Enhancing Multi-Tasking Efficiency through the Tiltable Pedal Assisted Computer Operations

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ABSTRACT
This paper introduces a novel approach to enhance multitasking efficiency through the use of the Tiltable Pedal as an assistive device for computer operations. By leveraging the insight that certain computer tasks can be controlled using alternative body parts, specifically the feet, we implemented the Tiltable pedal inspired by an electone musical instrument. This approach offers the potential to streamline multitasking processes and provide users with a more convenient and seamless multitasking experience.

Author Keywords
None.

CCS Concepts
•**Human-centered computing** → **Human computer interaction (HCI);** Interaction devices; Pointing devices.

INTRODUCTION
In our daily lives, we often find ourselves in situations that require multitasking. Whether it's cooking while following a recipe or working on assignments while browsing reference materials on a computer, these multitasking scenarios typically demand the use of both hands. As a result, our hands constantly switch between two tasks, such as alternating between holding a pen to write and operating a mouse to navigate through reference materials, which can be inefficient. This paper aims to address the inconvenience of continuously switching tasks while multitasking.

We have observed that in most multitasking scenarios, one of the tasks tends to be relatively static, such as reading or browsing content on a computer. Typically, people use a mouse to control their computers during these static activities. Therefore, we believe that these static computer operations do not necessarily require manual dexterity and can potentially be controlled using other body parts. With this insight in mind, we explored different alternative computer interactive methods and ultimately discovered the technique of theTiltable Pedal as an assistive device for multitasking computer operations.

In this paper, we will present our research findings on the utilization and conducted experiments and user studies to evaluate the feasibility and effectiveness of the Tiltable Pedal. Additionally, we will discuss the potential benefits and implications of integrating the Tiltable Pedal into everyday multitasking activities.

BACKGROUND KNOWLEDGE
In the search for suitable hands-free interaction methods for multitasking computer operations, various alternatives to manual hand control have been explored, including hand control, eye control, voice control, biosignal control, and foot control.

Facial Expression Interaction
Technologies such as "Camera Switches [1]" by Google and the built-in system [3] in iOS devices support the use of facial expressions, such as open mouth, smile, raise eyebrows, and looking in different directions, to control mobile phones and computers. While these methods offer a wide range of operations, they are not particularly convenient for scrolling during reading activities.

Eye Tracking Interaction
Eye tracking interaction utilizes the gaze of the eyes as input for controlling computer systems. For example, Microsoft has implemented eye tracking features [10] that allow users to control the cursor by gazing and select buttons by dwelling. In terms of reading, gaze-enhanced scrolling techniques have been developed, where the content automatically scrolls based on the user's eye movements, employing various algorithms to determine the timing, speed, and amount of scrolling [8] [12].

Although gaze-enhanced scrolling techniques address the issue of manual task switching, they come with the inconvenience and privacy concerns associated with camera usage. Moreover, during multitasking, the user's gaze tends to switch between different locations [4], making gaze-enhanced scrolling techniques less suitable for multitasking scenarios.

Foot Interaction
There are currently various foot switch pedals available in the market. These pedals typically consist of one to three buttons [2] and support simple tasks, such as starting or stopping recordings or turning pages in sheet music.

Foot Interaction in Electone

In our observations of everyday items that can be operated with the feet, such as bicycles and vertical fan buttons, most of them only involve pedaling or pressing. However, we discovered a different type of operation on the electone. The electone features two tiltable pedals located near the right foot [14], which are controlled by stepping on the pedal and vertically rotating the ankle joint to control the overall volume and add expressiveness to the music. We noticed that the vertical and continuous nature of these operations closely resembles the scrolling actions required during reading and browsing on a computer. Therefore, we aim to adapt this concept as an assistive device for multitasking computer operations.

Figure 1. Electone's tiltable pedal.

RELATED WORK

In the field of foot interaction devices, various approaches have been explored to enhance hands-free computer operations.

Virtual Foot Menu

Some of these devices do not feature physical buttons but instead utilize virtual button positions [16] and depth cameras [9] to capture foot movements. This method is particularly suitable for capturing actions such as kicking, lifting, and tapping, which may not be well-suited for physical devices but can be precisely detected through motion tracking.

An example of such a device is the Tap-Kick-Click [11], designed for foot interaction with a standing desk. It enables users to interact with spatial taps and kicks, leveraging the standing posture for input.

Shoe Mouse

Another approach involves using a sensor-integrated shoe as an information acquisition platform to sense the foot motion. The Shoe Mouse [15] is a sensor-integrated shoe that serves as an information acquisition platform for hands-free computer interaction. It offers a portable and wearable solution for individuals with limited hand mobility, and its applications extend to gait recognition, human identification, and motion monitoring.

Foot Pedal

Furthermore, foot pedals with improved designs, inspired by braking mechanisms, have been developed. For instance, the Foot-Rocker [7] extends the one-directional movement of commercial foot pedals by introducing a back-and-forth tilting motion and utilizing springs to return to the neutral position.

In our research, we carefully considered these existing approaches. However, we decided against virtual or wearable devices as we specifically aimed to enable vertical rotation of the ankle joint, which requires a point of force application. Thus, a tiltable pedal emerged as the most suitable choice for our intended purposes.

IMPLEMENTATION

The implementation of the proposed device was based on the structure of an electone. The size of the pedal panel was determined to be 28cm x 10.5cm, two standard deviations larger than the average foot size of Asian males [5]. To enable rotation, a horizontal bearing was placed at the center of the backside of the pedal. A slight weight was added to the bottom of the pedal to enhance stability. In addition, considering the presence of foot switches on both sides of electronic keyboards, joystick switches were installed on the left and right sides of the pedal to emulate foot switches.

For hard and soft ware implementation, an Arduino MPU sensor was employed to detect the tilt angle of the pedal. The collected data, including the pedal tilt angle and the activation of the joystick switches, were transmitted to a Python program via an Arduino Uno. The following control actions were implemented:

1. As the pedal tilt angle increased in the forward direction, the program emulated mouse scroll wheel movement, resulting in upward scrolling of the screen content, and vice versa.

2. When the left foot switch was activated, the program emulated a "Shift + Tab" keystroke, and when the right foot switch was activated, it emulated a "Tab" keystroke. This design allows for efficient control without the need for fine-grained mouse movements and enables users to select the desired key actions with ease.

EVALUATION

In this evaluation, we assess the efficiency and accurately of the Tiltable Pedal. While the pedal includes switches, our evaluation primarily focuses on the performance of the tilting mechanism. Our hypothesis is that the use of the Tiltable Pedals enhances multitask scrolling performance compared to conventional mouse usage.

Task

Participants were provided with the following materials:

1. A screen displaying an Excel spreadsheet with two rows: Row A labeled from 1 to 200, and Row B labeled with random alphanumeric codes from 10 to 99.

2. A stack of 20 question cards, each featuring a number from 1 to 200.

3. An answer sheet.

4. A pedal or a mouse.

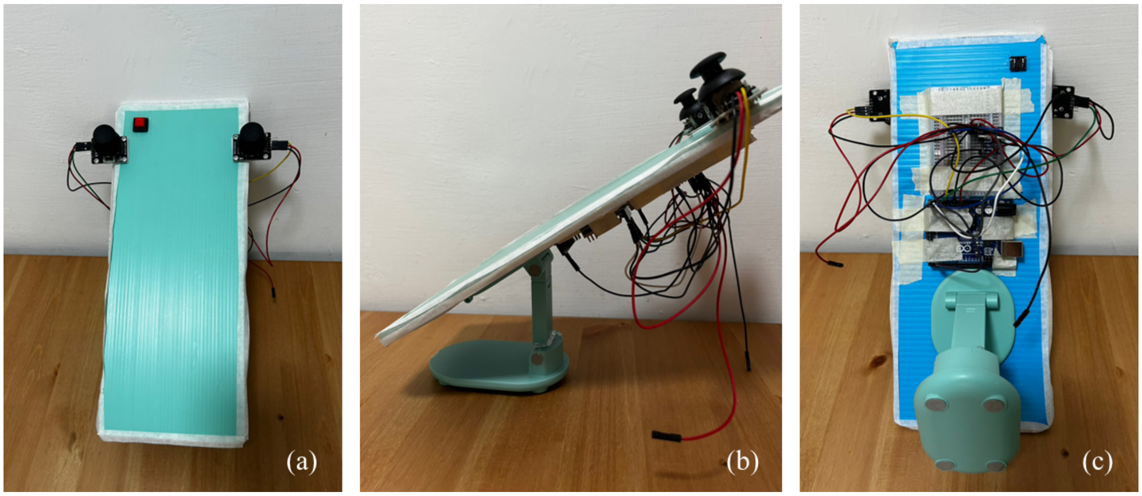

Figure 2. (a) The front, (b) side, and (c) back view of the pedal.

Participants were instructed to scroll through the Excel spreadsheet, either using the pedal or the mouse and locate the number on each question card in Row A n sequential order and record the corresponding number from Row B on the answer sheet.

To avoid the influence of reading comprehension skills on participants' performance and ensure quick and skill-independent responses, we opted for a task involving numerical search rather than reading a passage. The use of question cards instead of a single sheet with all the answers listed aimed to assess differences in scrolling methods, discourage participants from skipping or reordering questions, and encourage them to follow the given sequence, utilizing methods requiring less scrolling whenever possible.

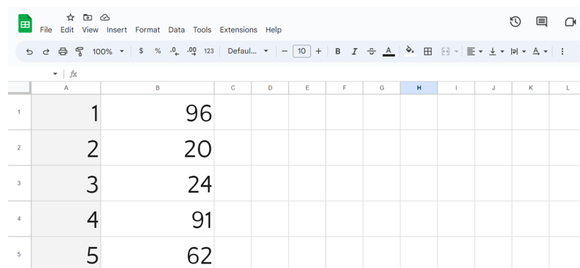

Figure 3. The Excel spreadsheet with two rows: Row A labeled from 1 to 200, and Row B labeled with random alphanumeric codes from 10 to 99.

Variables and Measurements

We considered two main variables. The first variable pertained to the method of input, which was the central aspect of our investigation. offering participants two options: using a mouse or using the Tiltable Pedal. To ensure fairness and eliminate potential biases, the second variable involved the order of the questions on the cards. We employed two possibilities: forward and reverse order of the same set of questions.

The reason for using the same set of questions in both forward and reverse order is to ensure that the displacement of scrolling in Excel is consistent between the two methods. Additionally, the numbers in the B row of the Excel sheet were randomized differently for each trial.

To measure the effectiveness of the different methods, we utilized two key metrics: time taken and accuracy [6]. We recorded the time participants spent completing the scrolling tasks using either the mouse or the pedal. Additionally, we assessed the accuracy of their responses on the answer sheet. These measurements allowed us to objectively compare the performance of the two input methods.

Figure 4. The question cards.

Experimental Design and Proceedure

The experimental design employed a within-subject approach, where each participant completed one trial using the mouse and one trial using the pedal. This design enabled us to directly compare the performance of each participant across the two methods. To account for potential order effects, we used a Latin square design, ensuring that each combination of input method and question order was represented equally across the participants.

Throughout the evaluation, participants followed a set of procedures. They were provided with a practice session using either the mouse or the pedal to familiarize themselves with the respective input method. Then, they completed the scrolling task using the mouse and the pedal in separate trials. Finally, participants were given an opportunity to provide feedback on their experience with each method.

The evaluation aimed to determine the impact of the Tiltable Pedal on multitask scrolling performance compared to the conventional mouse, considering variables such as task completion time and accuracy.

Figure 5. A participant using the Tiltable Pedal.

Results

A total of 4 participants, consisting of 3 females and 1 male, were recruited for the experiment. The accuracy of both methods among all participants was 100%. Given the simplicity of the task, it is reasonable to observe such high accuracy.

In terms of time usage, the average time taken for the mouse method was 143 seconds, whereas for the pedal method, it was 182 seconds. The mean difference between the two methods was -39 seconds. A two-tailed T-test was conducted, resulting in a p-value of 0.0135. These results indicate a significant difference between the two methods, with the mouse method performing better in terms of time efficiency.

	Time Used(sec)		**Accuracy**	
Participants	*Mouse*	*Pedal*	*Mouse*	*Pedal*
1	140	192	100%	100%
2	137	162	100%	100%
3	151	204	100%	100%
4	143	171	100%	100%

Table 1. The time taken for the mouse method was longer than for the pedal method for every participant and the accuracy of both methods among all participants was 100%.

User Feedback

During the user feedback phase, we received several positive comments regarding the foot-controlled device. Users expressed statements such as “Scrolling with the feet feels smoother than using hands,” “It’s actually quite convenient,” and “Once you get used to it, it becomes really useful.” These comments indicate a high level of user willingness to adopt and use the foot-controlled device.

There were also some negative feedback points raised by users. They mentioned that “The pedal feels a bit unstable, affecting the usability,” “My feet feel tired after using it for a while,” and “Sometimes it overshoots unintentionally.” However, it is important to note that these issues were attributed to design flaws in the mechanical structure rather than inherent problems with the concept of the foot-controlled device itself.

Therefore, although the test results deviated from our initial expectations, we acknowledge the need for improvement in the structural design. By addressing the design issues and conducting further testing, we anticipate obtaining results that are not influenced by such structural limitations.

CONTRIBUTION

technique for scrolling tasks. This innovative approach offers an alternative input method that enhances user experience and efficiency. Through successful implementation and user feedback, we demonstrate the feasibility and potential advantages of using the Tiltable Pedal, while also identifying areas for improvement in mechanical design.

CONCLUTION AND FUTURE WORK

In this paper, we have presented the concept of using the Tiltable Pedal as an assistive device to enhance multitasking efficiency in computer operations. Our research aimed to address the inconvenience of continuously switching tasks during multitasking scenarios, particularly during static computer operations. By leveraging the vertical rotation of the ankle joint, inspired by the design of the Electone musical instrument, we developed the Tiltable Pedal and conducted experiments to evaluate its feasibility and effectiveness.

Through our evaluation, we found that the use of the Tiltable Pedal didn’t improved multitask scrolling performance compared to conventional mouse usage. Participants achieved 100% accuracy in both tasks, but the mouse method demonstrated better time efficiency. However, user feedbacks during the evaluation highlighted the positive aspects of the foot-controlled device, such as smooth scrolling and convenience.

In future research, it is crucial to address design flaws in the mechanical structure of the tiltable Pedal to enhance usability. Issues such as instability, fatigue, and unintentional overshooting need to be resolved through improved stability, reduced unintended movements, and increased user comfort. Additionally, the switch functionality of the pedal should be further developed to cater to a wider range of applications and improve overall versatility.

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