



Faculty of Engineering

**SMART MEDICATION REMINDER SYSTEM FOR
PATIENT USING INTERNET OF THINGS**

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Bachelor of Engineering

Electrical and Electronics Engineering with Honours

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UNIVERSITI MALAYSIA SARAWAK

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Final Year Project Report

Masters

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**SMART MEDICATION REMINDER SYSTEM FOR
PATIENT USING INTERNET OF THINGS**

MYRELL NICOLE ROLAND

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering
Electrical and Electronics Engineering with Honours

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ABSTRACT

Medication adherence has grown into an important issue with the fast pace of modern living, often resulting in forgetfulness and failing to comply with recommended therapy schedules. This problem has been shown to have a negative impact on patient recovery time and overall treatments performance. Simple approaches, including electronic reminders, have demonstrated potential in improving adherence to medicines. However, current approaches of monitoring patient medication adherence rely mainly upon patient self-reporting or manual recording methods, which lack precision and real-time data on consumption time. The objective of this research project is to develop a smart medication reminder system that solves those patient compliance problems. There are three objectives to this project. First, existing medication reminder systems will be investigated to learn more regarding their capabilities and constraints. Secondly, a contrast study will be conducted to evaluate the feasibility of the proposed smart medication reminder system in comparing to existing approaches. Moreover, a user-friendly and effective smart pill box will be designed, which will be integrated with the Blynk platform and a mobile application in order to provide patients with a comprehensive medication reminder system. This system designed using Arduino IDE, Android Studio and Blynk platform. As a result, the proposed approach aims to improve patient adherence by giving appropriate and timely medication while also allowing caregivers to monitor medication adherence. This complete strategy is expected to improve health outcomes, ways of life, and overall standard of life for patients. Therefore, this research will bring an innovative approach to the issues associated with medication adherence, ultimately helping patients as well as doctors.

ABSTRAK

Kepatuhan pengambilan ubat telah menjadi isu penting dalam kehidupan moden yang pantas ini kerana sering kali mengakibatkan pesakit lupa dan gagal untuk mematuhi jadual pengambilan ubat yang telah disyorkan oleh doktor. Masalah ini telah memberi kesan negatif terhadap masa pemulihan pesakit dan prestasi rawatan secara keseluruhan. Pendekatan yang mudah, seperti alat elektronik untuk mengingatkan pesakit untuk mengambil ubat telah menunjukkan potensi dalam meningkatkan kepatuhan dalam pengambilan ubat. Walaubagaimanapun, pendekatan semasa dalam memantau kepatuhan pesakit untuk mengambil ubat hanya bergantung kepada laporan sendiri pesakit atau kaedah perekodan manual, yang kurang tepat dan tidak memberikan data masa pengambilan secara langsung. Penyelidikan dalam projek akhir tahun ini adalah untuk mempelajari dan menambah baik sistem peringatan pengambilan ubat yang dapat menyelesaikan masalah kepatuhan pengambilan ubat di kalangan pesakit. Terdapat tiga objektif utama dalam projek ini. Pertama, sistem peringatan pengambilan ubat sedia ada akan diselidik untuk mempelajari keupayaan dan batasannya. Selain itu, kajian perbandingan akan dijalankan untuk menilai kebolehpercayaan sistem peringatan pengambilan ubat yang akan dikemukakan berbanding pendekatan sedia ada. Akhir sekali, kotak ubat pintar yang mesra pengguna dan berkesan akan direka bentuk, yang akan diintegrasikan dengan platform Blynk dan aplikasi mudah alih dalam telefon pintar untuk memberikan pesakit dengan sistem peringatan pengambilan ubat yang menyeluruh. Sistem ini direka menggunakan Arduino IDE, Android Studio dan platform Blynk. Oleh itu, pendekatan yang dicadangkan bertujuan untuk meningkatkan kepatuhan pesakit dengan memberikan pengambilan ubat yang betul dan tepat pada waktunya, sambil membolehkan penjaga mengawasi kepatuhan pengambilan ubat. Strategi menyeluruh ini dijangka meningkatkan hasil kesihatan, gaya hidup, dan tahap kualiti hidup secara keseluruhan bagi pesakit. Justeru itu, penyelidikan ini akan membawa pendekatan inovatif kepada isu-isu yang berkaitan dengan kepatuhan pengambilan ubat, yang pada akhirnya akan membantu pesakit dan doktor.

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LIST OF ABBREVIATIONS

WHO	:	World Health Organization
IoT	:	Internet of Things
ChDS	:	Chronic Diseases
IR sensor	:	Infrared sensor
LED	:	Light Emitting Diode
CDC	:	Centres for Disease Control and Prevention
QR code	:	Quick Response Code
SMS	:	Short Message Service
GSM	:	Global System for Mobile communication

CHAPTER 1

INTRODUCTION

1.1 Background of study

According to a World Health Organization (WHO) 2003 report, the average medication adherence among patients with chronic illnesses in developing countries is just 50%, and it will be substantially lower due to a shortage of health resources and inequality in receiving healthcare [1]. Adherence is an important aspect in the success of all pharmacological therapy, but it is especially important for medication recommended for chronic conditions. Poor or insufficient medication adherence has a negative impact on patient health and even contributes to medication wastage through overdose, leading to relapses and re-hospitalizations, as well as increasing resistance to medications and making it harder for doctors to assess the efficiency of treatment toward them [2].

As a result of the importance of medication adherence for patients, many technologies, such as applications on mobile phones, have been introduced as a solution to this problem [3]. In fact, research has shown that applications on mobile phones can be used as a medium to remind patients to take their medicine due to its high penetration, adoption, and availability, as well as its ease of access and connection [3]. Therefore, improving medication adherence is more focused on patients who live at home and excludes those who are in care centres because their medications are professionally managed by caregivers [4]. Medication adherence is complex and multifaceted, posing several critical challenges for healthcare professionals, patients, and caregivers, including assessing current levels of medication adherence and improving medication adherence while maintaining levels of adherence for long-term or chronic conditions [4].

Nowadays, Internet of Things (IoT) is used in a variety of applications to make people's lives easier. Figure 1.1 illustrates the use of IoT in various contexts. The Internet of Things (IoT) is a network of devices that send data into a platform and are equipped with a sensor and software to enable communication with automated control through the

internet. It has become one of the most important technologies of the 21st century because it connects the physical and digital worlds. Furthermore, many captivating medical IoT applications have been used to enhance the end user's experience, such as monitoring health treatment and medication at home and health monitoring systems [5].

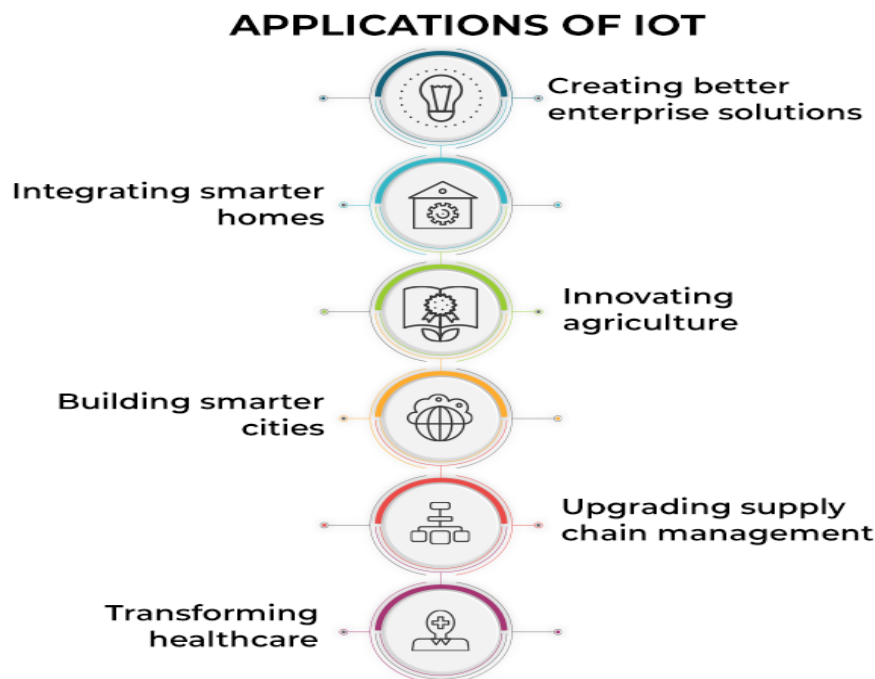


Figure 1.1: The application of IoT

Hence, the project main aim is to study the existing medication reminder system that have been developed and analyse the features of the system. This project also aims on identifying future improvements that can be done to the medication reminder system so the medication adherence can be achieved. Lastly, in this project it will include software and hardware to design a simple and efficient smart medication reminder system using IoT that connected to cloud computing.

1.2 Problem Statement

People easily forget due to busy schedule due brought on by the fast pace of life, especially when it comes to medication adherence. Many people did not take medication on time according to the schedule. In addition, the efficiency of patient treatment depends

on the ability to take their medication prescribed. If this is not considered in their daily life, it will affect to longer recovery time. As previously stated, one of the most common causes of medication adherence is forgetfulness. However, with simple interventions such as electronic reminders, it can be an effective solution for patients who inadvertently do not adhere to medication timing [6].

In other hand, the insufficient monitoring of patient medication adherence. Current measurement methods, medication monitoring for patients can only be measured accurately based on the number of pills taken, but this is insufficient because information about the time of taking medication cannot be provided unless the patient makes a self-report, such as keeping a diary or being questioned [6]. As a result, this method is very biased because it is very simple to implement for measuring medication adherence, but the patient is very likely to forget to record it [6].

Mostly patients with chronic illness such as cancer, heart disease, hypertension and diabetes will depend on the medication as a long-term treatment. Chronic Diseases (ChDs) is an illness that lasts for more than six months, regardless of medication, and results in death or disability [7]. Patients with chronic diseases are frequently associated with poor medication adherence, which can be seen through less effective medication intake, lifestyle changes, and proper diet [7]. Therefore, it is critical for the patient to take the medication at the correct dose and time in order to avoid further declines in the patient's quality of life and even tend to get other diseases.

1.3 Objectives

The purpose of this project is to address the above problems presented as the main factor behind patient non-compliance with medication. The main objectives of this project are listed below.

- i. To study the existing medication reminder systems that have been developed.
- ii. To compare the proposed smart medication reminder system with the existing ones.
- iii. To design a simple and efficient smart medication reminder system for the patient that consist of a smart pillbox connected with Blynk and mobile application in the patient's smartphone.

1.4 Scope

The project is about designing a smart medication reminder system that consist of a mobile application and smart pill box with infrared sensor and the patient's family will receive notification via Blynk application to monitor the medication adherence of the patient.

The system consists of two components, which are the smart pill box connected with Blynk and a simple mobile application on the patient's smartphone. The smart pill box has seven days compartment (Monday-Sunday) and each compartment will have an infrared (IR) sensor. An infrared sensor is a type of electronic devices that produces light to detect objects in its vicinity. A sensor with infrared wavelengths can detect motion as well as measure an object's heat. The application in the smartphone will store the database of the patient and the Blynk application connected to it. The data store in the cloud can be access by the patient's family to follow up the medication adherence of the patient.

The goal of this project is to propose and build an IoT-based smart medication reminder system for patients. Additionally, it also involves researching and comparing existing medication reminder systems to the proposed solution in order to improve medication adherence and patient outcomes.

1.5 Thesis Outline

This report is divided into five chapters. The Introduction is the first chapter, followed by the Literature Review and the Methodology. The two chapters following the Methodology are the Result and Discussion, followed by the Conclusion and Recommendation.

Chapter 1 which is the Introduction contains the following sections: background of study, problem statement, objectives and scope of project.

Meanwhile for the Chapter 2 comprises the literature review of the existing medication reminder system and how the features of system operate in maintaining medication adherence among the patients.

Next, Chapter 3 explains the project methodology which includes the project materials such as software and hardware use to develop the proposed smart medication reminder system with the proposed approach and general workflow of the project.

For Chapter 4, the outcomes of the proposed project design are discussed in detail, as well as the benefits and constraints.

Finally, Chapter 5 summarizes the proposed system's conclusion and provides additional recommendations.

Chapter 2

LITERATURE REVIEW

2.1 Overview

This chapter will discuss the related study about the Smart Medication Reminder System for Patients using Internet of Things (IoT). Furthermore, the terms of patient and medication adherence will be explained deeply in this chapter. These studies' information will be gathered and used for this project.

2.2 Definition of Patient

According to [8], a patient is an individual who receives medical treatment and who receives medical treatment for by a doctor or other medical professional when required. This also includes anyone who requires or receives health-care services, whether in a hospital or clinic. Patients might show up with a variety of illnesses, ailments, or trauma, requiring doctors to diagnose and treat their medical difficulties. Patients commonly take medication as part of their medical treatment. Doctors may prescribe medications to treat a wide range of ailments, illnesses, infections, and long-term diseases. Medications can be taken orally as tablets, capsules, or liquids, or through injections, patches, inhalers, or various other procedures dependent on the specific requirements of the patient as well as the kind of medication provided. When taking medications, patients must adhere to the specified doses and instructions supplied by doctors and nurses.

2.3 Medication Adherence among the Patient

As stated in a previous study, medication adherence can be defined as the act of taking medication as prescribed and in the recommended dosage at the appointed time determined by the Doctor or Pharmacist [3]. According to previous research, medication adherence is critical to the patient's well-being and safety [3]. The literature also stated that the rate of poor medication adherence ranges from 20% to 50% [3]. Some people do not take their medication for a variety of reasons, including forgetfulness (30%), other priorities (16%), a lack of information, and emotional factors (7%) [4]. Based on the percentages mentioned previously, forgetfulness was the primary reason why some patients did not take their medication on time.

Medications are commonly used to treat chronic health problems and increase life expectancy [9]. Chronic disease is the leading cause of death worldwide, lasting a year or more and necessitating ongoing medical care [10]. According to the Centres for Disease Control and Prevention (CDC), six out of all ten adults have a chronic disease, and four out of every ten adults have two or more chronic diseases [10]. Based on the World Organization Health (WHO) 2018, 41 million patients with chronic diseases die each year, accounting for 71% of all deaths worldwide [11]. Every year, 15 million patients aged 30 to 69 years old who suffer from chronic diseases die, with 85% of these deaths occurring in multiple countries [11].

Patients with chronic diseases are more likely to have complicated medication compliance due to the large number of medications that must be taken. This is because the complexity of the regimen, multiple medications, and pill burden, including the amount of tablets, frequency of administration and scheduling challenges, medication difficulty and friendliness, are all related to lower adherence in chronic disease patients [12]. Adherence to this medication is critical, but it must be examined from multiple perspectives to avoid the occurrence of things that can affect medication adherence in patients suffering from chronic diseases.

Patient adherence to medication regimens remains a major issue in almost all medical specialties, patient populations, and health conditions that have a significant impact on treatment outcomes. It will not only have an impact on clinical outcomes, but it will also put a financial burden on the patient, as well as reduce productivity and quality of life. There is a scarcity of data on patient treatment satisfaction and its relationship to medication adherence in chronically ill patients in the community [12]. According to study in [12], a total of 259 patients with chronic diseases were included to assess the level of satisfaction and medication adherence in a tertiary care teaching hospital in Kuala Lumpur. In addition, these 259 patients are from various backgrounds and ages. The demographic data for the 259 patients is shown in Table 2.1, with the majority of the patients seeming to be Malay (n=222, 85.7%) and female (n=150, 57.9%). The range age of the participants in this study was between 18 to 84 years old. Almost half of the patients (n=135, 52.3%) had tertiary education and were employed (n=106, 40.9%).

Table 2.1: Demographic Data of the 259 Patients [12]

Characteristics	n=259
Age (mean± SD) (range)	48.02 ± 18.49 (18-84)
No. of medications (mean± SD) (range)	9.12 ± 4.22 (2-18)
Gender, n (%)	
Male	109 (42.1)
Female	150 (57.9)
Race, n (%)	
Malay	222 (85.7)
Chinese	20 (7.7)
Indian	16 (6.2)
Others	1 (0.4)
Education, n (%)	
Primary school	47 (18.2)
Secondary school	76 (29.5)
University	135 (52.3)
Occupation, n (%)	
Employed	106 (40.9)
Unemployed	78 (30.1)
Retired	75 (29.0)

The result from study of the 259 chronic ill patients are shown in Table 2.2. These patients are from different ethnicity, education level and occupation. Based on the Table 2-2, overall the number of patient adherence to the medications is 34, which are 15 males and 19 females (13.13%) out of 259. There are 225 patients who are non-adherent to the medications which include 94 males and 131 females, it was demonstrated that adherent patients had a significantly lower number of medications than non-adherent patients. Meanwhile, according to Table 2.3, approximately half (n=140, 54.1%) of the patients in the study population were satisfied with their medication and admitted that they were satisfied with their medication if they felt that medications were easy to use compared to those who were not satisfied with their medication.

Table 2.2: Characteristic of 259 Patients Based on Level Adherence [12]

Characteristics	Adherent	
	Yes	No
Age (mean± SD)	39.9±218.2	49.2±18.3
No. of medications (mean± SD)	5.6±2.2	9.6±2.1
Gender, n		
Male	15	94
Female	19	131
Ethnicity, n		
Malay	30	192
Chinese	3	17
Indian	1	15
Others	0	1
Education, n		
Primary school	9	38
Secondary school	10	66
University	15	120
Occupation, n		
Employed	5	101
Unemployed	10	68
Retired	19	56