TrackMouse: a new solution for 2+2D interactions

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ABSTRACT
Desktop applications are more and more sophisticated. Often, the user needs several degrees of freedom (DOF) to accomplish his tasks. One solution is to provide two independent cursors for some types of interactions but this solution is mainly used in bi-manual interactions with multiple input devices. The goal of this paper is to provide a solution to manipulate two cursors with only one hand: a method for one user, with one hand, and two cursors. By this way, the second hand can be used for other purposes. We propose a new hybrid device between a haptic mouse and a trackball to give 2+2 DOF to user. A driver solution is shown to integrate this new device in Windows XP and to give an easy access to the new affordances. An application for pilot testing was implemented and the results show a high potential for the proposed solution.

Author Keywords
Multiple cursors, multiple mice, graphical interaction.

ACM Classification Keywords
H.5.2 [Information Interfaces And Presentation]: User Interfaces--- Graphical user interfaces (GUI), Haptic I/O, Input devices and strategies, Prototyping; I.3.1 [Computer Graphics]: Hardware Architecture--- Input devices.

INTRODUCTION
Novel desktop applications are more and more sophisticated: we can now find applications which provide high-level interactions with multiple pointing devices and cursors. Users have new kinds of interactions and the difficulty is to manage the streams of data from these devices and to develop new interaction methods. We can divide applications with multiple pointing devices in three categories: one user with one hand interactions, one user with bi-manual interactions, and groupware applications.

In the first category, a single input device is considered as a multiple input device. For example, the latest mice from Microsoft and Logitech combine two wheels in the same mouse. By this way, user controls the system cursor with the mouse and he controls scrolling in the X-axis and the Y-axis with the two independent wheels. These products are primarily dedicated for scrolling and it is difficult to control a secondary cursor with these two wheels. Recently even mice combined with a trackpoint or a trackball have become available (Figure 1).

In the second category, the user interacts with the system with two pointing devices, one in each hand, with sometimes their own cursors [2]. One hand controls the system cursor and the other controls a secondary one or gives additional information to the interaction task [5] [1]. For example, the left hand moves a see-through menu on the screen while the right hand selects an item from the menu to apply it on the data [5]. The role of each device is determined to help the user to achieve his goals.

In the last category the problem increases. The application is intended to deal with more than one user on the same desktop [8]. It must deal with multiple pointing devices with their own cursors. In fact, each user can use multiple mice with two hands or one hand. The problem of the definition of the interactions remains similar to the two previous categories with additionally the difficulty to manage the collaboration between users to realise a task.

This paper focuses on the first two categories of applications. We are working on a new device, the TrackMouse, to manipulate two independent cursors, the system cursor and the secondary cursor, with the same dominant hand. In the next sections, we briefly present the manufacturing of the new device before we indicate a software solution (API) designed for Windows XP. Then, we show the first results of pilot tests by comparing...
interaction with one mouse, bi-manual interaction with two mice, and interaction with the TrackMouse.

**TRACKMOUSE: THE HARDWARE**

Mice with two combined wheels can give the required degrees of freedom, 4 DOF, but they are not able to correctly control a secondary cursor. In addition, existing mice combined with a trackball are specific, so hard to use for development, and generally support only an exclusive working mode, mouse or trackball. So, we chose to manufacture our own device prototype, the TrackMouse. The hardware is based on the Logitech Wingman Force Feedback mouse, a 2 DOF haptic device (Figure 2).

**Figure 2. Logitech WingMan force feedback mouse.**

It is a mouse with true directional force feedback, a modality that will be used in further research but not in this paper. The mouse is fixed to an easy to modify pantograph with a fixed range of motion of about 2 inches by 2 inches. The two degrees of freedom are used for the system cursor.

To obtain the two additional degrees of freedom, we chose to add a true trackball to this mouse. The electronics of the buttons was removed before tolling it to obtain a plane surface (Figure 3a). An adapter with three contacts was designed by 3D digital scanning and manufactured by rapid prototyping (Figure 3b). The trackball is glued on the adapter which is simply put down on the mouse. The contacts guarantee the assembly and it is easy to change the trackball to do different tests with different devices. The result is a true 2+2 DOF device with the Marble TrackMouse (Figure 3c) and even a 2+2+1 DOF device with the TrackMan TrackMouse which has a wheel (Figure 3d). The two additional degrees of freedom are used for the secondary cursor.

**Figure 3. The TrackMouse manufacturing.**

**TRACKMOUSE: THE SOFTWARE**

The development of the software was complicated by the inability of Windows XP to distinguish the input from multiple mice including the trackballs. They all control the same system cursor both for movements and interactions. For the TrackMouse, we must be able to distinguish data incoming from the mouse and from the trackball. The movements of the mouse must control the system cursor while its buttons are ignored because they were removed. The movement of the trackball must control a secondary cursor (visible or not) while its buttons and its wheel must be used for interacting with the application and with the controls of Windows.

For the developer, the new device must be totally hidden by an API. The application must continue to receive the legacy messages of Windows for the system cursor e.g. WM_MOUSEMOVE while receiving specific messages for the secondary cursor e.g. MMI_MOUSEMOVE. To implement this API, we studied the Raw Input technique and a new driver implementation.

The Raw Input is a new low level API introduced in Windows XP to achieve input from multiple input devices such as keyboards and mice. Unfortunately, many problems appeared and couldn’t be solved at this time.

The implementation of a new driver is a lower level solution compared to the previous solution (Figure 4). We can filter data directly in the stream of the device before the computation by the Windows mouse subsystem. After several investigations, we based our driver on the driver provided by the CPN group [9] [3].

**Figure 4. The driver solution.**

The modified CPN driver is only installed for the trackball. The objective is to remove all events of trackball movements from the stream of events. By this way, the Windows mouse subsystem believes that the trackball never moves but the movements are sent to the Track Mouse API which is based on the CPN API. The main goals of this
Track Mouse API are to manage the display of the secondary cursor and to send the events of movements directly to the application with specific MMI_MOUSEMOVE messages.

The events for buttons remain in the stream. Thus, the Windows mouse subsystem interprets them as the buttons of the system cursor: accordingly, it sends usual legacy messages as WM_LBUTTONDOWN to applications. The interactions with the controls of Windows are done without any trouble. For the Logitech mouse, no data have to be filtered. The original haptic driver remains the same. By this way, the haptic possibilities of the mouse are always available and can be used without any risk of troubleshooting in further studies.

AN EMPIRICAL PILOT STUDY
To find out how the TrackMouse performs in practice we carried out an empirical pilot study with eight participants who were students and teachers of the University of Metz. There were seven men and one woman. The medium age of the users was 27 years, and they were all experienced users of desktop computers. In addition to testing TrackMouse we wanted to compare it to the normal situation with a mouse, and to two-handed situation where the dominant hand controlled a mouse and the non-dominant hand the trackball. Figure 5 shows the experimental setup.

**Figure 5. Experimental setup.**

**Experiment design**
The pilot test was a within subjects test with three input conditions: 1) one mouse, one hand, 2) two mice, two hands, and 3) TrackMouse with one hand. There were two tasks: drawing and selection (Figure 6). Each of 3*2 interaction situations was tested separately during 15 trials. Before actual testing the user could try out the task a couple of times, and then the timing was started. We counterbalanced the order of conditions in each task between the users, and also had a different order of devices in the first and second task for each user. Each task was started by clicking the left mouse button after which the timing began and the task continued as long as the objective was reached.

Task 1 was an accurate drawing task resembling the one used by Leganchuk et al. [6]. This task required drawing exactly the same ellipse that was presented on screen. With one mouse the action was a basic drawing action: the user drew the ellipse by dragging the mouse. With two hands and with TrackMouse the user controlled two separate cursors to adjust opposite corners of the bounding box of the ellipse. This was expected to be rather hard, since controlling the non-dominant hand is less accurate and more error-prone than controlling the dominant hand [6]. In addition, dividing the concentration between two parallel tasks, albeit related, is difficult when they need to be done accurately. We assumed that two hands and TrackMouse would not perform as well in this task than in a task that is designed for the asymmetric operation of the hands [4].

**Figure 6. Screenshots from task 1 (left) and task2 (right).**

In task 2 we draw a set of red and green dots (all the users had normal sight). The task was to select the green dots with an ellipse that enclosed only them. This task required less accuracy, since several ellipses were suitable. As soon as a correct selection was done the next set of points was shown. With one mouse the position of the selection ellipse was controlled when moving the mouse, and its dimensions were changed when moving the mouse with the right button down. With two hands and with TrackMouse the trackball controlled the dimensions. This is similar to some earlier studies of two-handed interaction [7] where trackball was proved to suit for the non-dominant hand. We expected that both two hands and TrackMouse would perform best.

**RESULTS AND DISCUSSION**
The results of the pilot study confirmed most of our expectations. Figure 7 shows the total time of doing 15 trials of task 1 in each interaction situation. The rightmost bars show the average values for all users.

**Figure 7. Performance in task 1 (drawing).**
In task 1 differences in performance between the one-handed and two-handed case (F(1,15)=6.45, p<0.05), and between the two-handed and TrackMouse cases (F(1,15)=5.04, p<0.05) were significant, but between one-handed and TrackMouse cases they were not. This was a little contrary to our expectations, since two-handed control of different cursors is a difficult manual task. The reason for good performance may be hard concentration in the task.

Task 2 that was better suited for parallel interaction requiring less accuracy from the second cursor gave interesting results: both the two-handed (F(1,15)=5.62, p<0.05) and TrackMouse (F(1,15)=5.07, p<0.05) situation were significantly faster than the one hand, one mouse situation, but there was no significant difference between these two. Thus, the users achieved equal performance using TrackMouse with only one hand compared to two-handed interaction. This result suggests that TrackMouse clearly has promise for being an effective device. Figure 8 shows the results of task 2 in the same manner as Figure 7.

User preferences were slightly in favor of two-handed interaction, followed by TrackMouse, and finally the common one mouse situation. In our preliminary tests we noticed that the trackball button was hard to keep pressed while rotating the ball. We decided not to require button to be pressed during the operation, only to begin the task. This is a little contrary to established interaction techniques in graphical user interfaces, but on the other hand the established techniques do not support the use of two cursors. New choices may be necessary in these situations.

Finally, it is clear that our pilot study does not provide extensive evidence for two-handed interaction or the use of two cursors with TrackMouse. The main goal of this study was to prove that TrackMouse works as a concept. This was accomplished since in the first task it seemed to outperform one mouse, and in the second task it even performed as well as the two-handed setup. Our results are in line with an earlier study that inspected mice in different tasks [10].

CONCLUSION

TrackMouse gives the user another pointing device that can be used in parallel with the primary pointer. The device can also be used as a normal mouse. Based on this study, one-handed two-cursor setup resembled two-handed interaction in that when the secondary action performed with the second cursor (as in task 2) was clearly related to the primary action, and did not require high accuracy, the performance was significantly better than one-handed performance. When the tasks had equal level of difficulty, the two-handed performance was the best, TrackMouse the second, but there was not statistical difference compared to the one mouse, one hand case. In our future studies we keep on experimenting with different devices to be used as a part of TrackMouse.

REFERENCES