PRODUCT DESIGN AND ANALYSIS OF WALKER USING IoT

NURUL SHAHIDA AKILA BINTI ZAINURIN
B091910330

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PRODUCT DESIGN) WITH HONOURS

2023

Faculty of Mechanical and Manufacturing Engineering Technology

Product Design and Analysis of Walker Using IoT

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

NURUL SHAHIDA AKILA BINTI ZAINURIN

Bachelor of Manufacturing Engineering Technology (Product Design) with Honors

2023

Product Design and Analysis of Walker Using IoT

NURUL SHAHIDA AKILA BINTI ZAINURIN

A thesis submitted
in fulfilment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled " Product Design and Analysis of Walker Using IoT" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : NURUL SHAHIDA AKILA BINTI ZAINURIN

Date : 11/1/2023

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

Signature :

Supervisor Name : *TS. DR. SYAHIBUDIL IKHWAN BIN ABDUL KUDUS*

Date : 11/1/2023

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEDICATION

This work is wholeheartedly dedicated to all my valuable treasures:

For my beloved parent:

Zainurin Bin Marsan

Rosmawati Binti Miskam

For my supportive siblings:

Nurul Syamimie Athirah Binti Zainurin

Nurul Safiya Arisha Binti Zainurin

Thank you for always providing me moral, emotional, financial support and gave me strength when I thought of giving up.

For my respective superviso:

Ts. Dr Syahibudil Ikhwan Bin Abdul Kudus

For all Utem lectures, Engineer Assistance, and my treasured friend:

Who shared their word of advice and encouragement to finish this study

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRACT

A walker is a device that is prescribed to help a certain user such as a lower limb disabled, elderly, or blind person move. Nowadays, technological advancements have the potential to improve the quality of life of the lower limb disabled or elderly by developing various types and functions of walkers to assist with their daily life activities; however, these walkers have limitations that may be harmful to the user's body. The aim of the research work described in this report is to design and phototype development of walker for IoT device monitoring analysis using Blynk application. Additionally, evaluating the performance of the variable device monitor, which is heart rate, step count and fall detection monitor. The QFD is a technique for gathering consumer feedback and converting the needs of the responders into technical specifications. In accordance with the information gathered from the interview session, the House of Quality (HOQ) of walker was constructed, which was then used to examine the product's features and its connection matrix. Besides, the standard walker will cause users to present a forward-leaning posture which will cause them to suffer from back or neck pain. The user's requirements were satisfied and the issues they ran into while using the walker were resolved via modification and enhancement of the device. In addition, the QFD integrated model is developed and validated via analysis of the design process and results. Simultaneously the next step is engineering drawing and 3D modelling. By utilising the QFD integration, the walker might be improved with a workable solution. By using the integration on QFD could help in improving the walker with a suitable solution. After do the 3D modelling, the process of prototype the walker has conducted. And the lastly is doing the testing on the walker. Usability test is the method that used in the testing product.

اونيۏرسيتي تيکنيکل مليسيا ملاک

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRAK

Pejalan kaki ialah peranti yang ditetapkan untuk membantu pengguna tertentu seperti anggota bawah yang kurang upaya, warga emas atau orang buta bergerak. Pada masa kini, kemajuan teknologi berpotensi untuk meningkatkan kualiti hidup anggota bawah OKU atau warga emas dengan membangunkan pelbagai jenis dan fungsi pejalan kaki untuk membantu aktiviti kehidupan seharian mereka; walau bagaimanapun, pejalan kaki ini mempunyai had yang mungkin berbahaya kepada badan pengguna. Matlamat kerja penyelidikan yang diterangkan dalam laporan ini adalah untuk mereka bentuk dan pembangunan fototaip walker untuk analisis pemantauan peranti IoT menggunakan aplikasi Blynk. Selain itu, menilai prestasi monitor peranti berubah-ubah, iaitu kadar denyutan jantung, kiraan langkah dan monitor pengesanan jatuh. QFD ialah teknik untuk mengumpul maklum balas pengguna dan menukar keperluan responden kepada spesifikasi teknikal. Selaras dengan maklumat yang dikumpul daripada sesi temu bual, House of Quality (HOQ) walker telah dibina, yang kemudiannya digunakan untuk meneliti ciri-ciri produk dan matriks sambungannya. Selain itu, pejalan kaki standard akan menyebabkan pengguna menunjukkan postur condong ke hadapan yang akan menyebabkan mereka mengalami sakit belakang atau leher. Keperluan pengguna telah dipenuhi dan isu yang mereka hadapi semasa menggunakan pejalan kaki telah diselesaikan melalui pengubahsuaian dan peningkatan peranti. Selain itu, model bersepadu QFD dibangunkan dan disahkan melalui analisis proses dan keputusan reka bentuk. Pada masa yang sama langkah seterusnya ialah lukisan kejuruteraan dan pemodelan 3D. Dengan menggunakan penyepaduan QFD, pejalan kaki mungkin dipertingkatkan dengan penyelesaian yang boleh dilaksanakan. Dengan menggunakan penyepaduan pada QFD boleh membantu dalam menambah baik walker dengan penyelesaian yang sesuai. Selepas melakukan pemodelan 3D, proses prototaip walker telah dijalankan. Dan yang terakhir adalah melakukan ujian pada walker. Ujian kebolehgunaan ialah kaedah yang digunakan dalam produk ujian.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the and Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform. Thank you also to the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

My utmost appreciation goes to my main supervisor, Ts. Dr Syahibudil Ikhwan Bin Abdul Kudus, Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM) for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights will forever be remembered. My special thanks go to Prof Dr. Lau Kok Tee and Dr. Muhd Hung for all the help and support I received from them.

Last but not least, I would like to thank my beloved parents Mr. Zainurin Bin Marsan and Mrs. Rosmawati for their endless support, love and prayers. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TABLE OF CONTENTS

		PAGE
DECLARATION		
APPROVAL		
DEDICATION		
ABSTRACT		**i**
ABSTRAK		**ii**
ACKNOWLEDGEMENTS		**iii**
TABLE OF CONTENTS		**iv**
LIST OF TABLES		**vii**
LIST OF FIGURES		**ix**
LIST OF SYMBOLS AND ABBREVIATIONS		**xiii**
LIST OF APPENDICES		**xiv**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Introduction	1
1.2	Background	1
1.3	Problem Statement	2
1.4	Research Objective	4
1.5	Scope and limitation	4
CHAPTER 2	**LITERATURE REVIEW**	**6**
2.1	Introduction	6
2.2	Walker	6
	2.2.1 Definition of Walker	6
	2.2.2 Type of Walker	8
	2.2.3 Specification Analysis of Walker	10
2.3	Block Diagram	23
2.4	Software Development	24
	2.4.1 Arduino	24
	2.4.2 Blynk	25
2.5	Hardware Development	28
	2.5.1 Buzzer	28
	2.5.2 Switch	29
	2.5.3 Sensor	30
	2.5.4 Battery	34
2.6	Summary	36

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 3 METHODOLOGY 37
3.1 Introduction 37
3.2 Research Design 37
3.3 Project Planning 39
3.4 Proposed Methodology 40
3.5 Design Improvement 41
3.6 Usability 42
3.7 Summary 42

CHAPTER 4 RESULTS AND DISCUSSION 44
4.1 Introduction 44
4.2 Product Analysis 44
4.2.1 Product Location and Market Analysis of Walker 44
4.2.2 Morphological Chart 53
4.3 Customer Needs 61
4.4 Quality Function Development (QFD) 65
4.5 Design Concept Development 67
4.6 Design Sketches 69
4.7 Final Design Selection 71
4.7.1 Introduction 72
4.7.2 Method 72
4.7.3 Result 73
4.8 Final Design 75
4.9 Software Development 76
4.9.1 Integrate Coding 76
4.9.2 Blynk 78
4.9.3 Electric Development 81
4.10 Prototype Development 85
4.11 Results and Analysis of comparison data 87
4.11.1 Objective 87
4.11.2 Method 88
4.11.3 Result 88
4.11.4 Discussion 92
4.12 Usability Test 93
4.12.1 Method 93
4.12.2 Participant 95
4.12.3 Procedure 97
4.12.4 Result 99
4.13 Summary 106

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS 107
5.1 Conclusion 107
5.2 Scope and limitation 108
5.3 Recommendations 109
5.4 Project Potential 109

REFERENCES 110

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPENDICES **112**

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1	Specification Analysis	11
Table 2.2	Explanation about Blynk app with its server and libraries	27
Table 2.3	Different Between Wearable Sensor Device and Non-wearable Sensor Device	31
Table 4.1	Position Map 1	44
Table 4.2	Position Map 2	45
Table 4.3	Grades for The Walker Based on The Performance	46
Table 4.4	Zone Description for Position Map 1	50
Table 4.5	Zone Description for Position Map 2	52
Table 4.6	Morphological Chart	54
Table 4.7	Need Statement	61
Table 4.8	Importance Weight of Customer Requirements	63
Table 4.9	House of Quality (HOQ)	65
Table 4.10	Product Feature	68
Table 4.11	Pugh Matrix	73
Table 4.12	Comparison of heart rate value and step count between walker and pulse oximeter	89
Table 4.13	The average value and percentage error for the heart rate value	90
Table 4.14	Comparison of heart rate value and step count between walker and manual count	91
Table 4.15	The average value and percentage error for the step count	92

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Table 4.16 Participant's weights and heights 96

Table 4.17 Explanation About the Usability, Applicability, and Effectiveness 97

Table 4.18 SUS Score 105

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	Main Design of the Walker	7
Figure 2.2	Farmer, 1978	7
Figure 2.3	Walkerette	8
Figure 2.4	Walker without the Wheel	8
Figure 2.5	Walker with the Wheels at Front	9
Figure 2.6	Walker with Wheels	10
Figure 2.7	Karman R-3600 Three-Wheel Rollators	11
Figure 2.8	Dive Medical Nitro Rollator (RTL10266)	12
Figure 2.9	Adult Cavalier Anterior Walker	13
Figure 2.10	Duo Walking Trolley	13
Figure 2.11	Walking Frame	14
Figure 2.12	Forearm Walking Frame	15
Figure 2.13	Upright Walker	16
Figure 2.14	Ez Fold “N Go Walker	17
Figure 2.15	Rollator Walker	17
Figure 2.16	Walking Tutor-Heavy Duty	18
Figure 2.17	Legged Lightweight Folding Rollator	19
Figure 2.18	Dual Riser Walking Frame	20
Figure 2.19	Block Diagram (Input, Processor and Output)	23
Figure 2.20	System-running Arduino IDE	25
Figure 2.21	IoT process	26

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 2.22 Server layer-Blynk 27

Figure 2.23 Blynk 27

Figure 2.24 Buzzer 29

Figure 2.25 Switch 30

Figure 2.26 Flow Chart of Heart Rate Monitoring System 34

Figure 2.27 Battery 35

Figure 3.1 Workflow of The Project 38

Figure 4.1 Position Map 1-Ergonomic design VS Adjustability 49

Figure 4.2 Position Map 2- Style VS Foldability 51

Figure 4.3 Design Concept 1 69

Figure 4.4 Design Concept 2 70

Figure 4.5 Design Concept 3 71

Figure 4.6 3D Model of The Walker 75

Figure 4.7 Assembly of The Walker 75

Figure 4.8 3D Rendering of The Walker 76

Figure 4.9 3D Rendering of The Walker 76

Figure 4.10 Library/ Header of The Coding 76

Figure 4.11 Coding for Wi-Fi setting 77

Figure 4.12 Coding for Fall Detector Sensor 77

Figure 4.13 Coding for Step Value Sensor 78

Figure 4.14 Coding for Sensor Calling 78

Figure 4.15 Device Connecting in Blynk 79

Figure 4.16 Dashboard for The Project Walker 79

Figure 4.17 Data Collected Within Specific Time 80

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 4.18 Graph Display on Blynk for Step Count 80

Figure 4.19 Graph Display on Blynk for Heart Rate 81

Figure 4.20 Flow Chart 82

Figure 4.21 Schematic Diagram 83

Figure 4.22 Circuit Diagram 84

Figure 4.23 Walker frame 85

Figure 4.24 Walker frame 85

Figure 4.25 Walker Frame 86

Figure 4.26 Walker Frame 86

Figure 4.27 Arduino installation 86

Figure 4.28 Arduino installation 86

Figure 4.29 Prototype Walker 87

Figure 4.30 Prototype Walker 87

Figure 4.31 Graph of Comparison of Heart Rate Value Between Walker and Pulse Oximeter 89

Figure 4.32 Graph of Comparison of Step Count Between Walker and Manual Count 91

Figure 4.33 Level of SUS Score (Andrew Smyk, May 2020) 94

Figure 4.34 The Walker is Easy to Use 99

Figure 4.35 The IOT for the Walker is Complicated to Operate 100

Figure 4.36 The Structure of Walker is Sturdy and Strong Enough to Support Maximum Weight 100

Figure 4.37 The Walker is Not Easy to Store in a Small Space 101

Figure 4.38 The Walker is Suitable for Everyone to Used It, e.g. People of All Ages 101

Figure 4.39 The walker does not function well (in terms of collecting data) 102

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 4.40 The Walker Can Be Used in Medical Related Area (Heart Rate and Step Count) 102

Figure 4.41 The Walker Cannot Be Assembled Quickly 103

Figure 4.42 The Walker Can Gather Information Quickly 103

Figure 4.43 The Walker Cannot Gather Information Accurately 104

Figure 4.44 SUS Score scale 106

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF SYMBOLS AND ABBREVIATIONS

IoT	-	Internet of Things
HMI	-	Human Machine Interface
IDE	-	Integrated Development Environment
bpm	-	Beats Per Minute
SUS	-	System Usability Scale
QFD	-	Quality Function Development
HOQ	-	House of Quality

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX A	Gantt Chart	112
APPENDIX B	The Figure of The Interview Session	113
APPENDIX C	Concept Development	118
APPENDIX D	Engineering Design of Final Design	121
APPENDIX E	Prototype Making	124
APPENDIX F	Smart Walker	133
APPENDIX G	Usability / Participant testing	135
APPENDIX H	Questionnaire Design (Google Form)	140

UTeM
اونيۏرسيتي تيکنيکل مليسيا ملاک
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter describes the framework of this study. It includes the research background of mobility aids, problem statement, objectives, the scope, and limitation of project.

1.2 Background

Walker are device that are utilised by millions of people throughout the world, even though most people are ignorant of their existence. People with disabilities endure obstacles that we could never anticipate, such as inconvenient incidents in their everyday lives. Year after year, the number of persons with disabilities will increase.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Walkers have been used by persons who have difficulty moving about or who are recovering and need rehabilitation for millennia. Nonetheless, the road to the creation of walker has not been smooth, and there are several flaws that must be addressed and improved. There are various types of walkers that can obtain in the marketplace that could optimize the life quality of user who has mobility issue such as canes, crutches, walkers, and wheelchairs. The walker, also known as a walking frame or Zimmer frame, is a popular mobility device that was first introduced in the early 1950s. A rollator is more advanced than a regular walker since it is lower in weight and is equipped with hand brakes to slow or halt the rollator's movement. (M.Martin, P.Santos, Neto, & Ceres, 2012)

Furthermore, several actual research show that walker users have a higher risk of falling. Approximately 80% of the participants purchase a rolling walker without having received proper operation instruction or consulting a medical expert, 61% operate the walker haphazardly, and 19% of users receive their walker from medical professionals without receiving proper operation instruction. The most prevalent issue was inappropriate rolling walker height, which accounted for 55% of all cases. Around 17% of the rolling walkers had maintenance issues. Furthermore, 40% of users will have a forward-leaning posture while standing and utilising the walker for support, and 50% will have a forward-leaning posture while using the walker to mobilise. A forward-leaning posture during mobilisation is most likely to result in the user falling ((Liu, 2009).

According to WHO, the world's elderly population is anticipated to increase from 900 million to 2.0 billion between 2015 and 2050. The demand for walker is increasing among the geriatric population, owing to the benefits they provide to users, such as improved balance, extra support, and the ability to carry out daily activities independently. Furthermore, due to the critical function that rehabilitation equipment plays in improving the lives of the physically challenged, demand for it is rising. In 2015, walkers had a profit share of 31.65%, which was a record high ((Reportlinker, 2016)). Walkers provide various benefits over traditional walker, including the potential to increase a user's walking abilities, ensuring safety and comfort while walking, and providing additional support as well as a high weight-bearing capacity.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.3 Problem Statement

Although walkers are helpful devices that help people enhance their quality of life by improving their balance and stability, they do have certain drawbacks. Walkers are often used by people who have weak lower limbs and are given walkers to compensate for their

condition. However, continuous use of walkers can put additional strain on upper extremity joints, leading to arthritis, tendinitis, and carpal tunnel syndrome. The loads applied to the walker by the user are determined by the person's medical condition. Users with lower limb prostheses and spinal cord injuries apply 85% to 100% of their full weight to the walker, whereas people with supranuclear palsy apply 30% of their body weight to the walker. By increasing the weight on the walker, the stresses on the user's upper extremities rise, increasing the likelihood of further issues occurring. (Foley, Johnson, E. Kalbach Jr., & McNally, 2010)

A considerable number of walker owners have reported difficulties with the usage or design of their walker, and the number of incidents has been growing faster than the number of users. Falls are the most often reported walker-related incidents. The more often a walker is used, the more accidents occur, raising the question of whether or not walkers are truly safe to use. Furthermore, in order to employ assistive equipment like walkers, physiotherapist must guarantee that patients walk for a suitable amount of time during the rehabilitation process. This is a difficult task. Physiotherapists must verify that patients are performing the necessary exercises to enhance their walking. As a result, they must assist patients in changing their walking pace in accordance with their disease, as well as specify specific limitations for walking distance workouts and give extra assistance when patients lose their balance. As a result, it is critical to identify ways to make this process more objective and productive. (M.Martin, P.Santos, Neto, & Ceres, 2012)

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1. Incorrect posture while using a walker leads to body pain ((Liu, 2009)
2. Physiotherapists need to ensure that the patients are doing the adequate exercises to improve their walking. (M.Martin, P.Santos, Neto, & Ceres, 2012)

1.4 Research Objective

The research objective that needs to be achieved in this research are:

1. To design and phototype development of walker for IoT device monitoring analysis using Blynk application.

2. Evaluating the performance of the variable device monitor, which is heart rate, step count and fall detection monitor.

1.5 Scope and limitation

The major goal of this project is to address the shortage of walker availability and reduce the risk of damage caused by improper posture when using it, as well as its mobility. Furthermore, the existing walker design does not take into account the actual user needs; the walker should be designed to be portable yet simple, with ergonomic considerations such as handgrip position and angle, walker height, and others, so that the user can enjoy using the walker that makes their life easier. Furthermore, scenarios such as the user who has recently been discharged from the hospital, long-term walker users, children with developmental disability problems, and others must be considered to guarantee that the walker design is innovations or designs in terms of inventive design, hence improving the design of walkers is required.

The restriction of this project is to build a walker that meets the demands of several types of users. For example, the user may be a young guy with mobility issues as a result of an accident, or an old person with a loss of individual strength, both of which must be considered when creating. Second, because only specific ethnic groups would utilise this product, finding responders will be challenging, particularly during this epidemic era. A