WAITING TIME PREDICTION SYSTEM USING LINEAR REGRESSION METHOD

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

A special thanks to all those who have supported, encouraged and inspired me, especially to my honourable supervisor, beloved family, and friends for all their guidance, love and attention which has made it possible for me to make it up to this point. I also like to thank the final year project (FYP) committees who organised the talks to share and guide the students in developing the project and FYP project.

ABSTRACT

Malaysia now has a wide range of dental facilities. In reality, the number of patients does not decrease because treatment in government clinics is still far less cost than treatment in private clinics. This project is about developing a management queue system that will solve current problems that dental clinics are experiencing, especially government clinics. In this study, prediction systems using 2 machine learning techniques, Linear Regression and Random Forest were developed and analysed to overcome this difficult scenario. This model was developed in Python using Jupyter Notebook. To examine the performance of this machine learning technique, the regression metrics Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) were used. A previously selected dataset from dental clinics was used to predict the duration of queueing in real life for this method. As a result, the RMSE and MAE values were shown in a table result, and Linear Regression has lower RMSE and MAE values than Random Forest, indicating a good machine learning performance model. The dataset's waiting time is displayed in minutes by developing a graphical user interface (GUI).

ABSTRAK

Malaysia kini mempunyai pelbagai kemudahan pergigian. Realitinya, bilangan pesakit tidak berkurangan kerana rawatan di klinik kerajaan masih jauh lebih murah berbanding rawatan di klinik swasta. Projek ini adalah untuk membangunkan sistem barisan pengurusan yang akan menyelesaikan masalah semasa yang dialami oleh klinik pergigian, terutamanya klinik kerajaan. Dalam kajian ini, sistem ramalan menggunakan 2 teknik pembelajaran mesin, Regresi Linear dan Hutan Rawak telah dibangunkan dan dianalisis untuk mengatasi senario sukar ini. Model ini dibangunkan dalam Python menggunakan Jupyter Notebook. Untuk mengkaji prestasi teknik pembelajaran mesin ini, metrik regresi Root Mean Square Error (RMSE) dan Mean Absolute Error (MAE) telah digunakan. Set data yang dipilih sebelum ini daripada klinik pergigian telah digunakan untuk meramalkan tempoh beratur dalam kehidupan sebenar untuk kaedah ini. Hasilnya, nilai RMSE dan MAE telah ditunjukkan dalam jadual hasil, dan Regresi Linear mempunyai nilai RMSE dan MAE yang lebih rendah daripada Hutan Rawak, menunjukkan model prestasi pembelajaran mesin yang baik. Masa menunggu set data telah dipaparkan dalam minit dengan mencipta antara muka pengguna grafik (GUI).

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LIST OF SYMBOLS AND ABBREVIATIONS

RMSE	:	Root Mean Square Error
MAE	:	Mean Absolute Error
R2	:	R-Squared
GUI	:	Graphical User Interface
ETA	:	Estimate Time of Arriving
ANN	:	Artificial Neural Network
KNN	:	K-Nearest Neighbors
GBM	:	Gradient Boosting Machine
CART	:	Classification and Regression Tree
SVM	:	Support Vector Machine
SDG	:	Sustainable Development Goals
ML	:	Machine Learning
AI	:	Artificial Intelligence

CHAPTER 1

INTRODUCTION

This chapter will discuss more in detail the project in the general background, problem statement, objectives, the scope of the project and project significant.

1.1 Project Background

Over the years, waiting in line has become one of the most inconvenient tasks all over the world. Queues are something that almost everyone experiences regularly. Queues are common in our daily lives and are a part of services, such as waiting for treatment in a clinic, waiting for groceries, waiting for cash out at an automated teller machine (ATM), and so on. Queuing issues also arise when multiple customers require a source of information and the service is unable to fulfil the level of demand. Nowadays, technology is rapidly advancing in all fields, including healthcare. The clinic's system's development will lead to better medical equipment and reduced complexity.

Following that, Malaysia has a variety of dental clinics. People who are sick will go to dental clinics, especially government clinics. The main reason why some people prefer to seek treatment at government clinics is that the cost of treatment is lower than in private clinics. However, the number of patients is not reducing even during the Covid-19 pandemic. While waiting for treatment, a patient has a lack of information about the waiting time to get treatment and unexpected delays that can be highly frustrating in a stressful environment.

Practically, government dental clinics in Melaka are still using the traditional queue system, which is the take number system. Typically, the patient must wait up, register, and then receive a ticket queue. The time difference between treatments would not be consistent since the medical management would differ. The time is determined by the doctor, which estimates how much time is required to complete each treatment, such as consultation, treatment, follow-up appointments, and so on. Nowadays, in waiting time prediction, artificial intelligence is used to estimate the patient's waiting time by employing a variety of machine learning techniques and comparing which model technique is particularly well suited.

The purpose of this project is to predict patient’s waiting times at the dental clinics. Hence, the development of Machine Learning in clinic management gives an effective and well-organised queueing process. Machine Learning is a sort of artificial intelligence (AI) that enables software applications to become more accurate at predicting outcomes without explicitly programming them to do so. Linear Regression is a machine learning approach that uses a straight line to estimate the relationship between the independent variable (input) and the dependent variable (predict). As previously stated, the data from Klinik Pergigian Alor Gajah in Melaka was used to develop this system. This study helps in time estimation and attempts to reduce waiting times in dental clinics, hence reducing crowds. Patients are given an estimated time for treatment so that they can effectively manage their time while waiting.

1.2 Problem Statement

Government clinics are crowded places where people will come every day since the cost of treatment in government clinics is much cheaper than in private clinics. They must deal with the long delay at the same time. If we are physically and emotionally stable, the waiting period would be normal. When it comes to the patient, things go in the opposite direction. Patients are mentally and physically unstable, as well as weak. Usually, the waiting area is crowded, and patients are asked to stand nearby or sit in a different place and come after a few minutes to check on their turn. It is difficult for the patient to move anywhere, and there is no way to estimate the waiting time for new cases, appointments, follow-ups, and other treatments.

Nowadays, our government is implementing a social distancing environment, where the waiting area is no longer enough space for all the patients. The covid-19 pandemic has made the situation worsen to the government hospitals are facing an unexpected number of patients. A web application is one of the latest technologies that can browse or read the pages, fill out forms, register for participating in transactions, and download and save the pages. Unfortunately, it must have a good internet connection to access it and also it will use the money to purchase the data connection to access the internet. If the website has some problems, it will also affect the website in web applications. It is pretty troublesome for the patients.

1.3 Objectives

The main objectives of this project are :

i. To develop a time prediction system using the linear regression method.

ii. To design a Graphical User Interface (GUI) that is much easier for the user to interact with it.

1.4 Scope of Project

This project aims to develop a queue system that will assist to predict waiting times in dental clinics. This project comprises Python Programming with the machine learning library for Python language. It consists of various algorithms and supports scientific libraries. Data pre-processing is the procedure for preparing suitable raw data in a machine learning model. Then, the dataset is normalised so that the dataset's variables lie within a specific range before splitting into training, and testing datasets. Linear Regression, one type of machine learning model algorithm is applied in this work. The performance of the prediction models is evaluated by computing the regression metrics: Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE). The important parameters are also identified and proposed with the best prediction model. Lastly, the development of GUI for the system is also be done for easy access to the dental clinic.

1.5 Project Significant

The objective of this project is to develop a time prediction system using the linear regression method. This is because linear regression is a much simpler technique than other machine learning techniques. It improves the estimation technique and, more crucially, these techniques have simple equations and an easy-to-understand interpretation on a modular level. Second, the objective of this project is to design a graphical user interface (GUI). This project makes it much easier for the user to engage with it, such as inserting data into the GUI using the instructions provided.

This project has the opportunity of commercialization because this system can be used in any clinic. This system is easier for patients to know the expected time to get their treatment from the doctor. A GUI has a simple design and is much easier to use. The user does not need to understand everything inside the GUI, such as data cleaning, data splitting, machine learning model error and accuracy, and so on.

CHAPTER 2

BACKGROUND STUDY

This chapter describes the phenomenon of queuing that happened not necessarily at the dental clinic but in other healthcare too. The literature related to the queueing waiting time system that used machine learning to predict the time of waiting lines. It is then followed by the type of machine learning used to improve the waiting time system.

2.1 Queueing System

Queuing is a common activity that people experience in their daily lives. Queue occurs when the demand for a service exceeds the total supply [1]. In our lives, we spend our time queuing up to meet our needs, even if it consumes much time. A queue is a waiting time that starts from when the customers get their number until they enter the consultation room for examination [2]. This scenario was likely to occur in healthcare sectors such as hospitals and clinics with higher customer presence. The customer or patient needs to wait for their number to be called up, where the numbers will be displayed and voiced out. Regardless of their level of health conditions, they will be gathered in a specific area or waiting room together with a printed slip paper while waiting for their turn to be called up. This will cause the waiting area to be bustled and uncomfortable.

Based on Ministry of Health Malaysia policies [2], the standard of waiting time for outpatients to get a consultation from a doctor is within 30 minutes except for emergency cases. A study found that in 21 hospitals in Malaysia, the average waiting time for the outpatient department to see a doctor is one hour, and they need to wait for another hour to take their medicine [3]. While a study has analysed that the waiting time to get a consultant from a doctor more than 2 hours will lead to patient dissatisfaction, thus affecting the hospital or clinic performance [4]. Such a result was interpreted where many factors contribute to patient dissatisfaction and clinic performance, such as lack of physicians, staff, facilities, etc. Figure 2.1 shows the typical hospital queue management system where patients need to wait in the waiting area without going anywhere while waiting for their turn to be called. As a result, they cannot simply go anywhere because they may miss their turn due to a lack of information regarding the queue's progress and, at the same time, their time was simply wasted. Therefore, the waiting time in healthcare needs to be improved to provide convenient services to the patient.

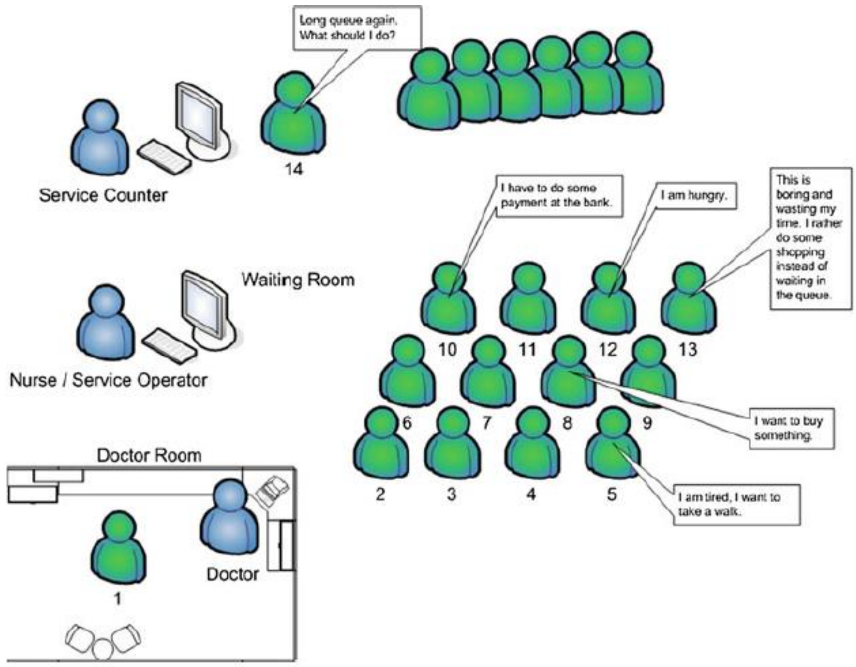

Figure 2.1: Hospital Queue Management System [5]

In order to enhance the traditional physical queue at the hospital, Hospital Service Queue System has been proposed [5]. This system aimed to help the public hospital that suffers from long queues. The system managed the hospital queue online, where customers, patients and stakeholders could access their queues remotely via a web application. The advantage of this system is that it allows people to monitor their queuing status and provides estimated time services through their smartphone via internet access. However, the proposed system not has been tested for real data thus, there was no experimental result reported.

Naim et.al [6], have proposed a push notification mobile application to alert the user when their number is called through the mobile device. The user needs to press the queueing device provided to get the queue number with a printed QR code during the registration at the counter. The push notification is triggered by the web