Interaction Design for Side-scrolling Game Genre on Mobile Devices

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***Abstract*—Most smartphones and tablets normally come with special features that are unavailable in personal computers such as touch screen and various sensors (accelerometer and gyroscope). Making use of these features in mobile device games introduces players to new challenging experience as well as improves their enjoyment. This research presents masterly designed interactions for side-scrolling games on mobile devices. After thoroughly reviewing of some relevant features and gameplays, researchers have developed an interaction model for side-scrolling game. In this model, utilizing accelerometer and touch screen to form an interaction framework that helps reduce time in the creation of the side-scrolling games. Developers can apply this framework to create or polish their games; hence, it could help providing the better players' gaming experience and enjoyment. The Udonthani Rajabhat University Running Game (UDRU Running Game) was developed by using this model and its interaction framework to validate this research work and also used as a development tutorial for other developers. The results show that applying this model to game design and development can improve players' satisfaction and enjoyment of the players. The feedback from game developers is also contentedly positive.**

***Index Terms*— Interaction Design; Interaction Framework; Mobile Devices; Side-scrolling Games**

I. INTRODUCTION

Currently mobile devices are very popular for their competitive prices and compact sizes that can conveniently portable. Mobile devices also provide high processing power and large memory storage, which is almost the same as those of personal computers. Additionally, mobile devices have unique user input methods, such as voice, accelerometer, touch and location [1]. With these special features, game developers prefer to release new games on mobile devices, and consequently the market of mobile games is largely expanded [2]. One popular type of mobile device games is the side-scrolling one such as Cookie run, Wind runner and Jetpack joy ride.

A unique feature of the side-scrolling games is the 2D graphics with side-view camera angles. Onscreen characters generally move from one side of the screen to the other to meet the objectives. The game characters will automatically be moved along the scenes on the screen. Players will control the characters to jump, crouch or shoot, collect items, attempt to avoid obstacles, and destroy enemies. When passing a stage level, players will receive awards or gain experience points which will increase their power in competing with other players. Players can repeatedly play each stage level to gain higher scores.

We have developed the following 5 interaction techniques for side-scrolling game genre on mobile devices: 1) Touch screen interaction 2) Accelerometer interaction 3) Gesture interaction 4) Proximity interaction and 5) Microphone interaction. A user interface has been created and game developers can use it as a model in developing side-scrolling games. As a proof of concept, we have tested a side-scrolling game called UDRU Running, using the user interface and interaction techniques as presented in this study. In the UDRU Running Game, onscreen character is controlled by touch screen that receives input from the player. The touch screen is divided into two square sides, left side for jumping and right side for sliding. The bottom left of the touch screen is for using items/assisting tools. Long press gesture anywhere on the screen is for shooting. Accelerometer sensor is activated when players tilt the mobile devices either to increase or reduce speed of the character. A playtest was experimented by 30 volunteers who also did the satisfaction survey questionnaires afterwards. Players' overall satisfaction is high as well as their contentment in the game's interaction techniques.

II. INTERACTION DESIGN OF SIDE SCROLLING GAME GENRE

A. Design of interactions

Most mobile devices come with touch screen and thus soft keypad (virtual keypad) is commonly used in playing games instead of traditional physical sticks and buttons. This however reduces space on the screen as well as players' gaming precision [3]. With our interaction design presented in this study, not only that there is more space of the main screen, but also there are more interaction techniques derived from special features of the mobile devices such as accelerometer, gyroscope, proximity sensor and magnetometer. This study presents the following 5 interaction techniques for mobile device side-scrolling games.

i. Touch screen interaction

Most side-scrolling games are landscape orientation [4] to facilitate two-handed operation. The goal of our touch screen interaction design is to increase output screen space. This interaction requires no involvement of soft keypad. The screen is divided into equal-sized squares for each designated actions such as jump, slide or shoot. The common method is to divide the screen into 2 or 4 squares for each specific action as shown in Figure 1.

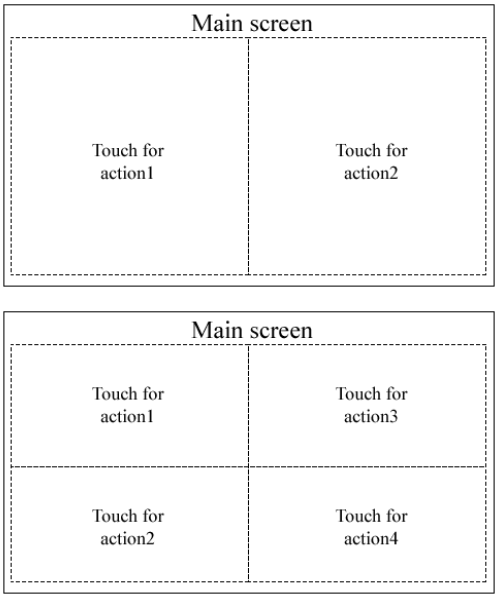

Figure 1: Touch screen interaction

ii. Accelerometer interaction

Accelerometer is used in this interaction to measure tilt angles of mobile devices [5]. It will detect tilt rotation around 3-axis (x, y and z) which normally generates multiple tilting positions as shown in Figure 2. Detected data received from tilting positions will be used to adjust viewing angels of the screen, enabling players to have different dimensional views of the game scenes.

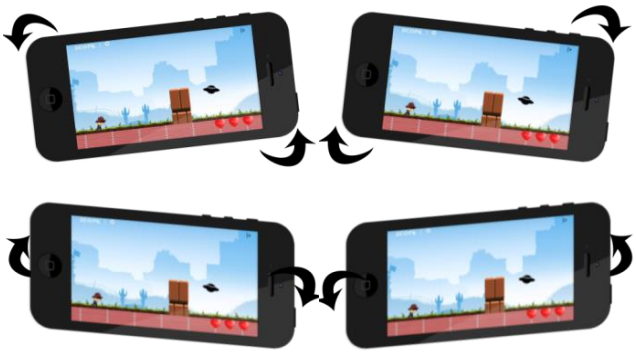

Figure 2: Accelerometer Interaction

iii. Gesture interaction

In this interaction, characters' actions will be generated from the mobile devices' recognition of various players' gestures [6]. The following 4 types of gestures are commonly used in the side-scrolling games

- long press gesture : touch on screen surface and hold
- double tap gesture : touch on screen surface with double tap
- swiping gesture : touch on screen surface and quickly move sideways i.e. left, right, up and down
- dragging gesture : touch on screen surface and move along without releasing finger

iv. Proximity interaction

Proximity sensors of the mobile devices will measure the distance of nearby objects. When the sensor is blocked by a fingertip, specific actions will be generated such as speed acceleration.

v. Microphone interaction

Blowing the microphone [7, 8] of the mobile devices will enable required actions.

B. Design interaction framework for side-scrolling games on mobile devices (IFSM)

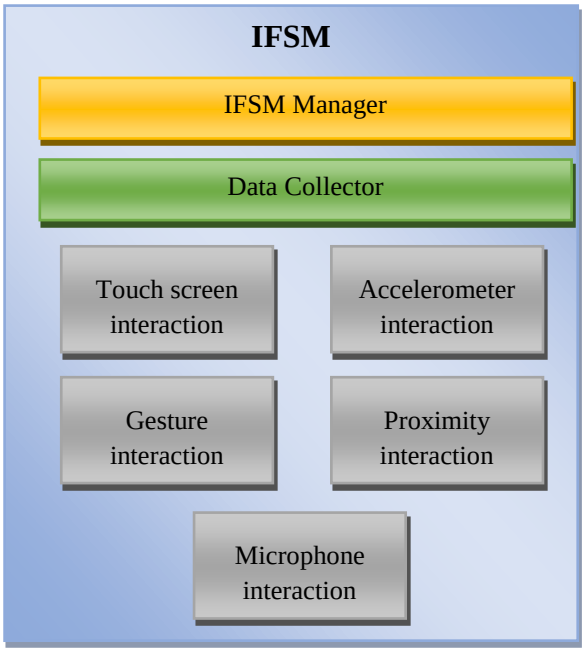

Figure 3: Interaction Framework for Side-scrolling Games on Mobile Devices (IFSM)

This research presents an interaction framework for side-scrolling games on mobile devices which comprises of 7 modules as shown in Figure 3. The framework collect interaction data received from all mobile device sensors before passing such data through algorithms of each module to the games for processing. Detailed functions of the 7 modules are as follow:

i. IFSM Manager

Main controller of IFSM. Controls and monitors the behaviors of all other modules in the framework.

ii. Data Collector (DC)

Collecting and compiling data from the other 5 modules include touch screen interaction, accelerometer interaction, gesture interaction, proximity interaction and microphone interaction.

iii. Touch screen interaction (TI)

Reading data from the quantity in touching the screen and the touching positions around x and y axis before sending input to Data Collector.

iv. Accelerator Interaction (AI)

Reading accelerating data from x, y and z axis in G's measurement unit before calculating tilt angels. Data of the following 3 angles will be derived from [9]: 1) pitch(ρ) - angle of x axis from the ground; 2) Roll (ϕ) – angle of y axis from the ground; and 3) Theta (θ) – angle of z axis from last gravity. Processed data will be transmitted to Data Collector.

v. Gesture Interaction (GI)

Detecting and identifying player's gestures if they are long press, double tap, swipe or drag before sending input to Data Collector.

vi. Proximity Interaction (PI)

Reading proximity values between the sensors and the nearby objects in centimeter/meter unit and sending the input to Data Collector.

vii. Microphone Interaction (MI)

Detecting the blowing of microphone and sending input to Data Collector.

C. User interface design

We have developed an interactive user interface for the screen to be handled horizontally, so players will use two hands in interaction with the game. Other features are also suitably arranged so that the output screen is not too occupied. Top left of the screen is allotted for showing status of the game such as life power, scores or collected gold, and top right of the screen is allotted for game shell where players can pause the game, continue, restart or quit (shown in Figure 4).

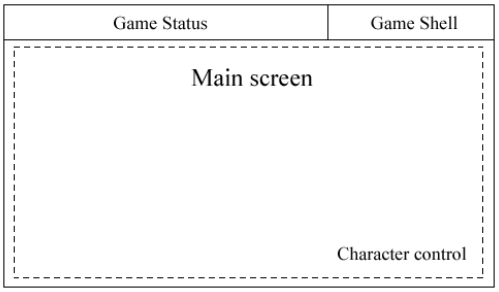

Figure 4: Interaction interface structure

III. PROOF OF CONCEPT

As a proof of concept for the presented interaction techniques, IFSM and user interface, a library called touch screen interaction is created from IFSM in order to create UDRU Running Game.

A. Design game flow

UDRU Running Game is 2D side-scrolling game. The game flow diagram is shown in Figure 5.

B. Implementation

The UDRU Running Game is designed with the application of 4 interaction techniques include touch, accelerometer, long press gesture and microphone interactions as well as IFSM , UI and [10]. From Figure 6, in the main scene of the game, the character will keep running unless controlled by player to perform other actions. When touching on the right side of the screen, the character will slide (as shown in Figure 7), and when touching on the left side of the screen, the character will jump (as shown in Figure 8).

In the game will have enemies, the player can destroy the enemies using long press gesture to shoot them (as shown in Figure 9). The player will get higher scores if the enemies are shot. Figure 10 shows character collecting items as assisting tools.

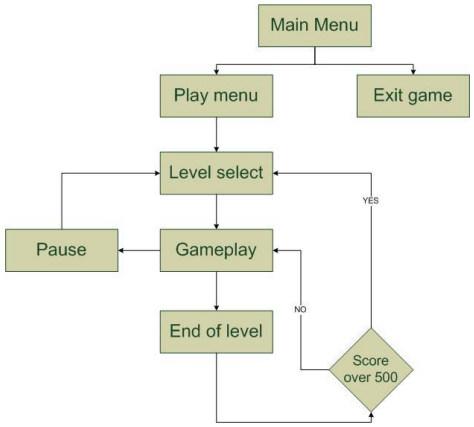

Figure 5: Diagram of game flow

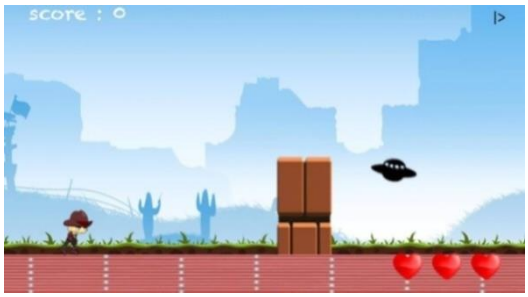

Figure 6: Character run

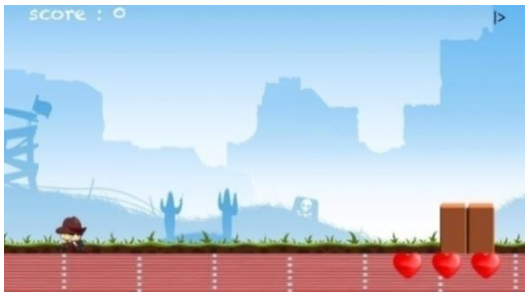

Figure 7: Character slide

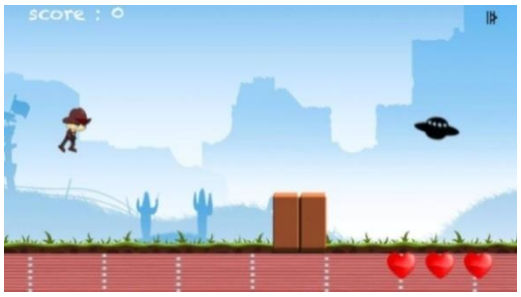

Figure 8: Character jump

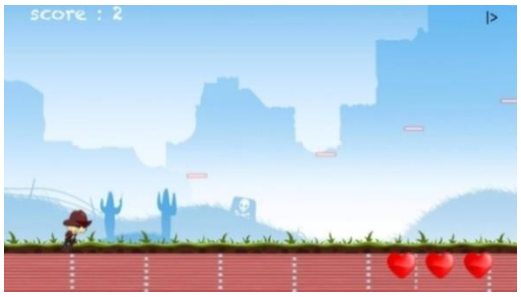

Figure 9: Character shoot

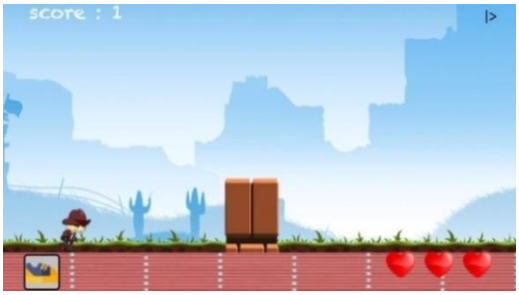

Figure 10: Character pick up item

IV. Result and Game Satisfaction Survey

By using touch screen interaction library for developing UDRU Running game comparing to development without using this library, line of code are reduced from 248 lines to 120 lines.

We tested the UDRU Running Game in 2 modes: touch screen mode and soft keypad mode, with 30 volunteers. After the playtest, they completed the satisfaction survey questionnaires (5 points scale), the results are as shown in Table 1 and Table 2.

Table 1
Satisfaction of UDRU Running Game

Satisfaction of game features	$\bar{X}$	S.D.	Level of satisfaction
1. Game appearance	3.97	0.81	High
2. Game difficulty (Learning Curve)	3.90	0.80	High
3. Game enjoyment	4.07	0.64	High
4. Game innovation	4.10	0.84	High
5. Touch screen interaction	4.37	0.84	High
6. Accelerometer interaction	3.87	0.90	High
7. Gesture interaction	4.07	0.91	High
8. Microphone interaction	4.00	0.91	High
Total	**4.04**	**0.83**	**High**

Table 2
Satisfaction of control method for UDRU Running Game

Satisfaction of control method	$\bar{X}$	S.D.	Level of satisfaction
1. Touch screen control	4.43	0.76	High
2. Soft keypad control	3.75	0.82	High

V. Conclusion

The interaction techniques presented in this study make use of special features of mobile devices to introduce new challenging experience among players. The model and its interaction framework could assist developers to easily and conveniently create their side-scrolling games on mobile devices. By using the library in development, code lines are reduced more than a half. This framework provides high reliable code based on well-tested process. According to the satisfaction survey, 30 volunteers who tested the UDRU Running Game are highly satisfied. Their satisfaction level on the touch screen interaction, the gesture interaction and the microphone interaction is very high, while the satisfaction level on the accelerometer interaction is average due to its complicated functions. Therefore, the interaction model in this research is efficiently suitable for the side-scrolling mobile game. Comparing touch screen control to soft keypad control, touch screen control is more satisfied than soft keypad control, indicating that touch screen control is more convenient than soft keypad control.

As a result it indicates that beside traditional interactions between players and mobile device games, new interaction methods help enrich gaming experiences and enjoyment.

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