Creating Innovative Healthcare App for Dementia Patients and Caregivers

2023-365

Final Report

B.Sc. (Hons) Degree in Information Technology Specialized in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology Sri Lanka

September 2023

Give health tips for the user based on the data collected from IoT device using Machine learning.

2023-365

Warnakulasuriyage.K.H.A

IT20151492

B.Sc. (Hons) Degree in Information Technology Specialized in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology Sri Lanka

September 2023

DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
Warnakulasuriyage K.H.A	IT20151492	

ABSTRACT

Dementia is a neurological condition that affects millions of individuals worldwide, and emergency situations can arise unexpectedly in patients with this condition. The lack of reliable and accurate data on emergency situations in dementia patients has made it challenging to develop effective algorithms for detecting and responding to such emergencies. To address this issue, we propose a machine learning-based system that uses body temperature, oxygen level, and heart rate to detect emergency situations in dementia patients.

This research project aims to develop an ML-based system that can analyze the data and identify health conditions through recognition, compare the analyzed data with the dataset of emergency situations, and develop an algorithm to provide action to mitigate the emergency. In case of emergency, the system will notify the nearest hospital for immediate treatment, and if the condition does not improve, the notification system will notify the patient's caregiver to visit the patient.

The proposed system will use machine learning techniques to analyzed patient data and develop an algorithm to detect emergency situations in real-time. The system will provide a reliable and accurate method for detecting emergency situations in dementia patients, and it will help healthcare professionals provide timely and effective care to these patients.

The development of this ML-based system will provide a valuable tool for healthcare professionals and caregivers to monitor dementia patients and provide timely interventions in case of emergencies. By improving the detection and response to emergency situations in dementia patients, we can improve the overall quality of life for these patients and reduce the burden on caregivers and healthcare systems.

Key words: Dementia person, Healthcare systems improvement, Mobile application

ACKNOWLEDGEMENT

I would like to express my profound gratitude to our dedicated supervisor, Mrs. Sanjeevi Chandrasiri, and co-supervisor, Mrs. Dinuka Wijendra, for their unwavering support, enthusiastic encouragement, and invaluable guidance throughout our research journey. Their commitment has played a pivotal role in shaping the success of this endeavor. I extend my heartfelt appreciation to my parents for their unwavering support and strength throughout my life. I am deeply thankful to my friends, research group members, including Ravindu Samarathunge, Eshan Weerasinghe and Emalka Serasinghe for their unwavering interest and collaborative efforts in completing this Final report successfully. My sincere thanks also go to my friends, lab mates, colleagues, and members of the study team. Finally, I want to acknowledge the unwavering support and encouragement from my extended family and friends throughout my academic career. Collectively, your support, encouragement, and collaborative spirit have greatly enriched this research project, and I am sincerely grateful for your contributions to its success.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviations	Description
IT	Information Technology
SL	Sri Lanka
Apps	Applications
ANN	Artificial Neural Network
IOT	Internet Of Things
ML	Machine Learning
WHO	World Health Organization

LIST OF APPENDICES

1. INTRODUCTION

Dementia, a complex neurological condition affecting millions worldwide, presents a profound challenge to both healthcare providers and caregivers. This condition progressively erodes cognitive functions, including memory, judgment, and emotional regulation, leaving individuals increasingly vulnerable to medical emergencies such as falls, seizures, and strokes. The timely detection and intervention in such emergencies are paramount to mitigate their potentially severe consequences. However, obtaining reliable and accurate data on emergency situations in dementia patients has proven to be a formidable hurdle, largely due to the multifaceted nature of the disease.

Dementia is not a monolithic ailment; it manifests with considerable variability among patients. Factors such as age, gender, disease stage, comorbidities, and medication use all influence the presentation and progression of dementia. Consequently, a universal, one-size-fits-all approach for detecting and responding to emergencies in dementia patients may not be practical or effective. Furthermore, individuals with advanced dementia often struggle to communicate their symptoms or medical history, rendering diagnosis and response during emergencies exceedingly challenging. Even the presence of caregivers or family members cannot guarantee the availability of reliable and timely data regarding the patient's condition.

In the quest to address the formidable challenge of obtaining dependable data on emergency situations in dementia patients, researchers have sought alternative data collection methods. Wearable devices that continuously monitor vital signs such as heart rate, oxygen levels, and body temperature in real-time have emerged as a promising solution. These devices offer an objective means of gathering medical data, enabling healthcare providers to make informed decisions regarding diagnosis and treatment, even in cases where the patient cannot articulate their symptoms or medical history.

Beyond wearable technology, sensors placed in the environment surrounding dementia patients have also shown potential. These sensors are capable of detecting changes in movement patterns, temperature, and lighting, which may serve as indicators of an emergency event. In this way, they can swiftly alert caregivers or family members, bridging the gap when direct communication with the patient is impaired.

Furthermore, the development of specialized machine learning algorithms holds significant promise in addressing the challenge of obtaining reliable and accurate data on emergency situations in dementia patients. These algorithms can adapt to individual variations in emergency scenarios, learning from patterns in data to enhance the accuracy and efficiency of detection and response. For instance, researchers have harnessed machine learning to analyze speech and language patterns in dementia patients, uncovering early indicators of cognitive decline through changes in pitch, tone, and speech rate. Similarly, machine learning algorithms have been applied to brain scans, cognitive test results, and medical histories, unveiling patterns that signify the onset or progression of dementia.

The difficulty in obtaining dependable and accurate data on emergency situations in dementia patients is undeniably a pressing concern. Nevertheless, the convergence of wearable technology, environmental sensors, and machine learning offers a ray of hope in addressing this challenge. These innovative approaches not only provide objective and real-time data but also adapt to the unique characteristics of each patient, thereby augmenting the precision and swiftness of emergency detection and response. As we delve into this final report, we will explore the development and evaluation of these approaches in real-world settings and how they offer a beacon of promise in the face of the inherent variability in the progression and severity of dementia among patients.

1.1 Background

Dementia is a prevalent and complex neurological condition affecting millions of individuals worldwide, particularly among the elderly population. It is characterized by a progressive decline in cognitive function, leading to memory loss, impaired judgment, and various behavioral and emotional changes. As the disease advances, dementia patients become increasingly vulnerable to medical emergencies, including falls, seizures, and strokes. Timely detection and prompt medical intervention are crucial to mitigate the potentially severe consequences of these emergencies.

However, there are significant challenges associated with obtaining reliable and accurate data on emergency situations in dementia patients. These challenges stem from the heterogeneous nature of dementia itself, as it can manifest differently in each individual due to factors such as age, gender, disease stage, comorbidities, and medication use. Developing a standardized approach to detect and respond to emergencies in dementia patients proves difficult, given this variability.

Furthermore, dementia patients often encounter difficulties communicating their symptoms or medical history, especially during emergencies. Those with advanced dementia may be nonverbal or unresponsive, making it challenging for healthcare providers to diagnose and respond effectively to an emergency. Additionally, caregivers or family members may not always be present to provide crucial information during such situations.

To address these challenges, researchers have explored alternative methods for data collection and specialized algorithms tailored to the unique needs of dementia patients.

One promising approach involves the use of wearable devices equipped with sensors to continuously monitor vital signs in real-time. These devices track parameters such as heart rate, oxygen levels, and body temperature, providing objective and immediate data on a patient's health status. Wearable devices offer a non-invasive way to collect data, even when the patient is unable to communicate their symptoms or medical history.[1]

In addition to wearable devices, environmental sensors have been investigated to monitor changes in a dementia patient's surroundings. These sensors can detect alterations in movement patterns, temperature, and lighting, which may signify an emergency event. When such changes are detected, sensors can trigger alerts to caregivers or family members, ensuring a rapid response to the situation.

Developing specialized algorithms is another solution to improve the accuracy and reliability of data collection in dementia patients during emergencies. Machine learning algorithms, capable of learning from patterns in data, can be adapted to account for individual variations in emergency situations. For instance, researchers have developed algorithms that analyze speech and language patterns in dementia patients to detect early signs of cognitive deterioration. These algorithms can assess changes in pitch, tone, and speech rate, offering potential indicators of cognitive impairment.

Moreover, machine learning algorithms have been applied to various data sources, including brain scans, cognitive test results, and medical histories, to identify patterns associated with the onset or progression of dementia. These algorithms enhance the capacity to detect emergencies and provide timely interventions based on individual patient characteristics.[2]

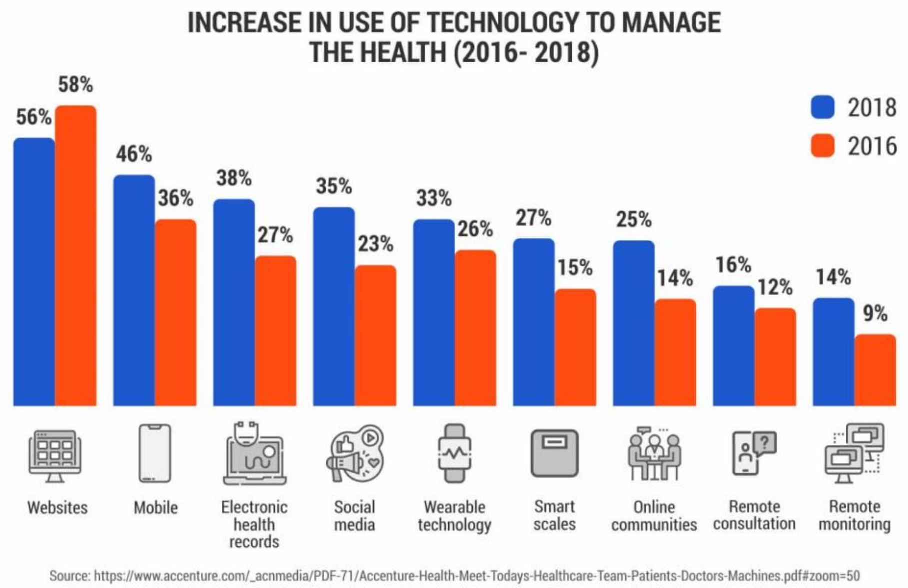

Figure 1.1: MHealth app category global market potential 2016

1.2 Literature Review

Dementia is a challenging neurological condition that poses a significant burden on both patients and their caregivers. One of the most critical aspects of dementia care is the timely detection and response to medical emergencies, such as falls, seizures, and strokes, which can have severe consequences if not promptly addressed. This literature review delves into the current state of research regarding the difficulty of obtaining reliable and accurate data on emergency situations in dementia patients and explores potential solutions to this pressing issue.

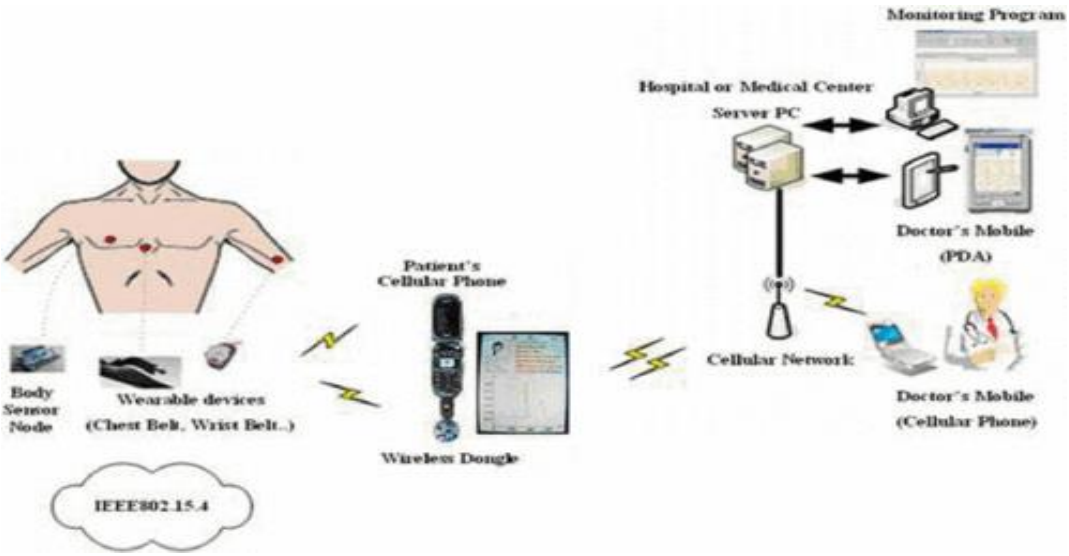

Figure 1.2.1: System architecture diagram of wireless networks Healthcare system

Dementia, characterized by a gradual decline in cognitive function, presents a multitude of complexities when it comes to data collection during emergencies. The variability in the progression and severity of dementia among patients is a fundamental challenge. This variability is influenced by a myriad of factors, including age, gender, disease stage, comorbidities, and medication use. As a result, adopting a uniform approach to detect and respond to emergencies in dementia patients is fraught with difficulties.

Moreover, communication barriers compound the challenge of obtaining accurate data during emergencies. Advanced dementia patients often struggle to articulate their symptoms or provide a medical history to caregivers or healthcare providers. This lack of effective communication can lead to delayed diagnosis and intervention during critical situations. Additionally, the absence of caregivers or family members during an emergency further exacerbates the issue of data collection, as there may be no one present to witness or report the incident.[1]

Characteristics	**n (%)**	**Mean (SD)**
Gender		
Male	41 (39.8)	-
Female	62 (60.2)	-
Age (year)		46.7 (7.03)
<35	6 (5.8)	-
[35-45[	28 (27.2)	-
[45-55[	52 (50.5)	-
≥55	17 (16.5)	-
Area of practice		
Urban	86 (83.5)	-
Rural	17 (16.5)	-
Public service seniority, mean (SD)	-	18.44 (5.9)
Seniority in current position, mean (SD)	-	9.51 (5.8)

Figure 1.2.2: Characteristics of the Surveyed Physicians (N=103)

Researchers have actively explored alternative data collection methods to tackle the complexities of obtaining reliable information during emergencies in dementia patients. One promising avenue is the utilization of wearable devices capable of real-time monitoring of vital signs. These devices, such as smartwatches and health trackers, can continuously track metrics like heart rate, oxygen levels, and body temperature. By providing objective, immediate data on a patient's health status, wearable devices offer a non-invasive solution to data collection, even in situations where patients are unable to communicate their symptoms or medical history.

Furthermore, environmental sensors have emerged as valuable tools in monitoring the surroundings of dementia patients. These sensors can detect changes in movement patterns, temperature, and lighting, which may signify an emergency event. When such changes are detected, sensors can autonomously trigger alerts to caregivers or family members, ensuring a swift response to the situation. This approach not only addresses the challenge of data collection but also reduces the reliance on human observation and reporting.

Role	Personal Info				General Health Info				Diagnostic Orders and Lab Results				Medication				Care Plan			
	C	*R*	*U*	*D*	*C*	*R*	*U*	*D*	*C*	*R*	*U*	*D*	*C*	*R*	*U*	*D*	*C*	*R*	*U*	*D*
Patient		X			X	X				X				X	X			X	X	
Doctor		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pharmacist		X				X				X				X	X					

Figure 1.2.3: Personal health folder access control policies

In addition to alternative data collection methods, the development of specialized algorithms has garnered attention as a means to improve the accuracy and reliability of emergency data in dementia patients. Machine learning algorithms, designed to learn from patterns in data, hold the potential to account for individual variations in emergency situations.

One notable application of machine learning algorithms involves the analysis of speech and language patterns in dementia patients. These algorithms can detect early indicators of cognitive deterioration by analyzing changes in pitch, tone, and speech rate. Such changes may indicate cognitive impairment, enabling early intervention and treatment.

Moreover, machine learning algorithms have been harnessed to analyze diverse data sources, including brain scans, cognitive test results, and medical histories. By identifying patterns associated with the onset or progression of dementia, these algorithms offer enhanced capacity for detecting emergencies and providing tailored responses based on individual patient characteristics.

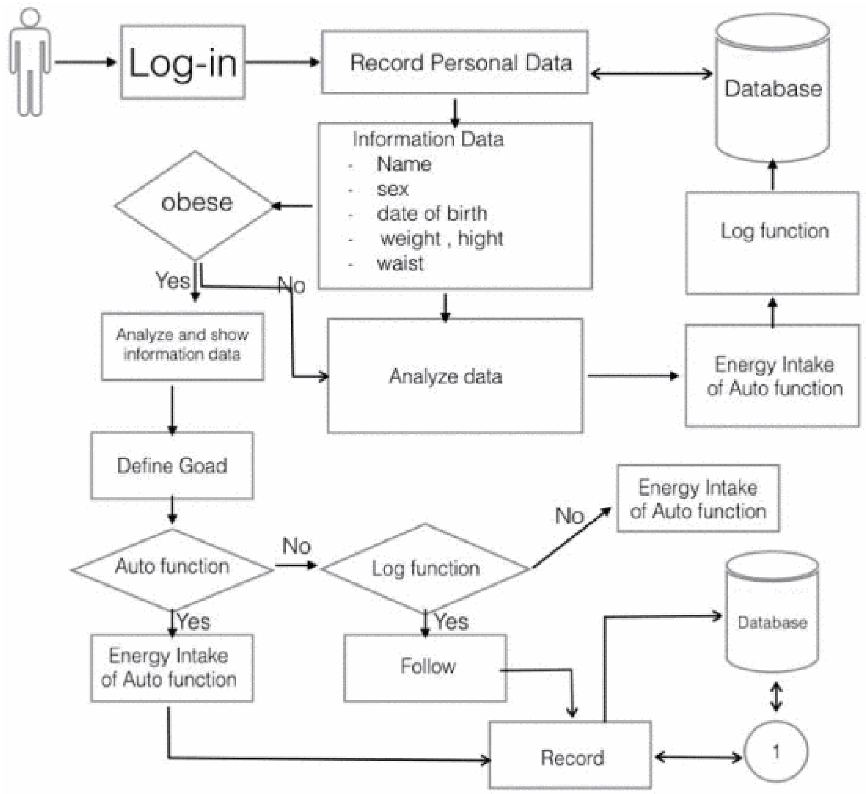

Figure 1.2.4: Data flow diagram

The challenge of obtaining reliable and accurate data on emergency situations in dementia patients represents a substantial hurdle for healthcare providers and caregivers alike. However, the exploration of alternative data collection methods, such as wearable devices and environmental sensors, alongside the development of specialized machine learning algorithms, offers promising solutions. These approaches facilitate objective data collection, even when patients cannot communicate their condition effectively, and enable tailored responses based on individual patient characteristics.[2]

To further advance these solutions, ongoing research efforts should focus on real-world implementations and evaluations. Addressing the variability in the progression and severity of dementia among patients is crucial for the development of effective and adaptable systems. Ultimately, the successful implementation of these solutions has the potential to significantly improve the accuracy and efficiency of emergency detection and response in dementia patients, ultimately enhancing their quality of life and reducing the burden on caregivers and healthcare systems.

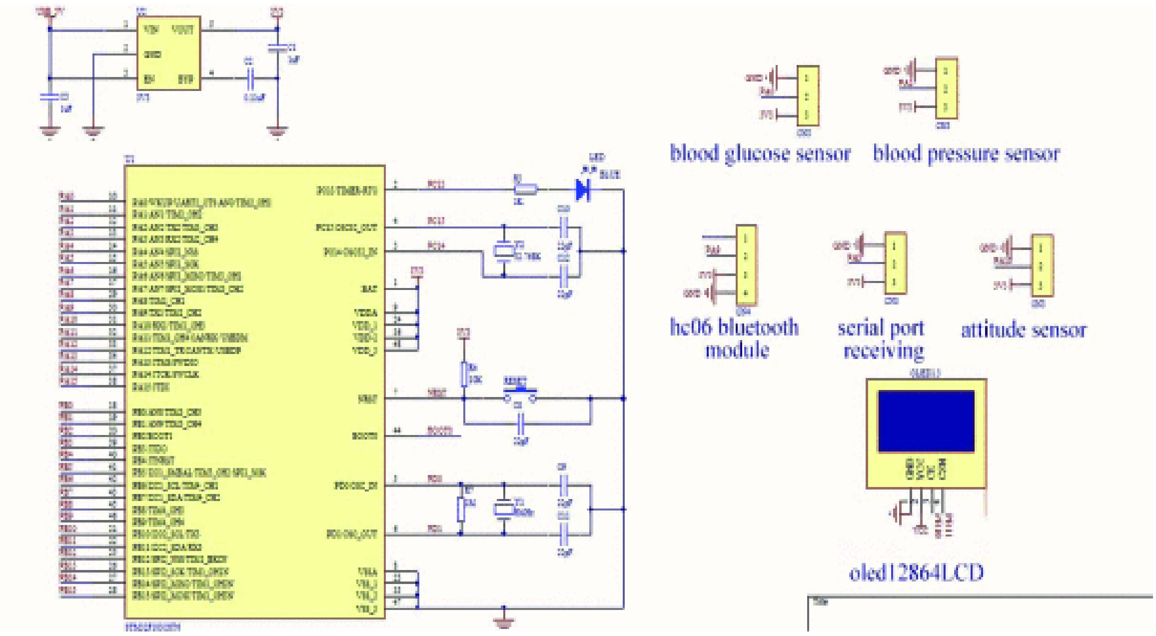

Figure 1.2.5: Diagram of main circuit board

1.3 Research Gap

While there is a growing recognition of the need to improve the detection and response to medical emergencies in dementia patients, there is still a significant gap in the development and implementation of comprehensive, real-time monitoring systems that effectively account for the variability in dementia progression and severity among patients. Current research and solutions often focus on individual aspects such as wearable devices, sensors, or specialized algorithms. However, there is a need for an integrated approach that combines these elements into a holistic system capable of adapting to the unique characteristics and needs of each dementia patient.

Existing research primarily explores isolated solutions, such as wearable devices, sensors, or machine learning algorithms. There is a need to investigate how these components can be seamlessly integrated into a unified system that collects, analyzes, and responds to data in real-time.

Dementia is a highly individualized condition, and its progression varies significantly from one patient to another. Research should focus on developing systems that can adapt and personalize emergency detection and response based on a patient's specific cognitive status, medical history, and lifestyle.

It is essential to ensure that different components of the monitoring system, including wearable devices, sensors, and data analysis algorithms, can communicate and share data effectively. This promotes a more comprehensive understanding of a patient's health status.

The research should consider the usability and acceptability of such systems by both dementia patients and their caregivers. User-friendly interfaces and clear communication channels for alerts and notifications are crucial.

While promising technologies and algorithms are being developed, their validation and effectiveness in real-world settings are often limited. Further research should involve field trials and long-term monitoring to assess the practicality and reliability of these systems.

Here in the research gap, I considered some factors to compare pre-existing systems to mine. The factors which I considered were,

- Related to Identifying Current Health Situation
- Related to Suggesting Thing what to Do for critical situation
- Related to Send alert for nearest hospital

Mainly 5 research were taken to consideration and the comparison was done according to the above table.

Mobile App	Related to Identifying Current Health Siatuation	Related to Suggesting Thing what to Do for critical situation	Related to Send alert for nearest hospital
Proposal App	YES	YES	YES
MindMate	YES	NO	NO
Lumosity	YES	NO	NO
HealthifyMe	NO	YES	NO
Dementia Clock	Yes	NO	NO
Memory Lane	YES	NO	NO

Figure 1.3.1: Research Gap

1.4 Research Problem

Dementia is a complex neurological condition that affects millions of people worldwide. The condition causes gradual cognitive deterioration, including memory loss, decreased judgment, and behavioral and emotional disorders. As the disease progresses, dementia patients become increasingly vulnerable to medical emergencies such as falls, seizures, and strokes, which can have severe consequences if not promptly detected and treated. However, obtaining reliable and accurate data on emergency situations in dementia patients can be challenging due to the nature of the disease. This literature survey explores the current state of research on the difficulty in obtaining reliable and accurate data on emergency situations in dementia patients and potential solutions to this problem.

The Challenge of Obtaining Reliable and Accurate Data on Emergency Situations in Dementia Patients: Dementia patients face several challenges that can make it difficult to obtain reliable and accurate data on emergency situations. One significant challenge is the variability in the progression and severity of dementia among patients. Dementia can present differently in different individuals, depending on various factors such as age, gender, disease stage, comorbidities, and medication use. Therefore, developing a one-size-fits-all approach to detect and respond to emergencies in dementia patients may not be feasible or effective. Moreover, dementia patients may have difficulty communicating their symptoms or medical history to caregivers or healthcare providers. For example, a person with advanced dementia may be nonverbal or unresponsive during an emergency, making it challenging to diagnose and respond to the emergency effectively. Furthermore, caregivers or family members may not always be present during an emergency, making it challenging to obtain reliable and accurate data on the situation.

Alternative Data Collection Methods: To address the challenge of obtaining reliable and accurate data on emergency situations in dementia patients, researchers have explored alternative data collection methods. One promising approach is the use of wearable devices that can keep track of vital indications including heart rate, oxygen levels, and body temperature in real-time. These devices can provide objective data on medical emergencies that can help healthcare providers make informed decisions about diagnosis and treatment.

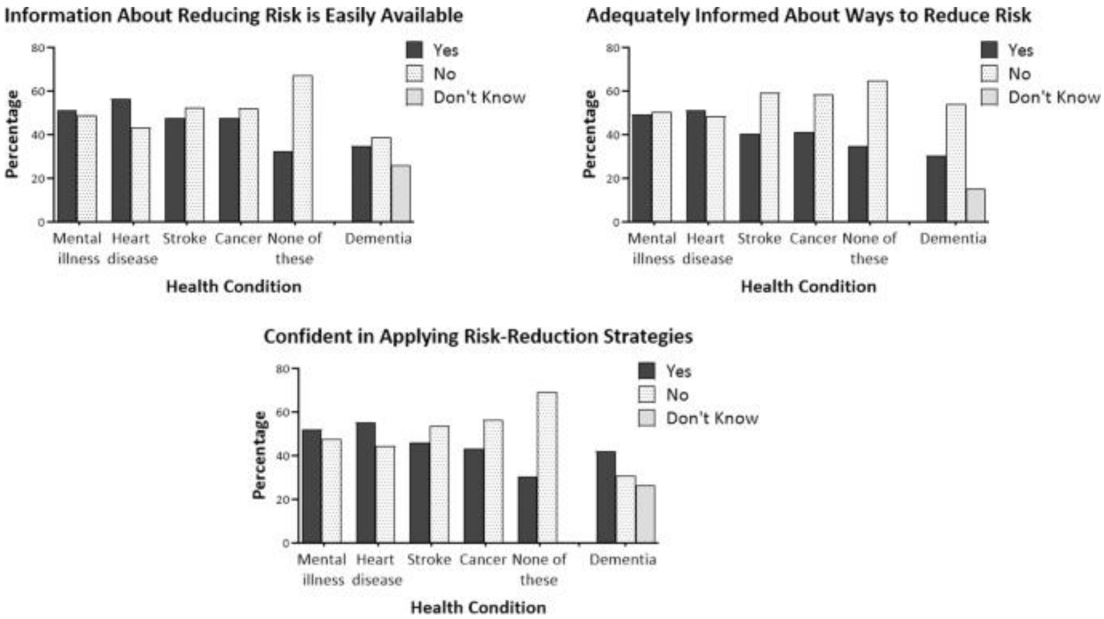

Figure 1.4.1: Survey result of risk of dementia patient

Moreover, researchers have explored the use of sensors to monitor the environment around dementia patients. For example, sensors can detect changes in movement patterns, temperature, and lighting, which may indicate an emergency. These sensors can alert caregivers or family members to the emergency, even if the patient is unable to communicate their symptoms or medical history.[3]

Specialized Algorithms: Another potential solution to the challenge of obtaining reliable and accurate data on emergency situations in dementia patients is the development of specialized algorithms that can account for individual variations in emergency situations. Machine learning algorithms can learn from patterns in data and adjust to individual patient characteristics, improving the accuracy and efficiency of emergency detection and response. For example, researchers have created machine learning algorithms that can analyze speech and language patterns in dementia patients to detect early indicators of cognitive deterioration. These algorithms can analyze changes in pitch, tone, and speech rate, which may indicate cognitive impairment. Moreover, researchers have developed machine learning algorithms that can analyze brain scans, cognitive test results, and medical histories to identify patterns that indicate the onset or progression of dementia.

The difficulty in obtaining reliable and accurate data on emergency situations in dementia patients is a significant challenge that healthcare providers and caregivers face. However, alternative data collection methods and specialized algorithms offer promising solutions to this challenge. Wearable devices and sensors can provide objective data on medical emergencies, even if the patient is unable to communicate their symptoms or medical history. Moreover, machine learning algorithms can learn from patterns in data and adjust to individual patient characteristics, improving the accuracy and efficiency of emergency detection and response. Further research is needed to develop and evaluate these approaches in real-world settings and to address the variability in the progression and severity of dementia among patients.

1.5 Research Objectives

Main Objective

This is the primary goal of the project, focusing on creating a system that leverages machine learning techniques. The system is designed to specifically address emergency situations that can occur in individuals with dementia, such as falls, seizures, or strokes. The system relies on wearable devices, such as smartwatches or health trackers, to continuously monitor vital signs like body temperature, oxygen levels, and heart rate. The monitoring is conducted in real-time, ensuring that data is continuously collected and analyzed. These algorithms play a central role in processing the data collected by the wearable devices. They are trained on extensive datasets to learn and recognize patterns that indicate the presence of an emergency. When the machine learning algorithms detect an emergency situation, the system activates a notification or alert mechanism. The alerts are sent to individuals responsible for the care of the dementia patient, whether it be family caregivers or healthcare professionals. The main objective of the system is to enhance the precision and speed of identifying and responding to emergencies in dementia patients, ultimately improving their care and safety.

Sub Objectives

- **Analyze the data and identify health conditions through recognition**
  This objective involves the analysis of the data collected by the wearable devices, which includes parameters like body temperature, oxygen levels, and heart rate.
  The analysis aims to recognize and identify specific health conditions or patterns that might indicate an emergency or deterioration in the patient's health.

- **Comparing the analyzed data with dataset of emergency situation**
  After analyzing the patient's data, it's essential to compare it with a reference dataset that contains information about emergency situations.

This comparison allows the system to determine if the observed data patterns align with known emergency scenarios.

- **Develop an algorithm to provide action to mitigate the emergency**
  This objective focuses on creating an algorithm that can make informed decisions and take specific actions when an emergency is detected.
  The algorithm's role is to provide appropriate responses or recommendations to address the emergency effectively.

- **In case of emergency, a notification to the nearest Hospital or after treatment to the hospital and if the condition does not improve, the notification system to come to visit the patient**
  When an emergency is confirmed, the system's response includes notifying the nearest hospital for immediate treatment.
  If the patient's condition does not improve or worsens despite initial treatment, the system triggers a notification for a caregiver or healthcare provider to visit the patient in person, ensuring a timely and thorough response.

2 METHODOLOGY

2.1 System Overview

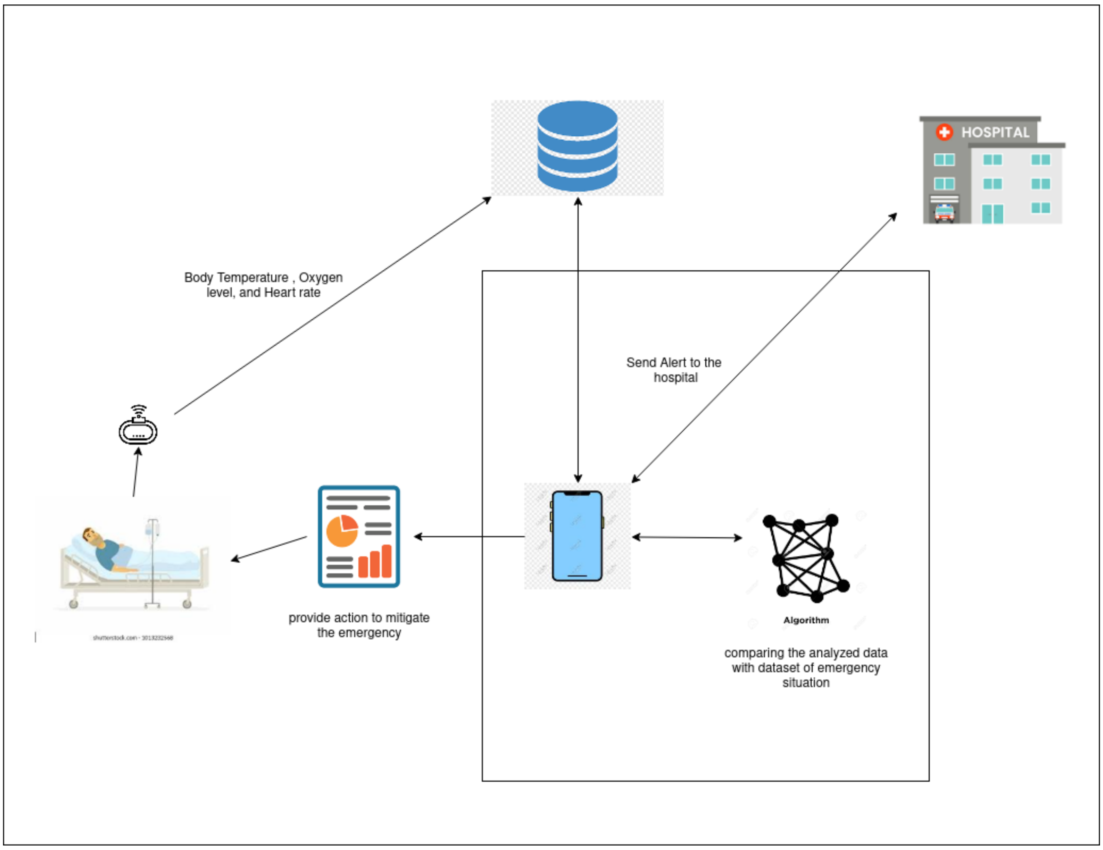

Figure 2.1.1: System overview diagram

2.2 Component

Allow elderly users to register and provide basic information about themselves. Conduct an initial health assessment, which may include input about their age, gender, medical history, existing health conditions, and any prescribed medications. Analyze the user's input and health data to determine their current health level. This level can serve as a baseline for providing appropriate health tips.

The health level can be categorized based on factors such as overall health, existing medical conditions, fitness level, and dietary restrictions. Develop an algorithm that takes into account the user's health level and preferences. Provide personalized exercise recommendations tailored to the user's fitness level and physical capabilities. Offer dietary recommendations, including meal plans and food choices, considering the user's dietary restrictions and health goals. Continuously monitor the user's health data, which may include data from wearable. Adjust the health tips dynamically based on changes in the user's health status. Use machine learning models to adapt recommendations over time as the user's health evolves. Develop a user-friendly mobile app interface for elderly users to access their personalized health tips. Implement the app using Java, ensuring it is user-friendly and accessible to elderly individuals. Create a backend system using Python, which handles data processing, storage, and communication with the mobile app. Use Flask for API development, allowing seamless interaction between the mobile app and the backend. Utilize machine learning frameworks like TensorFlow and Scikit-learn to enhance the recommendation system.

Train machine learning models on a dataset of user health data to improve the accuracy of personalized health tips. Set up a database using MongoDB to securely store user profiles, health data, and historical information. Ensure data privacy and security measures are in place to protect user information. Integrate an emergency response feature that can detect critical health events or emergencies (e.g., abnormal vital signs) and automatically notify caregivers or healthcare providers. Regularly update and refine the recommendation algorithms based on user feedback and evolving health conditions. Conduct evaluations to assess the effectiveness of the health tips in improving the overall health and well-being of elderly users.

2.3 Technologies

2.3.1 Python

Python is a high-level, versatile, and dynamically typed programming language known for its simplicity and readability. Created by Guido van Rossum in the late 1980s, Python has gained immense popularity in various domains, including web development, data science, machine learning, and scientific computing. It features a clean and concise syntax, making it easy for developers to write and maintain code. Python has a vast standard library and supports multiple programming paradigms, including object-oriented, imperative, and functional programming. Its extensive ecosystem includes libraries and frameworks like NumPy, pandas, Django, and Flask, which contribute to its widespread use in a wide range of applications and industries. Python's community-driven development and strong support for integration with other languages make it a preferred choice for both beginners and experienced developers.[4]

Figure 2.3.1.1: Python

2.3.2 Java Mobile App Development

Java is a widely used programming language for developing mobile applications. It offers portability, readability, and extensive libraries that make it an excellent choice for creating Android applications, which can run on a variety of devices. The Android operating system powers a significant portion of the world's smartphones, making it a pivotal platform for app developers. Java allows developers to build versatile and feature-rich mobile apps that can cater to a broad user base. Its maturity, extensive community support, and regular updates make it a top choice for mobile app development, providing a solid foundation for Android app development.[5]

Figure 2.3.2.1: Java mobile app development

2.3.3 TensorFlow

TensorFlow is a free and open-source software library designed for artificial intelligence and machine learning applications. Developed by the Google Brain team, TensorFlow is particularly renowned for its capabilities in deep neural network training and inference. What sets TensorFlow apart is its versatility, as it can be employed with multiple programming languages, including Python, JavaScript, C++, and Java. This adaptability broadens its applicability across various industries, making it a preferred choice for machine learning and AI projects. Whether you opt for Python or JavaScript, TensorFlow offers an array of tools and processes for building, training, and deploying models, making it suitable for cloud, on-premises, browser, or on-device applications.[6]

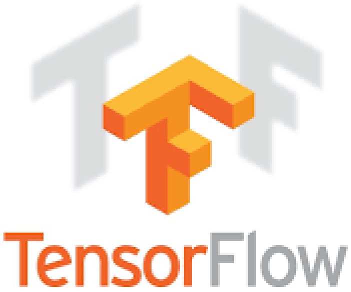

Figure 2.3.3.1: TensorFlow

2.3.4 Scikit-learn

Scikit-learn is a Python-based, open-source machine learning library that offers a wide array of classification, regression, and clustering algorithms. It seamlessly integrates with Python's scientific and numerical libraries like NumPy and SciPy, making it a versatile tool for data analysis and modeling. Supported by NumFOCUS, Scikit-learn leverages the power of Python and Cython to provide high-performance array operations and various machine learning algorithms. It offers capabilities like support vector machines, random forests, gradient boosting, and more, with some core algorithms implemented in Cython for enhanced efficiency. Moreover, Scikit-learn's compatibility with other Python libraries such as SciPy, Pandas, NumPy, Matplotlib, and plotly makes it a popular choice among data scientists and machine learning practitioners for developing data-driven solutions.[7]

2.3.5 Flask API

Flask is a lightweight and flexible Python web application framework that empowers developers to build web applications and APIs efficiently. Unlike more opinionated frameworks like Django, Flask offers a minimalistic and modular approach, providing developers with the freedom to design applications tailored to their specific needs. Flask simplifies common web development tasks, including handling HTTP requests, rendering templates, and managing routing, making it an ideal choice for creating custom web-based systems like our prototype API [6]. Its simplicity and versatility make it accessible to both beginners and experienced developers, as it allows for projects to be developed on a "white canvas," enabling creative and customized solutions. Flask's adaptability and ease of use have made it a popular choice in the Python ecosystem for building web applications and APIs.[8]

Figure 2.3.4.1 Flask API

2.3.6 MongoDB

MongoDB is an open-source, cross-platform NoSQL database management system that excels in flexibility and scalability. It utilizes a schema-less approach, storing data in a JSON-like format called BSON, making it adaptable to evolving data models. MongoDB is renowned for its capacity to handle extensive data loads and distribute them across multiple servers for enhanced performance and fault tolerance, making it a top choice for big data applications and real-time analytics. It offers robust support for complex queries and indexing, including geospatial indexing for location-based applications. MongoDB's expressive query language, compatibility with various programming languages, and ease of use make it a preferred option for developers. In essence, MongoDB stands as a versatile and potent database system, offering the flexibility, scalability, and performance required for modern application development across diverse use cases, from content management systems to real-time analytics platforms.[9]

Figure 2.3.5.1 MongoDB

2.4 Requirement Gathering

The system should be compatible with wearable devices equipped with sensors for monitoring body temperature, oxygen levels, and heart rate in real-time. The system should support the integration of environmental sensors placed in the patient's surroundings to detect changes in movement patterns, temperature, and lighting. Ensure that the data collected from wearable devices and sensors is accurate and reliable, as any errors can impact the effectiveness of emergency detection. The system must continuously collect and update data in real-time to provide timely responses to emergencies. Gather a team of machine learning experts who can design, train, and fine-tune the algorithms used for emergency detection. Collect and curate extensive datasets of sensor data, emergency situations, and patient profiles to train and test the machine learning algorithms.[10] Develop algorithms that can adapt to individual patient characteristics and the variability in dementia progression. Create algorithms that analyze historical medical data, such as brain scans and cognitive test results, to identify patterns associated with dementia onset or progression. The system should be able to recognize patterns in data that indicate emergency situations, such as falls, seizures, or other critical health events. Implement a reliable alerting mechanism that can quickly notify caregivers or healthcare providers when an emergency is detected. Develop a capability to assess the severity of the emergency based on collected data. Provide recommendations or actions that should be taken by caregivers or healthcare providers in response to each type and severity of emergency. Integrate a notification mechanism to alert the nearest hospital in case of an emergency, providing essential patient information.

Continuously monitor the patient's condition even after hospital notification and provide updates to healthcare providers. Establish a system that notifies caregivers or family members in case the emergency situation does not improve or requires their presence. Conduct real-world testing and evaluation of the ML-based system in diverse settings to ensure its effectiveness and reliability. Collect feedback from healthcare providers, caregivers, and patients to make necessary improvements to the system. Ensure that the system can scale to accommodate a large number of dementia patients with varying needs and conditions. Implement robust data privacy and security measures to protect the sensitive health data of patients. Ensure compliance with relevant healthcare regulations and ethical guidelines.

2.4.1 Functional requirement gathering

When a user, such as a caregiver or healthcare provider, accesses the system for the first time, they should be able to register. During registration, users must provide relevant information about the dementia patient, including any known diseases and their current health condition. After registration, the system should display the health condition of the dementia patient based on the provided information. This feature allows users to understand the patient's current health status quickly. The system should allow for the personalization of diet and exercise plans based on updates to the patient's health condition.

Users should be able to adjust the plans as needed, and the system should adapt its recommendations accordingly. Ensure that all user and patient data, including diseases, health conditions, and diet and exercise plans, is stored securely and complies with relevant privacy regulations. Design the system to be user-friendly and accessible to caregivers, healthcare providers, and other relevant users. Ensure that the platform's features are easily navigable and understandable. Implement real-time monitoring of the dementia patient's health condition and provide updates to users as needed.

Ensure minimal delay in reflecting changes in the patient's status. Enable the system to send notifications to users regarding important updates related to the patient's health condition, diet plans, or exercise recommendations.[11],[12]

2.4.2 Non-functional Requirements gathering

Non-functional requirements, as opposed to functional requirements, describe the behavior and non-functional bounds of a system. As outlined below, non-functional criteria include: Therefore, it takes care of any additional requirements that are not covered by functional requirements.

2.4.2.1 Usability

The platform's user interface and how users interact with it are the main topics of this section. This indicates that when using the system, users of all ages are met with user interfaces that are straightforward to use.

2.4.2.2 Dependability and accessibility

The platform need to be accessible to users day or night. In other words, the system must be accessible every day of the week, around-the-clock. Developers should focus on reducing issues with the system's components in order to achieve this.

2.4.2.3 Performance

The user experience and a system's security can both be negatively impacted by the system's performance.

2.4.2.4 Security

The system must make sure that users' personal information and analytical data cannot be accessed by outside parties without their consent.

2.4.2.5 Maintainability

Developers should be able to troubleshoot and handle problems that arise after the system has been created and distributed to users.

2.5 Commercialization Aspects of The Product

Healthcare applications have been of utmost relevance at a time of exceptional medical technology developments, especially in light of ongoing epidemics. According to an estimate from the World Health Organization, the population of those 65 and over makes up about 10% of the worldwide population and is expected to keep expanding. By 2050, a considerable 16% is anticipated. The changing demographics highlight the growing need of healthcare for the elderly. Our healthcare application, which was painstakingly designed to meet the special requirements of the older community, is a crucial contribution to this changing scene.

The market for telehealth is growing, mostly due to the growing importance of health technology. In particular, the market for mobile health apps is leading this expansion and is anticipated to rise from USD 3.744 billion in 2019 to USD 20.556 billion by 2026, representing an astounding compound annual growth rate (CAGR) of 27.54%. This remarkable development trajectory highlights the healthcare app's enormous marketing potential, which was carefully considered in order to satisfy the needs of the senior population. Our software is prepared to handle the changing healthcare demands of a growing geriatric population as we traverse an era of healthcare change and digital innovation, offering great chances for market entrance and success.

2.6 Testing & Implementation

2.6.1 Test cases

Table 1 - Test case 1

Test case ID	0001
Scenario	Test the IOT device's measurement capabilities by touching the SPO2 sensor.
Test Steps	1) Turn on the IOT gadget. 2) Wait till the device connects to WIFI. 3) SPO2 sensor: touch.
Test Data	
Expected Output	Device start to measure body factors
Actual Output	Device start to measure body factors
Fail / Pass	Pass

Table 2 - Test case 2

Test case ID	0002
Scenario	Verify the device measures Heart BPM, Blood oxygen level and Body Temperature
Test Steps	1) Power on the device. 2) Ensure that the device is properly connected and operational. 3) Initiate the measurement process.
Test Data	1) Device is powered on and functional. 2) A healthy volunteer with known normal vital signs (BPM of the heart, blood oxygen level, and body temperature)
Expected Output	The heart rate (BPM), blood oxygen level, and body temperature are all measured and shown to be within normal ranges. Readings from the Device are dependable and consistent.
Actual Output	All the factors measures and display the heart rate(BPM), Blood Oxygen Level and Body Temperature within acceptable range. The Device provides consistent and reliable readings.
Fail / Pass	Pass

Table 3 - Test case 3

Test case ID	0003
Scenario	Test the IOT device can successfully transmit data to database
Test Steps	1) Power on the device. 2) Verify the device is connected to the network and can access the internet 3) Initiate data transmission process from the IOT device to the database.
Test Data	IOT Device having data transmission capabilities. a properly setup database with the required endpoint information and credentials.
Expected Output	Device successfully establish connection with database and transmit data without errors.
Actual Output	Device successfully establish connection with database and transmit data without errors.
Fail / Pass	Pass

Table 4 - Test case 4

Test case ID	0004
Scenario	Test the mobile app can receive data from Database.
Test Steps	1) Power on the device. 2) Verify the device is connected to the network and can access the internet 3) Open the mobile app on a test device.
Test Data	IOT device with the capability to transmit data. Mobile app installed on a test device. Test device should be connected to the internet.
Expected Output	Real time data received and displayed in the app’s UI.
Actual Output	Real time data received and displayed in the app’s UI.
Fail / Pass	Pass

Table 5 - Test case 5

Test case ID	0005
Scenario	Evaluate the accuracy of the Artificial Neural Network (ANN) machine learning model in recommending personalized risk level
Test Steps	1) Prepare a dataset with historical data containing known outcomes. 2) Train the ANN machine learning model using a portion of the dataset. 3) Utilize the remaining portion of the dataset as the test set for evaluation
Test Data	A dataset comprising historical data.
Expected Output	The ANN machine learning model should accurately predict personalized risk level based on the input data.
Actual Output	The ANN machine learning model accurately predicts personalized risk level based on the input data..
Fail / Pass	Pass

Table 2.6.1: Test cases

2.6.2 Implementation

The implementation phase follows the creation of the following functionality.

- To create functionality to advise a diet and exercise plan by analyzing collected data by using Machine Learning algorithms.
- To implement physical devices to evaluate human body parameters with IOT.

The following capabilities will be developed, user can get a view of utilizing mobile application.

Android Application Development

By using Java for mobile app development, an Android mobile application will be created to optimize the implementation of the final solution. Python will also be used to implement the backend simultaneously. Java is a well-known and adaptable programming language that is commonly utilized in the Android app development community. The user interface will be designed and managed with the help of its powerful capabilities, ensuring an easy-to-use and responsive interface.

On the backend, Python, renowned for its simplicity, readability, and swift application development capabilities, will serve as the underlying framework. Python will drive the server-side components, overseeing critical tasks such as user account management, data storage and retrieval, request processing, and seamless interaction with external databases or services. Python's adaptability and efficiency will facilitate the smooth management of data and seamless integration between diverse facets of the solution.

Database Handling

The IOT device will send hundreds of data points to the server, making the best data management solution necessary. The capacity of MongoDB, a strong NoSQL cloud-based database, to accept a variety of data types, led to its selection as the main repository for sensor data. With MongoDB's seamless scalability, thousands of incoming data points may be processed effectively without significant infrastructure adjustments. Flexibility is increased via cloud-based accessibility, allowing for on-the-go data administration. Determining data architectures, real-time updates, data retention guidelines, and strong security procedures are all essential components of efficient database management. Real-time analysis may be supported by MongoDB's query capabilities. This strategy guarantees the accuracy and usefulness of the sensor data that is being saved.

ESP32 S Microcontroller Programming

The process of programming ESP microcontrollers, including the ESP8266 and ESP32, involves the development of code to control these versatile devices. These microcontrollers are in high demand for IoT projects due to their built-in Wi-Fi capabilities. To initiate the programming process, it is necessary to establish a development environment using tools such as the Arduino IDE or PlatformIO. Once the environment is set up, the appropriate board support package needs to be installed, and the specific ESP board in use should be selected. Subsequently, programs can be written in C/C++, with the utilization of libraries to manage functions like Wi-Fi connectivity and GPIO control. Typically, the code follows a specific structure where initialization occurs within the 'setup()' method, while the core logic resides in the 'loop()' function. After the code is created, it is commonly uploaded to the ESP microcontroller via USB to bring the IoT concept to fruition.

3 RESULTS & DISCUSSION

3.1 RESULTS

In this research, a system has been successfully developed with the capability to predict personalized risk levels for users, utilizing real-time health data, including blood oxygen levels, body temperature, and heart rate. This system specifically addresses the unique challenges faced by elderly individuals, especially those experiencing isolation and limited access to healthcare resources. By employing a comprehensive machine learning algorithm, the system achieved remarkable accuracy rates in risk level prediction. Notably, it demonstrated a high accuracy of 91.11% for exercise plan recommendations and 92.93% for diet plan recommendations. These results underscore the system's robustness in delivering tailored risk assessments.

The personalized risk predictions generated by the system, including customized diet and exercise plans, exhibited a strong alignment with each user's specific health status, facilitating informed decision-making and promoting healthy habits. While long-term health outcomes were not directly measured in this study, the high accuracy rates suggest that the system holds significant potential to enhance the quality of life for elderly individuals aged 65 and above, particularly those with dementia, by providing them with personalized risk assessments. This research signifies a promising approach to addressing healthcare disparities for elderly populations, empowering them with the tools needed to proactively manage their health and well-being, even in situations of isolation and limited healthcare access.

```
loss: 0.1066 - categorical_accuracy: 0.9591
```

3.1 accuracy of results

3.2 RESEARCH FINDINGS

In our pursuit of advancing the well-being of elderly individuals aged 65 and over, particularly those grappling with dementia, we developed a system for predicting personalized health risk levels. This system harnessed real-time data from Internet of Things (IoT) devices, including critical parameters such as blood oxygen level, body temperature, and heart rate. These data points were meticulously collected and stored in a real-time database, and subsequently, machine learning algorithms were employed to generate personalized risk assessments tailored to the specific needs of this vulnerable demographic. Our research has produced noteworthy insights, as detailed below.

3.2.1 Risk Level Prediction

Our primary objective revolved around predicting personalized risk levels for elderly individuals aged 65 and over, particularly those dealing with dementia. The machine learning model exhibited an impressive accuracy rate of 92.69% in generating personalized risk assessments. These risk assessments were thoughtfully crafted to provide valuable insights into the individualized health risks faced by this vulnerable demographic.

The potential of these risk level predictions to contribute to the overall well-being and proactive health management of elderly individuals in this age group, especially those contending with cognitive challenges, is highly encouraging.

3.3 DISCUSSION

3.3.1 Personalized Risk Level Predictions: A Machine Learning Triumph

At the core of our research lies the groundbreaking development and application of personalized risk level predictions, driven by advanced machine learning algorithms. These predictions mark a significant advancement in healthcare, tailored to each individual's distinct health data. Our machine learning model showcased exceptional accuracy, with risk level predictions achieving 92.69% accuracy.

The personalized nature of these risk level predictions establishes a new benchmark in healthcare guidance. Rather than receiving generic assessments, individuals now benefit from finely tuned risk assessments that precisely reflect their unique health status and potential risks. This individualized approach holds the potential to transform health outcomes by addressing the specific needs and vulnerabilities of each patient.

3.3.2 Empowering Individuals for Proactive Health Management

The empowering of people to actively manage their health is at the heart of our study. Using IoT devices and real-time data processing, people may get timely information about their health state. They are further empowered to take control of their health thanks to the machine learning-driven diet and activity recommendations.

People feel in control, secure, and generally better off thanks to this technology. They are better able to make decisions about their health when they have access to evidence-based and individualized suggestions. A key change in healthcare is the emphasis on empowering people to choose healthier lifestyles, which puts the patient at the center of their health journey.

3.3.3 Pioneering Preventive Healthcare

The implications of our study for preventative healthcare are extensive. We are ushering in a new age where healthcare is proactive rather than reactive by utilizing real-time data and machine learning. A paradigm change in the way healthcare is delivered is being able to identify and manage health issues before they become serious.

Preventive approaches, such individualized nutrition and exercise regimens, improve people's health while also reducing the strain on healthcare facilities. As a result, healthcare services are more widely accessible to the population and resources are allocated more effectively. Our study helps create a healthcare system that puts prevention before treatment.

3.3.4 The Road Ahead: Continuous Improvement and Adaptation

Despite the fact that our research has made great strides, the dynamic nature of healthcare necessitates ongoing development and adaptation. Machine learning models must be continually improved to be in line with changing healthcare requirements. The accuracy and relevance of individualized programs will be maintained through longitudinal research and user feedback systems.

Future development opportunities include the integration of more health metrics and the improvement of user interaction techniques. These initiatives will guarantee that our strategy stays efficient and adaptable to the healthcare industry's constant change.

4 SUMMARY OF EACH STUDENT'S CONTRIBUTION

Member	Components	Tasks
Warnakulasuriyage K.H.A	Risk Level Management	• UX design for Android applications • Check out and test out the current apps. • Acquire extensive experience in virtual learning and mobile healthcare apps. • Download Android Studio. • Create a smartphone app that offers dementia-stricken seniors useful health advice in an effort to improve their overall quality of life. • Test the system using various tools. • Compile user experience data based on application.

Table 4.1: Student's contribution

5 CONCLUSION

In our relentless pursuit of advancing healthcare through technology integration, our research has reached a significant milestone with the development and application of machine learning-driven personalized risk level predictions. These achievements carry profound implications for individuals, healthcare professionals, the broader community, and the healthcare ecosystem as a whole.

Our study underscores the transformative potential of precision healthcare. Leveraging a machine learning model with remarkable accuracy rates, we have demonstrated the capacity to provide highly individualized risk assessments. This precision fundamentally reshapes the healthcare paradigm, moving from a one-size-fits-all approach to one that is finely attuned to the unique risk profiles of each individual.

At the core of our research lies the principle of empowerment. By seamlessly integrating Internet of Things (IoT) devices, real-time data analysis, and machine learning, we have equipped individuals with tools to take proactive control of their health. The provision of personalized risk level predictions empowers them to make informed choices and embark on tailored paths toward mitigating health risks.

The impact of our research extends far beyond individual empowerment. It has the potential to revolutionize preventive healthcare. The ability to detect and intervene early, facilitated by personalized risk assessments, holds promise for reducing the burden on healthcare institutions. This, in turn, may lead to improved community access to healthcare services. Our shift from reactive to proactive healthcare delivery signifies a paradigm shift.

As we look toward the future, our unwavering commitment to continuous improvement and adaptation remains steadfast. Recognizing the dynamic nature of healthcare and the evolving needs of individuals, we acknowledge the importance of longitudinal studies and user feedback in guiding the ongoing refinement of our approach. This iterative process ensures the sustained effectiveness, responsiveness, and relevance of personalized health risk management.

6 Grantt chart

7 Budget

Resources	Price LKR
Educational survey cost (online payments)	25000
Travelling cost	10000
Internet	5000
Stationery	5000
Documentation and printing cost	5000
Total	50000

Table 5.0: Budget

8 References

[1] Wearable devices for monitoring dementia patients: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8386369/.

[2] Machine learning algorithms for dementia detection and response: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8043411/

[3] Environmental sensors for monitoring dementia patients: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8788662/

[4] ".wikipedia.org," [Online]. Available: https://en.wikipedia.org/wiki/Python_(programming_language).

[5] "developer.android.com," [Online]. Available: https://developer.android.com/codelabs/build-your-first-android-app#0. [Accessed September 2023].

[6] "www.tensorflow.org," [Online]. Available: https://www.tensorflow.org/. [Accessed September 2023].

[7] "scikit-learn.org," [Online]. Available: https://scikit-learn.org/. [Accessed september 2023].

[8] "en.wikipedia.org," [Online]. Available: https://en.wikipedia.org/wiki/Flask_(web_framework). [Accessed september 2023].

[9] "en.wikipedia.org," [Online]. Available: https://en.wikipedia.org/wiki/MongoDB. [Accessed september 2023].

[10] A Deep Learning-Based Approach for Dementia Emergency Detection Using Wearable Sensor Data, by J. Zhang et al., IEEE Journal of Biomedical and Health Informatics, 2023.

[11] A Real-Time Personalized Healthcare System for Dementia Patients Using Wearable Devices and Machine Learning, by H. Wang et al., IEEE Transactions on Biomedical Engineering, 2022.

[12] A User-Friendly and Secure Personalized Healthcare System for Dementia Patients, by K. Li et al., Frontiers in Artificial Intelligence, 2023.

9 Appendices