Gamepad vs. Touchscreen: A Comparison of Action Selection Interfaces in Computer Games

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(a) Gamepad interface (b) Touchscreen interface

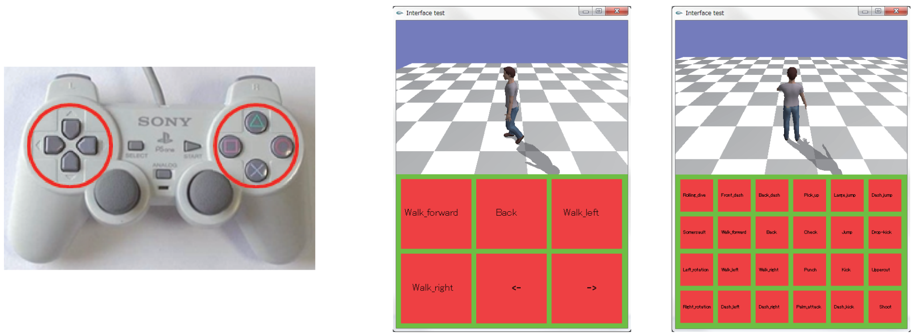

Figure 1: *User interfaces for the gamepad and touchscreen for action selection that are implemented in our experiment. (a) Gamepad interface. In addition to the 8 primary buttons, their combinations (pushing two buttons simultaneously or in sequence) are used to allow many types of actions. (b) Touchscreen interface. The virtual buttons are arranged in the bottom half area of the screen. The virtual buttons for page switching are also used to allow many types of actions. The tradeoff between the number and size of buttons is controlled (left and right).*

Abstract

In this paper, we compare gamepad and touchscreen interfaces for action selection tasks in computer games. Touchscreens are now widely used for computer games on tablets, smartphones and hand-held game consoles. However, in general, game players are considered to prefer a gamepad over a touchscreen. The motivation for this research is to compare gamepad and touchscreen interfaces. Our results show that the touchscreen interface achieved better than or similar results to the gamepad interface. We believe that our results can provide a guideline for choosing and designing interfaces for computer games.

CR Categories: I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction techniques;

Keywords: ser interface, touchscreen, gamepad, computer game, game design

1 Introduction

A gamepad has been the common input device for computer games for decades. Recently, as tablet computers and smartphones have become more common, touchscreens have also been widely used for computer games on such devices. In addition, recent hand-held game consoles such as the PS Vita, Nintendo DS and Wii U have both a gamepad and a touchscreen. The game developers have to choose which device they employ in their games. In general, it is believed that game players (especially core gamers) prefer a gamepad over a touchscreen, because gamepads are considered to be more accurate and responsive. The question is, how valid is this assumption? The motivation for this research is to compare a gamepad and a touchscreen as an input device for computer games.

In this research, we compared gamepad and touchscreen interfaces for action selection tasks which are very common operations in computer games. We implemented simple interfaces as shown in Figure 1. We also implemented a game-like interactive system for our experiment. We measured the performance of these interfaces. In addition, we tested several versions of each interface. For the gamepad interface, when combinations of multiple buttons are used, there is the option of pushing buttons simultaneously or in sequence. For the touchscreen interface, there is the option of using smaller buttons on one page or larger buttons on multiple pages.

In summary, our results show that the touchscreen interface achieved better or similar results to the gamepad interface.

Although we implemented standard gamepad and touchscreen interfaces, there are many variations to these interfaces. Moreover, the results may vary depending on the conditions and applications. However, since it is impossible to evaluate the interfaces under all possible conditions, we chose a standard condition on which we conducted our experiment. Even though the results may vary depending on specific interface designs and conditions, we believe that our results can provide guidelines for choosing and designing interfaces for computer games.

The rest of this paper is organized as follows. Section 2 reviews related work. Section 3 describes our experiment design. Section 4 presents the results of our experiment and Section 5 discusses them. Finally, Section 6 presents the conclusions to this study.

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2 Related Work

Touchscreens are widely used in many devices and applications. There is considerable research on enhancing the target selection task such as using the touchscreen to shift [Vogel and Baudisch 2007], rubbing and tapping [Olwal et al. 2008], or finger orientation [Wang et al. 2009]. These methods are designed to select a small target object among many nearby objects. Although we deal with only single touch in this research, multi-touch inputs [Moscovich and Hughes 2008] can be used to enhance user interactions. Other than using virtual buttons, various methods specifically for action selection using a touchscreen (touch/pen/mouse) have been proposed, such as stroke-based [Oshita 2005], gesture-based [Thorne et al. 2004] and sketch-based [Li et al. 2006] methods. Although these methods do not require the system to show virtual buttons on the screen, in general it takes more time to select an action and is not suited to action games. In this research, we chose to employ the most common approach which simply shows virtual buttons on part of the touchscreen, because many existing computer games employ a similar interface. Although a gesture-based interface is employed in some computer games on a touchscreen device, it has limitations in the number of actions it can enable because of recognition accuracy and difficulty in remembering all the gestures.

Various research studies have been conducted on the evaluation of touchscreen interfaces and devices. These researches [Vogel and Baudisch 2007] [Olwal et al. 2008] [Wang et al. 2009] include comparisons between the proposed and standard methods. Lee and Zhai [Seungyon Lee 2009] evaluated the performance of virtual buttons on small touchscreen devices compared with hard buttons. However, to our knowledge, there are no comparisons of gamepads and touchscreens focused on action selection tasks, even though this is a very important issue in designing computer games.

3 Experiment Eesign

In this section, we describe our experiment design for action selection tasks. We implemented simple gamepad and touchscreen interfaces, and a game-like interactive system in which the user can make a character perform various actions by selecting from a set of pre-defined actions using these interfaces. For our experiment, we defined 24 types of actions including walk, kick, punch and so on which are common actions in typical action games.

In the rest of this section, we describe the interface design for a gamepad and a touchscreen and then the experimental procedure.

3.1 Gamepad Interface Design

We used a standard gamepad device with 8 buttons as shown in Figure 1(a). Although there were additional side buttons and analog sticks on the gamepad, they were not used in this research. We used the 8 primary buttons which consisted of 4 buttons usually pushed by the left thumb and 4 buttons usually pushed by the right thumb. Eight actions are assigned to these buttons. To perform more than 8 actions, combinations of two buttons are used. We used combinations of two buttons being pushed simultaneously and in sequence. These types of combinations are commonly used in computer games. Our mapping between actions and buttons is shown in Appendix A.

3.2 Touchscreen Interface Design

For the touchscreen interface, we used virtual buttons where each button represented an action as shown in Figure 1(b). We divided the screen into the scene view and the interface area. The virtual buttons were arranged in a grid form on the interface area of the screen. The tradeoff between the number and size of the buttons could be controlled. To execute a large number of actions, requiring more than the number of buttons that can be displayed at the same time, the concept of a page was introduced. The actions could be assigned to multiple pages and the page being displayed on the screen was switched by pushing the specific virtual buttons (next and previous buttons). These types of virtual buttons and pages are commonly used in computer games. Although more sophisticated design may be used in actual computer games such as arranging buttons on the edges of the screen and using shift button or swipe for page switch, the function of the interface is basically the same.

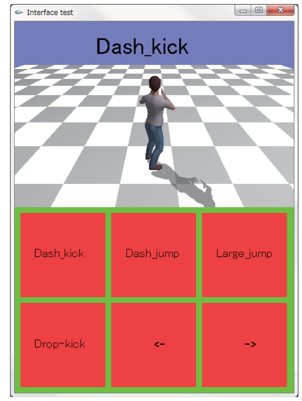

Figure 2: *Screenshot of the system for our experiment. The name of an action is displayed on the screen and the subject is expected to execute the action using a specified interface.*

In the tradeoff between the number and size of the buttons, we used two configurations. Through several tests, we chose to use 6 virtual buttons (3 columns and 2 rows) and 24 buttons (6 columns and 4 rows) as shown in Figure 1(b). In our environment, because we used a 12 inch touchscreen, the size of the buttons was either 3.5×3.4 cm (6 buttons) or 1.6×1.5 cm (64 buttons). We chose these sizes by referring to existing applications and through several tests. Our arrangement for the virtual buttons and pages is shown in Appendix A.

3.3 Experimental Procedure

We developed a game-like interactive system for evaluating the user interface as shown in Figure 2. During the experiment, the name of an action was displayed on the screen and the subject was expected to execute the action using a specified interface. The selection time from when the name of an action was displayed until the subject selected the action was measured. In the case when the subject selected wrong actions, the number of errors until the correct action was selected was also measured.

The subjects used in our experiments were 5 undergraduate and graduate students. They were all male and their ages were between 20 and 24. They all became familiar with using both gamepad and touchscreen devices.

We used a laptop PC that had a 12-inch touchscreen (Lenovo ThinkPad X61 Tablet). The touchscreen was a surface capacitive type which is in common use in newer devices. The resolution of the touchscreen was 1024×768. The PC was placed on a desk. (Although in general users sometimes hold the tablet, smartphone or handheld game console device while they play games, in our experiment, we placed the screen on the desk, to keep the same viewing

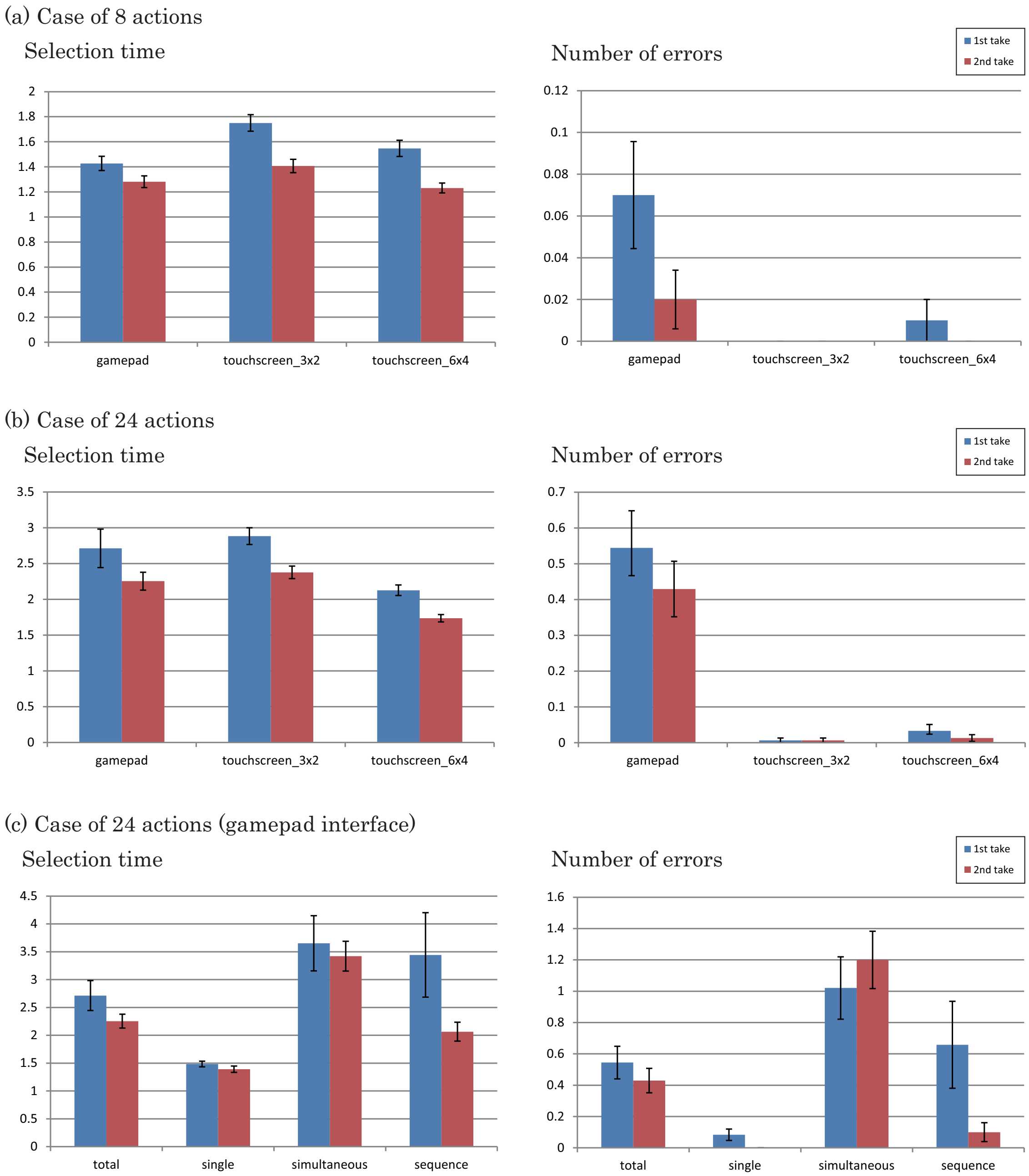

Figure 3: *Results of the experiment. (a) Case of 8 types of actions and (b) case of 24 types actions. (c) Further analysis of the results for the gamepad in the case of 24 actions.*

conditions as the gamepad interface.) The subjects were asked to operate the gamepad connected to the computer or the touchscreen of the computer. We evaluated the interfaces under several conditions, each interface over two steps to see the effects of practicing, and each interface with different numbers of actions (8 and 24) to see the effects of the number of actions.

The experimental procedure was as follows. We tested each interface in two steps. The first trial was after the subjects were instructed on how to use each interface and given a short time (5 minutes) to practice with it. The second trial was after the subjects had been given additional time to get used to each interface. The subjects were allowed to take time for practicing until they felt they were used to the interface. They spent about 7 to 10 minutes for the gamepad interface and about 5 minutes for the touchscreen interface.

Although players sometime spend hours or days getting used to an interface, in our experiment the subjects became used to them within a short time, because our game-like system and interfaces were very simple and required less time for practicing. On each trial, 50 action selections were performed by each subject for each interface. The first 20 actions were randomly chosen from a set of 8 actions and the next 30 actions were randomly chosen from a set of 24 actions.

Table 1: *Results of the experiment of each interface on the different numbers of actions on 1st and 2nd takes. The averages and standard deviations of the results are presented. The first, second and last groups of three rows are shown in Figure 3 (a), (b) and (c), respectively.*

Num. of actions	Interface	Selection time				Number of errors			
		1st take		2nd take		1st take		2nd take	
		Avg.	Dev.	Avg.	Dev.	Avg.	Dev.	Avg.	Dev.
8	Gamepad	1.42	0.057	1.28	0.046	0.07	0.026	0.02	0.014
8	Touchscreen 3×2	1.75	0.066	1.41	0.053	0.00	0.00	0.00	0.00
8	Touchscreen 6×4	1.54	0.065	1.23	0.039	0.01	0.01	0.00	0.00
24	Gamepad	2.71	0.268	2.25	0.125	0.54	0.104	0.08	0.078
24	Touchscreen 3×2	2.88	0.118	2.37	0.087	0.006	0.007	0.006	0.007
24	Touchscreen 6×4	2.12	0.074	1.73	0.051	0.03	0.017	0.01	0.009
24	Gamepad (single)	1.48	0.051	1.39	0.056	0.08	0.035	0.00	0.00
24	Gamepad (simultaneous)	3.65	0.493	3.42	0.267	1.02	0.198	1.20	0.182
24	Gamepad (sequence)	3.44	0.758	2.06	0.169	0.65	0.277	0.10	0.059

4 Results

The summary of results is shown in Figure 3 and Table 1. (Although the figure and table show the same results, we have presented both to provide specific values and intuitive comparisons.) The "touchscreen 3×2" presents a display of 6 relatively larger virtual buttons on the screen including two buttons for page switching (Figure 1(b) left), while the "touchscreen 6×4" presents a display of 24 relatively smaller virtual buttons on the screen (Figure 1(b) right).

In the case of 8 actions in Figure 3(a) the results of the gamepad (using a single button) and the touchscreen 6×4 (using a single page and smaller virtual buttons), were almost the same. However, the touchscreen 3×2 (using two pages and larger virtual buttons) took longer compared to the other interfaces. This is understandable considering this interface required additional time for a page switch.

In terms of the number of errors, because the touchscreen shows labels even when the subjects do not remember the mapping, there was a small number of errors, although there was also a small number of errors with the gamepad. The size of the buttons did not cause much difference in the conditions of our experiment. Although the selection times become shorter after practice, there was not much difference in the comparison of the interfaces.

We then evaluated the results in the case of 24 actions as shown in Figure 3(b). Comparing the results for the gamepad (using one or two buttons) and touchscreen 3×2 (using four pages and larger virtual buttons), the results were almost the same. However, the touchscreen 6×4 (using a single page and smaller virtual buttons) took a shorter time compared to the other two interfaces. This is understandable considering this interface did not require additional time for a page switch or pushing multiple buttons. In addition, the number of errors was small in the case of the touchscreen 6×4. The touchscreen 6×4 was better than the gamepad and touchscreen 3×2.

Finally, in the case of 24 actions, we further evaluated each method for the gamepad interface: pushing a single button, two buttons simultaneously and two buttons in sequence. Obviously, pushing a single button was the fastest. Comparing the two other methods, pushing two buttons in sequence achieved a better result than pushing two buttons simultaneously, especially in the second trial, even though it required two steps. We consider that this was because both thumbs had to be controlled when pushing two buttons simultaneously while only the right thumb was used when pushing two buttons in sequence in our mapping. The result improved on pushing two buttons in sequence because their mapping was not intuitive and it took some time for the subjects to master it, while the mapping for pushing two buttons simultaneously was straightforward.

5 Discussion

In summary, the touchscreen interface (touchscreen 6×4) achieved better results than the gamepad interface. Even the touchscreen interface with a small number of virtual buttons and page switching (touchscreen 3×2) achieved almost the same result as the gamepad interface. Considering these results, the overall touchscreen interfaces are relatively good compared to the gamepad interface despite the latter being the preferred option by game players in general. However, showing many buttons (such as the 24 buttons in the touchscreen 6×4 in our experiment) may not be practical for actual computer games. The number of buttons shown on the screen at the same time can be chosen based on the tradeoff between the required selection time and affordable area on the screen depending on the applications. Although the result may vary depending on conditions and applications, our results should encourage game developers to employ a touchscreen interface.

The results may also vary depending on the users. In our experiments, all the subjects became familiar with using both the gamepad and touchscreen devices. Conducting further experiments with a wide range of subjects is planned in future studies. We expect that if the subjects do not become familiar with both devices (such as older people), the touchscreen interface will achieve much better results than the gamepad interface, because it is considered that gamepads require practice.

In our experiments, subjects were asked to perform single actions at a time. After the subject selected one action, he was given enough time to prepare for the next action. However, in actual computer games, the players sometimes need to execute a series of actions quickly. In such cases, the results may also vary. Conducting further experiments covering such cases is also planned in future studies. We expected that the results for the comparison between the interfaces would not vary much from the results in our experiment, because the subjects' configurations before and after action selection were not significantly different.

We did not use a gesture-based interface for the touchscreen, because it required more time for task selection and was limited in the number of actions as discussed in Section 2. However, it has the advantage that players do not have to look at the buttons and can focus on watching the game screen as well as the gamepad interface. This feature can be important in some action games where players have to focus on the game screen and respond quickly. Conducting further experiments on such game systems is also for future study.

6 Conclusion

In this study, we compared gamepad and touchscreen interfaces for the action selection task. The results show that touchscreen interface achieved results that were better than or similar to the gamepad interface. Although further experiments are anticipated, we believe that our results can be a guideline for choosing and designing interfaces for computer games, especially when developers have to choose a device on a handheld game console such as PS Vita, Nintendo DS and Wii U, which has both a gamepad and a touchscreen.

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A Details of Interface Design

The details for the mapping between actions and buttons for the gamepad and touchscreen interfaces in our experiment are shown here.

Table 2 shows the list of actions and the mapping between actions and buttons in the gamepad interface. There are 8 buttons used (Up, Down, Left, Right, $\bigcirc$, $\times$, $\square$ and $\triangle$). First, 8 actions (group 1) were assigned to a single button. Second, 8 actions (group 2) were assigned to a combination of two buttons being pushed simultaneously. Third, 8 actions (group 3) were assigned to a combination of two buttons being pushed in sequence. To realize intuitive mapping, we assign special moving actions (running and rolling) to two buttons being pushed simultaneously, combinations of a button for specifying the direction of moving (left side button) and a button for specifying the action (right side button). We assigned special combat actions to two buttons being pushed in sequence, combinations of two buttons for specifying two corresponding actions (right side buttons).

Table 2: *The mapping between actions and buttons on the gamepad interface.*

Action	Button(s)
Walk forward	Up
Walk backward	Down
Walk left	Left
Walk right	Right
Kick	$\bigcirc$
Jump	$\times$
Punch	$\square$
Check	$\triangle$
Run forward	Up $+\bigcirc$
Run backward	Down $+\bigcirc$
Run left	Left $+\bigcirc$
Run right	Right $+\bigcirc$
Roll forward	Up $+ \times$
Roll backward	Down $+ \times$
Roll left	Left $+ \times$
Roll right	Right $+ \times$
Dash and kick	$\bigcirc \rightarrow \bigcirc$
Dash and Jump	$\bigcirc \rightarrow \times$
Strong kick	$\times \rightarrow \times$
Drop kick	$\times \rightarrow \bigcirc$
Uppercut	$\square \rightarrow \times$
Strong punch	$\square \rightarrow \square$
Shoot	$\triangle \rightarrow \square$
Pick up	$\triangle \rightarrow \bigcirc$

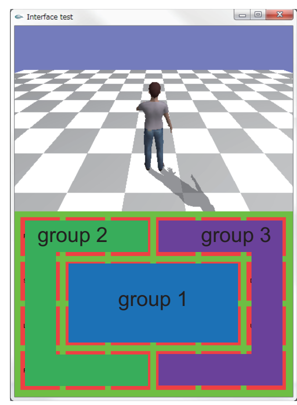

Figure 4: *Arrangement of virtual buttons on the touchscreen interface (64 buttons).*

The virtual button arrangement for the touchscreen interface is shown in Figure 1 (b). For the touchscreen 3×2, we divided the action lists (Table 2) into 6 groups (pages) based on the orders in the table. There was 1 group for walking, 1 group for standard actions, 2 groups for special moving actions, and 2 groups for special combat actions. For the touchscreen 6×4, we divided the button arrangement into 3 regions as shown in Figure 4. The walking and standard actions (group 1) were placed in the center. The special moving actions (group 2) were placed in the left side and corners. The special combat actions (group 3) were placed in the right side and corners.