Embedding Expert System into a Computerized Assessment Tool for Mouse Proficiency

Chih-Ching Yeh[1], Ming-Chung Chen[2], Chi-Nung Chu[3],
Chien-Chuan Cko[4], and Ting-Fang Wu[5]

[1] National Taiwan Normal University, Graduate Institute of Information and
Computer Education.
162, Sec. 1 Hoping East Rd., Taipei, Taiwan
z151@mail.cy.edu.tw
[2] National Chiayi University, Department of Special Education.
300 University Rd., Chiayi, Taiwan
mtchen@mail.ncyu.edu.tw
[3] China University of Technology, Department of Management of Information System.
56, Sec. 3, Shinglung Rd., Wenshan Chiu, Taipei, Taiwan
nung@cute.edu.tw
[4] National Chiayi University, Department of Computer Science and
Information Engineering. 300 University Rd., Chiayi, Taiwan
cccko@mail.ncyu.edu.tw
[5] National Taiwan Normal University, Graduate Institute of Rehabilitation Counsel.
162, Sec. 1 Hoping East Rd., Taipei, Taiwan
tfwu@ntnu.edu.tw

Abstract. This paper described an assessment system which embedded expert system based on the idea of neural network. Authors developed a computerized assessment tool for mouse operating proficiency and applied into clinical service. The result indicated that the objective tool had great contribution for selecting suitable pointing device for the client. However, clinical also found that comparing the effectiveness between different device and operation environment by some parameters was labor consuming. Expert system may be an available solution for clinical professional to select suitable pointing and selecting device more efficiently. Therefore, this study aimed to develop an embedding expert system into a computerized assessment tool for mouse operating proficiency.

Keywords: neural network, cursor movement, expert system.

1 Introduction

Mouse and keyboard are two popular kinds of devices used for interacting with computer. Mouse operating occurs more frequently than keyboard in graphic user interface (GUI), moreover, mouse movement is an integral part of human-computer interaction [1]. Operating a mouse poses no big problem for people without

disabilities. However, people with physical impairment experience many difficulties when using mouse.

There were many studies that focused on the issue of mouse operating for people with physical impairment [1],[2],[3],[4]. In the previous researches, the researchers suggested many parameters and explored their effectiveness. However, the objective assessment tools of mouse operating for clinical use were short on, so that the evaluator has to assess the mouse operation performance with subjective and nonsystematic methods. Besides, those measurement parameters were not integrated for the clinical practice.

Cursor moving, clicking and dragging are three essential mouse operating tasks needed to interact with computer. And the performance of these three tasks should be considered simultaneously when deciding a suitable pointing device. However, it is not easy for clinical professionals to make a suitable decision without objective tools. Therefore, authors developed a computerized assessment tool for mouse operating proficiency and applied into clinical service. The result indicated that the objective tool had great contribution for selecting suitable pointing device for the client. However, clinical also found that comparing the effectiveness between different device and operation environment by some parameters, such likes speed, accuracy and trajectory, task by task was labor consuming.

Expert system may be an available solution for clinical professional to select suitable pointing and selecting device more efficiently. Therefore, this study aimed to develop an embedding expert system into a computerized assessment tool for mouse operating proficiency.

2   Previous Research

In the research of cursor control measures, the analysis of computer screen cursor trajectories can provide insights into the factors limiting efficient cursor positioning and can assist in the design and improve the usage of the mouse. According to the literature, a number of mouse operating studies were on the basis of Fitts' law that examined gross characteristics of mouse movement, such as target sizes, target distances, directions, speed, accuracy and movement time [5],[6], [7],[8],[9],[10],[11], [12]. Next, throughput had been regarded as a new standard indicator to measure the effect of mouse recently (ISO 9241-9).

However, in stead of explaining the reason of the differences, these studies only indicated the existence of the differences. Therefore, some researchers began to propose the new accuracy measure methods and figured out some accuracy measurement parameters. Mackenzie, Kauppinen, and Silfverberg (2001) brought up seven new parameters as new measurement indicators, including target re-entry (TRE), task axis crossing (TAC), movement direction change (MDC), orthogonal direction change (ODC), movement variability (MV), movement error (ME), movement offset (MO)[7]. The result of their experiment indicated that only TRE and MO made a significant contribution to the prediction of throughput. Keates, Hwang,

Langdon, Clarkson, and Robinson (2002), studied the cursor trajectories according to the users' submovement structures, added missed click (MC) and ratio of path length to task axis length (PL/TA) to measure the course movement [2].

3   Method

This study aimed to embed expert system into a computerized assessment tool for mouse operating proficiency. The system was developed based on the previous efforts of the Computerized Assessment Tool (CAT) [13],[14].

3.1   The CAT System

Chen and his colleagues developed the CAT system [13],[14]. CAT was developed based on the results of related literature and the task analysis of mouse operating proficiency. The CAT system comprises three subsystems, namely Basic Skills (CAT-BS), Mouse Proficiency (CAT-MP) and Functional Performance (CAT-FP).

CAT-BS focuses on essential mouse proficiency testing, and provides standard evaluation tasks and procedures. The major aim of CAT-BS is to evaluate the fundamental mouse proficiencies. Evaluation results can be adopted to compare a user's performance with the average performance of all users. CAT-MP enables clinicians to set up various testing situations to explore the specific difficulties and suitable environments when client interacts with computer, such as appropriate interval between double-clicking, proper size of target for clicking, preferred color of the background. The CAT-FP system is used to determine the performance of multi-step functional interactions after equipping the client with some proper devices. This paper adopted the test tasks of CAT-BS and CAT-MP to develop the expert system.

3.2   Idea of Embedding Expert System

An Artificial Neural Network (ANN) or commonly just neural network (NN) is an interconnected group of artificial neurons that uses a mathematical model or computational model for information processing based on a connectionist approach to computation [15]. The back-propagation network (BPN) is more popular than other neural network types.

The major idea of the system was based on the neural network approach. The neural network consists of three-layers structure, namely, input layer, hidden layer and output layer. The neurons of input layer were the collected data that generated from clinical services. The adaptive computer device professionals evaluated the client's performance of operating different devices and operating in different environments by adopting the CAT system. The CAT system could collect speed, accuracy and coordinates that could be transformed into measurement parameters. The variables used for input layer are listed in table 1. As the table 1 released, there are 19 variables that resulted from the previous researches.

Table 1. Variables used for input layer

input variables	parameters
X1	Directions: 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°
X2	Target sizes: 0.5*0.5, 1.5*1.5
X3	Target distances: 5cm, 15cm
X4	Subtest: moving single clicking, moving double clicking, dragging
X5	Tools: mouse, joystick, trackball
X6	Accuracy: true or false
X7	D_CK_T: double click speed
X8	Path: actual distance of the path of the client's moving
X9	PL/TA: ratio of path length to task axis length
X10	RT: Movement Time, a target displayed for selection to the time the client activated the pointing device to move the cursor
X11	MT: Reaction time, the duration the cursor spent for reaching the target
X12	TT: Total Time, task complete time, TT=MT+RT
X13	Speed: cursor movement speed
X14	MDC: movement direction change
X15	ODC: orthogonal direction change
X16	TAC: task axis crossing
X17	MV: movement variability
X18	PV_Max: maximal peak velocity
X19	MU: movement unite

The number of neurons in the hidden layer was determined through experimentation. The neurons of output layer were the result of expert decisions . the parameter used for output layer are listed in table 2.

Table 2. Variables used for Output layer

Output	parameters
Y1	adjust the mouse speed
Y2	adjust the double-clicking speed
Y3	small size target practice
Y4	big size target practice
Y5	near distance practice
Y6	long distance practice
Y7	alternatives pointing devices

3.3 Tools of Developing Expert System

The authors developed an assessment system which embedded expert system based on the idea described above. The authors adopted MATLAB to construe the expert system. The system framework is shown in figure 1. As the figure 1 indicated, a client

interacts with computer based on the requirement of the assessment tasks generated from evaluation program. The program collects the response and stores the data into database. Then, the analysis program analyzes these law data into measurement parameters, as mentioned above. These parameters are adopted as input layer variables to train MATLAB Neural Network Toolbox for better understanding of cursor movements and then thought as an expert to propose the suggestion for individuals, ex. to adjust the Windows environment parameters, to use the alternative point devices.

For training neural network, authors used 41 training samples, 21 grade 5-6 primary school students and 20 mentally retarded students participated in experiment. By way of training, the neural network can provide correct classification for untrained patterns. Let the neural network learning iterative, until each input can be corresponding to the output correctly.
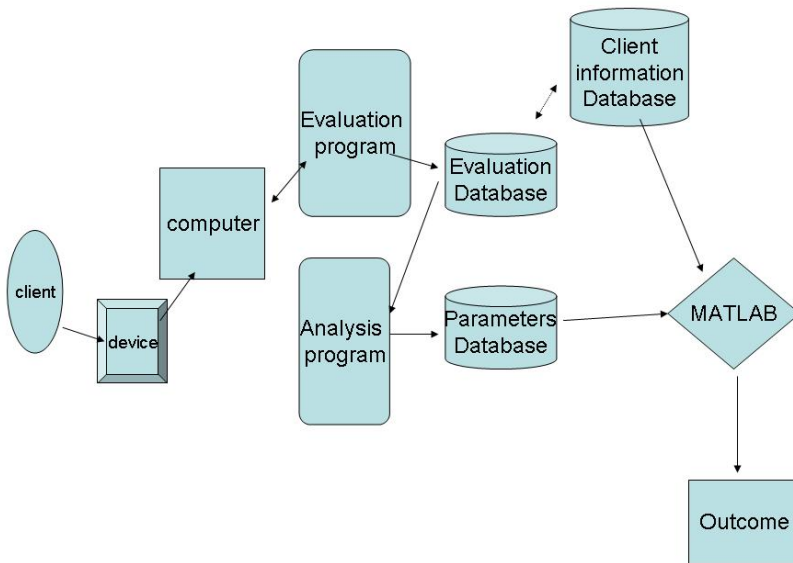

Fig. 1. The framework of an mouse proficiency assessment embedded expert system

4   Discussion and Conclusion

In this paper, the authors presented a novel method to analysis the cursor movement. In order to reduce the loading of analyzing mouse movement, authors tried to embed a expert network that adopted the result of the professional's decision and the data collected from CAT system. Then the authors conducted an experiment to exam the fitness of decisions between the real expert and the expert system. After training a neural network on parameters data, the trained neural networks successfully make the cursor trajectories of the test subjects less chaotic.

In the future, this embedded expert system could not only used to assist professionals to select suitable pointing devices more objectively and efficiently, but also help some professionals who do not have enough experiences of selecting pointing device to make suitable decision. Moreover, the system will help to diagnose specific difficulties and tailor interface environment or select suitable point device.

For future work, the embedded expert system will require more training samples and parameters for learning to reach the optimum. Furthermore, various tests will conduct in neural network model to determine the crucial parameters that affect the course movement performance.

References

1. Hwang, F., Keates, S., Langdon, P., Clarkson, J.: Mouse Movements of Motion-Impaired users: A Submovement Analysis. In: Proc of the 6th international ACM SIGACCESS conference on Computers and accessibility, pp. 102–109 (2004)
2. Keates, S., Hwang, F., Langdon, P., Clarkson, P.J., Robinson, P.: Cursor Measures for Motion-Impaired Computer Users. In: Proc of the fifth international ACM conference on Assistive technologies, pp. 135–142 (2002)
3. Kadouche, R., Abdulrazak, B., Mokhtari, M.: Designing an Evaluation Method for Computer Accessibility for People with Severe Disabilities. In: Miesenberger, K., Klaus, J., Zagler, W., Burger, D. (eds.) ICCHP 2004. LNCS, vol. 3118, pp. 845–848. Springer, Heidelberg (2004)
4. Rao, R.S., Seliktar, R., Rahman, T.: Evaluation of an Isometric and a Position Joystick in a Target Acquisition Task for Individuals with Cerebral Palsy. IEEE Transactions on Rehabilitation Engineering 8(2), 118–125 (2000)
5. Fitts, P.M., Peterson, J.R.: Information capacity of discrete motor responses. Journal of Experimental Psychology 67, 103–112 (1964)
6. Trankle, U., Deutschmann, D.: Factors influencing speed and precision of cursor positioning using a mouse. Ergonomics 34, 161–174 (1991)
7. MacKenzie, I.S., Buxton, W.: Extending Fitts' law to two-dimentional tasks. In: Proceedings of the CHI'92 Conference on Human Factors in Computing Systems, pp. 219–226 (1992)
8. Thomas, G.W., Henry, H.E.: Effects of angle of approach on cursor movement with a mouse: Consideration of Fitts' Law. Computer in Human Behavior 12, 481–495 (1996)
9. Phillips, J.G., Triggs, T.J.: Characteristics of cursor trajectory controlled by the computer mouse. Ergonomics 44(5), 527–536 (2001)
10. Boritz, J., Booth, K.S., Cowan, W.B.: Fitts' Law Studies of Directional Mouse Movement. In: Proceedings of Graphics Interface, pp. 216–233 (1991)
11. Epps, B.W.: Comparison of Six Cursor Control Devices Based on Fitts' Law Models. In: Proc. of the Annual Meeting of the Human Factors Society, pp. 327–331 (1986)
12. MacKenzie, I.S., Kauppinen, T., Silfverberg, M.: Accuracy Measures for Evaluating Computer Pointing Devices. In: Proceedings of CHI 2001, pp. 9–15. ACM Press, New York (2001)
13. Chen, M.C., Chu, C.N., Wu, T.F., Yeh, C.C.: Computerized Assessment Approach for Evaluating Computer Interaction Performance. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A.I. (eds.) ICCHP 2006. LNCS, vol. 4061, pp. 450–456. Springer, Heidelberg (2006)
14. Chen, M.C., Meng, L.F., Hsieh, C.F., Wu, T.F., Chu, C.N., Li, T.Y.: Computerized Assessment Tool for Mouse Operating Proficiency. In: Miesenberger, K., Klaus, J., Zagler, W., Burger, D. (eds.) ICCHP 2004. LNCS, vol. 3118, pp. 849–856. Springer, Heidelberg (2004)
15. Artificial neural network, http://en.wikipedia.org/wiki/Artificial_neural_network