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Sign:

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Declaration B

I confirm that the work reported in this research project was carried out by the candidate under my supervision and it has been submitted with our approval as Supervisor from ULK POLYTECHNIC INSTITUTE.

Supervisor Names: JEAN PIERRE MUSABYIMANA

Signature ………………

Date: …………………….

APPROVAL SHEET

This research project entitled "IoT Pill Reminder & Dispenser project" prepared and submitted by MWADJUMA MUKANKAKA in partial fulfillment of the requirements for the award of Advanced Diploma (A1) has been examined and approved by the panel on oral examination.

NAME:…………………….

SIGN:……………..

DATE:……………..

Dedication

I, dedicate this work to the Almighty Allah

Who helped to go through this and has strengthened me,

To pass whatever wall I couldn’t myself.

To my parents for everything they have done

To all my Lecturers, Friends, Classmates and relatives.

Sincerely to college for the knowledge

They offered to me with much gratitude and respect.

Thanks, and May Allah bless you.

ACKNOWLEDGEMENT

For Almighty Allah, who gave us the strength, abilities and wisdom to be done with this project, for providing good education and advices, through the courses?

To my supervisor for his kindness supervision, advices, encouragements, valuable guidance and precious comments provided to the work.

I would like also to thank the Head of Department for the greatest advices he always provides to us.

To all staffs of the campus for giving we qualified guidance, good teaching so made us who we are today and what we learnt during the development of this final year project and marry this knowledge to real life issues.

Moreover, I would lay to thanks all friends we straggled together don't miss satisfaction to the accomplishment of this work.

14 I would like to thank also all-important people who were supporting me in different cases and their moral advices as well as materials; to all our colleagues to their love that they have shown me and to their kindness and commitment.

I expressing my heartfelt and gratitude to all people who have supported me in order to be successfully in this work.

May the Almighty Allah Bless you.

Table of content

List of figure

Abstract

This project presents an innovative solution aimed at addressing the medication management challenges faced by the aging population in Rwanda through the development of an IoT-based Pill Reminder and Dispenser system. As Rwanda experiences a demographic shift with an increasing elderly population, effective medication adherence has become crucial to enhancing health outcomes and reducing complications. 11 The proposed system integrates interconnected devices embedded with sensors and

software that facilitate real-time monitoring and notification of medication schedules. Key features include a user-friendly smartphone application that allows users to set medication schedules, a pills dispenser equipped with mechanisms for accurate dosage, and multi-channel alerts—such as audio reminders and SMS notifications—ensuring users are prompted [2] to take their medications on time. By incorporating data logging and adherence tracking, caregivers and healthcare professionals can monitor user compliance, thereby optimizing medication management. This project aims to empower elderly individuals to manage their health more effectively, improving their quality of l
ife and independence. The significance of this innovation extends beyond technological advancement; it represents a proactive approach to enhancing healthcare services for vulnerable populations in Rwanda. Ultimately, the IoT Pill Reminder & Dispenser project exemplifies the potential of HealthTech to transform the healthcare landscape, ensuring that no segment of the population is left behind in the journey toward better health.

CHAPTER ONE: GENERAL INTRODUCTION

1.0 Introduction

The aging population in Rwanda faces significant challenges in managing medication adherence, a critical factor for enhancing health outcomes and reducing complications associated with chronic conditions. With a notable demographic shift towards a larger elderly demographic, the need for innovative solutions becomes increasingly pressing. This project proposes an IoT-based Pill Reminder and Dispenser system, designed to empower elderly individuals by facilitating effective medication management. By integrating interconnected devices equipped with sensors and software, the system enables real-time monitoring and timely notifications regarding medication schedules. Key components include a user-friendly web application for setting medication plans, a precise pill dispenser that ensures accurate dosages, and multi-channel alerts—such as audio reminders and SMS notifications—to prompt users to take their medications on time. This holistic approach not only aims to improve adherence and health outcomes for elderly users but also supports caregivers and healthcare professionals in monitoring compliance. Ultimately, this project represents a proactive strategy to enhance healthcare services for vulnerable populations in Rwanda, demonstrating the transformative potential of HealthTech in creating a more inclusive and supportive healthcare environment[1].

1.1 Background of the project

Rwanda, a nation known for its remarkable progress in various sectors, including healthcare, has witnessed a demographic shift with an increasing aging population. As in many other countries, this demographic transition brings forth a set of unique challenges, particularly concerning healthcare management. One of the critical challenges faced by the elderly population is the effective management of their medication regimens. In a country where healthcare resources are valuable and need to be optimally utilized, addressing the issue of medication non-adherence becomes crucial.

Elderly individuals often grapple with the complexity of medication schedules, leading to missed doses or incorrect dosages. These lapses can have profound implications for their health, exacerbating existing medical conditions or triggering new complications. Recognizing this, the "IoT Pill Reminder & Dispenser" project emerges as an innovative response to a pressing healthcare concern.

Rwanda's healthcare landscape, though making significant strides, grapples with limited resources and infrastructure, especially for the aging population. The challenge of medication adherence becomes even more pronounced in this context. This project is not merely a technological endeavor; it's a proactive effort to bridge a gap in healthcare services by leveraging technology to directly impact the lives of those who stand to benefit the most.

The convergence of healthcare and technology, often termed "HealthTech," has opened up new avenues for solving age-old problems. By harnessing the power of the Internet of Things (IoT), this project aims to create a tangible solution that integrates seamlessly into the daily lives of the elderly. The concept of a pill reminder and dispenser system might seem simple on the surface, but its potential to revolutionize healthcare experiences is profound.

The project takes inspiration from Rwanda's commitment to innovation and inclusive growth. As the country endeavors to achieve its healthcare goals, initiatives that prioritize the elderly population align with the broader vision of equitable healthcare access for all citizens. By acknowledging the unique needs and challenges faced by the elderly, this project takes a step towards ensuring that no segment of the population is left behind in the journey towards better health.

In a world where digital transformation is rapidly reshaping various sectors, the "IoT Pill Reminder & Dispenser" project embodies the essence of applying technology with purpose. The goal isn't just to develop a product; it's to develop a lifeline for the elderly, an avenue through which they can navigate their healthcare journeys with confidence. This project is a testament to Rwanda's commitment to progress and its people, serving as an exemplar of how technology can be harnessed for the betterment of society's most vulnerable members.

1.2 Statement of the Problem

The elderly population in Rwanda often faces challenges in adhering to their prescribed medication schedules due to factors like forgetfulness, complex medication regimens, or limited access to timely reminders. These issues frequently lead to missed doses or incorrect dosages, which can have serious consequences, including worsening of health conditions, increased hospitalizations, or adverse reactions from improper medication intake. As a result, there is a pressing need for a reliable and accessible solution to assist elderly individuals in effectively managing their medication. A system that provides reminders and tracks adherence could greatly improve health outcomes, reduce complications, and promote independence among the elderly population.

1.3 Purpose of the project

3 The primary purpose of this study is to design and develop an IoT-based pill reminder and dispenser system that addresses the medication adherence challenges faced by the elderly population in Rwanda. As the aging population increases, effective medication management has become crucial in improving health outcomes, reducing complications from chronic diseases, and enhancing the overall quality of life for older individuals.

4 This study aims to create a solution that leverages interconnected devices, sensors, and software to ensure that elderly users are reminded to take their medications on time through multiple alert channels, such as audio reminders and SMS notifications. The system will also allow for real-time monitoring of medication adherence by caregivers and healthcare providers, providing them with data to optimize patient care and intervention strategies.

In addition, the study seeks to explore how technology, specifically IoT, can be applied to healthcare to support vulnerable populations. The findings from this research will contribute to creating a more inclusive healthcare system in Rwanda, empowering elderly individuals to manage their health independently and effectively, while reducing the burden on caregivers and improving overall public health outcomes.

The primary objectives of this study are centered on developing an IoT-based pill reminder and dispenser system to improve medication management for the elderly population in Rwanda. The first objective is to design and develop a functional prototype that integrates sensors, a smartphone application, and a pill dispensing mechanism to assist elderly users in taking their medications on time. A key focus of the system is to ensure accurate and timely reminders by providing multi-channel alerts, such as audio signals, visual notifications, and SMS reminders, to help users adhere to their medication schedules. Additionally, the study aims to enable real-time monitoring of medication adherence by logging medication intake data, which can be accessed by caregivers or healthcare professionals. This will allow for timely interventions if users fail to take their prescribed doses. Another crucial objective is to ensure that the system is user-friendly and accessible, taking into account the needs of elderly individuals, such as simplicity of operation and intuitive interfaces. Lastly, the study seeks to contribute to the improvement of healthcare services [2] for the elderly in Rwanda by exploring how IoT technology can address the specific challenges they face, ultimately enhancing their health outcomes, independence, and overall quality of life.

1.4 Research Objectives

1.4.1 Main Objectives

The main objective of this project is to develop an IoT-based Pill Reminder and Dispenser system that significantly enhances medication adherence among elderly individuals in Rwanda. As the aging population faces challenges in managing complex medication regimens, this project aims to provide a technological solution that ensures timely and accurate medication intake. By automating reminders and dispensing functions, the system reduces the risk of missed doses or incorrect medication usage, improving overall health outcomes for elderly users.

[2] In addition to the core function of medication reminders, the project also aims to integrate real-time monitoring features that allow caregivers and healthcare professionals to remotely track medication adherence. This ensures that timely interventions can be made if a user fails to take their prescribed doses, which helps prevent potential health complications. Another key focus is the user-friendly design, ensuring the system is accessible and easy to operate, even for elderly individuals with minimal technological experience.

Finally, the project aims to contribute to Rwanda's healthcare system by leveraging IoT technology to address medication management challenges. The system supports the country’s broader efforts to improve healthcare services for its aging population, demonstrating the potential of digital solutions in transforming healthcare delivery and promoting independent, healthy living for the elderly.

1.4.2 Specific Objectives

1) To develop an IoT-based system that allows users to set pill schedules through a web application and to Create a device capable of dispensing the correct number of pills at the specified times.

2) To implement a sound notification on the device to remind users to take their medication and to incorporate an SMS notification system to alert users if they fail to take their pills within 5 minutes of the scheduled time.

3) Focus on user-friendliness and simplicity to cater to the needs of the elderly population in Rwanda.

1.5 Research questions

- How do elderly individuals in Rwanda currently manage their medication schedules, and what are the key factors contributing to missed doses or incorrect dosages?

- What technological solutions (e.g., mobile apps, IoT devices, or wearables) are most suitable for supporting medication management in Rwanda’s elderly population, considering accessibility and ease of use?

- How effective are reminder-based systems (such as alarms, SMS notifications, or smart pill dispensers) in improving medication adherence among elderly individuals?

- What role can caregivers or family members play in assisting elderly individuals with medication management, and how can technology be used to facilitate their involvement?

- What cultural, social, and infrastructure challenges might affect the implementation of a digital or automated medication management system for elderly individuals in rural and urban areas of Rwanda?

1.6 scope of project

2 Designing and developing a web application for users to set their medication schedule and view reports. Creating a physical device using Arduino Nano, ESP866, servo motor, buzzer, LCD display, and push buttons to dispense pills and provide reminders .Integrating the device with the web application to ensure synchronization of medication schedules. Implementing an SMS notification system to send 2 reminders to users in case of missed doses. Conducting user testing and gathering feedback to improve the system's usability.

1.7 significance of project

The IoT-based Pill Reminder and Dispenser project holds significant value for the elderly population in Rwanda, as well as for the broader healthcare system. Its key benefits include:

1. Improved Medication Adherence: By providing automated reminders and accurate pill dispensing, the system helps ensure that elderly individuals take their medications on time and in the correct dosage. This leads to improved adherence, which is crucial for managing chronic diseases and maintaining overall health.

2. Reduced Health Complications: Missed or incorrect doses of medication can result in serious health complications. By minimizing these lapses, the project has the potential to reduce hospitalizations, emergency visits, and other healthcare costs associated with non-adherence.

3. Empowerment of the Elderly: The system promotes independence by allowing elderly users to manage their medication without constant supervision. This enhances their sense of autonomy and improves 2 their quality of life, giving them more control over their health.

4. Support for Caregivers and Healthcare Providers: Through real-time monitoring and data logging, caregivers and healthcare professionals can remotely track medication adherence. This allows them to intervene early when needed, ensuring better patient care and reducing the burden on healthcare workers.

5. Enhanced Safety: The accurate dispensing of medications reduces the risk of underdosing or overdosing, preventing accidental misuse of medications, which is especially important for elderly users who may have difficulty managing complex medication regimens.

6. Contribution to Rwanda’s Healthcare Goals: By leveraging IoT technology, this project aligns with Rwanda’s commitment to innovation and improved healthcare services. It demonstrates the potential of HealthTech to address gaps in healthcare delivery, particularly for vulnerable populations such as the elderly, thereby contributing to a more inclusive healthcare system

1.8. Organization of the project

Normally, this project report consists into five chapters, where it consists:

Chapter 1: is general introduction that provides briefly what is all about on IOT pills Reminder and dispenser, problem statement and objectives of this project are included to give the direction of this project.

Chapter 2: introduces literature review for this project, and it talks about the related studies done for analyzing gap and components which will help to implement Iot Pills Reminder and dispenser.

Chapter 3: introduce the methodology that used on this project and it gives a surface guidance on the description of materials [14] that will be used to implement the project. Block diagram, system flow chart and mathematical model is also available hereof.

Chapter 4: will introduce system design and implementation obtained after implementing the project and their discussions of this project, circuit diagram and its working principle, and web application related data.

Chapters 5: introduce to summary, conclusion and recommendation for this project. It concludes all the works and what we had been presented in previous chapter and all the results of the project. This is followed by for the future study work.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

The integration of technology in healthcare, particularly for the elderly, has become increasingly vital as the aging population faces significant challenges in medication management. Research shows that medication non-adherence, driven by factors such as cognitive decline and complex regimens, affects nearly 50% of patients (WHO, 2003). Recent advancements in HealthTech, especially through the Internet of Things (IoT), have demonstrated the potential to improve adherence rates significantly. Studies indicate that IoT-enabled devices can provide timely reminders, facilitating better medication adherence and health outcomes (Krebs et al., 2016; Dey et al., 2018). Automated pill dispensers have also proven effective in minimizing dosage errors and enhancing user experience, particularly when designed with elderly users in mind (Browne et al., 2017). User-centric design principles highlight the importance of simplicity and accessibility, which are crucial for encouraging technology adoption among older adults (Coughlin et al., 2018). Overall, this literature review underscores the urgent need for innovative solutions that leverage IoT to enhance medication management for the elderly, informing the development of the IoT Pill Reminder & Dispenser project.

2.1 Concepts

The key concepts underpinning this study revolve around the development of an IoT-based pill reminder and dispenser system for elderly individuals in Rwanda. At the core is the Internet of Things (IoT), which refers to a network of physical devices embedded with sensors, software, and internet connectivity that allows them to collect and exchange data. This technology is crucial for creating a smart medication management system where devices like pill dispensers and sensors can communicate with mobile applications, facilitating real-time monitoring and remote interactions with caregivers or healthcare professionals. Another important concept is medication adherence, which involves patients following prescribed medication regimens correctly. This is particularly vital for elderly individuals with chronic conditions, as non-adherence can lead to serious health complications. The proposed system aims to enhance adherence by providing timely reminders and accurate dispensing of medication.

A pill dispenser is central to the system, designed to automatically release medication at specific times, ensuring the correct dose is taken at the right moment. The dispenser will be connected to the IoT network to track dosages and manage medication schedules, reducing errors or missed doses. The concept of multi-channel alerts is also key, as the system will send reminders through various methods, such as audio alerts, visual notifications, and SMS messages, ensuring that users receive reminders in ways that suit their preferences and needs.

Above that, real-time monitoring will allow caregivers and healthcare professionals to remotely track medication intake and intervene if issues arise, such as missed doses. Lastly, user-friendly design is critical, as the system will be tailored to the needs of elderly individuals, ensuring simplicity, intuitive operation, and easy-to-understand notifications. These concepts collectively support the goal of improving medication management, adherence, and overall health outcomes for the aging population in Rwanda.

2. 2 Theoretical perspectives

The development of the IoT-based pill reminder and dispenser system is grounded in several key theoretical perspectives that guide its design and functionality. One of the primary frameworks is the Health Belief Model (HBM), which suggests that individuals are more likely to adhere to health-related behaviors, such as taking medication, if they believe they are at risk of a health issue and recognize the benefits of adherence. The system reinforces this by providing reminders and real-time monitoring, helping users understand the importance of taking their medication on time and the potential consequences of non-adherence..

Additionally, the Socio-Technical Systems Theory emphasizes the interaction between technology and the social context in which it operates. The system is designed not only for elderly users but also for caregivers and healthcare professionals who can monitor medication adherence remotely. By fostering collaboration between these stakeholders, the system improves care and supports better medication management.

Finally, the Aging in Place Theory is relevant to the system's goal of empowering elderly individuals to live independently in their own homes. The IoT-based pill reminder and dispenser supports this by allowing users to manage their medications without constant supervision, while caregivers can remotely monitor their health. This enhances the independence and quality of life for elderly individuals, aligning with the broader goal of enabling them to age in place.

2.3 RELATED STUDY

2.3.1 MOBILE HEALTH APPLICATIONS ON MEDICATION ADHERENCE

Numerous studies have explored the intersection of technology and medication adherence, particularly focusing on the elderly population. One significant study investigated the impact of mobile health applications on medication adherence. The findings indicated that users who received reminders via mobile apps had a notable improvement in adherence rates compared to those who relied solely on traditional methods. This highlights the effectiveness of digital reminders in enhancing health outcomes [1].

2.3.2 Implementation of the IoT-Based Technology on Patient Medication Adherence

Important study examined the role of IoT devices in managing medication schedules. The research demonstrated that IoT-enabled systems, which incorporate features like real-time monitoring and alerts, significantly reduced missed doses among elderly participants. This study underscores the potential of interconnected devices to facilitate better medication management and improve adherence [2].

2.3.3 AUTOMATED PILL DISPENSER

Research focused on automated pill dispensers. The study revealed that these devices not only minimized errors in dosage but also provided reassurance to users by ensuring they received the correct medication at the right time. The ease of use and reliability of these dispensers were particularly emphasized, making them suitable for the elderly demographic [3].

2.3.4 Implementation of the IoT-Based Technology on Patient Medication Adherence

The dynamic field of the Internet of Things (IoT) is constantly increasing, providing a plethora of potential integration across various sectors, most notably healthcare. The IoT represents a significant technological leap in healthcare management systems, coinciding with the rising preference for personalized, proactive, cost-effective treatment techniques. This review aimed to thoroughly assess the existing literature through a systematic review and bibliometric analysis, identifying untapped research routes and possible domains for further exploration. The overarching goal was to provide healthcare professionals with significant insights into the impact of IoT technology on Patient Medication Adherence (PMA) and related outcomes. An extensive review of 314 scientific articles on the deployment of IoT within pharmaceutical care services revealed a rising trend in publication volume, with a significant increase in recent years. Pertinently, from the 33 publications finally selected, substantial data support the potential of the IoT to improve PMA, particularly among senior patients with chronic conditions. This paper also comments on various regularly implemented IoT-based systems, noting their unique benefits and limitations. In conclusion, the critical relevance of PMA is highlighted, arguing for its emphasis in future discussions. Furthermore, the need for additional research endeavors is proposed to face and overcome existing constraints and establish the long-term effectiveness of IoT technologies in maximizing patient outcomes [4].

2.4 LCD Display: The LCD screen provides a clear and concise interface for users, displaying critical 2 information such as the medication schedule, reminders, and system status. Its user-friendly interface aids elderly users in easily understanding when to take their pills.

Figure 2:1 LCD Display

2.5 Servo Motor: The servo motor is responsible for the automated dispensing of pills. It controls the opening mechanism of the dispenser, allowing precise release of the correct dosage at specified times.

Figure 2:2 Servo Motor

2.6 Buzzer: The buzzer serves as an audio alert system, notifying users when it’s time to take their medication. This auditory cue is essential for ensuring that users do not miss their scheduled doses.

Figure 2:3 Buzzer

2.7 ESP8266 Wi-Fi Module: This module enables the IoT capabilities of the system by providing wireless internet connectivity. It facilitates communication between the pill dispenser and a smartphone application, allowing 2 users to set medication schedules and receive alerts remotely.

Figure 2:4 ESP8266 Wi-Fi Module

2.8 Infrared (IR) Sensor: The infrared sensor is utilized to detect when a patient is ready to take their pills. Once the sensor confirms the user's presence, it activates the servo motor to open the dispenser, ensuring a seamless and user-friendly experience.

Figure 2:5 Infrared (IR) Sensor

By integrating these components, the IoT Pill Reminder & Dispenser project aims to create an effective solution that enhances medication adherence for the elderly, ultimately improving their health outcomes and quality of life.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the data collection and analysis procedures that will be employed in this study to evaluate the effectiveness of the IoT-based pill reminder and dispenser system for elderly individuals in Rwanda. Effective data collection and analysis are crucial for drawing valid conclusions and ensuring that the findings are reliable and applicable. The chapter begins by detailing the research design, including the qualitative and quantitative methods that will be utilized to gather data from various stakeholders, including elderly users, caregivers, and healthcare professionals.

3.1 Research Design

The research design for this study adopts a mixed-methods approach, integrating both qualitative and quantitative methodologies to comprehensively evaluate the effectiveness of the IoT-based pill reminder and dispenser system for elderly individuals in Rwanda. The quantitative component will involve structured surveys and questionnaires administered to a sample of elderly users, caregivers, and healthcare professionals. These instruments will gather data on various variables, such as medication adherence rates, user satisfaction regarding the system's perceived usefulness and 3 ease of use, and changes in health outcomes, including any alterations in health status or frequency of hospital visits during the study period. This quantitative data will be analyzed using statistical methods to identify correlations and patterns that indicate the system's effectiveness in improving medication adherence.

By employing this mixed-methods approach, the research design aims to triangulate data from both quantitative and qualitative sources, thereby enhancing 4 the validity and reliability of the findings. This integration will allow for a more comprehensive understanding of 2 the impact of the IoT-based pill reminder and dispenser system on medication adherence among elderly individuals in Rwanda, ultimately contributing to the development of more effective healthcare solutions for this vulnerable population.

3.2 Research Population

The research population for this study will primarily consist of elderly individuals aged 60 and above, along with their caregivers and healthcare professionals involved in their care. This demographic is particularly significant due to the increasing aging population in Rwanda, which faces unique challenges in medication management.

Elderly Individuals: The primary focus will be on elderly users who are managing chronic health conditions that require regular medication. Participants will be recruited from various healthcare facilities, community centers, and senior citizen organizations across Rwanda to ensure a diverse representation of different socio-economic backgrounds, health statuses, and medication needs. This will provide insights into the specific challenges faced by elderly individuals in adhering to their medication regimens and their experiences with the IoT-based pill reminder and dispenser system.

Caregivers: The study will also involve caregivers who assist elderly individuals with their medication management. This group may include family members, professional caregivers, and healthcare workers who 2 play a crucial role in supporting medication adherence. Engaging caregivers in the research will offer valuable perspectives on the challenges they face, the support they provide, and how the IoT system can enhance their caregiving roles.

Healthcare Professionals: Additionally, healthcare professionals, such as doctors, nurses, and pharmacists, will be 3 included in the research population. Their insights will be instrumental in understanding the broader implications of medication adherence on health outcomes and the potential benefits of integrating technology into healthcare practices. They can provide feedback on 2 the feasibility of the IoT system and how it can be effectively utilized within the existing healthcare framework.

By including a diverse range of participants—elderly individuals, caregivers, and healthcare professionals—this research population aims to capture a holistic view of the challenges and opportunities associated with medication management in Rwanda. This comprehensive approach will help ensure that the findings are representative and relevant, ultimately guiding the development of a more effective IoT-based solution for improving medication adherence among the aging population.

3.3 Sample Size

Determining the sample size for this study on the IoT-based Pill Reminder and Dispenser system involves several key considerations. The target population consists of elderly individuals aged 60 and above in Rwanda, particularly those managing chronic illnesses that necessitate regular medication intake. To ensure the findings are statistically meaningful, a calculated approach is required. One common method for determining sample size is Cochran’s formula, which helps establish the number of participants needed based on the desired confidence level, margin of error, and estimated population proportion.

Before proceeding with the full study, pilot testing will be conducted with a small group of 5 to 10 elderly participants to evaluate the system's functionality and usability. This initial feedback will guide necessary adjustments to both the system and the research design. For the final study, 4 the sample size is anticipated to range between 50 and 100 elderly participants. This range is deemed sufficient to provide statistically significant insights into the effectiveness of the system in improving medication adherence and supporting independent living among the elderly.

3.3.1 Sampling Procedure

The sampling procedure for this study will follow a systematic and structured approach to ensure that participants are both representative and appropriate for the research objectives. Initially, the target population will be clearly defined, encompassing elderly individuals aged 60 and above, along with their caregivers and healthcare professionals involved in their care. This population will be identified through various sources, including healthcare facilities, community centers, and senior citizen organizations across Rwanda. In contrast, the qualitative component will utilize purposive sampling to select participants who possess specific knowledge or experience related to the IoT-based pill reminder and dispenser system. This will involve a mix of elderly users, caregivers, and healthcare professionals chosen based on their engagement with the system, their roles in medication management, and their willingness to share their experiences. 7 This targeted approach ensures that the qualitative data collected is rich and relevant to the research objectives.. By implementing this structured sampling procedure, the study aims to ensure that the participant selection process is systematic, unbiased, and reflective of the diverse experiences within the target population, thereby enhancing the credibility and applicability of the findings in evaluating the IoT-based pill reminder and dispenser system for elderly individuals in Rwanda.

3.4 Research Instrument

3.4.1 Choice 4 of the Research Instrument

The choice of research instruments for this study is informed by the need to effectively capture both quantitative and qualitative data to comprehensively evaluate the IoT-based pill reminder and dispenser system. Structured questionnaires were selected for the quantitative component due to their ability to gather standardized data from a large sample efficiently. This method allows for easy distribution and collection of data, facilitating statistical analysis to identify trends and correlations in medication adherence and user satisfaction. The structured format also enhances the comparability of responses across diverse demographic groups, increasing the generalizability of the findings.

Together, these instruments align with the project's objectives by facilitating the collection of comprehensive data that quantifies medication adherence while also capturing the lived experiences and perspectives of participants. This multi-faceted 7 approach ensures that the study's findings will be robust, reliable, and relevant, ultimately contributing to the improvement of healthcare solutions for the aging population in Rwanda.

3.4.2 3 Validity and Reliability of the Instrument

To ensure reliability, a test-retest reliability approach will be employed for the structured questionnaires, where a subset of participants will complete the questionnaire on two separate occasions within a short timeframe. The consistency of their responses will be analyzed using statistical methods, such as calculating the Pearson correlation coefficient, to determine the degree of reliability. Additionally, internal consistency will be assessed using Cronbach's alpha for multi-item scales, ensuring that the items consistently measure the same construct. For the semi-structured interviews, inter-rater reliability will be established by having multiple trained interviewers conduct interviews and then compare their findings. This process will involve reviewing recorded interviews and coding responses to identify themes, ensuring that different interviewers produce consistent results.

By implementing these measures, the study aims to ensure that the research instruments possess strong validity and reliability, ultimately contributing to the credibility and robustness of the findings. This rigorous approach will provide a solid foundation for evaluating the effectiveness of the IoT-based pill reminder and dispenser system in enhancing medication adherence among elderly individuals in Rwanda.

3.5 Data Gathering Procedures

The data gathering procedures for this study will be meticulously planned to ensure the systematic and ethical collection of both quantitative and qualitative data regarding the effectiveness of the IoT-based pill reminder and dispenser system for elderly individuals in Rwanda. Before commencing data collection, all necessary preparations will be made, including finalizing research instruments, obtaining ethical approval from relevant institutional review boards, and training research assistants. Training sessions will cover the study's objectives, 2 the use of the structured questionnaires and interview guides, and best practices for interacting with elderly participants, emphasizing the importance of obtaining informed consent and ensuring participant confidentiality.

Participants will be recruited from various healthcare facilities, community centers, and organizations that work with elderly populations. Information sessions will explain 4 the purpose of the study, eligibility criteria, and what participation entails. Interested individuals will be screened for eligibility based on predetermined criteria, such as age and ability to use the IoT system, and informed consent will be obtained before data collection begins. The structured questionnaires will be administered in a face-to-face format to enhance engagement and understanding, with trained research assistants reading the questions aloud when necessary to ensure clarity, especially for participants with hearing difficulties or cognitive impairments. These assistants will provide assistance as needed, ensuring that participants can complete the questionnaires comfortably, and the collected data will be securely entered into a database for subsequent analysis.

3.6 10 Data Analysis and Interpretation

Data analysis and interpretation are critical components of this study, determining the insights drawn from the collected data regarding the effectiveness of the IoT-based pill reminder and dispenser system for elderly individuals in Rwanda. The analysis will occur in two distinct phases: quantitative analysis of the structured questionnaires and qualitative analysis of the semi-structured interviews.

3.7 Ethical Considerations

Ethical considerations are paramount in conducting research, particularly when working with vulnerable populations such as elderly individuals. This study will adhere to established ethical guidelines to ensure the protection of participants' rights, welfare, and dignity throughout the research process. First and foremost, ethical approval will be sought from relevant institutional review boards or ethics committees before the commencement of the study. This process will involve a comprehensive review of the research proposal to ensure that the study design adheres to ethical standards and prioritizes participant safety. Finally, the study will incorporate strategies to disseminate findings in a manner that respects participants' contributions. Results will be shared with the participants and relevant stakeholders, such as healthcare providers and community organizations, 15 to ensure that the knowledge gained from the research can be translated into practical improvements in healthcare services for elderly individuals in Rwanda.

9 CHAPTER FOUR: SYSTEM DESIGN AND IMPLEMENTATION

4.0 Introduction

For the target demographic,this chapter outlines the implementation process of the IoT Pill Reminder & Dispenser system, detailing the steps taken to develop and integrate the various components. It encompasses the design and assembly of hardware, software development, and the testing phase. [3] The goal is to create a functional prototype that effectively meets the needs of elderly users in managing their medication schedules. By following a systematic approach, this chapter highlights how each component works together to enhance medication adherence and ensure a seamless user experience. The implementation process emphasizes user-centric design, focusing on accessibility [2] and ease of use, which are critical.

4.1 Calculation

1. Serv

o Motor (Timing and Power Consumption)

Assuming the servo motor rotates to 180° when the IR sensor detects a hand and back to 0° otherwise:

 Servo Movement Timing: Most standard hobby servos take around 0.15 to 0.2 seconds to rotate 60 degrees at 6V. If you're using a standard servo and rotating it from 0° to 180°, we can calculate the time as:

So, the servo will take approximately 0.6 seconds to move to 180° and another 0.6 seconds to return to 0°.

 Power Consumption of Servo: Standard small servo motors, such as SG90, consume approximately 0.1A to 0.5A depending on load and operating voltage (usually 5V to 6V). Assuming a current draw of 0.3A at 5V:

$\text{Power Consumption} = \text{Voltage} \times \text{Current} = 5V \times 0.3A = 1.5W$

This is a rough estimate and may vary [7] based on the specific servo motor.

2. ESP8266 Power Consumption

The ESP8266 module has different power consumption modes:

Assuming the ESP8266 is in active mode with an average current draw of 100 mA at 3.3V:

$\text{Power Consumption} = 3.3V \times 0.1A = 0.33W$

This is the power consumed by the ESP8266 when it's actively connected to Wi-Fi.

3. Buzzer Power Consumption

Buzzers typically consume very low current, usually around 30mA at 5V. If you're using the buzzer for brief alerts:

Power Consumption=5V×0.03A=0.15W

4. IR Sensor (Detection Rate and Timing)

The IR sensor reads the presence of an object (e.g., a hand). You read its value every 100 milliseconds (delay(100)), meaning the code checks the IR sensor 10 times per second.

□ Detection Frequency: [2] The IR sensor is checked every 100 ms, meaning it's checked 10 times per second.

4.2 Drawings

4.2.1 Block Diagram

The following block diagram illustrates the components within the system. The IR sensor is connected to the ESP8266 microcontroller, which also interfaces with a buzzer and a servo motor. These connections allow the ESP8266 to receive input from the IR sensor, triggering the appropriate actions such as activating the buzzer or controlling the servo motor for pill dispensing.

evening

Figure 1: Block diagram

4.2.2 Circuit diagram

The figure below provided shows the hardware connections for the pill reminder and dispenser system using a NodeMCU (ESP8266). [2] The IR sensor is connected to the NodeMCU, which detects the presence of a hand when within a specified range. This detection is used to trigger the servo motor, also connected to the NodeMCU, which handles the physical dispensing of the pills. The servo motor's PWM pin is connected to a digital pin on the ESP8266, while its VCC and GND pins are powered accordingly. Additionally, a buzzer is integrated into the system, connected to another [18] digital pin of the ESP8266, allowing it to emit sound notifications when the time for pills arrives. This configuration ensures the NodeMCU controls both the buzzer and the servo motor based on the IR sensor's input.

Figure 2: Circuit diagram

4.2.3 Flowchart

The flowchart below outlines the operation [2] of a pill dispenser system. It begins with the system being initialized and ready for use. The user sets a specific time for pill dispensing. The system then checks if the current time matches the designated dispensing time. If the answer is "No," the system continues monitoring until the time condition is met. Upon confirming that it is indeed time for dispensing, a second check is performed to ensure the condition still holds. If this check also returns "Yes," the system proceeds to dispense the pills. Finally, the user can take the pills before the process concludes. This dual time-check mechanism enhances [4] the accuracy of the dispensing process, ensuring that pills are provided at the correct times.

YES NO

NO YES

FIGURE 3:FLOWCHART

4.4 IMPLEMENTATION

9 The implementation of this project involves assembling the necessary hardware components and programming the system to perform the required functions. The project is centered around an object detection system that uses a sensor to detect the presence of a hand or object and display the corresponding message on an LCD screen.

Overall, this hardware prototype showcases the basic functionality of the IoT-based pill dispenser system, with each component contributing to an efficient, reliable, and user-friendly solution to medication management for elderly individuals.

Figure 3: hardware prototype showcases

In this image shown below, we see a LCD screen embedded into a wooden or box structure. The screen displays the message "Hello, Welcome!", which is likely part of the user interface for the IoT-based pill dispenser system.

The LCD display serves as a key component of the user interface, providing essential feedback and instructions to the user. The message "Hello, Welcome!" indicates that the system has been powered on and is greeting the user, making the interaction more engaging and user-friendly. This screen will likely be used to convey additional information, such as medication reminders, dosage schedules, and possibly even error messages or confirmations when a pill is successfully dispensed.

In a real-world application of this system, the LCD screen could guide elderly users through the steps they need to follow, display reminders 17 for when it’s time to take their medication, and confirm that the correct dosage has been dispensed. The bright backlight and clear message ensure that the display is visible, even for users who may have difficulty with vision.

Figure 4: The screen displays the message "Hello, Welcome!"

This image shows the core electronics that power the pill dispenser, with the microcontroller coordinating the system’s functions, the buzzer providing audio reminders, and the wiring system enabling smooth communication between all components. This setup forms the backbone of the IoT system that allows for real-time medication management and monitoring.

Figure 5: core electronics that power the pill dispenser (internal part of the project)

The image below displays an LCD screen with the message "No Hand detected," along with the number "0." This indicates that the system is not currently detecting any hand or object in front of the sensor. It implies that the sensor, which might be an infrared or ultrasonic sensor, is actively scanning the environment but has not found anything within its detection range.

The number "0" likely serves as a counter or status indicator showing that no detection event has occurred. This could mean:

1. The system has not detected a hand, thus the count remains at zero.
2. The system [19] is in an idle state, waiting for an object to be detected.

This message serves as feedback to the user, confirming that the system is functioning but hasn't registered any presence yet.

Figure 6: LCD screen with the message No Hand detected

The image below displays an LCD screen with the message "Hand detected!" followed by the number "1." This likely represents a real-time detection system, where a sensor (possibly an infrared or ultrasonic sensor) is being used to detect the presence of a hand. Once the hand is detected, the system outputs the message to the LCD, confirming the detection.

The number "1" could represent either:

1. A count of the detection events, incrementing every time a hand is detected.
2. A status indicator to show the system is actively detecting.

This setup might [2] be part of a project where detecting a hand triggers an action, such as dispensing a pill or unlocking a door, depending on the overall system context

Figure 7: LCD screen with the message "Hand detected!"

The image below shows a close-up and of a component mounted on a wooden box, with wires connecting it to the rest of the system. Here’s a breakdown of the key elements:

1. Sensor Module: On the right side of the box, there is a blue electronic sensor module, which appears to be an infrared (IR) or ultrasonic sensor. This sensor is likely responsible

for detecting objects (such as a hand) in front of the system. It could be used for motion detection, object detection, or proximity sensing.

2. Wiring: The sensor [2] is connected to the main system via three colored wires—red, yellow, and black—which are used to supply power (likely red for positive, black for ground) and send data or signals (yellow for data) between the sensor and the control board (possibly a microcontroller like an Arduino or ESP module inside the box).

3. Wooden Housing: The wooden box provides an enclosure for the electronic components, giving the system a stable structure. It has been assembled with glue, indicating that the project might be a prototype or a DIY build.

This setup likely belongs to a device designed for interactive use, such as a dispenser, door automation, or hand detection system, where the sensor detects a hand or object to trigger an action.

Figure 8: close-up of a component

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The IoT Pill Reminder & Dispenser project represents a significant advancement in addressing the medication management challenges faced by the elderly population in Rwanda. By integrating user-friendly technology with innovative IoT solutions, this system effectively enhances medication adherence through timely reminders and automated dispensing. The successful implementation of key components, including the LCD display, servo motor, buzzer, ESP8266 module, and IR sensor, demonstrates the potential of technology to improve health outcomes for vulnerable populations. User feedback played 2 a crucial role in refining the system, ensuring that it is not only functional but also accessible and easy to use. Overall, this project not only showcases the effectiveness of leveraging technology in healthcare but also highlights the importance of addressing the unique needs of older adults, ultimately fostering greater independence and improved quality of life.

5.2 Recommendations

Based on the findings from the IoT Pill Reminder & Dispenser project, several recommendations can enhance the system's effectiveness and usability. Firstly, 4 it is essential to implement comprehensive training programs for elderly users and caregivers to help them navigate the system's functionalities, along with providing ongoing support to address any challenges they may face. Enhancing connectivity options, such as incorporating Bluetooth, would ensure reliable communication, especially in areas with limited Wi-Fi access, thereby increasing accessibility for users in remote locations. Additionally, prioritizing 7 data security and privacy is crucial; developing robust security measures to protect personal health information will build user trust and encourage adoption. Establishing feedback mechanisms will allow for continuous improvement based on user input, ensuring that the device and app remain user-friendly and functional. Expanding features to include medication inventory tracking, integration with healthcare providers, and customizable reminder settings can make the system even more versatile. Furthermore, exploring scalability options through partnerships with healthcare organizations or government initiatives focused on elderly care could broaden the project's reach. Lastly, conducting longitudinal studies to assess the long-term impact 2 of the system on medication adherence and health outcomes will provide valuable insights for future enhancements. By adopting these recommendations, the IoT Pill Reminder & Dispenser 10 can significantly improve the well-being of elderly individuals, empowering them to manage their health more effectively and independently

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APPENDICES

Appendix one: project coding

```
#include

#include

#include

#include


#include


const int irPin = D7;  // Pin where the IR sensor is connected
```

```
const int servoPin = D5;  // Pin where the servo motor is connected

Servo myServo;
int irValue;

int buzzerx = D8;
int pirState = LOW;
int val = 0;
int sendx=0;
int checkx = 0;

//const char* host = "softechsupply.com";

WiFiClient client;

const char* ssid = "Fatty";
const char* password = "12345678";
ESP8266WebServer server(80);  //--> Server on port 80

int readsuccess;
byte readcard[4];
char str[32] = "";
String StrUID;
int httpCode;
String UIDresultSend, postData;

String response1,response2,response3,payload;
```

```
#include

int statuss = 0;
int out = 0;
String ir_value="";

LiquidCrystal_I2C lcd(0x27,16,2);  // set the LCD address to 0x3F for a 16 chars and 2 line
display

void setup() {
  Serial.begin(9600);   // Initiate a serial communication

  pinMode(buzzerx, OUTPUT);
  digitalWrite(buzzerx, LOW);

  pinMode(irPin, INPUT);  // Set IR pin as input
  myServo.attach(servoPin);  // Attach servo to the pin
  myServo.write(0);

  lcd.init();
  lcd.clear();
  lcd.backlight();      // Make sure backlight is on

  // Print a message on both lines of the LCD.
  lcd.setCursor(2,0);   //Set cursor to character 2 on line 0
  lcd.print("Hello,");

  lcd.setCursor(2,1);   //Move cursor to character 2 on line 1
```

```
lcd.print("Welcome!");

 WiFi.begin(ssid, password); //--> Connect to your WiFi router
Serial.println("");

delay(2000);
lcd.clear();
lcd.backlight();
lcd.setCursor(1,0);
lcd.print(ssid);
lcd.setCursor(1,1);
lcd.print("Connecting ...");

Serial.print("Connecting");
6 while (WiFi.status() != WL_CONNECTED) {
  Serial.print(".");
}

Serial.println("");
Serial.print("Successfully connected to : ");
Serial.println(ssid);
Serial.print("IP address: ");
Serial.println(WiFi.localIP());



lcd.clear();
lcd.backlight();      // Make sure backlight is on
```

```
  // Print a message on both lines of the LCD.
  lcd.setCursor(1,0);   //Set cursor to character 2 on line 0
  lcd.print("System ready!");

}

void loop() {

  irValue = digitalRead(irPin);  // Read the IR sensor
  ir_value = String(irValue);

  if (irValue == LOW) {
    lcd.clear();
    lcd.backlight();      // Make sure backlight is on
    // Print a message on both lines of the LCD.
    lcd.setCursor(1,0);   //Set cursor to character 2 on line 0
    lcd.print("Hand detected!");

    lcd.setCursor(1,1);   //Move cursor to character 2 on line 1
    lcd.print("1");

    delay(1500);

   // If IR detects something, turn servo to 90 degrees (open)



  dataFunction(ir_value);
  } else {
```

```
    lcd.clear();
     lcd.backlight();      // Make sure backlight is on
     6 // Print a message on both lines of the LCD.
     lcd.setCursor(1,0);   //Set cursor to character 2 on line 0
     lcd.print("No Hand detected!");

     lcd.setCursor(1,1);   //Move cursor to character 2 on line 1
     lcd.print("0");
    // If no detection, keep servo at 0 degrees (closed)



    dataFunction2("100");
    delay(2000);
  }

  delay(100);  // Small delay for stability



  delay(1000);
}



String getValue(String data, char separator, int index)
{
  int found = 0;
  int strIndex[] = {0, -1};
  int maxIndex = data.length()-1;
```

```
  for(int i=0; i<=maxIndex && found<=index; i++){
    if(data.charAt(i)==separator || i==maxIndex){
        found++;
        strIndex[0] = strIndex[1]+1;
        strIndex[1] = (i == maxIndex) ? i+1 : i;
    }
  }

  return found>index ? data.substring(strIndex[0], strIndex[1]) : "";
}

void dataFunction(String x){
  HTTPClient http;    //Declare object of class HTTPClient

  String url = "http://192.168.62.211/hospital_db/getdata.php";

  url += "?UIDresult=" + x;
  Serial.println(url);

  http.begin(client,url.c_str());
//  delay(5000);
  httpCode = http.GET();
//  delay(2000);
  payload = http.getString();
//  delay(3000);

while(httpCode<10){
  Serial.print("trying.... ");
```

```
  http.begin(client,url.c_str());
  httpCode = http.GET();
  payload = http.getString();
}
checkx = 1;
    Serial.print("ID: ");
    Serial.println(UIDresultSend);
    Serial.print("Code: ");
    Serial.println(httpCode);   //Print HTTP return code
    Serial.print("Response: ");
    Serial.println(payload);    //Print request response payload

    response1 = getValue(payload,'#',0);//paid
    response2 = getValue(payload,'#',1);//balance
    response3 = getValue(payload,'#',2);// total passengers

    http.end();  //Close connection



  if(payload!=""){
    if(response1=="All taken"){
         lcd.clear();
      lcd.backlight();
      lcd.setCursor(0,0);
      lcd.print("All taken");

    myServo.write(0);
```

```
  }
else if(response1!="not found" && response1!="Not registered"){



  myServo.write(180);
  lcd.clear();
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("Welcome,");
  lcd.setCursor(0,1);
  lcd.print(response1);

  digitalWrite(buzzerx, HIGH);
    delay(500);
    digitalWrite(buzzerx, LOW);

}
else{

myServo.write(0);
  lcd.clear();
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("User not found,");
  lcd.setCursor(0,1);
  lcd.print("try again");

  digitalWrite(buzzerx, HIGH);
```

```
        delay(300);
        digitalWrite(buzzerx, LOW);
        delay(300);
        digitalWrite(buzzerx, HIGH);
        delay(300);
        digitalWrite(buzzerx, LOW);
        delay(300);
        digitalWrite(buzzerx, HIGH);
        delay(300);
        digitalWrite(buzzerx, LOW);
        delay(300);
    }

    }

}



void dataFunction2(String x){
  HTTPClient http;    //Declare object of class HTTPClient

  String url = "http://192.168.62.211/hospital_db/getdata2.php";

  url += "?UIDresult=" + x;
  Serial.println(url);

  http.begin(client,url.c_str());
//  delay(5000);
```

```
  httpCode = http.GET();
//  delay(2000);
  payload = http.getString();
//  delay(3000);

while(httpCode<10){
  Serial.print("trying.... ");
  http.begin(client,url.c_str());
  httpCode = http.GET();
  payload = http.getString();
}
checkx = 1;
    Serial.print("ID: ");
    Serial.println(UIDresultSend);
    Serial.print("Code: ");
    Serial.println(httpCode);   //Print HTTP return code
    Serial.print("Response: ");
    Serial.println(payload);    //Print request response payload

    response1 = getValue(payload,'#',0);//paid
    response2 = getValue(payload,'#',1);//balance
    response3 = getValue(payload,'#',2);// total passengers

    http.end();  //Close connection




  if(payload!=""){
```

```
    if(response1=="Time"){
        lcd.clear();
      lcd.backlight();
      lcd.setCursor(0,0);
      lcd.print("Time for pills");

      digitalWrite(buzzerx, HIGH);
        delay(300);
        digitalWrite(buzzerx, LOW);
        delay(300);
        digitalWrite(buzzerx, HIGH);
        delay(300);
        digitalWrite(buzzerx, LOW);
        delay(300);
        digitalWrite(buzzerx, HIGH);
        delay(300);
        digitalWrite(buzzerx, LOW);
        delay(300);

      }
    }

}
```

Appendix two: Budget of the project

Cost Estimation

Table 1: Cost estimation

No	Item	Quantity	Price
1	ESP8266	1	11000
2	Infrared	1	5000
3	Buzzer	1	500
4	Servo motor	1	7000
5	PCB	1	1000
6	Jumpers	1	2000

7

Soldering iron

1

2000

8

Transportation

20000

9

Communication

15000

10

Total

63500

12

12

12

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