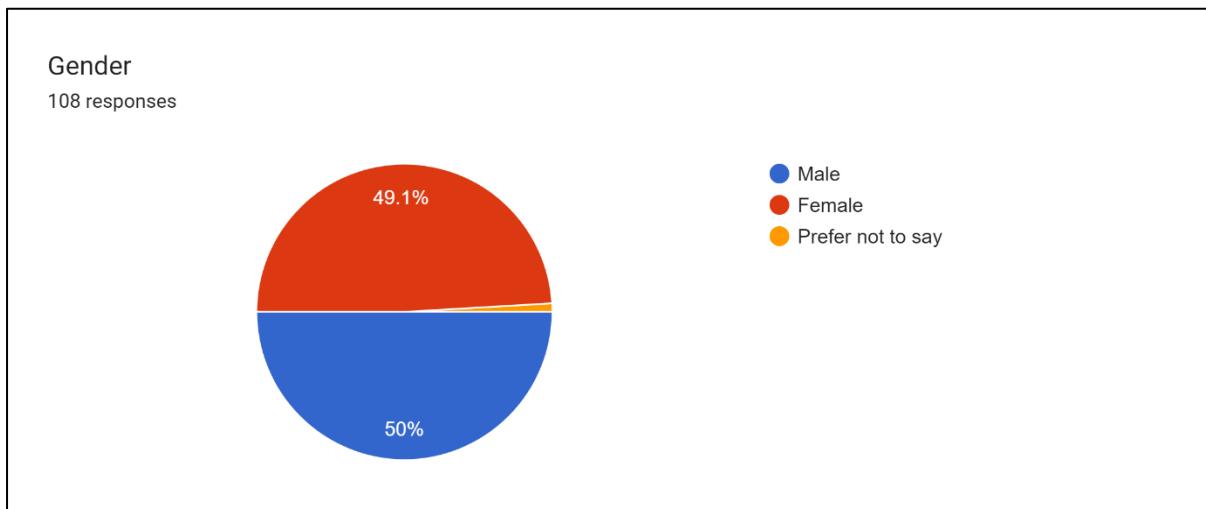
## CHAPTER 6: REQUIREMENTS VALIDATION

### 6.1 Analysis of Data Collected through Questionnaire

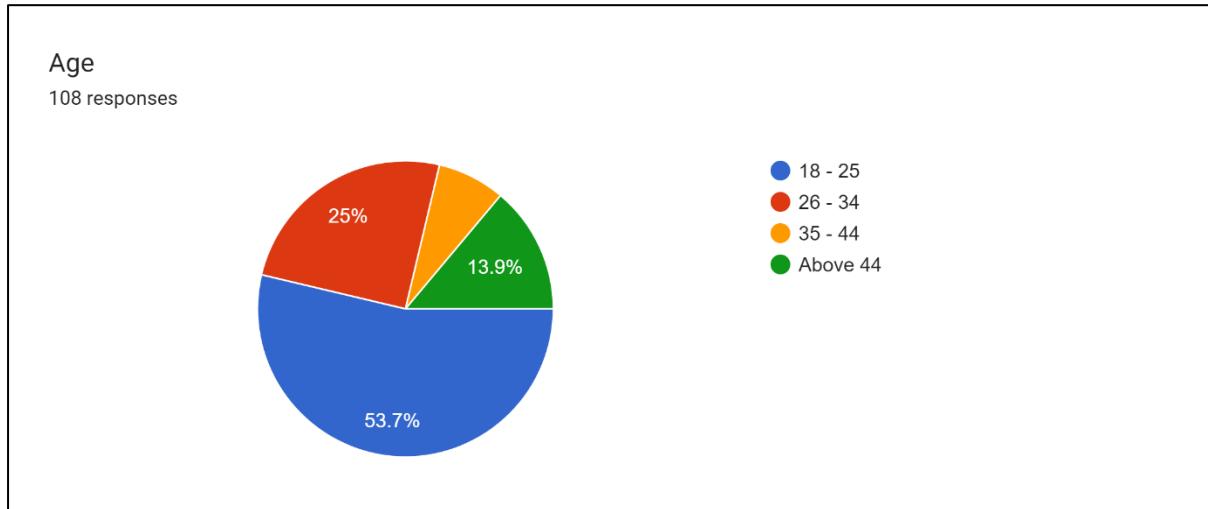
During the data collection process, a questionnaire is distributed to the developer's friends, family, lecturers, classmates, and others through social media, such as Microsoft Team, Facebook, Instagram, WhatsApp, and Wechat. The developer has collected 108 responses in total. The results will be mainly displayed in a pie chart and bar chart and analyzed in this section.



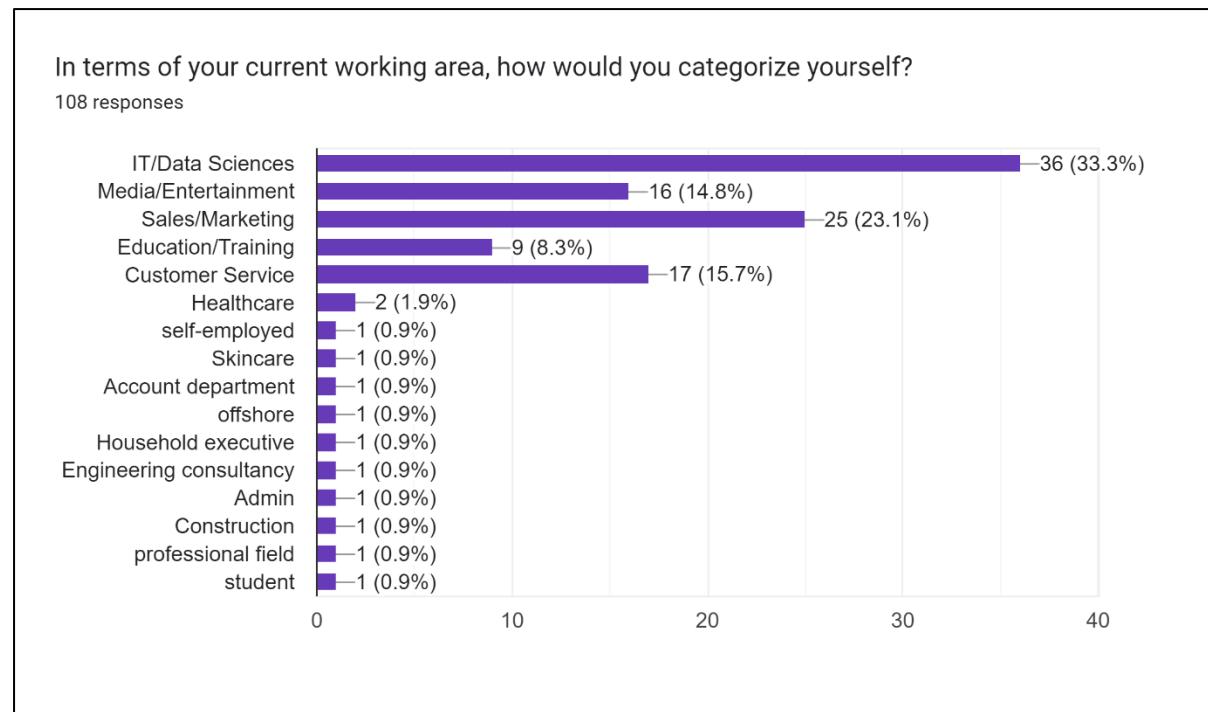
The result shows that all the respondents understood the purpose of this research and agreed to contribute to this survey honestly and truthfully. Hence, there will be no ethical concerns raised in this survey.



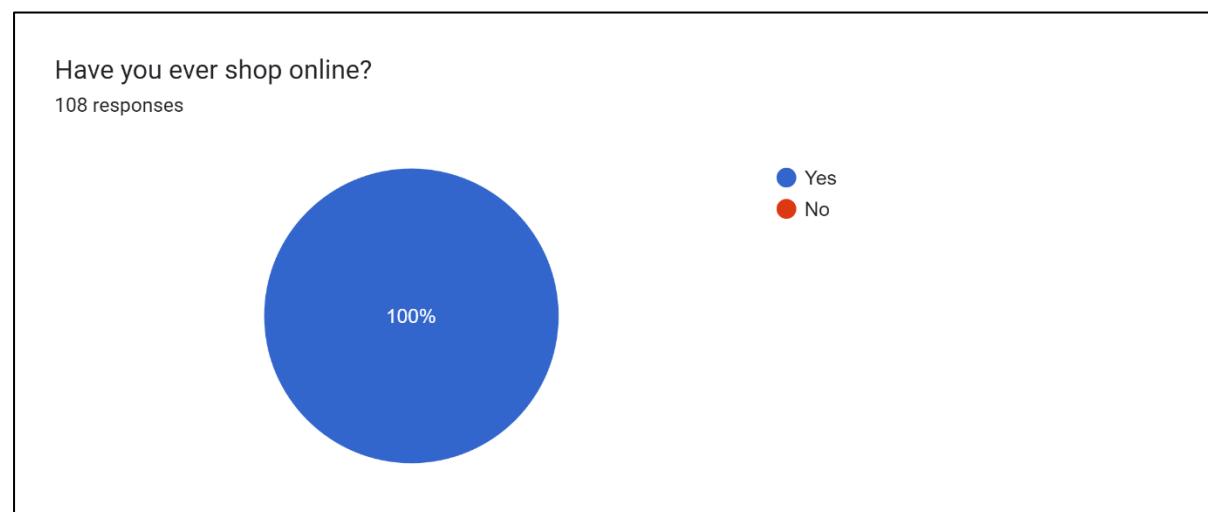
The result shows that 50% of respondents are male, 49.1% are female, and only one respondent does not prefer to share his/her gender. During the survey, the men and women were almost equally distributed. The researcher was not biased in favor of any gender, and the people shopping online also did not incline toward any gender.



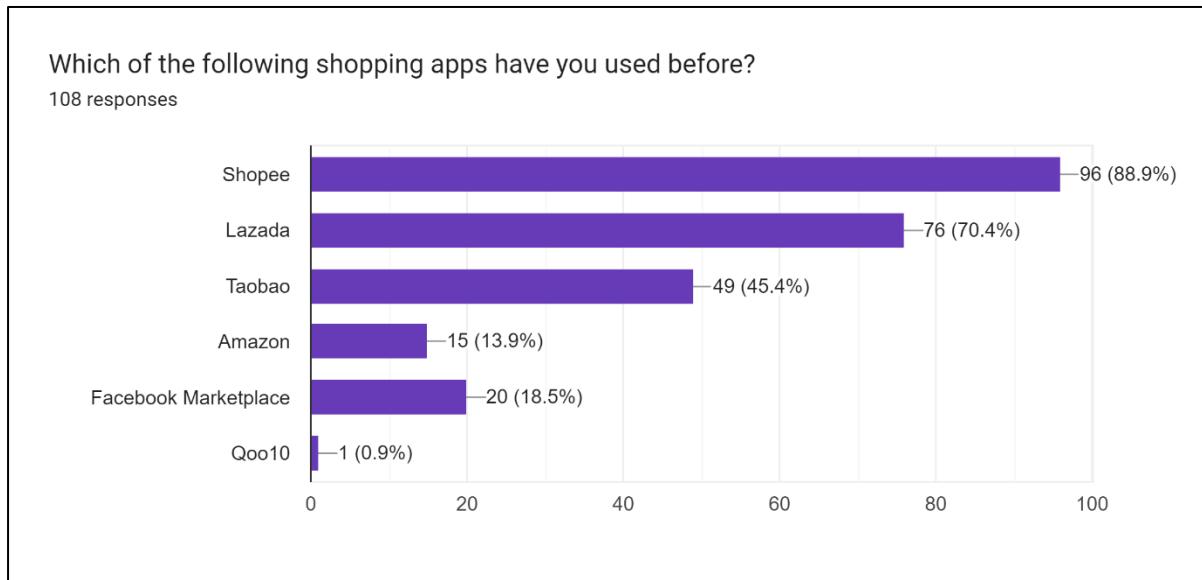
According to the above pie chart, the majority of respondents were in the age group of 18 to 25 years, occupied 53.7%. 25% of the respondents are between 26 and 34 years old, while 13.9% are above 44 years old. It can be analyzed that most online shopping users are university students, fresh graduates, and working professionals who belong to Gen Z and millennials.



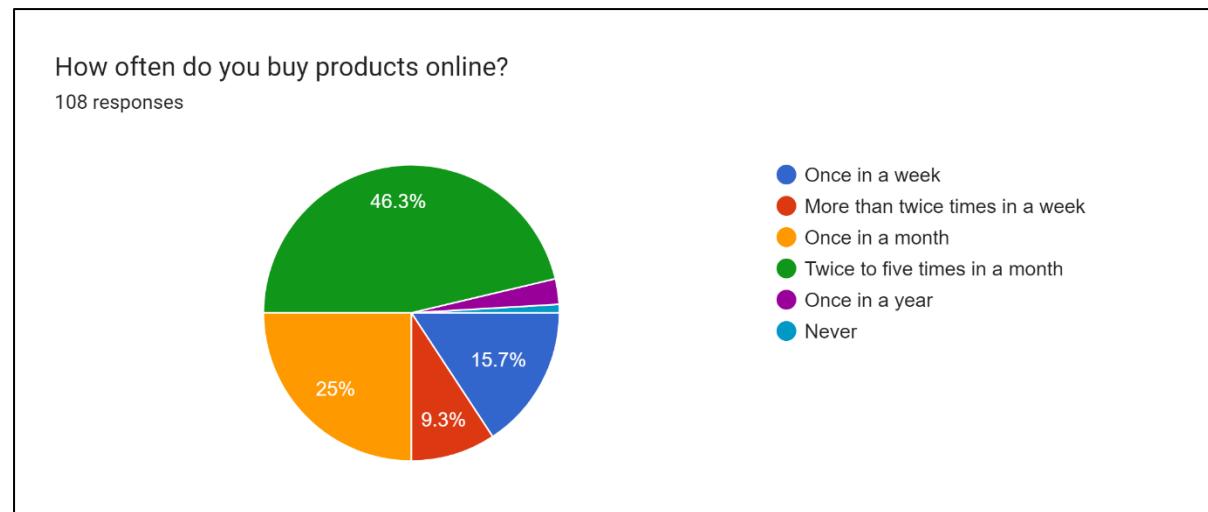
The bar chart above indicates that most of the respondents are from the IT/data sciences aspect gaining 33.3% of the total. The second most respondents' jobs are related to the sales/marketing areas, consisting of 23.1%. Customer service earns 15.7% of the respondents, while 14.8% of the respondents work in the media/entertainment area. The result shows that participants from the mentioned aspects are more likely to be interested in this sentiment analysis research. The researcher can consider these working areas as the target market while deploying the proposed system.



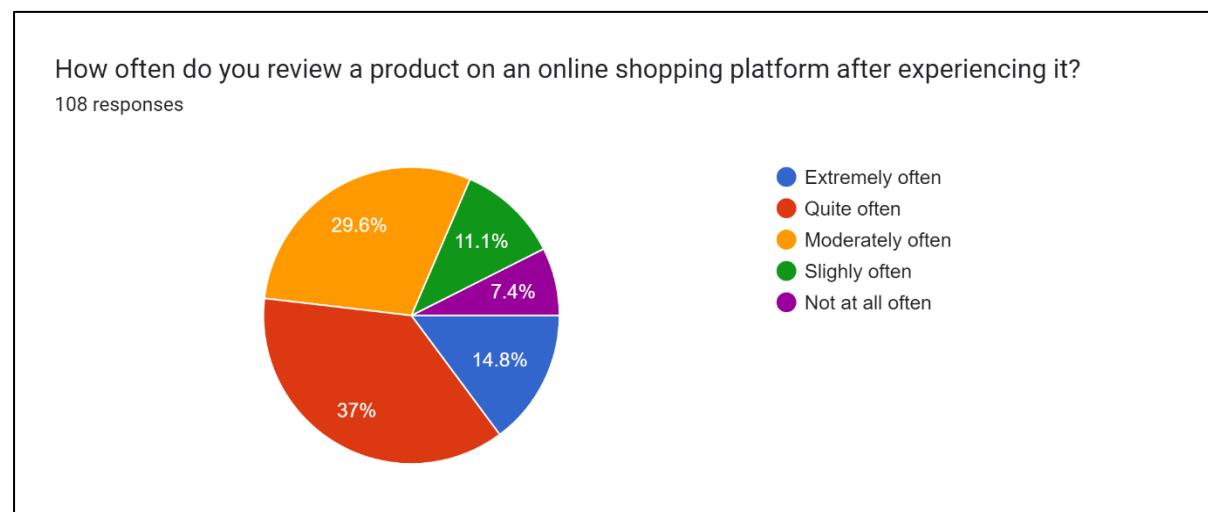
All respondents have online shopping experiences indicating that shopping online is the new normal of the current shopping mode. It also shows that there is a potential market for the proposed system.



The result shows that Shopee is the online shopping application that most respondents have experienced before, with 88.9%. 70.4% of the respondents have used Lazada, 45.4% have been shopping on Taobao, and 18.5% have experienced Facebook Marketplace. There are 15 out of 108 respondents who have used Amazon before, and there is only one respondent who has shopped on Qoo10. It is evident that Shopee is the most popular shopping application in Malaysia, and the developer can do more research on Shopee regarding its embedded sentiment analysis tools. Besides, the developer can investigate the possibility and methods of integrating the proposed system with the mentioned shopping applications in the coming future. It is able to assist the developer in exploring a new opportunity and market to introduce the proposed system to the public.

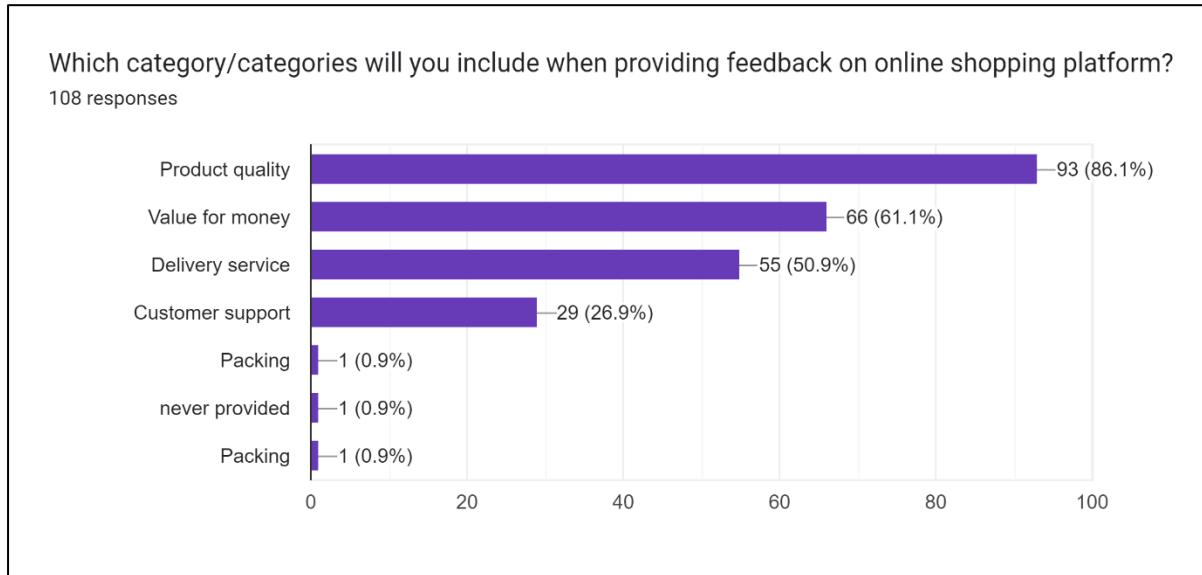


The above pie chart shows that 46.3% of the respondents usually shop online twice to five times a month, 25% often shop online once a month, and 9.3% typically perform online shopping more than twice a week. It indicates online shopping platform is an essential application for an individual to purchase items in the current market. This new normal might be because of the Covid-19 pandemic that restricted people from stepping out of their living areas and forced people to conduct online shopping. Hence, there is a potential market for the proposed system to assist their decision-making while purchasing online. However, there is a respondent who never purchases an item online. It is probably because of the difficulty for him/her to adapt to new technology and perform online shopping.



The result shows that most respondents quite often review a product, with a result of 37%. Following that, 29.6% of the respondents moderately often provide their feedback, 14.8% extremely often give comments on a product, 11.1% slightly often offer a product review, and

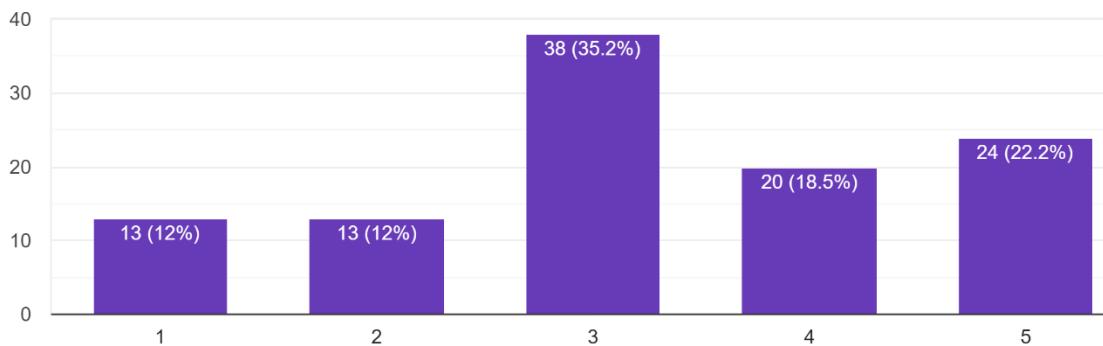
the rest do not at all often review a product. Overall, most of the respondents are willing to give their feedback on a product after experiencing it. It is a good sign for the researcher to collect accurate data in this research. Besides, the large size of the input product review dataset from the online shopping platform can ensure the accuracy of the machine learning model.



According to the above horizontal bar chart, the majority of the respondents will provide feedback regarding the product quality, agreed by 86.1% of the respondents. 61.1% of the respondents will offer comments related to the product's value for money, 50.9% will give opinions associated with the delivery service, and 26.9% will provide thoughts regarding customer support. It can be analyzed that people tend to care about the product quality they purchase. The developer needs to include all the mentioned categories in the product title tagging features in order to assist users in identifying the product review categories. There is a respondent who chooses "never provided" the feedback. It is reasonable as there is a respondent who has never bought products online before.

You are always affected by your emotions (joy, sadness, anger, surprise) while providing product reviews.

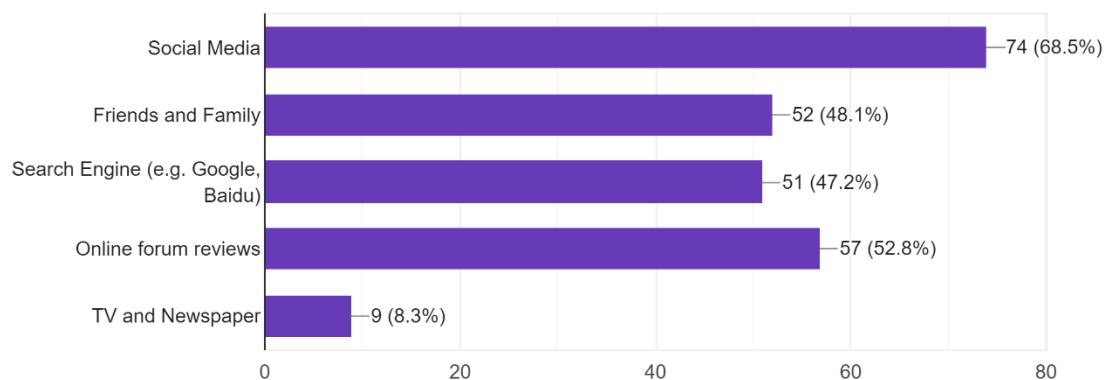
108 responses



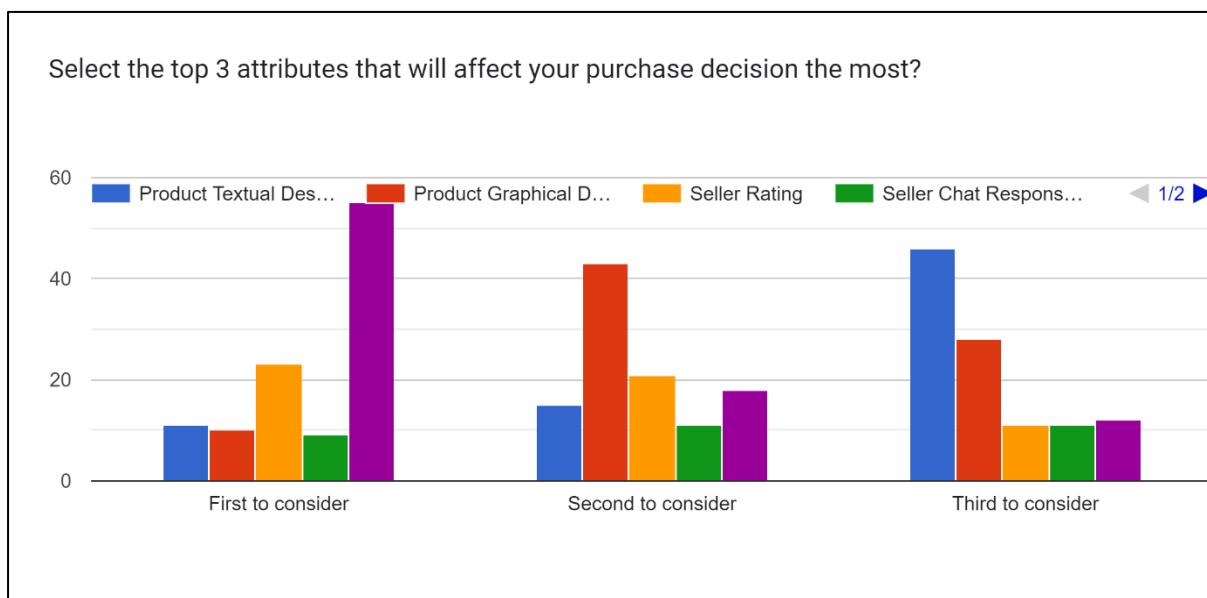
The result shows that only 22.2% of the respondents rated 5, meaning that they were usually affected by their emotions when providing feedback, and 12% of the respondents rated 1, meaning that they typically provided feedback without showing their emotions. However, most respondents who rated 3 will sometimes add some emotional element while offering a comment, occupied 35.2%. Overall, the respondent tended to rate 4 and 5 instead of 1 and 2. It can be concluded that people are mostly affected by their emotions in writing a product review. Hence, it is predicted that the proposed system is able to have a good performance while analysing the sentiment of product reviews.

How do you find information about your desired product (e.g. electronic device, fashion item)?

108 responses

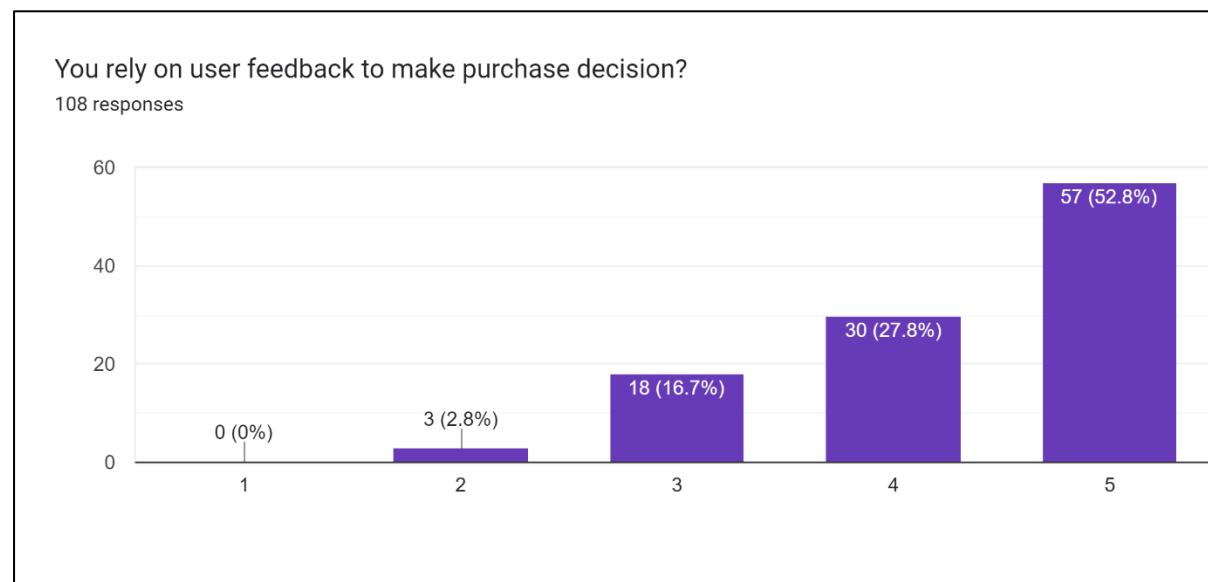


The horizontal bar chart above shows that social media was chosen by 68.5% of the respondents as the most popular source for participants to find information about their desired product. Following that, 52.8% of the respondents search for product information through online forum reviews, 48.1% seek information by asking friends and family, 47.2% get the information from a search engine, and 8.3% obtain product information through TV and newspaper. Most participants chose to use online methods, such as social media and online forum reviews. It might be because the majority of participants are between 18 and 25 years old. The 9 participants who selected the traditional TV and newspaper approaches might be above 44 years old. Since social media gained the most interest from the public, the developer may consider embedding the proposed sentiment analysis model into social media platforms for analysing the posts and comments to assist customers in making better purchase decisions as further improvement of this research.

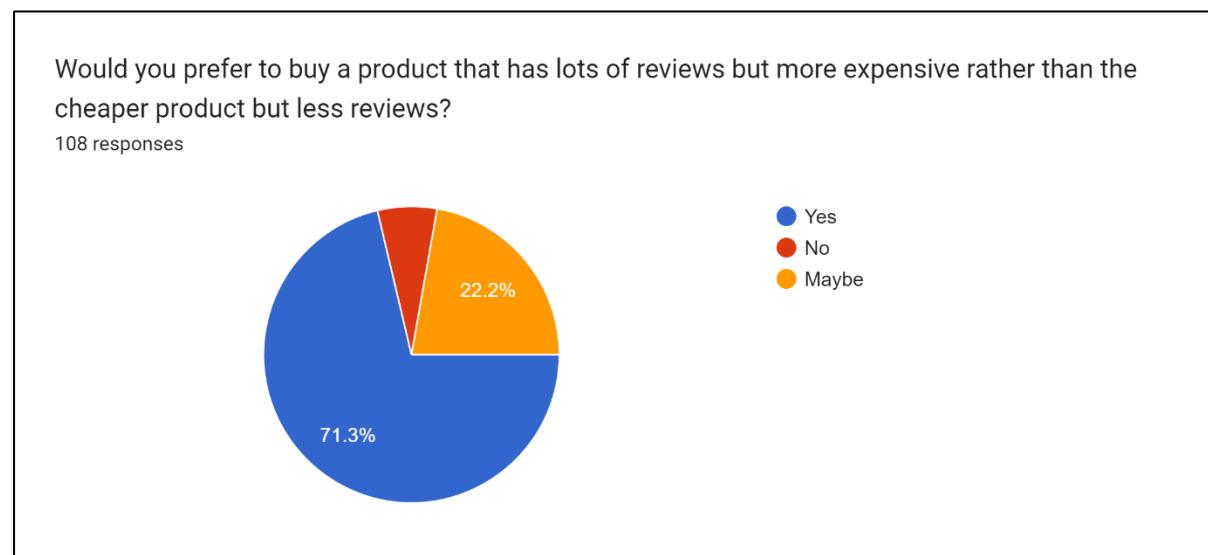


Note: Purple color bar is **Product Review**

The analysis above shows that the product review affected respondents the most during online shopping. The graphical description was chosen as the second consideration, and the textual product description was selected as the third. This scenario indicates that people rely on other users' experiences to decide whether the product benefits them. It is evident that product review is a crucial element that controls product sales and customer flow. Therefore, a product review analysis system will be a better choice for e-commerce businesses to increase profits and customers.



The bar chart above shows that 52.8% of the respondents rated 5, strongly agreeing that they make purchase decisions depending on user feedback. Following that, 27.8% of the respondents rated 4, 16.7% rated 3, and the rest rated 2. Therefore, it can be concluded that the comment feature plays a crucial role for online shopping customers in the decision-making process. As most respondents rely on user feedback to make purchase decisions, the researcher is heading in the correct research direction of developing the product review analysis tool.

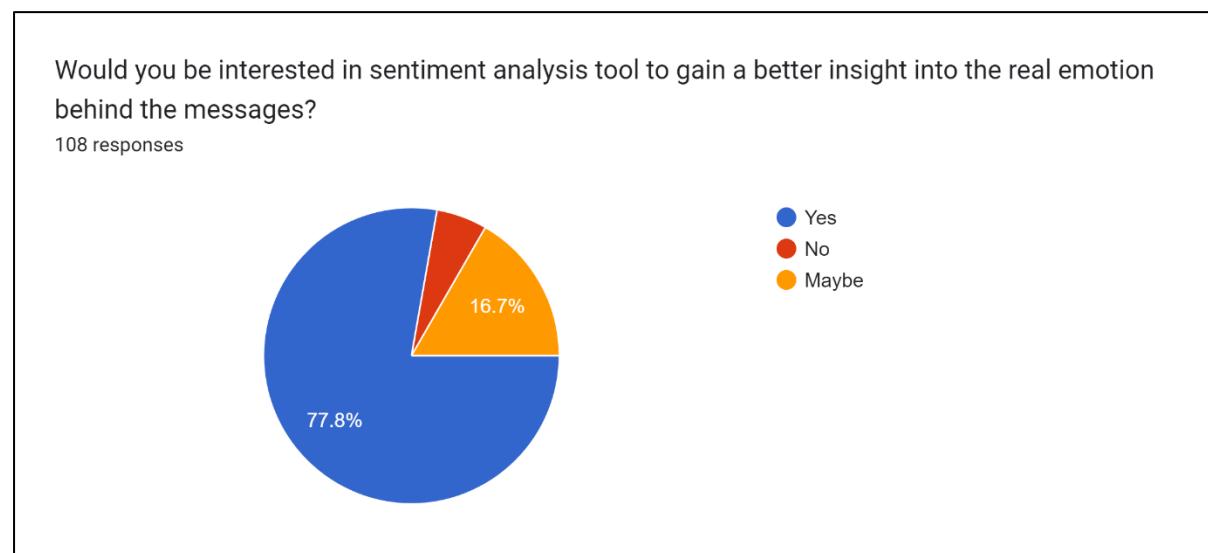


The pie chart above shows that 71.3% of respondents preferred to pay for the product with more reviews but more expensive, 22.2% may buy the product, and the rest did not. It might

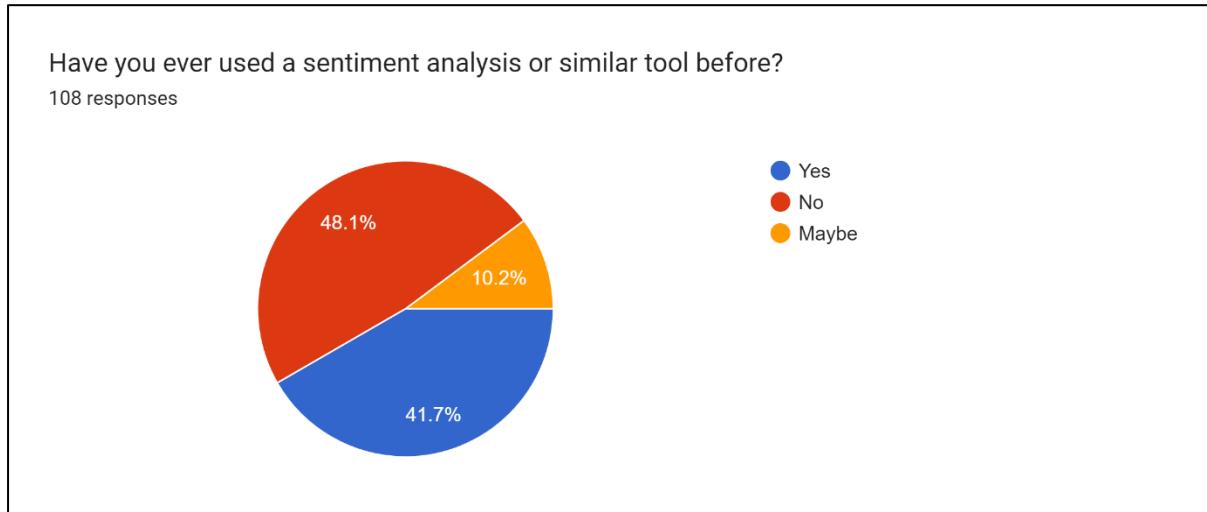
be because most respondents are not willing to take the risk for the cheaper product. The analysis also demonstrates that the product review is more important than the price.



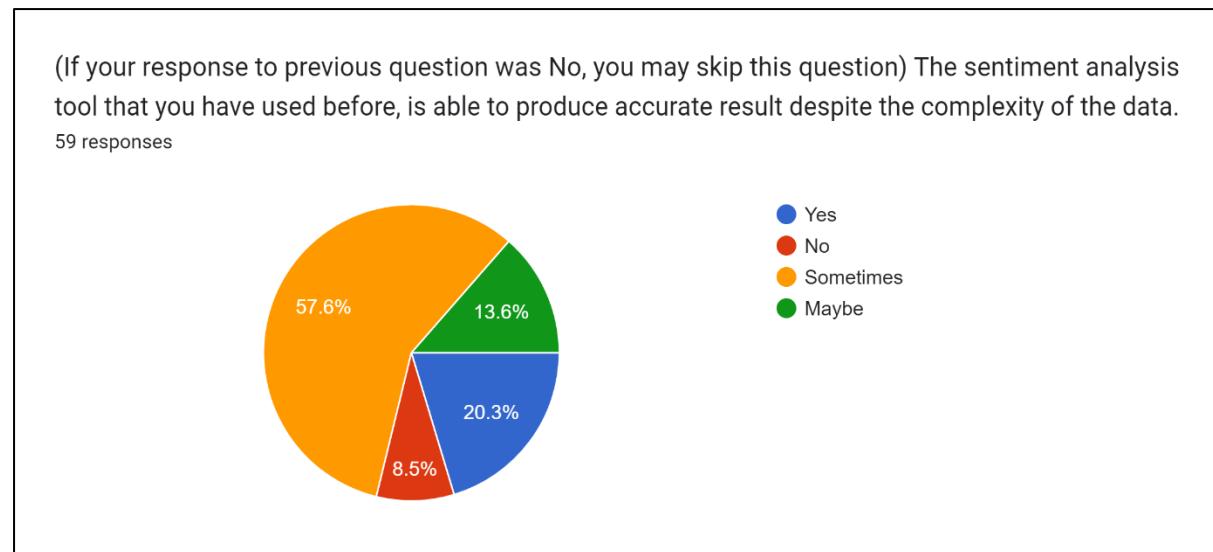
According to the above pie chart, most respondents did not agree that some positive product reviews are fake or posted by the e-commerce company itself, with 51.9%. On the other hand, 32.4% think some product reviews may be fake or commended by their own company, and the rest answered "Yes" to the above statement. Therefore, the result can be analyzed that people mostly believe in the product reviews posted on online shopping platforms. However, the researcher can decide on including the product review verification feature in the proposed system because some respondents lack trust in the product reviews.



The pie chart above shows that 77.8% of respondents were interested in sentiment analysis-based products, 16.7% may have interests, and the rest were not. This analysis indicates a strong demand for the sentiment analysis technique to provide insight into the messages from online users.



The pie chart above shows that 48.1% of respondents had not used a sentiment analysis tool before, 41.7% had experienced it before, and the rest may have used it. Although most respondents did not have the chance to experience the sentiment analysis-based product, the high ‘Yes’ result is reasonable as most respondents work in IT, data science, sales, and marketing. These mentioned departments have a higher opportunity to perform sentiment analysis in their daily tasks. Due to the high proportion of respondents who did not experience the sentiment analysis tool before, the developer should consider some user-friendly interface and features in the proposed product review analysis system in order to assist the beginner during their first navigation of this sentiment analysis application.

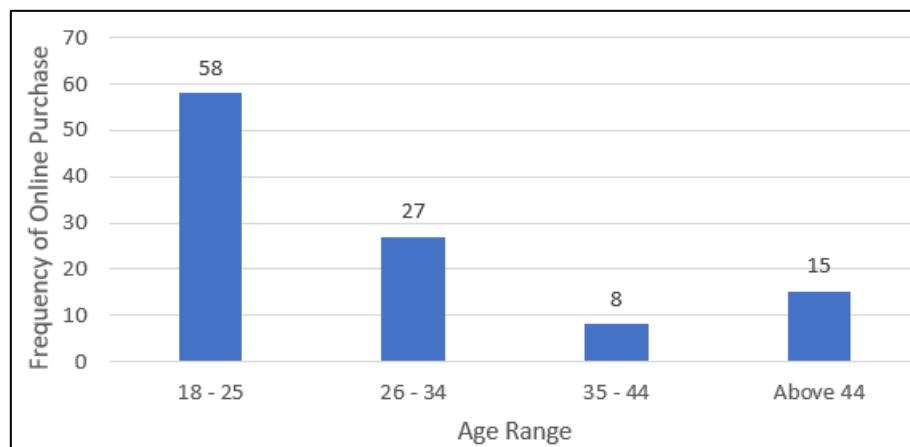


The result shows that 57.6% of the respondents answered “Sometimes,” indicating that the sentiment analysis tool they used occasionally will generate accurate results. 20.3% of the respondents were able to produce accurate sentiment classification, followed by 13.6% who were not sure about the accuracy of the sentiment analysis system, and the rest were disappointed with the system output. The analysis indicates that the performance of the market available sentiment analysis product is not high enough, and further improvement on its accuracy is required.

## 6.2 Cross-sectional Analysis

In this section, the developer will combine two or more questionnaire results for further analysis in order to find the hidden patterns among the respondents. The primary purpose of conducting the cross-sectional analysis is to study the relationships between variables in analyzing the public's reactions toward online shopping, which can be helpful in understanding how variables are related in the present.

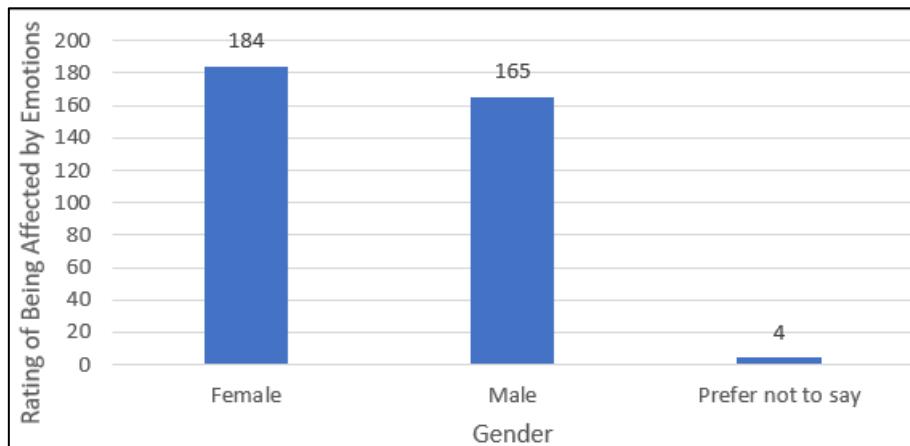
### 6.2.1 Common Age Group of Online Shoppers



| Axis | Question Title                          |
|------|---|
| X    | "Age"                                   |
| Y    | "How often do you buy products online?" |

The analysis above integrates the respondent's age with their online purchase frequency. It is obvious that respondents between 18 to 25 years old are more likely to go shopping online. The fast-growing technology has affected the new generation changing their item purchase habits from physical retail to online shopping platforms. It may be because of the convenience and variety of products provided by online shopping platforms, allowing them to shop anywhere and anytime for their desired products. The development of a product review analysis system will definitely help them in choosing reliable online retailers and products.

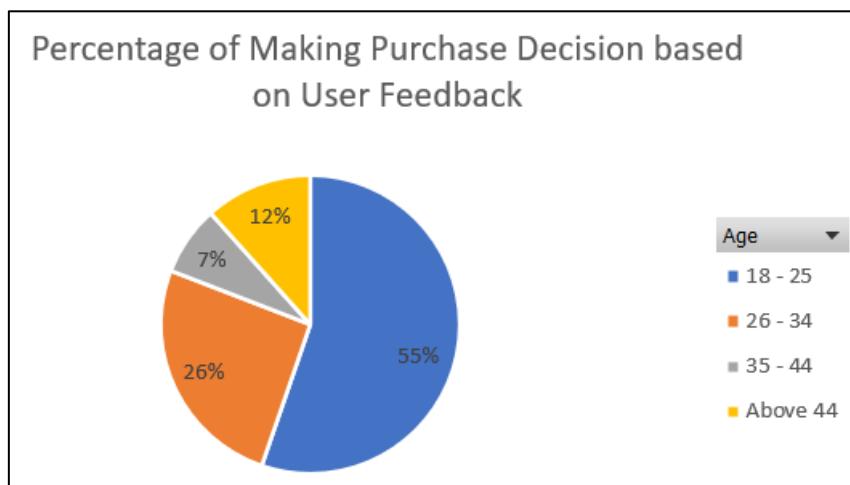
### 6.2.2 Relationship between Gender and Emotional Expression



| Axis | Question Title  |
|------|---|
| X    | “Gender”  |
| Y    | “You are always affected by your emotions (joy, sadness, anger, surprise) while providing product reviews.” |

The analysis above integrates the respondent's gender with the likeliness of being affected by emotions while providing product reviews. As a result, there are slightly more female respondents than male respondents meaning that women are more emotional than men. When providing customer feedback, women are more likely to express their joy, sadness, anger, and surprise in comparison with men. It may affect potential customers' decision-making abilities, leading them to make choices they may regret later. A sentiment analysis-based product will classify the customer reviews and identify areas of the product that are causing frustration or dissatisfaction, avoiding regretful purchases.

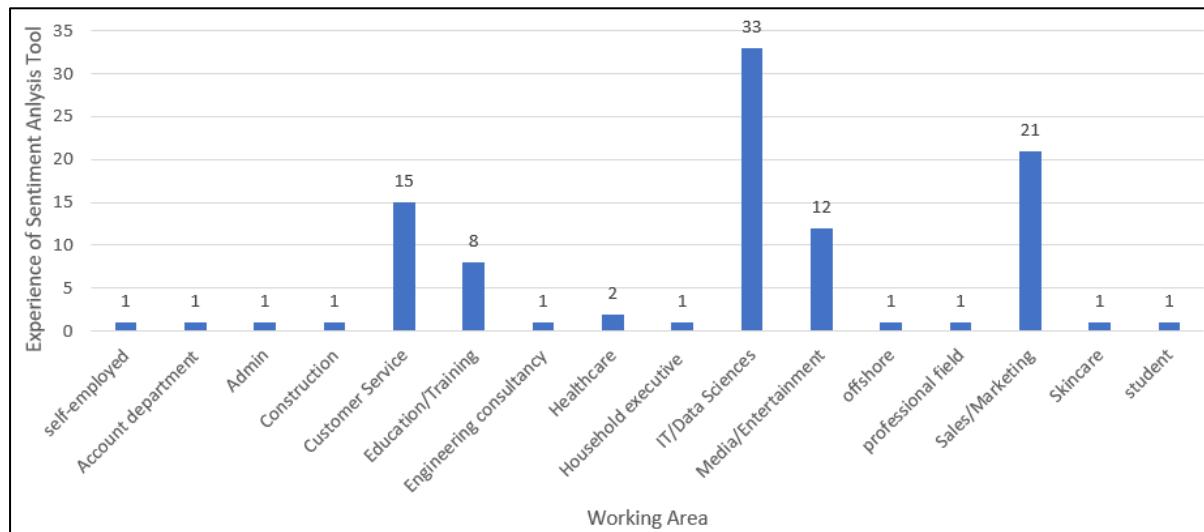
### 6.2.3 Common Age Group Reliance on Customer Reviews



| Axis | Question Title   |
|------|--|
| -    | “Age”  |
| -    | “You rely on user feedback to make purchase decision?” |

The diagram above integrates the respondent's age with the reliance on user feedback to make purchase decisions. The result shows that the respondents between 18 to 25 years old tend to buy products according to the existing customers' reviews. In contrast, respondents between 35 to 44 years old do not care about product reviews and make purchase decisions directly. This scenario might be affected by their daily routine as people between 35 to 44 years old spend most of their time on jobs instead of online shopping. They do not wish to compare the items according to the product reviews during their online shopping as they lack time to research them. To solve this issue, sentiment analysis is able to help online shoppers analyze and summarize the sentiment of product reviews. Hence, potential customers can get a sense of the overall sentiment toward a particular product or service.

### 6.2.4 Common Career Fields of Using Sentiment Analysis Products



| Axis | Question Title  |
|------|---|
| X    | “In terms of your current working area, how would you categorize yourself?” |
| Y    | “Have you ever used a sentiment analysis or similar tool before?”           |

The diagram above combines the respondent's working area and the total number of their experience using sentiment analysis-based products. Most respondents who have experience in sentiment analysis tools are from the IT/Data Sciences aspects meaning sentiment analysis is a popular technique implemented in that areas. It might be because IT/Data Sciences requires sentiment analysis to develop their software, AI systems, or chatbots. However, due to the growing popularity of sentiment analysis products, respondents from other working areas also experienced sentiment analysis techniques, especially in Customer Service and Sales/Marketing. It might be because Customer Service requires sentiment analysis to understand customers and assist them in solving their problems. On the other hand, Sales/Marketing may utilize the sentiment analysis result to develop a strategic marketing plan and improve product quality in order to increase business sales. Nowadays, with the growing volume and variety of data, sentiment analysis is gaining its reputation in each aspect. Therefore, in the coming future, there will be an increasing number of organizations implementing sentiment analysis-based products to replace traditional manual data processing and understand human behaviors better.

### 6.3 Summary

Overall, the result of this questionnaire is satisfying, and a majority of respondents are optimistic about the characteristic of the proposed system and its usefulness in analyzing the sentiment of product reviews. As a result of diverse viewpoints offered by respondents, the researcher was able to determine the most popular online shopping platform, the attributes that affect the purchase decision the most, the dependency on product reviews, the interest in sentiment analysis-based products, and other facts. According to most of the responses, the idea of sentiment analysis on product reviews was well-liked. Due to the overwhelming support for the proposed system, the researcher has decided to proceed with the study without changing the aims and deliverables. However, the respondents also expressed their high expectations on the accuracy of the results obtained from the sentiment analysis tool. Hence, the developer must prioritize the accuracy of the classifier, as it is the feature that target users value the most.

## Chapter 7: System Architecture

### 7.1 Introduction

As mentioned in Chapter 1 deliverables, the proposed project is a web-based project review analysis system to provide a platform for current product users to review the products, assist potential customers in decision-making, and help businesses enhance their products and customer services. This web application includes a machine learning model to analyze the customer's feedback on e-commerce businesses' products. In this chapter, the system's functionalities and business logic will be explained in detail for the reader's understanding.

This system is mainly designed for accepting product reviews from customer roles. Hence, the business roles will describe their products on the proposed web application with their characteristics, such as product names, descriptions, and photos. To avoid cluttered reviews on the website, each review will be added at least one and up to three tags by customers to categorize them. Examples of review tags include seller service, delivery service, product quality, and others. Hence, the business will have a better understanding and clearer views of complex information by organizing them into smaller, more manageable units.

After accepting reviews from customers, the other main feature of this system is sentiment analysis which analyses the customer reviews and classifies them into three polarities, which are positive, neutral, and negative. The customer reviews newly added by customers will be stored in Cloud Firestore. After that, the machine learning algorithm will listen to the Firestore and retrieve the reviews as input text for processing sentiment analysis. The detected sentiment will then be stored again in the Cloud Firestore for displaying on the web application. The machine learning algorithm is written in another Python script different from the web application development. This algorithm will keep looping once run and monitoring the Cloud Firestore to wait for a new customer review.

Apart from that, there is a web page designed for businesses to view the overall product analysis. The analysis includes the total number of customer reviews added to their products per day, month, and years, sentiment breakdown by products, and sentiment breakdown by review tags. This analysis can provide valuable insights and data about the products that are of most interest to potential customers, which can inform the business's marketing and product development efforts. In Chapter 9 Implementation, the details of each feature will be discussed in more detail.

## 7.2 Abstract Architecture

Abstract architecture refers to the high-level design of a system, which defines its overall structure and the relationships between its components. In this section, system design, database design, and user interface design will be introduced.

### 7.2.1 System Design

System design is a crucial step in system development as it determines the structure of the system and how the system will be implemented. It involves the use of modelling and simulation tools to outline the overall system architecture, such as a use case diagram and class diagram.

#### 7.2.1.1 Use Case Diagram

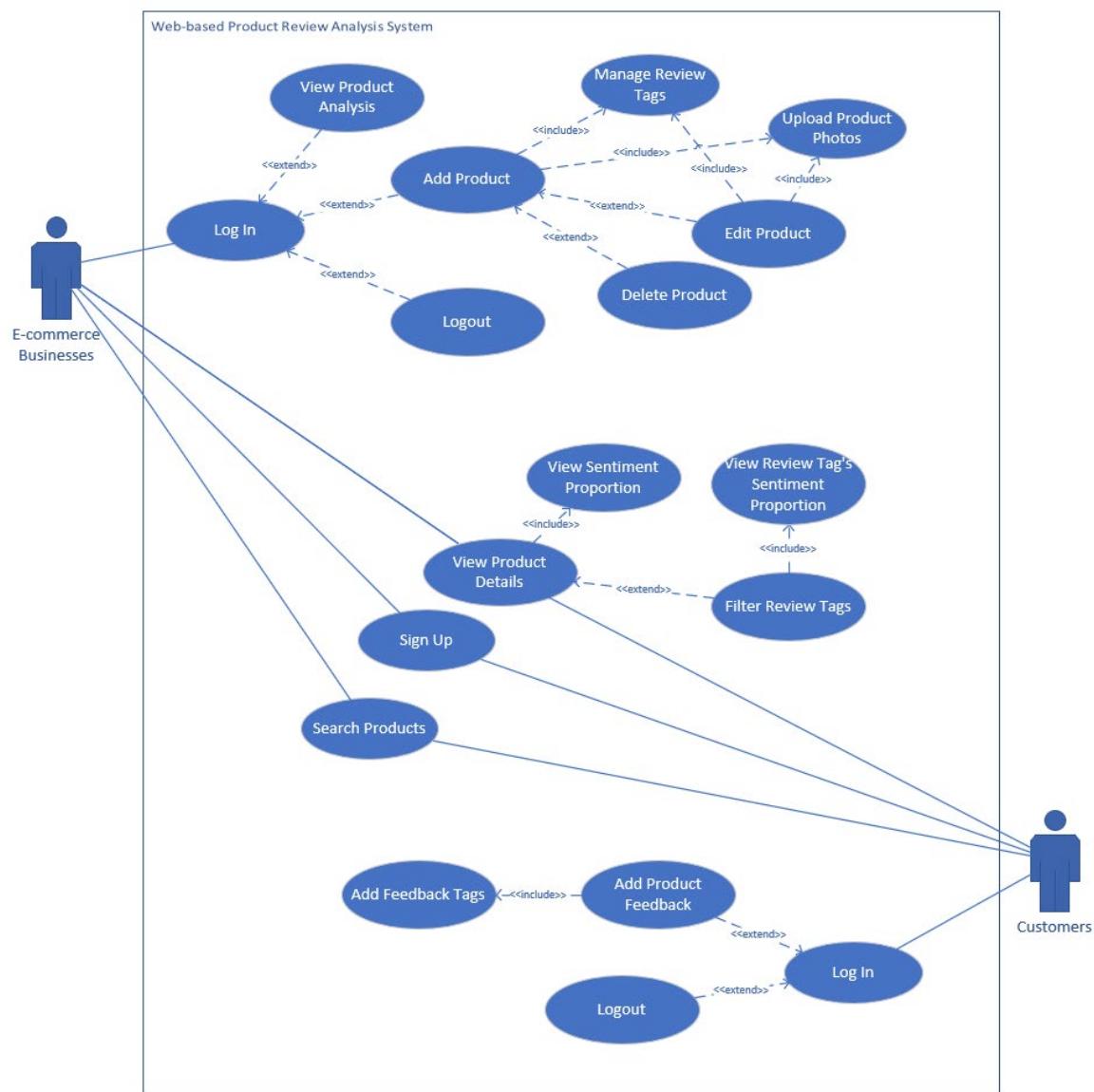


Figure 24 Use Case Diagram

|                       |  |
|-----------------------|--|
| <b>Use Case</b>       | Sign Up  |
| <b>Description</b>    | Users register for an account for the system   |
| <b>Actor</b>          | E-commerce businesses, Customers   |
| <b>Dependency</b>     | -  |
| <b>Basic Workflow</b> | Users fill in the required information, such as email, name, password, and others, on the Customer/Business Registration Page. |

|                       |  |
|-----------------------|--|
| <b>Use Case</b>       | Log In   |
| <b>Description</b>    | Users log in to the web application                              |
| <b>Actor</b>          | E-commerce Businesses, Customers                                 |
| <b>Dependency</b>     | -  |
| <b>Basic Workflow</b> | Users fill in their email, password, and role on the Login Page. |

|                       |  |
|-----------------------|--|
| <b>Use Case</b>       | View Product Analysis  |
| <b>Description</b>    | Users will be able to view the product analysis, including the total number of customer reviews, and sentiment breakdown by products and review tags |
| <b>Actor</b>          | E-commerce Businesses  |
| <b>Dependency</b>     | Log In   |
| <b>Basic Workflow</b> | Users click on “Product Analysis” button and it will navigate to Product Analysis Page, showing the analysis results.                                |

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | Add Product   |
| <b>Description</b>    | Users will be able to add a product   |
| <b>Actor</b>          | E-commerce Businesses   |
| <b>Dependency</b>     | Log In  |
| <b>Basic Workflow</b> | Users fill in product name, description, product review tags, and product photos on Add Product Page. |

|                    |   |
|--------------------|---|
| <b>Use Case</b>    | Manage Review Tags  |
| <b>Description</b> | Users will be able to select and deselect a review tag for a product. Users also will be able to add a new tag with manual input. |

|                       |   |
|-----------------------|---|
| <b>Actor</b>          | E-commerce Businesses   |
| <b>Dependency</b>     | Add Product / Edit Product  |
| <b>Basic Workflow</b> | Users select or deselect a review tag on the Add/Edit Product Page. |

|                       |  |
|-----------------------|--|
| <b>Use Case</b>       | Upload Product Photos  |
| <b>Description</b>    | Users will be able to upload photos in jpg, png, jpeg, or gif format for a product.            |
| <b>Actor</b>          | E-commerce Businesses  |
| <b>Dependency</b>     | Add Product / Edit Product   |
| <b>Basic Workflow</b> | Users click on “Choose Files” button and select the photo photos on the Add/Edit Product Page. |

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | Edit Product  |
| <b>Description</b>    | Users will be able to edit a product that they added previously   |
| <b>Actor</b>          | E-commerce Businesses   |
| <b>Dependency</b>     | Add Product   |
| <b>Basic Workflow</b> | Users click on “Edit” button for a specific product on the Business Homepage. Users fill in the product name, description, product review tags, and photo on the Edit Product Page. |

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | Delete Product  |
| <b>Description</b>    | Users will be able to delete a product that they added previously   |
| <b>Actor</b>          | E-commerce Businesses   |
| <b>Dependency</b>     | Add Product   |
| <b>Basic Workflow</b> | Users click on “Delete” button for a specific product on the Business Homepage. A confirmation message will be shown and users can click on the “Delete” button to permanently delete the product or the “Cancel” button to stop the process. |

|                    |   |
|--------------------|---|
| <b>Use Case</b>    | Add Product Feedback                            |
| <b>Description</b> | Users will be able to add feedback on a product |
| <b>Actor</b>       | Customers                                       |

|                       |   |
|-----------------------|---|
| <b>Dependency</b>     | Log In  |
| <b>Basic Workflow</b> | Users enter the review title, contents, date of experience, and review tags on the Add Review Page. |

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | Add Feedback Tag  |
| <b>Description</b>    | Users will be able to choose at least one and up to three review tags designed by the business on the product |
| <b>Actor</b>          | Customers   |
| <b>Dependency</b>     | Add Product Feedback  |
| <b>Basic Workflow</b> | Users choose review tags for “First Tag,” “Second Tag,” and “Third Tag” on the Add Review Page.               |

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | Logout  |
| <b>Description</b>    | Users log out of the system                                   |
| <b>Actor</b>          | E-commerce Businesses, Customers                              |
| <b>Dependency</b>     | Login   |
| <b>Basic Workflow</b> | Users click on the “Logout” button to sign out of the system. |

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | Search Product  |
| <b>Description</b>    | Users will be able to search products based on the product name or business name  |
| <b>Actor</b>          | E-commerce Businesses, Customers  |
| <b>Dependency</b>     | -   |
| <b>Basic Workflow</b> | Users enter the product name or business name at the search input on the navigation bar, click on the “Search” button, and the homepage will show only the products related to the input. |

|                    |  |
|--------------------|--|
| <b>Use Case</b>    | View Product Details                           |
| <b>Description</b> | Users will be able to view the product details |
| <b>Actor</b>       | E-commerce Businesses, Customers               |
| <b>Dependency</b>  | -  |

|                       |  |
|-----------------------|--|
| <b>Basic Workflow</b> | Users click on “Details” button of one of the products, and the system will navigate to the Product Detail Page, showing all the product details and customer reviews. |
|-----------------------|--|

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | View Sentiment Proportion   |
| <b>Description</b>    | Product Detail Page will calculate and show the sentiment proportion bar according to all the customer reviews                                |
| <b>Actor</b>          | E-commerce Businesses, Customers  |
| <b>Dependency</b>     | View Product Detail   |
| <b>Basic Workflow</b> | After clicking on “Details” button, the Product Detail Page will calculate and show the sentiment proportion bar of all the customer reviews. |

|                       |   |
|-----------------------|---|
| <b>Use Case</b>       | Filter Review Tags  |
| <b>Description</b>    | Users will be able to filter the customer reviews according to the clicked review tag button                                      |
| <b>Actor</b>          | E-commerce Businesses, Customers  |
| <b>Dependency</b>     | View Product Details  |
| <b>Basic Workflow</b> | Users click on one of the review tags, and the Product Detail Page will show only the reviews related to the selected review tag. |

|                       |  |
|-----------------------|--|
| <b>Use Case</b>       | View Review Tag's Sentiment Proportion   |
| <b>Description</b>    | Product Detail Page will only calculate and show the sentiment proportion bar according to the filtered review tag                         |
| <b>Actor</b>          | E-commerce Businesses, Customers   |
| <b>Dependency</b>     | Filter Review Tags   |
| <b>Basic Workflow</b> | After clicking on one of the review tags, the Product Detail Page will show the sentiment proportion bar based on the selected review tag. |

### 7.2.1.2 Class Diagram

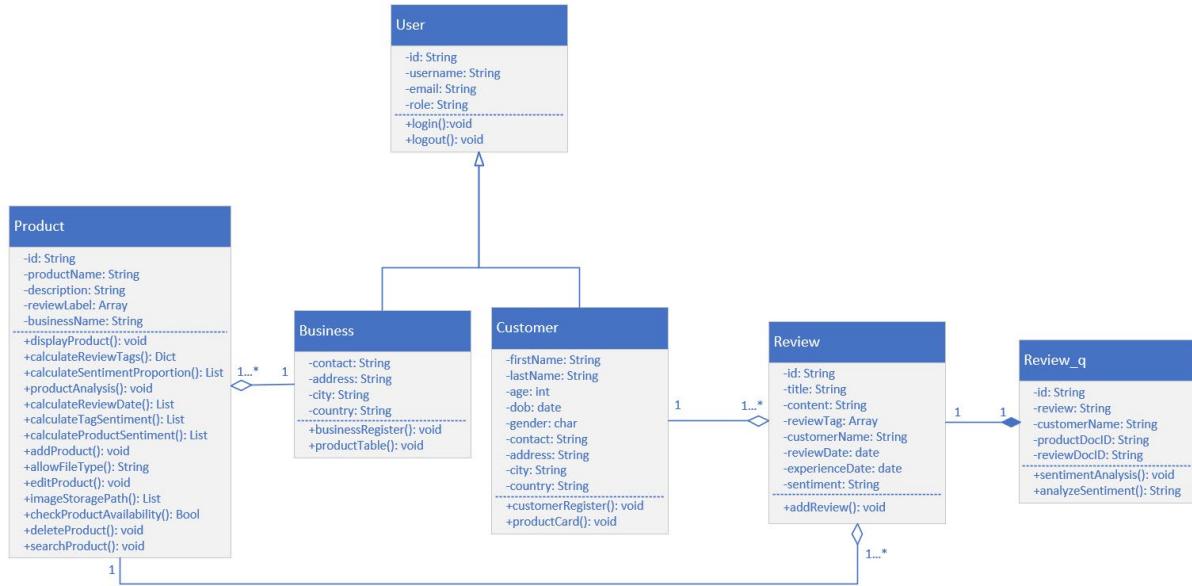


Figure 25 Class Diagram of the Proposed System

## 7.2.2 Database Design

The proposed project uses Cloud Firestore, a NoSQL document database, to store the data of the web-based product review analysis system. In Cloud Firestore, data is stored in the form of documents, which are organized into collections. Each document is a self-contained unit of data that contains key-value pairs, similar to a JSON object. Documents can contain nested data structures, such as lists and maps, and they can be organized into collections of documents, which can be further organized into subcollections. In this section, both Entity Relationship Diagram (ERD) and database table structure will be shown to have a better understanding of the proposed system's database architecture.

### 7.2.2.1 Entity Relationship Diagram (ERD)

An ERD will outline the structure and relationships of the proposed system's database in graphical representation.

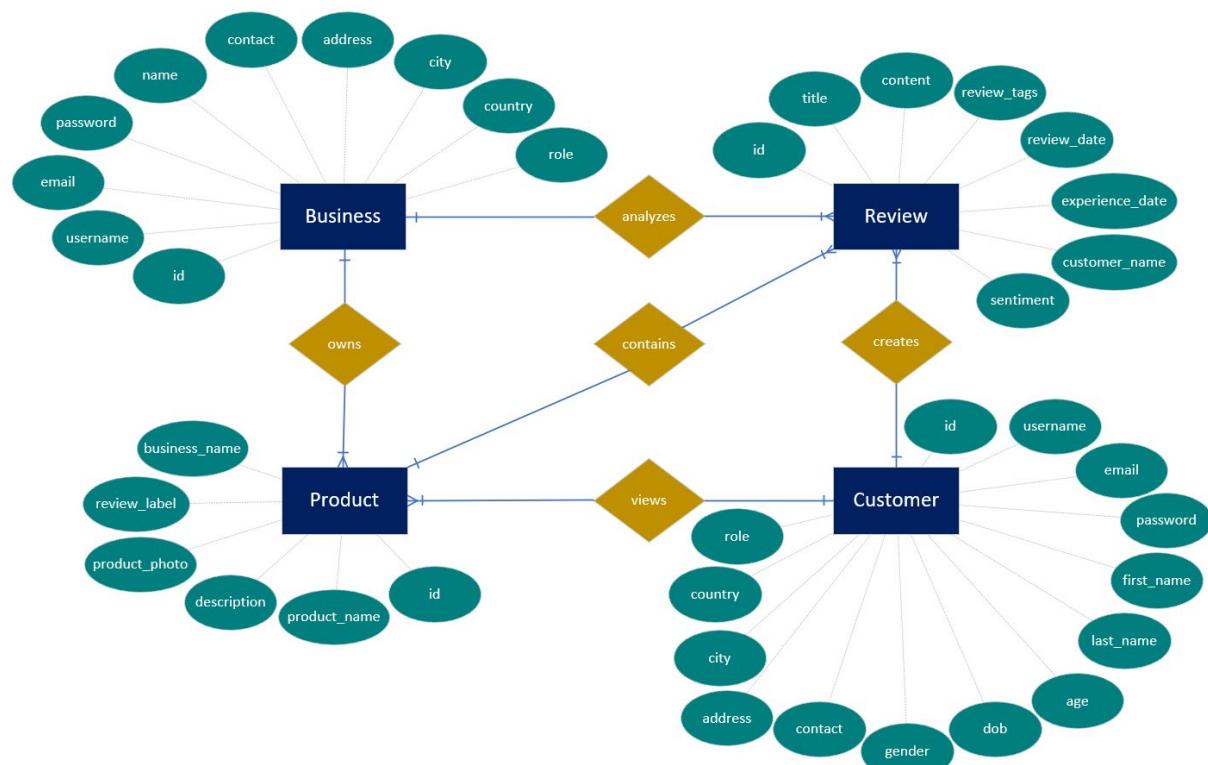


Figure 26 Entity Relationship Diagram (ERD) of the Proposed System

### 7.2.2.2 Database Table Structure

Database table structure will be an extension of ERD, showing more detailed information on the data stored in the proposed system's database

|                    |   |
|--------------------|---|
| <b>Table Name</b>  | Business  |
| <b>Description</b> | To store the information of e-commerce businesses which have been registered. |

| <b>Column Name</b> | <b>Description</b>   | <b>Data Type</b> |
|--------------------|--|------------------|
| id                 | Unique identification number of business                             | String           |
| username           | Username of business as identification (Same as name)                | String           |
| email              | Email of business to login to the web application                    | String           |
| password           | Password to login to the web application                             | String           |
| name               | Business name displayed on the web application (Same as username)    | String           |
| contact            | Contact number of business   | String           |
| address            | Business's current address   | String           |
| city               | Business's current city  | String           |
| country            | Business's current country   | String           |
| role               | User role automatically captured by the system (default as business) | String           |

Table 12 Business Table Structure

|                    |   |
|--------------------|---|
| <b>Table Name</b>  | Customer  |
| <b>Description</b> | To store the information of customers who have been registered. |

| <b>Column Name</b> | <b>Description</b>                                | <b>Data Type</b> |
|--------------------|---|------------------|
| id                 | Unique identification number of customer          | String           |
| username           | Username of customer as identification            | String           |
| email              | Email of customer to login to the web application | String           |
| password           | Password to login to the web application          | String           |
| first_name         | First name of customer                            | String           |

|           |   |        |
|-----------|---|--------|
| last_name | Last name of customer   | String |
| age       | Age of customer   | int    |
| dob       | Customer's date of birth  | Date   |
| gender    | Gender of customer  | Char   |
| contact   | Contact number of customer  | String |
| address   | Customer's current address  | String |
| city      | Customer's current city   | String |
| country   | Customer's current country  | String |
| role      | User role automatically captured by the system<br>(default as customer) | String |

Table 13 Customer Table Structure

|                    |  |
|--------------------|--|
| <b>Table Name</b>  | Product  |
| <b>Description</b> | To store the details of products added by the e-commerce business. |

| Column Name   | Description   | Data Type |
|---------------|---|-----------|
| id            | Unique identification number of product   | String    |
| product_name  | Product name as identification  | String    |
| description   | Product description as a textual explanation of the product   | String    |
| product_photo | Product photo as a graphical explanation of the product (Stored in Firebase Storage)                | Image     |
| review_label  | Review label according to the product characteristics to allow customer to choose for their reviews | Array     |
| business_name | Name of business which added the product  | String    |

Table 14 Product Table Structure

|                    |   |
|--------------------|---|
| <b>Table Name</b>  | Review  |
| <b>Description</b> | To store the details of the review added by the customer. |

| Column Name | Description                            | Data Type |
|-------------|--|-----------|
| id          | Unique identification number of review | String    |

|                 |  |        |
|-----------------|--|--------|
| title           | Review title according to the review content                           | String |
| content         | Review content used for processing sentiment analysis                  | String |
| review_tags     | Review tags according to the review content                            | Array  |
| review_date     | Date of review automatically captured by the system without user input | Date   |
| experience_date | Date of product experience manually added by the customer              | Date   |
| customer_name   | Name of customer who created the review                                | String |
| sentiment       | Sentiment polarity according to the review content                     | String |

*Table 15 Review Table Structure*

### 7.2.3 Interface Design

The end product of this project will include a web application designed for a product review analysis system. There will be two user roles included in this system, which are businesses and customers. This section will introduce the wireframe of the proposed web application using simple shapes and lines to represent various elements of the user interface, such as buttons, text boxes, and menus. The purpose of interface design is to help communicate the basic structure and layout of the proposed system and to ensure that all necessary elements are included. Detailed visual design elements, such as colors, fonts, and graphics, will be further improved during the system development.

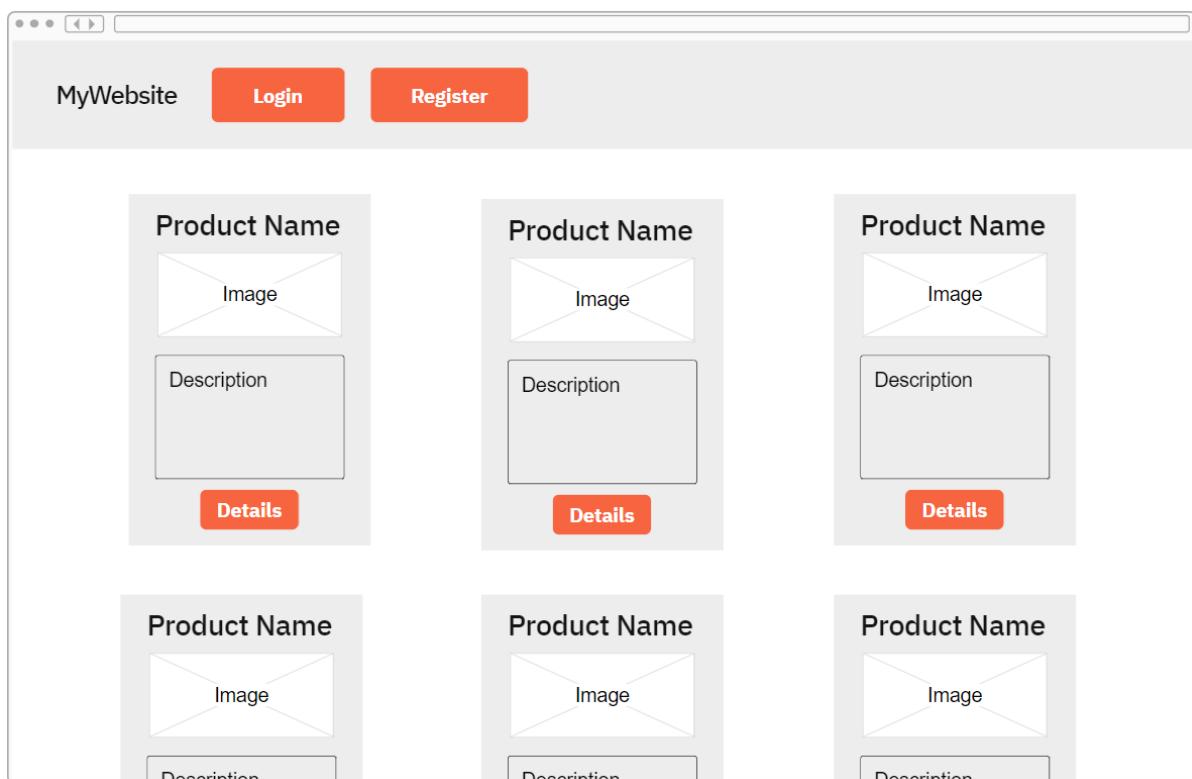
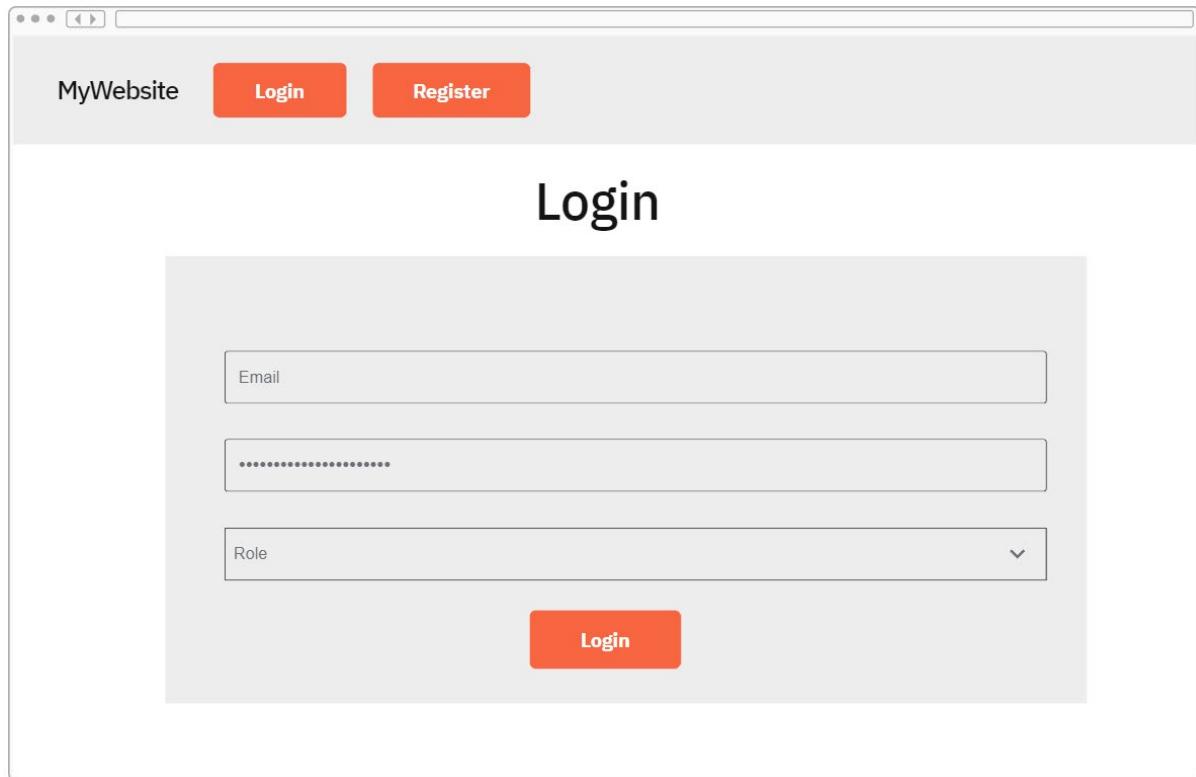
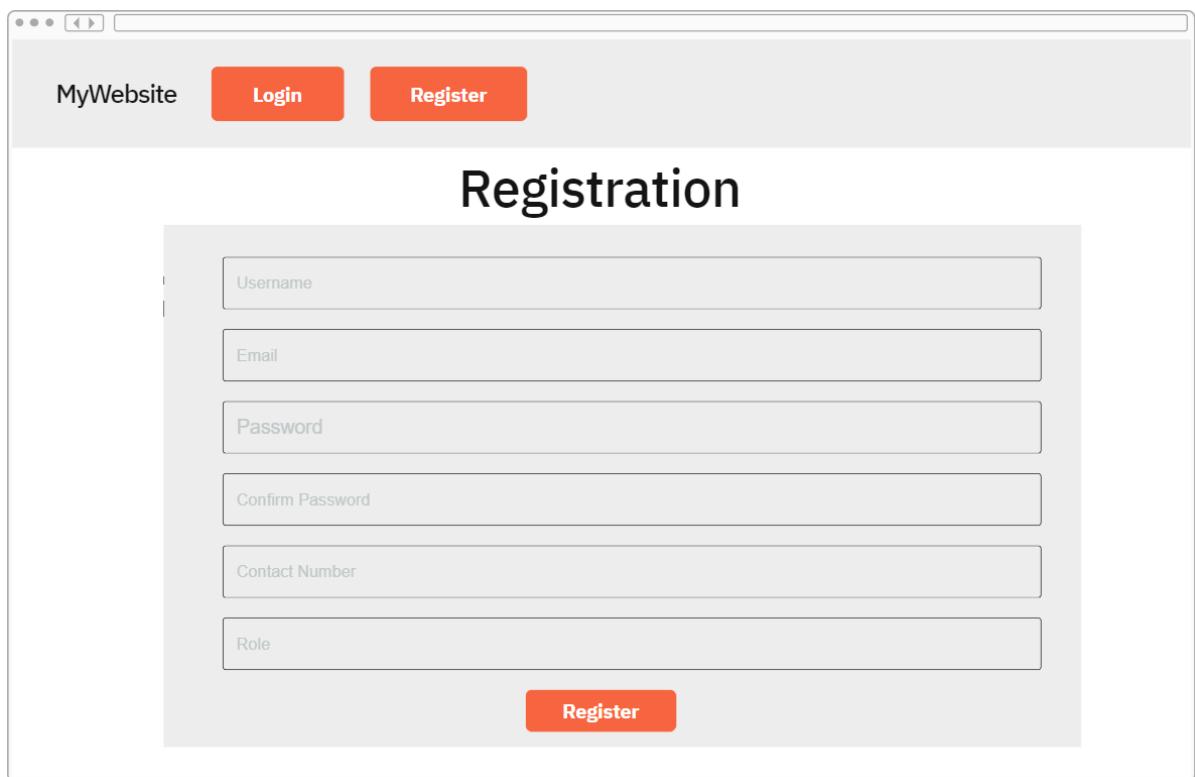


Figure 27 Interface Design for Home Page (Unregistered Users)



The screenshot shows a web browser window with a light gray header bar containing the text "MyWebsite" and two orange rectangular buttons labeled "Login" and "Register". Below the header is a large, bold, black "Login" title centered on the page. The main content area contains three input fields: a top field labeled "Email", a middle field with placeholder dots ".....", and a bottom field labeled "Role" with a dropdown arrow icon. At the bottom center is a large orange rectangular button with the word "Login" in white.

Figure 28 Interface Design for Login Page



The screenshot shows a web browser window with a light gray header bar containing the text "MyWebsite" and two orange rectangular buttons labeled "Login" and "Register". Below the header is a large, bold, black "Registration" title centered on the page. The main content area contains six input fields arranged vertically: "Username", "Email", "Password", "Confirm Password", "Contact Number", and "Role". At the bottom center is a large orange rectangular button with the word "Register" in white.

Figure 29 Interface Design for Registration Page

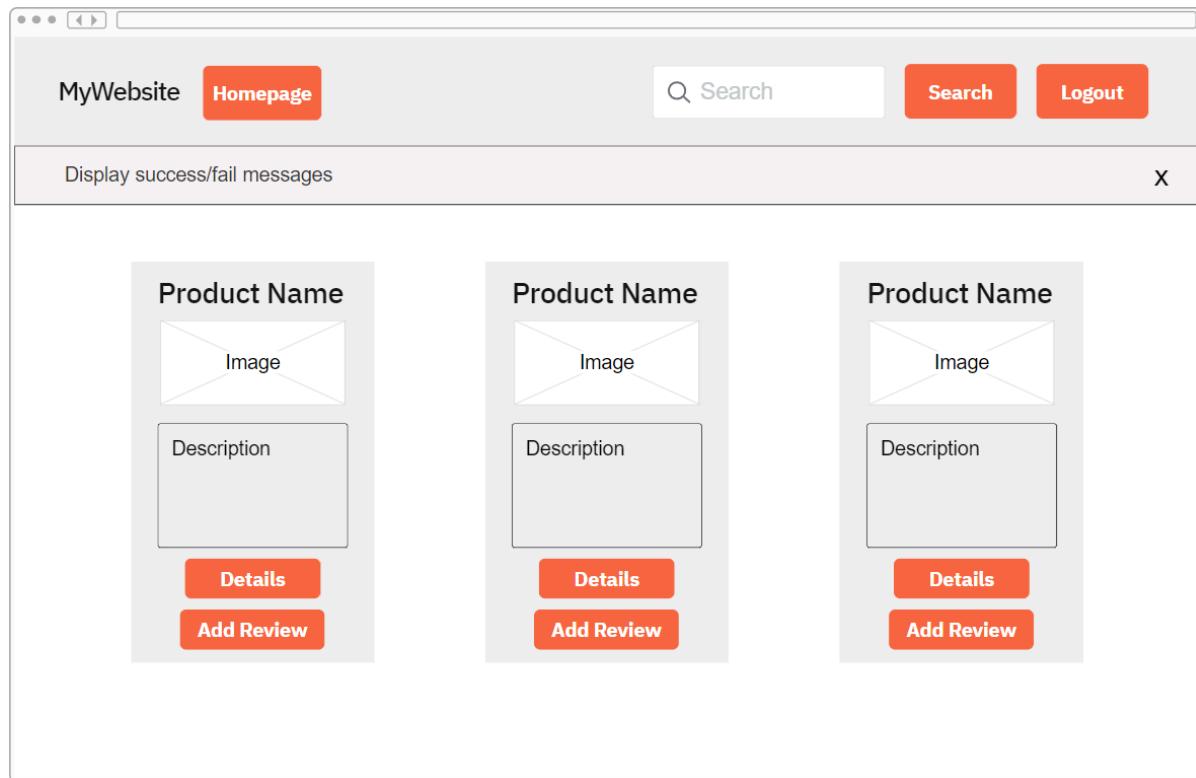


Figure 30 Interface Design for Home Page (Customer)

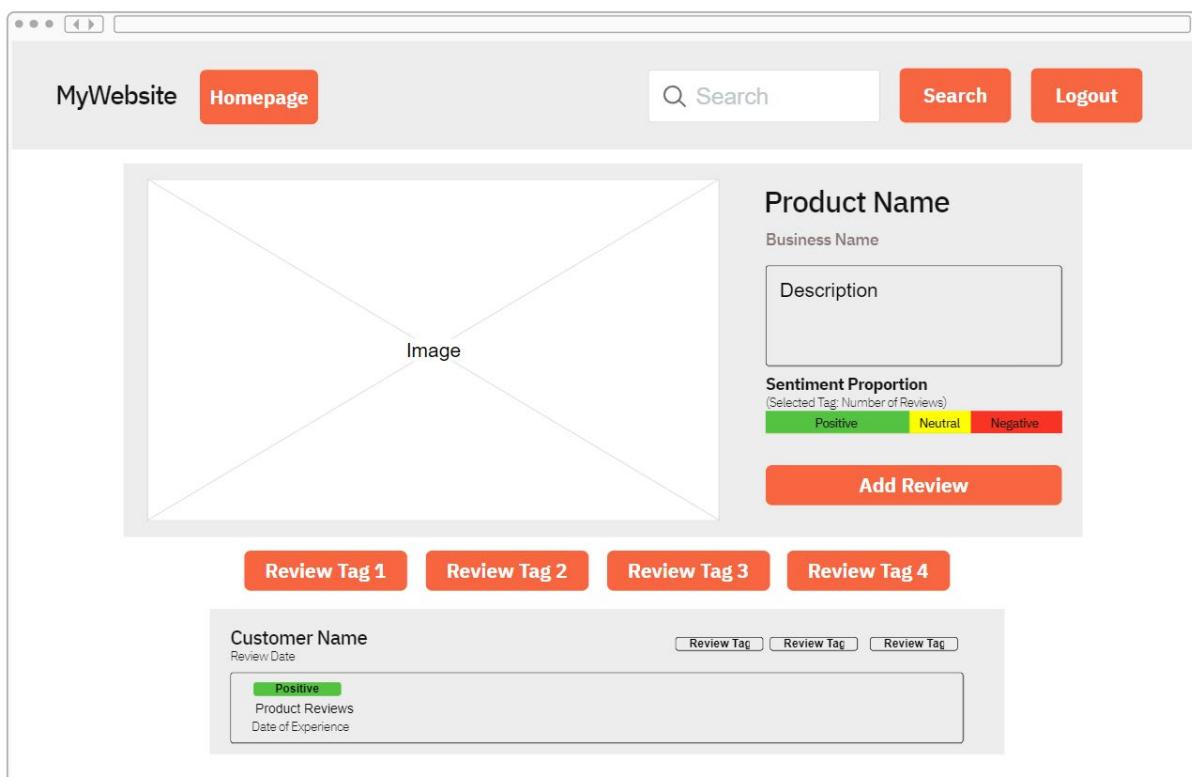


Figure 31 Interface Design for Product Details Page

MyWebsite [Homepage](#)

Search [Search](#) [Logout](#)

Image **Product Name**

**Product Review**

Title:

Text Area

Review Content:

Text Area

Review Tag

I agree that ...

**Add Feedback**

Figure 32 Interface Design for Add Review Page (Customer)

MyWebsite [Homepage](#) [Add Product](#) [Product Analysis](#)

Search [Search](#) [Logout](#)

Display success/fail messages X

| Sr | Image | Name | Description | Edit                 | Delete                 |
|----|-------|------|-------------|----------------------|------------------------|
| 1  | Image | Name | Description | <a href="#">Edit</a> | <a href="#">Delete</a> |
| 2  | Image | Name | Description | <a href="#">Edit</a> | <a href="#">Delete</a> |
| 3  | Image | Name | Description | <a href="#">Edit</a> | <a href="#">Delete</a> |
| 4  | Image | Name | Description | <a href="#">Edit</a> | <a href="#">Delete</a> |

Figure 33 Interface Design for Home Page (Business)

The screenshot shows a web browser window with a light gray header bar containing the text "MyWebsite" and three red buttons labeled "Homepage", "Add Product", and "Product Analysis". To the right of these buttons are a search bar with a magnifying glass icon and a text input field, a red "Search" button, and a red "Logout" button. Below the header is a light gray rectangular area with the text "Add Product" centered. Underneath this are two text input fields: one for "Product Name" containing the placeholder "Text Area" and another for "Description" also containing "Text Area". To the left of the "Description" field is the text "Product Review Tags:". Below this are three checkboxes: Tag 1 (unchecked), Tag 2 (checked), and Tag 3 (checked). To the right of the "Product Review Tags:" section is a "Add new tag:" label followed by a text input field and a red "Add" button. Below these sections is a "Product Photos" label with a "Choose Files" button and a text input field showing "No file chosen". At the bottom of the form is a red "Add Product" button.

Figure 34 Interface Design for Add Product Page (Business)

The screenshot shows a web browser window with a light gray header bar containing the text "MyWebsite" and three red buttons labeled "Homepage", "Add Product", and "Product Analysis". To the right of these buttons are a search bar with a magnifying glass icon and a text input field, a red "Search" button, and a red "Logout" button. Below the header is a light gray rectangular area with the text "Edit Product" centered. Underneath this are two text input fields: one for "Product Name" containing the placeholder "Text Area" and another for "Description" also containing "Text Area". To the left of the "Description" field is the text "Product Review Tags:". Below this are two checkboxes: Tag 1 (unchecked) and Tag 2 (checked). To the right of the "Product Review Tags:" section is a "Add new tag:" label followed by a text input field and a red "Add" button. Below these sections is a "Previous Uploaded Photos" label with three placeholder image boxes, each containing the word "Image". Below this is a "Product Photos" label with a "Choose Files" button and a text input field showing "No file chosen". At the bottom of the form is a red "Edit Product" button.

Figure 35 Interface Design for Edit Product Page (Business)

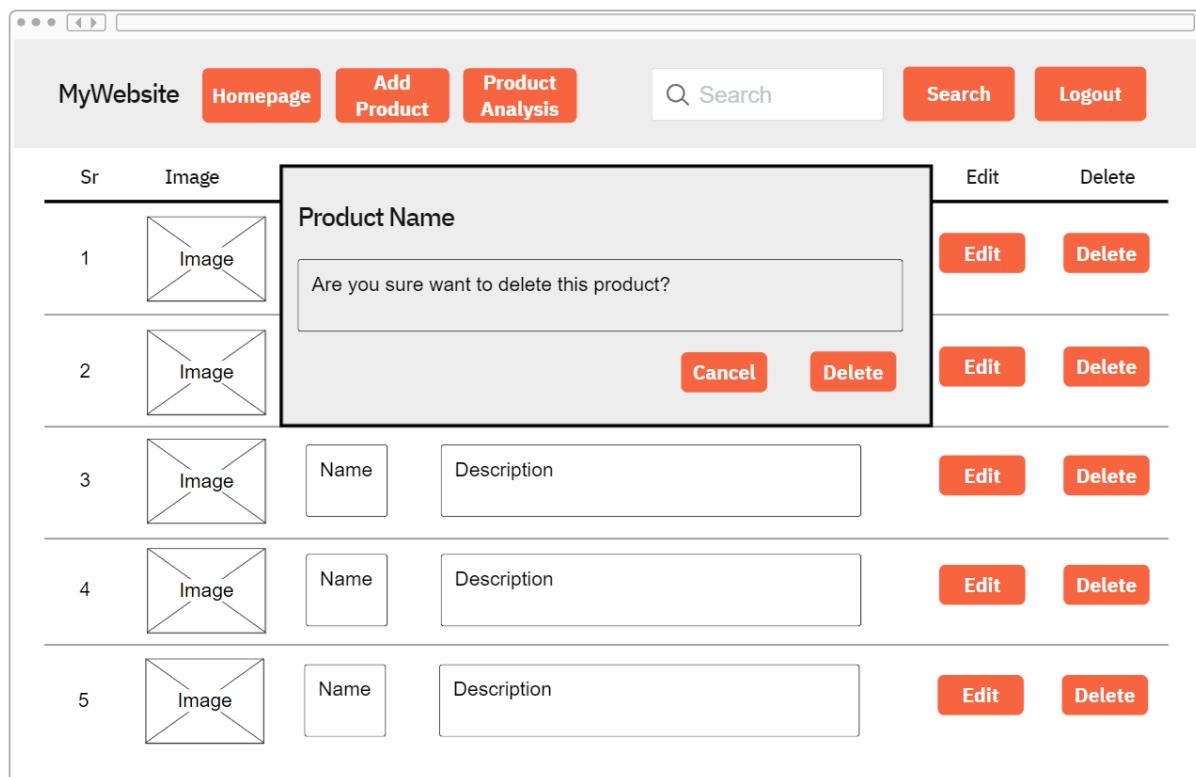


Figure 36 Interface Design for Delete Product (Business)

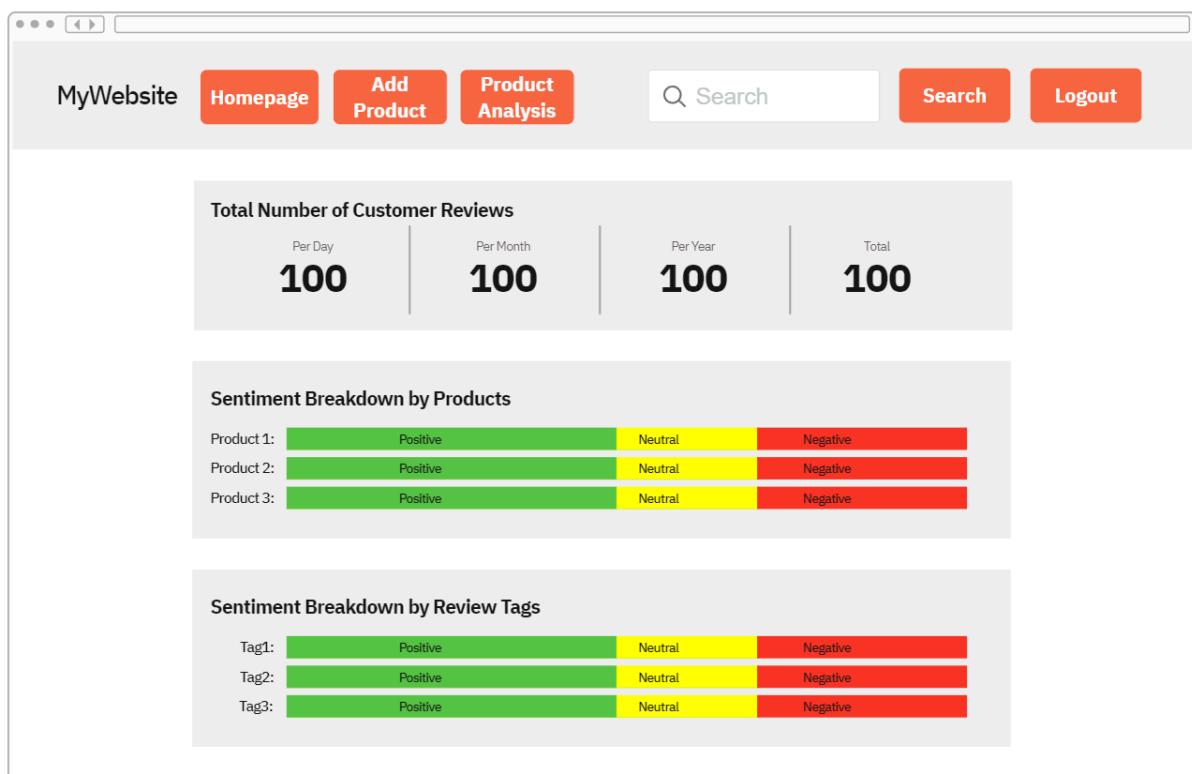


Figure 37 Interface Design for Product Analysis (Business)

### 7.3 Summary

This chapter has provided an overview of the proposed project from a conceptual view, including system design, database design, and interface design. It provides a reference for the development stage of the projects, allowing the developer to quickly understand the overall structure and design of the system. Besides, it helps to ensure that the system is reliable, as the architecture can be designed to provide redundancy and failover capabilities.

In the system design, the use case diagram provides a high-level view of the system, showing the interactions between the system and external actors, such as businesses and customers. Throughout the system, businesses can provide their product information and view the analysis of their products, while customers can review the products and view the sentiment proportion of the products calculated with other customer reviews. On the other hand, the class diagram provides a detailed view of the structure of the system, showing the relationships between different classes and their attributes and behaviors. It is used by the developer to generate code or other implementation artifacts. There are six classes included in this system: user, business, customer, product, review, and review\_q. Most of the attributes included in the classes are private, while most of the operations are public.

Entity relationship diagram (ERD) and database table structure are provided in the database design, allowing the developer to have a clear visual representation of the relationships between different entities and a deeper understanding of the database structure. In the Cloud Firestore, there will be a minimum of four collections which are business, customer, product, and review added to store the user input data. All the entities are connected with each other by the presence of diamonds on the line to represent their relationships. Most of the relationships used are one-to-many relationships. For example, a customer can create one or many reviews and view one or many products.

Lastly, the interface design provides the wireframe designed for the proposed system as a low-fidelity representation of the layout and structure of the user interface. It allows the developer to quickly and easily experiment with different layout and navigation options without the overhead of creating detailed visual designs.

## Chapter 8: Project Plan

### 8.1 Release Plan

A release plan acts as a roadmap for the developer, helping him to understand the overall plan for releasing the project and track progress towards the release date. In this section, the developer will introduce different versions of the proposed product review analysis web application.

According to the chosen system development methodology in Chapter 4, which is SCRUM, each iterative sprint will take up to three to four weeks, around one month for each release. Hence, the following release plan will be designed according to the sprint backlog by explaining product features in detail.

#### 8.1.1 Version 1.1

The proposed web application's initial release was planned for the second week of October 2022. The developer will have three weeks to develop the first version of the web-based product review analysis system. The final product of this version will consist of the fundamental features of a web application, which are user registration and verification, product management, and review tag management. The user interface in this version will be simple without including the CSS technique but able to show the navigation between different pages. The connection between the web application and the Cloud Firestore database will be initiated to store the user and product data. For the sentiment analysis model, some libraries and Amazon product review data will be imported to Google Colab as preparation for the model development. The developer will continue to research the implementation of the machine learning technique in order to apply it during the following sprint.

#### 8.1.2 Version 1.2

The proposed web application's second version will be released in the second week of November 2022. A total of four weeks will be provided for developing this version. This release will significantly improve the interactive user interface of the web application. The newly added features include product search, product review, review filtering, and product detail displaying along with its feedback. Some of the web pages will be beautified by implementing the CSS technique. The database in this version will be rearranged according to the need of the application requirements by adding more columns to connect different collections, such as the business ID included in the product collection and the customer ID

included in the product review collection. However, this website only contained the conventional functions that are sufficient to operate the application at a bare minimum. For example, the users are able to view the product review details except for the sentiment of the review, as the machine learning model is still under research and development.

### **8.1.3 Version 1.3 (Beta Version)**

The Beta version of the proposed web application was planned to be released in the first week of December 2022. During the four-week development, the developer will concentrate on developing, training, and testing the machine learning algorithm. Hence, the final product of this version will be able to proceed with sentiment analysis of the product review using the embedded machine learning model. Before connecting with the web application, the developer will evaluate the model by manually feeding some text to ensure that positive, neutral, and negative reviews can be detected and classified accurately. Besides, most of the user interface in the web application will be updated in this version to ensure it consists of clean and uncluttered design elements, such as white space, typography, and color, to create a pleasing and inviting visual experience. Overall, this Beta version will be ready for the developer to gather feedback from testers or users to identify the issues or bugs before the final release.

### **8.1.4 Version 2.0 (Demo Version)**

The final release of the web application was scheduled for the last week of December 2022. After three-week development, the developer will deploy a fully-functional web-based product review analysis system as the Demo version available for target users. All the web application user interfaces will be updated and tested to ensure the navigation between pages follows the developer's intention. Besides, one of the most important updates for the Demo version is the sentiment visualization showing the proportion of the product review polarity. Users will get insight into the desired products with a summary of all the existing customers' reviews. Also, the product reviews will be classified according to the review tags. Users will be able to filter the product feedback and look into the overall sentiment based on the selected tag. As the system's final version, this release will be used to demonstrate to the public.

## 8.2 Test Plan

The project has two outputs, which are a sentiment analysis machine learning model and a web-based product review analysis system. The proposed machine learning model is designed to extract information from three types of input, such as paragraphs, sentences, and phrases, and classify the polarity for that input. The system should be able to preprocess the input data and detect the positive, neutral, and negative sentiment with high accuracy, low bias, and acceptable levels of variance.

On the other side, the proposed web-based product review analysis system is a platform for connecting e-commerce businesses and customers. Its primary goal is to allow existing customers to leave their reviews on a specific product and let e-commerce businesses and potential customers observe the polarity percentage of product reviews according to the product characteristics to assist in their decision-making process. The sentiment analysis machine learning model is embedded inside the proposed system to provide insight into existing customers' feedback, analyze the customer's sentiment for a specific product's characteristics, and display the analysis result on the product review page with a graphical representation and their contained percentages. The product review analysis system should be able to communicate with the machine learning model successfully by sending the product reviews and receiving the polarity of the reviews. To produce a bug-free web application, various test cases will be conducted before the deployment of the application in the real world. During the testing process, the target users who are Malaysian, including Asia Pacific University students, lecturers, and administrations, will be invited to conduct the testing.

### 8.2.1 Unit Testing Plan

Each of the application's individual components will undergo examinations on atomic pieces of the codebase to validate their functionality, called unit testing. The developer will conduct this testing in Google Colab for the machine learning algorithm and Visual Studio Code for the front-end web application. During both tests, the Python and HTML code will be split into blocks according to their functionalities. Each function will be tested separately to make sure the feature is working properly. Unit testing will narrow the scope of the issue and make it simpler to identify any errors that may appear during the following testing phase. The unit test template for the proposed sentiment analysis machine learning model is shown as follows:

| Test Case | Function  | Input   | Expected Output   | Actual Output | Status (FAIL/PASS) |
|-----------|---|---|---|---------------|--------------------|
| A1        | Import Tensorflow Dataset                       | -   | Amazon product review dataset from TensorFlow is imported and converted to data frame format.   |               |                    |
| A2        | Mapping Star Rating to Sentiment Labels         | Original product review dataset with star rating column (0-5).                    | Product review dataset with an extra column “Sentiment” (0: Negative; 1:Neutral; 2:Positive).   |               |                    |
| A3        | Data Filtering                                  | Dataset with 16 columns and over 100,000 rows.                                    | Dataset with two columns (Customer Review, Sentiment) and 50,000 rows.  |               |                    |
| A4        | Split Dataset into Training and Validation Data | Two lists, which are “reviews” and “labels”, separated from the filtered dataset. | Four lists: training sentences, validation sentences, training labels, and validation labels. The ratio of training data to validation data is 8:2. |               |                    |
| A5        | Word Tokenization                               | Training sentences and validation sentences.                                      | Word encodings of training and validation sentences containing input ids and attention masks.   |               |                    |
| A6        | Model Training and Fine-tuning                  | DistillBert model, Adam optimization algorithm,                                   | Fine-tuned DistillBert model with training loss, training accuracy,   |               |                    |

|    |  |   |  |  |  |
|----|--|---|--|--|--|
|    |  | training dataset (reviews and labels), and validation dataset (reviews and labels).   | validation loss, and validation accuracy.  |  |  |
| A7 | Model Performance Visualization        | Fine-tuned DistillBert model, validation sentences, and validation labels.  | Confusion matrix heatmap of three different sentiment classes: Negative, Neutral, and Positive.  |  |  |
| A8 | Model Integration with Web Application | Documents from the “Review_q” collection in Firebase containing customer name, review content, product document ID, and review document ID. | <b>Database:</b> Add the customer review’s sentiment to the review document in the “customer_reviews” subcollection in the product’s document. |  |  |

Table 16 Unit Testing Template for Sentiment Analysis Machine Learning Model

The unit test template for the proposed product review analysis system is shown as follows:

| Test Case | User Type                          | Nature of Issue | Scenarios/Description   | Expected Output   | Actual Output | Status (FAIL/PASS) |
|-----------|------------------------------------|-----------------|---|---|---------------|--------------------|
| B1        | All users                          | Login           | Users login by filling in the <b>CORRECT</b> email, password, and role.                               | <b>For businesses:</b> direct to the business homepage and show the success login message.<br><b>For customers:</b> direct to the customer homepage and show the success login message. |               |                    |
| B2        | All users                          | Login           | Users login by filling in <b>INCORRECT</b> email or password or role.                                 | Show an error message by mentioning an unregistered email or incorrect password.  |               |                    |
| B3        | All users                          | Login           | Users login by <b>NOT</b> filling in either email, password, or role.                                 | Show an error message to remind users to fill in the empty columns.   |               |                    |
| B4        | All users                          | Login           | Users login by filling in the <b>INCORRECT</b> email format.  | Show an error message to remind users to include “@” in the email input.  |               |                    |
| B5        | Unregistered E-commerce businesses | Register        | Users register themselves as businesses by filling in business detail with the <b>CORRECT</b> format. | Login automatically and direct users to the business homepage with a welcome message.   |               |                    |

|    |                        |          |  |  |  |  |
|----|------------------------|----------|--|--|--|--|
|    |                        |          |  | <b>Database:</b> add the business details to a new document in the “businesses” collection. Add the business’s email, username and role to the “users” collection. Add a new user for the business in Firebase Authentication.   |  |  |
| B6 | Unregistered Customers | Register | Users register themselves as customers by filling in customer detail with the <b>CORRECT</b> format. | Login automatically and direct users to the customer homepage with a welcome message.<br><br><b>Database:</b> add the customer details to a new document in the “customers” collection. Add the customer’s email, username and role to the “users” collection. Add a new user for the customer in Firebase Authentication. |  |  |

|     |                       |                    |   |  |  |  |
|-----|-----------------------|--------------------|---|--|--|--|
| B7  | Unregistered Users    | Register           | Users register by filling in <b>INCORRECT</b> email/phone number format (only digits acceptable). | <b>Wrong email:</b> Show an error message to remind users to include "@" in the email input.<br><b>Wrong phone number format:</b> Show an error message to remind users to enter only digits |  |  |
| B8  | Unregistered Users    | Register           | Users register by filling in the <b>REGISTERED</b> email/username/business name.                  | Show an error message to inform users that the email/username/business name has been registered.   |  |  |
| B9  | Unregistered Users    | Register           | Users register by filling in <b>DIFFERENT</b> input for "Password" and "Confirm Password."        | Show an error message to inform users that the input for "Password" and "Confirm Password" is not the same.  |  |  |
| B10 | All users             | Return to Homepage | Users clicked on the "MyWebsite" button on the navigation bar.                                    | Direct users to business/customer/unregistered users' homepage.  |  |  |
| B11 | E-commerce businesses | Add New Product    | Users click on the "Add Product" button with the <b>FILLED</b> product                            | Direct users to the business homepage with a product successfully added message.   |  |  |

|     |                       |                      |   |  |  |  |
|-----|-----------------------|----------------------|---|--|--|--|
|     |                       |                      | name, description, review labels and photos.  | <b>Database:</b> add the product details to a new document in the “products” collection. Add the product photos to Firebase Storage under the product name folder. |  |  |
| B12 | E-commerce businesses | Add New Product      | Users click on “Add Product” button by <b>NOT</b> filling in the product name or description or <b>NOT</b> selecting a photo. | Show an error message to remind users to fill in the product name or description or to select a photo.   |  |  |
| B13 | E-commerce businesses | Add Product Photos   | Users add a product photo by selecting files <b>OTHER THAN</b> png, jpg, jpeg, and gif format.                                | Show an error message to remind users to select only png, jpg, jpeg, and gif files.  |  |  |
| B14 | E-commerce businesses | Add Review Label     | Users add a new tag for the review label.   | The newly added tag shows on the “Add Product Page” with an empty check box.   |  |  |
| B15 | E-commerce businesses | Edit Product Details | Users click on the “Edit” button for a specific product.  | Direct to “Edit Product Page” with filled previous product name, description, review labels, and uploaded photos.  |  |  |

|     |                       |                      |  |  |  |  |
|-----|-----------------------|----------------------|--|--|--|--|
| B16 | E-commerce businesses | Edit Product Details | Users click on the “Update Product” button with the <b>FILLED</b> product name, description, review labels, and uploaded photos. | Direct users to the business homepage with a product successfully updated message.<br><b>Database:</b> update the product details in the “products” collection. Delete the previous product photos and add the new photos to Firebase Storage under the product name folder. |  |  |
| B17 | E-commerce businesses | Edit Product Details | Users click on the “Update Product” button with <b>EMPTY</b> product name, description, or photos.                               | Show an error message to remind users to fill in the product name or description or to select a photo.   |  |  |
| B18 | E-commerce businesses | Delete Product       | Users click on the “Delete” button for a specific product.   | A confirmation dialogue box is shown. If users click on “Delete,” the product will be deleted; if users click on “Cancel,” it will return to the business homepage without deleting the product.   |  |  |

|     |                       |                     |  |   |  |  |
|-----|-----------------------|---------------------|--|---|--|--|
|     |                       |                     |  | <b>Database:</b> add the product details to the “deleted_products” collection. Delete the product document from the “products” collection. Delete the product photos from Firebase Storage.                   |  |  |
| B19 | E-commerce businesses | Search Product      | Users enter any part of a product name in the “Search” input and click on the “Search” button on the navigation bar. | Direct users to the business homepage by showing only the products matched with the “Search” input in <b>TABLE</b> format.  |  |  |
| B20 | E-commerce businesses | View Product Detail | Users click on a specific product name link on the business homepage.  | Direct users to the “Product Detail Page” of the selected product. The web page displays the product name, description, photos, sentiment proportion bar, business name, review labels, and customer reviews. |  |  |

|     |           |                     |  |  |  |  |
|-----|-----------|---------------------|--|--|--|--|
| B21 | Customers | Search Product      | Users enter any part of a product name in the “Search” input and click on the “Search” button on the navigation bar. | Direct users to the customer homepage by showing only the products matched with the “Search” input in <b>CARD</b> format.  |  |  |
| B22 | Customers | View Product Detail | Users click on the “Details” button under a specific product on the customer homepage.                               | Direct users to the “Product Detail Page” of the selected product. The web page displays the product name, description, photos, sentiment proportion bar, business name, “Add Review” button, review labels, and customer reviews. |  |  |
| B23 | Customers | Add Review          | Users click on the “Add Review” button under a specific product on the customer homepage.                            | Direct users to “Add Review Page” by showing the selected product name and photo.  |  |  |
| B24 | Customers | Add Review          | Users click on the “Add Review” button under the sentiment proportion on the “Product Detail Page.”                  | Direct users to “Add Review Page” by showing the selected product name and photo.  |  |  |

|     |           |            |  |   |  |  |
|-----|-----------|------------|--|---|--|--|
| B25 | Customers | Add Review | Users tick the acknowledgment checkbox and click on the “Add Feedback” button with the <b>FILLED</b> feedback title, content, date of experience, and review tags ( <b>AT LEAST 1 tag</b> ). | Direct users to the customer homepage and show a review successfully added message.<br><b>Database:</b> Add the product review details in the “customer_reviews” subcollection in the product’s document. Add the customer name, review, product and review document ID to the “Review_q” collection. |  |  |
| B26 | Customers | Add Review | Users tick the acknowledgment checkbox and click on the “Add Feedback” button with <b>EMPTY</b> feedback title, content, date of experience, or review tags.                                 | Show an error message to remind users to fill in the feedback title, content, date of experience, or review tags.   |  |  |
| B27 | Customers | Add Review | Users tick the acknowledgment checkbox and click on the “Add Feedback” button with <b>REPEATED</b> review tags.  | Show an error message to remind users not to select the same tags.  |  |  |

|     |   |  |   |   |  |  |
|-----|---|--|---|---|--|--|
| B28 | Unregistered Users                      | Search Product                             | Users <b>WITHOUT LOGIN</b> enter any part of a product name in the “Search” input and click on the “Search” button on the navigation bar. | Direct users to the homepage by showing only the products matched with the “Search” input in <b>CARD</b> format.  |  |  |
| B29 | Unregistered Users                      | View Product Detail                        | Users <b>WITHOUT LOGIN</b> click on the “Details” button under a specific product on the customer homepage.                               | Direct users to the “Product Detail Page” of the selected product. The web page displays the product name, description, photos, sentiment proportion bar, business name, review labels, and customer reviews. |  |  |
| B30 | All users                               | Filter Product Reviews based on Review Tag | Users click on one of the review tag buttons (contains review tag and number of reviews) on the “Product Detail Page.”                    | Shows only the customer reviews matched with the selected review tag. The sentiment proportion bar calculates its proportion based on the selected review tag.  |  |  |
| B31 | Logged in E-commerce business/Customers | Logout                                     | Users clicked on the “Logout” button on the navigation bar.   | Direct users to login page and show a successfully logout message.  |  |  |

Table 17 Unit Testing Template for Web-based Product Review Analysis System

### 8.2.2 Model Performance Testing Plan

Model performance testing is carried out to evaluate the machine learning classification model in terms of its precision, accuracy, and performance. While developing the machine learning model, the input dataset will be divided into two categories that are training data (80%) and validation data (20%). Training data will be used to train the machine learning model, while validation data will be applied for the evaluation of the model to produce the actual accuracy of the model. Some techniques used for model performance testing include precision recall, confusion matrix, F-score, and others. The developer decided to implement a confusion matrix for model performance testing. There are four cases included in the matrix: true positive, true negative, false positive and false negative. A detailed explanation for each case is shown as below:

**True Negative (TN):** The prediction of the model is “No,” and the actual value is “No.”

**True Positive (TP):** The prediction of the model is “Yes,” and the actual value is “Yes.”

**False Negative (FN):** The prediction of the model is “No,” and the actual value is “Yes.”

**False Positive (FP):** The prediction of the model is “Yes,” and the actual value is “No.”

However, the calculation for each case in the three classes' confusion matrix differs from the traditional two classes. The confusion matrix template for the proposed sentiment analysis machine learning model is shown as following:

| N = number of predictions | Predicted: Negative | Predicted: Neutral | Predicted: Positive |
|---------------------------|---------------------|--------------------|---------------------|
| Actual: Negative          | Cell 1              | Cell 2             | Cell 3              |
| Actual: Neutral           | Cell 4              | Cell 5             | Cell 6              |
| Actual: Positive          | Cell 7              | Cell 8             | Cell 9              |

Take “Negative” sentiment as an example, TP is Cell 1, FP is the sum of Cell 4 and Cell 7, FN is the combination of Cell 2 and Cell 3, and TN is the sum of Cell 5, Cell 6, Cell 8, and Cell 9.

A confusion matrix is able to produce various calculations for evaluating each class of the machine learning model. The details of evaluation metrics are provided below:

**Precision:** Measure the classifier's accuracy when it predicts a correct class.

**Recall:** Measure the classifier's ability to find all the correct instances.

**F1-Score:** Harmonic mean of precision and recall.

**Micro Averaging:** Average precision, recall, or F1-score with equal weight to each instance.

**Macro Averaging:** Average precision, recall, or F1-score with equal weight to each class.

**Weighted Averaging:** Average precision, recall, or F1-score with different weights for each class.

Apart from that, the sentiment analysis model requires a more detailed performance testing plan by giving different input text with positive, negative, and neutral sentiments to ensure the model is functioning as intended. The following table will show the model performance test template with different test cases:

| Test Case | Input Test  | Expected Output    | Actual Output | Status (FAIL/PASS) |
|-----------|---|--------------------|---------------|--------------------|
| C1        | High-quality product. Good price for the nice quality. I will buy it again.                           | Positive Sentiment |               |                    |
| C2        | The product was okay. I don't know if I would buy it again or not.                                    | Neutral Sentiment  |               |                    |
| C3        | The product is not functioning at all. I definitely wouldn't purchase it again.                       | Negative Sentiment |               |                    |
| C4        | The delivery is fast as I get my parcel within two days only.   | Positive Sentiment |               |                    |
| C5        | The product is just normal. Not sure about comparing it with another brand.                           | Neutral Sentiment  |               |                    |
| C6        | The seller is not friendly and his service is a nightmare. Not reply any message after I paid for it. | Negative Sentiment |               |                    |
| C7        | Wow, I just love spending a small fortune on this ridiculously overpriced product! Five stars!        | Negative Sentiment |               |                    |

Table 18 Model Performance Testing Template

### 8.2.3 User Acceptance Testing Plan

User acceptance testing is implemented to examine the final product's acceptability. During this phase, the testers, end-users, or clients will be invited to make sure that the application has met the predefined requirements collected through the data gathering techniques, such as surveys and questionnaires. The user acceptance test template for the proposed product review analysis system is shown as following:

## USER ACCEPTANCE TESTING (UAT)

**Tester Name:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Occupation:** \_\_\_\_\_

**Start Time:** \_\_\_\_\_

**End Time:** \_\_\_\_\_

*Instruction: Please select your answer with a ✓ symbol for the following criteria:*

| Criteria   | Poor | Fair |   |   | Good |   |   | Very Good |   | Excellent |
|--|------|------|---|---|------|---|---|-----------|---|-----------|
| Sentiment Analysis Model   | 1    | 2    | 3 | 4 | 5    | 6 | 7 | 8         | 9 | 10        |
| <b>Accuracy</b>  |      |      |   |   |      |   |   |           |   |           |
| • Sentiment can be detected and classified accurately.   |      |      |   |   |      |   |   |           |   |           |
| <b>Performance</b>   |      |      |   |   |      |   |   |           |   |           |
| • The model can analyze and produce the sentiment in a short time.                                     |      |      |   |   |      |   |   |           |   |           |
| <b>Model Integration</b>   |      |      |   |   |      |   |   |           |   |           |
| • After reviewing a product, the website can show the reviews without crashing.                        |      |      |   |   |      |   |   |           |   |           |
| Web-based Product Review Analysis System   | 1    | 2    | 3 | 4 | 5    | 6 | 7 | 8         | 9 | 10        |
| <b>User Interface</b>  |      |      |   |   |      |   |   |           |   |           |
| • The website is user-friendly and the design is uncluttered, providing an inviting visual experience. |      |      |   |   |      |   |   |           |   |           |
| <b>Navigation</b>  |      |      |   |   |      |   |   |           |   |           |
| • The website presents information and options logically and intuitively.                              |      |      |   |   |      |   |   |           |   |           |

|   |  |  |  |  |  |  |  |  |  |
|---|--|--|--|--|--|--|--|--|--|
| • Every button and link leads to the correct pages.   |  |  |  |  |  |  |  |  |  |
| <b>Functionality</b>  |  |  |  |  |  |  |  |  |  |
| <ul style="list-style-type: none"> <li>The web application provides the features that users need to complete their tasks.</li> <li>The system is free from bugs.</li> <li>Error messages can be displayed once the users operate the system incorrectly.</li> </ul> |  |  |  |  |  |  |  |  |  |
| <b>Performance</b>  |  |  |  |  |  |  |  |  |  |
| <ul style="list-style-type: none"> <li>The features within the website can operate smoothly without crashing.</li> <li>The web application can load and respond quickly, with minimal downtime or errors.</li> </ul>  |  |  |  |  |  |  |  |  |  |
| <b>Other suggestion/comments from tester:</b>   |  |  |  |  |  |  |  |  |  |
|   |  |  |  |  |  |  |  |  |  |

Table 19 User Acceptance Testing (UAT) Template

### 8.3 Summary

This chapter provided detailed project plans, including the release and test plan, that will be conducted after developing the sentiment analysis model and web-based product review analysis system. The release plan helps the developer to outline the tasks, dependencies, and milestones throughout the project development. This release plan is designed according to the project's objectives and deliverables, except for the extra features. However, extra features will also be included in the demo version of the system if time allows. The timeline listed in the release plan must be followed by the developer to ensure the project can be delivered before the submission date. On the other hand, the developer decided to conduct unit, model performance, and user acceptance testing as approaches to evaluate the performance of the sentiment analysis model and proposed web application. The primary purpose of this project test plan is to outline a clear and comprehensive strategy for testing the system and ensure the system is able to function as desired. The result of the test plan will be shown in Chapter 10.

## Chapter 9: Implementation

### 9.1 Sentiment Analysis Model Development

The main feature of the proposed system is sentiment analysis, classifying customer reviews into three categories: positive, neutral, or negative. The proposed model is a transformer-based DistilBERT model. This section will explain the overall model training and evaluation process along with the source code. Besides, the developer will also carry out model performance comparisons with different algorithm parameters and machine learning models.

#### 9.1.1 Model Training Implementation Code

The full source code with comments explaining each function in detail has been provided in the attached source code zip file under the AIModel folder, called “DistilBERT\_Model\_Training.”

First of all, the developer imports the required libraries and dataset from Tensorflow and converts the dataset into a data frame format in order to fit the model input requirement. After that, Exploratory Data Analysis (EDA) is provided to analyze and understand the dataset structure, which involves exploring the data, looking for patterns and trends, and preprocessing the data for preparing to feed into the DistilBERT model. Before undergoing the tokenization process, the dataset is split into training and evaluation data along with their sentiment labels. Word tokenization is then implemented to divide the training and evaluation data into smaller units called tokens. Subsequently, the model training process starts by fine-tuning the DistilBERT model with the training dataset using Adam Optimization Algorithm. The output of model training will be the input for model performance evaluation to create a confusion matrix and calculate the accuracy, precision, recall, F1-score, and Micro and Macro Averaging. Lastly, the model will be tested with manual input text to ensure the model can be applied and functions as expected when embedding in the proposed system.

## Mapping Ratings into Sentiment Classes

```
# Assign sentiment labels (Positive/Neutral/Negative) to each consumer review
# Mapping ratings 1 and 2 to Negative(0), 3 to Neutral(1), 4 and 5 to Positive(2)
def to_sentiment(rating):
    rating = int(rating)
    if rating <= 2:
        return 'negative'
    elif rating == 3:
        return 'neutral'
    else:
        return 'positive'

# Mapping
df["Sentiment"] = df["data/star_rating"].apply(to_sentiment)
df['Sentiment'] = df['Sentiment'].map({'positive':2, 'negative':0, 'neutral': 1})
```

Figure 38 Source Code for Sentiment Mapping

As the imported Amazon product review dataset only consists of product ratings from 1 to 5, the developer converts the star ratings into sentiment labels with 0 (negative), 1 (neutral), and 2 (positive). The reason for mapping the star ratings to integers 0 to 2 instead of textual sentiment is that the machine learning model fitting only accepts integer labels as input.

## Word Tokenization

```
# Create an instance to store the tokenizer model
# In the distilbert-base-uncased model, all text is lowercased before being processed by the model.
tokenizer = DistilBertTokenizerFast.from_pretrained('distilbert-base-uncased')
# DistilBERT word tokenization as input to the DistilBERT model
train_encodings = tokenizer(training_sentences,
                            truncation=True,
                            padding=True,
                            max_length=128)
val_encodings = tokenizer(validation_sentences,
                          truncation=True,
                          padding=True,
                          max_length=128)
```

Figure 39 Source Code for Word Tokenization

Before feeding the data into the DistilBERT model, the data must be tokenized into tokens and divided into subwords that are easier for a model to understand and process. In the proposed model, the tokenizer uses the ‘distilbert-base-uncased’ parameter in order to convert the data into lowercase before tokenization. This allows the model to handle a larger vocabulary and to perform well on a wide range of texts. When performing word tokenization, “truncation” will truncate the input text if it is longer than the specified "max\_length" argument, and “padding” will add padding tokens to the beginning and end of the input text if it is shorter than the specified “max\_length” argument.

## Model Training

```
# Create an instance to store the initialized DistilBERT model
model = TFDistilBertForSequenceClassification.from_pretrained('distilbert-base-uncased',num_labels=3)
# Create an instance of the "Adam" optimizer class
optimizer = tf.keras.optimizers.Adam(learning_rate=5e-5, epsilon=1e-08)
# Specify the details of the training process
model.compile(optimizer=optimizer, loss=model.hf_compute_loss, metrics=['accuracy'])

# Start Model Fitting with Fine-tuning
model.fit(train_dataset.shuffle(100).batch(16),
          epochs=8,
          batch_size=16,
          validation_data=val_dataset.shuffle(100).batch(16))
```

Figure 40 Source Code for Model Training

The developer first creates a classification model using the ‘distilbert-base-uncased’ pre-trained model with three output labels. Compared with ‘distilbert-base-cased,’ the proposed method is more useful for tasks involving a large number of rare or out-of-vocabulary (OOV) words, such as hippopotamus, as the model will be able to break these words down into smaller subwords that are more common in the proposed dataset. Besides, the developer uses the Adam Optimization Algorithm with a 5e-5 learning rate and 1e-08 epsilon. The adaptive learning rate is one of the main advantages of this algorithm to speed up convergence and improve the model performance. This algorithm also uses momentum, which helps to smooth out the optimization process and can reduce the oscillation of the gradients.

During the training and testing process, the ‘hf\_compute\_loss’ is implemented to calculate the proposed model’s loss, and the metrics ‘accuracy’ is used to evaluate the model performance. While fine-tuning the proposed model, the training and validation dataset is shuffled before being divided into batches of specified size. ‘Epochs’ is the number of times that the model will be trained on the training dataset, while ‘batch\_size’ specifies the number of samples in each batch of data.

## Model Evaluation

```
# Calculate the confusion matrix
y_preds = []

# Iterate on the validation dataset
for val_text in validation_sentences:
    # Encode the sentences
    tokenized_val_text = tokenizer.encode(val_text,
                                            truncation=True,
                                            padding=True,
                                            return_tensors="tf")

    # Predict the sentiment
    tf_output = loaded_model.predict(tokenized_val_text)[0]
    tf_prediction = tf.nn.softmax(tf_output, axis=1)
    label = tf.argmax(tf_prediction, axis=1)
    label = label.numpy()
    y_preds.append(label[0])
conf_matrix = confusion_matrix(validation_labels, y_preds)
```

Figure 41 Source Code for Model Evaluation

Lastly, a model evaluation is carried out to measure the proposed model performance. During the model evaluation process, the developer iterates over the validation dataset and predicts the sentiment output using the trained model. The sentiment output is then stored in a list and compared with the actual output, building a confusion matrix. Lastly, the confusion matrix is visualized and used to calculate the accuracy, precision, recall, F1-score, and Micro and Macro averaging. The results, along with the explanation, will be shown in Chapter 10.2, Model Performance Testing section.

### 9.1.2 Model Performance Metrics

| Epochs | Batch Size | Accuracy | Macor-averaged F1-Score | Training Time |
|--------|------------|----------|-------------------------|---------------|
| 2      | 16         | 0.918    | 0.8046                  | 1.32 hrs      |
| 4      | 16         | 0.8522   | 0.716                   | 2.63 hrs      |
| 6      | 16         | 0.8547   | 0.7286                  | 4.14 hrs      |
| 8      | 16         | -        | -                       | -             |

Table 20 DistilBERT Model Performance Metrics

To carry out the model performance, 50000 sample data are used with 40000 training data and 10000 evaluation data. Due to the Graphic Processing Unit (GPU) usage limit in Google Colab, the developer is not able to carry out the model performance testing for 8 epochs. Based on the table above, the higher number of epochs, the longer the training time required.

However, the model performance is not enhanced when the number of epochs increases. Hence, the developer decided to choose and train with 2 epochs as it can achieve the highest accuracy and F1-score with the least training time.

### 9.1.3 Machine Learning Model Comparison

| Machine Learning Model   | DistilBERT Model | Naïve Bayes |
|--|------------------|-------------|
| <b>Accuracy</b>  | 0.918            | 0.8011      |
| <b>Training Time</b>   | 1.32 hrs         | 0.0464 sec  |
| <b>F1-Score (Neutral Sentiment)</b>  | 0.54             | 0.1034      |
| <b>Macro-averaged F1-score</b>   | 0.8046           | 0.5743      |
| <b>“High-quality product. Good price for the nice quality. I will buy it again.”</b>     | Positive         | Positive    |
| <b>“The product is not functioning at all. I definitely wouldn’t purchase it again.”</b> | Negative         | Negative    |
| <b>“The product was okay. I don’t know if I would buy it again or not.”</b>              | Neutral          | Negative    |
| <b>“The product is just normal. Not sure about comparing it with another brand.”</b>     | Neutral          | Negative    |

Table 21 DistilBERT and Naïve Bayes Model Performance Comparison

The developer has carried out the model performance comparison between a transformer-based and traditional-based machine learning model using the same dataset (Amazon product review dataset). The result shows that the DistilBERT model is able to achieve a higher accuracy but longer training time. The Naïve Bayes model has an unsatisfying prediction result, especially in classifying the input text with a neutral sentiment. Hence, the DistilBERT model is a better choice to embed in the proposed system as classifying the neutral sentiment is also one of the system's core features.

## 9.2 Screenshot of Web Application Designs

### 9.2.1 Unregistered User's Homepage

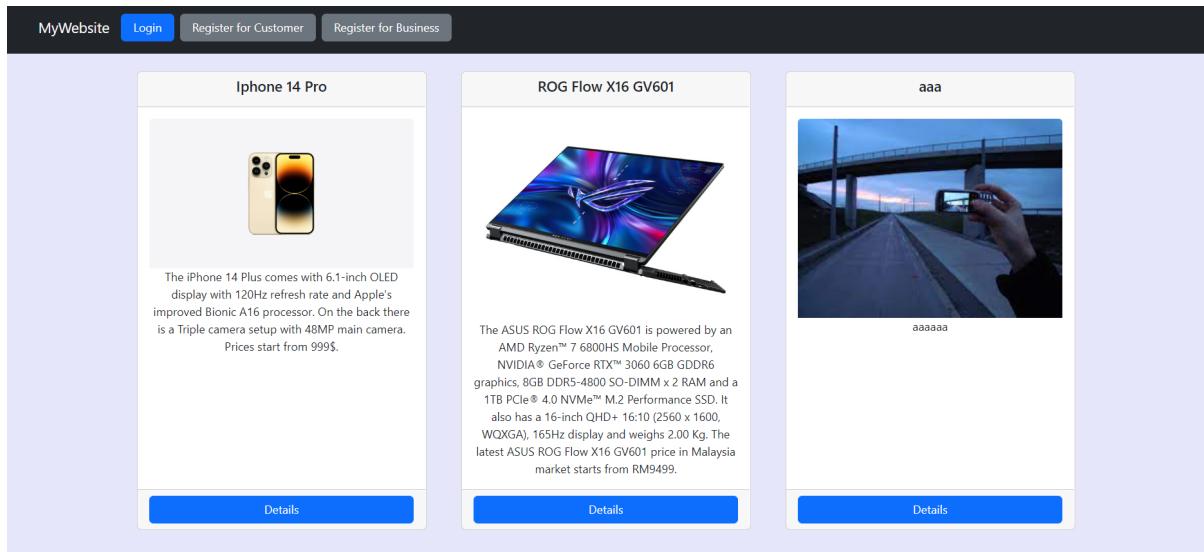


Figure 42 Screenshot of Unregistered User's Homepage

This is the first webpage that shows to all the users once entering the website URL. On this homepage, users are able to select login or register as a customer or business. Other than that, users are also allowed to view the product details but are not allowed to add a product review.

### 9.2.2 Login Page

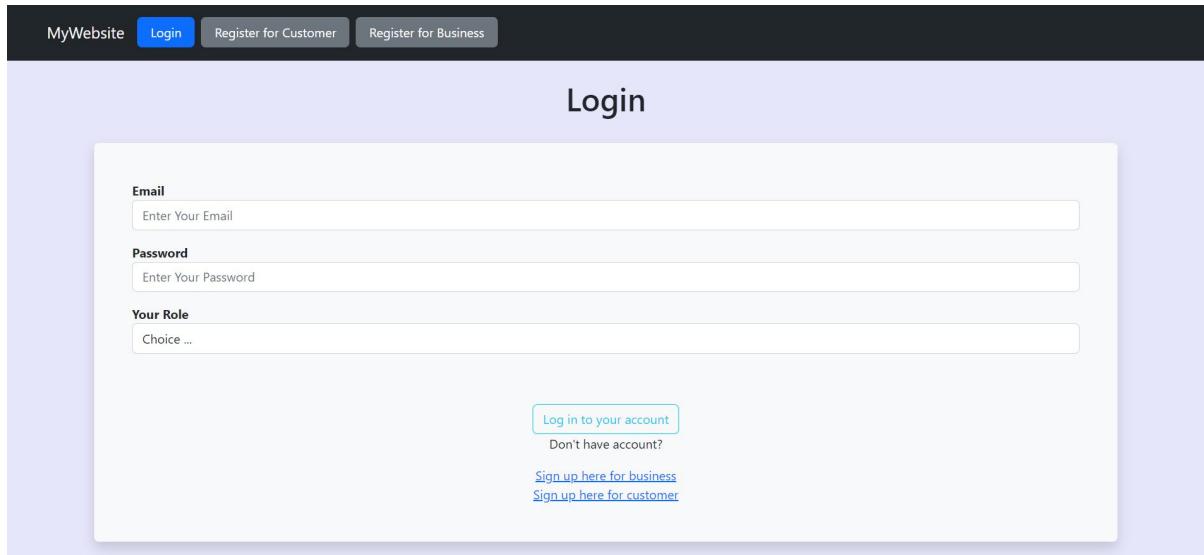


Figure 43 Screenshot of Login Page

This is the login page where users need to enter the correct email, password, and role. Otherwise, unregistered users can choose to sign up for a business or customer through the button in the navigation bar or the link below the "Log in to your account" button. All the

information must be filled in correctly before clicking the login button. If a customer enters the correct email and password but chooses a “business” role, an error message will be shown.

### 9.2.3 Customer Registration Page

The screenshot shows a "Customer Registration" form with the following fields:

- Username:** Enter Your Desired Username
- First Name:** Enter Your First Name
- Last Name:** Enter Your Last Name
- Gender:** Not prefer to say
- Date of Birth:** dd/mm/yyyy
- Email:** Enter Your Email
- Password:** Enter Your Password
- Confirm Password:** Confirm Your Password
- Contact Number:** Enter Your Contact Number (Only numbers are accepted)
- Address:** Enter Your Address
- City:** Enter Your City
- Country:** Enter Your Country

At the bottom of the form, there is a "Register new account" button and a link "Already have an account? [Sign in here](#)".

Figure 44 Screenshot of Customer Registration Page

This is the customer registration page where users are required to enter a desired username, first name, last name, gender, date of birth, email, password, contact number, address, city, and country. Otherwise, registered customers can choose to sign in to their account directly through the link below the “Register new account” button. An error message will be displayed if users enter a registered username or email. Besides, the input for “Password” and “Confirm Password” fields must be the same.

### 9.2.4 Business Registration Page

The screenshot shows a 'Business Registration' page with the following fields:

- Business Name:** Enter Your Business Name
- Email:** Enter Your Business Email
- Password:** Enter Your Password
- Confirm Password:** Confirm Your Password
- Contact Number:** Enter Your Contact Number (Only numbers are accepted)
- Address:** Enter Your Address
- City:** Enter Your City
- Country:** Enter Your Country

At the bottom right, there is a 'Register new account' button and a link 'Already have an account? [Sign in here](#)'.

Figure 45 Screenshot of Business Registration Page

This is the business registration page where users are required to fill in the business name, email, password, contact number, address, city, and country. Similar to customer registration, if users fill in the registered business name or email, an error message will be displayed.

## 9.2.5 Business Homepage

| Sr | Image | Name  | Description  | Edit                 | Delete                 |
|----|-------|---|--|----------------------|------------------------|
| 1  |       | <a href="#">iPhone 14 Pro</a>                 | The iPhone 14 Plus comes with 6.1-inch OLED display with 120Hz refresh rate and Apple's improved Bionic A16 processor. On the back there is a Triple camera setup with 48MP main camera. Prices start from 999\$.  | <a href="#">Edit</a> | <a href="#">Delete</a> |
| 2  |       | <a href="#">ROG Flow X16 GV601</a>            | The ASUS ROG Flow X16 GV601 is powered by an AMD Ryzen™ 7 6800HS Mobile Processor, NVIDIA® GeForce RTX™ 3060 6GB GDDR6 graphics, 8GB DDR5-4800 SO-DIMM x 2 RAM and a 1TB PCIe® 4.0 NVMe™ M.2 Performance SSD. It also has a 16-inch QHD+ 16:10 (2560 x 1600, WQXGA), 165Hz display and weighs 2.00 Kg. The latest ASUS ROG Flow X16 GV601 price in Malaysia market starts from RM949.  | <a href="#">Edit</a> | <a href="#">Delete</a> |
| 3  |       | <a href="#">FUJIFILM X-T30 II Body XT30II</a> | Offering powerful stills and video features, coupled with a compact, functional design, the FUJIFILM X-T30 II is a versatile mirrorless camera distinguished by advanced stills and video recording along with sleek and intuitive handling characteristics. Featuring a revised image sensor and processor, both high-resolution stills and 4K video can be recorded while an enhanced autofocus system delivers fast and accurate focusing performance. The 26.1MP APS-C-format X-Trans CMOS 4 image sensor features a back-illuminated design to promote greater image quality throughout the sensitivity range along with a 425-point phase-detection autofocus system for quick, precise AF performance and subject tracking. The 100% phase-detect autofocus provides strong face and eye detection autofocus with a new Face Selection option. Complementing the imaging and focusing is the X-Processor 4, which uses four CPUs for faster image processing as well as continuous shooting up to 8 fps with a mechanical shutter, 30 fps shooting at a 1.25x crop and electronic shutter, and internal DCI/UHD 4K30 video recording. | <a href="#">Edit</a> | <a href="#">Delete</a> |

Figure 46 Screenshot of Business Homepage

This is the business homepage after business users successfully log in to the system. The homepage displays the added products with their name, image, and description in a table format. Users can choose to add a new product, edit or delete a product, search for a product according to the product name, or view the product analysis. The elements in the navigation bar are the same for all business users and are available while browsing every web page.

## 9.2.6 Add Product Page

Add a product

Product Name

Description

Product Review Tags:

- Product Quality
- Delivery Service
- Seller Service
- Performance
- Durability
- Effectiveness
- Material
- Design

Add new tag:  [Add](#)

Product Photos

[Choose File](#)  No file chosen

[Add Product](#)

Figure 47 Screenshot of Add Product Page

This is the add product page where business users must fill in the product name, description, product review tags, and product photos before clicking the “Add Product” button. There are three default review tags (Product Quality, Delivery Service, Seller Service) that are

automatically added for all the products. Users can select or deselect any of the review tags apart from the mentioned review tags. Users can also add a new tag by manually filling it in the “Add new tag” field. At least a product photo in jpg, jpeg, png, and gif format must be chosen to avoid the error message.

### 9.2.7 Edit Product Page

The screenshot shows the 'Edit Product' page with the following fields:

- Product Name:** Iphone 14 Pro
- Description:** The iPhone 14 Plus comes with 6.1-inch OLED display with 120Hz refresh rate and Apple's improved Bionic A16 processor. On the back there is a Triple camera setup with 48MP main camera. Prices start from 999\$.
- Product Review Tags:** A list of checkboxes for review tags, with most checked:
  - Product Quality
  - Delivery Service
  - Seller Service
  - Performance
  - Durability
  - Effectiveness
  - Material
  - Design
  - Camera
  - Storage
- Add new tag:** An input field with an 'Add' button.
- Previous Uploaded Photo:** Three thumbnail images of the iPhone 14 Plus.
- Product Photos:** A file upload section showing 'Choose Files' and 'No file chosen'.
- Update Product:** A green 'Update Product' button at the bottom.

Figure 48 Screenshot of Edit Product Page

This is the edit product page where business users can edit the product name, description, review tags, and product photos. Same as Add Product Page, all the fields must be filled in to avoid the error message.

### 9.2.8 Delete Product Modal

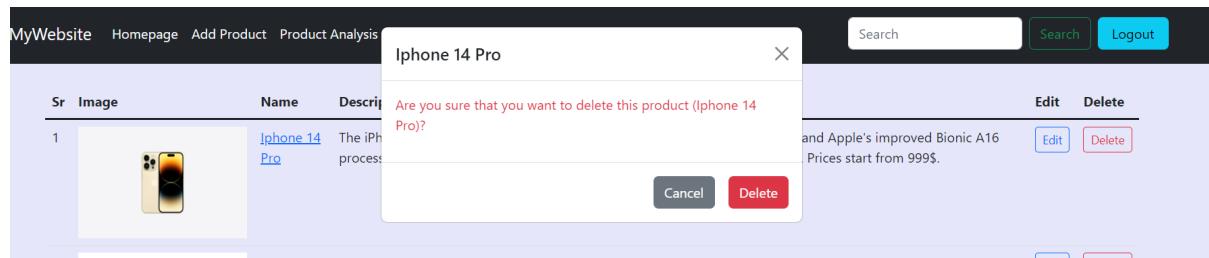


Figure 49 Screenshot of Delete Product Modal

A confirmation dialog will be displayed once the business users click on the “Delete” button for a specific product. It is an action to prevent users from deleting the product accidentally. If users click on “Delete” button, the product will be deleted permanently; if users click on “Cancel” button, the system will do nothing and navigate back to business homepage.

### 9.2.9 Product Analysis Page

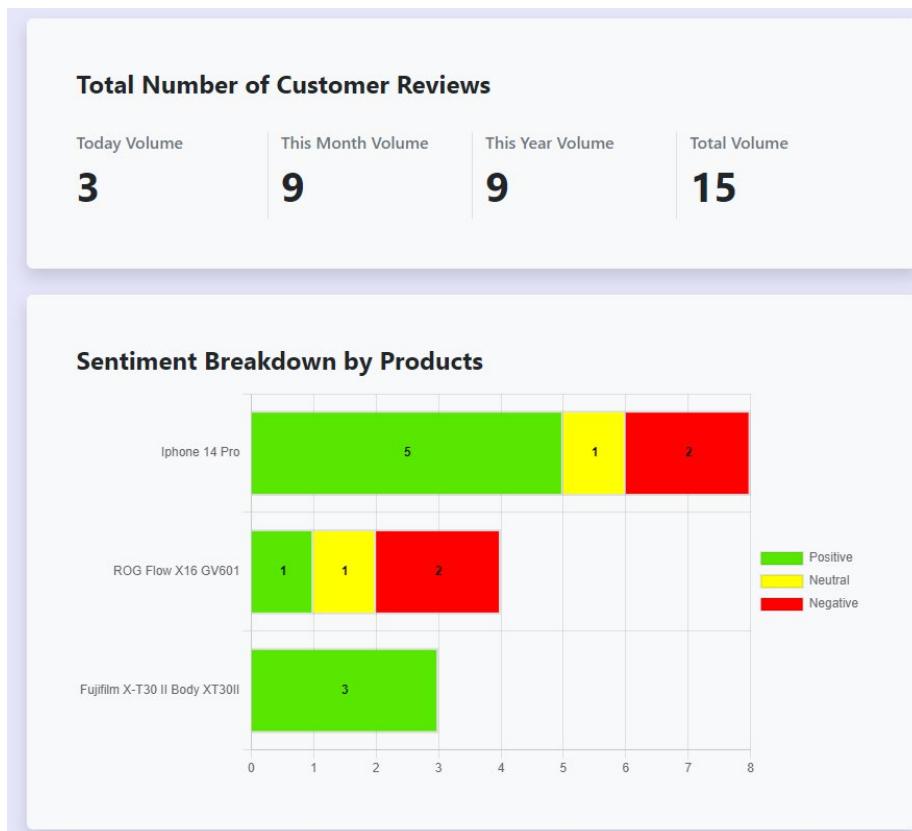


Figure 50 Screenshot of Product Analysis Page Part I

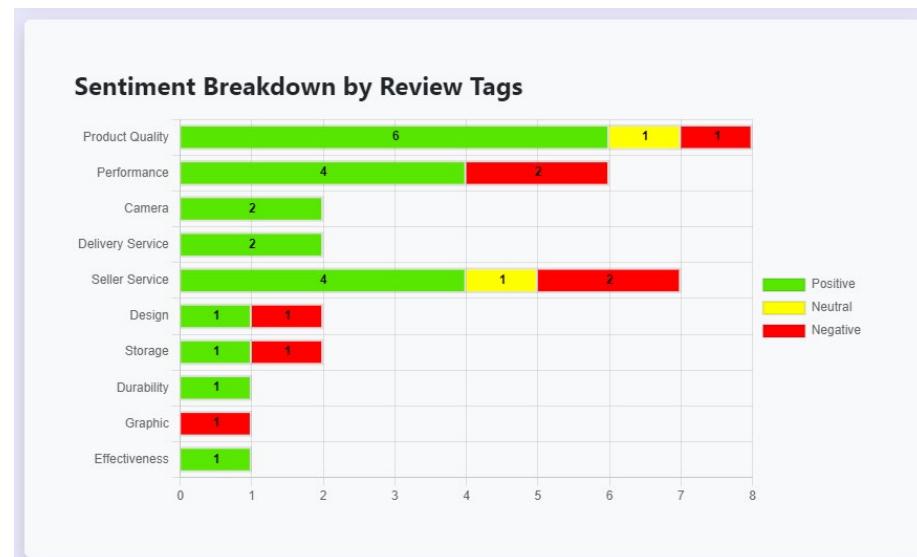


Figure 51 Screenshot of Product Analysis Page Part 2

Both figures above show the product analysis with the total number of customer reviews, sentiment breakdown by products, and sentiment breakdown by review tags. The total number of customer reviews is calculated according to the current date, month, and year. The other two sentiment breakdown analyses describe the product users' overall sentiment, providing better insight for businesses to improve their products.

### 9.2.10 Customer Homepage

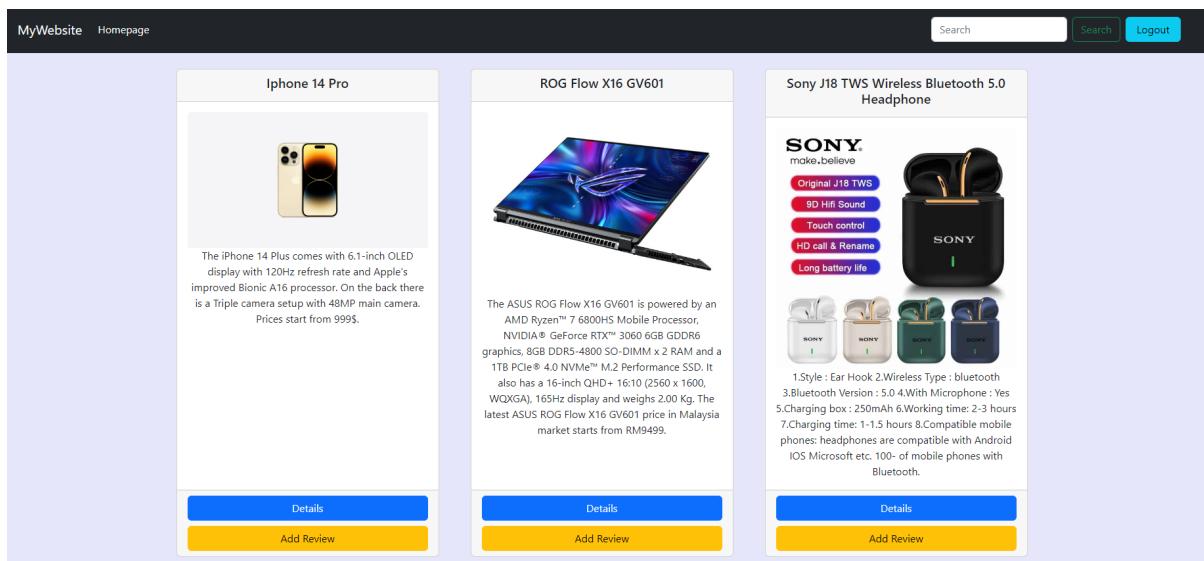


Figure 52 Screenshot of Customer Homepage

This is the customer homepage after customer users successfully log in to the system. The homepage displays all the products added by businesses with their name, image, and description in a card format. Users can choose to view the product detail or add a review for a

specific product. The elements in the navigation bar are the same for all customer users and are available while browsing every web page.

### 9.2.11 Product Detail Page

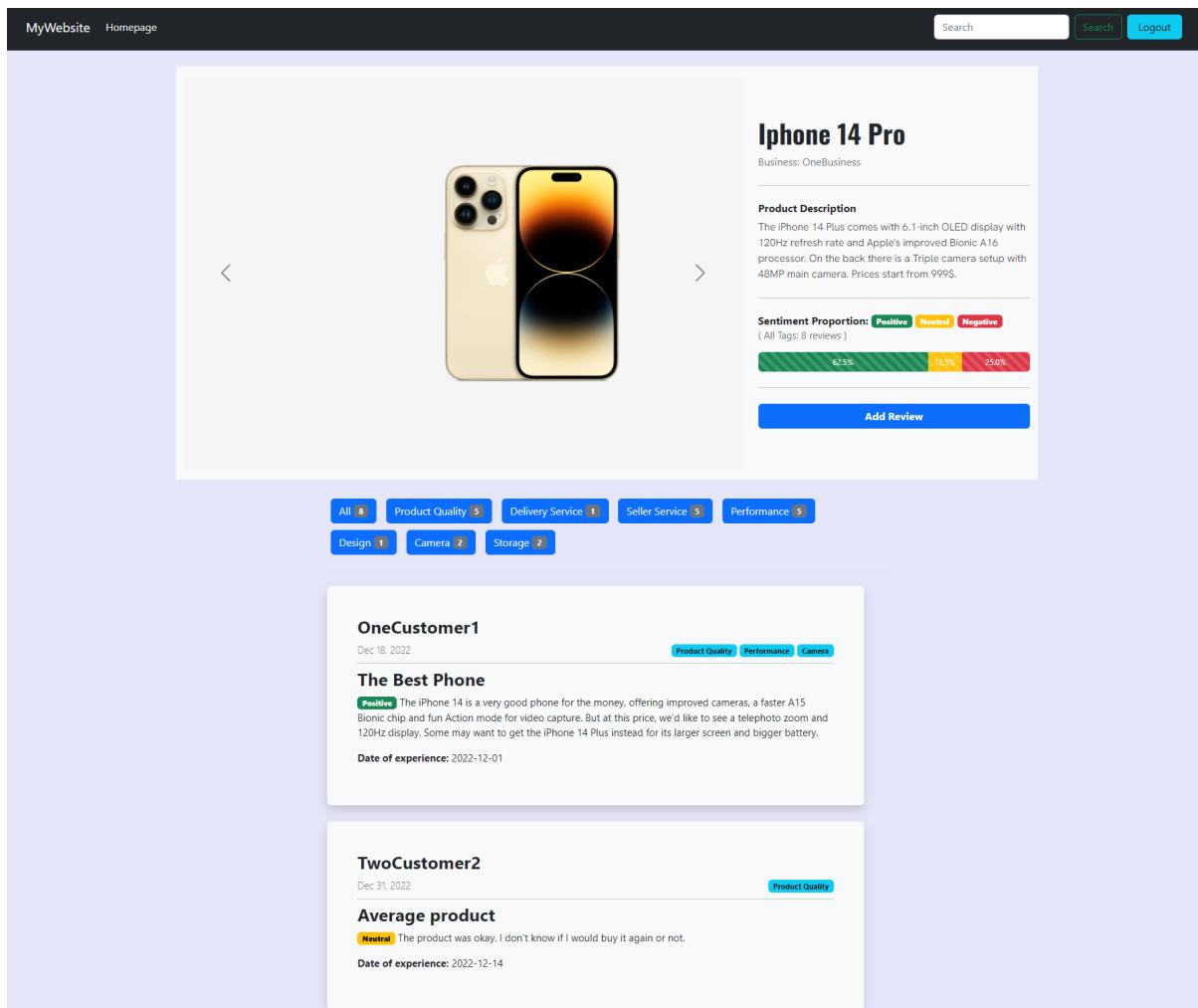


Figure 53 Screenshot of Product Detail Page

This is the product detail page showing the product details and customer reviews. Users can browse the product photos by clicking the previous and next navigation arrows. Moreover, users can choose to filter customer feedback by clicking one of the review tag buttons. When a review tag is selected, the customer reviews will be filtered and displayed according to the selected review tag. Besides, the sentiment proportion will also be recalculated and displayed based on the selected label, like the figure below. The “Add Review” button will only be available for the customer users.

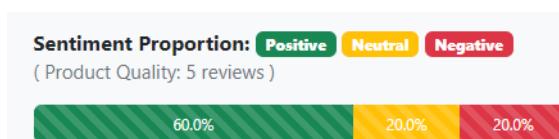


Figure 54 Screenshot of Sentiment Proportion based on the Selected Review Tag

**9.2.12 Add Review Page**

The screenshot shows a mobile application interface for adding a review. At the top, there is a small image of an iPhone 14 Pro and the text "Iphone 14 Pro". Below this, a section titled "Tell us about your recent experience" contains fields for "Give Your Feedback a Title" (a text input field) and "Your Feedback" (a larger text area asking "What made your experience great? How is this product help you?"). A "Date of Experience" field includes a date picker set to "dd/mm/yyyy". Under "Select a Tag for Other People Reference", there are three dropdown menus labeled "First Tag", "Second Tag", and "Third Tag", each with the placeholder "Choice ...". A note below states: "Note: Please select at least 1 tag and don't select the same tag." At the bottom, a checkbox agreement is present: "I confirm this feedback is about my genuine experience. I am eligible to leave this review, and have not been offered any incentive or payment to leave a review for this business." A large blue "Add Feedback" button is located at the bottom right.

Figure 55 Screenshot of Add Review Page

This is the add review page where customer users must fill in the review title, content, and date of experience and choose at least one and up to three review tags. Users must agree and click on the terms and conditions to enable the “Add Feedback” button. All the fields must be filled in except for “Second Tag” and “Third Tag” to avoid the error message.

### 9.3 Sample Implementation Code

The full source code with comments explaining each function in detail has been provided in the attached source code zip file. Hence, this section will only provide the source code of some important features along with the explanation.

#### 9.3.1 Sentiment Analysis Model Implementation

The flow chart of the sentiment analysis model development will be shown as follows to show the steps or tasks involved in the process and the relationships between those steps.

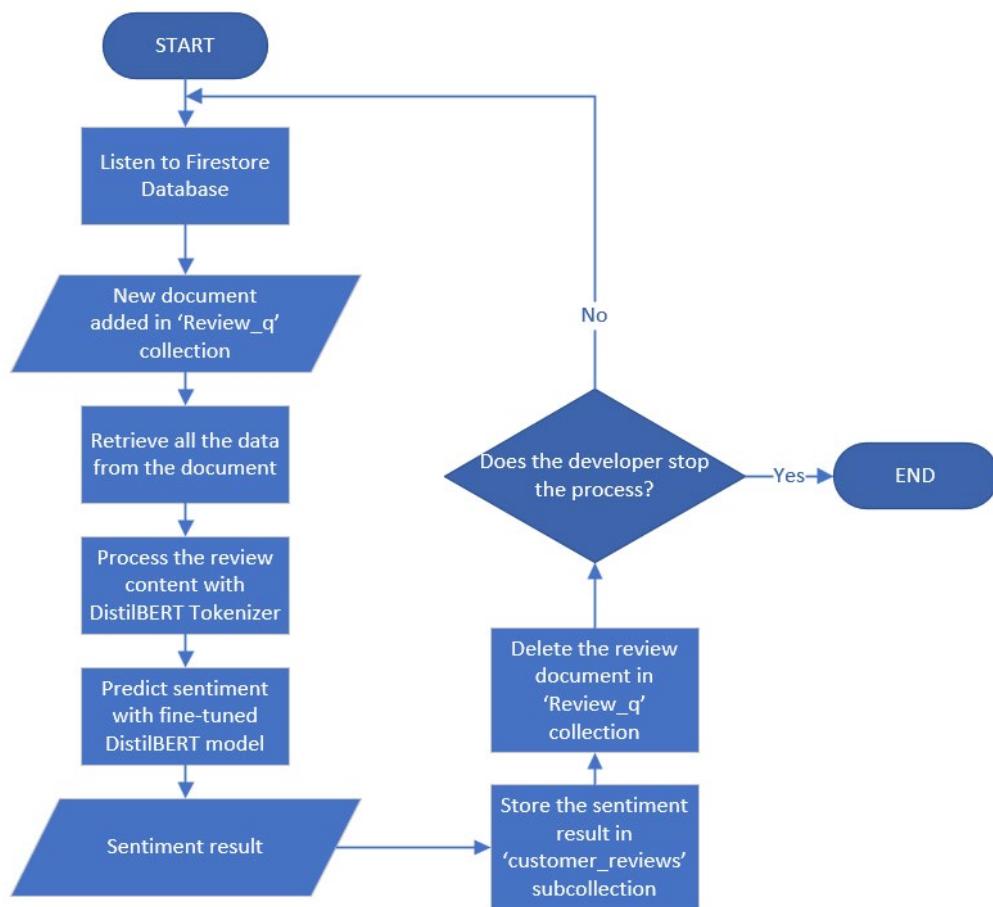


Table 22 Sentiment Analysis Model Implementation Flowchart

### Monitoring Cloud Firestore in Real-time

```
# Create a callback on_snapshot function to capture changes
def on_snapshot(col_snapshot, changes, read_time):
    # Listener that listen to review document
    print(u'Callback review document')
    review_queue = []
    customer_name_list = []
    doc_list = []
    for change in changes:
        # When there is a document added to the "Review_q" collection, it will start the process
        if change.type.name == 'ADDED':
            print(f'New document: {change.document.to_dict()}')
            dic = change.document.to_dict()
            if (change.document.id == 'default'):
                # Skip the default file that no need to process
                print('Skip the default file')
                continue
            else:
                queue_doc_id = change.document.id
                # Get all the fields saved in the Firestore
                customer_name = dic.get("customer")
                review = dic.get("review")
                product_doc = dic.get("productDocID")
                review_doc = dic.get("reviewDocID")
                # Add review into queue list
                review_queue.append(review)
                customer_name_list.append(customer_name)
                # Save all the document ID into a list
                doc_id = []
                doc_id.append(queue_doc_id)
                doc_id.append(product_doc)
                doc_id.append(review_doc)
                doc_list.append(doc_id)
```

Figure 56 Source Code for Monitoring Cloud Firestore in Real-time

The function above will keep looping to listen to the Cloud Firestore ‘Review\_q’ collection. When a document is added to the collection, the ‘on\_snapshot’ function will detect the changes in the collection and retrieve the data, including customer name, review content, product document ID, and review document ID from the newly added document. These data will be stored in a list for processing with sentiment analysis. After that, the results will be kept back in the ‘customer\_review’ collection.

### Sentiment Analysis

```
# Create a function for analyzing sentiment
def analyze_sentiment(review):
    # Convert the review sentence into a list of tokens according to the model's requirement
    predict_input = TOKENIZER.encode(review, truncation=True, padding=True, return_tensors="tf")
    # Apply pre-trained DistilBERT Model for predicting the sentiment
    tf_output = LOADED_MODEL.predict(predict_input)[0]
    # Map the model output to either 0, 1, or 2
    tf_prediction = tf.nn.softmax(tf_output, axis=1)
    # Return only the largest value across axes of a tensor
    label = tf.argmax(tf_prediction, axis=1)
    label = label.numpy()
    return LABELS[label[0]]
```

Figure 57 Source Code for Sentiment Analysis Implementation

Basically, the processes of sentiment analysis implementation in the proposed system are similar to the processes in model development. The input text (review content) will be tokenized into a list of tokens and fed to the DistilBERT model to predict and classify the review into one of the sentiment classes: 0 (Negative), 1 (Neutral), or 2(Positive). The integer outputs will then be converted into textual sentiment labels and returned back to the ‘on\_snapshot’ function to store in Cloud Firestore.

### 9.3.2 Web Application Implementation

#### Firebase Connection

```
# Firebase config
config = [
    "apiKey": "AIzaSyCH-oeHe3XD9tYnY8ukCWEXJgWhux_5ch4",
    "authDomain": "sentimentanalyais-4721b.firebaseio.com",
    "projectId": "sentimentanalyais-4721b",
    "storageBucket": "sentimentanalyais-4721b.appspot.com",
    "messagingSenderId": "906296566901",
    "appId": "1:906296566901:web:9400fdfd405c45c58f843c",
    "measurementId": "G-048H4L8JD4",
    "databaseURL": ""
]

# Init Firebase REST API
firebase = pyrebase.initialize_app(config)
# Auth Instance
auth = firebase.auth()

# Connect Firebase service account
cred = credentials.Certificate("./serviceAccountKey.json")
# Init Firebase admin
firebase_admin.initialize_app(cred, {
    'storageBucket': 'sentimentanalyais-4721b.appspot.com'})
# Firestore database instance
db = firestore.client()
# Firebase storage instance
bucket = storage.bucket()
storage_client = sto.Client.from_service_account_json("./serviceAccountKey.json")
```

Figure 58 Source Code for Cloud Firestore Database Connection

The source code above is the Firebase configuration that connects the proposed system with the Firebase while initializing the web application. By connecting to Firebase, the developer is able to access the Cloud Firestore, Firebase Storage, and Authentication, which are required to store the user’s input data. As every Firebase project is unique, the ‘config,’ ‘storageBucket,’ and ‘serviceAccountKey’ must be correct in order to connect to the related Firebase project.

## Customer Registration

```

# Customer Registration
@app.route('/customer/register', methods=['GET', 'POST'])
def customer_register():
    # Create instance of registration form
    form = RegistrationForm()
    # If the form is valid on submission
    if form.validate_on_submit():
        input_username = form.username.data
        input_email = form.email.data
        password = form.password.data
        email_list = []
        username_list = []
        # Get all the registered username and email
        docs = db.collection(u'users').get()
        for doc in docs:
            all_username = doc.get("username")
            all_email = doc.get("email")
            username_list.append(all_username)
            email_list.append(all_email)
        # Check the availability of username
        for username in username_list:
            if input_username == username:
                flash("This username have been registered", 'danger')
                return render_template("customer/register.html", title='Customer Registration', form=form)
        # Check the availability of email address
        for email in email_list:
            if input_email == email:
                flash("This email have been registered", 'danger')
                return render_template("customer/register.html", title='Customer Registration', form=form)
    try:
        # Add email and password into authentication
        user = auth.create_user_with_email_and_password(input_email, password)
        login_data = {
            u'username': form.username.data,
            u'email': form.email.data,
            u'role': 'customer'
        }
        # Add a new doc in collection 'users' with random document ID
        db.collection(u'users').document().set(login_data)
        age = datetime.date.today().year - form.dob.data.year
        data = {
            u'username': form.username.data,
            u'firstName': form.firstName.data,
            u'lastName': form.lastName.data,
            u'gender': form.gender.data,
            u'age': age,
            u'dob': str(form.dob.data),
            u'email': form.email.data,
            u'contact': form.contact.data,
            u'address': form.address.data,
            u'city': form.city.data,
            u'country': form.country.data,
            u'role': 'customer'
        }
        # Add a new doc in collection 'businesses' with random document ID
        db.collection(u'customers').document().set(data)
        # Set the session
        session['userID'] = user['idToken']
        session['email'] = form.email.data
        session['name'] = form.username.data
        session['role'] = 'customer'
        flash(f'Welcome {form.firstName.data}! Thanks for registering', 'success')
        return redirect(url_for('home'))
    except Exception as e:
        flash(f'Can not register the customer. Error: {str(e)}', 'danger')
        return render_template('customer/register.html', title='Customer Registration', form=form)
    return render_template('customer/register.html', title='Customer Registration', form=form)

```

Figure 59 Source Code for Customer Registration

```
# Registration Form
class RegistrationForm(FlaskForm):
    username = StringField('Username', validators=[DataRequired()])
    firstName = StringField('First Name', validators=[DataRequired()])
    lastName = StringField('Last Name', validators=[DataRequired()])
    gender = SelectField('Gender', choices = [('N', 'Not prefer to say'), ('M', 'Male'), ('F', 'Female')])
    dob = DateField('Date of Birth', format='%Y-%m-%d', validators=[DataRequired()])
    email = EmailField('Email', validators=[DataRequired()])
    password = PasswordField('Password', validators=[DataRequired(),
                                                    EqualTo('password2', message='Passwords Must Match!')])
    password2 = PasswordField('Confirm Password', validators=[DataRequired(message='Password Confirmation is required!')])
    contact = StringField('Contact Number: ', validators=[DataRequired(),
                                                          Regexp('[0-9]', message='Only numbers are accepted!'),
                                                          Length(min=10, max=12, message='Field must be between 10 and 12 numbers long.')])
    address = StringField('Address: ', validators=[DataRequired()])
    city = StringField('City: ', validators=[DataRequired()])
    country = StringField('Country: ', validators=[DataRequired()])
    submit = SubmitField('Register new account')
```

Figure 60 Code Snippets for Registration Form

Figure 59 shows the business logic for registering a customer, while Figure 62 is the customer registration form to enable users to fill in the customer details. The ‘validate\_on\_submit’ function is used to check whether all the fields are filled in the correct manner. For example, the input text for Password and Confirm Password must be the same. After that, the function will check whether the username or email has been registered as another user. If not, the function will create a user with the input email and password in Firebase Authentication, like Figure 61. All the passwords stored in Firebase are encrypted and even the developer also could not check their passwords. Apart from that, the function will store the customer information in both the ‘users’ collection with username, email, and role and the ‘customers’ collection with all the input fields separately. Lastly, the function will redirect users back to the customer home page.

| Identifier               | Providers | Created ↓  | Signed in  | User UID                     |
|--------------------------|-----------|------------|------------|------------------------------|
| testbus@gmail.com        | ✉         | 7 Jan 2023 | 7 Jan 2023 | SDLqQKHpbBc5WbUeSgCsmDk8...  |
| 1201300175@student.mm... | ✉         | 2 Jan 2023 | 2 Jan 2023 | REMeQxt9fnZTkRJymns6C49BSvJ2 |

Figure 61 User Interface of Firebase Authentication

## Add Product

```
# Add Product
@app.route("/addproduct", methods=["GET", "POST"])
def add_product():
    # Create instance of product form
    form = ProductForm()
    # When the connected html passing POST request (Submit Button is clicked)
    if request.method == "POST":
        exist_in_database = False
        review_labels = []
        file_names = []
        business_name = session['name']
        product_name = form.name.data
        description = form.description.data
        files = request.files.getlist('files[]')
        selected_labels = request.form.getlist('selected_labels[]')
        review_labels = COMPULSORY_LABELS + selected_labels
        # Create a new list to temporarily store the all the labels (default labels & self-added labels)
        all_labels = review_tags_list(review_labels)
        # Check the product name availability
        exist_in_database = check_product_availability(product_name, None)
        if exist_in_database:
            flash("This product has been added to database", 'danger')
            return render_template('product/addproduct.html', title='Add Product Page', form=form, all_labels=all_labels, compulsory_labels=COMPULSORY_LABELS, selected_labels=selected_labels)
        # Check the uploaded file types
        for file in files:
            if file and allow_file_type(file.filename):
                filename = secure_filename(file.filename)
                file_names.append(filename)
                # Save image file to project root
                file_path = os.path.join(app.config['UPLOAD_FOLDER'], filename)
                file.save(file_path)
            else:
                flash('Allowed image types are -> png, jpg, jpeg, gif', 'danger')
                return render_template('product/addproduct.html', title='Add Product Page', form=form, all_labels=all_labels, compulsory_labels=COMPULSORY_LABELS, selected_labels=selected_labels)
        # Upload images to Firebase Storage
        for image in file_names:
            image_path = os.path.join(app.config['UPLOAD_FOLDER'], image)
            sto_path = product_name + '/' + image
            blob = bucket.blob(sto_path)
            blob.upload_from_filename(image_path)
            # Delete images from project root
            os.remove(image_path)
        # Define product details
        data = {
            'productName': product_name,
            'description': description,
            'businessName': business_name,
            'reviewLabel': review_labels
        }
        # Add a new doc in collection 'products' with random document ID
        db.collection('products').document().set(data)
        flash(f'The product ({product_name}) was successfully added in database', 'success')
        return redirect(url_for('business'))
    return render_template('product/addproduct.html', title='Add Product Page', form=form, all_labels=DEFAULT_LABELS, compulsory_labels=COMPULSORY_LABELS)
```

Figure 62 Source Code for Adding a Product

```
# Product Form
class ProductForm(FlaskForm):
    name = StringField('Product Name', validators=[DataRequired()])
    description = TextAreaField('Description', validators=[DataRequired()])
    submit = SubmitField('Add Product')
```

Figure 63 Code Snippet for Product Form

Figure 62 shows the business logic for adding a product to the database, while Figure 63 is the product form to enable users to fill in the product details. First of all, when the function receives a POST request from HTML (when users click submit), the function will retrieve the user's input from the product form. The uploaded photos will be temporarily stored in the project root folder. The system will then check whether the product has been added to the database before. If yes, the function will redirect users back to Add Product Page and show an error message; if no, the function will check the uploaded photo types to ensure the photos are in jpg, jpeg, png, or gif format. After that, the function will upload the photos from the local project root to Firebase Storage. The photos in the project root will be deleted once they are

successfully uploaded to the database. Lastly, the function will store the product details, including name, description, review labels, and business name, in the Cloud Firestore and redirect the users back to the business homepage. The “Add Product” function is similar to “Edit Product ” function. However, the “Edit Product” function will retrieve the previously saved product details before redirecting users to the Edit Product Page.

## Review Date Calculation (Product Analysis)

```
def calculate_review_dates(review_list):
    review_numbers = []
    current_date = datetime.date.today()
    # Total number of reviews
    review_numbers.append(len(review_list))
    # Initialize counters for years, months, and days
    year_counts = 0
    month_counts = 0
    day_counts = 0
    # Iterate over the review list
    for review in review_list:
        review_date = review[2]
        # Parse the date string into a datetime object
        date = datetime.datetime.strptime(review_date, '%Y-%m-%d')
        if date.year == current_date.year:
            year_counts +=1
        if date.month == current_date.month:
            month_counts +=1
        if date.day == current_date.day:
            day_counts +=1
    # Append results review number list
    review_numbers.append(year_counts)
    review_numbers.append(month_counts)
    review_numbers.append(day_counts)
    return review_numbers
```

Figure 64 Source Code for Review Date Calculation

Review date calculation is one of the functions under product analysis. The input for this function is the review list, containing all the customer reviews with the product name, review tags, sentiment, and review date. However, this function only requires the review date for calculation. The review date in the format “Year-Month-Day” will be split into year, month, and date. The function will calculate the total number of reviews according to the current day, month, and year. Hence, it will check whether the review date matches the current day, month, and year. If yes, each class’s count will be increased by 1; otherwise, the function will keep looping until the end of the review list. Lastly, the function returns the total number of reviews per day, month, and year back to product analysis.

## Review Tag Sentiment Calculation (Product Analysis)

```
def calculate_tag_sentiment(review_list):
    all_tag_sentiment = []
    tag_list = []
    positive_data = []
    neutral_data = []
    negative_data = []
    tag_index = 999
    # Iterate over the review list
    for review in review_list:
        # Iterate over the review tags list
        for tag in review[0]:
            # If the tag is not in tag_list, add it into the tag_list, and add 0 to the end of sentiment list and get the index no
            if tag not in tag_list:
                tag_list.append(tag)
                positive_data.append(0)
                neutral_data.append(0)
                negative_data.append(0)
                tag_index = -1
            # If the tag is not in tag_list, get the index no in the tag_list
            else:
                tag_index = tag_list.index(tag)
            # Check the sentiment of this review
            if review[1] == 'Positive':
                positive_data[tag_index] +=1
            elif review[1] == 'Neutral':
                neutral_data[tag_index] +=1
            elif review[1] == 'Negative':
                negative_data[tag_index] +=1
    all_tag_sentiment.append(tag_list)
    all_tag_sentiment.append(positive_data)
    all_tag_sentiment.append(neutral_data)
    all_tag_sentiment.append(negative_data)
    return all_tag_sentiment
```

Figure 65 Source Code for Review Tag Sentiment Calculation

## Product Sentiment Calculation (Product Analysis)

```
def calculate_product_sentiment(review_list):
    all_product_sentiment = []
    product_list = []
    positive_data = []
    neutral_data = []
    negative_data = []
    product_index = 999
    # Iterate over the review list
    for review in review_list:
        # If the product is not in product_list, add it into the product_list, and add 0 to the end of sentiment list and get the index no
        if review[3] not in product_list:
            product_list.append(review[3])
            positive_data.append(0)
            neutral_data.append(0)
            negative_data.append(0)
            product_index = -1
        # If the product is not in product_list, get the index no in the product_list
        else:
            product_index = product_list.index(review[3])
        # Check the sentiment of this review
        if review[1] == 'Positive':
            positive_data[product_index] +=1
        elif review[1] == 'Neutral':
            neutral_data[product_index] +=1
        elif review[1] == 'Negative':
            negative_data[product_index] +=1
    all_product_sentiment.append(product_list)
    all_product_sentiment.append(positive_data)
    all_product_sentiment.append(neutral_data)
    all_product_sentiment.append(negative_data)
    return all_product_sentiment
```

Figure 66 Source Code for Product Sentiment Calculation

The business logics for both the review tag and product calculation are similar. The inputs of both functions are the same as the input of Review Date Calculation. To calculate the overall sentiment of all the products, the function will create four lists for storing the product name, positive, neutral, and negative sentiment data. After that, the function will loop the

review list and check whether the product is in the ‘product\_list.’ If the product exists in the list, it will retrieve the element index; otherwise, it will add the product to the list and the element index will be -1. Then, the function will check the review sentiment and increase the number of sentiment counts in either positive, neutral, or negative classes by 1 if the sentiment matches the class. Lastly, the function will combine all the lists and store them in the ‘all\_product\_sentiment’ list, returning it to product analysis.

## Delete Product

```
# Delete Product
@app.route('/deleteproduct/<string:name>', methods=["GET", "POST"])
def delete_product(name):
    try:
        list_img = []
        # Find the product's document from Firestore
        docs = db.collection(u'products').where("productName", "==", name).stream()
        for doc in docs:
            data = {
                u'productName': doc.get("productName"),
                u'description': doc.get("description"),
                u'businessName': doc.get("businessName"),
                u'reviewLabel': doc.get("reviewLabel")
            }
            # Save a copy of deleted product into 'deleted_products' collection
            db.collection(u'deleted_products').document(doc.id).set(data)
            # Delete the product from 'products' collection
            db.collection(u'products').document(doc.id).delete()
            # Find the product image path from Firebase Storage
            list_img = image_storage_path(name)
            # Delete product photos in Firebase Storage
            for img in list_img:
                blob = bucket.blob(img)
                blob.delete()
        flash(f'The product {name} was deleted from your database', 'success')
        return redirect(url_for('home'))
    except Exception as e:
        flash(f'Can not delete the product. Error: {str(e)}', 'danger')
        return redirect(url_for('home'))
```

Figure 67 Source Code for Delete Product

## Chapter 10: System Validation

### 10.1 Unit Testing Result

The unit testings for both sentiment analysis machine learning model and web-based product review analysis system are conducted by the developer. The results will be shown as below:

| Test Case | Function  | Input   | Expected Output   | Actual Output | Status (FAIL/PASS) |
|-----------|---|---|---|---------------|--------------------|
| A1        | Import Tensorflow Dataset                       | -   | Amazon product review dataset from TensorFlow is imported and converted to data frame format.   | As expected.  | PASS               |
| A2        | Mapping Star Rating to Sentiment Labels         | Original product review dataset with star rating column (0-5).                    | Product review dataset with an extra column “Sentiment” (0: Negative; 1:Neutral; 2:Positive).   | As expected.  | PASS               |
| A3        | Data Filtering                                  | Dataset with 16 columns and over 100,000 rows.                                    | Dataset with two columns (Customer Review, Sentiment) and 50,000 rows.  | As expected.  | PASS               |
| A4        | Split Dataset into Training and Validation Data | Two lists, which are “reviews” and “labels”, separated from the filtered dataset. | Four lists: training sentences, validation sentences, training labels, and validation labels. The ratio of training data to validation data is 8:2. | As expected.  | PASS               |

|    |  |   |  |              |      |
|----|--|---|--|--------------|------|
| A5 | Word Tokenization                      | Training sentences and validation sentences.  | Word encodings of training and validation sentences containing input ids and attention masks.  | As expected. | PASS |
| A6 | Model Training and Fine-tuning         | DistillBert model, Adam optimization algorithm, training dataset (reviews and labels), and validation dataset (reviews and labels).         | Fine-tuned DistillBert model with training loss, training accuracy, validation loss, and validation accuracy.                                  | As expected. | PASS |
| A7 | Model Performance Visualization        | Fine-tuned DistillBert model, validation sentences, and validation labels.  | Confusion matrix heatmap of three different sentiment classes: Negative, Neutral, and Positive.  | As expected. | PASS |
| A8 | Model Integration with Web Application | Documents from the “Review_q” collection in Firebase containing customer name, review content, product document ID, and review document ID. | <b>Database:</b> Add the customer review’s sentiment to the review document in the “customer_reviews” subcollection in the product’s document. | As expected. | PASS |

Table 23 Unit Testing Result for Sentiment Analysis Machine Learning Model

| Test Case | User Type                          | Nature of Issue | Scenarios/Description   | Expected Output   | Actual Output | Status (FAIL/PASS) |
|-----------|------------------------------------|-----------------|---|---|---------------|--------------------|
| B1        | All users                          | Login           | Users login by filling in the <b>CORRECT</b> email, password, and role.                               | <b>For businesses:</b> direct to the business homepage and show the success login message.<br><b>For customers:</b> direct to the customer homepage and show the success login message. | As expected.  | PASS               |
| B2        | All users                          | Login           | Users login by filling in <b>INCORRECT</b> email or password or role.                                 | Show an error message by mentioning an unregistered email or incorrect password.  | As expected.  | PASS               |
| B3        | All users                          | Login           | Users login by <b>NOT</b> filling in either email, password, or role.                                 | Show an error message to remind users to fill in the empty columns.   | As expected.  | PASS               |
| B4        | All users                          | Login           | Users login by filling in the <b>INCORRECT</b> email format.  | Show an error message to remind users to include "@" in the email input.  | As expected.  | PASS               |
| B5        | Unregistered E-commerce businesses | Register        | Users register themselves as businesses by filling in business detail with the <b>CORRECT</b> format. | Login automatically and direct users to the business homepage with a welcome message.   | As expected.  | PASS               |

|    |                        |          |  |  |              |      |
|----|------------------------|----------|--|--|--------------|------|
|    |                        |          |  | <b>Database:</b> add the business details to a new document in the “businesses” collection. Add the business’s email, username and role to the “users” collection. Add a new user for the business in Firebase Authentication.   |              |      |
| B6 | Unregistered Customers | Register | Users register themselves as customers by filling in customer detail with the <b>CORRECT</b> format. | Login automatically and direct users to the customer homepage with a welcome message.<br><br><b>Database:</b> add the customer details to a new document in the “customers” collection. Add the customer’s email, username and role to the “users” collection. Add a new user for the customer in Firebase Authentication. | As expected. | PASS |

|     |                       |                    |   |  |              |      |
|-----|-----------------------|--------------------|---|--|--------------|------|
| B7  | Unregistered Users    | Register           | Users register by filling in <b>INCORRECT</b> email/phone number format (only digits acceptable). | <b>Wrong email:</b> Show an error message to remind users to include "@" in the email input.<br><b>Wrong phone number format:</b> Show an error message to remind users to enter only digits | As expected. | PASS |
| B8  | Unregistered Users    | Register           | Users register by filling in the <b>REGISTERED</b> email/username/business name.                  | Show an error message to inform users that the email/username/business name has been registered.   | As expected. | PASS |
| B9  | Unregistered Users    | Register           | Users register by filling in <b>DIFFERENT</b> input for "Password" and "Confirm Password."        | Show an error message to inform users that the input for "Password" and "Confirm Password" is not the same.  | As expected. | PASS |
| B10 | All users             | Return to Homepage | Users clicked on the "MyWebsite" button on the navigation bar.                                    | Direct users to business/customer/unregistered users' homepage.  | As expected. | PASS |
| B11 | E-commerce businesses | Add New Product    | Users click on the "Add Product" button with the <b>FILLED</b> product                            | Direct users to the business homepage with a product successfully added message.   | As expected. | PASS |

|     |                       |                      |   |  |              |      |
|-----|-----------------------|----------------------|---|--|--------------|------|
|     |                       |                      | name, description, review labels and photos.  | <b>Database:</b> add the product details to a new document in the “products” collection. Add the product photos to Firebase Storage under the product name folder. |              |      |
| B12 | E-commerce businesses | Add New Product      | Users click on “Add Product” button by <b>NOT</b> filling in the product name or description or <b>NOT</b> selecting a photo. | Show an error message to remind users to fill in the product name or description or to select a photo.   | As expected. | PASS |
| B13 | E-commerce businesses | Add Product Photos   | Users add a product photo by selecting files <b>OTHER THAN</b> png, jpg, jpeg, and gif format.                                | Show an error message to remind users to select only png, jpg, jpeg, and gif files.  | As expected. | PASS |
| B14 | E-commerce businesses | Add Review Label     | Users add a new tag for the review label.   | The newly added tag shows on the “Add Product Page” with an empty check box.   | As expected. | PASS |
| B15 | E-commerce businesses | Edit Product Details | Users click on the “Edit” button for a specific product.  | Direct to “Edit Product Page” with filled previous product name, description, review labels, and uploaded photos.  | As expected. | PASS |

|     |                       |                      |  |  |              |      |
|-----|-----------------------|----------------------|--|--|--------------|------|
| B16 | E-commerce businesses | Edit Product Details | Users click on the “Update Product” button with the <b>FILLED</b> product name, description, review labels, and uploaded photos. | Direct users to the business homepage with a product successfully updated message.<br><b>Database:</b> update the product details in the “products” collection. Delete the previous product photos and add the new photos to Firebase Storage under the product name folder. | As expected. | PASS |
| B17 | E-commerce businesses | Edit Product Details | Users click on the “Update Product” button with <b>EMPTY</b> product name, description, or photos.                               | Show an error message to remind users to fill in the product name or description or to select a photo.   | As expected. | PASS |
| B18 | E-commerce businesses | Delete Product       | Users click on the “Delete” button for a specific product.   | A confirmation dialogue box is shown. If users click on “Delete,” the product will be deleted; if users click on “Cancel,” it will return to the business homepage without deleting the product.   | As expected. | PASS |

|     |                       |                     |  |   |              |      |
|-----|-----------------------|---------------------|--|---|--------------|------|
|     |                       |                     |  | <b>Database:</b> add the product details to the “deleted_products” collection. Delete the product document from the “products” collection. Delete the product photos from Firebase Storage.                   |              |      |
| B19 | E-commerce businesses | Search Product      | Users enter any part of a product name in the “Search” input and click on the “Search” button on the navigation bar. | Direct users to the business homepage by showing only the products matched with the “Search” input in <b>TABLE</b> format.  | As expected. | PASS |
| B20 | E-commerce businesses | View Product Detail | Users click on a specific product name link on the business homepage.  | Direct users to the “Product Detail Page” of the selected product. The web page displays the product name, description, photos, sentiment proportion bar, business name, review labels, and customer reviews. | As expected. | PASS |

|     |           |                     |  |  |              |      |
|-----|-----------|---------------------|--|--|--------------|------|
| B21 | Customers | Search Product      | Users enter any part of a product name in the “Search” input and click on the “Search” button on the navigation bar. | Direct users to the customer homepage by showing only the products matched with the “Search” input in <b>CARD</b> format.  | As expected. | PASS |
| B22 | Customers | View Product Detail | Users click on the “Details” button under a specific product on the customer homepage.                               | Direct users to the “Product Detail Page” of the selected product. The web page displays the product name, description, photos, sentiment proportion bar, business name, “Add Review” button, review labels, and customer reviews. | As expected. | PASS |
| B23 | Customers | Add Review          | Users click on the “Add Review” button under a specific product on the customer homepage.                            | Direct users to “Add Review Page” by showing the selected product name and photo.  | As expected. | PASS |
| B24 | Customers | Add Review          | Users click on the “Add Review” button under the sentiment proportion on the “Product Detail Page.”                  | Direct users to “Add Review Page” by showing the selected product name and photo.  | As expected. | PASS |

|     |           |            |  |   |              |      |
|-----|-----------|------------|--|---|--------------|------|
| B25 | Customers | Add Review | Users tick the acknowledgment checkbox and click on the “Add Feedback” button with the <b>FILLED</b> feedback title, content, date of experience, and review tags ( <b>AT LEAST 1 tag</b> ). | Direct users to the customer homepage and show a review successfully added message.<br><br><b>Database:</b> Add the product review details in the “customer_reviews” subcollection in the product’s document. Add the customer name, review, product and review document ID to the “Review_q” collection. | As expected. | PASS |
| B26 | Customers | Add Review | Users tick the acknowledgment checkbox and click on the “Add Feedback” button with <b>EMPTY</b> feedback title, content, date of experience, or review tags.                                 | Show an error message to remind users to fill in the feedback title, content, date of experience, or review tags.   | As expected. | PASS |
| B27 | Customers | Add Review | Users tick the acknowledgment checkbox and click on the “Add Feedback” button with <b>REPEATED</b> review tags.  | Show an error message to remind users not to select the same tags.  | As expected. | PASS |

|     |   |  |   |   |              |      |
|-----|---|--|---|---|--------------|------|
| B28 | Unregistered Users                      | Search Product                             | Users <b>WITHOUT LOGIN</b> enter any part of a product name in the “Search” input and click on the “Search” button on the navigation bar. | Direct users to the homepage by showing only the products matched with the “Search” input in <b>CARD</b> format.  | As expected. | PASS |
| B29 | Unregistered Users                      | View Product Detail                        | Users <b>WITHOUT LOGIN</b> click on the “Details” button under a specific product on the customer homepage.                               | Direct users to the “Product Detail Page” of the selected product. The web page displays the product name, description, photos, sentiment proportion bar, business name, review labels, and customer reviews. | As expected. | PASS |
| B30 | All users                               | Filter Product Reviews based on Review Tag | Users click on one of the review tag buttons (contains review tag and number of reviews) on the “Product Detail Page.”                    | Shows only the customer reviews matched with the selected review tag. The sentiment proportion bar calculates its proportion based on the selected review tag.  | As expected. | PASS |
| B31 | Logged in E-commerce business/Customers | Logout                                     | Users clicked on the “Logout” button on the navigation bar.   | Direct users to login page and show a successfully logout message.  | As expected. | PASS |

Table 24 Unit Testing Result for Web-based Product Review Analysis System

## 10.2 Model Performance Testing Result

This model performance testing is conducted by the developer. The proposed system uses the fine-tuned DistilBERT model with the Amazon product review dataset for sentiment analysis. Two test results will be shown: the overall confusion matrix and specific sentiment prediction with the certain input text.

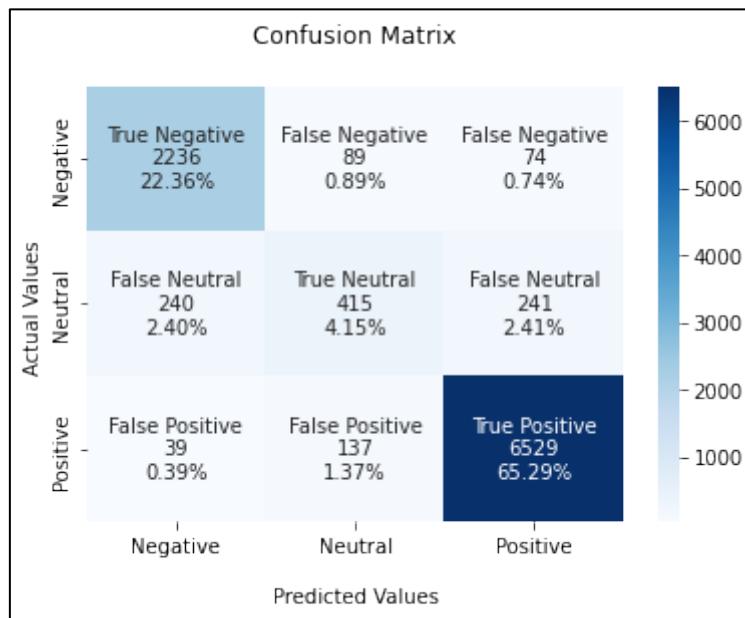


Figure 68 Confusion Matrix of the Proposed Sentiment Analysis Model

The confusion matrix above is drawn according to the sentiment prediction of the fine-tuned DistilBERT model based on 10000 validation data samples. With the confusion matrix, the overall model accuracy and each class's precision, recall, and F1-score will be calculated. Apart from that, micro and macro averaging representing a classifier's average precision, recall, and F1-score across multiple classes will also be computed.

|                           | Precision | Recall | F1-Score | Accuracy |
|---------------------------|-----------|--------|----------|----------|
| <b>Negative</b>           | 0.8891    | 0.9321 | 0.9101   |          |
| <b>Neutral</b>            | 0.6474    | 0.4632 | 0.54     |          |
| <b>Positive</b>           | 0.954     | 0.9738 | 0.9638   |          |
| <b>Micro Averaging</b>    | 0.918     | 0.918  | 0.918    | 0.918    |
| <b>Macro Averaging</b>    | 0.8302    | 0.7897 | 0.8046   |          |
| <b>Weighted Averaging</b> | 0.9109    | 0.918  | 0.9129   |          |

Table 25 Testing Result for Model Performance with 10000 Validation Data Samples

The table below shows the model performance testing with specific test cases.

| Test Case | Input Test  | Expected Output    | Actual Output      | Status (FAIL/PASS) |
|-----------|---|--------------------|--------------------|--------------------|
| C1        | High-quality product. Good price for the nice quality. I will buy it again.                           | Positive Sentiment | As expected.       | PASS               |
| C2        | The product was okay. I don't know if I would buy it again or not                                     | Neutral Sentiment  | As expected.       | PASS               |
| C3        | The product is not functioning at all. I definitely wouldn't purchase it again.                       | Negative Sentiment | As expected.       | PASS               |
| C4        | The delivery is fast as I get my parcel within two days only.   | Positive Sentiment | As expected.       | PASS               |
| C5        | The product is just normal. Not sure about comparing it with another brand.                           | Neutral Sentiment  | As expected.       | PASS               |
| C6        | The seller is not friendly and his service is a nightmare. Not reply any message after I paid for it. | Negative Sentiment | As expected.       | PASS               |
| C7        | Wow, I just love spending a small fortune on this ridiculously overpriced product! Five stars!        | Negative Sentiment | Positive Sentiment | FAIL               |

Table 26 Testing Result for Model Performance with Certain Input

### 10.3 User Acceptance Testing Result

The user acceptance testing is conducted by three different testers from the workplace and university. Each tester is given the web-based product review analysis system without further instructions or guidelines on utilizing and navigating the website.

#### Tester 1 Result

## USER ACCEPTANCE TESTING (UAT)

Tester Name: Lim Shueh Ting

Date: 02.01.2023

Occupation: Software Developer

Start Time: 10:23a.m

End Time: 11:05a.m.

*Instruction: Please select your answer with a ✓ symbol for the following criteria:*

| Criteria  | Poor | Fair |   |   | Good |   |   | Very Good |   | Excellent |
|---|------|------|---|---|------|---|---|-----------|---|-----------|
| Sentiment Analysis Model  | 1    | 2    | 3 | 4 | 5    | 6 | 7 | 8         | 9 | 10        |
| <b>Accuracy</b><br>• Sentiment can be detected and classified accurately.   |      |      |   |   |      |   |   |           | ✓ |           |
| <b>Performance</b><br>• The model can analyze and produce the sentiment in a short time.  |      |      |   |   |      |   |   |           |   | ✓         |
| <b>Model Integration</b><br>• After reviewing a product, the website can show the reviews without crashing.   |      |      |   |   |      |   |   |           |   | ✓         |
| Web-based Product Review Analysis System  | 1    | 2    | 3 | 4 | 5    | 6 | 7 | 8         | 9 | 10        |
| <b>User Interface</b><br>• The website is user-friendly and the design is uncluttered, providing an inviting visual experience.                       |      |      |   |   |      |   |   | ✓         |   |           |
| <b>Navigation</b><br>• The website presents information and options logically and intuitively.<br>• Every button and link leads to the correct pages. |      |      |   |   |      |   |   |           |   | ✓         |

|  |  |  |  |  |  |  |  |   |   |  |
|--|--|--|--|--|--|--|--|---|---|--|
| <b>Functionality</b>   |  |  |  |  |  |  |  |   | ✓ |  |
| <ul style="list-style-type: none"> <li>The web application provides the features that users need to complete their tasks.</li> <li>The system is free from bugs.</li> <li>Error messages can be displayed once the users operate the system incorrectly.</li> </ul>  |  |  |  |  |  |  |  |   |   |  |
| <b>Performance</b>   |  |  |  |  |  |  |  | ✓ |   |  |
| <ul style="list-style-type: none"> <li>The features within the website can operate smoothly without crashing.</li> <li>The web application can load and respond quickly, with minimal downtime or errors.</li> </ul>   |  |  |  |  |  |  |  |   |   |  |
| <b>Other suggestion/comments from tester:</b>  |  |  |  |  |  |  |  |   |   |  |
| Overall, the project idea is great and the system is well-developed. Almost all the sentiments can be classified accurately. However, some web pages require some time to load and display the contents, especially for both business and customer homepages. Can improve the speed of retrieving product details from the database. |  |  |  |  |  |  |  |   |   |  |

Table 27 UAT Result from Tester 1

## Tester 2 Result

# USER ACCEPTANCE TESTING (UAT)

Tester Name: Ng Zer Dan

Date: 02.01.2023

Occupation: Student

Start Time: 1:05p.m.

End Time: 1:45p.m.

Instruction: Please select your answer with a ✓ symbol for the following criteria:

| Criteria   | Poor | Fair |   | Good |   |   | Very Good |   | Excellent |    |
|--|------|------|---|------|---|---|-----------|---|-----------|----|
| Sentiment Analysis Model   | 1    | 2    | 3 | 4    | 5 | 6 | 7         | 8 | 9         | 10 |
| <b>Accuracy</b>  |      |      |   |      |   | ✓ |           |   |           |    |
| <ul style="list-style-type: none"> <li>Sentiment can be detected and classified accurately.</li> </ul>             |      |      |   |      |   |   |           |   |           |    |
| <b>Performance</b>   |      |      |   |      |   |   |           |   |           | ✓  |
| <ul style="list-style-type: none"> <li>The model can analyze and produce the sentiment in a short time.</li> </ul> |      |      |   |      |   |   |           |   |           |    |

|   |   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|---|----|
| <b>Model Integration</b>  |   |   |   |   |   |   |   |   |   | ✓  |
| <b>Web-based Product Review Analysis System</b>   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| <b>User Interface</b>   |   |   |   |   |   |   |   |   |   | ✓  |
| <ul style="list-style-type: none"> <li>The website is user-friendly and the design is uncluttered, providing an inviting visual experience.</li> </ul>  |   |   |   |   |   |   |   |   |   |    |
| <b>Navigation</b>   |   |   |   |   |   |   |   |   |   | ✓  |
| <ul style="list-style-type: none"> <li>The website presents information and options logically and intuitively.</li> <li>Every button and link leads to the correct pages.</li> </ul>  |   |   |   |   |   |   |   |   |   |    |
| <b>Functionality</b>  |   |   |   |   |   |   |   |   | ✓ |    |
| <ul style="list-style-type: none"> <li>The web application provides the features that users need to complete their tasks.</li> <li>The system is free from bugs.</li> <li>Error messages can be displayed once the users operate the system incorrectly.</li> </ul> |   |   |   |   |   |   |   |   |   |    |
| <b>Performance</b>  |   |   |   |   |   |   |   | ✓ |   |    |
| <ul style="list-style-type: none"> <li>The features within the website can operate smoothly without crashing.</li> <li>The web application can load and respond quickly, with minimal downtime or errors.</li> </ul>  |   |   |   |   |   |   |   |   |   |    |
| <b>Other suggestion/comments from tester:</b>   |   |   |   |   |   |   |   |   |   |    |
| The website is almost bug-free. But the system performance is not good enough in terms of smoothness. Also, the model accuracy sometimes is not accurate, especially for the reviews with sarcasm or irony.   |   |   |   |   |   |   |   |   |   |    |

Table 28 UAT Result from Tester 2

**Tester 3 Result****USER ACCEPTANCE TESTING (UAT)**Tester Name: RevonDate: 02.01.2023Occupation: Digital MarketerStart Time: 8:00p.mEnd Time: 8:53p.m.*Instruction: Please select your answer with a ✓ symbol for the following criteria:*

| Criteria  | Poor | Fair |   |   | Good |   |   | Very Good |   | Excellent |
|---|------|------|---|---|------|---|---|-----------|---|-----------|
| Sentiment Analysis Model  | 1    | 2    | 3 | 4 | 5    | 6 | 7 | 8         | 9 | 10        |
| <b>Accuracy</b><br>• Sentiment can be detected and classified accurately.   |      |      |   |   |      |   |   |           |   | ✓         |
| <b>Performance</b><br>• The model can analyze and produce the sentiment in a short time.  |      |      |   |   |      |   |   |           |   | ✓         |
| <b>Model Integration</b><br>• After reviewing a product, the website can show the reviews without crashing.   |      |      |   |   |      |   |   |           |   | ✓         |
| Web-based Product Review Analysis System  | 1    | 2    | 3 | 4 | 5    | 6 | 7 | 8         | 9 | 10        |
| <b>User Interface</b><br>• The website is user-friendly and the design is uncluttered, providing an inviting visual experience.                       |      |      |   |   |      |   |   |           | ✓ |           |
| <b>Navigation</b><br>• The website presents information and options logically and intuitively.<br>• Every button and link leads to the correct pages. |      |      |   |   |      |   |   |           |   | ✓         |
| <b>Functionality</b><br>• The web application provides the features that users need to complete their tasks.<br>• The system is free from bugs.       |      |      |   |   |      |   |   |           |   | ✓         |

|   |  |  |  |  |  |  |  |  |   |
|---|--|--|--|--|--|--|--|--|---|
| <ul style="list-style-type: none"> <li>Error messages can be displayed once the users operate the system incorrectly.</li> </ul>  |  |  |  |  |  |  |  |  |   |
| <b>Performance</b> <ul style="list-style-type: none"> <li>The features within the website can operate smoothly without crashing.</li> <li>The web application can load and respond quickly, with minimal downtime or errors.</li> </ul> |  |  |  |  |  |  |  |  | ✓ |
| <b>Other suggestion/comments from tester:</b>   |  |  |  |  |  |  |  |  |   |
| This system provides a good insight into the products on any online shopping platform, which is useful for e-commerce businesses to better understand customer feedback and improve customer service.                                   |  |  |  |  |  |  |  |  |   |

Table 29 UAT Result from Tester 3

## 10.4 Summary

In this section, the developer has conducted unit and user acceptance testing for both the sentiment analysis model and web-based product review analysis system, as well as model performance testing for the sentiment analysis model. All the test cases designed for unit testing are carried out and passed successfully. However, for the model performance testing, the proposed model did not pass the C7 test case. It may be because of the sarcasm in the product reviews that makes the algorithm difficult to classify. Sarcasm is often conveyed through irony, tone, and context, which can be challenging for a machine learning technique to interpret. Currently, some sentiment analysis algorithms are designed to take into account contextual information and use it to make more accurate predictions. For example, some algorithms may be trained on large datasets that include sarcastic statements in order to learn to recognize the characteristics of sarcastic language. However, the Amazon product review dataset used for training the proposed model is not designed to classify sarcastic statements. This issue can be a future research direction for the developer to improve the proposed system, achieving higher accuracy while performing sentiment analysis.

On the other hand, the testing result of the model performance table, which consists of precision, recall, F1-score, and accuracy of each class, shows that the proposed model is able to perform well in classifying positive and negative product reviews, reaching 96.38% and 91.01% F1-score respectively. Nevertheless, the model is less effective in predicting the neutral sentiment, with only 54% F1-score. It may be because sometimes language is ambiguous, and it is challenging to determine a statement's sentiment without additional explanation. Besides, some product reviews may lack explicit sentiment, making it difficult to classify them as either positive, negative, or neutral.

For the user acceptance testing, the results interpret that most of the testers were satisfied with both the sentiment analysis model and web-based product review analysis system in terms of their performance, functionality, and user interface. However, some testers claim that an improvement can be made to the system performance to solve the web page delay and model accuracy issue. Hence, the developer will implement a future improvement for the proposed system to resolve the mentioned problems.

As a testing phase's result, it can be concluded that the overall result is satisfying and the proposed system has met the project aim by providing e-commerce businesses with better insight into their products and assisting potential customers in making purchase decisions.

## CHAPTER 11: CONCLUSION AND REFLECTIONS

### 11.1 Critical Evaluation

During the second half of the Final Year Project (FYP), the developer initially put all the effort into machine learning model development. At the early stage, the developer could not obtain a satisfying accuracy result with the developed model. The accuracy is only between 30% and 70% with the traditional-based machine learning model, but applying the transformer-based model significantly improves the overall accuracy and model performance. Hence, the developer decided to fine-tune to a pretrained transformer-based model instead of developing a new model to ensure the proposed system can classify the customer reviews accurately.

As the developer didn't learn web development techniques using Python before, lots of time is contributed for the developer to understand the logic and structure of the Python Flask to develop a web application. As a result, the developer has the chance to build and enhance the front-end programming skills, such as HTML, CSS, and Javascript.

As a future improvement of the proposed system, the plans are described as below:

1. Improve the machine learning model with sarcasm detection ability.
2. Implement a better Graphic Processing Unit (GPU) to train the model with higher epochs.
3. Compare the proposed model with other sentiment analysis approaches to evaluate the model performance and computational efficiency
4. Develop the review reply functions for e-commerce businesses to interact with their customers
5. Develop the upvote and downvote functions to avoid the fake customer reviews

## 11.2 Conclusion

In conclusion, throughout the whole Final Year Project (FYP), the developer has investigated various critical aspects and developed both web-based product review analysis system and sentiment analysis machine learning model. After conducting detailed research on the background and problems encountered by the current online shopping users, the developer proposed a sentiment analysis technique embedded in a web-based product review analysis system to assist online shopping customers in making purchase decisions and e-commerce businesses in increasing customer satisfaction. The project scope and objectives give the developer a general idea of the expected output to facilitate the smooth implementation and development process in the second half of FYP. Through carrying out in-depth literature reviews, the possibility of turning this idea into reality has increased significantly.

The proposed system will be developed with the assistance of research on technical tools and system development methodology in this report. The chosen programming language to develop the web-based product review analysis system is Python, which includes Tensorflow and Transformers libraries that assist the developer in building a machine learning model. The developer also decided to utilize Cloud Firestore as a NoSQL database and Flask as a web framework as the proposed system is a small, lightweight project. SCRUM agile methodology that breaks the entire project lifecycle into several manageable sprints will be implemented to guide the developer in producing a high-quality system within the short timeline.

Through gathering and analyzing the public's opinions on the project ideas with the questionnaire technique via Google Form, the developer is able to verify the market demand for the sentiment analysis-based product. Designing the proposed system's abstract architecture helps the developer identify and have a better understanding of the system and database structures along with the user interface design. The developer can also define the milestones and break the project scope into smaller, more manageable chunks through a project release plan. On the other hand, the project test plan outlines the scope of the unit, model performance, and user acceptance testing and defines the criteria for determining the success of a test case.

While developing the machine learning model and web-based product review analysis system, the developer also includes the user interface and output in this report with further explanation. Some sample implementation codes of both deliverables are also provided with justification to indicate the logic of the system's components and their relationships. Lastly, the system validation with unit testing, model performance testing, and user acceptance testing

is able to ensure the system meets its requirements and identify potential improvements in future research. Moreover, the system validation also helps to confirm the system behavior under different conditions and scenarios. This can help to ensure that the system performs as intended in different environments and use cases.

This FYP report has significantly enhanced the developer's skills in coding, report writing, data collection and analysis, critical thinking, and time management. Overall, the developer has put much effort into carrying out investigations and research to develop the proposed system and validate the functional and technical requirements. The developed system is able to provide a platform for existing customers to express their opinions on the purchased products, potential customers to make purchase decisions, and e-commerce businesses with better insight into their products.

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## APPENDICES

### FYP Poster

**SENTIMENT ANALYSIS OF  
PRODUCT REVIEWS  
USING MACHINE  
LEARNING**


**A · P · U**  
ASIA PACIFIC UNIVERSITY  
OF TECHNOLOGY & INNOVATION

**By: Mr. Lew Jun Long (TP059638)**  
 B.Sc. (Hons) Computer Science (Intelligent Systems)  
 APD3F2205CS(IS)  
 Supervisor: Assoc. Prof. Dr. Imran Medi  
 2nd Marker: Assoc. Prof. Dr. Selvakumar Samue











**Introduction:**  
 Millions of online reviews are posted daily to represent the latest consumer preference trends. Most prospective buyers will view product reviews before making purchase decisions. Therefore, the sentiment analysis that classifies the textual data into positive, neutral, or negative statements, is vital for e-commerce businesses in tailoring products and services to meet the client's needs.

**Objectives:**

- To provide a platform for existing customer to express their opinions on the purchased product.
- To provide e-commerce businesses with better insight into their products.
- To assist potential customers in decision-making while purchasing a product.



**Core Features:**

- Allow businesses to manage products and review tags on their pages
- Allow users to view product feedback provided by existing customers
- Allow users to filter the product reviews based on the review tags
- Allow users to view the bar chart showing the proportion of positive, neutral, and negative feedback based on the chosen product review tag

**Implementation:**

- Sentiment analysis model is developed with Python by fine-tuning the DistilBERT model.
- Web application is developed using Python Flask with the combination of HTML and CSS.
- This project uses Firebase as the database.



**Iphone 14 Pro**  
Business: OneBusiness

**Product Description**  
 The iPhone 14 Plus comes with 6.1-inch OLED display with 120Hz refresh rate and Apple's improved Bionic A16 processor. On the back there is a Triple camera setup with 48MP main camera. Prices start from \$999.

**Sentiment Proportion:** Positive 62.5% | Neutral 12.5% | Negative 25.0%

**Add Review**

|          |                   |                    |                  |               |
|----------|-------------------|--------------------|------------------|---------------|
| All 8    | Product Quality 5 | Delivery Service 1 | Seller Service 5 | Performance 4 |
| Design 2 | Camera 1          | Storage 1          |                  |               |



**Conclusion:**  
 The proposed system is able to achieve the aim and objectives, classifying the product reviews into positive, neutral, or negative accurately. However, there is still plenty of room for improvement. As future development, the sentiment analysis model can be trained for accepting different languages, such as Malay and Mandarin.

## Project Log Sheet

### Meeting 1

|  |  |
|--|--|
|   | <small>(APU: Serial Number)</small><br><small>PLS V1.0</small> |
| <b>Project Log Sheet – Supervisory Session</b>   |  |
| <p><b>Notes on use of the project log sheet:</b></p> <ol style="list-style-type: none"> <li>1. This log sheet is designed for meetings of more than 15 minutes duration, of which there must be at minimum <u>SIX (6)</u> during the course of the project (SIX mandatory supervisory sessions).</li> <li>2. The student should prepare for the supervisory sessions by deciding which question(s) he or she needs to ask the supervisor and what progress has been made (if any) since the last session, and noting these in the relevant sections of the form, effectively forming an agenda for the session.</li> <li>3. A log sheet is to be brought by the STUDENT to each supervisory session.</li> <li>4. The actions by the student (and, perhaps the supervisor), which should be carried out before the next session should be noted briefly in the relevant section of the form.</li> <li>5. The student should leave a copy (after the session) of the Project Log Sheet with the supervisor and to the administrator at the academic counter. A copy is retained by the student to be filed in the project file.</li> <li>6. It is recommended that students bring along log sheets of previous meetings together with the project file during each supervisory session.</li> <li>7. The log sheet is an important deliverable for the project and an important record of a student's organisation and learning experience. The student <b>must</b> hand in the log sheets as an appendix of the final year documentation, with sheets dated and numbered consecutively.</li> </ol> |  |
| <p>Student's name: <u>Lew Jun Long</u>      Date: <u>28/6/2022</u>      Meeting No: <u>1</u></p>   |  |
| <p>Project title: <u>Sentiment Analysis of Product Reviews using Machine Learning</u><br/>     Intake: <u>APD3F2205CS(IS)</u></p>  |  |
| <p>Supervisor's name: <u>Prof Dr Imran Medi</u>      Supervisor's signature: <u>Imran Medi</u></p>   |  |
| <p><b>Items for discussion (noted by student <u>before</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. Is my project idea suitable to be used for FYP?</li> <li>2. What are the advice and tips for improving the IR after reviewed my PPF?</li> <li>3. Where can I find the materials for writing the FYP proposal documentation?</li> </ol>  |  |
| <p><b>Record of discussion (noted by student <u>during</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. The project idea is suitable for FYP.</li> <li>2. Professor has given the student some feedbacks for the PPF including:           <ul style="list-style-type: none"> <li>• The introduction should be tightly related to the project topic.</li> <li>• The problem statement should be written in paragraphs instead of point forms.</li> <li>• The objectives should be designed to meet the project aim.</li> <li>• It is a must to have a summary at the end of the literature review section.</li> <li>• The project deliverables can be divided into two categories: Sentiment Analysis Model and Product Review Analysis System</li> </ul> </li> </ol>  |  |
| <p><b>Action List (to be attempted or completed by student by the <u>next</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. The student has to complete the PSF according to the advice from the supervisor.</li> <li>2. The student must do more research on the project topic before working on the IR.</li> </ol>   |  |
| <i>Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.</i>   |  |
| <small>Project Log Sheet</small>   |  |

## Meeting 2

|  |   |
|--|---|
|   | <b>(APU: Serial Number)</b><br>PLS V1.0 |
| <b>Project Log Sheet – Supervisory Session</b>   |   |
| <p><b>Notes on use of the project log sheet:</b></p> <ol style="list-style-type: none"> <li>1. This log sheet is designed for meetings of more than 15 minutes duration, of which there must be at minimum <u>SIX (6)</u> during the course of the project (SIX mandatory supervisory sessions).</li> <li>2. The student should prepare for the supervisory sessions by deciding which question(s) he or she needs to ask the supervisor and what progress has been made (if any) since the last session, and noting these in the relevant sections of the form, effectively forming an agenda for the session.</li> <li>3. A log sheet is to be brought by the STUDENT to each supervisory session.</li> <li>4. The actions by the student (and, perhaps the supervisor), which should be carried out before the next session should be noted briefly in the relevant section of the form.</li> <li>5. The student should leave a copy (after the session) of the Project Log Sheet with the supervisor and to the administrator at the academic counter. A copy is retained by the student to be filed in the project file.</li> <li>6. It is recommended that students bring along log sheets of previous meetings together with the project file during each supervisory session.</li> <li>7. The log sheet is an important deliverable for the project and an important record of a student's organisation and learning experience. The student <b>must</b> hand in the log sheets as an appendix of the final year documentation, with sheets dated and numbered consecutively.</li> </ol> |   |
| Student's name: <u>Lew Jun Long</u> Date: <u>14/7/2022</u> Meeting No: <u>2</u>  |   |
| Project title: <u>Sentiment Analysis of Product Reviews using Machine Learning</u><br>Intake: <u>APD3F2205CS(IS)</u>   |   |
| Supervisor's name: <u>Prof Dr Imran Medi</u> Supervisor's signature: <u>Imran Medi</u>   |   |
| <p><b>Items for discussion (noted by student <u>before</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. What are the advice and tips for improving the IR after reviewed the student PSF?</li> <li>2. The system will include filtering the useless comments, categorizing the comments, and sentiment analysis of the comments. Will it out of topics if the student only includes sentiment analysis in my project title?</li> <li>3. Do the student need to specific a category for the project to build a domain-specific machine learning model?</li> </ol>  |   |
| <p><b>Record of discussion (noted by student <u>during</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. Professor has given the student some feedbacks for the PSF including:           <ul style="list-style-type: none"> <li>• The problem statement should be explained in more details.</li> <li>• The aim of the project should be revised.</li> <li>• The system development plan and test plan should be designed according to the proposed system instead of general concept.</li> </ul> </li> <li>2. The student should reconsider the project title by including the text analysis.</li> <li>3. The project can be general and not specific to certain domain according to the dataset that is used to build the model.</li> </ol>  |   |
| <p><b>Action List (to be attempted or completed by student by the <u>next</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. The student has to come out with a new project title by including the text analysis.</li> <li>2. The student must do more research on the project topic before working on the IR.</li> <li>3. The student ought to rewrite certain parts of PSF according to the advice from the supervisor.</li> </ol>  |   |
| <i>Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.</i>   |   |
| Project Log Sheet  |   |

### Meeting 3

|   |   |
|---|---|
|    | <b>(APU: Serial Number)</b><br>PLS V1.0 |
| <b>Project Log Sheet – Supervisory Session</b>  |   |
| <b>Notes on use of the project log sheet:</b> <ol style="list-style-type: none"> <li>1. This log sheet is designed for meetings of more than 15 minutes duration, of which there must be at minimum <u>SIX (6)</u> during the course of the project (SIX mandatory supervisory sessions).</li> <li>2. The student should prepare for the supervisory sessions by deciding which question(s) he or she needs to ask the supervisor and what progress has been made (if any) since the last session, and noting these in the relevant sections of the form, effectively forming an agenda for the session.</li> <li>3. A log sheet is to be brought by the STUDENT to each supervisory session.</li> <li>4. The actions by the student (and, perhaps the supervisor), which should be carried out before the next session should be noted briefly in the relevant section of the form.</li> <li>5. The student should leave a copy (after the session) of the Project Log Sheet with the supervisor and to the administrator at the academic counter. A copy is retained by the student to be filed in the project file.</li> <li>6. It is recommended that students bring along log sheets of previous meetings together with the project file during each supervisory session.</li> <li>7. The log sheet is an important deliverable for the project and an important record of a student's organisation and learning experience. The student <b>must</b> hand in the log sheets as an appendix of the final year documentation, with sheets dated and numbered consecutively.</li> </ol> |   |
| Student's name: <u>Lew Jun Long</u> Date: <u>16/8/2022</u> Meeting No: <u>3</u>   |   |
| Project title: <u>Sentiment Analysis of Product Reviews using Machine Learning</u><br>Intake: <u>APD3F2205CS(IS)</u>  |   |
| Supervisor's name: <u>Prof Dr Imran Medi</u> Supervisor's signature: <u>Imran Medi</u>  |   |
| <b>Items for discussion (noted by student <u>before</u> mandatory supervisory meeting):</b> <ol style="list-style-type: none"> <li>1. What are the advice and tips for improving the IR after reviewed the student IR?</li> <li>2. How are the marking schema for the IR and FYP?</li> <li>3. What is the advice for the second phase of FYP (implementation stage)?</li> </ol>   |   |
| <b>Record of discussion (noted by student <u>during</u> mandatory supervisory meeting):</b> <ol style="list-style-type: none"> <li>1. Professor has given the student some feedbacks for the IR including:           <ul style="list-style-type: none"> <li>• The domain research within the literature review should be more than 2000 wordcounts.</li> <li>• The frontend programming language should be included.</li> <li>• There should be a summary at the end of every chapters.</li> <li>• Scrum system development methodology should be customized with individual component instead of default group work.</li> <li>• The questionnaire analysis should include a deeper analysis. Cross-sectional analysis can be included.</li> </ul> </li> <li>2. Professor has suggested the student to inquire Mr Dhason for the IR and FYP marking schema.</li> <li>3. The student has to start the FYP implementation as soon as possible as the Year 3 second semester will have tight due date of all the subjects</li> </ol>   |   |
| <b>Action List (to be attempted or completed by student by the <u>next</u> mandatory supervisory meeting):</b> <ol style="list-style-type: none"> <li>1. The student should rewrite certain parts of IR according to the advice from the supervisor.</li> <li>2. The student must do more research on the project topic while working on the FYP implementation stage.</li> <li>3. The student ought to have a detailed plan with schedule in order to complete FYP within the timeline.</li> </ol>   |   |
| <i>Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timetables. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.</i>   |   |
| <b>Project Log Sheet</b>  |   |

## Meeting 4

|  |   |
|--|---|
|   | <b>(APU: Serial Number)</b><br>PLS V1.0 |
| <b>Project Log Sheet – Supervisory Session</b>   |   |
| <p><b>Notes on use of the project log sheet:</b></p> <ol style="list-style-type: none"> <li>1. This log sheet is designed for meetings of more than 15 minutes duration, of which there must be at minimum <u>SIX (6)</u> during the course of the project (SIX mandatory supervisory sessions).</li> <li>2. The student should prepare for the supervisory sessions by deciding which question(s) he or she needs to ask the supervisor and what progress has been made (if any) since the last session, and noting these in the relevant sections of the form, effectively forming an agenda for the session.</li> <li>3. A log sheet is to be brought by the STUDENT to each supervisory session.</li> <li>4. The actions by the student (and, perhaps the supervisor), which should be carried out before the next session should be noted briefly in the relevant section of the form.</li> <li>5. The student should leave a copy (after the session) of the Project Log Sheet with the supervisor and to the administrator at the academic counter. A copy is retained by the student to be filed in the project file.</li> <li>6. It is recommended that students bring along log sheets of previous meetings together with the project file during each supervisory session.</li> <li>7. The log sheet is an important deliverable for the project and an important record of a student's organisation and learning experience. The student <b>must</b> hand in the log sheets as an appendix of the final year documentation, with sheets dated and numbered consecutively.</li> </ol> |   |
| Student's name: <u>Lew Jun Long</u> Date: <u>17/10/2022</u> Meeting No: <u>4</u>   |   |
| Project title: <u>Sentiment Analysis of Product Reviews using Machine Learning</u><br>Intake: <u>APD3F2205CS(IS)</u>   |   |
| Supervisor's name: <u>Prof Dr Imran Medi</u> Supervisor's signature: <u>Imran Medi</u>   |   |
| <p><b>Items for discussion (noted by student <u>before</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. For the machine learning model, is fine-tuning a pre-trained model, such as BERT, GPT, RoBERTa, for sentiment classifier instead of building a new model acceptable?</li> <li>2. In the Investigation Report (IR), the student stated that the proposed programming language is Python and proposed IDE is Visual Studio Code. However, the student is going to use the Google Colab (Jupyter) for training the machine learning model but the frontend web application is still using Visual Studio Code. Do the student need to add on Google Colab in my FYP report? If so, is it adding in the IDE section?</li> </ol>  |   |
| <p><b>Record of discussion (noted by student <u>during</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. Fine-tuning a model for sentiment classifier is suitable. However, the student need to document it very well to show that there has been a concerted effort to optimize the model.</li> <li>2. Student should include Google Colab in FYP report's IDE section.</li> </ol>  |   |
| <p><b>Action List (to be attempted or completed by student by the <u>next</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. The student has to focus on developing the machine learning algorithm and complete it as soon as possible.</li> <li>2. More research should be conducted to ensure that the fine-tuned model can achieve a higher accuracy.</li> </ol>   |   |
| <i>Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.</i>   |   |
| <small>Project Log Sheet</small>   |   |

**Meeting 5**

|  |   |
|--|---|
|   | <b>(APU: Serial Number)</b><br>PLS V1.0 |
| <b>Project Log Sheet – Supervisory Session</b>   |   |
| <p><b>Notes on use of the project log sheet:</b></p> <ol style="list-style-type: none"> <li>1. This log sheet is designed for meetings of more than 15 minutes duration, of which there must be at minimum <u>SIX (6)</u> during the course of the project (SIX mandatory supervisory sessions).</li> <li>2. The student should prepare for the supervisory sessions by deciding which question(s) he or she needs to ask the supervisor and what progress has been made (if any) since the last session, and noting these in the relevant sections of the form, effectively forming an agenda for the session.</li> <li>3. A log sheet is to be brought by the STUDENT to each supervisory session.</li> <li>4. The actions by the student (and, perhaps the supervisor), which should be carried out before the next session should be noted briefly in the relevant section of the form.</li> <li>5. The student should leave a copy (after the session) of the Project Log Sheet with the supervisor and to the administrator at the academic counter. A copy is retained by the student to be filed in the project file.</li> <li>6. It is recommended that students bring along log sheets of previous meetings together with the project file during each supervisory session.</li> <li>7. The log sheet is an important deliverable for the project and an important record of a student's organisation and learning experience. The student <b>must</b> hand in the log sheets as an appendix of the final year documentation, with sheets dated and numbered consecutively.</li> </ol> |   |
| Student's name: <u>Lew Jun Long</u> Date: <u>9/12/2022</u> Meeting No: <u>5</u>  |   |
| Project title: <u>Sentiment Analysis of Product Reviews using Machine Learning</u><br>Intake: <u>APD3F2205CS(IS)</u>   |   |
| Supervisor's name: <u>Prof Dr Imran Medi</u> Supervisor's signature: <u>Imran Medi</u>   |   |
| <p><b>Items for discussion (noted by student <u>before</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. What are the advice and tips for improving the source codes for machine learning algorithm and web application?</li> <li>2. Should all the deliverables be included as the system features?</li> </ol>  |   |
| <p><b>Record of discussion (noted by student <u>during</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. Professor has given the student some feedbacks for the source codes including:           <ul style="list-style-type: none"> <li>• The system should be bug-free.</li> <li>• Ensure the model accuracy is above 70-80%.</li> <li>• There should be a button in the navigation bar for guiding users back to the homepage.</li> <li>• Include more product, review, and user sample before the system demo section.</li> <li>• If time allows, the student can develop the extra features.</li> </ul> </li> <li>2. All the deliverables must be included to ensure mark will not be deducted, except for the extra features.</li> </ol>   |   |
| <p><b>Action List (to be attempted or completed by student by the <u>next</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. The student should improve the system according to the advice from the supervisor.</li> <li>2. The student has to document the Chapter 9 Implementation by including the screenshot of source code and justification after completed the software part.</li> </ol>   |   |
| <i>Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.</i>   |   |
| <small>Project Log Sheet</small>   |   |

**Meeting 6**

|  |   |
|--|---|
|   | <b>(APU: Serial Number)</b><br>PLS V1.0 |
| <b>Project Log Sheet – Supervisory Session</b>   |   |
| <p><b>Notes on use of the project log sheet:</b></p> <ol style="list-style-type: none"> <li>1. This log sheet is designed for meetings of more than 15 minutes duration, of which there must be at minimum <u>SIX (6)</u> during the course of the project (SIX mandatory supervisory sessions).</li> <li>2. The student should prepare for the supervisory sessions by deciding which question(s) he or she needs to ask the supervisor and what progress has been made (if any) since the last session, and noting these in the relevant sections of the form, effectively forming an agenda for the session.</li> <li>3. A log sheet is to be brought by the STUDENT to each supervisory session.</li> <li>4. The actions by the student (and, perhaps the supervisor), which should be carried out before the next session should be noted briefly in the relevant section of the form.</li> <li>5. The student should leave a copy (after the session) of the Project Log Sheet with the supervisor and to the administrator at the academic counter. A copy is retained by the student to be filed in the project file.</li> <li>6. It is recommended that students bring along log sheets of previous meetings together with the project file during each supervisory session.</li> <li>7. The log sheet is an important deliverable for the project and an important record of a student's organisation and learning experience. The student <b>must</b> hand in the log sheets as an appendix of the final year documentation, with sheets dated and numbered consecutively.</li> </ol> |   |
| Student's name: <u>Lew Jun Long</u> Date: <u>26/12/2022</u> Meeting No: <u>6</u>   |   |
| Project title: <u>Sentiment Analysis of Product Reviews using Machine Learning</u><br>Intake: <u>APD3F2205CS(IS)</u>   |   |
| Supervisor's name: <u>Prof Dr Imran Medi</u> Supervisor's signature: <u>Imran Medi</u>   |   |
| <p><b>Items for discussion (noted by student <u>before</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. What are the advice and tips for improving the FYP report after reviewed the student FYP report?</li> <li>2. How are the marking schema for the FYP?</li> </ol>   |   |
| <p><b>Record of discussion (noted by student <u>during</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. Professor has given the student some feedbacks for the FYP including:           <ul style="list-style-type: none"> <li>• The literature review should include the research of the proposed model.</li> <li>• The unit testing plan should be designed in more detail.</li> <li>• The User Acceptance Form (UAT) should focus on the project's aim and objectives.</li> <li>• The implementation chapter should include the model development source code with the explanation.</li> <li>• A summary is required at the end of every chapter.</li> </ul> </li> <li>2. Professor has suggested the student to inquire Mr Dhason for the FYP marking schema.</li> </ol>  |   |
| <p><b>Action List (to be attempted or completed by student by the <u>next</u> mandatory supervisory meeting):</b></p> <ol style="list-style-type: none"> <li>1. The student should rewrite certain parts of FYP reports according to the advice from the supervisor.</li> <li>2. The student must complete the documentation as soon as possible before the submission date.</li> </ol>  |   |
| <i>Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.</i>   |   |
| <small>Project Log Sheet</small>   |   |

## Project Proposal Form (PPF)

|   |   |
|---|---|
| <b>Office Record</b><br>Date Received:<br>Received by whom: | <b>Receipt</b><br>Student name:<br>Student number:<br>Received by:<br>Date: |
|---|---|



### DRAFT PROJECT PROPOSAL FORM

**Proposal ID:**

**Name of supervisors proposed:**

- 1. Prof Dr Imran Medi (agreed to be supervisor)

**Student Name :** Lew Jun Long

**Student No :** TP059638

**Email Address :** tp059638@mail.apu.edu.my & junlong7368@gmail.com

**Programme Name :** Computer Science (Intelligent Systems)

**Title of project :** Sentiment Analysis of Product Reviews using Machine Learning

Please record which module(s) your topic is related to:

**Introduction to Artificial Intelligence (CT017-3-1-IAI)**

**Introduction to Database (CT042-3-1-IDB)**

**AI Methods (CT002-3-2-AIM)**

**Text Analytics and Sentiment Analysis (CT107-3-3-TXSA)**

### 1. Introduction

*Assume the reader has very little knowledge of the subject. Introduce the topic, the sector of business/industry concerned and how the project relates to it. Define the context of the problem and identify the research required to solve it.*

From Motorola DynaTAC only supporting 30-minute talk to iPhone 13 supporting 5G mobile network, from Z1 computer weighing one ton to Dell XPS 13 weighing 1.2kg, human is on the threshold of a new era in technology. The latest lifestyle trend is upshifting. People nowadays tends to seek faster speed and higher quality on every aspect, including the transformation from physical cash to online transaction. Online payments stimulate the growth of e-commerce which transformed the traditional physical shopping to online shopping. According to the survey by Chevalier (2022), there has been a gradual rise in the amount of retail e-commerce sales worldwide, from 1.3 trillion U.S. dollars in the year 2014 to 4.9 trillion U.S. dollars in the year

2021, and it is expected to continue increasing after 2021, reaching around 7.4 trillion U.S. dollars by the year of 2025.

Compared to physical store, online shopping platform provides massive commodity information assisting customers to make comparison among different sellers. For example, the famous footwear manufacturing companies Nike and Skechers have their official stores on the Lazada online shopping platform. Customers can browse the shoes on Lazada instead of visiting the physical retail shops which have a few distance away from their living places. However, criminal activities also undergo digital transformation, happening in the virtual environment and conning buyers out of their savings. New Straits Times reported that Malaysians had lost about RM58 million due to online shopping scams in the year 2021 (Kalbana Perimbanayagam, 2021). The scammer pretended as a legitimate seller on the online shopping platform and delivered the products different from the customer's expectations, or customers will receive nothing after they paid.

To prevent the crime, online shopping platform usually provides opportunities for customers to review the product and give their ratings after they used the product. With this insightful information, the potential customers will be able to make a better buying decision. When more and more customers bought the products and shared their experiences, there comes a problem that the feedbacks will overflow the product review page resulting in users feel bewildered by the sheer variety of customer reviews. Hence, the proposed product review analysis system will help to filter and categorize the large set of product reviews according to the polarity of the feedbacks.

## 2. Problem Statement

*Identify past and current work in the subject area. Outline the key references to other people's work, indicate for the most pertinent of these how your proposal relates to the ideas they contain.*

### 1. Potential Customers Lack Confidence in Decision-making

Lack of product reviews will cause an “unknown” for the specific product. Image advertising used to describe the product in photography is a way to increase the brand awareness and attract the potential customer to click on the product. However, sometimes, the quality of the product may not meet the customer’s expectation as the image advertisement was taken in the best condition by the professional photographer instead of the perspective from the ordinary people. On the other hands, good product reviews will increase the potential customer’s confidence during their purchase. It can create customer loyalty and boost the product sales as potential customers will be influenced by user feedbacks before they paid for the product. The existing literature on online reviews has highlighted variant of product review could confuse customers in decision making as it is hard to distinguish the product attributes according to customer’s preferences (Wang & Wang, 2020). Hence, a product review analysis system plays a huge role in providing better insights into the product in order to assist potential customers to classify the polarity of the user feedbacks.

### 2. Cluttered Information of the Product Reviews

Uncategorized product reviews will lead to inconsistent and disordered structure of user interface. The valuable feedbacks are intermixed with the noisy data which is not relevant with the product characteristics. Sentiment analysis distinguishing the comments into positive, negative, or neutral words is a natural language processing (NLP) technique to have a better understanding on the customer preferences. Categorizing the messy user feedbacks according to the product features can assist customer to find their preferences directly and ease the process of comparing with other brands. For example, customer looking for longer-lasting smartphone can filter the user feedbacks to show only the comments relevant with the battery life.

### 3. Project Aim and Objectives

*Identify the AIM(s) of the project, i.e. what the overall achievement is intended to be, in terms of both academic and commercial/industrial advances. Identify the particular intellectual difficulties posed by the proposal, the problems to be addressed, and explain how these might be solved. Clearly list individual measurable OBJECTIVES which can be related to the workplan and deliverables.*

*Aims and objectives are subject to approval from supervisor and students are expected to revise them if deemed inappropriate for a Level 3 project.*

**Aim:** To develop a product review analysis system that able to extract the information from few words, sentences or paragraphs by existing customers, and classify the polarity of the information which would optimize potential customer's decision-making in order to increase customer satisfaction.

**Objectives:**

1. To investigate existing text analysis system
2. To identify artificial intelligence algorithms suitable for categorizing pieces of writing.
3. To propose rules for determining sentiments according to the product reviews.
4. To design artificial intelligence system for analyzing the customer reviews and rating the products.

### 4. Literature Review

Sentiment analysis has been performed in different fields, such as market research, customer support, social media, and others. From the perspective of customer reviews on the e-commerce website, there are thousands of textual data generated from product ratings, feedbacks and recommendations. Therefore, sentiment analysis of customer reviews currently has been implemented on some online shopping platforms, such as Amazon.

Wassana and his research team (2021) have implemented Social Network Analysis (SNA) methods to study the connections within the network structure and analyze the polarity and item's characteristics according to the user feedbacks on the Amazon worldwide online shopping website. The machine learning technique has been used to analyze the sentiments from two different perspectives, that are "polarity" and "subjectivity". Polarity refers to the comments toward to positive, negative, or neutral words, while subjectivity relates to customer's thoughts and opinions for the specific product. By analyzing this information in depth, it will assist company to grasp the

customer's preference in order to produce better marketing strategies to increase the revenue (Wassana et al., 2021).

Deep learning modified neural network (DLMNN) classifier can also be used for analyzing the customer feedbacks on the seller's product based on the ratings and comment contents. The research also implemented improved adaptive Neuro-fuzzy Inferences System (IANFIS) to predict the future online product by weighting the keyword frequency, confidence level, and entropy. The product reviews have been categorized into three scenarios, which are grade-based, content-based, and collaboration-based. Grade-based methodology will accept the user ratings as input and analyze the polarity (positive, negative, or neutral) of the product, while content-based will go through the preprocessing, feature extraction, feature selection using Spider Monkey Optimization (SMO) algorithm, and product review classification. Collaboration-based scenario is similar with content-based and uses the result for future prediction (Sasikala & Mary Immaculate Sheela, 2020).

Chinnalgu and Durairaj (2021) have found that the fastText linear model working on generic hardware by Facebook AI research lab able to achieve a higher accuracy when analyzing and categorizing the customer reviews compared to Linear Support Vector Machine (LSVM) and Sentiment Analysis Bi-directional Long Short-Term Memory (SA-BLSTM), which is 90.71%. The main benefits of using fastText library is it will consider the out-of-vocabulary (OOV) words to determine the hidden information within the words and sentences (Chinnalagu & Durairaj, 2021).

## 5. Deliverables

*Provide a clear list of the outputs from the project.*

The final product will be a web-based Product Review System that enables current product users to provide rating and reviews for the product and assists potential customers in decision-making process. The following functionalities will be included in the proposed system:

1. Allow users to search for a product based on its categories or the company name
2. Allow existing customer to comment the product
3. Allow existing customer to rate the product on a scale from 1 to 5
4. Allow existing customer to post photos or videos for the product
5. Allow existing customer to upvote or downvote the product review
6. Allow potential customer to choose the product review categories
7. Allow potential customer to filter the user reviews based on the rating
8. Allow potential customer to view rating and feedback provided by existing customer
9. Allow users to view the chart showing the proportion of positive, neutral, and negative feedback.

All the existing customers are required to register and login to the Product Review System before providing the feedback for the product.

## 6. References

- Chevalier, S. (2022). Global retail e-commerce market size 2014-2023 | Statista. Retrieved 2 June 2022, from <https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/>
- Chinnalagu, A., & Durairaj, A. (2021). Context-based sentiment analysis on customer reviews using machine learning linear models. *Peerj Computer Science*, 7, e813. <https://doi.org/10.7717/peerj-cs.813>
- Kalbana Perimbanayagam. (2021). Malaysians lost RM58 mil to online shopping scammers this year. Retrieved 2 June 2022, from <https://www.nst.com.my/news/nation/2021/11/743575/malaysians-lost-rm58-mil-online-shopping-scammers-year>
- Sasikala, P., & Mary Immaculate Sheela, L. (2020). Sentiment analysis of online product reviews using DLMNN and future prediction of online product using IANFIS. *Journal Of Big Data*, 7(1). <https://doi.org/10.1186/s40537-020-00308-7>
- Wang, H., & Wang, Y. (2020). A Review of Online Product Reviews. *Journal Of Service Science And Management*, 13(01), 88-96. doi: 10.4236/jssm.2020.131006
- Wassana, S., Xi Chen, X., Shen, T., Waqar, M., & Jhanjhi, N. (2021). Amazon Product Sentiment Analysis using Machine Learning Techniques. *Revista Argentina De Clínica Psicológica*, 30(01), 695-703. <https://doi.org/10.24205/03276716.2020.2065>

## Project Specification Form (PSF)

Asia Pacific University

Project Specification Form (PSF)

PSF – Project Specification Form

**STUDENT ID** : TP059638

**INTAKE ID** : APD3F2205CS (IS)

**STUDENT NAME** : Lew Jun Long

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Project Title: Sentiment Analysis of Product Reviews using Machine Learning

### Project Background

#### Project Context

One of the main reasons that affect the customers' online product purchase decisions is the opinions of other customers (Kumar et al., 2018). The product review is able to help potential customers decrease the purchase risk and the search cost while making decisions (Wang et al., 2020). A lack of product reviews will cause an "unknown" for the specific product. Without the other customer's evaluation, it would be challenging for potential customers to build trust towards the product. Today's customers tend to make purchase decisions based on the review score information given by the current users instead of the product descriptions offered by the sellers (Camilleri, 2020). Hence, it is crucial to provide a platform including the product feedback features for e-commerce businesses and their customers.

According to the research by Xun Xu (2021), the increasing number of product reviews will encourage customers' behaviours regarding leaving their own feedback. Day after day, it generates an enormous amount of publicly available data that leads to cluttered information of the product reviews. However, the existing literature on online reviews has highlighted that variant of product reviews could confuse customers in decision-making as it is hard to distinguish the product attributes according to customers' preferences (Wang & Wang, 2020). Categorizing the messy user feedback according to the product features can assist the customer in finding their preferences directly and ease the process of comparing with other brands. For example, a customer looking for a longer-lasting smartphone can filter the user feedback to show only the comments relevant to the battery life.

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Millions of online reviews are posted daily to represent the latest consumer preference trends. Most prospective buyers will view the product reviews related to product quality and its ease-of-use regarded with the consumer emotions or attitudes before making the purchase decisions (Jang et al., 2021). Zablocki (2019) and his research team found that emotional feedback has a more significant effect on determining customer preference than informational feedback. Positive emotional comments, such as excitement and happiness, considerably improve the general attitude about a product (Zablocki et al., 2019). Sentiment analysis distinguishing the comments into positive, negative, or neutral words is a natural language processing (NLP) technique to have a better understanding of customer preferences (Birjali et al., 2021). Analyzing and displaying the polarity of user emotions towards the products will increase the potential customer's confidence during their purchase.

From the business perspective, manually analyzing the product reviews requires human resources, which are limited and easily prone to human error. Besides, a human may make conflicting decisions while processing large amounts of data, leading to inaccurate analysis results. In contrast, these repetitive tasks can be performed by Artificial Intelligence that achieves low management cost and short analyzing time compared to human beings (Bhbosale et al., 2020; Pallathadka et al., 2021). By implementing sentiment analysis in an online shopping platform, it will provide a business with better insight into their products by classifying the polarity of the product reviews (Ireland & Liu, 2018).

**Rationale**

Compounding with the problem context, the proposed end product will be a web-based Product Review Analysis System that will provide two main functionalities. First and foremost, the system will be a platform for connecting e-commerce businesses with their customers. Businesses can collect customer feedback that could help develop a strategic business plan for improving their products and services. Besides, they can improve their brand reputation and credibility of reliable services when more customers give positive reviews on their products and services. As a result, customer satisfaction will be achieved to maintain the business's competitive advantage. Secondly, the embedded sentiment analysis model accepts the paragraphs or sentences

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as input. The input will go through the data pre-processing and will be broken into pieces of words. Each word will be proceeded with the sentiment analysis algorithm and return the polarity score as the output. The result will then be visualized as a graphical representation of the insightful information. Apart from product reviews on online shopping platforms, the designed sentiment analysis model can also collect different data for analyzing user behavior, such as opinions shared on social media, ideas shared on forums, and articles posted in newspapers. By feeding suitable datasets for training the classifier, it can contribute to various fields of application: from the stock market to tourism; from healthcare to the election (Abualigah et al., 2019; Bansal & Srivastava, 2018; Mohan et al., 2019; Zvarevashe & Olugbara, 2018). By utilizing sentiment analysis, it will avoid the wastage of human resources for classifying the large quantity of data and reduce human error while performing the monotonous, repetitive, time-consuming tasks in order to produce a more accurate finding effectively (Kaličanin et al., 2019). Compared with the lexicon-based sentiment analysis techniques, machine learning can achieve higher accuracy and eliminate the shortcomings of manually labeling a few documents that are required in the lexicon-based approach (Brizolakis et al., 2020).

**Tangible Benefits**

- Reduction of business employee's workload as the system can deliver the result of sentiment analysis automatically
- Eliminate human error caused by traditional, manual analytical methods
- Resource cost saving by minimizing the needs of business analyst team in analysing the product reviews due to natural language processing technique adoption
- Savings on analyzing time where employees do not have to label the massive amount of data as positive, neutral, or negative comment
- Cutting losses of customers since the online shopping scams will be decreased

**Intangible Benefits**

- Increase customer's satisfaction by providing a platform for expressing their feedbacks to the e-commerce business
- Improve user experience where the product reviews are classified and labelled as positive, neutral, or negative feedback
- Bolster customer's confidence in decision-making process while comparing the products from different online retailers

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- Facilitate the development of strategic business plan according to the results of sentiment analysis on product reviews

**Nature of Challenge**

While developing the proposed system, the developer will encounter a series of challenges that are required to be solved in order to produce satisfactory system quality, achieve the project objectives, and satisfy the end-user requirements. By defining the factors that may affect the project's success at the early stage, the project failure risk will be decreased, and the success rate will be increased. First and foremost, developing a sentiment-based product review analysis system would be a new challenge for the developer. Having intermediate programming skills is not enough to complete the project. The developer ought to enhance the programming level by continuously practicing self-learning with the correct learning goals and appropriate resources throughout the system development process. The required knowledge for building a web application is Java, while Python is the necessary technique for developing a sentiment analysis model. The integration of multiple programming languages is needed to be carried out to meet the proposed system scope.

Apart from the coding skill, the developer has to encounter the complex machine learning algorithm and Natural Language Processing libraries. Due to the lack of exploring the sentiment analysis technique, it will be a new experience for the developer to build a model with high accuracy, low bias, and acceptable levels of variances. Therefore, a massive amount of research has to be conducted by the developer when choosing the suitable dataset and implementing the appropriate machine learning algorithm in the proposed system.

Besides, word ambiguity is one of the challenges in sentiment analysis when classifying the sentence's polarity. A single word can have multiple meanings depending on its usage in the sentence and the domain area. For example, the term 'return' in the banking industry might mean the amount of made profit that leads to a positive label. Conversely, from the retail sector, 'return' means giving back something interpreting a damaged product to the seller resulting in a negative label. Without the appropriate context, the machine learning model will face obstacles while

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performing sentiment analysis in product reviews that contribute to incorrect language interpretation.

Furthermore, some customers will provide their feedback with sarcastic remarks. From the sentence's literal meaning, the trained sentiment analysis model will not get the impression that the customer was being ironical. For example, the statement "the bed is super comfortable that I feel like lying on the floor" will provide a false impression resulting in positive feedback as the phrase "super comfortable" on the surface seems that the customer was leaving a good review. However, by connecting with the context "I feel like lying on the floor," the user is obviously expressing frustration about the product quality using sarcasm. This type of comment makes the sentiment analyzing process more challenging to label the polarity of the sentence.

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## Project Objectives

### Aim and Objectives

**Aim:** To develop a product review analysis system that able to extract the information from few words, sentences, or paragraphs by existing customers, and classify the polarity of the information which would provide e-commerce business with better insight into their products and optimize potential customer's decision-making.

### Objectives:

1. To design a user-friendly web application by utilizing the human-computer interaction (HCI) concept and following design guidelines in graphical user interface (GUI) development.
2. To apply text analysis technique in data preprocessing to transform the raw data into the correct format.
3. To propose rules for determining sentiments of product reviews according to the product characteristics.
4. To integrate machine learning model into web application for analyzing the customer reviews and rating the products.

### Deliverables

The proposed Product Review Analysis System will be a web application that enables current product users to provide rating and reviews for the product, assists potential customers in decision-making process, and helps businesses to enhance their products and customer services. The application will include a sentiment analysis model that is pre-trained using the Amazon product review dataset to classify the product reviews according to their polarity.

The target users of the Product Review Analysis System are:

1. E-commerce businesses
2. Customers

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- a. Existing customers
- b. Potential customers

The business-end Product Review Analysis System will include the following functions:

- Allow businesses to register themselves as a business
- Allow businesses to login the system with the correct email and password
- Allow businesses to logout from the system
- Allow businesses to add, remove, and modify the product on their pages
- Allow businesses to add, remove, and modify the tags for the product review titles
- Allow businesses to view the feedbacks provided by existing customers
- Allow businesses to filter the product reviews based on their titles
- Allow businesses to view the bar chart showing the proportion of positive, neural, and negative feedbacks based on the chosen product review title

The customer-end Product Review Analysis System will include the following functions:

- Allow customers to register themselves as a customer
- Allow customers to login the system with the correct email and password
- Allow customers to logout from the system
- Allow customers to search for a product based on its names or the company name
- Allow customers to view feedbacks provided by existing customers
- Allow customers to filter the product reviews based on their titles
- Allow customers to view the bar chart showing the proportion of positive, neural, and negative feedbacks based on the chosen product characteristics
- Allow existing customers to comment the product and choose the title for their comments

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The following deliverables are the extra features of Product Review Analysis System that will be developed if time permits:

- Allow existing customer to upvote or downvote the product review after provided their own feedbacks
- Allow business to reply to the product reviews

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## Needed Resources

### Hardware

The minimum requirements of hardware which a computer should possess for developing the proposed system are listed as below:

- Central Processing Unit (CPU): Intel Core i5/AMD Ryzen 5 with a clock speed of 3GHz
- Random Access Memory (RAM): 8GB
- Keyboard
- Trackpad/Mouse
- Monitor
- RJ45 Port/Wi-Fi Card

### Software

The minimum requirements of software which a computer should possess for developing the proposed system are listed as below:

Programming Language:

- Python 3.9 (Backend)
- HTML/CSS/JavaScript (Frontend)

Integrated Development Environment (IDE) for Programming:

- Visual Studio Code
- PyCharm Community Edition 2021.3.3

Libraries:

- NLTK 3.7
- Numpy 1.22.4
- Matplotlib 3.5.2
- Scikit-learn 1.1.1

Database:

- Firebase Cloud Platform

Survey Tool:

- Google Forms

Asia Pacific UniversityProject Specification Form (PSF)**Documentation and Planning**

The implemented software applications for graph design and documentation are as below:

- Microsoft Office 365 (including Microsoft Word, Microsoft Excel)
- Microsoft Visio Professional 2019

**Access to information/ expertise**

To build the proposed system, an individual who is an expert in web application development and database development will be consulted to request advice regarding the concepts, programming structures, and system design. Besides, the developer will also consult the AI specialists about developing the machine learning model with high accuracy. Experienced experts include Mr. Zailan, Dr. Vinothini, and other Asia Pacific University lecturers. Furthermore, the opinions and feedback from Malaysians or APU students will be collected to validate the system requirements through surveys, such as interviews or questionnaires.

**User Involvement**

The roles of the proposed Product Review Analysis System are E-commerce businesses and customers. Hence, the target users who are going to participate in the data gathering stage and user acceptance testing phase are the Malaysians, Asia Pacific University students, lecturers, and administrations in order to ensure the data quality and examine the system performance.

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**Academic research being carried out and other information, techniques being learned.****Books**

Name: Natural Language Processing with Python

Author: Steven Bird, Ewan Klein, Edward Loper

Publisher: O'Reilly Media, Inc.

Name: Machine Learning with PyTorch and Scikit-learn

Author: Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili

Publisher: Packt

Name: Sentiment Analysis and Opinion Mining

Author: Bing Liu

Publisher: Morgan & Claypool Publishers

**Journals**

Name: Amazon Product Reviews: Sentiment Analysis using Supervised Learning Algorithms

Author: Mohibullah Hawlader, Arjan Ghosh, Zaoyad Khan Raad, Wali Ahad Chowdhury, Md.

Sazzad Hossain Shehan, Faisal Bin Ashraf

Publisher: IEEE

Name: Amazon Product Sentiment Analysis using Machine Learning Techniques

Author: Sobia Wassan, Xi Chen, Tian Shen, Muhammad Waqar, NZ Jhanjhi

Publisher: *Revista Argentina De Clinica Psicológica*

Name: Context-based sentiment analysis on customer reviews using machine learning linear models

Author: Anandan Chinmalagu, Ashok Kumar Durairaj

Publisher: National Center for Biotechnology Information

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Name: Sentiment analysis of online product reviews using DLMNN and future prediction of online product using IANFIS

Author: P. Sasikala, Mary Immaculate Sheela

Publisher: Springer

Name: Sentiment Analysis of Product Reviews using Supervised Learning

Author: Arkesha Shah

Publisher: -

**Online Resources**

Jim. (2021). *Flask Course - Python Web Application Development* [Video]. Youtube.

Lee, K. (2022). *Amazon Sentiment Analysis*. Kaggle.com. Retrieved 13 July 2022, from <https://www.kaggle.com/code/kennethleeje8/amazon-sentiment-analysis>.

McAuley, J. (2018). *Amazon review data*. Jmcauley.ucsd.edu. Retrieved 13 July 2022, from <https://jmcauley.ucsd.edu/data/amazon/>.

Symeonidis, S. (2018). *5 Things You Need to Know about Sentiment Analysis and Classification - KDnuggets*. KDnuggets. Retrieved 13 July 2022, from <https://www.kdnuggets.com/2018/03/5-things-sentiment-analysis-classification.html>.

## System Development Plan

The developer decided to implement SCRUM methodology for developing the proposed product review analysis system. It is because SCRUM is able to achieve rapid software development that allows the developer to produce the end product within a short time. SCRUM methodology separates the entire system development lifecycle into multiple standalone phases, called sprint. Every iterative sprint is an increment of product quality. Usually, each sprint takes up to one to four weeks. In every sprint, the development team are required to complete the tasks listed in the sprint backlog during the sprint planning conference. Sprint backlog acts as a subset of product backlog that include prioritized dynamic requirements which are the project detailed features and characteristics determined by the development team and product owner. The item order inside product backlog is prioritized based on their importance and can be modified when a new requirement added to the list. The product backlog including the project goals is usually done during the first sprint according to the user stories which are the informal document describing the product or software features using the natural language from the end-user perspective (Hema et al., 2020).

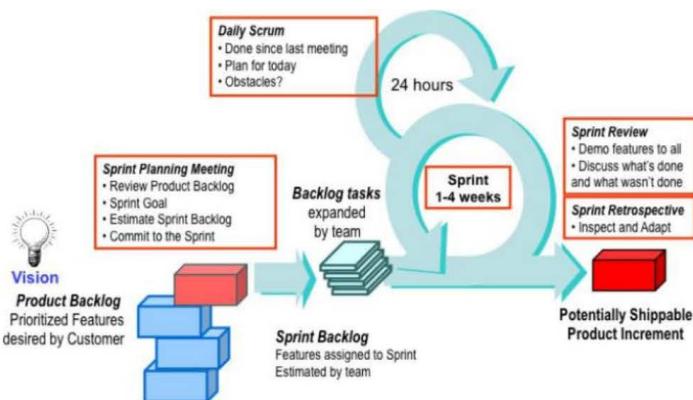


Figure 1 SCRUM Workflow (Hema et al., 2020)

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The above diagram shows the working flow of SCRUM from the planning stage to the retrospective stage. After product backlog is identified, it will start looping the sprint to complete all the item listed in the product backlog. Each sprint is started with the sprint planning meeting hosted by the Scrum Master. Every sprint member is required to join the meeting to have a clear understanding of the sprint goal and their duties that will be carried out in the sprint. During the meeting, the participants will break down the project backlog into individual, standalone tasks for sprint backlog and assign with timeline and budget. When the sprint backlog is determined, it indicates the beginning of the sprint development. A daily meeting which is usually less than 15 minutes will be conducted on a day-to-day basis. The main purpose of the daily startup is to ensure the transparency across the development team. During the meeting, the discussed items by each team member include the progress of their tasks, the work they are going to accomplish on the current day, and the issue arisen throughout the development. After completed all the tasks listed in the sprint backlog, a sprint review meeting will be conducted. The Scrum master, development team, and stakeholders which are identified by the Product Owner are required to join the meeting. The development team needs to carry out the demonstration of developed product that includes the latest features and the key increments in order to request feedback from the stakeholders. Besides, stakeholder can express their doubts about the product features and request a new requirement. The development team will note down the discussions including the modified product backlog and refer it during the upcoming sprint planning meeting. At the end of the sprint, a sprint retrospective that reflects on the process of the current sprint and the possible improvement for the following sprint will be carried out to discover the new opportunities of success for the proposed project. Throughout the sprint retrospective, the team member is able to learn from their mistakes during the past work and improves themselves.

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Asia Pacific UniversityProject Specification Form (PSF)

By implementing SCUM methodology into the proposed product review analysis system, the detailed plan for each sprint will be shown as below:

## Sprint 1:

- This sprint is planned to spend three weeks.
- The first cycle will be concentrating on the fundamental feature of web-based product review analysis system.
  - User register (E-commerce business and Customer)
  - User login and logout (E-commerce business and Customer)
  - Add, remove, and modify product (E-commerce business)
  - Add, remove, and modify tag for product review titles (E-commerce business)
  - Graphical User Interface (GUI) design of web application

## Sprint 2:

- This sprint is planned to spend four weeks.
- This loop will focus on the rest of the interactive user interface for web application.
  - Search for business's product (Customer)
  - Provide product review and choose a title for the comment (Existing Customer)
  - Filter product review based on the titles (E-commerce business and Customer)
  - View feedbacks provided by existing customers (E-commerce business and Customer)
  - Graphical User Interface (GUI) design of web application

## Sprint 3:

- This sprint is planned to spend four weeks.
- This increment will concentrate on developing the machine learning algorithm and training the sentiment analysis model.
  - Input data
  - Data pre-processing (Sentence segmentation, word segmentation, punctuation and symbols removal, stop words deletion)
  - Split train data and test data
  - Model selection
  - Model training
  - Classify polarity of the product review
  - Data visualization

## Sprint 4:

- This sprint is planned to spend three weeks.
- The last sprint will focus on the integration between sentiment analysis machine learning model and web-based product review analysis system.
  - Integrate machine learning model with the web application
  - View bar chart showing the proportion of the product review polarity
  - Graphical User Interface (GUI) design of web application
  - Upvoting and downvoting the other customer's product reviews (Exiting customer)  
(Extra feature)
  - Reply to customer review (E-commerce business) (Extra feature)

## Evaluation and Test Plan

The project has two outputs, which are sentiment analysis machine learning model and product review analysis system. Hence, separated test plans will be conducted for testing two different deliverables.

### **Sentiment Analysis Machine Learning Model**

#### **Success Criteria**

The proposed machine learning model is designed to extract information from three types of input, such as paragraphs, sentences, and phrases, and classify the polarity for that input. The system should be able to preprocess the input data and detect the positive, neutral, and negative sentiment with high accuracy, low bias, and acceptable levels of variances. The developer will carry out two types of testing technique, which are unit testing and model performance testing.

#### **Unit Testing**

Each of the application's individual component will undergo examinations on atomic pieces of the codebase to validate their functionality, called unit testing. During this testing, the machine learning algorithm will be split into blocks according to their functionalities. Each function will be tested separately to make sure the feature is working properly. Unit testing will narrow the scope of the issue and make it simpler to identify any errors that may appear during the integration testing phase. The unit test template for the proposed sentiment analysis machine learning model is shown as following:

| Test Case | Function                        | Input | Expected Output | Actual Output | Status (FAIL/PASS) |
|-----------|---------------------------------|-------|-----------------|---------------|--------------------|
| A1        | Sentence Segmentation           |       |                 |               |                    |
| A2        | Word Tokenization               |       |                 |               |                    |
| A3        | Punctuation and Symbols Removal |       |                 |               |                    |

Asia Pacific UniversityProject Specification Form (PSF)

|    |  |  |  |  |  |
|----|--|--|--|--|--|
| A4 | Stop Words Deletion                    |  |  |  |  |
| A5 | Split Dataset into Train and Test Data |  |  |  |  |
| A6 | Sentiment Score Calculation            |  |  |  |  |
| A7 | Data Visualization                     |  |  |  |  |

**Model Performance Testing**

Model performance testing is carried out to evaluate the machine learning classification model in terms of its precision, accuracy, and performance. While developing machine learning model, the input dataset will be divided into three categories that are training data (80%), validation data (10%) and test data (10%). Training data will be used to actually train the machine learning model, validation data will be applied to improve the performance of model, and the test data is utilized for final evaluation of model to produce the actual accuracy of the model. Some of the techniques used for model performance testing includes precision recall, confusion matrix, F-score, and others. The developer decided to implement confusion matrix for model performance testing. There are four cases included in the matrix: true negative, true positive, false negative and false positive. The detailed explanation for each test case is shown as below:

**True Negative:** The output/prediction of the model is “No”, and the real/actual value is “No”

**True Positive:** The output/prediction of the model is “Yes”, and the real/actual value is “Yes”

**False Negative:** The output/prediction of the model is “No”, and the real/actual value is “Yes”

**False Positive:** The output/prediction of the model is “Yes”, and the real/actual value is “No”

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The confusion matrix template for the proposed sentiment analysis machine learning model is shown as following:

| N = number of predictions | <b>Actual: No</b>   | <b>Actual: Yes</b>  |
|---------------------------|---------------------|---------------------|
| <b>Predicted: No</b>      | True Negative (TN)  | False Positive (FP) |
| <b>Predicted: Yes</b>     | False Negative (FN) | True Positive (TP)  |

Confusion matrix is able to produce the various calculation for evaluating the machine learning mode. The formulas for each calculation are provided below:

**Classification Accuracy:**  $(TP+TN) \div (TP+FP+FN+TN)$

**Misclassification Rate:**  $(FP+FN) \div (TP+FP+FN+TN)$

**Precision:**  $TP \div (TP+FP)$

**Product Review Analysis System****Success Criteria**

The proposed product review analysis system is a platform for connecting e-commerce business and customer. Its primary goal is to allow existing customer to leave their review on a specific product and let e-commerce business and potential customer to observe the polarity percentage of product reviews according to the product characteristics in order to assist in their decision-making process. The sentiment analysis machine learning model is embedded inside the proposed system to provide insight into existing customer's feedback, analyze the customer's sentiment for a specific product's characteristics, and display the analysis result on the product review page with graphical representation and their contained percentages. The product review analysis system should be able to communicate with the machine learning model successfully by sending the product reviews and receiving the polarity of the reviews. To produce a bug-free web application, various test cases will be conducted before the deployment of the application in the real world. During the testing process, the target users who are Malaysian, Asia Pacific University students, lecturers, and administrations will be invited to carry out the testing.

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**Unit Testing**

The unit test template for the proposed product review analysis system is shown as following:

| Test Case | User Type           | Scenarios/Description                    | Test Step | Expected Output | Actual Output | Status (FAIL/PASS) |
|-----------|---------------------|--|-----------|-----------------|---------------|--------------------|
| B1        | All user            | Register                                 |           |                 |               |                    |
| B2        | All user            | Login                                    |           |                 |               |                    |
| B3        | E-commerce business | Add a new product                        |           |                 |               |                    |
| B4        | E-commerce business | Modify product tag title                 |           |                 |               |                    |
| B5        | All user            | Filter product reviews with their titles |           |                 |               |                    |
| B6        | Existing customer   | Write a product review                   |           |                 |               |                    |

**User Acceptance Testing**

User acceptance testing is implemented to examine the final product's acceptability. During this phase, the testers, end-users, or clients will be invited to make sure that the application has met the predefined requirements collected through the data gathering techniques, such as surveys and questionnaires. The user acceptance test template for the proposed product review analysis system is shown as following:

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## USER ACCEPTANCE TESTING

Tester Name: \_\_\_\_\_

Date: \_\_\_\_\_

Occupation: \_\_\_\_\_

Signature: \_\_\_\_\_

*Instruction: Please select your answer with a ✓ symbol for the following criteria:*

| Criteria   | Poor | Fair |   | Good |   | Very Good |   | Excellent |   |   |
|--|------|------|---|------|---|-----------|---|-----------|---|---|
|  |      | 1    | 2 | 3    | 4 | 5         | 6 | 7         | 8 | 9 |
| Accuracy of Machine Learning Model                         |      |      |   |      |   |           |   |           |   |   |
| Precision of Machine Learning Model                        |      |      |   |      |   |           |   |           |   |   |
| Performance of Machine Learning Model                      |      |      |   |      |   |           |   |           |   |   |
| Attractiveness of Product Review Analysis System Interface |      |      |   |      |   |           |   |           |   |   |
| Navigation of Product Review Analysis System               |      |      |   |      |   |           |   |           |   |   |
| User Friendliness of Product Review Analysis System        |      |      |   |      |   |           |   |           |   |   |
| Usefulness of Product Review Analysis System               |      |      |   |      |   |           |   |           |   |   |
| Other suggestion/comments from tester:                     |      |      |   |      |   |           |   |           |   |   |
|  |      |      |   |      |   |           |   |           |   |   |

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Written by: Lew Jun Long

Asia Pacific University

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Written by: Lew Jun Long

## Ethics Form

|                   |                                       |
|-------------------|---------------------------------------|
| Office Record     | Receipt – Fast-Track Ethical Approval |
| Date Received:    | Student name:                         |
| Received by whom: | Student number:                       |
|                   | Received by:                          |
|                   | Date:                                 |

| APU / APIIT FAST-TRACK ETHICAL APPROVAL FORM (STUDENTS)  |  |
|--|--|
| <p>Tick one box (level of study):</p> <p><input type="checkbox"/> POSTGRADUATE (PhD / MPhil / Masters)<br/> <input checked="" type="checkbox"/> UNDERGRADUATE (Bachelors degree)<br/> <input type="checkbox"/> FOUNDATION / DIPLOMA / Other categories</p>   | <p>Tick one box (purpose of approval):</p> <p><input checked="" type="checkbox"/> Thesis / Dissertation / FYP project<br/> <input type="checkbox"/> Module assignment<br/> <input type="checkbox"/> Other: _____</p> |
| <p>Title of Programme on which enrolled ... ... ... <u>B.Sc. (Hons) Computer Science (Intelligent Systems)</u> ... ...</p> <p>Tick one box: <input checked="" type="checkbox"/> Full-Time Study or <input type="checkbox"/> Part-Time Study</p> <p>Title of project / assignment ... ... ... <u>Sentiment Analysis of Product Reviews using Machine Learning</u> ... ...</p> <p>Name of student researcher ... ... ... <u>Lew Jun Long</u> ... ... ...</p> <p>Name of supervisor / lecturer... ... ... <u>Assoc. Prof. Dr Imran Medi</u> ... ... ...</p> |  |

**Student Researchers- please note that certain professional organisations have ethical guidelines that you may need to consult when completing this form.**

**Supervisors/Module Lecturers - please seek guidance from the Chair of the APU Research Ethics Committee if you are uncertain about any ethical issue arising from this application.**

|   |   | YES                                 | NO | N/A |
|---|---|-------------------------------------|----|-----|
| 1 | Will you describe the main procedures to participants in advance, so that they are informed about what to expect?                                   | <input checked="" type="checkbox"/> |    |     |
| 2 | Will you tell participants that their participation is voluntary?   | <input checked="" type="checkbox"/> |    |     |
| 3 | Will you obtain written consent for participation?  | <input checked="" type="checkbox"/> |    |     |
| 4 | If the research is observational, will you ask participants for their consent to being observed?  | <input checked="" type="checkbox"/> |    |     |
| 5 | Will you tell participants that they may withdraw from the research at any time and for any reason?   | <input checked="" type="checkbox"/> |    |     |
| 6 | With questionnaires and interviews will you give participants the option of omitting questions they do not want to answer?                          | <input checked="" type="checkbox"/> |    |     |
| 7 | Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs? | <input checked="" type="checkbox"/> |    |     |
| 8 | Will you give participants the opportunity to be debriefed i.e. to find out more about the study and its results?                                   | <input checked="" type="checkbox"/> |    |     |

If you have ticked **No** to any of Q1-8 you should complete the full Ethics Approval Form.

|    |   | YES | NO                                  | N/A |
|----|---|-----|-------------------------------------|-----|
| 9  | Will your project/assignment deliberately mislead participants in any way?  |     | <input checked="" type="checkbox"/> |     |
| 10 | Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort? |     | <input checked="" type="checkbox"/> |     |
| 11 | Is the nature of the research such that contentious or sensitive issues might be involved?                            |     | <input checked="" type="checkbox"/> |     |

If you have ticked **Yes** to 9, 10 or 11 you should complete the full Ethics Approval Form. In relation to question 10 this should include details of what you will tell participants to do if they should experience any problems (e.g. who they can contact for help). You may also need to consider risk assessment issues.

|    |   | YES  | NO | N/A |
|----|---|--|----|-----|
| 12 | Does your project/assignment involve work with animals?   |  | ✓  |     |
| 13 | Do participants fall into any of the following special groups?<br><br>Note that you may also need to obtain satisfactory clearance from the relevant authorities  | Children (under 18 years of age)<br>People with communication or learning difficulties<br>Patients<br>People in custody<br>People who could be regarded as vulnerable<br>People engaged in illegal activities ( eg drug taking ) | ✓  |     |
| 14 | Does the project/assignment involve external funding or external collaboration where the funding body or external collaborative partner requires the University to provide evidence that the project/assignment had been subject to ethical scrutiny? |  | ✓  |     |

If you have ticked Yes to 12, 13 or 14 you should complete the full Ethics Approval Form. There is an obligation on student and supervisor to bring to the attention of the APU Research Ethics Committee any issues with ethical implications not clearly covered by the above checklist.

#### STUDENT RESEARCHER

Provide in the boxes below (plus any other appended details) information required in support of your application, THEN SIGN THE FORM.

#### Please Tick Boxes

|   |   |
|---|---|
| I consider that this project/assignment has no significant ethical implications requiring a full ethics submission to the APU Research Ethics Committee.  | ✓ |
| Give a brief description of participants and procedure (methods, tests used etc) in up to 150 words.<br><br>The data collection method that will be implemented for this project to determine the system requirement is a questionnaire. The set of questions is designed in Google Form to collect the data. The target survey participants are the general population who have used online shopping platforms. The planned number of respondents for this questionnaire is around 100 persons. This survey will be shared via Google Form URL to the public through communication platforms, such as Microsoft Team, WhatsApp, Instagram, and others. |   |
| I also confirm that:<br>i) All key documents e.g. consent form, information sheet, questionnaire/interview are appended to this application.<br><br>Or<br>ii) Any key documents e.g. consent form, information sheet, questionnaire/interview schedules which need to be finalised following initial investigations will be submitted for approval by the project/assignment supervisor/module lecturer before they are used in primary data collection.  | ✓ |

E-signature.....  Print Name..... Lew Jun Long Date... 18/7/2022 ...  
(Student Researcher)

**Please note that any variation to that contained within this document that in any way affects ethical issues of the stated research requires the appending of new ethical details. New ethical consent may need to be sought.**

The completed form (and any attachments) should be submitted for consideration by your Supervisor/Module Lecturer

**SUPERVISOR/MODULE LECTURER  
PLEASE CONFIRM THE FOLLOWING:**

**Please Tick Box**

|   |                                     |
|---|-------------------------------------|
| I consider that this project/assignment has no significant ethical implications requiring a full ethics submission to the APU Research Ethics Committee   | <input checked="" type="checkbox"/> |
| i) I have checked and approved the key documents required for this proposal (e.g. consent form, information sheet, questionnaire, interview schedule)<br><br>Or<br><br>ii) I have checked and approved draft documents required for this proposal which provide a basis for the preliminary investigations which will inform the main research study. I have informed the student researcher that finalised and additional documents (e.g. consent form, information sheet, questionnaire, interview schedule) must be submitted for approval by me before they are used for primary data collection. | <input checked="" type="checkbox"/> |
|   |                                     |

**SUPERVISOR AND SECOND ACADEMIC SIGNATORY**

**STATEMENT OF ETHICAL APPROVAL (please delete as appropriate)**

- 1) THIS PROJECT/ASSIGNMENT HAS BEEN CONSIDERED USING AGREED APU/SU PROCEDURES AND IS NOW APPROVED
- 2) THIS PROJECT/ASSIGNMENT HAS BEEN APPROVED IN PRINCIPLE AS INVOLVING NO SIGNIFICANT ETHICAL IMPLICATIONS, BUT FINAL APPROVAL FOR DATA COLLECTION IS SUBJECT TO THE SUBMISSION OF KEY DOCUMENTS FOR APPROVAL BY SUPERVISOR (see Appendix A)

E-signature ... *Imran Medi* ... ... Print Name... ... Assoc. Prof. Dr Imran Medi ... ... Date... 29/7/2022  
(Supervisor/Lecturer)

E-signature... ... ... ... ... Print Name... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...  
(Second Academic Signatory)

|                   |   |
|-------------------|---|
| Office Record     | Receipt – Appendix A (Fast-Track Ethics Form) |
| Date Received:    | Student name:                                 |
| Received by whom: | Student number:<br>Received by:<br>Date:      |

**APPENDIX A  
AUTHORISATION FOR USE OF KEY DOCUMENTS**

**Completion of Appendix A is required when for good reasons key documents are not available when a fast track application is approved by the supervisor/module lecturer and second academic signatory.**

I have now checked and approved all the key documents associated with this proposal e.g. consent form, information sheet, questionnaire, interview schedule

Title of project/assignment... ... ... Sentiment Analysis of Product Reviews using Machine Learning ... ...

.....  
Name of student researcher ... ... ... Lew Jun Long ... ... ...

Student ID: ... ... ... TP059638 ..... Intake: ... ... ... APD3F2205CS(IS) .....

E-signature Imran Medi ... Print Name... ... Assoc. Prof. Dr Imran Medi ... ... Date... 29/7/2022 ...  
(Supervisor/Lecturer)

## Gantt Chart for whole FYP

| ID | Task Name                                 | Duration | Start       | Finish      |
|----|---|----------|-------------|-------------|
| 1  | Project Proposal Form (PPF)               | 12 days  | Mon 23/5/22 | Fri 3/6/22  |
| 2  | Introduction                              | 1 day    | Mon 23/5/22 | Mon 23/5/22 |
| 3  | Problem Statement                         | 2 days   | Tue 24/5/22 | Wed 25/5/22 |
| 4  | Project Aims and Objectives               | 1 day    | Thu 26/5/22 | Thu 26/5/22 |
| 5  | Literature Review                         | 4 days   | Fri 27/5/22 | Mon 30/5/22 |
| 6  | Deliverables                              | 2 days   | Tue 31/5/22 | Wed 1/6/22  |
| 7  | References                                | 1 day    | Thu 2/6/22  | Thu 2/6/22  |
| 8  | Project Specification Form (PSF)          | 27 days  | Mon 6/6/22  | Sat 2/7/22  |
| 9  | Problem Context                           | 1 day    | Mon 6/6/22  | Mon 6/6/22  |
| 10 | Rationale                                 | 3 days   | Tue 7/6/22  | Thu 9/6/22  |
| 11 | Tangible Benefits                         | 1 day    | Fri 10/6/22 | Fri 10/6/22 |
| 12 | Intangible Benefits                       | 1 day    | Sat 11/6/22 | Sat 11/6/22 |
| 13 | Nature of Challenge                       | 3 days   | Sat 11/6/22 | Tue 14/6/22 |
| 14 | Project Aim and Objectives                | 1 day    | Tue 14/6/22 | Wed 15/6/22 |
| 15 | Deliverables                              | 1 day    | Wed 15/6/22 | Thu 16/6/22 |
| 16 | Hardware                                  | 1 day    | Thu 16/6/22 | Fri 17/6/22 |
| 17 | Software                                  | 1 day    | Fri 17/6/22 | Sat 18/6/22 |
| 18 | Documentation and Planning                | 1 day    | Sat 18/6/22 | Sun 19/6/22 |
| 19 | Access of Information/Expert              | 1 day    | Sun 19/6/22 | Mon 20/6/22 |
| 20 | User Involvement                          | 1 day    | Mon 20/6/22 | Tue 21/6/22 |
| 21 | Academic Research being carried out       | 1 day    | Tue 21/6/22 | Wed 22/6/22 |
| 22 | System Development Plan                   | 4 days   | Wed 22/6/22 | Sun 26/6/22 |
| 23 | Evaluation and Test Plan                  | 4 days   | Mon 27/6/22 | Thu 30/6/22 |
| 24 | References                                | 1 day    | Fri 1/7/22  | Fri 1/7/22  |
| 25 | Investigation Report (IR)                 | 38 days  | Mon 4/7/22  | Tue 9/8/22  |
| 26 | Chapter 1: Introduction to the Study      | 5 days   | Mon 4/7/22  | Fri 8/7/22  |
| 27 | Chapter 2: Literature Review              | 12 days  | Sat 9/7/22  | Wed 20/7/22 |
| 28 | Chapter 3: Technical Research             | 5 days   | Thu 21/7/22 | Mon 25/7/22 |
| 29 | Chapter 4: System Development Methodology | 4 days   | Tue 26/7/22 | Fri 29/7/22 |
| 30 | Chapter 5: Research Methods               | 4 days   | Sat 30/7/22 | Tue 2/8/22  |
| 31 | Chapter 6: Requirements Validation        | 5 days   | Wed 3/8/22  | Sun 7/8/22  |
| 32 | Chapter 7: Conclusion and Reflections     | 1 day    | Tue 9/8/22  | Tue 9/8/22  |
| 33 | Final Submission of IR                    | 0 days   | Wed 10/8/22 | Wed 10/8/22 |

