Surveying the Accessibility of Mobile Touchscreen Games for Persons with Motor Impairments: A Preliminary Analysis

Yoojin Kim[1], Nita Sutreja[2], Jon Froehlich[2], Leah Findlater[1]

[1]Inclusive Design Lab | HCIL
College of Information Studies
University of Maryland, College Park
{ykim0710, leahkf}@umd.edu

[2]Makeability Lab | HCIL
Department of Computer Science
University of Maryland, College Park
jonf@cs.umd.edu

ABSTRACT
Touchscreen devices have rapidly become one of the most pervasive video game platforms in the world and, in turn, an integral part of popular culture; however, little work exists on comprehensively examining their accessibility. In this poster paper, we present initial findings from a survey and qualitative analysis of popular iPad touchscreen games with a specific focus on exploring factors relevant to persons with motor impairments. This paper contributes a novel qualitative codebook with which to examine the accessibility of touchscreen games for users with motor impairments and the results from applying this codebook to 72 iPad games.

Categories and Subject Descriptors
K.4.2 [**Computer and Society**]: Social Issues-Assistive technologies for persons with disabilities

Keywords
Accessible gaming, touchscreen accessibility, survey

1. INTRODUCTION
Since the iPhone's release in June 2007, the video game industry has undergone a dramatic transformation. Analysts estimate that more games have been developed for the Apple iPhone and iPad than any other platform in history [6]. Games are also the most downloaded software category by a factor of four on the Apple App and Google Play stores [2]. Despite this popularity, few studies have explored the accessibility of touchscreen games. Indeed, recent survey papers on game accessibility only minimally cover touchscreen games at best [5, 8], and do not do so in the context of our focus: motor impairments.

To characterize the accessibility of mainstream touchscreen games, we present initial findings from a survey and qualitative analysis of 72 iPad games. Two independent researchers played, analyzed, and qualitatively coded each game using a novel touchscreen accessibility coding set that we developed. The codebook focuses on factors relevant to accessibility and motor impairments, such as target size, gesture type, genre, game speed, and penalty (how the game reacts to incorrect input). To validate the conclusions from the survey, we are also beginning user trials with participants with motor impairments (*e.g.,* Figure 1); as this aspect of our research is in progress, we do not report on it here.

This paper contributes: (1) a novel qualitative codebook with which to examine the accessibility of touchscreen games for persons with motor impairments, and (2) the results from applying this codebook to 72 iPad games.

2. SURVEY OF IPAD GAMES
Our survey has two aims: first, to understand what interactions are being used in iPad games and, second, to assess how these interactions may impact accessibility. To develop a codebook, we followed an iterative coding process prescribed by Hruschka *et al.* [3]. First, we created a preliminary version based on existing guidelines (*e.g.,* [5, 8]) and our own touchscreen accessibility work (*e.g.,* [1]). We then refined and expanded the codebook by analyzing a pilot set of 40 popular iOS games as listed on technology websites (*e.g.,* cnet.com).

Figure 1: A user with a spinal cord injury playing *Subway Surfer* (left) and *Flow* (right). According to our coding analysis, *Subway Surfers* is an *action* game that requires fast *short taps* and *swipes* with a *high* penalty for input mistakes. *Flow* should be more accessible: it is a *puzzle* game with *low* speed that relies on *steering* interactions and has only *minimal* penalties for erroneous input.

With this codebook, we began our more formal study. For this, we downloaded and analyzed a random selection of the top 100 free iPhone and 100 free iPad games in the Apple App store for the week of November 18, 2012. This set included 72 iPad games and 28 iPhone games (100 in total). For the coding process, two researchers independently analyzed both the main gameplay and the configuration screens (*e.g.,* start and setup menus) by playing each game until they reached at least the third level. The 100 games were divided into three blocks, and the two researchers met after coding each block to discuss codes and achieve consensus; in cases of disagreement, the entire research team of four helped derive the final code. Although we used a consensus-based approach, for completeness we computed Cohen's kappa agreements on the initial codes. Scores ranged from κ=0.18-1 (*avg*=0.50; *SD*=0.28). The highest areas of agreement were for *gestures*, *number of required hands*, and *game speed* while the lowest involved *target size*, *penalty*, and *direct manipulation*. Although there is no universally agreed upon scale for evaluating κ values, 0.50 is within the range of "reasonable" agreement by Landis and Koch [4].

2.1 Touchscreen Game Accessibility Codebook
The final codebook, with examples from our study dataset:

Surface Gestures: We coded eight touchscreen surface gestures including *short taps, long taps, swipe, drag, steer, two-finger pinch, free-form drawing,* and *two-finger rotate.*

Device Motion Gestures (tilt and/or shake): Some games require the user to move or re-orient the device itself (*e.g., Super Falling Fred* requires *tilt* to play).

Genre: Game interaction forms are often strongly related to game genre [7]. We identified 15 game genres in our dataset, which we derived from App Store categories as well as previous work [7]: *action, adventure, board, casino, kids activity, maze, platform,*

puzzle, *quiz*, *racing*, *running (e.g., Temple Run)*, *role playing*, *simulation*, *strategy*, or *word.* In our coding scheme, a game can belong to only one code genre.

Game Speed (none, minimal, or high): We coded the physical movement speed required for gameplay. Some action games, for example, require *high* speed to avoid obstacles or enemies (*e.g., Zombiewood* and *MetalStorm*). Other games simply provide bonus points for fast completion (coded as *minimal; e.g., Bingo Blingo* and *Bejeweled Blitz*). Still others have no time-related consequences (coded as *none; e.g., Flow* and *Sudoku*).

Penalty (none, minimal, or high): Games with *high* penalty end the game or result in significant point loss if the user makes an input error such as an accidental touch (*e.g., Subway Surfers* and *Temple Run*). *Minimal* penalty games incur some penalty, but not to a substantial degree (*e.g., Angry Birds*). Finally, *none* applies if no detrimental effects occur from erroneous input (*e.g., The Sims*).

Target Size (tiny, medium, and/or large): A *tiny* target is one where a finger occludes the target on hover/press, a *medium* target is about the size of an application icon on the iPad (~14x14mm), and a *big* target is large enough to fit at least three fingers at once.

Number of Hands (one or two): Some games require *two* hands for motion gestures or for simultaneous input at different points on the screen (*e.g., Extreme Road Trip 2* and *Punch Quest*) Other games require only *one* hand (*e.g., Bubble Mania*).

Multi-touch (yes or no): *Yes* applies to games that require multi-touch input using two or more fingers from a single hand or from both hands (*e.g., The Sims* requires two fingers to perform *pinch* and *rotate* gestures); otherwise, *no*.

Direct Manipulation (yes, no, or both): *Yes* applies to games where users control game objects by directly touching them (*e.g., Angry Birds*). In contrast, some games use indirect control (coded as *no*), such as using software joysticks (*Extreme Road Trip 2*). Some games use a mixture of the two, coded as *both*.

User Customization (yes or no): A game is coded *yes* if some interaction and/or gameplay attributes can be customized (*e.g.,* difficulty level, speed, input mappings); otherwise, *no*.

2.2 Coding Results

Due to space constraints, we focus only on the iPad games, since iPads offer a larger interactive surface than iPhones and are more popular among people with motor impairments [1]. As well, we focus on gameplay interaction rather than configuration elements.

Gestures & multi-touch: The top five surface gestures were: *short tap* (89%), *drag* (61%), *swipe* (40%), *two-finger pinch* (21%), and *long tap* (14%). For device motion gestures, six games (8%) used *tilt* and one used *shake* (*Atari Outlaw*). Of the 72 games, 14 relied on a single gesture type for all gameplay interaction. Nine of the 14 used only *short taps* and one game each used *tilt, swipe, steer, long tap,* and *drag*. Seventeen games (24%) required multitouch.

Genres: The top five genres included: *simulation* (17%), *puzzle* (15%), *action* (13%), *strategy* (10%), and *adventure* (8%). More interesting, however, is the relationship between genre and other game attributes that may affect accessibility. For example, unsurprisingly, 7 of the 9 *action* games were coded as *high* speed and all 9 had at least *minimal* interaction speed requirements, which may make them more challenging for users with motor impairments. In contrast, *puzzle* and *simulation* games should be more accessible, with only 1 of 11 *puzzle* games and 1 of 13 *simulation* games were coded as *high* speed; 71% were coded as having *no* speed requirement. Similarly, we found a strong relationship between genre and number of hands: all but one *action*, one *platform*, two *racing*, and two *simulation* games required two-handed interaction. None of the other 10 game genres in our dataset required two-hands.

Speed: Overall, most games were coded as having *no* speed requirements (47%) followed by *high* (29%) and *minimal* (24%). Just as genre is related to game speed, so too is game penalty. All *high* speed games had at least a *minimal* penalty for making an input mistake. On the other hand, none of the *no* speed games had a *high* penalty. *High* speed games were also much more likely to require *two-handed* operation (57%).

Summary of Other Codes: Nearly a quarter (24%) of iPad games in our dataset required two-handed input. For target sizes, 19% of games used *tiny* targets—one of which, *Word Search Unlimited*, used only tiny targets and no medium or large targets. Just over 15% of games incorporated more accessible *large* targets. Most (88%) used medium targets either alone or in combination. In terms of customizing gameplay and/or user input, 24% of games surveyed allowed for this. Some of these customizations have implications for motor input accessibility—*e.g.*, in Pac-Man, the game controls can be set to *swipe*, *joystick*, or *accelerometer*—though most were not directly related to motor impairments (*e.g.*, adding subtitles or high-contrast modes).

3. DISCUSSION AND FUTURE WORK

Through our codebook development and survey, we have revealed a number of suspected accessibility challenges with touchscreen games for people with motor impairments. Few games specifically support user customization for accessibility, 24% require two-handed input (especially action games), 50% required complex surface gestures such as *swiping* or *two-finger pinch*, and 10% used motion gestures—all of which have important implications for motor-impaired accessibility. At the same time, however, our coding allows us to identify games that are more likely to be accessible. For example, *Free Flow* requires only one-handed input, requires no speed, and incurs minimal penalty from incorrect input. In ongoing work, we are validating the codebook and predictions about the accessibility of different games through in-person user studies. Finally, although establishing the right dynamic between gameplay and input is challenging in game design, allowing for user customization (like in *Pac-Man*) for input controls would increase accessibility.

4. REFERENCES

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