Augmented Reality Block Building Game for Enhancing Creativity: Block Sculptures

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Abstract:  
Augmented reality (AR) is a combination of a real scene viewed by users and a virtual scene generated by a computer that augments the scene with additional information. Ivan Sutherland created first VR and AR head-mounted display in 1968 called The Sword of Damocles, to develop an innovative program that influenced alternative forms of interaction with computers (Sutherland, I. E, 1965). AR was initially experienced in a lab, but the advancement and affordability of smartphones have sparked a resurgence of interest in mobile AR applications. With the launch of the Pokémon mobile AR game in 2016, there has been renewed excitement from users to experience AR games via their mobile devices (McCartney, M, 2016). This creates the opportunity to design and explore AR platform games for enhancing creativity. The transformative aspects of this technology are its ability to enhance creativity playing with virtual objects. The intent of this project is to enhance creativity by using AR platform to overlay virtual game object over the real world. This will teach players to take a different approach to connect game objects of different textures to randomly generated objects to create block structures of player imagination.

Introduction:  
There are few block building games like Minecraft (Persson, M., & Bergensten, J, 2011), development platform games like Roblox which uses blocks to create virtual world (Baszucki, D. B., & Cassel, E. S,2011) but it limits users within the scope of the virtual world they build. AR will create an opportunity to imagine what they build in the real world and think from a different perspective. For example, the Babel Build game Spross, M. C. (2013), which used large building blocks to build tower kind structures in public helped in breaking normal social barriers but still does not make use of AR. AR will help the players to connect virtual object overlaying with the physical world. This will help them to enhance creativity as the build.

Papert, S. (1980) stated that constructionist learning is when one learns to construct mental models to understand the world around them. For example, rather than lecture based learning, students learn through participating in project-based learning where they effectively make the connection between different ideas. In another example, it is proved that playing and making games for learning helped in developing creative models (Kafai, Y. B, 2006). Kafai, Y. B., & Resnick, M. (1996) proposed and evaluated an approach to developing a constructionism in practice by designing, thinking, and learning in a digital world. This was an exploration is an effective approach that cultivates creativity and improves practical abilities. Feiner, S., Macintyre, B., & Seligmann, D, (1993) study on Knowledge-based augmented reality describes that students showed interest to learn more about the subject. Similarly, another study by Klopfer & Yoon, 2004 results showed that augmented reality foster student creativity and imagination.
The immersion, interaction and navigation features of AR improve user’s motivation to learn, assist with knowledge comprehension, and is potentially useful in learning task that requires experiments, spatial ability, and collaboration (Dalgarno & Lee, 2010; Di Serio, Ibanez, & Kloos, 2013; Dunleavy, Dede, & Mitchell, 2009). Since in AR we overlay the game with the real world, the creative design process can be improved by considering the environmental influence. Ambaline and Kramer (2003) stated that the external motivation like environment factor was influenced greatly when they were engaged in the outdoor activity and their outcome were more likely to be creative if they applied their creative skills. The environment will be more supportive in terms of information, opportunities, freedom when they think. Additionally, Squire and Klopfler (2008) stated when users played a virtual game outdoor resulted in making a much more informative decision considering the surrounding environment. Users can master the domain-relevant knowledge of creativity design using AR (Maclntyre, Gandy, Dow & Bolter, 2004).

Moreover, implementing AR can reduce the cost of the design process as it is extensively being used in prototyping process (Nee, Ong, Chryssouris, & Mourtzis, 2012) to improve product design. AR will also be helpful in assembly, maintain and layout planning and other manufacturer activities (Li, Xi, Yu & Fung 2004; Ong & Nee, 2004). For example, AR was used in interior design to visualize creative interior décor (Phan & Choo, 2010). The interest in the mobile AR application for viewing 3D objects in the real world is increasing with increased number of smartphones. Current smartphones and tablets possess fast processing with graphic hardware, a large touch screen and various onboard sensor like in the built-in camera, GPS, compass and accelerometer making them ideal for indoor, outdoor experience and portability (Billinghurst & Dunser, 2012). Additionally, AR enables viewing of 3D objects in the physical world or real world which allows one to visualise how it would look with other surrounding effects (Arvanitis et al., 2007; Dunleavy et al., 2009).

About the Game:
Block Sculptures is an augmented reality block building game. The main goal of the game is to connect each block to reach the randomly generated cube. Cubes with different textures are the main building blocks of the game. To load the game, the player scans a target AR image. A transparent plane, the playing area, will be loaded, and a cube will be generated in a random location on the plane. The goal is to build a structure out of blocks to reach the randomly generated cube. This is done by placing a cube anywhere within the playing area, provided it is adjacent to another cube, until they connect the plane to the randomly generated cube to end the game.

Design and Development:
I Implemented the game design and development through an Iterative prototyping approach. I developed a rapid prototype design model by designing, incrementally adding, and testing new mechanics, starting with a simple feature. For each implementation, a new prototype iteration was created and tested, each with one new feature added. Game user research methods such as retrospective interview, think aloud protocol and observing players during the playtest helped to identify and understand the player experience. This also helped in making the gameplay more enjoyable. Finally, the MDA framework was used to understand the game mechanics, dynamics and aesthetics (Hunicke, R., LeBlanc, M., & Zubek, R, 2004). This helped me bridge gap between design and development process. By dissecting the game into mechanics, dynamics and aesthetics, the game development process was strengthened.

To develop an augmented reality game, I used Vuforia plugin in Unity 3D game engine. By using Vuforia application we can store the target image in Vuforia database and load the game objects when we scan the target image from our
phones. I then used the target image as the base to spawn game objects dynamically. The idea was to develop different game objects dynamically and encourage users to design and development using the game objects by overlaying it with the real world. Additionally, the base image was developed to look like a transparent plane, which gives the player a seamless overlay over the physical world and helps the player to place the block on the plane. Players can play the game anywhere with the mobile if they have the target image to load the game. Finally, the game was built and tested on an android mobile device (can be built for IOS, Windows and HoloLens).

Design Iterations: The features that were incrementally added with each iteration were as follows:

1. loading a base image by scanning target image using Vuforia, Generating and Positioning of game objects on the plane of Base image
2. Transparent plane and gravity to game objects
3. Different types of textured game objects and selection UI
4. Random game object spawning and UI

Each iteration had three phases of testing:
- Phase 1 - Self test
- Phase 2 - Playtest with 4 friends
- Phase 3 - Playtest with 5 strangers

Iteration 1- Build with white blocks
In playtesting one, loading a base image by scanning target image using Vuforia and cube generation was implemented. In phase one, testing was performed to verify that the core game mechanics of generating cubes was working. Also, I verified if the base image was loading on scanning the target image. In phase two, all 4 participants could spawn game objects on the base image created. Most of them created randomly arranged collections of game objects on the base image. The following observations were made by using think-aloud protocol and player interaction during the testing. It was observed that the players had no excitement because the game lacked to challenge them but they just built randomly shaped models like layouts and buildings. In phase three, the participant had no idea about augmented reality, they were excited at the start of the game but I observed that the players eventually become bored of the gameplay.

Figure 1: Built with white blocks

Iteration 2 – Gravity and transparent plane base image.
In the second iteration, I added gravity to the game objects to check if players had fun and a transparent base image to overlay with the physical layer. In phase one, I tested if the transparent base image loaded when target image was scanned. Secondly, I verified if the changes made in the second iteration had any impact on the present build. Finally, testing was done to check if the basic functionality implemented in build one were working and verified if gravity was added to the game objects that were generated. In phase two and three, it was observed through interaction that the players had fun creating game objects, but it was observed that players were facing difficulty in constructing what they wanted to build. More linear models were developed and players took many attempts to build tower like structures.

Figure 2: Added gravity to cubes
Iteration 3 - Different types of textures to game objects
In iteration 3, I implemented game objects with different textures and added buttons to select the textures. In phase one, I tested all the implementation of build one, two and changes made in this build. In phase two and three, participants created specific structures that they could make out of the blocks. Implementing textures to blocks had a huge impact and players associated each texture to some object in the game and thus more meaningful, representational structures like pyramids and forts were built. Even though the players built creative structures, it was observed by following up with a retrospective interview that the players did not experience completeness of the game without a goal.

Figure 3: Adding different types of textures to cubes.

Iteration 4 - Random object spawning, the goal
For this iteration, I implemented a goal to challenge players by creating a random game object spawning above the base image. In phase one, it was important to verify if the changes made in this build had any effect to the previous implementations. I was aiming to see if the random objects generated were spawning at a different location every time a new game was loaded. In phase two and three, it was observed that the player enjoyed the game.

I implemented an MDA matrix to analysis their response (figure 5). Every time they played the game, different creative structures were developed, and emergent behavior could be observed. Players tried different approaches to achieve the same goal and it was challenging. A few started the game by using single texture game object, while others used multiple game object and some even started the construction from the random object itself, building down towards the transparent plane.

Figure 4: Random game object spawning

Figure 5: MDA Framework

Summary:
In this paper, I presented the design approach I implemented in developing an augmented reality block building game connecting the random game object to enhance creativity. An iterative design approach was used to build the game. For each of the four iterations of the game, a new feature was implemented based on the previous playtest and for every new mechanics added, a rapid prototype was developed and tested recursively. Game user research methods such as retrospective, think aloud and observing players during the playtest was used to measure the player’s experience. And MDA framework helped bridge gap between design and development process. It was a constructionist learning process for me to develop the game.

Future:
There are few areas that I would like to consider working on. Primarily, I would like to focus on implementing different polyhedra other than cubes, such as tetrahedron, octahedron and see if it will have any impact on the approach the players build the models. Secondly, it would be interesting to see if this game could be played by
multiplayer, each player taking turns to accomplish a single goal.

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Reference -


