CONCEPTUAL DESIGN OF THE COMPUTER MOUSE FOR HEALTHY WORKSTATION USING CONCURRENT ENGINEERING METHOD

LEE CHING HUNG

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CONCEPTUAL DESIGN OF THE COMPUTER MOUSE FOR HEALTHY WORKSTATION USING CONCURRENT ENGINEERING METHOD

LEE CHING HUNG

A report submitted

in fulfilment of the requirements for the degree of

Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I hereby declare that this project report entitled "Conceptual Design of The Computer Mouse for Healthy Workstation Using Concurrent Engineering Method" is the result of my own work except as cited in the references.

Signature : 

Name : LEE CHING HUNG

Date : 20/6/2021

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : …….

Supervisor's Name : DR. MOHD ADRINATA BIN SHAHARUZAMAN

Date : …….

ABSTRACT

Computer mouse has been a staple in the world of computers since its introduction in the 1960s. In fact, it is one of the two most important devices in the computer's graphical user interface other than the keyboard. Computer mouse has gone through a series of evolution. As of now, the design of the computer mouse has been expanded indefinitely. From the trackball mice to the current laser and light-emitting diode mice, and from the regular horizontal mice to the exceptional ergonomic mice, computer mouse indeed has come a long way since its invention. The ultimate purpose of this project is to develop a new conceptual design of an ergonomic mouse with the purpose of achieving a healthy workstation among the users. The relative knowledge of the topic is sourced from the past studies. In specific, there are three objectives in this project and all are converging towards the same ultimate goal. The first of which is to generate the conceptual designs for the new ergonomic mouse. Five conceptual designs were presented via TRIZ-PDS-morphological chart approach. The second objective is to select the best material for the mouse. Literatures related to the potential ergonomic mouse material were studied and information were extracted where necessary. Then, the best material was determined after utilising the analytic hierarchy process, one of the multiple criteria decision-making technique. The third objective for this project is to select the best design concept of the mouse. The analytic hierarchy process was also applied in fulfilling this objective. The results showed that the best material and design concept for the new ergonomic mouse is the man-made cellulose/PLA and Concept 2 respectively. The best material had scored a priority of 0.4251 (42.5%) and the best design concept had scored a priority of 0.4220 (42.2%). This report has provided an insight on designing a new product in concurrent engineering perspective and has the potential for further research.

ABSTRAK

Tetikus komputer telah menjadi suatu benda yang tidak dapat dikurangi dalam dunia komputer sejak diperkenalkan pada tahun 1960-an. Sebenarnya, ia merupakan salah satu daripada dua peranti yang terpenting dalam antara muka pengguna grafik komputer selain daripada papan kekunci. Tetikus komputer telah melalui satu siri evolusi. Sehingga kini, reka bentuk tetikus komputer telah diperluas tanpa had. Dari tetikus bebola jejak ke tetikus laser dan diod pemancar cahaya semasa, dan dari tetikus mendatar biasa ke tetikus ergonomik yang luar biasa, tetikus komputer sememangnya telah melalui jauh sejak ciptaannya. Tujuan akhir bagi projek ini adalah untuk menghasilkan reka bentuk konsep baru bagi tetikus ergonomik dengan tujuan mencapai tempat kerja yang sihat di kalangan pengguna. Pengetahuan berkenaan topik ini bersumber dari kajian lepas. Secara khusus, terdapat tiga objektif dalam projek ini dan semuanya menuju ke arah tujuan akhir yang sama. Yang pertama adalah menghasilkan reka bentuk konseptual untuk tetikus ergonomik baru. Lima reka bentuk konseptual telah dikemukakan melalui kaedah TRIZ-PDS-carta morfologi. Objektif kedua adalah memilih bahan terbaik bagi tetikus tersebut. Sastera yang berkaitan dengan bahan tetikus ergonomik yang berpotensi telah dikaji dan maklumat telah diekstrak jika perlu. Kemudian, bahan terbaik telah ditentukan setelah menggunakan proses hierarki analitik, salah satu teknik membuat keputusan pelbagai kriteria. Objektif ketiga bagi projek ini adalah memilih konsep reka bentuk yang terbaik untuk tetikus. Proses hierarki analitik juga dipakai dalam memenuhi objektif ini. Hasil kajian telah menunjukkan bahawa bahan dan juga konsep reka bentuk yang terbaik bagi tetikus ergonomik baru adalah selulosa buatan manusia/PLA dan Konsep 2 masing-masing. Bahan terbaik mendapat skor keutamaan sebanyak 0.4251 (42.5%) dan konsep reka bentuk terbaik mendapat skor keutamaan sebanyak 0.4220 (42.2%). Laporan ini telah memberikan pandangan mengenai mereka bentuk produk baru dalam perspektif kejuruteraan serentak dan mempunyai potensi untuk penyelidikan lebih lanjut.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my special thanks of gratitude to my project supervisor Dr. Mohd Adrinata bin Shaharuzaman who had guided me along the two semesters of this final year project.

Also, I would like to thank the Dean of Faculty of Mechanical Engineering Dr. Ruztamreen bin Jenal for giving me the wonderful opportunity to work on this project.

Particularly, I would also like to express my deepest gratitude to all my peers and family members who had given me their moral supports in completing the Bachelor course.

Lastly, huge thanks to everyone who had been crucial to the realisation of this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

3D	Three-dimensional
AHP	Analytic hierarchy process
ANP	Analytic network process
APA	American Psychological Association
CAD	Computer-aided design
CE	Concurrent engineering
CI	Consistency index
CR	Consistency ratio
CTS	Carpal tunnel syndrome
ELECTRE	Elimination and Choice Translating Reality
GUI	Graphical user interface
HCI	Human-computer interaction
HOQ	House of quality
LED	Light-emitting diode
MCDM	Multiple criteria decision-making
NFPC	Natural fibre-reinforced polymer composite
PDP	Product development process
PDS	Product design specification
PE	Polyethylene
PLA	Polylactic acid
PP	Polypropylene
PROMETHEE	Preference Ranking Organization Method for Enrichment of Evaluations
QFD	Quality function deployment
RI	Random index
TBD	To be determined
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
TRIZ	Theory of Inventive Problem Solving

CHAPTER 1

INTRODUCTION

1.1 Background

A computer mouse is the most common input device on a computer other than the keyboard and it is virtually present in every office or household since the introduction of graphical user interface (GUI) in the 1980s. It was called as a "mouse" back then due to the resemblance of the rodent, with the cord represents the tail. Figure 1.1 shows the world's first computer mouse made from a big block of wood with only one button on it as well as a cord connected to the rear, in which its appearance was similar to a real-life mouse. As of now, most of the regular computer mice are designed to be gripped with more or less pronated forearm and the movement is being controlled by the wrist actions (Gustafsson & Hagberg, 2003).

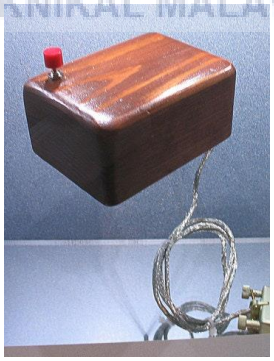

Figure 1.1: Engelbart mouse (Beschizza, 2007).

The evolution of computer mouse has come a long way. Back then, the mouse used to have a trackball beneath it which was held by a socket. The trackball is connected to the mechanical sensors which can detect the rotation of the trackball about two axes. Currently,

optical or laser mice are the norm in the computer industry. The source of illumination is the reason in which the optical mouse and laser mouse differ. For instance, the optical version and the laser variant utilise infrared light-emitting diode (LED) and laser to illuminate the contact surface respectively.

The word ergonomics comes from two Greek words, "ergon" and "nomos", of which essentially mean "laws of work". The study of interaction between the human and the machine, as well as what begets the interaction, is what the word "ergonomics" means (Bridger, 2008). For instance, workstation ergonomics is the study of increasing the productivity as well as comfortability for workers at their workplace. By definition, to increase the productivity and comfortability at work, workstation ergonomics attempts to reduce strain, fatigue and injuries by ameliorating the workspace arrangement as well as machine design to optimise performance. An ergonomist's role is to design or modify the work environment to suit the worker but not the other way around.

Combining computer mouse and the principle of ergonomics, we get an ergonomic mouse. An ergonomic mouse is a unique kind of mouse which utilises the principle of ergonomics and design to provide optimum comfort for the user. Ergonomic mice may come from all kinds of design criteria. However, it may not be suitable for everyone. For instance, finger support like the thumb rest is one of the ergonomic characteristics of a mouse. The existence of the thumb rest may provide a level of comfort for some users while others may find it unnecessary.

1.2 Problem Statement

Some musculoskeletal symptoms such as the carpal tunnel syndrome (CTS) is a common disease among computer users who use the computer mouse extensively. To reduce the strain and fatigue on the forearm, most of the ergonomic mice are designed to be held by the palm vertically, which is a natural position for a resting forearm. As a result, the user will feel lesser soreness and fatigue on their arms and shoulders for using the ergonomic mouse over the traditional horizontal mouse.

According to a research conducted by Kao and Hwang (2013), individuals who spend long hours working with the mouse experience CTS. The research had proposed a shortlist of design criteria in general for achieving a healthy workstation. However, the knowledge of the research was limited.

This project aspires to explore ergonomic options in achieving a healthy workstation. To do this, a conceptual design of an ergonomic mouse was proposed. The design of the ergonomic mouse was carried out using concurrent engineering method. The data collected from a particular crowd was infused into the mouse design.

1.3 Objective

The following are the purposes of this project:

1. To generate the conceptual designs of an ergonomic mouse for healthy workstation using concurrent engineering method.
2. To select the best material for the ergonomic mouse using concurrent engineering method.
3. To select the best design concept for the ergonomic mouse using concurrent engineering method.

1.4 Scope of Project

The following are the scopes of this project:

1. The design and selection of this study considers only in the early conceptual design stage in new product development.
2. The conceptual design stage in this research consists of the TRIZ-PDS-morphological chart.
3. The material and design concept selection for the ergonomic mouse will apply the analytic hierarchy process (AHP) as the main multiple criteria decision-making method.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter includes a more detailed information and insight on the related sub-topics of the report. Literatures were surveyed and analysed, and key information were extracted from it. In this chapter, further details regarding the computer mouse were studied. And, each of the associated ideas and knowledge in this project were also discussed.

2.2 Mouse – History, Function and Design

In 1963, a world's first computer mouse prototype was developed by an American inventor named Douglas Engelbart (Perez-Molina, 2017). The main idea in inventing the mouse was inspired by the trackball which was developed by Ralph Benjamin. The trackball was used by the British to track aircraft on a radar during post-Second World War era (Gunnarsson, 2019). Then, it was classified as a military secret by the British army (Copping, 2013).

Since its introduction, the mouse plays a crucial role in the human-computer interaction (HCI). A GUI in a computer allows users to interact with it via visual components that carry information (Levy, 2018). Alongside with keyboard, the mouse is a device that operates around the GUI. The main function of the mouse is to execute an action in the computer such as opening a folder. An arrow-shaped cursor on the computer screen is what represents the positioning of the mouse and it can be navigated virtually across the screen

by moving the physical mouse in X and Y-direction. Today, the mouse is an integral component of a computer and a study found out that the usage of the mouse during one computer operation session is about two-thirds of the session (Johnson et al., 1993, as cited in Fogleman & Brogmus. 1995).

The basic design of a regular mouse in recent times consists of left and right buttons, a scroll wheel, and some special buttons which can be configured based on users' needs. Clicking the buttons once will select the item and clicking twice enables users to execute a program in the GUI, as in most computers by default. Usually, the scroll wheel sits in between the left and right buttons and its function is to ease the users to scroll the screen up or down instead of pointing the cursor to the scroll bar at the side of the screen. Figure 2.1 shows the common design of a mouse.

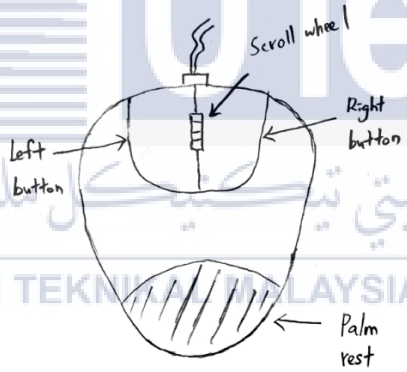

Figure 2.1: Common design of a mouse.

2.3 Carpal Tunnel Syndrome (CTS) – Cause, Effect and Past Studies

Typically, when a person is using the traditional mouse, there are four principal hand motions which are the forearm's pronation, wrist's ulnar and radial deviation, wrist's dorsiflexion, and fingers' extension, bending and lateral motions (Faraji & Farahmand, 2014). An excessive amount of the motions mentioned will increase the pressure in the carpal

tunnel which compresses the median nerves at the palm side of the hand (Fagarasanu & Kumar, 2003).

The most common musculoskeletal disorder associated with this issue is the CTS. CTS is a condition where a person suffers numbness, tingling and weakness in their hands due to the median nerves located at the wrist are being compressed or squeezed. Naturally, the median nerves run through the length of the entire arm, and passes through the carpal tunnel at the wrist to the fingers as shown in Figure 2.2. Except the little finger, all the other fingers' motions and sensations are controlled by the median nerves. The patients who suffer from the CTS are certain to sense numbness, tingling and weakness in their hands all the way up to the shoulders. In fact, it is the dominant hand that will experience the worst symptoms (National Institute of Neurological Disorders and Stroke, 2020).

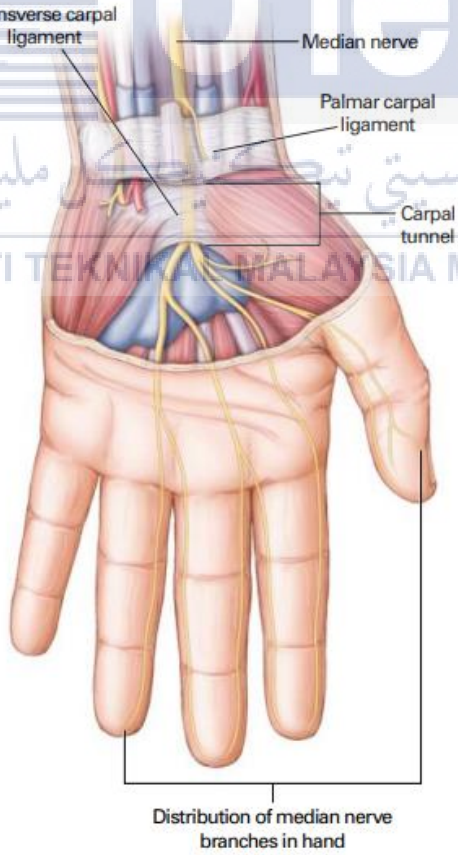

Figure 2.2: Anatomy of the hand (Katz & Simmons, 2002).

Many studies have shown a high prevalence in upper extremity musculoskeletal disorders associated among computer users. An upper extremity is also known as the upper limb which includes the shoulder, upper arm, forearm, wrist and hand. CTS is one of the major discomforts suffered among computer users according to many studies done in the past. According to Andersen et al. (2003), extensive use of the mouse is the cause of the CTS where the patients suffer pain in their forearm (Kryger et al., 2003), elbow, wrist and hand (Lassen et al., 2004).

Almost every computer mouse that has been manufactured today are designed in such a way that it is gripped with a pronated forearm and is being moved around using wrist actions (Figure 2.3). As such, Zipp et al. (1983) stated that forearm pronation might be the reason why musculoskeletal disorders occur at the elbow and forearm. Typically, the ulnar deviation of wrist occurs frequently on mouse users (Karlqvist et al., 1994). And this kind of action will inflict compression on the median nerve. Figure 2.4 shows the types of wrist movement.

Figure 2.3: Pronated hand position (left) and resting hand position (right) (Gustafsson & Hagberg, 2003).

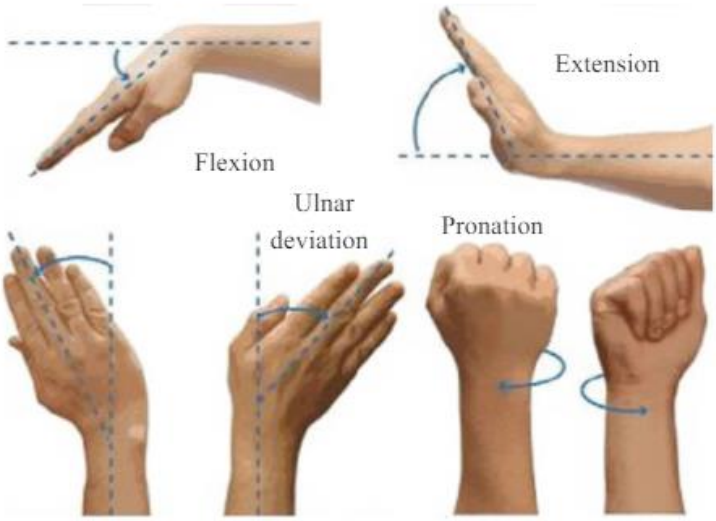

Figure 2.4: Types of wrist movement (Romero-Ángeles et al., 2019).

Aarås et al. (2001) conducted an experiment where a group of people had to use a computer mouse that required a less pronated grip. The result of the experiment showed that after using the mouse for six months, the recorded discomforts experienced by the participants were less than those who used a traditional horizontal mouse. It was clearly recorded that there was a notable reduction in the neck, shoulder, forearm, wrist and hand pain suffered by the participants.

2.4 Concurrent Engineering – An Overview

As in the word "concurrent" in concurrent engineering (CE), which also means "simultaneous", CE is a flow of engineering processes in which the processes happen at the same time. CE is the new norm in modern product design and development as stated by Junjie et al. (2006). In modern new product development process (PDP), CE is crucial where it relates in overlapping multiple stages of PDP in order to minimise delays (Hambali et al., 2009). According to Sapuan (2006), the time taken and cost of PDP can be reduced by utilising CE.