

# **EYE DRAWING USING GAZE ESTIMATION MODEL**

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## ABSTRACT

Eye movements are an informative source of a person's intentions. The eyes are always looking at something and their movements can reveal a lot of what a person is currently paying attention to. Interaction based on eye movement constitutes a new area of human computer interaction intended for the community of able-bodied and disabled people. Many researchers have increasingly employed eye movements in eye typing for over twenty years. However, research on eye drawing techniques is still in the nascent stage. Eye drawing interaction techniques provide a different set of problems and challenges compared to existing human computer interaction techniques. The existing eye drawing interaction techniques suffer from *Midas Touch* problem, a usability problem of gaze-based interaction that activates unintended selections, simply because the user is looking at the interface. Besides that, some pictures that are drawn using the existing eye drawing techniques are difficult to recognise while the other drawings that are recognisable consist of unintended gap between lines.

Therefore, the prime purpose of this research is to develop a gaze-based drawing interaction technique. In particular, this research explores users' eye gaze pattern while fixating at specific positions on the computer screen. The results demonstrate the selection problem when fixating at small targets. This has led to the development of a novel eye movement data-interpretation model in the drawing context. Specifically, this model interprets the patterns of users' eye movement that fit into one of two mutually exclusive categories of behaviour: drawing and searching. This eye movement data-interpretation model is implemented and tested with different dispersion thresholds in order to achieve best system performance. This thesis also demonstrates that the proposed prototype performs better than the latest eye

drawing application in terms of effectiveness, efficiency, user satisfaction and drawing quality. The limitations of the findings and how they can be overcome are discussed in future research section.

## **ABSTRAK**

*Pengerakan mata merupakan sumber informatif mengenai kehendak manusia. Mata sentiasa memerhati sesuatu dan pergerakan tersebut mendedahkan perhatian seseorang terhadap sesuatu. Interaksi berasaskan pergerakan mata membawa satu bidang baru dalam interaksi antara manusia untuk komuniti orang upaya dan orang kurang upaya. Kebanyakan penyelidik mengaplikasikan pergerakan mata dalam kerja menaip berasas mata untuk lebih daripada dua puluh tahun. Walau bagaimanapun, kajian teknik melukis berasas mata masih berada dalam peringkat sedang tumbuh. Teknik interaksi melukis berasas mata menyediakan masalah dan cabaran yang berlainan berbanding teknik interaksi antara manusia yang sedia ada. Teknik interaksi melukis berasas mata yang sedia ada menghadapi masalah Midas Touch, merupakan masalah kegunaan dalam interaksi berasas mata yang mengaktifkan pilihan yang tidak diinginkan, kerana pengguna tersebut memerhati antaramuka itu. Selain itu, terdapat gambar yang dilukis menggunakan teknik melukis berasas mata yang sedia ada adalah susah untuk dikenal pasti, sementara lukisan yang lain mengandungi ruang kosong yang tidak diinginkan di antara garisan.*

*Oleh itu, objektif utama dalam kajian ini ialah untuk membangunkan satu teknik interaksi dalam lukisan berasas mata. Secara khusus, kajian ini menyelidik corak pergerakan mata pengguna semasa merenung pada koordinat tertentu dalam skrin komputer. Ini memaparkan masalah memilih semasa merenung target yang kecil. Ini telah membawa kepada pengenalan satu perkembangan model interpretasi-data baru dalam konteks melukis. Secara spesifik, model ini menginterpretasi corak pergerakan mata pengguna kepada dua kategori saling eksklusif: melukis and mencari. Model interpretasi-data pergerakan mata ini telah dilaksana*

*dan diuji dengan ambang sebaran yang berlainan untuk mencapai sistem pretasi yang terbaik. Tesis ini juga memaparkan bahawa sistem prototaip berfungsi lebih baik berbanding dengan aplikasi melukis berasas mata yang terbaru dari segi efektif, efisien, kepuasan pengguna dan kualiti lukisan. Had-had hasil dapatan dan bagaimana ia boleh diatasi dalam penyelidikan pada masa akan datang juga dibincangkan dalam bahagian masa hadapan kajian.*

# TABLE OF CONTENTS

Acknowledgements.....	ii
Abstract .....	iii
<i>Abstrak</i> .....	v
Table of Contents.....	vii
List of Tables .....	xiv
List of Figures .....	xv
List of Publications .....	xviii
Chapter 1 INTRODUCTION.....	1
1.1 Introduction .....	1
1.2 Background.....	1
1.3 Research Problems .....	2
1.4 Research Objectives .....	3
1.5 Scope of Study.....	3
1.6 Limitation of Research .....	3
1.7 Thesis Organisation .....	4
Chapter 2 LITERATURE REVIEW .....	6
2.1 Introduction .....	6
2.2 Eye Movements.....	6
2.3 Saccadic Eye Movements.....	8
2.4 Eye Tracking Techniques .....	9
2.4.1 Techniques based on Electric Skin Potential.....	9
2.4.2 Techniques based on Contact Lenses.....	9
2.4.3 Techniques based on Reflected Light.....	10

2.4.3.1	Limbus Tracking.....	10
2.4.3.2	Pupil Tracking .....	10
2.4.3.3	Pupil Centre Corneal Reflection.....	11
2.5	Gaze-based Interaction .....	11
2.5.1	Object Selection.....	12
2.5.2	The “Midas Touch” Problem.....	12
2.5.3	Eye Cursor.....	13
2.6	Fixation Identification .....	13
2.6.1	Velocity-threshold Fixation Identification .....	14
2.6.2	Hidden Markov Model Identification.....	15
2.6.3	Dispersion-Threshold Identification.....	16
2.6.4	Area-of-Interest Identification.....	19
2.7	Eye Gaze Applications .....	22
2.7.1	Eye Typing .....	22
2.7.2	Eye Drawing.....	25
2.8	Summary.....	28
Chapter 3	RESEARCH APPROACH.....	30
3.1	Introduction .....	30
3.2	Specific Problem.....	30
3.3	Phases of Study.....	31
3.3.1	Eye Gaze Target-Pointing .....	31
3.3.2	Design.....	33
3.3.3	Implementation.....	33
3.3.4	Testing.....	33

3.3.5	Evaluation.....	34
3.4	Summary.....	34
Chapter 4	EYE GAZE TARGET-POINTING (PHASE I) .....	35
4.1	Introduction .....	35
4.2	Aims.....	35
4.3	Methodology.....	36
4.3.1	Preliminary Investigation .....	36
4.3.2	Task .....	36
4.3.3	Participant.....	37
4.3.4	Equipment and Setting .....	37
4.3.5	Procedure.....	38
4.3.6	Software.....	39
4.3.7	Procedure of Analysis.....	40
4.4	Results of Eye Gaze Target-Pointing .....	43
4.4.1	Eye Gaze Pointing Results .....	43
4.4.2	Analysis of Horizontal and Vertical Gaze Point Dispersion.....	44
4.4.2.1	Cumulative Percent Frequency.....	46
4.5	Discussion.....	47
4.6	Summary.....	48
Chapter 5	CONCEPTUAL DESIGN OF GEM (PHASE II).....	49
5.1	Introduction .....	49
5.2	Gaze Estimation Model (GEM) Architecture.....	49
5.3	Input Phase .....	50
5.4	Movement Patterns Interpretation Phase.....	51

5.4.1	Significant Dispersion Between Points (SDP) .....	52
5.1.1.1	Significant Gaze Duration (SGD).....	56
5.1.1.2	Gaze Point Estimation .....	56
5.4.2	Large Dispersion Between Points (LDP) .....	57
5.5	Behaviour Interpretation Phase .....	57
5.5.1	Drawing .....	58
5.5.2	Searching .....	59
5.6	Summary.....	59
Chapter 6	IMPLEMENTATION OF GEM (PHASE III) .....	61
6.1	Introduction .....	61
6.2	Overview of The Overall Prototype System Implementation .....	61
6.3	Implementation Tools.....	62
6.3.1	Eye Tracking Equipment.....	62
6.3.2	Calibration .....	62
6.3.3	Programming Language .....	63
6.4	Eye Movement Data .....	63
6.5	Movement Patterns Interpretation .....	66
6.6	Behaviour Interpretation.....	67
6.7	How GEM System Works .....	69
6.8	Debugging Process .....	71
6.9	Summary.....	72
Chapter 7	TESTING (PHASE IV) .....	73
7.1	Introduction .....	73
7.2	GEM Experiment.....	73

7.2.1	Aims and Research Questions .....	74
7.2.2	Methodology .....	75
7.2.2.1	Application Domain .....	75
7.2.2.2	Task .....	75
7.2.2.3	Participants .....	76
7.2.2.4	Experiment Design .....	76
7.2.2.5	Measurement .....	77
7.2.2.6	Equipment and Setting.....	79
7.2.2.7	Procedure .....	79
7.2.3	GEM Result .....	81
7.2.3.1	Effectiveness.....	81
7.2.3.2	Efficiency (Task Completion Time).....	82
7.2.3.3	User Satisfaction.....	83
7.2.3.4	Drawing Quality .....	84
7.3	EyeDraw Experiment .....	86
7.3.1	EyeDraw Result.....	88
7.3.1.1	Effectiveness.....	88
7.3.1.2	Efficiency (Task Completion Time).....	89
7.3.1.3	User Satisfaction.....	90
7.3.1.4	Drawing Quality .....	91
7.4	Discussion.....	94
7.5	Comparison between GEM and EyeDraw Thresholds.....	97
7.6	Summary.....	97

Chapter 8	EVALUATION (PHASE V).....	98
8.1	Introduction .....	98
8.2	Aims and Research Questions .....	98
8.3	Methodology.....	99
8.3.1	Application Domain .....	99
8.3.2	Task .....	99
8.3.3	Experiment Design .....	99
8.3.4	Measurement .....	100
8.3.5	Participants .....	100
8.3.6	Equipment and Setting .....	100
8.3.7	Procedure.....	101
8.4	Results .....	101
8.4.1	Effectiveness.....	101
8.4.2	Efficiency .....	102
8.4.3	User Satisfaction.....	102
8.4.4	Drawing Quality .....	103
8.4.4.1	Drawing Ranking.....	103
8.4.4.2	Drawing Rating.....	106
8.5	Discussion.....	107
8.10	Summary.....	108
Chapter 9	CONCLUSION .....	109
9.1	Introduction .....	109
9.2	Contribution of the Research .....	109
9.3	Limitations of the Gaze-based Interaction Technique.....	112

9.4	Future Work.....	112
9.5	Concluding Remarks .....	113
	REFERENCES .....	115
	Appendix A: Consent Form .....	120
	Appendix B: Instruction.....	121
	Appendix C: Plots of Gaze Point Dispersion.....	122
	Appendix D: Significant Dispersion Calculation .....	128
	Appendix E: Questionnaire – Testing (Phase IV).....	129
	Appendix F: Drawing Evaluation Questionnaire – Testing (Phase IV) .....	131
	Appendix G: Results of Testing Experiment .....	133
	Appendix H: Questionnaire – Evaluation (Phase V) .....	140
	Appendix I: Drawing Evaluation Questionnaire – Evaluation (Phase V) .....	142
	Appendix J: Results of Evaluation Experiment .....	144

## LIST OF TABLES

Table 4.1	An Example of Eye Movement Data .....	41
Table 7.1	Task Descriptions .....	75
Table 7.2	Experimental Design.....	77
Table 7.3	Drawing Ranking and Rating Criteria .....	79
Table 7.4	Variance of Task Completion Time (GEM) .....	82
Table 7.5	Variance of User Satisfaction (GEM).....	83
Table 7.6	Correlation of GEM Evaluators' Ranking Result (A, B, C = evaluator name)..	84
Table 7.7	Correlation of GEM Evaluators' Rating Result (A, B, C = evaluator name).....	84
Table 7.8	Variance of Task Completion Time (EyeDraw).....	89
Table 7.9	Variance of User Satisfaction (EyeDraw) .....	90
Table 7.10	Correlation of EyeDraw Evaluators' Ranking Result (A, B, C = evaluator name).....	91
Table 7.11	Correlation of EyeDraw Evaluators' Rating Result (A, B, C = evaluator name).....	91
Table 7.12	Research Questions Summary for GEM and EyeDraw Systems .....	96

## LIST OF FIGURES

Figure 2.1	Usage of Eye Movement .....	6
Figure 2.2	Eye gaze Tracker System (LC Technologies Inc, 2005).....	11
Figure 2.3	Velocity-threshold Fixation Identification .....	15
Figure 2.4	Hidden Markov Model Identification.....	16
Figure 2.5	Dispersion (Salvucci and Goldberg, 2000). .....	16
Figure 2.6	Dispersion-Threshold Identification (Widdel, 1984 cited by Salvucci and Goldberg, 2000) .....	17
Figure 2.7	Dispersion-Threshold Identification (Hornof et al.'s algorithm in Eye Draw system) .....	18
Figure 2.8	Area-of-Interest Identification.....	19
Figure 2.9	Area-of-Interest Identification (MacKenzie and Zhang, 2008).....	20
Figure 2.10	Fixation Identification Method Summary (adapted from Salvucci and Goldberg, 2000) .....	21
Figure 2.11	Gaze on a Desired Letter, "E" at an Alphabetical Keyboard. ....	23
Figure 2.12	The First Screen of Two-level Speller.....	24
Figure 2.13	This Screen is Displayed when ABCDE Button is Pressed .....	24
Figure 2.14	Eye Typing using Next-letter Prediction and Highlighting Techniques from MacKenzie and Zhang (2008).....	24
Figure 2.15	Eagle-Paint Drawing from Gips and Olivieri (1996) .....	26
Figure 2.16	Free-eye Drawing from Tchalenko (2004).....	26
Figure 2.17	State Transition Diagram.....	27
Figure 2.18	Drawings Made by Children without Disabilities using Eye Draw Version 1 (Hornof et al., 2004).....	28

Figure 3.1	Phases of this Research .....	32
Figure 4.1	Overview of the Experiment Setting Layout.....	37
Figure 4.2	Screen Snapshot of Point-Select Task.....	38
Figure 4.3	Flowchart of Experiment Procedure.....	39
Figure 4.4	Flowchart for Procedure of Analysis of User's Gaze Dispersion.....	40
Figure 4.5	Horizontal and Vertical Dispersion Calculation.....	42
Figure 4.6	A Gaze Path of a Participant during Eye Gaze Pointing Task .....	43
Figure 4.7	Horizontal Gaze Points Dispersion, $d_x$ of a Participant.....	45
Figure 4.8	Vertical Gaze Points Dispersion, $d_y$ of a Participant.....	45
Figure 4.9	Cumulative Percent Frequency over 50 Tasks for All Participants at Different $d_x$ and Different $d_y$ .....	46
Figure 5.1	Gaze Estimation Model (GEM) Architecture.....	50
Figure 5.2	User Looked at Two Points on the Computer Screen.....	53
Figure 5.3	Estimated Target Point .....	57
Figure 5.4	Example of Drawing a Point .....	58
Figure 5.5	Example of Searching.....	59
Figure 6.1	Overall System Prototype Flowchart.....	61
Figure 6.2	Algorithm for Smoothing Eye Movement Data .....	64
Figure 6.3	A Graphical View of the Smoothed x Coordinates.....	65
Figure 6.4	Algorithm for Drawing the Eye Cursor.....	66
Figure 6.5	Algorithm for Movement Patterns Interpretation.....	67
Figure 6.6	Algorithm for Searching Mode .....	68
Figure 6.7	Algorithm for Drawing Mode .....	69
Figure 6.8	How a User Draws a Line in the Proposed GEM System.....	70

Figure 7.1	Flowchart of Experiment Procedure.....	80
Figure 7.2	Sample Drawings (GEM).....	81
Figure 7.3	Efficiency of GEM .....	82
Figure 7.4	User Satisfaction (GEM).....	83
Figure 7.5	Drawing Ranking of GEM Drawings.....	85
Figure 7.6	Best and Worst Sample Drawings in Ranking using Different Types of Dispersion Threshold (G1-G16: GEM participants, $\sigma = \text{Target}$ ) .....	85
Figure 7.7	Drawing Rating (GEM).....	86
Figure 7.8	Sample Drawings (EyeDraw).....	89
Figure 7.9	Efficiency of EyeDraw .....	89
Figure 7.10	User Satisfaction (EyeDraw).....	90
Figure 7.11	Drawing Ranking of EyeDraw Drawings.....	92
Figure 7.12	Best and Worst Sample Drawings in Ranking using Different Types of Euclidean Dispersion Threshold (E1-E16: EyeDraw Participants, $\sigma = \text{Target}$ )	93
Figure 7.13	Drawing Rating (EyeDraw).....	94
Figure 8.1	Effectiveness.....	101
Figure 8.2	Task Completion Time .....	102
Figure 8.3	Drawing Ranking for Task 1 .....	103
Figure 8.4	Drawing Ranking for Task 2 .....	104
Figure 8.5	Highest and Lowest Ranked Drawings (G – GEM, E – EyeDraw, 1-16: Participant) .....	105
Figure 8.6	Drawing Rating .....	106

## LIST OF PUBLICATIONS

1. Chiu, P.C. and Yeo, A. (2006). Eye Drawing with Gaze Estimation Model. *Proc. Eye Tracking Research and Application (ETRA 2006)*, ACM. San Diego, California.
2. Yeo, A. and Chiu, P.C. (2006). Gaze Estimation Model for Eye Drawing. *Proc. CHI 2006*, ACM. Montréal, Québec, Canada.
3. Chiu, P.C. and Yeo, A. (2007). Eye Drawing using Gaze Estimation Model. *2nd Postgraduate Colloquium 2007*, Faculty of Computer Science and Information Technology, UNIMAS.

## CHAPTER 1 INTRODUCTION

### 1.1 Introduction

The physically impaired have difficulties in accessing computers due to functional and movement limitations. Many individuals with physical impairments are unable to control the standard mouse, for example, people with severely impaired motor disabilities, who do not have or cannot move their limbs or speak, such as *tetra-amelia* people – those who are born without arms and legs and people with partial paralysis resulting from Amyotrophic Lateral Sclerosis (ALS, or “Lou Gehrig’s disease”), brain injury or cerebral palsy. These people are severely limited in their ability to interact and communicate with the rest of the world. Despite these severe disabilities, many of these users retain normal control of their eyes. The eye movements may be the sole user input to access computer for the disabled people, instead of manual input using a mouse (Jacob, 1991).

### 1.2 Background

Interaction based on eye movement is one of the current research areas in human computer interaction (HCI). It constitutes a new area of human computer interaction intended for the community of able-bodied and disabled people. This area has attracted much interest from HCI researchers (Hornof et al., 2004; Majaranta et al., 2002; Zhai et al., 1999; Jacob, 1990; Ware et al., 1987).

Eye movement reveals a person’s thoughts and intentions and can be used as an input device for drawing, typing, playing music and games (Jacob, 1991). Commands are

invoked by looking or *fixating* at the items displayed at different locations on the computer screen. According to Majaranta et al. (2002), many researchers have been building eye typing systems for over twenty years. Eye typing refers to the process of producing text by using the focus of the gaze as a means of input (Majaranta et al., 2002). However, research on eye drawing techniques is still at the nascent stage. Hornof and Cavender (2005) noted that only few eye drawing software applications have been designed to draw pictures with eyes.

### **1.3 Research Problems**

Eye drawing interaction techniques provide a different set of problems and challenges compared to existing human computer interaction techniques. With a mouse, selection is usually carried out by pointing at the object and then pressing a button. Unlike a mouse, eye movements are always “on”. It is difficult to judge whether the user is *gazing* on a target to select it or just looking at the target. This problem is known as the “*Midas Touch Problem*”. Jacob (1991) defined the Midas Touch problem as a usability problem of gaze-based interaction that activates unintended selections, simply because the user is looking at the interface. Besides that, the challenge in building a useful eye drawing software is to produce recognisable drawings. However, some pictures that are drawn using existing eye drawing techniques are difficult to recognise (Tchalenko, 2004; Gips and Olivieri, 1996). In addition, some recognisable drawings consist of unintended gaps between lines in the drawings (Hornof et al., 2004).

## **1.4 Research Objectives**

This research focuses on four main objectives:

- To investigate and address the problems of current gaze-based interaction techniques in the drawing context.
- To develop a new eye movement data-interpretation model for eye drawing based on the characteristics of users' eye movement behaviours.
- To develop a simple eye drawing prototype which incorporates the eye movement data-interpretation model.
- To develop a methodology of comparison between the proposed system with the existing eye drawing system.

## **1.5 Scope of Study**

This research focuses on gaze-based interaction in the drawing context. In this domain, this research investigates the eye movement pattern to demonstrate the improvement of eye drawing in terms of effectiveness, efficiency, user satisfaction and drawing quality. This thesis focuses on saccadic eye movements, the most common type of eye movement. Other types of eye movements, such as nystagmus or convergence eye movements (Kowler, 1990) are beyond the scope of this research.

## **1.6 Limitation of Research**

This research does not take the effect of gender, age, computer knowledge, visual impairment and lighting noises into consideration during the evaluation of the proposed prototype. Another limitation of the research is small number of participants involved in

this research. Besides that, this research applies basic analysis such as mean and variance. Other limitation of this research is level of difficulty task in the experiments is low.

## **1.7 Thesis Organisation**

The structure of the thesis is organised in the following order:

Chapter 2 : The Literature Review chapter discusses existing gaze-based interaction for eye drawing approaches. The comparison and discussion of current gaze-based interaction approaches are highlighted and identified.

Chapter 3 : The Research Approach chapter outlines the phases of this research.

Chapter 4 : The exploratory study on eye gaze target-pointing refines the problem identified in the literature review.

Chapter 5 : The Conceptual Design chapter covers the approach towards solving the problems highlighted earlier. The design of the proposed prototype is covered in this chapter.

Chapter 6 : The Implementation chapter details the realisation of the proposed prototype with algorithm.

Chapter 7 : This chapter comprises two parts. Part 1 covers the experiment and evaluation of the proposed prototype. Part 2 details the experiment and evaluation of an existing eye drawing application.

Chapter 8 : The Evaluation chapter details the comparison of the effectiveness, efficiency, user satisfaction and drawing quality between the proposed prototype and an existing eye drawing application.

Chapter 9 : The Conclusion chapter summarises the research carried out and concludes with the contribution of this research, as well as limitations encountered. Future works are also presented.

## CHAPTER 2 LITERATURE REVIEW

### 2.1 Introduction

This chapter provides an overview of work in gaze-based interaction areas and describes how this work relates to the work in this thesis. The overview comprises six sections. The first section introduces the use of eye movement in human computer interaction. The second section discusses on saccadic eye movements, a characteristic of natural eye movements. In the third section, various types of eye tracking techniques are reviewed. The fourth section addresses the specific issues arising in the interaction techniques. The fifth section reports the fixation identification methods used in gaze-based and human computer interaction. Finally, previous works on gaze-based interaction are presented.

### 2.2 Eye Movements

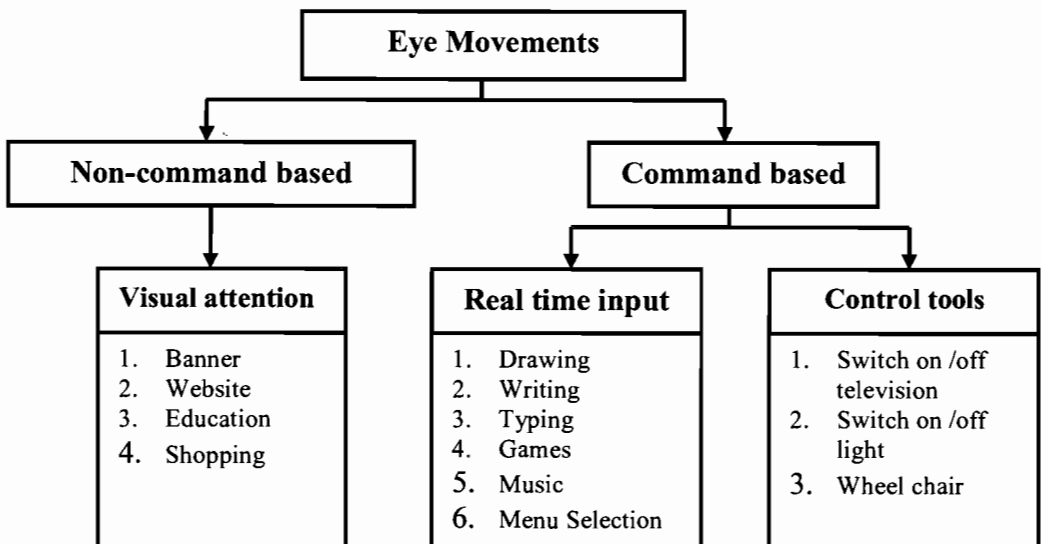


Figure 2.1 Usage of Eye Movement