Development of Educational Game for Primary School Mathematics using Microsoft Kinect

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Abstract

This research focuses on the design and development educational game using Microsoft Kinect. The edugamecan be used as educational tool in a classroom as to create an interesting and interactive learning process. This research is also focused on mathematics as its educational content using Microsoft Visual C#, XNA Game Studio, Microsoft Kinect for Windows SDK, and Microsoft Kinect as the main hardware. There are about eleven topics regarding mathematics based on the module provided by the Malaysian Ministry of Education. The interface of the game has been designed and developed to be interactive and attractive using some cartoon graphics, such as Ipin, Boboiboy, and Yaya. The developed game is a quiz base program, where student will have 10 questions each round and 4 choices of answers for every question. Currently, this educational game is designed for Year 1, Year 2 and Year 3 primary school students, and it has been evaluated by a group of 8 students. Furthemore, it has been evaluated and validated by a school teacher, in which they confirm the effectiveness of the developed game to improve student's learning on Mathematics.

Keywords*: educational game, edugame, Microsoft Kinect, skeleton tracking, movement tracking*

1. Introduction

Education is a process of accumulation of knowledge in several ways including teaching, training, research and others. Today, education is known as formal learning in the classroom. Education is one of the most important factors in a person's life, particularly in the expansion of early age ranged from 4 to 17 years. This is the age at which parents will usually send their children to such institutions or certain schools to acquire education. It is very important because often the level of education a person will determine his or her future.

The appearances of gadgets have a great impact on the world today. There is a high potential that we could use this gadget as a learning tool in the classroom, and attract children to learn on their own without having to be forced. Children will volunteer to participate in the class rather than just sit back and avoid getting asked or answered questions. The educational games will be able to help to solve the problems as evidenced in [1, 2].

Microsoft Kinect can realize the dream for a teacher to get an effective and interactive class environment favourable to learning and children. Duties of a teacher will be easier with the presence of the Microsoft Kinect which will introduce the new ways of learning [3]. Kinect is a versatile sensor that introduced by Microsoft on November 2010. Kinect sales reach 8 million units in just 60 days, holds the Guinness World Record as the fastest selling consumer electronic device in history [4]. Kinect, for Xbox 360, was introduced with the aim of video games using only body movements and voice commands to play, no controller required like any other video game platforms.

Most people know that Kinect just as a tool to play video games on Xbox 360 while in fact Microsoft has released an open source toolkit to enable Kinect on a Windows PC. The connection between the Kinect and Windows PCs opened up vast possibilities of Kinect game development. There are still many diverse uses of Kinect sensor which has not been fully utilized yet [5, 6]. To use Microsoft Kinect in education, the problem is only in programming and finding the appropriate program design to attract the children attention and may also attract more youth groups to this new and beneficial learning system [7].

Microsoft Kinect has been used for various purposes. Campbell [8] used a custom Kinect installation to browse through medical images and real-time X-rays while repairing an aneurism in a patient's aorta. The system created allows surgeons to call up images or perform a number of other tasks without assistance and without having to touch anything, thus avoiding any potential contamination. Kinect has been used as well in 3D teleconferencing as experimented in [9].

In educational field, especially mathematics, several researches have attempted to utilize Kinect. Ayala, et al. [10] using the method called kinaesthetic learning using Kinect to attract students to learn mathematics. Johnson, et al. [11] developed a KinectMath software that encourages students to understand abstract algebraic functions. The developed software plot algebraic graphs and then students can modify the graph or add another graphs using their embodied interactions. On the other hand, Thakkar, et al. [12] used gesture to help students learning math more interactively. They used Kinect and Blender in developing their MathMazing games. Moreover, Rothschild and Williams [13] use Kinect for young children learning of Mathematics. In summary, the gamification of difficult subject, such as Mathematics, could help the student's learning process as stated in [3] and [7].

Although many researches have been conducted on the use of educational game to improve teaching and learning process, however not much researches has been focused on the use of Microsoft Kinect to improve student's participation in the class for difficult subject like Mathematics targeted at primary school. Therefore, the objective of this research is to investigate, design, and develop educational game for primary school Mathematics using Microsoft Kinect. It is expected that our developed educational game will help teacher and students in improving the teaching and learning process for other primary school subjects.

2. Primary School Education

The goal of the Primary School Standard Curriculum for Mathematics subject is to develop students' understanding of number concepts, basic skills in math, understand the idea of simple mathematical and competent to apply mathematical knowledge and skills to use it effectively and become responsible in everyday life as stated in [14]. Effective communication of mathematical ideas can help students clarify and strengthen the understanding of mathematics. Sharing an understanding of math writing and with classmates, teachers and parents, students will be able to increase self-confidence and in return help teachers monitor the development of their mathematical skills. Communication plays an important role in ensuring mathematically meaningful learning. Through communication, ideas mathematics can be expressed and understood better [14]. Mathematical communication, either oral, in writing or use symbols and visual representation (with using charts, graphs, diagrams, etc.), can help students understand and apply mathematic more effectively.

Communication with peers, parents, adults and teachers can help students describe, explain and reinforce ideas and their mathematical understanding. To ensure the generation, sharing and increase understanding, student should be given the opportunity to debate the mathematical ideas analytically and systematically. Communications involving different perspectives and point of view can help students enhance better understanding of mathematics. Important aspects of effective communication in mathematics are the ability to provide information effectively, and understand and apply mathematical notation correctly.

3. Proposed Educational Game System

In this section, the hardware and software setup as well as the educational game will be presented. The hardware and software needs to be setup properly so that it can be used to create Kinect educational game. The flowchart of the proposed educational game will be discussed in more details.

3.1. Hardware Setup

Figure 1 shows the proposed hardware setup of Kinect educational game. A laptop or a PC is connected to Microsoft Kinect which is placed in front of the player together with the LCD screen or LCD projector. Kinect depth sensors consist of an IR emitter (left circle) and an IR depth sensor (right circle) which work together. The IR emitter is an IR projector that constantly

emits infrared light in a pseudo-random dot pattern over objects in front of it. These dots are normally invisible, but it can be captured its depth information using an IR depth sensor. Kinect color camera (middle circle) supports a speed of 30 frames per second at a resolution of 640 x 480 pixels, and a maximum resolution of 1280 x 960 pixels at 12 frame per second. The viewable range for the Kinect cameras is 43° vertical by 57° horizontal. The image processing part was mainly handled by the Kinect itself utilizing the PrimeSense chip. In addition, Kinect has tilt motor which can be used to change the camera and sensor's angles up to 27° to obtain the correct position of the human skeleton within the game environment.

There are four microphone arrays spaced equally at the bottom of Kinect sensor. The microphone array enables Kinect to capture and recognizing voice more effective with enhanced noise suppression, echo cancellation, and beam-forming technology. Kinect can identify the source of the sound and recognize the voice, irrespective of the noise and echo present in the environment. Therefore, we could utilize Kinect for image capturing and sound recognition in our educational game development.
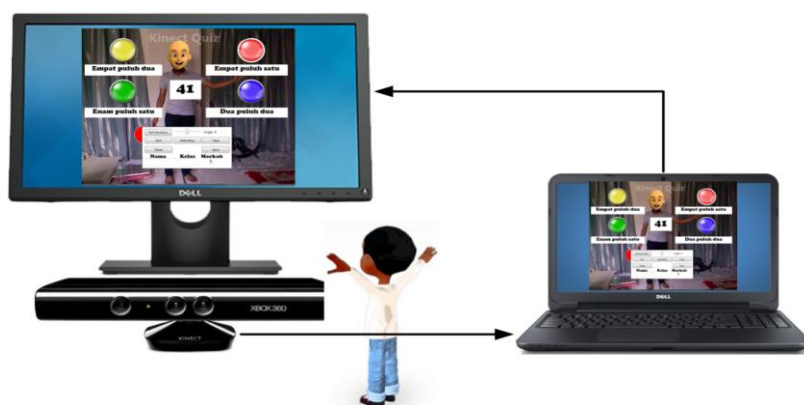

Figure 1. Proposed Hardware Setup of Kinect Educational Game

3.2. Software Setup

To setup Microsoft Kinect, a few installation of software and drivers are required in order to connect the Kinect with PC or laptop. The minimum requirement for the PC or laptop is to operate with windows 7 operating system and above to be able to utilize the official Kinect SDK provided by Microsoft. The following are the list of software and drivers that need to be installed: (a) Visual Studio Express 2010 C# or above, (b) Microsoft XNA Game Studio 4.0 or above, (c) Kinect for Windows SDK, and (d) Kinect Sensor USB drivers. It is advisable to follow the order of the installation based on the previous list to avoid any problems regarding to get proper connection between Microsoft Kinect and PC or laptop.

Kinect for Windows SDK can be downloaded for free [15]. The SDK provides a set of libraries that enables people to add to their own programs and games so they can use the sensor. The SDK also contains all the drivers that we need to link a Kinect to PC and laptop. Kinect SDK can be used using a managed code programming language (such as C# or Visual Basic.NET) or from unmanaged C++. The SDK provides a set of objects that expose properties and methods that we can use in our programs.

3.3. Proposed Educational Game

Figure 2 shows the flowchart of the proposed Kinect educational game and its core movement tracking. Figure 2(a) shows the main program, in which the game is started when the Kinect is on. After that, Kinect will try to locate and track one player to proceed. The player can virtually press start button using his hand in the air to start the game. The mathematical quiz is then displayed and Kinect track the movement and submit the answer to be checked for its correctness. After the game has finished, then the game will display its final score. Figure 2(b) shows the core of movement tracking, in which the program will compare each new image with the previous one to detect and record any significant movement.
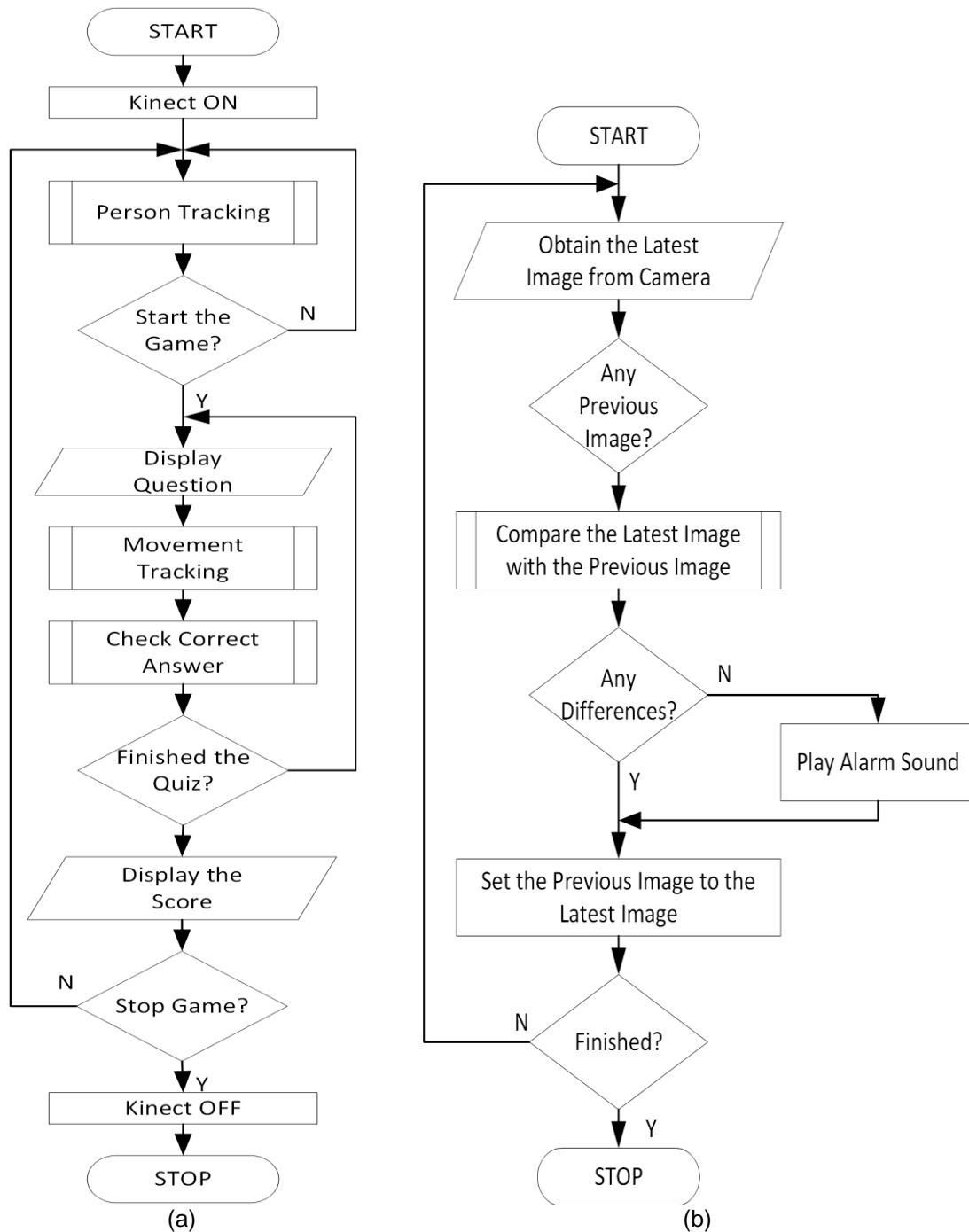
Figure 2. Flowchart of (a) Kinect Educational Game and (b) Movement Tracking

We need to properly consider on what form of games and what topics suitable for the games. On the game form, we have decided to adopt quiz form, in whichthere will be around 10 questions and four choices of answer. To create the quiz base application software, we need to apply the 'if else' function which is repeated 10 times (or any number of questions).The 'if else' function is repeated accordingly to the number of questions needed. Figure 3 shows the selected topics which is based on the Mathematics standard document provided by the Malaysian Ministry of Education [14]. The level of difficulty could be adjusted according to the teacher or student requirements. Furthermore, the game is created in Bahasa Malaysia as it is designed for local student.

YEAR 1	YEAR 2	YEAR 3
1. Addition	1. Addition	1. Addition
2. Subtraction	2. Subtraction	2. Subtraction
3. Words to numbers	3. Time estimation	3. Multiplication
4. Numbers to words		4. Division

Figure 3. Selected Math Topics for Year 1, Year 2, and Year 3

Next part is the design of graphical user interface for our educational game. Because the game is targetedfor the primary school student, we have decided to add some familiar cartoon characters to further attract the student to participate and play the games, including Ipin, Boboiboy, and Yaya, as shown in Figure 4. To attract the students, the player can choose the selected character in which their face will be virtually replaced by the cartoon characters.

Ipin   *Boboiboy*   *Yaya*

Figure 4. Popular Cartoon Characters

4. Results and Discussion
4.1. Actual Game Interface
The educational game was developed on a Windows 10 machine with i5 -6200u CPU and 8GB of memory. Before the actual implementation of our educational game, we have conducted experiments on Kinect initialization and setup, mirror image effects, saving pictures, Kinect motion detection, Kinect skeleton tracking and Kinect connecting dots simple game. This is to test various parts of Kinect hardware and software so that it can be used properly for the proposed educational game.

Figure 5 shows the actual Kinect educational game setup at SekolahKebangsaan Ulu Jempol, Pahang. More or less, it follows the proposed setup as described in Figure 1. A 23-inch LCD monitor was used, and Microsoft Kinect is placed at the bottom of the LCD monitor. The indoor light was turned on so that good image could be captured by Microsoft Kinect. As shown in Figure 6, we also add toolbox at the bottom screen which can perform various useful functions, such as set the elevation of the Kinect, selecting cartoon characters, reset the game, and save the score.

Figure 5. Actual Kinect Educational Game Setup at Sekolah Kebangsaan Ulu Jempol, Pahang

The proposed educational game is in the form of quiz base. There is one question in the middle of the screen and four choices of answers. There are 10 questions per sub topic. To answer the question, the player must be visible in the screen to be able to control two red round cursors to select the answer. User need to place the one of the red round cursor in any of the colour buttons for about 3 seconds to select and submit the answer. The game will then record and compare the submitted answer with the correct answer, in which the score is then will be displayed.

Figure 6. Actual Game Interface of the Kinect Educational Game

4.2. Subjective Evaluation

After the test finished, we have sometimes to have an informal interview with the teacher to evaluate our educational game using Kinect. The questions we asked regarding some aspects of the performance of the game and also the educational content itself. The full interview questions can be referred to Figure 7. To summarize, she said the presentation of the game is interesting because we are using popular cartoon characters as part of the graphic. It seems to make the student laugh, interested and at the same time learning by answering the questions given. Thus, this can be considered as interactive way of learning session. The length or duration for the game which is 10 questions per round seems reasonable. She also said that the set-up is really easy and does not require much computer knowledge to operate this game. The instructions of the game are also very clear. The student does not find any difficulty in playing the game in term on what the question want and what gestures they supposed to use. In term of the educational content, it is said to be a little bit easy which can be easily adjusted in the next development.

No	Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	This game would work with existing curriculum	1	2	3	4	5
2	Game has clear learning objectives	1	2	3	4	5
3	Requires little computer knowledge to use the game	1	2	3	4	5
4	It does not require the student to refer to the manual	1	2	3	4	5
5	Game has clear and easy to understand interface	1	2	3	4	5
6	It promotes high student involvement	1	2	3	4	5
7	The game content are appropriate for student	1	2	3	4	5
8	The game graphic and sound are appropriate for student	1	2	3	4	5
9	The gestures used are interesting	1	2	3	4	5
10	Length (time) of game is appropriate	1	2	3	4	5
11	The difficulty of the game content is appropriate	1	2	3	4	5

Figure 7. Questionnaire for Subjective Evaluation

5. Conclusions and Future Works

This paper has presented the design and development of Kinect educational game for primary school Mathematics. Arelatively simple educational game has been developed successfully in the form of quiz based game with some popular cartoon character. Through this simple application, it effectively attracts primary school students to learn difficult subject, such as Mathematics. Around eight students have been participated and evaluated this game, and all of them show their attractiveness to this game. This can be due to the familiar cartoon character that we used, or the game is relatively easy and fun. Informal interview with the school teacher validated our proposed educational game, in which the teacher said that the game was effective to attract students to learn difficult subjects, such as Mathematics. Further works includes adjusting the level of questions following the student's progress and use of speech recognition part to develop more attractive and interactive educational games.

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