Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Design and Evaluation of Text-free Map Interfaces

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Information Technology

School of Engineering and Advanced Technology

At Massey University, Albany

New Zealand

BOJIAN BAO

2016

Design and Evaluation of Text-free Map Interfaces

Abstract

The aim of this research is to design and evaluate a text-free online map interface for illiterate people and non-local-language speakers. The use of online maps is developing rapidly and while a large majority of people are using these applications, there are many illiterate people who find them extremely difficult to use due to their inability to read the text on the maps. Symbols and audio are two methods that can be used to replace the reliance on traditional text. The research conducts two surveys to define the suitable symbol type and identify features for online map design; designs a set of text-free online map applications and finally, evaluates each designed map application based on a sample of 90 participants (Native English Speakers, non-English Speakers and Illiterate People). The results illustrate that illiterate people find it more difficult to use the online map application compared with literate people. Text-free online map interfaces are necessary to support illiterate people and the map that included both symbol and audio was the most suitable type of text-free online map.

Key Words: Illiterate People, Text-free online map, user interface design

Acknowledgements

Any successful project is completed through the support and generosity of people and the author would like to thank all those people who have contributed to this research. First, I would like to thank Massey University for providing me the opportunity to complete this master thesis and enhance myself. I would like to say thanks to my family for their continued encouragement and support throughout my research. I must also thank my supervisor Dr. Kristin Stock who has undertaken and supervised several projects related to this research, including the collecting of descriptions for current locations, formulating spatial relation expressions by using a constrained natural language, selecting geometric configurations to match spatial expressions, interpreting the meaning of geographic concepts and collecting conversations to give directions to pedestrians. Key to this involvement was the review of my final report. Most especially, in my most difficult times where my faith waived, Kristin Stock provided me with the technical support and important encouragement to re-build my confidence by holding meetings for student groups involved in research and enabling us to communicate with each other to problem solve. Another group that has played an important part in my research is the survey participants. My thanks to the Native English Speakers and non-English Speakers who shared their ideas about improvements on the map interface. I would especially like to say thanks to the Illiterate People group for spending an enormous amount of time helping me finish evaluating tasks for my map application and coming up with their own ideas for improving the text-free maps. The Chinese and New Zealand GIS Experts shared advice about how to design the map application. Last but not least, I also should say thanks again to Massey University that our survey was ensuring that illiterate participants were fully informed and our study followed the Massey University Code of Ethical Conduct.

Table of Contents

Abstract 1
Acknowledgements 2
1. Introduction 9
1.1 Overview 9
1.2 Background 9
1.2.1 Illiterate People 9
1.2.2 Non-local-language Speakers 10
1.2.3 Mapping Technology and Text-free Interfaces 10
1.2.4 The Need for Text-free Maps to Help Illiterate People and Non-local-language Speakers to Find their Way Around 11
1.3 Aims and Objectives 12
1.4 Research Questions 12
2 Literature Review 13
2.1 Conveying Information in Text-free Interfaces 13
2.2 Illiterate People and Non-local-language Speakers need Text-free Maps 14
2.2.1 Illiterate People and Non-local-language Speakers Need Text-free Interfaces 14
2.2.2 Maps play an Important Part in our Daily Lives 17
2.2.2.1 Cartographic Symbol Construction 17
2.2.2.2 Ontology 18
2.2.3 Wayfinding for Illiterate People 19
2.3 Theory on How People Conceptualize Space for Way-Finding 21
2.3.1 How people Conceptualize Space 21
2.3.2 Way-finding is based on Space Conceptualization 22
2.3.3 The Factors that affect people's Spatial Conceptualizations 23
2.3.4 Mental/Cognitive Maps 24
2.4 Online Maps to Reflect the Mental Maps held by Users 26
2.4.1 Online Map Technology is Developing Rapidly 26
2.4.2 Online Map and symbols 26
2.4.2.1 Symbols for Landmarks 27
2.4.2.2 Location Based Services (LBS) 28
2.5 Usability 29
2.6 Summary 30
3. Research Procedure 32
3.1 Introduction 32
3.2 Detailed Research Procedure 32
3.4 Summary 33
4 Survey One – Symbol Type Selection 34
4.1 Introduction 34
4.1 Methodology 34
4.3 Results 35
4.4 Summary 38
5. Survey Two — Map Feature Selection 39

5.1 Introduction 40
5.2 Methodology 40
5.3 Results 41
5.3.1 Search Bar 41
5.3.2 Satellite View 42
5.3.3 History Records 43
5.3.4 Pan and Zoom 44
5.3.5 Positioning 44
5.3.6 Audio Notice 45
5.4 Summary 48
6. Web Map Design 49
6.1 Introduction 49
6.2 Web Map Design Produce 49
6.3 Obtain the online OpenStreetMap as the tile Map 51
6.4 Insert the Symbols for Landmarks (Including showing Images & Audio) 51
6.5 Pan and Zoom 53
6.6 Obtain Current Location 54
6.7 Search Bar 55
6.6 Cut the Text 57
6.8 Map Publish 58
6.9 Summary 58
7. Usability Study Methodology 59
7.1 Introduction 59
7.2 Sample 59
7.3 Experimental Design 60
7.4 Ethics 62
7.5 Pilot Study 62
7.6 Summary 62
8. Results 63
8.1 Introduction 63
8.2 Pre-Question Analysis 63
8.3 Time-Taken Analysis 65
8.3.1 Time-taken analysis for Different Groups 65
8.3.2 Time-taken Analysis for Map Types 67
8.3.3 Significance Difference Testing for Time-Taken 68
8.4 Usability Test 70
8.4.1 Significance Testing for Difference in SUS Score 71
8.5 Evaluation for Map Features 73
8.5.1 Positioning 74
8.5.2 Pan and Zoom 74
8.5.3 Text Search Bar 76
8.5.4 Audio Search Bar 78
8.5.5 Symbol Search Bar 82
8.6 Other Analysis 85

8.6.1 Evaluation of Layout 85
8.6.2 The Difficult Features 86
8.6.3 The Meaning of Symbols 87
8.7 Summary 88
9. Discussion 89
9.1 Introduction 89
9.2 Difference among each kind of Participant 89
9.3 Comparison amongst different Online Map Interfaces 90
9.4 Discussion of Individual Map Features 90
9.4.1 Positioning 90
9.4.2 Pan and Zoom 90
9.4.3 Text Search Bar 91
9.4.4 Audio Search Bar 91
9.4.5 Symbol Search Bar 91
9.5 Research Question Validation 91
9.6 Research Limitations 92
9.6.1 Lack of Illiterate People 92
9.6.2 Different Previous Map Use Experience 92
9.6.3 Low Quality of Voice Recognition System 93
9.7 Summary 93
10. Conclusion and Future Work 94
11. Reference 96
12. Appendix 104
Appendix A: All Designed Symbols 104
Appendix B: Questionnaire One 106
Appendix C – Questionnaire Two: Feature Selection 111
Appendix D – Insert Symbols 112
Appendix E —Detailed Design of Pan and Zoom 114
Appendix F - Obtain Current Location 116
Appendix G – Search Bar 119
Appendix H – Cut the Text 125
Appendix I - Map Published 126
Appendix J – Questionnaire for Map Evaluation 128
Appendix K: Analysis of the Statistical Significance of Differences in Time-Taken 134
Appendix L: How to calculate SUS Score 136
Appendix M: Significant Difference of SUS scores for each Group 138
Appendix N: Test Record 141
Appendix O: Questionnaire for Map Evaluation (Chinese Version) 144

List of Figures

Figure-1: Structure of Symbol Fragment 15
Figure-2: Igwana Interface 16
Figure 3 Ontology 19
Figure 4: Signs for Hospital 19
Figure 5: Text-Free Maps 20
Figure 6: Example of Cognitive Map 25
Figure-7: Model of Research Produce 33
Figure-8: Accuracy of Symbol Match 36
Figure-9: Accuracy of Symbol Match for Different Landmarks 36
Figure-10: Approval Rating of each Symbol Type 37
Figure-11: Approved Rating for Search Bar 41
Figure 12: Approved Rating for Satellite View 42
Figure 13: Approved Rating for History Records 43
Figure 14: Approved Rating for Pan and Zoom 44
Figure 15: Approved Rating for Positioning 44
Figure 16: Approved Rating for Audio Notice 45
Figure 17: Approved Rating for Showing the Picture on Symbol click 46
Figure 18: Add Location 47
Figure 19: Approved Rating for Favorite 47
Figure 20: Text Map Design Process 50
Figure 21: Text-free Map Design Process 50
Figure 22: Tile Map 51
Figure 23: Symbol Insert 52
Figure-24: From Albany Shopping Center to Albany Browns Bay (Pan) 53
Figure 25: From New Zealand to North Island of New Zealand 53
Figure 26: Example of Obtain Current Location 54
Figure-27: Layout of Search Bar 55
Figure 28: Find Location 56
Figure 29: Input Text 56
Figure 30: Find Location 56
Figure 31: Input Voice 56
Figure 32: Find Location 57
Figure 33: Select Icon 57
Figure 34: All Downloaded Vector Data 58
Figure 35: Text-Free Map Configuration 58
Figure 36: Age-Bracket for each Group 63
Figure 37: English Speaking Level for each Group 64
Figure 38: Previous Map Use Experience 64
Figure 39: Previous Online Map Use Experience 65
Figure 40: Average Time-Taken for each Group 66
Figure 41: Time Taken on Task Find a Shortest Route between Two Landmarks 67
Figure 42: Time-Taken on Task “Find Three Given Landmarks” 67
Figure 43: The Rate of Success in Using Feature “Positioning” 74
Figure 44: Time Taken on all Three Landmarks of each Group 78
Figure 45: Time Taken on all Three Landmarks of each Group 81

Figure 46: Time Taken on all Three Landmarks of each Group.....84
Figure 47: Appreciate Rate of Layout.....85
Figure 48: Main Problems of Layout.....85
Figure 49: Main Difficult Features 86
Figure 50: The Rate of Understood Symbols.....87
Figure 51: Main Misunderstood Symbols.....87

List of Tables

Table 1: Landmark Collection 34
Table 2: Time-Taken on Symbol-Landmark Match 37
Table 3: Features comparison 39
Table 4: Potential Features 41
Table 5: Opinions on Search Bar 42
Table 6: Opinions on Satellite View 43
Table 7: Opinions on History Records 43
Table 8: Opinions on Pan and zoom 44
Table 9: Opinions on Positioning 45
Table 10: Opinions on audio notice 45
Table 11: Opinions on Showing the Picture on Symbol click 46
Table 12: Opinions on Add Location 47
Table 13: Opinions on Favorite 48
Table 14: Features for Text-free Map 48
Table 15: Allocation for participants to evaluate online maps 61
Table 16: Significance Difference for Time-Taken 68
Table 17: SUS Scores for different participants 70
Table 18: Significant Difference of SUS score – Native English Speakers 71
Table 19: Significant Difference of SUS score – Non- English Speakers 72
Table 20: Significant Difference of SUS score – Illiterate People 72
Table 21: Time-Taken for finding symbols 74
Table 22: Significant Difference on Time-Taken 75
Table 23: The case of finding second and third symbol by using pan and zoom 75
Table 24: The case of First landmark search by “Text Search Bar” 76
Table 25: The distribution of groups for finding the first landmark successfully 76
Table 26: The Success Rate of Second and Third Landmark Searching 77
Table 27: Significant Difference on Time-Taken for Searching three Landmarks 78
Table 28: The case of First landmark search by “Audio Search Bar” 79
Table 29: Time Taken on all three Landmarks of each Group 79
Table 30: The Case of Searching the Second AND Third Landmarks 80
Table 31: Significant Difference on Time-Taken for Searching three Landmarks 81
Table 32: The case of First landmark search by “Audio Search Bar” 82
Table 33: Time Taken on all three Landmarks of each Group 82
Table 34: The Case of Searching the Second AND Third Landmarks 83
Table 35: Significant Difference on Time-Taken for Searching three Landmarks 84