Rover: A virtual reality puzzle game about creating an experience that helps the player rediscover something about themselves, like dream and family.

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Rover

A virtual reality puzzle game about creating an experience that helps the player rediscover something about themselves, like dream and family.

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<tr>
<td>3D</td>
<td>Three-Dimensional.</td>
</tr>
<tr>
<td>AO Map</td>
<td>Ambient Occlusion.</td>
</tr>
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<td>Blueprint</td>
<td>The Blueprint is a visual scripting system in Unreal Engine.</td>
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<tr>
<td>Diffuse Map</td>
<td>The color and pattern of the object.</td>
</tr>
<tr>
<td>High-Poly</td>
<td>3D model with a relatively large number of polygons.</td>
</tr>
<tr>
<td>Low-Poly</td>
<td>3D model with a relatively small number of polygons.</td>
</tr>
<tr>
<td>MAYA</td>
<td>A 3D computer animation software.</td>
</tr>
<tr>
<td>Metallic Map</td>
<td>A metallic map describes which parts of a object are metal or not.</td>
</tr>
<tr>
<td>Normal Map</td>
<td>An image that stores a direction at each pixel.</td>
</tr>
<tr>
<td>PBR</td>
<td>Physically based rendering.</td>
</tr>
<tr>
<td>Proprioception</td>
<td>The sense of the relative position of one’s own parts of the body.</td>
</tr>
<tr>
<td>Real-Time Rendering</td>
<td>Producing and analyzing images in real time.</td>
</tr>
<tr>
<td>RGB</td>
<td>Red, Green and Blue channel.</td>
</tr>
<tr>
<td>Roughness Map</td>
<td>Representing how smooth or rough a surface is.</td>
</tr>
<tr>
<td>Somatosensory</td>
<td>The somatosensory system is a part of the sensory nervous system.</td>
</tr>
<tr>
<td>UE4</td>
<td>Unreal Engine 4</td>
</tr>
<tr>
<td>Vestibule</td>
<td>The sensory system that leads balance and spatial orientation.</td>
</tr>
<tr>
<td>VR</td>
<td>Virtual Reality</td>
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<td>White-box</td>
<td>The prototype of level design.</td>
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<tr>
<td>X, Y, Z</td>
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Abstract

With the development of virtual reality technology, VR is currently replacing old systems and modifying practices and processes in many fields, such as automotive, healthcare, training and psychological therapies (Salanitri et al., 2018). Amongst these fields, the industry of games particularly enjoys an increasingly mature technique in virtual reality technology. It is in no small part because such technology provides an immersive experience during the games, and it in turn enhances players’ comprehension upon the affections incurred in the games. Encountered with such an emerging visual carrier, many products and programs await creation. Throughout this project, motion patterns and visual presentations in the world of games are critically discussed, as well as the distinctive values that are communicated via a combination between virtual reality technology and the view of first person. To present this, players will be provided with inspirations to re-discover themselves from aspects or a dream or a memory.

Keywords

Virtual reality, Interaction design, gameplay design, immersive experience, storyboard, emotional experience, empathy, level design
Introduction

Situation

In today's world, an increasing population would rather work and live in well-developed cities than stay in their hometown, which is even enhanced by the industrialization and modernization. Specifically, in China, there is currently an upward trend amongst the population migrating from rural areas to urban districts. From 2010 to 2017, the urbanization rate increased from 49.95% to 58.52%, with an average increase rate of 1.22%. As to the ratio of permanent residents who are also migrant people, it is respectively 67.7%, 40.52%, 38.01% and 37.3% in the four biggest cities in China, i.e., Shenzhen, Shanghai, Guangzhou and Beijing. In 2012, China's internal migratory population (both inter- and intra-provincial) exceeded 250 million people (Thomas, 2013).

Those adult migrants leave their hometown and separate with their family, which results in today's public attention to "left-behind children". According to relevant statistics, there were as many as 15,505,600 "left-behind children" in the year of 2017. Official figures from 2016 suggest there are 9.02 million children under the age of 16 living without either of their parents in rural China (Hunt & Katie, 2018). Hereby, one question inevitably comes that which is more worthwhile, to give up their career or to give their family.

Problem Statement

When faced with unavoidably increasing pressures in life, many adults are likely to yield to an unfavorable job in an unfamiliar city. It thus results in an imbalance between work and life, negatively influencing their own daily life as well as their family. In this way, it is more recommended to those migrants to take a break from their intense lifestyle and to recognize themselves about what they are really seeking for. This project is thus aimed to provide players with an opportunity to achieve this self-recognition by immersing into the plotted situations created by virtual reality technology, so as to finally realize that family and dream matter much more than a hasty career.
Context

Virtual Reality Technologies
As to the virtual reality technology, during which participants are involved into an interaction with the virtual circumstances, it makes an effective use of people’s cognition to the surroundings, so as to help participants comprehensively perceive a variety of spatial information as well as logical information. The immersive nature of both VR and 360-degree video are understood to substitute real-world sensory perceptions with digitally generated ones, which produces the sensation of actually being in life-sized and real-world environments (Durnell et al., 2018). As virtual reality technology creates a brand new interactive mode, combining both visual presentation and information forms, in the world of games, it thus provides an interactive narrative story to establish the immersive game experience as well as the specific empathy with the players. So, these game players are enabled to genuinely feel the emotions throughout the virtual world. In VR, the immersive environment can be understood as a simulation of different sensory information used to provide context and can provide meaningful and emotional experiences regardless of the technical distinctions. In this way, people participating in both immersive environments can have unique and compelling experiences that were never possible before (Durnell et al., 2018). As suggested above, the access to a perception on genuine emotions is considered as the primary motivation to conduct this research project.

Games and Concepts
With the development in game techniques and its presentation, the electronic game, known as the ninth art, carries the significance not only originated from entertainment. Computer games arguably define the richest and most dynamic form of human computer interaction; they may elicit complex patterns of emotion at multiple and diverse facets of player immersion (Yannakakis et al. 2014). As a vast majority of game designers are taking the products as a channel to express their emotion, games are gradually becoming an art form, similar to paintings and photography, and moreover, these game products are as well significantly influencing every single audience.

For instance, <Detroit: Become Human> tells a story about the fights between androids and human, which raises the relevant consideration to science technology, human nature and conflicts between human races. Moreover, in the <Old Man’s Journey>, the value in relationships is also vividly expressed by helping the old man reflect on his old days.

The way to reveal one’s emotion via games combines the entertainment with logical thinking so as to motivate these players to better understand the main ideas in the games during their involvement. Therefore, it is expected to adopt the channels established in the games when attempting to convey some ideas to the audience, as games are more likely to enhance the acceptability of the audience to one certain idea, which is proved to be more effective and efficient than simple words.
Design Process and Solution

Background and Storyboard

Generally, prior to the creation of one certain independent game, it is suggested to introduce the overall background story as well as the core concept, including, the history and aims of characters, the circumstances, etc. All these factors are designed to immerse the players into the development of the story. As the ultimate expectation is to encourage players to reflect upon themselves, thus, the background story is designed based upon daily life experience in the real world so as to establish players' empathy and increase their immersion. Games can be utilized as an arena for eliciting, evaluating, expressing and even synthesizing emotions, we argue that one of the primary aims of the study of emotion in games is the understanding of players’ emotions and its link with their experience (Yannakakis et al. 2014).

Background story

The main character in this story is a teenager from a distant village, who came to the metropolitan city, expecting to make a great career. However, pressures made him stuck in the endless work during day and night, and gradually, he became exhausted and even confused. One day, he worked so late at night as usual, and could not help falling into sleep on his desk. (The story is illustrated in Figure 1 below.) He dreamed a beautiful dream where he returned home, met his family and friend and recalled his childhood dream. Thus, the story begins in this dream. During the game, players are required to address a series of puzzles and problems to help the character find his lost memories.

![Figure 1. The graphic design of story.](image)

Sketches

After the presentation of the background story, a visual presentation was also established (Figure 2). A picture of the hometown was created, a tranquil small village close to the sea where many old houses stand in rows with a lighthouse extending away to the sea and a peaceful church protecting those lovely residents.

![Figure 2. The sketch of background story.](image)
White-box

Meanwhile, a certain number of simple squares and basic patterns were created by using Maya software so as to establish the whole level in a 3D structure (Figure 3, 4). It was aimed to make a vivid presentation on buildings and terrains inside the game, as shown in Figure 3 and Figure 4.

Figure 3. Perspective view of white-box.
Figure 4. Top view of white-box.

Storylines and Storyboard

During the establishment on the overall 3D structure in the game, further recognitions and innovations were developed in terms of the future presentation which was expected to be achieved. Meanwhile, the major plots and clues throughout the whole game were gradually visualized via composing the play and painting the Storyboard. Specifically, by the simulation in the Storyboard, the expected behavior routes of participants were thus constructed, mainly in relevance to the affection and paths that these players were to be encountered with, such as their birthplaces, the interactive factors, the process to address the puzzles, the ultimate aims to pass game levels, the control on difficulties, etc. It was regarded that such conceptions were very helpful to the control over the procedures in the game, especially in the virtual reality world. Here, players are encouraged to conceive the whole game world from the view of first person with a full focus upon the game experience; thus, every single detail inside the game requires 100% assurance so as to make effective and efficient adjustments upon the overall game procedures. As follows, the first level in the game is introduced.

In the character’s dream, he tried to open his eyes. He found that he was on a vast prairie with an island in the distance. He looked around, only to see a half-opened door, from which a faint light came out, and then, he slowly walked towards the door. However, when he stood up, he found himself out of control dashing forward. He glanced through this half-open door, with the lights inside the room glaring on his eyes, and a few seconds later, he found himself sucked in to another space, a beach. It was a sunset, as the sky became suffused with a bright pink, the surf beating upon the beach, some small crabs scrambling on the beach, and a troop of seagulls sleeping on the water.
Now, players in this game are supposed to help the character find out his memories in his childhood dream. Three puzzles are provided yet hidden in an interestingly designed small island, encouraging players to browse around, as to enjoy and to explore the circumstances is the most important thing during the game.

At the beginning of this game, players are supposed to find a photo frame. Then players will walk around on the island, discover the puzzles and put these puzzle pieces together. Then they solve the puzzle into the frame, and see a little boy playing with a toy boat. Through the puzzles in this level, players are expected to help the character rediscover his childhood dream to become a captain sailing in the ocean.

![Figure 5. Player collect puzzles into the frame.](image)

Based upon the content above, the storyboard (Figure 6-8) is developed as below which visualizes the memory triggers in the game.

![Figure 6.](image) ![Figure 7.](image) ![Figure 8.](image)

*Figure 6, 7, 8. Storyboard shows the process of the game.*
Visual Design

Initial Design and Studies

Prior to the design on the ultimate visual effects, it was firstly to confirm the top view as well as the relevant presentation on the key factors based upon the story. Therefore, it was very necessary to conduct designing concept art. For example, in the first level, players are required to pass the lighthouse and the boat at the destination. Concept design could help arrive at the integrity and harmony throughout the visual presentation by repeated tests on the design of factors and components in the circumstances, and moreover, figure out the clue throughout the following construction on the models and maps. Figure 9 shows the design of fish boat and rough map of first level. Figure 10 shows rough map of second level.

![Figure 9. The initial maps and sketches of first level.](image1)

![Figure 10. The initial maps and sketches of second level.](image2)

Modeling and Texturing

Construction on models was achieved by using MAYA. What is very worth noting is that, due to the excessive production quantity in the modeling as well as the time limits on the project processing, two methods were adopted during the modeling.

Firstly, indispensable models and reusable models should be clarified, and the complicated models were supposed to be modularized. In this way, through the combination of different modules and assets, various models were then achieved, which was practically similar to building block, using the same blocks to make up different structures. For example, in one of the scenes, a large number of tombstones yet in different patterns were needed, and then, such modularization was thus applied to separate each tombstone into the pedestal and the trunk (Figure 11). By combining different pedestals with different trunks, a large number of models for tombstones were created, and they were totally distinctive from each other. Thus, the scene now looks vivid and interesting. Figure 12 shows the final real-time render of environment design.
Secondly, to save time, the next generation modeling approach was not applied which was to make high-poly model in the first place and then to transit it into a low-poly model. Instead, the low-poly model was firstly established, and afterwards, through normal map and parallax occlusion map, the details in the model were then presented. However, it inevitably raised the difficulty in creating the maps. During the creation on maps, Substance Painter was primarily adopted. As UE4 supports PBR rendering, when maps were output, AO map, Metallic map and Roughness map were specifically combined into the RGB channel in one texture (Figure 14), which thus decreased the storage for maps and provided convenience to the optimizing process in late stages. Figure 13 shows real-time render of lighthouse with textures.

Figure 11. The tombstones are separate into the pedestal and the trunk.

Figure 12. The final real-time render of environment design.

Figure 13. The real-time render of lighthouse in UE4.

Figure 14. Diffuse map, normal map, metallic map and roughness map.
What is also worth noting is that, in the virtual reality world, excessively pointed objectives were very much likely to make players in discomfort and tension. However, faces would increase when smoothing the objectives, which would in turn greatly increased the consumption on storage. As such, in order to make objectives in the low-poly model smoother within the UE4, the model to make maps was firstly processed by ‘Soften Edge’ in the MAYA (Figure 15 shows the soften-edge cube), and then input into Substance Painter for the construction on normal map. In this way, the objectives in the UE4 model turned out to be very smooth, which effectively decreased the stiffness resulting from fewer faces.

![Figure 15. The low-poly cube with ‘Soften Edge’](image)

**Level Design**

During the design on levels, integrity and harmony throughout the visual presentation are specially considered. At this stage, apart from the necessity to reasonably place the model into the levels in accordance with Sketches, it is also very necessary to assure each factor and each component in the model is created in the correct ratio.

Particularly, in the virtual reality game world, players are very sensitive to every single factor and emphasize the cognition to these factors; thus, once any illogical objectives occur, the overall immersive experience would be seriously influence, or even ruined. At this stage, all the components of the model are effectively combined with maps throughout the levels, and moreover, a certain number of natural lights and light resources are thus added to the visual presentation, for instance, through a severe fog to amplify the visual effects. The figures (16, 17, 18, 19, 20) below are presenting the final real-time render in this independent game.
Figure 16. The process of modeling and texturing.

Figure 17. First person view of game.

Figure 18. The real-time render of first level.

Figure 19. The real-time render of second level.

Figure 20. The real-time render of tutorial level.
Interaction Design

Movement

In the virtual reality dev community, it has been critically discussed about how to realize the unlimited movements initiated by players. Many game designers have attempted a wide range of solutions and interactive modes. Mainly, these solutions could be categorized into three as follows: teleport, carrier and control. Specifically, as to how to realize teleport, players are required to select a certain destination via the controller, and to arrive at the spot by pressing corresponding buttons. When it comes to the carrier, it is even easier, as players are seated in a carrier which is moving in a certain speed, such as a horse, a car, a ship, etc. With help of the motion of the carriers, players are enabled to move around in the virtual reality world. Hereby, however, the primary means to realize free motion is to control, which is divided into remote control and body control. Firstly, the remote control represents the motion achieved by traditionally pressing the direction buttons, which is simple in operation yet tedious in experience. When it comes to body control as the major motion method to be discussed, issues as follows are supposed to be firstly discussed in priority to the discussion about how to use body control to realize the free motion in the game world.

- Why are the players expecting to move?
- How could the dizziness be decreased during the motion to players?

As to the first question, it can be imagined that in this independent game world, players are required to make interaction frequently with a variety of factors and components, so as to complete puzzle tasks; moreover, the game could not be a simply linear process, and instead, it is a completely open world, which requires the design to allow players to move in a free manner, by freely controlling the directions, like they do in the real world. As to the second question, dizziness has been a significant issue disturbing the sectors of 3D games and virtual reality games. As such, through a certain amount of research, conception patterns to determine whether one would feel the dizziness could be classified as visual, vestibule and somatosensory. The integration of visual, vestibular, and somatosensory components are used to maintain one’s postural balance (Figure 21). Postural control represents a complex interplay between the sensory systems which involves perceiving environmental stimuli, responding to alterations, and maintaining the body’s center of gravity within the base of support (Gaerlan & Mary Grace, 2010).

Figure 21. Dizziness is controlled by vestibule, vision and somatosensory.
At least two out of these three conception patterns are required to be combined so as to lower down the sense of dizziness. For instance, people are feeling dizzy when sitting in a car, which is mainly due to the mismatch between vision and somatosensory. However, when people see a car reversing or moving forward, these human bodies are passively conceiving the sense raised by the reversing or forwarding cars, which is not raised or determined by the human body itself.

But, if the passengers are changed into drivers, they would be unlikely to feel the dizziness, as drivers are controlling the car motion, which makes the vision in good integrity with the somatosensory. In this way, it is easier to arrive at the conclusion that when all the three conception patters are maintained in unity, the dizziness would correspondingly become lowered down.

After realizing the two questions above, one specific motion pattern is thus confirmed, which allows the players to move in a free manner and to control their somatosensory by themselves. Thus, after repeated tests and simulations, such motion pattern as to require players to stand at one certain spot during the game with controllers in hands is selected. Specifically, players are enabled to move their hands up and down, like running, to realize the character motion. Through such simulation to the walking patterns in reality, players are allowed to move in a much more free manner in the virtual reality world, as it has helped lower down the sense of dizziness and meanwhile satisfy the matching requirements between visual and somatosensory, i.e., proprioception. Proprioception is a motion pattern composed of by two methods as follows:
1. Players control the camera and the motion direction by moving their heads;
2. Players decide to move or not by swing their hand (Figure 22).

![Figure 22. Swing hand to move in the VR world.](image)

**Interacting with the Virtual World**

Interaction in virtual reality is often described as the ability of the user to move within the virtual world and to interact with the objects of the virtual world (Nalbant et al., 2006). Interaction with factors involved into
the puzzling activities in the scene is proved to be indispensable, and also, crucial. During the research on the game usability, it is discovered that the audience are mostly those with none experience in virtual reality games, or even with none game experience. Therefore, to such a group of audience, it is proved to be of more importance to make it easier for them to immerse into the games. It cannot be expected that every player would be able to achieve a great comprehension over the game like the designers do, or that the audience could only understand the games through a large amount of practice. As such, the audience would be more likely to suffer from the operations during the game rather than entertain themselves through the participation into the puzzles, and even worse, ignore their affections and values during the games. It is not what every single game designer expects.

In this way, when it comes to the ultimate interaction patterns, all the operation patterns are integrated so as to simply the operation into simply pressing the motion controller trigger which could complete all the interactive operations, such as opening the door, closing the door, grabbing or releasing something, collecting pieces, etc. It provides audience with convenience to avoid the complicated learning process, and motivates them to only focus upon the experience throughout the visual and hearing presentation, and thus, to comprehend the core concept that this independent game is designed to convey.

![Figure 23. Swing hand to move in the VR world.](image)

**Tutorial Level Design**

To every single complex electronic game, a tutorial is more than necessary. The tutorial is aimed to guide and to assist the players to successfully achieve a good experience throughout the game without any external assistance, as well as, to encourage the players to explore the game world. Tutorials play a crucial role in game design, and a properly created tutorial can make a good game a great one (Snyder, J. 2015). However, tutorials in the virtual reality world and the normal games are very different.

The challenge to be faced with is about how to draw the attention of the players. In the virtual reality world, where the players are looking at is unpredictable and as well, impossible to realize. Moreover, it is hardly plausible to control the focus of the audience by controlling the camera, as it would probably decrease their game experience and even result in dizziness. Thus, when designing the tutorial, an
independent level is thus created prior to the play begins. Three guidance methods are mainly applied to complete the certain tasks:

1. **Guide the players where to go via the particles in the scene (Figure 24).**
   In this level, moving particles are designed to fly to the next destination set for the players, and players are able to follow these particles to move around so as to find the tasks. As such, it is aimed to draw the audience attention, and provide them with guidance in the operation. Such guidance method is available in many 3D games, such as <Monster Hunter: The World>, where players are enabled to immediately find the monsters by following the particles.

2. **Apply red bubbles to suggest the current task objectives (Figure 25).**
   A certain number of stubbing red bubbles are added into the game in case that the audience might get lost, as these red bubbles are set to tell them about where to find their objectives. It is similar to the red dots on the apps in the mobile phones when unread news exists.

   ![Figure 24.](image1) ![Figure 25.](image2)

   **Figure 24.** Particles guide the players to the object.
   **Figure 25.** Red point highlight the object.

3. **Use 3D widgets as an interface to guide the players in words (Figure 26).**
   3D widgets are objects in the virtual world that present an intuitive, direct manipulation interface to the user (Wloka, 1995). In tutorial, proper words are necessary. For instance, when the players are approaching the objectives, words will appear in the screen to give tips about what to do next, in case that they get confused.

   ![Figure 26.](image3)

   **Figure 26.** 3D widgets shows the tips of objects.
Implementation in Unreal Engine 4

Many designers are focusing too much on the effects in presenting the effects when considering the functions and visual effects, which results in the ignorance in the potential issues and difficulties during the actual operation. For example, all the functions and visual effects discussed above are supposed to be designed out of the consideration upon the experience rather than the simple words and actions.

In order to address such issues, UE4 and HTC VIVE are mainly adopted. UE4 could realize all the design patterns, and meanwhile, its internal structure is visualized, which provides great convenience to the designers with no programming background. In this way, through most functions and logics could be realized by connecting some pitch points. What is also worth noting is that the compatibility between HTC VIVE and UE4 perfectly realizes the real-time testing upon the project, and then, effectively corrects BUG and achieves the updates. It is more than exciting for any visual designer, as it makes every imagination into reality.

Blueprint

Blueprint is one of the most important systems that this game project relies upon. Blueprint realizes logics and core patterns in many levels, including the switches between levels, trigger on levels, presentation of special effects, and so on. Hereby, it is to specifically introduce the way to realize the core operation in the game, i.e., to operate by moving arms up and down.

Prior to this function, it is necessary to disassemble the function into two major questions, including how to tell the time to move, and how to tell the time to stop moving.

As is known, moving arms is classified into two processes, such as moving up and moving down. Thus, when the players are moving their both hands, it is suggesting that they are about to move; when they only move either arm, the motion is then not authorized. Through the Motion controller from the HTC VIVE, the (X, Y, Z) could be achieved in terms of the players’ both hands; thus, during one certain time, the distance between the two locations of Y refers to the motion distance between the player’s hand. In this way, the players intention to move or not will be even more accurately calculated, and when the distance reaches one certain index, it would be regarded as an effective motion triggered by the player’s hands. Figure 27 shows the flow chart of logic frame.

As shown in Figure 27, the logic frame first records the motion data of the right hand, and then compares it with the threshold X. If it is greater than X, it will enter the AND node, and then the moving status will be triggered. If it is not greater than X, it will exit the logic frame.

Figure 27. Flow chart of movement.
Based upon the logic frame discussed above, Blueprint is suggested to be applied so as to easily and effectively realize the motion function, and moreover, many other functions are expected to be reached by such separation patterns. Figure 27 shows the screen shot of movement blueprint in UE4.

*Figure 28.* Screen shot of movement blueprint.
Results

After such design throughout this project, a test is held to the audience in public, incorporating as many as 32 players (Figure 29, 30) with totally different backgrounds and experiences, and their feedbacks were collected. Of all these testing players, 17 could effectively comprehend the core concept conveyed through the game, while the others were able to do so after some proper guidance. For example, some players communicated their own childhood dreams and described their own hometown in memory. Such positive feedbacks have proved that this research project is valuable, and the primary aim is reached. In the future design program, the content is expected to be enriched so as to enhance the players’ comprehension on the core concept contained by the game. Through this research project, I have gained a further understanding upon the design of virtual reality games, such as the interactive patterns, the motion patterns, the visual presentation patterns, camera languages, and so on. Meanwhile, this research project provides a distinct method to communicate concepts, which is a brand new way to encourage people recognize themselves, as well as something outweighing their busy careers.

Figure 29. Adults and children were playing the game.
Figure 30. Photo of older player.
Conclusion

Virtual reality technology, as an emerging technology, is turning into maturity as well as popularity. An increasing number of designers and engineers are committed to the exploration into this future technology, such as virtual image transmission, virtual communities, and even brain-computer interface (BCI). In this research project, particularly in terms of the interaction patterns throughout the virtual reality games, visual presentation and emotion transportation are both further explored. And VR technology provides a new way to tell story, it can bridge audience and story content by immersive experience, interactive story telling and deepening the understanding of narrative.

To the future generations in this independent game, players’ game experience is expected to be enhanced by enriching the stories and levels as well as improving its affections. Such method to communicate concepts by virtual reality games is a field with great values to be discovered, especially with the constant development in science technology which makes it unlimited in potential.

In conclusion, this project is virtual reality puzzle game with an emotional and interactive story. When players leave this experience, they can rediscover that there is as well some unforgotten memory inside them. When they dream, they can realize what they want, their dream and family.
Reference


