A Novel User Interface Approach For Managing Large Character Set on Small Mobile Screen

Raj Kishen Moloo
Computer Science and Engineering Dept
University of Mauritius
Reduit, Mauritius
r.moloo@uom.ac.mu

Pascal Grosset
Computer Science and Engineering Dept
University of Mauritius
Reduit, Mauritius
p.grosset@uom.ac.mu

Abstract- The constrained nature of Mobile devices imposes great challenges on effective user interfaces for game playability. This paper addresses the issue controlling large set of characters on small screens with constrained mobile keys. To this effect we implemented the a mobile version of the Mauritian Domino (MomoDomino) game consisting of 27 dominoes to test our novel interface design for the control of large character on small screens using the same mobile keys. We investigated on various display layout and their corresponding algorithm and complexity before choosing an optimal layout. In addition, we investigated on an intuitive and seamless game play interface, the novelty being the ability to select and play dominoes using the same key-inputs. Game design methodologies and game mechanics were included for enhanced user-immersion in the game. The results of our design proved to be very intuitive and hence conclusive in terms of game playability. Besides an optimized display strategy of game components was achieved, hence maximizing space usage on small screens. Our game was tested with excellent feedback by university students. The results obtained can therefore provide a useful guidance for future interface design on small display devices.

Keywords: Mobile User Interface, Mobile Game

1. INTRODUCTION
With increased sophistication, processing capabilities and memory capacity, a shift in mobile usage has been noted. From mere phone calls and SMS, nowadays mobiles have become an ideal platform for game development. The challenge in implementing successful game is the ability to reconcile small mobile screens and mobile key inputs with intuitive and seamless game playability. As proposed by [9][10], the challenging problems faced by mobile interface designers include the ability to display a lot of information at the same time on a small screen and a mobile key has generally more than one control function. Over the years lots of literatures has mushroomed in designing and implementing successful mobile games. These are discussed in more details in the literature review section. Our aim was to meet the challenge of displaying several characters on a small display screen with the ability to manage them using the same mobile keys in an optimized way, without compromising the game playability aspect. To this effect we implemented MomoDomino, a domino game. MomoDomino is an adaptation of the Mauritian domino game on mobile phones that can be played in a single-player or multiplayer mode. Quite a few domino games exist in electronic form but they are rarely played like we play domino in Mauritius, i.e., matching the ends of the domino on the board with those in the players hand and counting the score of the loser after each turn until reaching the score of 101. Moreover, besides the rules being not the same, mobile dominos on the market are meant for higher end mobiles like PDAs and smart phones with touch interface.

This paper addresses the issue controlling large set of characters on small screens with constrained mobile keys. To this effect we implemented the a mobile version of the Mauritian Domino (MomoDomino) game consisting of 27 dominoes to test our novel interface design for the control of large character on small screens and same mobile keys. We investigated on various display layout and their corresponding algorithm and complexity before choosing an optimal layout. In addition, we investigated on an intuitive and seamless game play interface, the novelty being the ability to select and play dominoes using the same key-inputs. Game design methodologies and game mechanics were included for enhanced user-immersion in the game. The results of our design proved to be very intuitive and hence conclusive in terms of game playability. Besides an optimized display strategy of game components was achieved, hence maximizing space usage on small screens. Our game was tested with excellent feedback. The results obtained can therefore provide a useful guidance for future interface design on small display devices.

The rest of this paper is organised as follows. Section 2 provides an overview of some related works. Section 3 provides the game mechanics of the game. Section 4 and 5 shows our game interface design, while section 6 describes our implementation. And finally section 7 and 8 discusses the extent to which our novel design was a success.
2. Literature Review

This section provides an overview of some works done on game design and playability. [1] describes and evaluates the experiences gathered while using a scenario-based player study to inform pervasive mobile game design. Key findings were summarized into design requirements that were then adopted as goals for the game design. The game scenarios were created on the basis of several game concepts that were brainstormed collaboratively by the research team and the research partners. Scenarios were realized in a comic strip format that was considered illustrative and quite easily comprehended by the informants.

[2] illustrates how accelerometers provide the possibility of a no-button mobile game. It explored a tilt interface for a 3-D graphics first-person driving game titled Tunnel Run, and compared the user experience playing the same game with a traditional phone joystick interface. The results show that the tilt interface was experienced as fun, and certainly seemed more attractive to players, who said they would not have played this type of game otherwise.

[3] investigated on an input data from slide on-off and microphone interface for mobile gaming. It describes the design and development of their approach and compare it with a tradition mobile keypad interface. The slide on-off interface to control the user’s various movements and the microphone interface proved to be highly immersive of the specific game. The research recommends the selection and design of these interfaces should consider the intended user experience for the game.

[4] uses Augmented Reality (AR) enable the creation of user interactions that expand traditional HCI from 2D to 3D spaces. It introduces a mobile AR cooking game based on the integration of adopted AR interaction. These embedded interactions are designed with considerations and spatial mappings to real cooking mechanisms in order to provide a unique gaming experience and increased engagement for a better overall AR interaction on the multimodal mobile device.

[5] explored the playability problems in mobile multiplayer games and expanded their playability heuristic model with a new module. Based on its findings from their literature review and their playability evaluation, it formulated 8 multi-player playability heuristics. The heuristics related to communication, collaboration, deviant behavior, amount of players, visibility of other players, and social interaction in groups and communities and network connection. Multi-player heuristics complement the playability heuristic model and increase usefulness of the model since it can be applied in evaluations of a broader range of mobile games.

[6] defines game mechanics, using concepts from object-oriented programming, as methods invoked by agents, designed for interaction with the game state. It provide a tool to discover, describe, and interrelate game mechanics in any given game. In addition, it defines mechanics also in relation to elements of the game system, game hardware and player experience, mapping mechanics to input procedures and player emotions.

[7] focuses on elusive topic of how one can ensure a title has the best gameplay possible. It discusses in detail key game design topics including game balancing, storytelling, non-linearity, player motivations, input/output, artificial intelligence, level design, and playtesting. It delves into the entire breadth of interactive games, covering computer, console, and arcade titles, and spanning a variety of gaming genres including strategy, adventure, simulation, action, role-playing, sports, and wargames.

3. Game Mechanics

Based on the recommendations in [1] our game was designed taking care of the following playability issues:

- Ensure that movement will not become too much of a burden to the players.
- Allow different modes of gameplay and support various player types.
- Design the interface so that it requires only a minimum amount of handling of the device and pressing of the buttons
- Integrate all the game elements as seamlessly as possible.
- Player control and security
  - Support the players’ control and feeling of control
  - Ensure players’ security and give them the possibility to stay anonymous to other players.

3.1 Playing the game

MomoDomino is played like the standard Mauritian domino game with the same rules applied. The twenty-seven dominoes is initially shuffled and each player is randomly assigned an equal number of dominoes while keeping three dominoes hidden (the “packet”). The game is played by matching the dominoes in a player’s hand to what is available on the board. The first player to get rid of all his dominoes wins and the points left in the hand of every opponent is counted and added to his score (which is initially zero). When the points of any player reach 101, that player loses the game. Initially, it will be a Single Player game against AI and as future work, the game will be enhanced into a multiplayer game.

32 Win / lose / draw

The aim of the game is to rid yourself of your domino. So at the end of a game we might have the following scenarios:

1. One player has rid himself of all his dominoes and therefore is the winner and the other lose. The points in the hand of the loser are counted and this is added to his score.
2. No player has got rid of all of his/her dominoes but no one can play. Points for each player are counted and the
player with the lowest points for this turn is the winner. If all players have the same number of points we have a draw.

4. INTERFACE DESIGN

With a vast panoply of mobile phones, the complexity of our interface design was to try to have an interface which could cater for the majority of them. According to[8], the vast majority of devices share just three screen widths; 128, 240 and 176 pixels, with many of the remaining values; 120, 130, 160, 208 and 220 pixels, not diverging too far from these three core values. Hence grouping of the mobile devices are as follows: tiny: 84, 96, 101, 128, 130, 132; small: 160, 176; medium: 208, 220, 240; large: 320, 360, 480+.

The challenging part of our interface was the following:

- Ability to display all the 24 dominoes being played on a reference screen size. (Default size 240 x 320 px) but with the ability to port it on smaller screens and larger one.
- Ability to show each player’s set of dominoes on the same screen and also the players score
- Ability of the player to select his domino and play seamlessly.
- Dominoes were to be an acceptable visible size
- Devise a placement algorithm to best-fit the screen size.

4.1 Domino size

Proper design of the dominoes is of vital importance since a maximum of 24 dominoes have to fit on a screen. Based on the screen size and the ability to discern the domino by users we found that the 14 x 29 pixels was an ideal best minimum size, with 70% of surveyed people (of a population of 25) finding it Ok while the rest finding it too small. Also 82% found that they could easily discern and distinguish among the dominoes. Figure 1 below is a representation of the domino design, each square in the figure representing a pixel.

4.2 An evaluation of Three(3) Domino layout on the Board

Proper design of the dominoes is of vital importance since a maximum of 24 dominoes have to fit on a screen. We investigated on the following three (3) layout settings for maximum space use.

Assumptions

For the purpose of this game the following assumptions were made:

1. Domino size is 29 px by 14px
2. For any domino placed on the board, there is a distance of 1 Pixel in-between.
3. Always start with a domino positioned at the middle of the screen.
4. Then on successive turns, players can either play to the RIGHT or to the LEFT of the first domino.
5. Each Domino keeps the direction it will be moving and they are as follows:
   - LEFT,RIGHT,UP,DOWN
6. When reaching the screen boundary,
   - if player was playing on the RIGHT, then move UPWARDS.
   - else if player was playing on the LEFT, then move DOWNWARDS
   - Successive domino base its direction on it previous domino.

4.2.1 LAYOUT A

Figure 3 is our optimal domino layout interface minimizing the mobile screen coverage to an optimum level. Its algorithm is as follows:

1. Start at the middle.
2. Play domino either to the LEFT or to the RIGHT - horizontal position, except Double Domino (played on vertical position)
3. When screen boundary( Left and Right) is reached,
   - if player was playing on the RIGHT, then move UPWARDS, i.e, the successive domino is played in the vertical position. The NEXT domino to be played will be in the LEFT direction. -RIGHT->UP->LEFT
1. The algorithm is as follows:

\[ f(x) = DR \times (W/dW+1) + DR-1 \]

where \( DR = (H/(dW+1))-1 + ((H/(dW+1)) \times (W/(dW+1))) \)

**Example:** for a Domino table size of 180x150 and domino Size 29x14

- We will have 150/30 = 5 domino rows, hence total dominos will be 4+5*(180/30) = 34 dominos
- Hence space efficiency will be 34/24 *100 = 142%.

2. LAYOUT B

Figure 4 - Layout B is a more generous version of Layout A with the same algorithm. Except that distance between 2 domino rows is 44 (29+14+1) pixels, i.e the size of 1.5 domino width + 1 pixel. Hence from the above the number of dominos that can be placed on the screen can be mathematically modeled as follows:

Number of Domino Rows(DR): ((H/(dW+1))-1 + ((H/(dW+1)) \times (W/(dW+1)))

\[ f(x) = DR \times (W/dW+1) + DR-1 \]

where \( DR = (H/(1.5dW+1))-1 + ((H/(1.5dW+1)) \times (W/(dW+1))) \)

**Example:** for a Domino table size of 180x150 and domino Size 29x14

- We will have 150/30 = 5 domino rows, hence total dominos will be 4+5*(180/30) = 34 dominos
- Hence space efficiency will be 34/24 *100 = 142%.

3. LAYOUT C

The Whirlpool layout (Figure 5) interface minimizing algorithm is as follows:

1. Start at the middle.
2. Play domino either to the LEFT or to the RIGHT -> horizontal position, except Double Domino (played on vertical position)
3. When screen boundary (Left, Right, Up and Down) is reached,
4. if player was playing on the RIGHT, successive dominos will be played in the UPWARD directionS, i.e, -RIGHT->UP
5. if player was playing on the LEFT, successive dominos will be played in the DOWNWARD directionS, i.e, -LEFT->DOWN
6. if player was playing in the UPWARD Direction, successive dominos will be played in the LEFT direction, i.e, -UP->LEFT
7. if player was playing in the DOWNWARD Direction, successive dominos will be played in the RIGHT direction, i.e, -DOWN->RIGHT

**NB:** Every time we reach the screen boundary, we switch row by a size of 1 domino width + 1 pixel. That is, there is a distance of 30 (29+1) pixel separating 2 domino rows. Hence from the above it can be inferred that given a Domino Table size with a given Width(W) and Height (H) and a domino having a width (dW) and height( dH), the number of dominos that can be placed on the screen can be mathematically modeled as follows:

Number of Domino rows (DR): \((H/(1.5dW+1))-1 + ((H/(1.5dW+1)) \times (W/(dW+1)))\)

\[ f(x) = \frac{W-dW+1}{dW+1} + \frac{H-2-n(dW+1)}{dW+1} \]

where \( n = \frac{1/2 H}{dW+1} \)

**Example:** for a Domino table size of 180x150 and domino Size 29x14

- We will have 180-30/30 + 180-60/30 + (150/2-30)/30 + (150/2-60)/30 + 180/30 = 2*(5+4+2+1) + 6 = 30 Dominos
- Hence space efficiency will be 30/24 *100 = 125%.

5. GAME PLAY INTERFACE DESIGN

5.1 Playability and Input Design

In this section, emphasis is placed on playability. This helps the player to play the game more easily. The game is to be designed to be as intuitive as possible with the following components to increase intuitiveness. The novelty in our approach was the ability to select and play dominos using the same key-inputs. E.g. Left Press and Right Press to navigate in one’s set of dominos but also to choose where to place the dominos on the board, either to the LEFT or to the RIGHT. And to minimize players mistake, i.e wrongly placing dominos (no matching dominos) on the board, we implemented a play module with the ability to check if the domino selected is good to play on the board, green indicator meaning ok and red indicators meaning not good and where it can be played on the board (left or right). Table 1 below describes the game components.

| Turn indicator | This orange bar indicates that it is the player’s turn to play |
A – This indicator tells the player that he can play the domino at the position indicated on the screen. If the indicator is red, means that he cannot play.
B – The score indicator for the player.
C – The domino chosen to be played, is shifted slightly upward. The score for the mobile dominoes fit the mobile screen. Testing on the default screen size, all dominoes could fit on the screen. For smaller screens our game provided a scrolling mechanism to be able to see the dominoes outside screen boundaries.
Domino size of 14x29px was found to be an acceptable discernible size by the testers.

6. IMPLEMENTATION
Implementation of the game was done on the J2ME SDK 3.0 platform with MIDP 2.0 and CLDC 1.1. Netbeans 6.9 was used as our Integrated Development Environment (IDE). The game was developed over 2 Months. The Game interface was devised on the Canvas feature provided in J2ME. In addition, for performance and efficiency reason, the dominoes as well were implemented using the Canvas class providing basic drawing interface such as rectangles and circles, instead of using images. Also the implementation was initially focused on the default screen size of 240 x 320 px on the DefaultCldcPhone emulator provided by Netbeans and later tested on other smaller and bigger screens.

7. EVALUATION AND DISCUSSION
Evaluation of the Game was based on the Heuristics of Game design proposed by [12,13] as follows and subsequently the 25 testers, namely university students, were asked to fill in a survey questionnaire. The results are as follows:

Table 2 shows commendable results concerning our devised domino game. It was also encouraging to note that the domino game was up to the expectation of the testers whereby the game provided the intuitiveness, immersiveness, and same game sensation as a normal domino game. In addition, our proposed layout algorithm allowed most of the game components to fit on the same default screen. The game mechanics and playability was also appreciated by the gamers whereby most of them seamlessly and effortlessly used the same mobile keys on different mode of play. This provided conclusive results on the novelty of our approach to game playability using the same mobile keys to control a large set of characters and to change mode of play seamlessly. Besides, it also confirmed the viability and flexibility of our layout algorithm with the ability to fit all the dominoes on the screen providing an overall visibility of the domino game status at any point in time.
8. CONCLUSION
The purpose of this research was to confirm our hypothesis that it was well possible to control a large set of game characters on a small mobile screen using the same mobile keys. To this effect, a domino game was implemented with 27 dominoes on screen at a time and tested on a 2 player game mode whereby each player could choose his domino in hand and play the domino using the same mobile input.

Scientifically we reached an optimum game character (domino) size visible by most of the gamers. We also came up with an optimal domino layout algorithm to fit a small screen with a 142% space efficiency gain, after investigating on several other layout systems. We also tested our novel interface for controlling a large set of characters, dominoes in our case, with the ability to select a domino, to select where to play the domino on board and to play the domino, with the same mobile input keys.

Our game interface was tested with 25 university students who provided excellent feedback in terms of game mechanics and playability with the ability to seamlessly change game mode using the same mobile keys. The game itself was very well appreciated by gamers, giving them the same immersiveness and feeling as the real domino game while providing a very intuitive mobile interface using the same mobile input.

The results obtained can therefore provide a useful guidance for future interface design on small display devices.

9. REFERENCES

... (continued with more references)