Performance of Tilt and Touch in Mobile Games

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Abstract

We present an experiment comparing the relative performance tradeoffs of tilt and touch control in mobile games. We specifically target games that use two (virtual) analog sticks for control, one to move a player and one to aim and shoot. We include conditions that use tilt control in lieu of one virtual joystick or the other. Results of the study indicate that tilt control can successfully be used to supplement touch-based controls.

Keywords: Tilt control, touch control, mobile games.

Index Terms: H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces; K.8.0 [Personal Computing]: Games.

1 Introduction

As mobile technology matures, so too does mobile game complexity. It is now common to see both new and ported games requiring dual-analog control on mobile devices. However, in the absence of physical gamepads, mobile games instead employ virtual (or soft) controls. For example, many games of this nature employ touchscreen-based simulated analog sticks. These virtual controls have several limitations compared to physical controls including the absence of tactile feedback (i.e., users cannot *feel* the position of the joystick) and occlusion (i.e., users covering parts of the screen with their fingers/thumbs).

We argue that tilt control can be employed as an adjunct to touch control in such games. Tilt control entirely avoids the occlusion issue associated with touch controls. And, while tilt control does not offer tactile feedback, its absence is compensated for via proprioception[4].

We present a study investigating the performance tradeoffs between touch and tilt control in a mobile top-down shooter game. The standard control method employs two virtual joysticks, one to move the player, and one to rotate them (and simultaneously shoot in that direction). The player can also move independent of their shooting direction. Three tilt-based conditions are also studied: one using tilt for movement (and a virtual joystick to aim), one using tilt for aim (and a virtual joystick to move), and one relying exclusively on tilt control for both aiming and movement.

2 Related Work

Results of studies comparing tilt and touch control for games are mixed. Browne and Anand [2] compared virtual control touch input to tilt input. Participants played the game significantly more effectively with tilt input. In contrast, Medryk and MacKenzie [3] report that touch control offered better performance than tilt. While these results may appear to contradict each other, there are differences in the control implementations that may explain this inconsistency. For example, Browne and Anand's game employed virtual/soft controls (like our study) while Medryk and MacKenzie's study used a direct mapping of touched position to paddle position in a Pong-like game. More recently, Teather and MacKenzie [6] found that differences in tilt vs. touch control are largely dependent on the order of control used. Position-control mappings offered superior performance to velocity-control mappings for both tilt and touch input methods. There was otherwise no significant difference between tilt and touch control.

In all of these studies, relatively simple games (e.g., simple space shooters, Pong-like games, etc.) have been used to evaluate touch or tilt as primary controls. More recent work by Alankuş [1] studied considerably more complex first-person shooter controls and found that tilt can be successfully employed as an *adjunct* to physical primary controls (e.g., using a joystick to aim). Using tilt to adjust the gain level for aiming offered better performance than a purely tilt-based control scheme; however, it did not outperform a purely joystick-based control scheme. Because touch based controls have been shown to offer inferior performance to physical game controls [5, 7] our work is an attempt to determine if tilt can supplement touch controls to offer a superior level of performance than either control scheme individually.

3 Methodology

We conducted an experiment to evaluate four control methods using combinations of touch and tilt control for a mobile game. Eight participants (7 male, 6 right-handed) took part in the study. Their ages ranged from 19 to 34 (mean age 23, *SD* 5.1 years).

We used a custom game derived from the Unity Technologies Inc. AngryBots sample project/tutorial[1]. The game uses a top-down view and involves running through an environment while avoiding and/or shooting enemy robots. See Figure 1.

Figure 1. The game used in the experiment. The player (centered) must navigate the maze while destroying enemy robots.

We modified the game to automate data collection, and to implement three new control options employing tilt control (in addition to the existing dual-joystick option provided). These conditions are described below. We made the level plainly navigable with a mini-map and moving directional arrows to guide the user along a non-branching path. The mini-map is visible at the top-right of Figure 1.

Participants were instructed to complete the game as quickly as possible while destroying as many enemy robots as possible. They

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1 http://unity3d.com/showcase/live-demos#angrybots

were also instructed to keep their accuracy high (e.g., by only shooting when necessary). A trial ended upon reaching and destroying a large boss robot that appeared at the end of the level. Participants completed four trials with each control method.

The experimented used a 4x4 within-subjects design. The independent variables were:

- *control method*: touch+touch, touch+tilt, tilt+touch, tilt only
- *trial*: 1, 2, 3, 4

In touch+touch, player movement and orientation were controlled by virtual joysticks. In touch+tilt, movement was controlled by a virtual joystick, while aiming (orientation) was controlled using an absolute mapping of tilt control (i.e., tilting to the right would aim the player right). Tilt+touch mirrored this: tilt controlled the player's movement, while a virtual joystick controlled their aim. Tilt only employed device tilt exclusively: tilting both moved and oriented the player in the same direction. In all cases, the "right" virtual joystick acted as a fire button.

The dependent variables were level completion time (in seconds), accuracy (%), and environment collisions (number of times the player bumped into an obstacle).

4 Results

Level completion time was the average time to complete the level, in seconds. There were significant main effects for both control method ($F_{3,7} = 10.99$, $p < 0.001$) and trial ($F_{3,7} = 10.27$, $p < 0.001$) on level completion time. The interaction effect was not significant though ($F_{9,63} = 1.85$, $p = 0.076$). Tukey-Kramer multiple comparisons revealed that the Tilt+Touch and Touch+Touch control methods offered significantly faster level completion time than the other two control methods ($p < .05$). Average level completion time scores are shown in Figure 2.

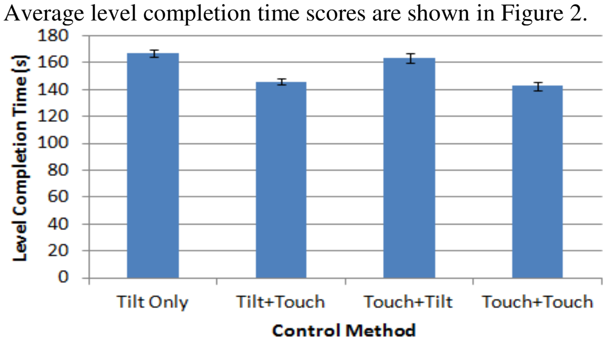

Figure 2. Average level completion time by control method. Error bars show ±1*SE*.

Accuracy was the ratio of player shots that hit enemies. It was calculated as hits divided by shots fired, and is expressed as a percentage. Surprisingly, accuracy was not significantly different between any of the control methods ($F_{3,7} = 1.46$, $p = 0.25$). Trial was also not significant ($F_{3,7} = 0.97$, ns). See Figure 3.

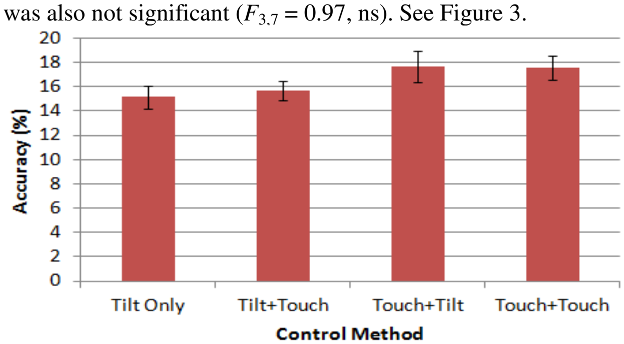

Figure 3. Average shooting accuracy by control method. Error bars show ±1*SE*.

The software also recorded how frequently participants bumped into walls and other obstacles present in the game. A higher number of environment collisions was thought to reflect difficulty in using a particular control method. There were significant main effects for both control method ($F3,7 = 5.71$, $p < .01$) and trial $F3,7 = 4.56$, $p < .05$). Interestingly, the interaction effect between control method and trial was significant ($F_{9,63} = 2.22$, $p < 0.5$). Average environment collisions by trial number and control method are shown in Figure 4.

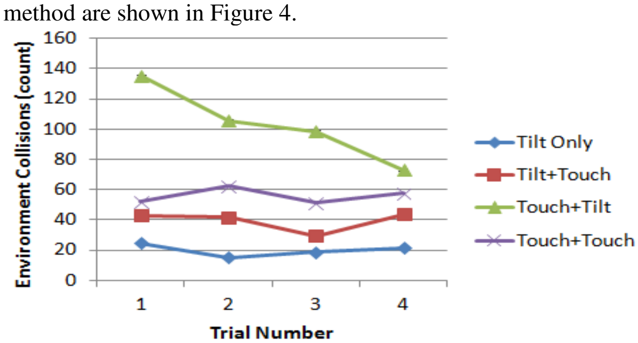

Figure 4. Average environment collisions for each control method by trial.

5 Discussion and Conclusions

While touch+touch was the most familiar control method, it did not necessarily offer the best performance. For example, the level completion time offered by tilt+touch was comparable (and not significantly slower). Similarly, using tilt to aim offered comparable accuracy to using a virtual joystick, although no condition was significantly different. Figure 3 suggests clear groups of the conditions in terms of accuracy. With additional participants, this difference may be revealed to be significant. Finally, control precision (in terms of environment collisions) was surprisingly best with tilt control. In fact, touch+touch was roughly in the middle. The interaction effect for this metric reveals that participants improved fastest with touch+tilt. Consequently, we argue that there is merit to the idea of employing tilt control to supplement touch-based controls, and plan to investigate this further.

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