Enhancing Touch-Driven Navigation Using Informed Search in Ms. Pac-Man

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***Abstract*—This short paper highlights an investigation into the application of A* search to facilitate forms of input for games on touchscreen mobile devices. We focus this work specifically on navigation games such as Ms Pac-Man. This project proposes two alternative methods for touch-control that utilise A* pathfinding for navigation purposes - a touch to destination and a 'sweep' input. We then assess whether these methods lead to improved performance and user experience through human participation.**

I. Introduction

Games on touchscreen devices such as smartphones and tablets have became increasingly common, with titles such as *Angry Birds* (Rovio Entertainment, 2009) that caters not only to the audience these devices are open to, but puts the technology to full effect. However, there are issues with using touchscreens for input; the user experience of a game with virtual (on-screen) buttons can be impeded by fingers obscuring the screen and the lack of tactility in control when compared to traditional methods.

Despite these issues, there is little research into touchscreen input for games. We feel that utilising AI methods to improve accessibility could improve user experience. In this short paper, we investigate pathfinding methods in a touchscreen implementation of *Ms Pac-Man* (Midway, 1981). We implementing a series of control methods for touchscreen devices, where two methods reduce the workload on the user by adopting A* pathfinding. These approaches were tested by human participants to determine if these methods improve player performance and user experience.

II. Background and Literature Review

Touchscreen mobile devices are now prevalent and commonplace, with games on iOS devices the largest category on the app store, accounting for 17% of all apps [1]. Surveys in in [2] show 50% of participants play games on touchscreens, with market research indicating growth in games played on mobile devices increasing: from 52% to 61% in 2011-2012 [3].

This transition has resulted in use of 'simulated button' control schemes. Yet there is little research in their effectiveness in comparison to traditional approaches. One notable example found in [4] compared iOS and Nintendo DS versions of *Assassins Creed: Altair's Chronicles* (Gameloft, 2008), with the Nintendo DS version allowed for significantly better player performance, with level completion 42% faster, the number of deaths per level lowered and a shallower difficulty curve. Other mobile games research has focussed on screen-occlusion; times in which user's fingers cover vital parts of thescreen [5]. In certain games, the user may cover areas of game maps they need to access inadvertently. To avoid this issue, [6] explored use of touchpads on the back of different sized devices. No major differences in scores on games played were observed between touchscreen controls and the rear-mounted approach.

III. Implementation

To determine if touchscreen-based navigation games could be enhanced with the use of informed searches to improve a players performance and user experience, we isolated different kinds of input that could be used in a navigation game. While some of these adhere to traditional approaches, we introduced two alternatives that employ A* search to reduce the need to select every individual movement and encouarge more strategic gameplay.

To test our hypothesis that these methods would improve player scores and user-experience, we chose to use Ms Pac-Man, given it requires navigating around a set maze to collect items whilst avoiding enemy characters; a problem that necessitates effective and precise control of the avatar. We leveraged the existing Ms Pac-Man vs Ghosts League software framework detailed in [7]. The framework implements functionality from the classic Ms Pac-Man game in Java; the native language of the Android platform. We subsequently modified the framework so it ran as Android application. This introduced not only the changes to the control scheme, but also introduced data collection faculties by assessing the performance of the user.

The Ms Pac-Man version released on iOS has three methods of input: on-screen arrow keys, gestures on the screen and one of a tilt-driven method using the device accelerometer (Namco Bandai Games, 2012). As this work focussed only on touch interaction, our testing assessed the first two input methods as traditional non-informed search assisted methods in addition to three further alternatives. First we had yielding simulated arrow keys, a traditional control scheme where pressing Up, Down, Left or Right moves Ms Pac-Man on the current time-step. In addition we had a variant with persistent ('sticky') keys, where execution of the selected action occurs the next time it is feasible, providing the ability to select a direction prior to reaching the junction. The third method was

978-1-4673-5311-3/13/$31.00 ©2013 IEEE

inspired by the iOS release of Ms Pac-Man, where the user must swipe the screen in the direction they wish to go.

Our first A*-driven method *'Tap-Plan'*, shown in Figure 1, creates paths using A* based upon a destination tapped within the maze. This path is highlighted so the user understands where Ms Pac-Man will subsequently move. In addition, we had *'Swipe-Plan'*, where we pay attention to where the finger moves after the screen is initially touched. This scheme polls the maze every 500 milliseconds to create a series of checkpoints and visits them in-turn using A* for navigation.

Fig. 1. A screenshot of Ms Pac-Man running on a *Google Nexus 7*. While using the 'Tap-Plan' control scheme, the game displays the constructed path to the touched location to aid the users understanding.

IV. Human Testing & Results

These control schemes were assessed by introducing the new version of the game to 30 human participants. Each participant was asked to play the five control schemes for one minute each, with the option to play their favourite after a post-study survey. All participants considered themselves to have average or greater skill in video games and were familiar with a version of Pac-man. Despite this familiarity with games, 50% played games on mobiles for less than an hour per week and less than 50% noted they enjoy mobile games.

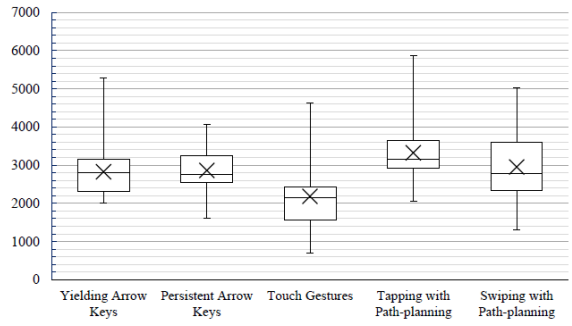

Fig. 2. A chart of scores accrued by participants using different control schemes.

We break down the scores accrued in Figure 2, where using of the A* approaches met or exceeded scores using the simulated arrow keys. Furthermore, data in Table I suggests that players performed better using A*-driven methods despite a very brief time in control: higher scores were accrued and more ghosts on average were consumed. However, this increase in score is only by a small margin. Furthermore, while the percentage of successful taps - where the device could understand the users tap - was increased by a small margin, the numbers of deaths increased on average but no as sharply as using the existing gesture-driven method.

TABLE I. Sumary of performance across control schemes.

	Yielding	'Sticky'	Gestures	Tap-Plan	Swipe-Plan
Mean Pills	207	214	165 ±40	213.6	211
Pills Std. Dev.	±31.3	±39	±40	±24.6	±43.8
% Successful Taps	96.75%	95.95%	82.68%	96.26%	98.34%
Mean Ghosts Eaten	1.87	1.97	1.3	3	2.2
Mean Deaths	3.83	3.67	5.1	4.07	4.13

In addition to the aforementioned metrics, we also asked for qualitative feedback from our users. The feedback on A*-driven methods in contrast to simulated buttons was majoritively positive, which users described them as "intuitive", "[having] a fun tactical element" and "[more] reliable". Interestingly, multiple users suggested they "changed the emphasis to be more about the strategy rather than [...] reflexes." Interestingly, while 50% of users stated the simple gesture method as their least favourite method of control, 60% of users voted either Tap-Plan (37%) or Swipe-Plan (23%) as their favourite, with the next most popular being the 'sticky' keys at 20%.

V. Conclusion

We have highlighted an investigation into whether control for navigation games on touchscreen devices can be improved through the use of informed search. Data accrued from human participation suggests that this approach carries merit: while player performance gains were marginal, user experience was largely positive. It is our intent to explore the applicability of this approach further to facilitate accessibilty for touch games and further consult users on how to improve these methods.

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