Gesture Recognition for Educational Games: Magic Touch Math

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Abstract. Children nowadays are having problem learning and understanding basic mathematical operations because they are not interested in studying or learning mathematics. This project proposes an educational game called Magic Touch Math that focuses on basic mathematical operations targeted to children between the age of three to five years old using gesture recognition to interact with the game. Magic Touch Math was developed in accordance to the Game Development Life Cycle (GDLC) methodology. The prototype developed has helped children to learn basic mathematical operations via intuitive gestures. It is hoped that the application is able to get the children motivated and interested in mathematics.

1. Introduction

Educational games are designed to help people to learn about certain subjects, to expand concepts, to reinforce development, to understand an historical event or culture or to assist them in learning a new skill as they play. According to Pappas [1], the global eLearning market has reached USD107 billion in 2015. The global self-paced eLearning market reached USD32.1 billion in revenue in 2010, with a five year compound annual growth rate of approximately 9.2%. This means that the self-paced eLearning market should see estimated revenues of USD49.9 billion in 2015. Worldwide, the market for mobile learning products and services has reached USD5.3 billion in 2012. With a compound annual growth rate of 18.2% for the next five years, it is estimated that the worldwide mobile learning market in 2015 will reach USD8.7 billion and it will even reach USD12.2 billion by 2017. It is worth to note that while in 2012 the top buyers of mobile learning products and services were US, Japan, South Korea, China, and India, and it is expected that by 2017 the top buyers of mobile learning products and services will be China, US, Indonesia, India, and Brazil.

Video games in particular, can easily consume the attention of children and even adolescents. As educators, governments, and parents realize the benefits of gaming on learning, educational games have become a new tool in education. Games are able to teach children regarding us goals, rules, adaptation, problem solving, interaction, all represented as a story. Educational games also provides enjoyment, passionate involvement, structure, motivation, ego gratification, adrenaline, creativity, social interaction and emotion during play [2]. To take advantage of the new role that a game plays in education, this project propose a touch-and-play educational game on mathematics called Magic Touch Math. Children are able to learn basic mathematical operators such as addition, subtraction, multiplication, and division in a more interactive manner.
The main goal of this project is to develop a touch-and-play educational game based on gesture recognition technology. In achieving this, two aspects are of the utmost importance; the (1) game mechanics and the (2) gesture recognition. Game mechanics are the rules, processes, and data at the heart of a game. They define how the game play progresses, what happens when, and what conditions determine victory or defeat. In video game industry, it usually prefers the term game mechanics over the term game rules because rules are considered printed instructions that the player is aware of, while the game mechanics are hidden from the player. The term core mechanics are the most influential, affecting many aspects of a game and interacting with mechanics of lesser importance. The core mechanics are mostly hidden from the player, but player will learn to understand the mechanics while playing the game [3, 4, 5, 6, 7].

Meanwhile, touchscreen technology has seen a surge in adoption led by smartphones, tablets, laptops, and recently smartwatches. According to [9], a touch screen is a touch-sensitive display screen on a computer or other electronic device, whereby touching different portions of the screen with a finger or stylus will cause the device to take actions determined by a computer program. A gesture is a hand-drawn shape on a touch screen [10]. It may have one or multiple stroke and each stroke is a sequence of timed points. A user-defined gesture can be recognized by a Gesture Library in a specific application. Today, gesture recognition is perceived as the natural evolution of intuitive user interfaces. Since the creation of touch screens, gestures have reigned in an entirely new aspect as to how we interact with our devices. Gestures allow users to perform specific tasks in an extremely efficient and more dynamic manner.

The remainder of this paper is organized as follows. Section 2 presents reviews on similar applications to the proposed gesture-based educational game for Mathematics, Magic Touch Math. Section 3 presents the methodology for developing the Magic Touch Math, and finally Section 4 concludes the project with some indication for future works.

### 2. Related Work

In benchmarking the gesture-based educational game application, two games existing in the market are chosen; Magic Touch: Wizard for Hire developed by Nitrome and Gesture Dance developed by ProGaming. Both games are available in Google Play. Magic Touch Math is different from the existing applications because it is the first game focusing on learning mathematics but using custom gestures drawing.

#### 2.1. Magic Touch: Wizard for Hire

Magic Touch: Wizard for Hire (refer Figure 1) is an android game developed by Nitrome Limited, a British independent game development company based in London. Magic Touch: Wizard for Hire is an endless game. In Magic Touch: Wizard for Hire, the player plays as a wizard who has to prevent knights descending via balloons from landing on a castle. Each balloon has a symbol on it, which when drawn will pop the balloon. When a symbol is drawn, all balloons on screen that have that symbol will pop, and when a knight is out of balloons it will fall to the ground and be destroyed. A destroyed knight will add point to the player’s score and also yield some coins. Popping multiple balloons with one drawn symbol that causes multiple knights to die will cause a combo, which will grant extra coins and points. If a single knight lands on the castle, the player loses. Coins can be used to buy backgrounds, spells or other wizards.

#### 2.2. Gesture Dance

Gesture Dance is an android-based game developed by ProGaming. Gesture Dance is a 3D mobile dancing game. In Gesture Dance, player plays as a dancer who wants to become dancing superstar. Player match the notes by performing common gestures such as single tap, double taps, swiping left/right/up/down at the right time in order to score points. Figure 2 shows the gameplay for Gesture Dance.
3. Methodology

Game application development requires a systematic approach of methodology in order to produce a satisfying result. Therefore, the Game Development Life Cycle (GDLC) model is selected in this project as the most suitable methodology of application development life cycle to complete the system. A proper methodology is crucial to ensure that the project is planned correctly that ensure effectiveness and efficiency during the project to develop the proposed Magic Touch Math. According to the GDLC methodology, it can be classified into 6 phases which are initiation, pre-production, testing, beta, and release. Figure 3 shows the phases in the GDLC model.

3.1. Initiation phase

Initiation phase is the first phase of GDLC methodology. This phase is where analysis of similar games, idea generation, hardware and software requirements are generated. Magic Touch: Wizard for Hire developed by Nitrome and Gesture Dance developed by ProGaming has been chosen as the subjects. The gameplay of both the game is very similar in certain aspects of the proposed project title, Magic Touch Math. Analysis and study on both games are performed by observation and hand-on experience of the games by playing it. Observing the games gives a rough idea on how the gameplay works and game mechanics of the game. By experiencing
the game itself, one can feel how well the game plays such as performance, game balance, game
design, and user experience. Observation and experience the games itself provide valuable data
and a good insight for the future development of the proposed project.

3.2. Pre-production phase
Pre-production phase is the phase where game design is developed, which will be the most
crucial step in game development. In game design, the details of the game concept, the game
genres, game character, game physics, interaction, storyboard of the game, fun factor and the
game features are included. Graphics design of the game will be more towards adorable cartoon
style design, which makes the appearance of the game more attractive and easily capture the
attention of young players. In addition, navigation structure is very important part of the game
interface, it guides the player through the game application. Figure 4 shows the navigation
structure of the game.

3.3. Production Phase
After the pre-production phase has been completed and the blueprint of the game has been
finalized, the development of the game enters the production phase. Production phase is the
core phase of the game development lifecycle. In this phase, there are two sub-phases that are
considered to produce the game, which are game assets and programming. [11] describes game
assets as artwork, sounds, video, maps, and other data. For game programming, Magic Touch
Math is developed using Java programming language and XML for the layout design.

3.3.1. Spaceship  The main character in Magic Touch Math is the spaceship. Spaceships are the
enemy in the game which the player have to defeat. The spaceship will be carrying mathematics
equation on it, in which the player need to solve, and start descending from on top of the screen.
The spaceship will be generated on the screen by using a method call drawBitmap() which
draw the spaceship on a canvas. To make the spaceship descend from on top of the screen, a
method called update() will be call to handle the movement of the spaceship. The spaceship
will be randomly generated using a method called randomBitmap() and each time a spaceship
reaches on the bottom of the screen a new spaceship with different mathematics equation will
be generated on top of the screen.
3.3.2. Gesture Input  Gesture will be the primary input to play the game as shown in Figure 5. The custom gestures consist of gestures from number 0 to 9 and are stored in a gesture file bundled with the game application. The custom gesture file are designed using the Gesture Builder application which is bundled with the samples package supplied as part of the Android SDK. Once the custom gestures have been designed, the gesture file is added to the game application. Within the game application code, the file is then loaded into a GestureLibrary instance where it can be used to search for matches to gestures performed by the player. Figure 5 shows the spaceships descending from top of the screen with example of custom gesture input.

3.3.3. Record High Score  A custom dialog will pop up each time the player manages to beat the previous high score recorded after the game has ended. The player can either choose to save and replace the current high score or do not want to do anything and just press the cancel button. If the player choose to save his/her high score, using SharedPreferences class which provide a general framework that allows you to save and retrieve in the form of key, value pair. To use the shared preferences, a method called getSharedPreferences() will be used which return a SharedPreferences instance pointing to the file that contains the values of preferences and editor.putString() and editor.putInt() to save player’s name and high score.

3.3.4. Score and Timer  Score is used to determine how good the player is when playing the game and a timer to determine when the game will be over as shown in Figure 6. Each time the player solved a mathematics equation, score point and timer point will be rewarded to the player and the score and timer will increment.

3.3.5. Tutorial  When the player first time launch the game a custom dialog will pop up, asking the player would he/she like to enter the tutorial. If the player pressed “Yes”, it will bring the...
player to the tutorial interface. A tutorial is implemented in the game application which is an image consists of description explaining the game elements.

3.4. Testing Phase
In testing phase, evaluation of the prototype is conducted. The problems of the game encountered are discovered. Alpha testing is conducted in this stage. Alpha testing is required to identify errors/glitches/bugs in the game. Besides that, alpha testing is also required to identify the difficulty level of the game, missing features, and extra features to make the game more interesting. Alpha testing will be done by the developer of the game using functionality testing, where functionality testers look for general problems within the game itself or its user interface, such as stability issues, game mechanic issues, and game asset integrity. At the end of the phase, there are two decisions to make, first is to go back to the pre-production phase to improve the game design and the second decision is to enter beta phase, the following phase of the production
phase, where beta testing is conducted. Table 1 describes the result of alpha testing. For the most part of the game, the game works as the developer intended it to be. However, during the test to save high, an error occurred when the player wants to save his/her high score. Player’s high score did save into a file as intended. Therefore, a corrective action is made to fix the problem.

| Test                              | Expected result            | Actual result       | Pass/ Fail | Corrective action               |
|-----------------------------------|----------------------------|---------------------|------------|-------------------------------|
| Play button                       | Proceed to the gameplay    | Work as expected    | Pass       | -                             |
| Tutorial button                   | Proceed to tutorial interface | Work as expected | Pass       | -                             |
| Gesture recognition               | Recognize players input    | Work as expected    | Pass       | -                             |
| Saving high score                 | Save high score into file  | Does not work as expected | Fail | Making changes in the codes |
| Retry the game after game over    | Proceed to the gameplay    | Work as expected    | Pass       | -                             |

3.5. Beta phase
In beta phase, this phase is to test the game by third party people or the player. The goal of the beta test is to determine the bugs that are not uncovered during the alpha testing of the testing phase and to collect feedbacks by the third party people. Based on the result of the beta testing, the decision to move to the next phase, the release phase or to go back to the pre-production phase are decided. Beta testing is conducted by the end user to test and measure user acceptance which the game application is tested by a limited number of users other than the developer itself and to find error or bug that are not discovered during the alpha testing. The target users for the game are from the range of 3 to 5 years old.

The testing is categorized into two components which are user acceptance and functionality of the game. In user acceptance, four questions were asked as follows:

- Question 1: The game is fun to play?
- Question 2: Do you like the game?
- Question 3: Do you like the game design?
- Question 4: The game is easy to understand?

Meanwhile, for functionality of the game, three questions were asked as follows:

- Question 1: The game can run smoothly?
- Question 2: Do you like the gesture control?
- Question 3: Instructions from the tutorial is clear?

Figure 7 and Figure 8 show the results for the user acceptance and functionality test for Magic Touch Math, which produced a satisfying result. This is because most of the respondents agreed that the game is fun to play and most of them like it. Besides that, the game design is good and it is easy to understand.
3.6. **Release phase**  
Release phase is the last phase in the GDLC model. In this phase, the game is already completely refined means that the game is done polished in terms of removing all errors and with refined interface design of the game. The game is ready to be released to the market.

4. **Conclusions and Future Work**  
This project proposed an educational game for Mathematics called the Magic Touch Math, which focuses on basic mathematical operations targeted to children between the age of three to five years old based on gesture recognition. Magic Touch Math has its own advantages in comparison with similar existing games. One of the advantages of the game is that it helps the player to learn basic mathematics operation. The game uses gesture recognition to play the game, which can improve and train player’s fine motor skills. There is less game that take this approach and
thus, it makes the game more unique as compared to other games available. Besides that, the player also get to improve his/her critical thinking skills through solving mathematics equation.

Apart from the advantages available, there are a few limitations or drawbacks that exist in the game. One of it is that the gesture recognition takes time to recognize player’s input gesture. It may cause the player to lose the game because Magic Touch Math uses a timer system to determine whether when the game is over. The game also does not have support for two-digit input (e.g. 12). This is due to the drawback of the gesture recognition which takes time to perform the recognition process.

In the future, Magic Touch Math is projected to make further enhancements such as tougher mathematics question to make the game more challenging, ability to place image so player gets to place their picture alongside with his/her name and score, support for multiplayer gameplay that allows the player to play with other player, integration with Google+ account, and finally cloud saving so the player’s game progress can be saved on the cloud, hence the player does not lose his/her game progress such as in the event that the player uninstall the game and reinstall the game back or playing the game on a new device. In the nutshell, a good mobile game requires a good gameplay, good design, uniqueness, and easy to learn to play. Magic Touch Math is developed to be fun and educational at the same time and it has been developed successfully and achieving all the objectives of the game that are outlined in the report.

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References
[1] Pappas C 2015 The Top eLearning Statistics and Facts For 2015 You Need To Know - eLearning Industry eLearning Industry (http://elearningindustry.com/elearning-statistics-and-facts-for-2015).
[2] Communications N 2013 Educational Video Games Can Boost Motivation to Learn New York University, CNYU (https://www.nyu.edu/about/news-publications/news/2013/11/06/educational-video-games-can-boost-motivation-to-learn-nyu-cuny-study-shows-.html).
[3] Adams E and J Dormans 2012 Game Mechanics Berkeley, California, New Riders.
[4] Singh R 2014 An Overview of Android Operating System and Its Security Features Journal of Engineering Research and Applications 4(2):519–519.
[5] Fields T 2014 Mobile & social game design: Monetization methods and mechanics, CRC Press.
[6] Dondlinger M 2007 Educational Video Game Design: A Review of the Literature Journal of Applied Educational Technology 4(1):22.
[7] Plass J, P O’Keefe, B Homer, J Case, E Hayward, M Stein and K Perlin 2013 The Impact of Individual, Competitive, and Collaborative Mathematics Gameplay on Learning, Performance, and Motivation Journal of Educational Psychology 105(4):1050–1066.
[8] Drake E 2013 A Guidelines of Game Development Life Cycle (v2.0) Games, Applications, Driving, and Beyond (https://personanonymou.wordpress.com/2013/07/17/a-guidelines-of-game-development-life-cycle-v2-0/).
[9] The Definition of Touch Screen Dictionary.com (http://www.dictionary.com/browse/touch--screen?s=t).
[10] Android Developers Developer.android.com (https://developer.android.com/reference/android/gesture/package-summary.html).
[11] Carter B 2004 The Game Asset Pipeline Charles River Media.