Research on User Experience of VR Games Based on ISM Theory

Yu-Liang Feng¹,², Chun-chin Chen²* and Shu-Ming Wu³

¹Arts Department, Huangshan University, Huangshan, 245041, China
²National Kaohsiung Normal University Department of Industrial Design, Gaoxiong, 82941, China;
³Tung Fang Design of University Graduate Institute of Cultural and Creative Design, Gaoxiong, 82941, China;
*Corresponding author’s e-mail: ccchen@nknucc.nknu.edu.tw

Abstract. This paper explores the starting point of VR (virtual reality) game experience by 5 “W” of care (What, Why, Who, Where and When), uses STEEP method to analyze the problems in different aspects of the user experience, and invites two senior people to evaluate 11 important factors. Then, the factor relationship hierarchy analysis graph is obtained with the ISM theoretical operation, and the VR game users’ problems and goals that urgently need to change are obtained. The main issue in the research is that the quality of the game story determines the experience of the users, and the side issues are the sound effect, art effect, and special effect.

1. Introduction

1.1 Research background and motivation

In 2004, Seligman proposed three positive goals in life: a happy life, a serious life and a meaningful life. Based on the direction of the research in this paper, the goal is determined to be a happy life. and then combined with the eight care levels of society in the care theory, the goal is determined to be care for strangers and distant people. Finally, the caring ethics and users is combined, the goal is determined to be making people free through designing. The sources and clues of problem are determined by the above steps, as shown in Figure 1.

![Figure 1 Research direction](image)

1.2 VR Game Background

Through the highly virtual reality representation technology, VR technology users use helmets, haptic devices, interactive mobile devices, olfactory devices, audio devices, and terminal devices to enter the virtual world, and experience different experience with previous two-dimensional images and input devices. The game industry is a combination of novelty and stimuli. The VR technology has a unique...
immersion and experience, which has injected new attractions into the game industry. Samsung Gear VR, developed by Samsung Electronics and Oculus VR, has been sold more than 5 million units worldwide since its launch in late 2015, which is currently the largest-selling VR device; Oculus Rift, HTC Vive and Google Day Dream VR are all sold within 500,000 units. VR devices are steadily increasing in the market.

Researchers have found that users who have experienced VR games said the games are very novel and stimulating, and the experience is different from the previous game. Based on this comment, the study of VR game user experience has become an important research topic. From the perspective of caring for VR game experiencers, the researchers try to explore the factors of the fascination of the VR game user experience, provide the reference factors for the later VR game designers, improve the game product design level and optimize the user experience and feel.

1.3 5 “W” of care and research purposes

Starting from 5 “W”, understand the affairs, causes, objects, locations, and times of care, and find the entry points and possibilities of the VR game experience, as shown in Table 1.

| What | Influence factors of user experience charm in VR games. |
| Why | User experience promotes development and upgrade of VR game design for a better gaming experience. |
| Who | VR game player. |
| Where | VR game experience store in mainland China. |
| When | In a VR game experience process. |

It is the starting point of design thinking that find out the main problems and goals of the VR game user experience charm factors by rational analysis and discussion.

2. Literature discussion

2.1 VR game

VR Technology was first invented by Morton Heilisch in 1973, which was a first large VR electronic device and was called the ancestor of VR. The development of VR technology is generally divided into four stages: the first stage is the simulation with the sound and shape; the second stage is the germination stage; the third stage is the concept and theory formation stage, and the fourth stage is the theoretical perfection and application stage, which is the current stage and relevant commercial applications is releasing. At present, the VR application field is very extensive, such as: education and training, game industry, simulation laboratory, municipal engineering, architectural display, etc. The game industry is the industry closest to the VR technology that is cognitive by ordinary people. From the perspective of the whole process of game interaction, Tao Yu (2019) proposed that the game interface can be divided into four categories: functional interface, operational interface, story scene interface and sound interface[1]. Yu Aiqi (2016) described the design of an immersive VR game, summed up the design considerations of VR game as a new medium, introduced the game's composition content, target, operation mode, game interface, scene, level design and interactive element design[2]. Huang Maomao (2010) studied the state of human consciousness and body in immersive VR, and consider that, in the VR environment, people are in a special state of separation of mind and body [3]. The purpose of VR is to make people completely immersed in the virtual world. At present, only some requirements are met visually and auditorily. In the future, the real world should be simulated in terms of tactile, olfactory, gustatory, kinesthetic and vestibular sense. The traditional way of interacting between the human and the game world is limited to a certain button controller (keyboard, mouse, handle). The body in the game is stationary, and the feedback only includes visual and auditory information. Chris Crawford, a famous game designer, believes that “interactivity is the selling point of computer games”. Schubert (2001) believes that the acquisition of
on-site reality feeling includes three elements: spatial presence, realness and involvement [4]. Slater M. (2003) has two important introductions in VR, namely Immersion and Presence. Mel Slater defines immersion, which means the objective level of sensory fidelity provided by VR. It is the user's subjective psychological feelings about the system [5]. Riva G (2004) believes that optimal presence requires a perfect combination of form and content [6].

2.2 ISM Interpret Structure Mode
Using ISM to analyze the relationship between the various elements, Warfield (1974) proposed the analysis steps as follows, as shown in Figure 2:

(1) The relationship between the production factors is positive, 0 means no relationship, 1 means that there is a certain relationship, and the different two pairs are compared to establish a relationship matrix.

(2) Using the ISM operation to obtain the reachable matrix.

(3) Convert the reachable matrix into a hierarchical matrix.

(4) Make a hierarchy diagram.

(5) A \( D + R _ D R \) scatter plot is obtained, where \( D \) is the horizontal sum of reachable matrix, and \( R \) is the direct rows sum of reachable matrix. The first level element is the main problem area and the second level element is the main target area.

![Figure 2 ISM analysis diagram](image)

3. Research methods and processes
This study explores the VR game user experience, understands the relationship between various elements through ISM analysis, and uses the analyzed problems and objectives as design starting points to propose the elements that affect the design. We hope this can be used as an important reference in the later design.

3.1 Experimental procedure
The study was conducted in three steps. The first step is diverging and converging. After using 5 “W” to define the target, various aspects of the problems in the VR game user experience are collected, and then uses STEEP method to distribute and divergence to find out the direction that can be further explored and screen. The second step is analysis and discussion, use ISM analysis to screen out the main factors, and then study the correlation and hierarchical diagram between the various elements, and fine the main problems and objectives. The third stage is design creation, design based on the analysis problem and target.

3.2 STEEP analysis
Using STEEP method to analyze the problems of the VR game user experience at all levels, diverging 50 directions that can be explored and developed. And after integrating the concept of high similarity, select 22 elements that are more developmental, and find two other people who are more interested in virtual reality games to discuss and score the 22 elements together, and finally 11 elements are obtained, as shown in Table 2.
4. Research and conclusion

4.1 ISM operation

The ISM is operated according to a fixed algorithm. This study is based on the research method proposed by Hwang & Lin. The main steps are as follows:

(1) First, the factor or element (extracted element) is obtained. From the relationship diagram, factor 3 and factor 1, 3, 4 are related, as shown in Figure 3.

(2) Compare the relationship between the 11 elements to establish a relationship matrix diagram, as shown in Figure 4.

The 11 elements selected after scored. Compared each element pairs, as shown in the following Table 3. 0 means no relationship, 1 means that there is a certain relationship. The relationship between the elements is not necessarily opposite, as shown in Table 3.

(3) ISM operation: establish a reachable matrix

The adjacent matrix adds a unit matrix I and becomes a matrix containing its own causal relationship, which is denoted by B. And then bring B into the Boolean algebra algorithm to convert it into a “reachable matrix”.

When matrix B uses the Boolean algorithm to convert into “B” to n=3, the matrix is no longer changed, and the establishment of the reachable matrix is completed. The log₂(n-1)+1 operation is performed by the successive flat method, when the unit matrix is 5, it takes three times to get the reachable matrix:

The final results are shown in table 4:
Table 4 Reachability matrix

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | D+R | D-R |
|---|---|---|---|---|---|---|---|---|---|----|----|-----|-----|
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 14  |
| 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3   | 1   |
| 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5   | 3   |
| 4 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5   | 3   |
| 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3   | 1   |
| 6 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1   | 6   |
| 7 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1   | 6   |
| 8 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1   | 6   |
| 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1   | 6   |
| 10| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1   | 6   |
| 11| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1   | 6   |

(4) Establish a hierarchical matrix
A. Convert the reachable matrix into a hierarchical matrix
Convert the reachable matrix into a "reachable set and an antecedent set relational table". In the reachable matrix, the straight line is the reachable set, and the horizontal column is the antecedent set, as shown in Table 5.

Table 5 Reachable set and antecedent set relationship

| Element | R reachable set | A antecedent set | R ∩ A |
|---------|-----------------|-----------------|------|
| 1       | 1               | 1, 2, 3, 4, 5   | 1    |
| 2       | 1, 2, 3, 4, 5   | 2               | 2    |
| 3       | 1, 2, 3, 4, 5   | 2, 3, 4         | 3,4  |
| 4       | 1, 2, 3, 4, 5   | 2, 3, 4         | 3,4  |
| 5       | 1, 2, 3, 4, 5   | 2, 3, 4         | 3,4  |

Establish a hierarchical matrix, the same hierarchy needs to satisfy the R=R∩A relationship, the reachable set and the antecedent set are compared as R∩A, and if it is confirmed 1 is the first level, the comparison data is eliminated. And then the second level is deduced until the operation is completed.

(5) Establish a hierarchy graph based on hierarchical analysis, as shown in Figure 6.

Figure 5 Hierarchy diagram

(6) According to the sum of the horizontal elements (D) and the sum of the vertical elements (R) of the reachable matrix, a structural relation graph is drawn based on the data of the paired values (D+R, D-R) in the reachable matrix, as shown in figure 7.-
4.2 Analysis summary
The first layer is of 1 (Experience in quality), an element;
   1 (Experience in quality) influence 2 (art style), 5 (operation mode), 8 (level design), 9 (interaction element), 10 (sound effect), 11 (special effect);
   The second layer is 2 (art style), 5 (operation mode), 8 (level design), 9 (interactive element), 10 (sound effect), 11 (special effect) Six elements;
   Among them, 10 (sound effect) affects 3 (immersion degree), 4 (stimulation degree), 11 (special effect) influence 3 (immersion degree), 4 (stimulation degree);
   The third layer is 3 (immersion degree), 4 (stimulation degree) two elements; 3 (immersion degree) influence 6 (comfort degree), 7 (enjoy degree);
   The main issue is one part: 1 (Experience in quality) The quality of the game story determines the experience of the experience.
   The side issue is divided into two parts. The sound quality of the 10 (sound effect) affects the immersion of VR. At present, the VR game is only focused on the visual but not on the sound effect. 11 (special effects) is known as visual content. The production cost of special effects is relatively large in money and time, but it only affects the environmental and physical realism, and there is still room for improvement in special effects.
   The main goal is divided into four parts:
   Part I: improve the content of VR game production: 2 (art style), 8 (level design), 9 (interactive elements);
   Part II: Improving the VR operation experience: 3 (immersion degree), 5 (operation mode);
   Part III: Improving the experience level: 4 (stimulus degree);
   Part IV: Improving the comfort level: such as wearing, lightweight, etc.: 6 (comfort degree), 7 (enjoy degree).

Foundation project
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