Faculty of Cognitive Science and Human Development

A COMPARISON STUDY ON USER PERFORMANCE AND EASE OF USE BETWEEN THE TRADITIONAL MOUSE AND THE TOUCHPAD

Christina anak Anthony

UNIVERSITI MALAYSIA SARAWAK
2003

UNIVERSITI MALAYSIA SARAWAK

BORANG PENGESAHAN STATUS TESIS

JUDUL: A Comparison Study on User Performance and Ease of Use between the Traditional Mouse and the Touchpad

SESI PENGAJIAN: 2002/2003

Saya CHRISTINA ANAK ANTHONY

mengaku membenarkan tesis * ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Sarawak
2. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan untuk tujuan pengajian sahaja
3. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat pendigitan untuk membangunkan Pangkalan Data Kandungan Tempatan
4. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi
5. ** sila tandakan (√)

	SULIT	(mengandungi maklumat yang berdarjah keselamatan atau kepentingan seperti termaktub dalam AKTA RAHSIA RASMI 1972)
	TERHAD	(mengandungi maklumat Terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
√	TIDAK TERHAD	

Disahkan oleh

(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat Tetap:
Lot 228, Taman Bintang,
96500 Bintangor,
Sarawak

Tarikh: 14.03.03

Catatan: * Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah, Sarjana dan Sarjana Muda
* Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD

A COMPARISON STUDY ON USER PERFORMANCE AND EASE OF USE BETWEEN THE TRADITIONAL MOUSE AND THE TOUCHPAD

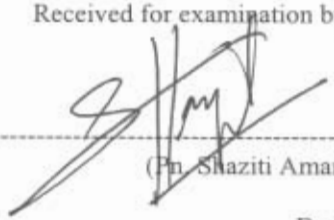
by

Christina anak Anthony

This project is submitted in partial fulfillment for a Bachelor of Science (Honours) in Cognitive Science
Faculty of Cognitive Sciences and Human Development,
Universiti Malaysia Sarawak

The project entitled 'A Comparison Study on User Performance and Ease of Use between the Traditional Mouse and the Touchpad' was prepared by Christina anak Anthony and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science (Honours) in Cognitive Science.

Received for examination by:



(Pn. Shaziti Aman)

Date:

1/4/03

ACKNOWLEDGEMENT

First and foremost I would like to thank the almighty God because of His continuous blessing I am able to come this far and continue my journey in seeking the fountain of Knowledge.

I am very grateful to my project supervisor, Pn. Shaziti Aman for all her guidance and support in making this idea of a project a reality.

To my parents, Anthony Phillip and Helen Rebecca Anis, I love you mom and dad! Thanks for believing in me and supporting me in this quest for knowledge. Thanks for pushing me when I am lagging and being by my side when I fall.

My dearest grandmother, Love you lots 'Ini'. This is for you.

My brothers and sister; Raymond, Alexander and Jacqueline. Thanks for your understanding and encouragement. Especially to all my nephews and nieces; Rozana (Zana), Matilda (Da), Fabian (Tandai), Raphael (Boy), Fiona, Camelia (Cimo), Celvin (E-ben), Hillary (Anis), Audrey (A Yee), Fezzane (Kecik), and McLaren (Mac). Aunty loves all of you very much.

Aunty Rusea (Dr. Rusea Go), you are my inspiration.

To my fellow SK friends; the journey is just beginning. Many thanks to my best friend; Zab and Kak Mah. My wonderful friends; Mina, Angel, Anym, Aty. I appreciate your gift of friendship. My housemates; Mami, Mina, Ju, Vic and Aling (un-official housemate); thanks for being such wonderful housemates. Not forgetting my dearest Anna, Ayeng, Jenn and Sula, thanks for being such good companions. May God bless all of you.

To Leong Wai, thanks for your encouragement and support.

Lastly, I would like to dedicate this in loving memory of my grandfather, the late Phillip Umpo. Grandpa, your memory shall remain forever.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

A COMPARISON STUDY ON USER PERFORMANCE AND EASE OF USE BETWEEN THE TRADITIONAL MOUSE AND TOUCHPAD

CHRISTINA ANAK ANTHONY

This research was conducted to compare two types of pointing devices, which is the traditional mouse and the touchpad, in terms of user performance and ease of use. This research also aims to determine the correlation between the independent variable (comfort and maneuverability) and the dependent variable (accuracy and user satisfaction) of the pointing devices. This research was conducted in the premises of Universiti Malaysia Sarawak. Sample for this research consists of 30 respondents (15 males and 15 females). Experiment and observation method were used in this research. The questionnaire was used as the main instrument in this research. The questionnaire was self-developed and measured the respondents' background, the ease of use and the performance of the pointing devices. A descriptive statistical method comprising of percentage, frequency and mean was used to provide a summary for the overall set of data and impact of the ease of use of pointing device on the performance of the pointing device. The inferential statistical method used to test the hypotheses formulated were the Pearson's Product Moment Coefficient Correlation 'r' and T-Test for Significant Difference. The research findings revealed that there is strong correlation between ease of use and performance of the pointing devices. The findings also revealed that the traditional mouse provides greater ease of use and performance than the touchpad.

ABSTRAK

A COMPARISON STUDY ON USER PERFORMANCE AND EASE OF USE BETWEEN THE TRADITIONAL MOUSE AND TOUCHPAD

CHRISTINA ANAK ANTHONY

Kajian ini dijalankan untuk membandingkan dua jenis 'pointing device', iaitu tetikus tradisional dan touchpad dari segi 'user performance' dan 'ease of use'. Kajian ini turut bertujuan menentukan korelasi antara pembolehubah tidak bersandar (keselesaan dan kebolehgerakan) dan pembolehubah bersandar (ketepatan dan kepuasan pengguna) pada 'pointing device' tersebut. Kajian ini dijalankan di Universiti Malaysia Sarawak. Sampel kajian terdiri daripada 30 responden (15 responden lelaki dan 15 responden perempuan). Eksperimen dan pemerhatian merupakan kaedah yang digunakan dalam kajian ini. Borang soal selidik merupakan alat kajian utama dalam kajian ini. Borang soal selidik in direka sendiri dan mengandungi latar belakang responden, 'ease of use' serta 'performance' 'pointing device' tersebut. Kaedah statistik deskriptif yang terdiri daripada peratusan, kekerapan serta min digunakan untuk mendapat rumusan mengenai keseluruhan st ata serta kesan 'ease of use' pada 'pointing device' kepada 'performance' ' pointing device' tersebut. Kaedah statistik inferensi yang digunakan adalah kaedah Pekali Koeffisien Pearson 'r' serta T-test untuk perbezaan ketara. Dapatan kajian menunjukkan bahawa terdapat korelasi yang kuat di antara 'ease of use' dan 'performance' 'pointing device'. Dapatan turut menunjukkan bahawa tetikus tradisional adalah lebih baik dari segi 'ease of use' dan 'performance'.

CHAPTER 1
INTRODUCTION

1.1 Introduction

The development in computer technology has resulted in the increased use of computers in workstations. Since 1993, software developments (Windows 95/98/NT) and the growth of the Internet (including electronic mail) have increased the need for use of a pointing device, such as a mouse. Current navigation of World Wide Web pages is almost solely dependent upon a computer-pointing device.

The mouse was invented in 1965 as an economic replacement for light-pens, the mouse remains as the primary pointing and selecting device for desktop computers. Found to be easier to use and less demanding to learn than trying to remember different keywords, the mouse quickly gains its popularity. Hence, the development of new computer operating systems and applications which integrates the use of a pointing device.

The need for mobile computing has resulted in the development of the laptop. Therefore, a pointing device such as the mouse is considered a hassle to carry around and difficult to be used in small spaces. Thus, the use of a pointing device known as the touchpad.

This study aims to assess and compare the comfort level of the user and their performance when using the traditional mouse and the touchpad. The main objective is to determine which type of pointing devices gives the most comfort and maximizes user performance.

1.1.1 The Computer Mouse

The computer mouse, which revolutionized the computer technology, was created by Douglas C. Engelbart of the Stanford Research Institute (SRI) in 1963. In 1964, a working prototype of the mouse was made with a graphical user interface (GUI) 'windows'. The first mouse consists of a wooden shell and two metal wheels.

The modern mouse consists of a metal or plastic housing or casing, a ball that sticks out of the bottom of the casing and is rolled on a flat surface, one or more buttons on the top of the casing, and a cable that connects the mouse to the computer. As the ball is moved over the surface in any direction, a sensor sends impulses to the computer that causes a mouse-responsive program to reposition a visible indicator (called a *cursor*) on the display screen. The positioning is relative to some variable starting place. Viewing the cursor's present position, the user readjusts the position by moving the mouse.

The most conventional kind of mouse (i.e.: the traditional mouse) has two buttons on top: the left one is used most frequently. In the Windows operating systems, it lets the user click once to send a "Select" indication that provides the user with feedback that a particular position has been selected for further action. The next click on a selected position or two quick clicks on

it causes a particular action to take place on the selected object. For example, in Windows operating systems, it causes a program associated with that object to be started. The second button, on the right, usually provides some less-frequently needed capability. For example, when viewing a Web page, you can click on an image to get a pop-up menu that, among other things, lets you save the image on your hard disk. Some mouses have a third button for additional capabilities. Some mouse manufacturers also provide a version for left-handed people.

Windows 95 and other operating systems let the user adjust the sensitivity of the mouse, including how fast it moves across the screen, and the amount of time that must elapse within a "double click". In some systems, the user can also choose among several different cursor appearances. Some people use a mouse pad to improve traction for the mouse ball.

The original mouse, invented by Doug Engelbart, celebrates its 30th birthday on December 9, 1998. Encased in a carved wooden housing, Engelbart's mouse used a single button and parallel wheels to track its position on a display screen.

Figure 1: Image of first computer mouse

1.1.2 The Touchpad

The touchpad was invented as a replacement for the mouse as pointing device in portable computer such as the laptop. Used to minimize the space needed to maneuver the pointing device and increase mobility, the touchpad became a standard pointing device for portable computers. . A touchpad works by sensing the user's finger movement and downward pressure. George E. Gerpheide invented the first touchpad in 1988. Apple Computer was the first to license and use the touchpad in its Powerbook laptops in 1994.

The touchpad contains several layers of material. The top layer is the pad that you touch. Beneath it are layers (separated by very thin insulation) containing horizontal and vertical rows of *electrodes* that form a grid. Beneath these layers is a circuit board to which the electrode layers are connected. The layers with electrodes are charged with a constant alternating current (AC). As the finger approaches the electrode grid, the current is interrupted and the interruption is detected by the circuit board. The initial location where the finger touches the pad is registered so that subsequent finger movement will be related to that initial point. Some touchpads contain two special places where applied pressure corresponds to clicking a left or right mouse button. Other touchpads sense single or double taps of the finger at any point on the touchpad.

1.2 Problem Statement

Modern personal computers typically offer a computer mouse in conjunction with a keyboard as the preferred input device configuration. Typical software programs for word processing, spreadsheet, database and graphics operation may require computer mouse use for up to two-thirds of the time [(Johnson *et. al.*, 1993), in Hedge *et. al.*, 1999].

Although there are many types of pointing devices, the designs of the pointing devices may not contribute to the increased performance and comfort level. In order to develop the ideal pointing device, the characteristics contributing towards optimum performance must be identified. There is a need to determine the relation between the user performance and ease of use in pointing devices.

An assumption made by many pointing device user is that the design of the touchpad does not contribute towards optimum performance and ease of use compared to the traditional mouse. This research aims to investigate the assumption and identify the weaknesses (if any) of the pointing devices.

1.2 Objectives of the Research

1.2.1 General Objective

Generally, this research is conducted to determine the correlation between ease of use and performance level when using the traditional mouse and the touchpad in terms of usability and functionality.

1.2.2 Specific Objectives

Specifically, this research is conducted to determine which type of pointing device provides the best ease of use in terms of comfort and maneuverability. It is also to determine which type of pointing device provides the best performance in terms of accuracy and user satisfaction. The research also aims to determine the difference between the two types of pointing device in terms of its ease of use and performance level.

1.3 Questions imposed for the Research

1. Is there a relationship between comfort and performance of traditional mouse in terms of accuracy?
2. Is there a relationship between comfort and performance of traditional mouse in terms of user satisfaction?
3. Is there a relationship between maneuverability and performance of traditional mouse in terms of accuracy?
4. Is there a relationship between maneuverability and performance of traditional mouse in terms of user satisfaction?
5. Is there a relationship between comfort and performance of touchpad in terms of accuracy?
6. Is there a relationship between comfort and performance of touchpad in terms of user satisfaction?
7. Is there a relationship between maneuverability and performance of touchpad in terms of accuracy?

8. Is there a relationship between maneuverability and performance of touchpad in terms of user satisfaction?
9. Is there significant difference between mouse and touchpad in terms of comfort?
10. Is there significant difference between mouse and touchpad in terms of maneuverability?
11. Is there significant difference between mouse and touchpad in terms of accuracy?
12. Is there significant difference between mouse and touchpad in terms of user satisfaction?

1.4 Research Hypotheses

This research aims to determine the correlation between user comfort and performance of two different types of pointing devices (traditional mouse and touchpad). The hypotheses derived are

H_o = There is no significant relationship between comfort and performance of traditional mouse in terms of accuracy
H_o = There is no significant relationship between comfort and performance of traditional mouse in terms of user satisfaction
H_o = There is no significant relationship between maneuverability and performance of mouse in terms of accuracy
H_o = There is no significant relation between maneuverability and performance of mouse in terms of user satisfaction
H_o = There is no significant relationship between comfort and performance of touchpad in terms of accuracy
H_o = There is no significant relationship between comfort and performance of touchpad in terms of user satisfaction
H_o = There is no significant relationship between maneuverability and performance of touchpad in terms of accuracy
H_o = There is no significant relationship between maneuverability and performance of touchpad in terms of user satisfaction
H_o = There is no significant difference between mouse and touchpad in terms of comfort
H_o = There is no significant difference between mouse and touchpad in terms of maneuverability
H_o = There is no significant difference between mouse and touchpad in terms of accuracy
H_o = There is no significant difference between mouse and touchpad in terms of user satisfaction

1.5 Definitions

1.5.1 Human-Computer Interaction

According to Baecker & Buxton (1987), Human-Computer Interaction refers to a set of processes, dialogues, and actions that a user employs in interacting with a computer (Preece, 1998). It mainly concerns the understanding, design, evaluation and implementation of an interactive computing system for human use [(ACM SICGHI, 1992), in Preece, 1998]. Human-Computer Interaction focus on developing and improving the safety, utility, effectiveness, efficiency, and the usability of the systems, which includes computer systems (Preece, 1998). Hartson & Hix (1993) defines Human-Computer Interaction as the event when a human user

and a computer system interacts to perform tasks. In this research, Human-Computer Interaction refers to the user's interaction with the input device (i.e.: the pointing device)

1.5.2 Ergonomics

According to the Oxford Advance Learner's Dictionary (1995), Ergonomics by definition is the study of work and working conditions in order to improve people's efficiency. This definition is adapted from the scientific definition that explains the relationship of the environment and workplace, the tools and machinery that provide a comfort fit to the worker (Lund, 1990). Besides that, it is 'a study of how people interact with machines'. The purpose of ergonomics is to define and design tools for different work, leisure and domestic environments to suit the capacities and capabilities of users (Preece, 1998). The objectives of ergonomics are to maximize an operator's safety, efficiency and reliability of performance, to make a task easier, and to increase feelings of comfort and satisfaction (Preece, 1998). Two of the sub disciplines in Ergonomics are Design and Human-Computer Interaction. In this research, ergonomic factors refers to the correlation between the type of pointing device and its comfort and performance level in terms of providing a 'good fit' between the user and the pointing device.

1.5.3 User/Human Performance

User or Human Performance the level of ability to operate efficiently in regards to a person using something (Oxford Advanced Learner's Dictionary, 1995). In the context of this research it is the achievement level in performance of the user when using the different types of pointing device when given a specific task. Performance in this study refers to the quality and productivity level of the user when using the pointing device to the given task.

1.5.4 Usability

Usability is a measure of the ease with which a system can be learned or used, its safety, effectiveness and efficiency, and the attitude of its users towards it (Preece, 1998). Usability is concerned with making systems easy to learn and to use (Preece, 1998). Usability is a combination of the following user-oriented characteristics, ease of learning, high speed of user task performance, low user error rate, subjective user satisfaction, and user retention over time [(Shneiderman, 1992) in Hartson & Hix, 1993]. In the context of this research, usability factors are the concept of ease in learning, using and what the user might expect when using a pointing device, and the different kinds of pointing devices.

1.5.5 Functionality

Functionality refers to the product being able to perform its function within is specific limits (Norman, 1988). In this research, functionality reflects on the performance of the pointing device when performing the given tasks.

1.6 Importance of the Study

The importance of this study is to evaluate the performance and the ease of use of two types of pointing device (i.e.: the traditional mouse and the touchpad). Factors affecting performance and ease of use could be determined and suggestions could be made on improving

the present design of the pointing device. Good design is crucial in determining the performance and ease of use of the pointing device. This will not only benefit the users but the designers and developers of the pointing device themselves.

1.7 Limitations of the Study

This research will only be conducted in the premises of Universiti Malaysia Sarawak (UNIMAS), where the study will be conducted locally. However, the results can also be used in the population as the test conducted in this study is very general and does not require any special ability.

The pointing devices selected in this study are only the traditional mouse and the touchpad. Since the study concentrates on the determining the correlation and the comparison between the two types of pointing device, the study only focuses on the usability and functionality of the pointing devices, in terms of ease of use and performance.

1.8 Conceptual Framework

Figure 2 below shows the theoretical concept framework, which is going to be used in this research to determine the correlation between ease of use and performance.

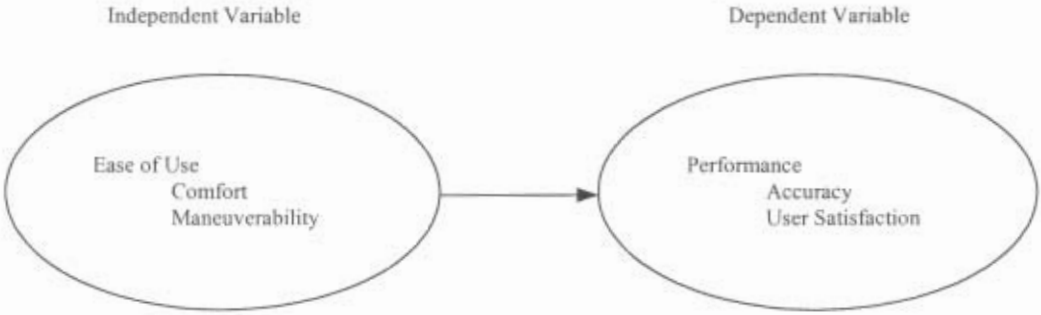


Figure 2: Research framework for determining the correlation between ease of use and performance.

Figure 3 below shows the theoretical framework, to determine the difference between the two types of pointing device in terms of ease of use and performance.

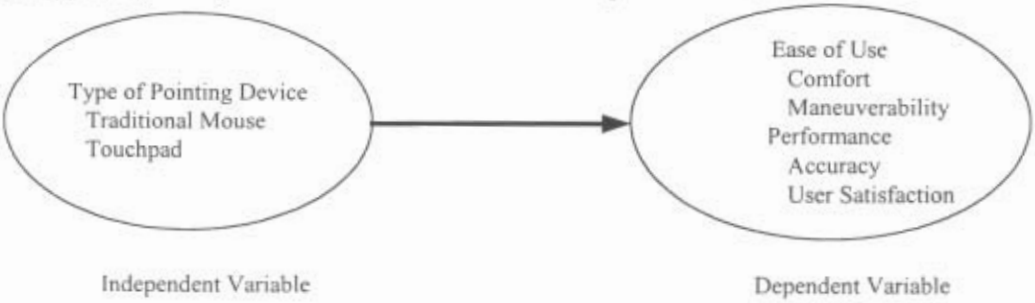


Figure 3: Research framework for determining the difference between the two types of pointing device in terms of ease of use and performance.

1.9 Summary

This chapter has discussed the objectives of the research. The hypotheses of the research are formed based on the objectives. The conceptual framework of the research is constructed based on the research hypotheses and will be the guideline in conducting the research.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

In this chapter, a collection of literature review is listed for the purpose of providing an insight to the current research based on previous works by other researchers. Besides that, there are explanations to theories that are related and will be used in the study.

2.1 Related Theories

There are several theories are related to the current research of usability and functionality in pointing devices. These theories provide a guideline to the researcher in studying the usability and functionality of the pointing devices and to be used in discussing the research findings.

2.1.1 Human-Computer Interaction

The Human-Computer Interaction is one (or more) human(s) and one (or more) computer(s) interacting to achieve a goal. The computer can be thought as any object, appliance or device used by human to perform a task.

There is a need to make the transition from the functionality aspect (what can be done) to match the user's need (usability) smoothly in the natural work environment. Hence, the need to select the appropriate input devices for the task and likewise the appropriate output devices (Preece, 1998).

2.1.2 Ergonomics

Ergonomic is the interaction of human and the device they use to achieve their goals. The ergonomic factor will influence the performance of the user and the product. According to Mahmood Nazar (1996), the ergonomic factors are vital in producing a working environment that is comfortable and synchronize with the user and device in the working environment.

B. Mustafa Pulat (1992) states that the effects of ignoring human factors in designing products or devices as reduction in productivity, loss of time, high cost of medical cost, increased cost of resources, reduction in quality of work and accidents occurring in the workplace.

2.1.3 Usability Evaluation

Usability is the fit between the user's goal and their limitations. Usability refers to the ease of the user in finding the means of achieving their goal (Preece & Keller, 1990). In other words, bridging the gap and ensuring that a good fit exists between the device and the user's psychological and physiological capabilities.

In order to evaluate usability, it is important to identify the probability of a failure in fitting of the device to the user's needs. The information or the control devices must be easily understood by the user and the occurrence of errors must be minimized. The use of the control devices or the interface must be easy to use and does not cause discomfort to the user.

In the international standard ISO 9421(1998), usability is defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. Effectiveness means the accuracy and completeness with which users achieve specified goals, efficiency refers to resources expended in relation to that accuracy and completeness, and satisfaction is freedom from discomfort, and positive attitudes to the use of the product. Satisfaction is not a less important usability attribute than effectiveness or efficiency - in fact, in many voluntarily used product categories it is just the opposite.

Nielsen (1993) emphasizes the importance of having practical measurable components for usability. He defines it by giving the following five usability attributes; learnability, efficiency, memorability, errors and satisfaction. Learnability is the system or control device provides ease in learning so that the user can rapidly start getting some work done with the system or control devices. Meanwhile, efficiency is the high level of productivity achieved with the use of the system or control devices. Memorability is the ease of remembering the functions of the system or control devices in order to allow the user to use the system or control devices, even after some period of absence, without having to learn the functions again. The system should have a low error rate, so that users make few errors during the use of the system, and so that if they do make errors they can easily recover from them. Furthermore, catastrophic errors must not occur. Satisfaction refers to the system or control devices being pleasant to use, so that users are subjectively satisfied when using it and they like it.

2.1.4 User Centered Design

A usable design should fit to the user's needs and limitations. However, it seems that the designer tends to ignore the needs and abilities of the user but focus on the aesthetic aspect of the design. According to Preece (1998), the designer must understand the requirements of the product and develop the product. Understanding the requirements involves looking at similar products, discussing the needs of the people using the product and analyzing any existing systems to discover the problems with current designs. The development may include producing a variety of representations until a suitable artefact is produced.

2.1.5 Buxton's 3-state Model for Graphical Input Devices

The model is a simple expression of the operation of computer pointing devices in terms of state transitions. It is described simply as a vocabulary to recognize and explore the relationship between pointing devices and the interaction techniques they afford (Buxton, 1990). In this sense, it is a paradigm of descriptive modeling. The three states are identified in Figure 4, annotated for mouse interaction.

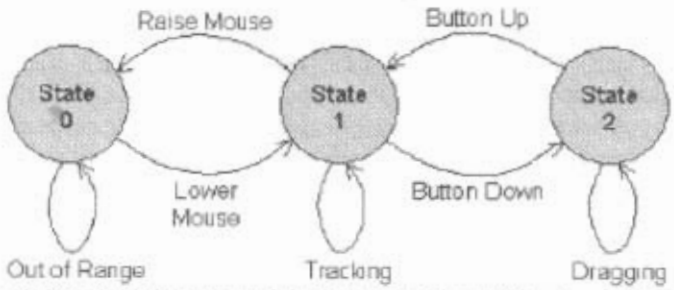


Figure 4: Buxton's 3-state model of graphical input (Buxton, 1990).

Left-to-right in Figure 4, the states are *Out of range* (State 0) for clutching or repositioning a mouse on a mouse pad, *Tracking* (State 1) for moving a tracking symbol such as a cursor about a display, and *Dragging* (State 2) for moving an icon on the desktop or for grouping a set of objects or a range of text. The model seems simple and obvious, yet, the model can be extended to capture additional aspects of pointing device interaction such as multi-button interaction, stylus input, and direct vs. indirect input.

2.2 Reviews from Previous Researches

Previous researches have been conducted to evaluate the usability and functionality of pointing devices. This part discusses the previous researches related to this research.

2.2.1 Comparison of Efficiency between Four Pointing Devices

Card, Moran and Newell compared the efficiency of four different types of pointing device, including a mouse and a joystick, in terms of several categories, including ease of learning, number of errors, speed of editing, and retention. The task used to evaluate the efficiency of each pointing device is to move the cursor to the target. Their findings indicate that the mouse is the most efficient in terms of speed, minimal errors and the fastest rate of improvement for amateur users.

2.2.2 The Trackpad™- Study on User Comfort and Performance

Çakir, Çakir and Unema conducted a study on the TrackPad(tm), a new touch tablet technology input device, to investigate the impact of the use of the device on the biomechanical load and postural comfort of the users. In a one day test, the subjects, experienced Macintosh users, performed tests and worked on tasks, using a portable computer, that were organized to resemble normal office tasks and measure performance. The tasks included intensive use of the keyboard.

The performance was measured by text editing tasks and eight Fitts's Tests with two levels of difficulty. The biomechanical load was measured and evaluated by means of EMG and postural (motion) analyses. General comfort and postural comfort was evaluated with questionnaires.

The analyses of the EMG-measurements yielded no indication of progressive fatigue or increased muscular load from one session to the next. On the contrary, the recorded EMG-levels showed a decrease in muscular activity. The postural analyses indicated that undue deviation, extension, or flexion of the hands, which may cause discomfort, generally did not occur. The