Shih, J. L. et al. (Eds.) (2019). Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for Computers in Education

CodAR: An Augmented Reality Based Game to Teach Programming

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Abstract: In recent years, technology has revolutionized all spheres of life. Since programming is the heart of software technology, it is thus imperative that the demand for programmers is also increasing day by day. With advancements in the field of augmented reality (AR) and Computer Vision (CV), we can now develop applications for unique experiences in the field of education. This study aims to develop a game for elementary school students to learn programming skills. Students are provided with cards which act as markers for our Game. Each marker acts a distinct programming block in AR which causes our game character to perform a certain action. The student needs to place these blocks in the right manner to accomplish a given task. It thus enables students to learn some basic programming skills in a way appealing to them.

Keywords: Augmented reality (AR); elementary education; programming; gamification; interactive learning environment; skill development

1. Introduction

Programming is involved behind every new technology developed around us. Therefore, learning how to program is becoming more and more common among individuals day by day. Research has shown that programming promotes logical thinking, reasoning skills, and general problem-solving skills in students of all age groups (Liao & Bright, 2011). Recent developments in the field of AR have created new opportunities for unique experiences in healthcare, education, and entertainment. This study uses AR to develop coding skills of elementary school students. The research involves the integration of computer vision techniques with AR to develop an AR-based game: CodAR. The developed game enables students to learn the importance of algorithms, sequencing and loops in an interactive and visually appealing way. The game has been developed in Unity3D software with support of Vuforia software development kit. We believe that the introduction of this game will captivate students' interest in the field of programming and give them an intuitive understanding of the same.

In the following sections, we discussed the related work (Section 2), elaborated the design and development of the game (Section 3) and followed by conclusion and future directions (Section 4).

2. Related work

Gamification in education refers to the inclusion of game design and principles in education to provide unique and engaging experiences. Research has shown that it can influence users in mainly three aspects - cognition, emotion and social (Detering, Khaled, Nacke & Dixon, 2011). Gamification broadens the player's perception about learning, besides teaching users the process of thinking (Detering, Khaled, Nacke & Dixon, 2011). Many research works have been done in this field, but we did not find such an AR-based game to learn programming skills. Guenaga et al. (2014) developed a game to learn programming skills but it was not totally AR-based.

Lee and Hammer (2011) proposed the use of game-like rules system, player experiences and cultural roles to shape learners' behavior. Researchers have also used meta-analytic techniques to show that Serious games influence learning in two ways, by changing cognitive processes and by affecting

motivation (Wouters, Van Nimwegen, Van Oostendorp, & Van Der Spek, 2013). Games invoke a variety of emotional experiences - from frustration to joy. Students learn to see failure as an opportunity and in turn try to find out the cause of the error instead of feeling helpless about it. Our research, therefore, not only helps in cognitive development but also motivates the next generation of innovative programmers.

3. Proposed system

The proposed system is developed using a smartphone/computer and a set of markers which are provided to the user as cards. Figure 1 shows the markers used in the proposed system. There are five types of markers used in this game. The detailed purpose of each marker is described below:

a) Task - It generates a virtual game area on the screen comprises of our game character, generated level and the task of the level.
b) Direction - It moves the game character one block forward in the direction it is facing
c) Rotation - It rotates the game character by 90˚ in the clockwise/anti-clockwise direction
d) For Loop - It repeats the marker placed immediately before a given number of times, which is generated automatically by the level
e) While Loop - It repeats the set of markers placed before it infinitely or till level completion.

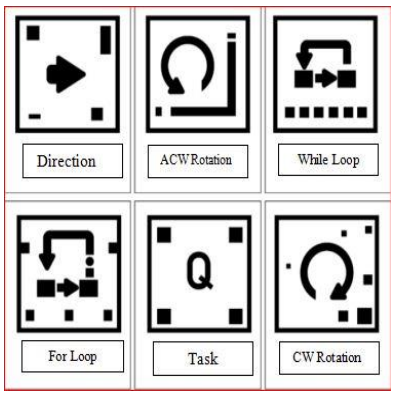

Figure 1. Markers

Figure 2. Screen of the proposed system

Figure 2 shows the screen of the proposed system. On the screen, a virtual block corresponding to the recognized marker is displayed. The user moves the marker which moves the corresponding virtual block on the screen. The virtual blocks are brought in the scene one by one and placed next to each other to generate a sequence of commands. The set of these virtual blocks corresponding to each marker is shown in Figure 3.

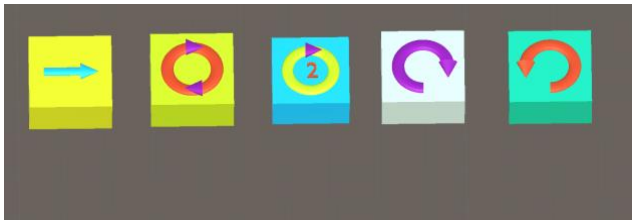

Figure 3. Virtual Blocks corresponding to the markers

After the user is satisfied with his/her sequence of markers, the play button should be pressed. Then, our game character performs actions corresponding to the set of instructions received, if feasible. The type of markers and the number of each marker required on each level are displayed in the upper right corner

of the screen. The task is displayed on the upper left corner of the screen. The user has to complete the task using the specified type and number of markers. As the user clears easier levels, the game automatically starts incorporating the use of Loops and tougher Sequences. In Figure 4(a) the user has to complete the level just by using simpler blocks (Direction and Rotation). There can be various solutions to the same level also. Such a solution to the same level is shown in Figure 4(b) where the user is trying to clear the level by using For Loops. This analogy between conventional programming and virtual programming helps the user to understand the intuition of using Loops better.

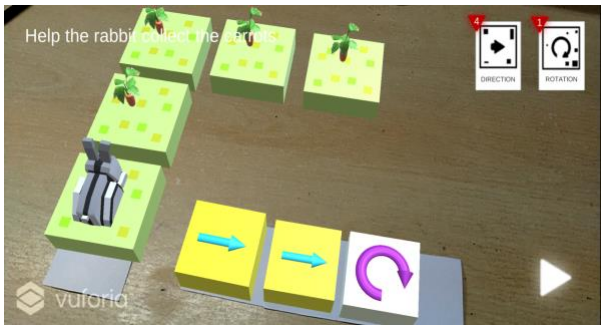

Figure 4(a). Solution 1 to Game level

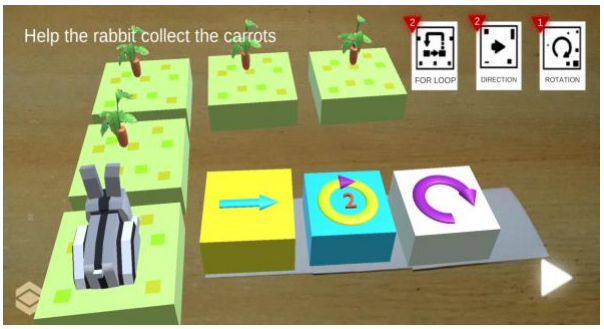

Figure 4(b). Solution 2 to same Game level

4. Conclusion and future directions

Conventional techniques to teach programming generally require a good understanding of various mathematical concepts and are difficult to visualize. Therefore, various visual programming techniques are being developed to teach concepts of programming to younger students. In this paper, we presented CodAR which takes this idea to the next level in terms of user understanding and engagement concepts by practical implementation and visualization. Our approach is unique mainly because of three reasons. First, there is a simple relationship between abstract mathematical concepts of programming viz. Sequence, For Loop and While Loop and the Virtual Blocks. Second, the game is developed using AR, which makes it quite engaging and interactive. Third, with recent smartphone penetration, such devices are now easily accessible. This makes our approach quite portable and easily scalable to a wider audience.

Our work certainly has a limitation. Currently, we have not conducted an empirical evaluation of our developed game. We are currently working on it. Some future improvements which can be made to the game include the addition of more types of markers corresponding to Conditionals, Boolean, Switches, Data Structures, Debugging etc. along with more challenging levels.

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