Computerized Assessment Approach for Evaluating Computer Interaction Performance

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Abstract. This study presents a computerized assessment approach for evaluating a subject's pointing and selecting proficiency using computer input tools, to aid access tool selection for users with severe disabilities. The CAT system consists of three subsystems. The CAT system not only provides clinicians with an objective means of evaluating clients' specific mouse operating difficulties, but also allows them to compare the performance improvement made by a client make during the device selection and training period. The client's performance in each assessment task is assessed on the basis of speed, accuracy and efficiency. Besides introducing the CAT system, this study also describes an example of adopting the CAT system to assist a client to select a suitable pointing device.

1 Introduction

Computer and Information Technology (CIT) plays an increasingly important role in daily life. CIT can assist physically challenged individuals to participate in educational, vocational, societal and other daily activities in many ways. Moreover, CIT is considered as an "equalizer" for people with disabilities to participate fully in e-society. However, older people or people with disabilities encounter various difficulties when interacting with computers, and need extra adaptive solutions to help them to interact with CIT.

Many adaptive strategies for computer access and various alternative input devices are available for older people and people with disabilities [1]. Selecting suitable strategies and devices for a client is difficult for rehabilitation professionals, partly due to the lack of an adequate assessment tool to evaluate a client's performance of interacting with computer. Clinicians need related methods to assist them to execute a proper computer interaction evaluation. Clinicians require tools to assess the client's mouse operating capability during the evaluation process and determine suitable access methods; to compare the performance of

feasible devices, and to understand the change of client's performance during training program delivery.

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Some assessment approaches, including checklist, flow chart, evaluation tasks battery and software, are available for clinical use[2,8,9,10,11]. Checklists and flow charts focus on an assessment procedure that provides systemized evaluation steps and corresponding strategies or devices. An evaluation task battery provides a group of essential mouse operating tasks. Evaluators score a client's mouse operating performance by asking clients to complete some tasks and judge by themselves. Evaluation software allows clients to complete mouse operating tasks generated by software and collect clients' response automatically. Many such software systems have been developed, but mostly for specific research purposes. Moreover, these computerized assessment tools assess pure mouse proficiency instead of functional mouse operating performance. Evaluating clients' functional mouse operating performance provides practical information for both clinical rehabilitation professionals and clients. This information is very important for selecting the most appropriate device for interacting with computers in authentic situations.

In addition to the essential evaluation tasks, previous studies also considered what information data should be collected and analyzed is also an important consideration in the past researches. Speed, accuracy and efficiency are regarded as essential indicators of mouse operating performance. Recent studies have particularly emphasized efficiency as a fundamental indicator. Efficiency is defined in terms of stability when moving the cursor, such as the inconsistency between the trajectory of cursor movement and ideal straight line, movement variability, and sub-movements appeared during movements [2,5,6]. The qualitative data helps clinicians understand the effect of different factors, such as distance, direction and device, on cursor movements.

Our previous study had previously presented a Computerized Assessment Tool for Mouse Proficiency (CAT-MP) [4]. The authors aim to develop an integrated evaluation system based on the features of CAT-MP, containing pure mouse proficiencies and functional interaction skills, as well as measuring important indicators mentioned above.

2 CAT System

To develop a system containing essential mouse proficiencies and important functional interactions, this study reviewed related literature and analyzed the tasks or components of common interactions in advance. A checklist for conducting an investigation was drafted from the analytical results. The checklist has two parts, one focused on mouse proficiencies which contained static clicking, cursor moving, pointing and clicking, and dragging; the other one focused on functional interactions that comprise Operation System manipulating, window operation and word processing.

Eleven professionals from special education, rehabilitation, computer education, and computer science participated in the investigation, by ranking the degree of importance of each task in measuring the above proficiencies and interactions. The responses indicate that the professionals regarded most of the tasks as "important". These important tasks were included in the Computerized Assessment Tool (CAT), which contains three sub-assessment systems,

namely Basic Skills (CAT-BS), Mouse Proficiency (CAT-MP) and Functional Performance (CAT-FP).

Based on the design idea, 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 multistep functional interactions after equipping the client with some proper devices.

2.1 System Overview

CAT consists of three modules, namely client's Basic Data Module, Assessment Module and Analysis Module. The Basic Data Module records clients' related data, including computer usage needs, capability of sensory, motor control, and cognition, device used for assessment. The Assessment Module comprises assessment program and corresponding database. The Assessment program allows clinical evaluators to set up assessment tasks, and tests the client performance. The database records the client's detail responses, and gives data to the Analysis Module to understand the client's performance and difficulties.

2.2 Assessment Module

As mentioned earlier, the Assessment Module has three sub-assessment systems in. Each sub-assessment system has its own specific purpose and assessment items.

CAT-BS. CAT-BS system only comprises three tests, each with one task to evaluate. CAT-BS involves "targeting and left-single clicking", "targeting and left-double clicking" and "dragging". Each test comprises 32 tasks generated from four distances (1 cm, 5cm, 10cm, 15cm), each with eight directions (0, 45, 90, 135, 180, 225, 270, 315). The "targeting and left-single clicking" test requires clients to move the cursor from an initial icon to the target icon and activate left-single clicking. The "targeting and left-double clicking" test assesses the cursor moving and left-double clicking performance. The "dragging" test asks the user to move an icon to a target area by maintaining the left click down on a target icon, and releasing it on when moving it in the target area.

Although the program does not permit parameter setting, and automatically controls the assessment procedure, CAT-BS can be utilized to examine clients' basic mouse operating skill and compare the performance of various interaction devices or preintervention and prointervention.

CAT-MP. The CAT-MP system encompasses four tests, each consisting of three evaluation tasks, namely "targeting", "stationary clicking", "targeting and clicking" and "dragging". Within each test, the evaluator can flexibly set up the target size, target color, targeting distance, targeting direction, amount of testing of each task and time permitted for each trial. Test tasks can be arranged uniquely according to the client's proficiency or aim of the

assessment. For instance, a dragging task of 15cm and 5cm moving distance with a $1cm^2$ icon is chosen if the assessment measures the

distance that a client can drag. Conversely, the evaluator could fix the moving distance and change the icon size to explore the most suitable size for a client to click the mouse button.

In the "targeting" test, the client has to move the cursor to the specified icon and keep the cursor in the icon for a second. This test explores the performance of moving cursor in different distance and directions.

"stationary clicking" measures the subject's stationary clicking performance regardless of clicking device. Without moving cursor, a subject must click the target icon by pressing the button. The test results not only investigate the button activation situation, but also detect the proper interval of time between two clicks. This approach is useful for setting the double-click time interval.

"targeting and clicking" studies the ability to move the cursor and click coordinately. The "dragging" test aims to measure the client's dragging performance. The client is asked to drag the target icon by maintaining the button down, and to drop it when the target icon is located in the destined area. These two tests are performed when the client could move cursor and clicks the button, and examine a user's coordination when moving the cursor and pressing a button either sequentially or simultaneously. For instance, a possible test is to move the mouse cursor to a destined area 15cm away in eight radial directions with a trackball, and activate a single switch to click inside a 1 cm^2 icon, to determine whether he could move the cursor to the destination and simultaneously click the target icon by a trackball with a left-click switch.

CAT-FP. Unlike the aforementioned two systems, CAT-FP focuses on typical interactions in a real Windows system. CAT-FP comprises three tests, namely "Operation System manipulating", "window operating" and "word processing". Each test involves several typical evaluation tasks. The "Operation System manipulating" test includes manipulating the "start menu", copying an icon and pasting it, executing a file on desk and shutting down system. Every test task requires many subtasks to be completed in multiple steps. For example, when a client wants to complete the task of "manipulating "start menu"", he needs to move mouse cursor to the "Start" icon located at the corner of the screen and perform a left click at first; then move the mouse cursor straight up to the "program" and turn mouse cursor right to a specified program, and finally perform a left click to execute the program. A real interaction is complex for a client in accomplishing each test task. However, the data collected from each task shows each client's specific difficulties in a subtask by recording the sub-task responses in detail.

2.3 Analysis Module

The CAT system measures the speed, accuracy and efficiency of each evaluation task. The speed is the time spent to accomplishing a single test item correctly. The accuracy is the percentage of correct responses from all trails in each test task. The efficiency is the trajectory of the cursor moving, and is measured by two indicators, the number of submovement and ratio of actual moving path and distance of a task. Speed and accuracy are defined as quantitative indicators of mouse operation performance, while efficiency is a qualitative indicator.

Since the CAT system is case-based approach, the evaluation data were recorded in each single client's database. Rather than analyzing a group subjects' average

performance, the Analysis module is designed to understand each client's performance in a single assessment or the difference between two assessments. Figure 1 shows the quantitative information of speed and accuracy shown. The Analysis Module is adopted to analyze the cursor movement trajectory. Figure 2 indicates the trajectory originated from real cursor movement during a dragging task. The data in Figure 2 reveals that the client could move the icon to the destination, but could not release the button when the icon was there. Furthermore, as the trajectory indicated in Figure 2, the difficulties this client met were :1) starting to move the icon toward to destination, 2) targeting on the destined area correctly, and 3) releasing the icon inside the destined area.

Additionally, the program records the cursor coordinates at every decisecond. The coordinate data demonstrate the pattern and fluency of movements. Figures 3 and 4 indicate the speed changed during a task of "targeting and left-single clicking". In the figures, the *x*-axis denotes movement time (decisecond), and the *y*-axis represents distance (pixels). The

performance result reveals that the cursor was
moved intermittently. The cursor speed increased quickly, and then decreased immediately. Figure 4 indicates a different scenario. The client needed about 2.5 seconds to start mouse cursor, and then created two major submovements before reaching the target. He activated the left-single click about 2.5 seconds after the cursor had been finally stopped.

Fig. 1. An example of outcome screen of a dragging task

Fig. 2. An example of path of a dragging task

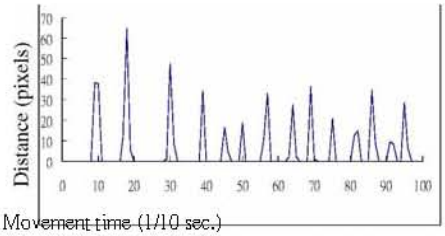


Fig. 3. An example of cursor moving with many submovements

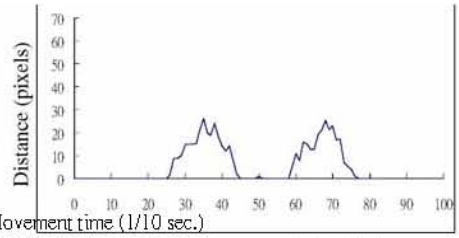


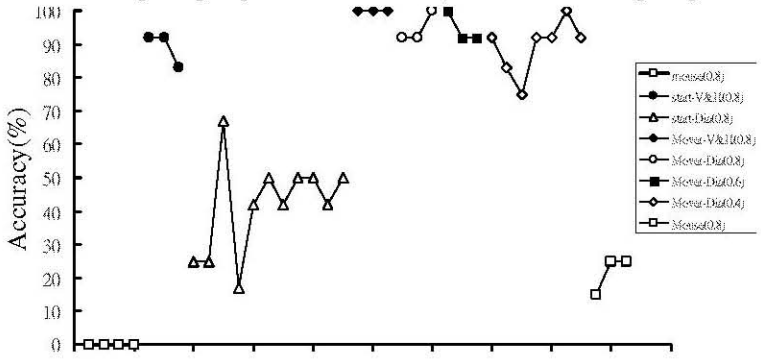
Fig. 4. An example of cursor moving with two major submovements

3 Comparability

Some comparability tests were performed with a trackball, a joystick and a multi-switch mouse, which are popularly used as alternative point and selecting devices. Two undergraduates who were familiar with mouse manipulating participated in the evaluation. The comparability test results demonstrate that these devices can complete all evaluation tasks in the CAT system.

4 Application

This study reports a case study of choosing the appropriate device for a 5th grade girl with cerebral palsy (CP). This girl could not interact with a computer through a standard mouse, but she needed to read independently and effectively on a computer. To select an appropriate device, two kinds of multi-switches mouse, Star (a switch mouse manufactured by TASH Inc.) and grouped switches mouse (five single switches) equipped with a Mouse Mover (an adaptor, also manufactured by TASH Inc.) were selected as candidates to examine their performance by conducting a training program after the revealing performance of five devices. Figure 5 illustrates the performance result of the two devices in "targeting and clicking". As Figure 5 indicates, by using Start, she could moving horizontally and vertically well, but her diagonal moving performance was poor even after practicing eleven times. However, she performed very well when using the grouped switches mouse, even when the target square size was



reduced from 0.64cm^2 to 0.16cm^2. Finally, the grouped switches mouse was adopted to assist her to learn to read digital text on the computer.

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Trials

Fig. 5. Accuracy of cursor moving using three devices

5 Discussion and Conclusion

This study describes the major tests of a computerized assessment tool and its application for selecting proper pointing and selecting device for a client. The CAT

system was developed through an extensive literature review, task analysis of fundamental mouse operations and expert review. Clinical rehabilitation professionals can adopt the CAT system to help them to evaluate a client's computer interaction performance. The CAT system comprises three subsystems, which not only involve the full range of needed mouse tasks, but also the essential functional mouse activities when interacting with a computer. The preliminary application of the CAT system indicates that the CAT system is useful in clinic intervention. However, further clinical application studies involving individuals with different disabilities or limitations are still needed in the future. Additionally, an expert system to diagnose the most appropriate) operating environment and pointing devices may be integrated into the future system to provide clinicians with the most valuable data.

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References

1. Alliance for Technology Access: Computer and web resources for people with disabilities (5th ed.). Alameda, CA: Hunter House (2004).
2. Anson, D. K.: Alternative Computer Access: A Guide to Selection. F. A. Davis, Philadelphia (1997).
3. Anson, D., Lawler, G., Kissinger, A., Timko, M., Tuminski, J., & Drew, B. Efficacy of three head-point devices for a mouse emulation task. Assisstive Technology, (2002)14(2), 140-150.
4. Chen, M. C., Meng, L. F., Hsieh, T. F., Chu, C. N., & Li, T. Y.: Computerized assessment tool for mouse operating proficiency Lecture Notes in Computer Science, (2004)3118, 849-856.
5. Capilouto, G. J. :Movement variability and speed of performance using a head-operated device and expand membrane cursor keys. Lecture Notes in Computer Science, (2004)3118, 820-826.
6. Hwang, F., Keates, S., Langdon, P., & Clarkson, J.: A submovement analysis of cursor trajectories. Behavior & Information Technology, (2005)24(3), 205-217.
7. Kadouche, R., Abdulrazak, B., & Mokhtari, M.: Designing an evaluation method for computer accessibility for people with severe disabilities. Lecture Notes in Computer Science, (2004) 3118, 845-848.
8. Lane. A., & Ziviani. J.: Introduction to the Test of Mouse Proficiency. The Occupational Therapy Journal of Research: Occupation, Participation and Health, (2002)22(3), 111-118.
9. Mazer, B., Dumont, C., & Vincent, C.: Validation of the Assessment of Computer Task Performance for Children. Technology and Disability, (2003)15, 35-43.
10. Wright, C., & Nomura, M.: From Toys to Computer: Access for the Physically Disabled Child. Authors, San Jose (1985).
11. Wu, T. F., Meng, L. F., Wang, H.. P., Wu, W.T., & Li, T. Y.: Computer Access Assessment for Persons with Physical Disabilities: A Guide to Assistive Technology Interventions. Lecture Notes in Computer Science, (2002)2398, 204-211.

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