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A Research on the Usability Evaluation of AV Player with Virtual Reality Application*

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ABSTRACT

Since the end of the 20th century, the usability of a product has been highly emphasized such that companies in developed countries have established exclusive groups of experts to research usability. In addition, they have spent an enormous amount of funds to avail the differentiated convenience of their own products. The usability of a product means designing a user-friendly product which a consumer can use conveniently, and companies have used the evaluation system for the usability-oriented users in a lab to use the actual products and evaluating the pros and cons of products. Yet, this system requires budgeting for the establishment of experiment and bringing subjects (users) who live in various locations to the lab, and the relevant conditions might result in the usability outcome which the users experienced in their unfamiliar settings. For this study, the so-called AV Player usability evaluation system was showcased in virtual reality in order to solve the problem mentioned above, and also proving that this experiment in virtual reality could result in the same effect as the former experiments which have used the actual products and working mock-up sessions for the purposes of the usability evaluation.

1. Introduction

1.1 Need for the study

The direction of product design should always be focused on the user convenience, and should also be developed in a form which the users can accept (Won, 2000).

Since the end of the 20th century, the importance of product usability has been highlighted by companies, and advanced foreign companies have conducted research on the usability by creating a team dedicated to the usability for decades.

Today, the digital products can be divided into a control unit where the users organize the product

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and an execution unit that performs the internally commanded functions. The control unit carries on the same cognitive properties that are sensed and reacted, whereas the execution unit does not directly relate to the user, so it is not limited by physical properties such as shape, volume, and material. Therefore, in the design where only a single function was given to one button, a multi-function is used for one button, and it has also demonstrated a product with a black box-like tendency, where it is difficult to guess the use based on the shape alone. As the substance disappears, the usability between humans and products University Master's thesis. becomes more important. As such, it relieves the intellectual burden of digital products, but on the other hand, it does create a need for new intellectual activities, thereby increasing the intellectual burden on the users (Lee et al., 2004).

In this study, we examine whether real products and products using virtual reality may bring about the same effect in terms of the usability evaluation by using virtual reality to reduce the time and cost for the elements of problems which may occur in the usability of the AV Player product, and also intend to prove the effectiveness of the method of using virtual reality for the usability evaluation through the AV Player experiments.

1.2 Design of the study

This study primarily examines virtual reality using the Internet, which is undergoing active development in recent years, through literature. Following which, as for the usability evaluation of the product, we compare and analyze the virtual reality product and the real product through a questionnaire, and prove the effectiveness of the virtual reality centric usability evaluation through the experiment. The AV Player is selected as the test subject, a prototype of virtual reality is produced, the experiment is conducted, and the result is analyzed (Fig. 1).

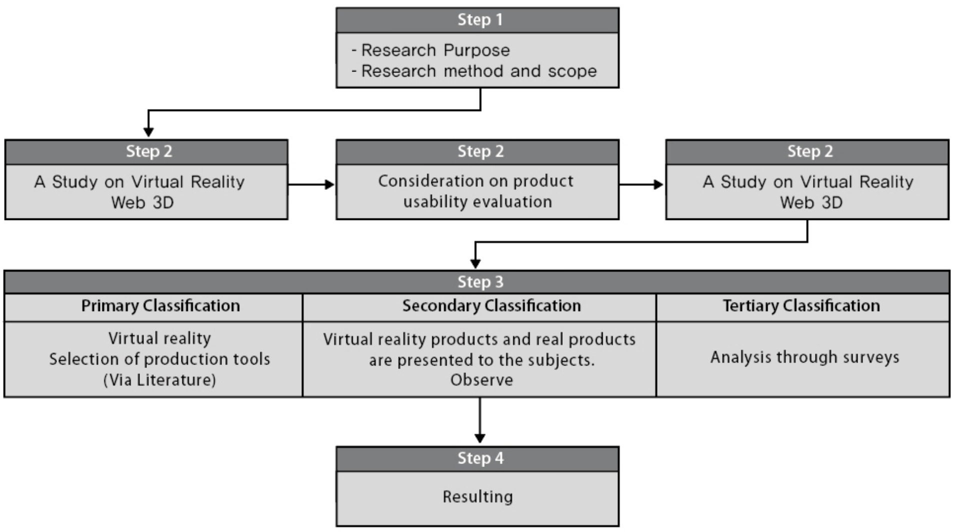


Fig. 1. Flowchart of the study

2. Theoretical Study of the Well-Being Wear Industry

2.1 Concept of virtual reality (VR)

The term VR (virtual reality) is sometimes referred to as artificial reality, and it was first used by Jaron Lanier (VRL Lab, USA) in 1989. Steve Aukstskslines and David Blatner said, “Virtual reality is Interactions with humans representing, hearing, and feeling complex computer-generated data” by definition.

The world of virtual reality makes the imaginary world like reality, and the human body's sensory organs (sight, hearing, touch, smell, taste) are immersed in an artificially created world. It is a world of cyber space, and this virtual space must be directly manipulated by the experiencer, and must be able to interact with everything in the space.

In other words, virtual reality has the effect of recognizing objects expressed in two dimensions as if they exist in three dimensions through sense organs such as sight, hearing, smell, taste, and touch in a three-dimensional virtual space where a computer image is built. Technology (Samsung SDS (2005). IT REVIEW, Understanding Virtual Reality) enables the world of cyber s Space, where all sensory organs of the human body are immersed in an artificially created world, the illusion of being right there, and the experience of real subjects.

Unlike video or simple graphic images, virtual reality based on live-action provides an interactive function that can control all movements and actions according to the intention of the user rather than the intention of the creator, so as to indirectly experience situations that cannot be experienced directly. It is one of the new paradigms in the field of information activity made to be experienced (Fig. 2).

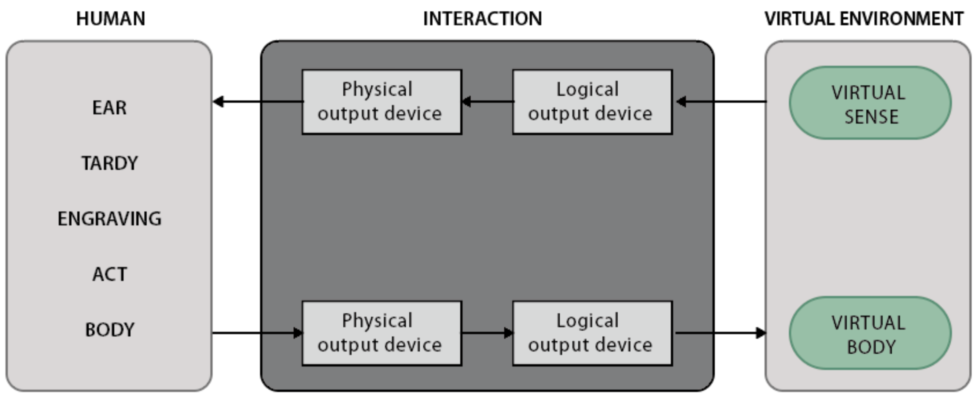


Fig. 2. VR Simulation Validation

2.2 Types of VR (virtual reality) and applications

Virtual reality can be broadly divided into immersive virtual reality, desktop virtual reality, Internet virtual reality, and simulator type. The immersive virtual reality is a virtual reality system that is completely immersed in a three-dimensional environment created using a computer, experiences the world defined in it, and exchanges information interactively. While it is the most ideal virtual reality system, it has the disadvantage of being economically expensive for each individual use. For this reason, it is currently being conducted experimentally in a few special university research labs and corporate groups.

2.2.1 Immersive Virtual Reality

It is a virtual reality system that is completely immersed in a three-dimensional environment created using a computer, experiences the world defined in it, and exchanges information interactively.

While it is the most ideal virtual reality system, it has the disadvantage of being economically expensive for the individuals to use. For this reason, it is currently carried out experimentally in a few special university research labs and corporate groups.

Immersive virtual reality systems include Dome, Screen, HMD (Head Mounted Display), Data Glove, space tracking device, 3D Audio, and an image generating computer that can control these systems and output images (Fig. 3). While they are highly immersed in the virtual world, they have the disadvantage that they can be used only for one-time use. This system has several problems, such as the use of a head tracking device to track the position and direction in advance to draw a real-time image, so it is a system with a lot of room for improvement.

HMD is progressing with the development of glasses-type devices that transmit images by irradiating a laser beam to the human eye (retina) instead of a crude helmet shape. Also, unlike HMD worn on the head, a device called HMD (Head Mounted Display) is a device for observing by placing your head on a periscope-type display used in submarines and rotating the handles on both sides. The advantage of this device is that it can be enjoyed in high resolution without feeling the burden of the weight of the HMD attached to the head.

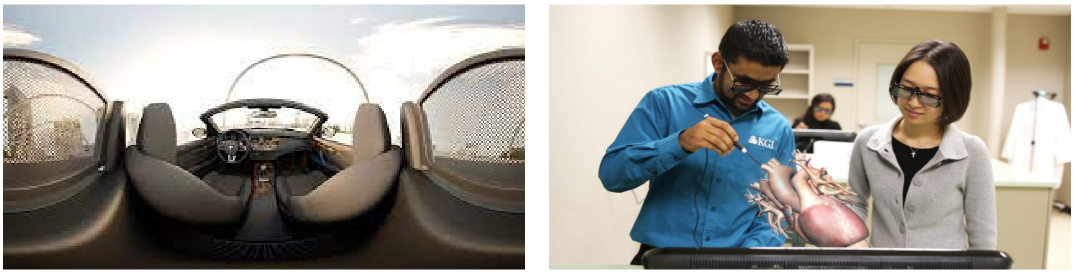


Fig. 3. Immersive virtual reality

2.2.2 Desktop Virtual Reality

It is a system which allows one to feel the virtual reality through images displayed on a graphic screen without a high-resolution screen displayer and cumbersome peripheral devices by using a computer monitor (Fig. 4).

The characteristic of this method is that it has a lower sense of reality and immersion than the immersive type, but it can be popularized. Currently, many university laboratories and companies in Korea are conducting education and research using this system in a way that can be easily used by providing a specific device to the computers that are common around us.

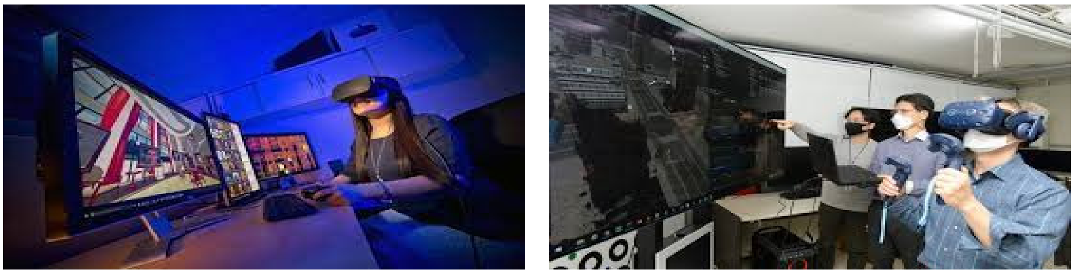


Fig. 4. Desktop virtual reality

2.2.3 Projection type

It is a system in which a user enters a room where a video screen and a video camera are installed, takes a picture of themselves, and displays it again on the screen by a previously planned synthesis method (Fig. 5).

It is a system through which the user interacts with the virtual world only with his or her bodily movements without attaching any peripheral devices thereupon. It appears to be moving in a virtual environment, adding to the sense of reality. The internal software removes the blue image to accept only the user's gestures. At this time, it should be noted that the lighting should not be too bright due to the strength and weakness of the lighting, and the lighting should be installed in a location where there is no shadow generation.

The advantage is that one can enjoy the virtual world in a comfortable position, and the immersion is improved because one can see one’s whole appearance as it is. It is mainly used for entertainment or exhibition events.

Examples of the third virtual reality simulator include election broadcasts of the broadcasting stations and weather forecasts.

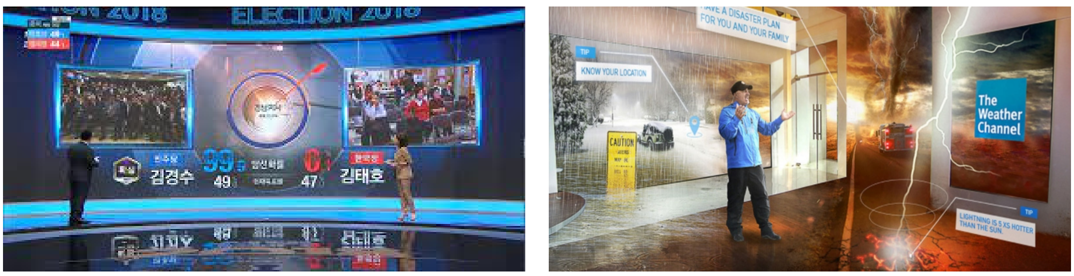


Fig. 5. Projection type virtual reality

2.2.4 Internet virtual reality

Currently, the fastest growing and most important field of virtual reality is the Internet (Fig. 6). This is so because, according to the new version of the Internet standard VRML (Virtual Reality Modeling Language), the development of the first generation of the web-based 3D authoring tools, browsers, and related products has been triggered. VRML2.0, released in August 1996, was developed in cooperation with major Internet companies such as Netscape, Microsoft, Sun Microsystems, and Silicon Graphics. These companies anticipate that the market for online virtual reality training, simulation data visualization, and other technologies will grow rapidly as a stable platform is available. (The human world, virtual reality)

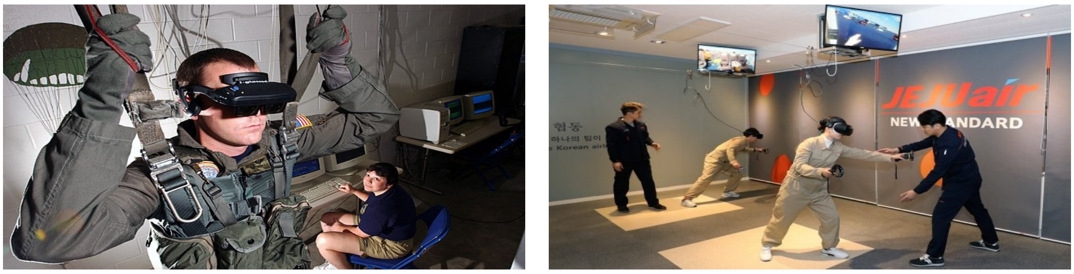


Fig. 6. Internet-type virtual reality

2.2.5 Simulator type

It is mainly used for applications that want to improve the performance of repetitive training, such as in the field of military education and training. This method consumes the most high cost among virtual reality systems, and in particular, it is connected with other peripheral devices, so it is necessary to secure a certain space. In the case of the simulator, it was initially developed for pilot training of aircraft and helicopters (Fig. 7). After that, it developed into a state-of-the-art tangible motion-based simulator with a motion base platform of 6 Degrees of Freedom with three-dimensional position and direction values, and is actively applied for the military training or civilian tangible game machines.

Fig. 7. Simulator-type virtual reality

2.3 Using VR(Virtual Reality) in Product Design

The diversification and individualization of consumer needs, shortening of product life span, high quality, and globalization of competition among companies are leading to an era in which large-scale companies have a relative advantage. In particular, in today's time-competitive environment, how quickly a product is launched on the market is the key to corporate survival, so all companies are focusing their efforts on shortening the product development period. The product design also represents the current situation well.

In order to create a single product, decisions are made while going through processes such as industrial design, engineering design, and production design. From the past few years, the product lead time has been reduced by integrating data for each field, and now virtual reality is being used. In other words, in order to more smoothly support the concept of concurrent engineering, the recently developed concept model is replaced with a digital model, and virtual design technology that performs various tests on this model with a computer has been developed and applied. This model is generally called a digital model, and this digital mock-up is a computer model corresponding to the physical mock-up produced in the initial development stage. It can be used to simulate all development processes of analysis, processing, production, and assembly stages in the initial product development stage (Lee, 1998).

By applying it to the product design, it ultimately played a decisive role in shortening product development period, reducing production cost, and improving product quality.

In addition, if virtual reality is used in the product design process, the product before completion can be visualized, and the usability and interference that may occur while the consumer uses it can be found and improved.

In addition, it is possible to check whether the desired design is achieved by checking the state of the overall layout. In this process, the design can be verified by participating with experts from various fields.

2.4 Define Web 3D

Web 3D is a technical language or programming to reproduce interactive 3D objects or virtual reality (hereinafter VR) world, and refers to all solutions that implement product information with VR technology. In addition, it is a concept that refers to the world of Cyber Space where you can feel as if you are right there by immersing yourself in an artificially created world that creates an imaginary world like reality, regardless of the physical conditions of reality.

In the past, virtual reality technology, which used to work only in specific fields using high-performance image output devices and various equipment, is becoming more and more popular with the rapid development of the Internet and the advancement of personal PC specifications.

2.5 Web 3D technology and content implementation process

Web 3D is a technology that enhances realism such as effective use of textures and reflection effects. The technology for interactive interaction was initially VRML, which provided only fairly limited functions in the early days, but through EAI, the interaction technology of VRML, Java, and JavaScript, It has been solved to some extent, and now many Web 3D technologies based on Java are being announced.

The process of implementing Web 3D content is divided into many stages. Through each process, web content suitable for use on the web and interactive with users can be produced.

There are knowledge required to produce Web 3D, and the following knowledge is required.

1) 3D programs such as 3D MAX, Maya, Lightwave, Rhino, etc.
2) Web or program script or language such as html, Javascript, Java, C, XML, Lingo
3) 2D graphic program such as Photoshop, Paintshop, Illustrator, Freehand
4) Authoring programs for the web such as Dreamweave, Namo, Edit plus, XMLspy

2.6 Types of Web 3D Authoring Tools

2.6.1 Cult 3D

Cult 3D is a kind of virtual reality solution that shows 3D simulations on the Internet in real time. Unlike VRML and programs, which are mainly used in the past, Cult 3D is characterized by being able to easily implement web 3D on the Web (Fig. 8).

3D technology is applied to Cult 3D to enable the real-time reflection, and the data transmission method is consisted of a method by which the user first receives an existing file, previews it, then gradually completes the download. Cult 3D technology is a technology created by a European company called Cycore, and is widely known as a streaming Web 3D technology that transmits sequentially while synchronizing video compression, animation and audio with Progressive Mesh technology. Even on a low-spec computer, it is possible to implement Web 3D graphics with its own engine alone.

Applications of Cult 3D		
		
car	watch	INTERIOR DESIGN

Fig. 8. Applications of Cult 3D

2.6.2 VET

The VET (Viewpoint Experience Technology) developed by Viewpoint allows one to view the demo of the product made in 3D through the screen of the Web browser even with a 28.8K modem. VET is a format for Real-time 3D Rendering that is implemented at a high speed on the Web, and enables high-quality rendering to be implemented at a high speed. (Fig. 9).

Viewpoint has two main functions:

- Ability to show 3D Contents on the Web
- It is a storytelling technology that allows large-capacity images to be displayed on the web.

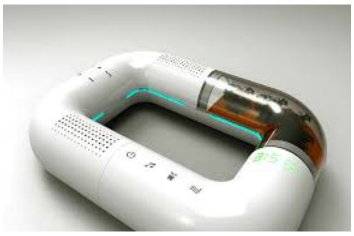
Applications of VET		
		
PRODUCT	SHIP	INTERIOR DESIGN

Fig. 9. Applications of VET

2.6.3 Turntool

Turntool is a Web 3D real-time graphics solution aimed at the growing 3D market on the Internet (Fig. 10). In addition to being able to easily implement a high-quality graphic processing technology and various interactive functions, and while it is a recently released technology, its utility is already appreciated and on the rise across various fields, and unlike the existing Web 3D solution, it provides its own interface. The familiarity of 3D Studio Max, which is the most widely used in the world, and the establishment of various interactions, are used a lot for the web 3D content creations.

The rendering engine, designed with the greatest emphasis on realism, consists of individual components in the library, enabling continuous development and special replay through the efficient update of software. It is done within the interface of 3D Studio Max, providing a friendly user experience. Anyone who has worked with the existing 3D Studio Max can learn it easily.

Turntool is widely used by many companies in the field of architecture, and provides the most powerful and high-quality results for 3D visualization of not only existing buildings but also unfinished buildings and structures. The State-Of-Art-Aliasing function of the object provides excellent quality graphics, providing everything from visualization in construction, architecture, and product fields to spectacular 3D games (Park, 2005).

Applications of TURNTOOL		
		
PRODUCT	INTERIOR DESIGN	AIRPLANE SIMULATION

Fig. 10. Applications of Turntool

2.6.4 AXEL3D

AXEL is an innovative Web 3D solution developed by Softimage's development team, and is a web entertainment program that implements the flash effect in three dimensions. (www.v3d.co.kr) (Fig. 11).

AXEL can be described with the following characteristics.

- Provides an integrated user interface.

By providing a modeling interface for users and a programming interface for designers, modeling, animation, texture, light, and Publish Interactive functions are possible by implementing an integrated authoring environment. Surface creation through Curve, IK & FK (Inverse or forward kinematics) animation, Subdivision Surface, Morphing, etc., are the professional 3D softwares.

- Provides the sequencer function that supports Multiple Animation.

It supports automatic recording function and manual key frame setting function at the same time, and provides various animation effects through particle animation such as flame smoke and shape effect through object transformation. Sequencer shows both key frame and sensor information, and also shows sound flow.

- Provides a powerful user interaction function.

Interaction, the most powerful feature in AXEL, creates event functions with a very convenient and easy interface.

In addition, it is possible to implement advanced animation between objects by providing Pose, Direction, Snap, Spring, and Constraint functions.

- Automatic interworking/interaction between HTML and AXEL files

One can control the AXEL file without knowing the script, and one can also create unique interactions using AXEL's own scripts based on Java.

- Compatibility with Flash

By exporting the contents worked in AXEL as a Flash Movie file, one can export the Flash Movie file in Axel to give interaction. Therefore, the range of 3D expression in Flash, which has been limited so far, has been diversified, and various operations are possible with the Flash files.

- Automatic publishing function

Publishes objects such as Automatic HTML, Code generation, user-defined streaming function, Transparency, Z-Indes, and Windowless automatic script generation.

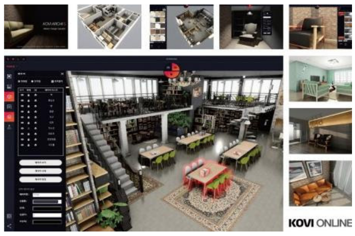
Applications of AXEL		
		
PRODUCT	INTERIOR DESIGN	VIRTUAL SIMULATION

Fig. 11. Applications of AXEL

3. Usability Evaluation

3.1 Concept of Compatibility

Usability means that the users use the product to quickly and easily complete their tasks. This thesis is based on the following four points. (Dumas et al., 2004).

3.1.1 Usability is customizing to the user.

In order to develop an easy-to-use product, one needs to understand and work with the people who can represent one’s current or potential users of one’s product. No one can replace users. Developers, managers, administrators, etc., cannot replace the end users.

3.1.2 Users want to increase productivity by using the product.

A product that is easy to learn and easy for users to use refers to a product that can complete a task quickly, a product that does not require many sculpting steps, and a product that can be used intuitively. Users want to achieve their unique goals by using the product's interface and related documentation.

In the end, in order to develop a product with good usability, it is necessary to understand what the user's goal is. In short, an accurate understanding of the user's job and task is required.

3.1.3 The user wants to complete the task through the product.

We use hardware or software to work and get paid. Hardware and software are tools for the work you do to get paid. Product documentation also exists as a tool to help you use these hardware and software. People are stingy with the time it takes to learn to use these tools.

This is also true for families. Suppose one desires to record using a VCR. The user's goal is to view the recorded program, and the tool he uses to achieve this goal is the VCR. Many VCRs fail usability tests. Users fail to record programs within the bounds of effort and time they put in. Although many VCRs may have high potential, it is well known that they have low usability.

3.1.4 The user decides whether the product is easy to use.

The users, not designers or developers, decide as to whether a product is easy to use. Basically, people are very busy, so they are always weighing whether or not they can get a fair price through their time and effort invested. Among the functions of a word processor, spreadsheet, website, or microwave, if it were easy to learn, easy to use, and easy to remember, it is necessary to talk about how much time and effort should be invested in the functions that would have been used frequently. The learning curve of many products reflects the fact that they are very difficult to learn. Most users end up failing to master a larger number of features. In other words, the majority of users are using only a small fraction of the many features of the product.

3.2 Types and Classification of Usability Evaluation Methods

The usability evaluation method is a method used to check the interaction between people and systems that can improve usability (Lee, 2005).

Currently, a wide variety of evaluation methods have been proposed, and these methods show a significant difference in purpose of use and application period. In addition, different classifications are made depending on the person who studies this. Nielsen (1995) suggested four basic methods to evaluate usability as follows.

- Automatic method: A method of calculating the measure of usability by executing a usability specification through an automated program.
- Empirical method: A method for evaluating usability tests with real users.
- Formal method: An evaluation method using an equation or an accurate model to calculate the usability measure
- Informal method: An evaluation method based on the experience and general skills of the evaluators. The automated method does not find usability problems well, and the structured method is difficult to use and difficult to apply when there are many forms of usability to evaluate. Also, Nielsen (1995) introduced the ease of use evaluation method as shown in the table below, and summarized the advantages and disadvantages of each method, and the phases of the use cycle.

Hom (1998) described the evaluation method as an inspection method in which usability experts evaluate usability, and the evaluator how helpful the user is when performing daily tasks while using the system or prototype. Testing methods to find out by conducting an experiment, and a questioning method in which the evaluator can obtain information about user preferences, requirements, and system comprehension by talking with them, observing, or asking various types of questions (inpuiry method), and detailed evaluation items were presented (Coi, 2005) (Table 1).

Table 1. Hom (1988) usability evaluation method

Types of UEMS	Usability evaluation method
Inspection	Heuristic evaluation, Cognitive walkthroughs, Formal usability inspections, Pluralistic walkthroughs, Feature inspection, Consistency inspection, Standards inspection, Guideline checklist
Testing	General concepts, Thinking aloud protocol, Co-discovery method, Question asking protocol, Performance measurement
Inquiry	Contextual inquiry, Ethnographic study, Field observation, Interviews and Focus groups, Journaled sessions, Survers, Questionnaires, Self-reporting logs, Screen

Perlman (1996) divided the practical usability evaluation method into four categories as follows:

- Inspection: A method that helps developers or evaluators evaluate potential problems, such as empirical inspection methods and evaluation checklists.
- Observational skills and video: A method that can detect major usability problems in the early stage of system development, including accident occurrence methods and user experiments.
- Program instrumentation: A method of classifying frequently used or infrequently used functions by recording the user's use of the system and examining the execution time and frequency of use.
- Survey method (questionnaires): A method to structurally collect information about the usability of a system and to help users to suggest general solutions to evaluators. Gray et al. (1998) largely analyzed the usability evaluation method) method and empirical method. They said that there are heuristics evaluation, guidelines, and GOMS as analytical methods, and various methods expressed as simple user experiments as empirical methods. In addition, they presented the strengths, weaknesses, and outlines of each usability evaluation method.

4. Usability evaluation using virtual reality

4.1 Virtual reality applicability analysis

Virtual reality is the best way to explore and capture design ideas. Virtual reality is a draft or simulation that can be easily changed, at least in terms of usability. There is a wide variety of virtual reality, from very low-fidelity sketches of what the flow of usability or structure will look like to high fidelity interactions that are inherently difficult to distinguish from the final product.

Creating virtual prototypes is an excellent strategy for a number of reasons. Creating a prototype is economically beneficial and concrete, promotes alternative proposals and iterative design, and is a way for users to actively participate in the design phase. A virtual prototype can greatly reduce development costs, and the earlier a usability problem is found in the development process, the lower the cost of solving the problem.

The later in the product development process, the more time and money it takes to change the problem.

Therefore, it is possible to develop a good product in usability only when it is possible to evaluate and improve the design in the early stages of the development process.

Pressman (1992) estimates that the cost of a change is 1.5-1.6 times when it occurs during product development, but increases by 60-100 times after the product is released (Pressman, 1999).

The virtual reality technique is a method of explaining or predicting the contents of an actual task by composing a dynamic model that implements an actual task and allowing the user to manipulate the model. In particular, with the development of computers, the expressive power of dynamic models and the reproducibility of functions have increased, and the values input by the input means can be converted into quantitative input data, making statistical analysis of the data easy, involving strengths, weaknesses, and outlines of each usability evaluation method.

One of the most exciting aspects of creating virtual reality simulations is that it allows users to intervene early and deep into product design. Without a virtual reality prototype, you will have a hard time drawing a picture of what your product will look like. Without a virtual reality prototype, users have nothing to work with until late in the development process, at which point it is impossible to change the product, and if so, it is highly likely to cause a lot of economic loss. Developers who know what is valid and what may not be valid in the technology that will be used in the final product also has information to contribute (Hackos et al., 1999).

There are many things that must be considered when making a virtual reality prototype, such as the efficiency, accuracy, and adoption of the correct model of the virtual reality prototype, but the most important point is the provision of data to be analyzed. In particular, in the case of simulation of the operation contents, there is a high possibility that merely simulating the operation contents is nothing more than an explanation of how to use it. If the purpose of simulation is to find and improve problems with the designed content, a method to measure the operation content is needed for analysis. In other words, the method of content description such as automatic aggregation of various types of data such as the degree of use error during operation, the operation step in which the wrong operation occurs, the recording of the operation time or operation sequence, and the learning effect by repeated operation, and appropriate It is necessary to use an analysis method. If not, it is impossible to judge whether the usability design content is designed to meet the purpose through simulation or whether it has been improved compared to the previous one.

The purpose of using virtual reality simulation in the usability development process is to reduce the time and cost required to develop a program that can be used for experiments with real users. Virtual reality simulation technology is considered as an effective way to evaluate usability in advance. However, there has not been sufficient verification of virtual reality simulation in terms of usability evaluation yet.

In this study, we establish the following experimental hypothesis and conduct an experiment to see if using virtual reality is effective for usability evaluation.

① When using a real product and a virtual prototype, there is not much difference in execution time.

② There is not much difference in execution time when the user's skill level uses the real product and the virtual product.

4.2.1 Selection of experimental products

The actual product of the test subject was selected as an AV PLAYER developed by DM Technology, and based on this model, a virtual reality prototype was produced using Turntool, a virtual reality authoring tool (Fig. 12).

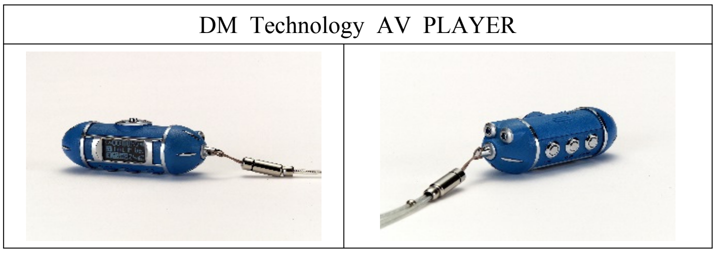


Fig. 12. Real product selection

4.2.2 Virtual product manufacturing process using virtual reality

First, modeling was performed using Rhino 3D in order to produce based on the actual product selected above. And as the next step, each part was exported to 3DMAX and material mapping was performed.

A recently developed program among virtual reality authoring tools that designers can use easily, the Turntool developed as a plug-in of 3D MAX was used to create a virtual reality product.

Then, so that the user can use the function in the product, an event was set in 3D MAX to manipulate the function (Fig. 13).

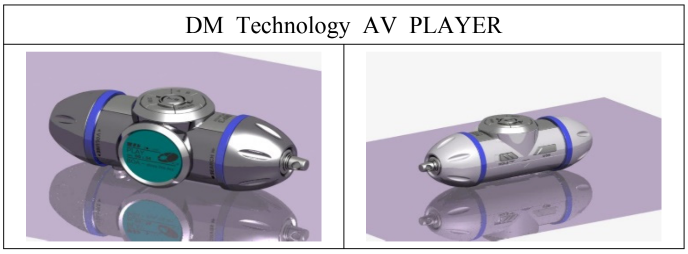


Fig. 13. Real product selection

4.2.3 Selection of functions to be used

In the task selection criteria of this experiment, the functions most frequently used by users when using the Player were defined first.

For task selection, the functions of the player are presented to the people in their 20s and 30s who use the AV player the most (male: 33, female: 17) as shown below, and the three functions that the user uses the most are selected through a questionnaire. Functions were selected based on the survey results.

Through the questionnaire, three tasks were selected based on the data obtained from the questionnaire, which are the most basic functions of the AV Player, such as ① power on, ② play button, and ③ next button.

4.3 Experimental development method

In the process of this study, 100 users in their 20s and 30s were alternately used with real players and virtual prototype players to perform the three functions presented above in the same way. The class used the real product first, then the virtual product, and the rest performed usability evaluation in the opposite process.

First, we conducted an experiment by making a virtual prototype as shown below with the functions most frequently used by users with the AV Player of the virtual prototype for the three functions identified through the questionnaire.

In this study, we try to find out that the effectiveness of usability evaluation of virtual products is good by finding out that there is no difference in execution period between the actual product and the virtual product in the usability evaluation. The function was given a suggestion time of 2 minutes to perform.

Therefore, each operation performed was considered a failure after 2 minutes and the experiment was performed (Fig. 14).

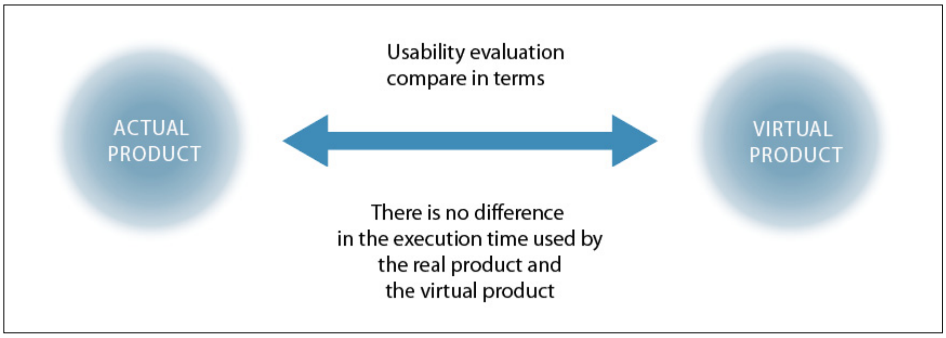


Fig. 14. Experimental development method

4.4 Analysis of experimental results

In this experiment, the data of the AV Player function execution period and the usage error were collected for the result analysis (Table 2). In general, performance speed and accuracy are used as quantitative measures to evaluate human performance and performance of functions. In this study, function execution time was analyzed in terms of speed and usage errors in terms of accuracy. The significance level of these tests was set to 0.05.

The analysis performed by statistical analysis investigated into the number of times for the execution period and usage errors of the function.

First, the significance of the real product and the virtual product was examined for each function, and as a result, all null hypotheses for the function were adopted. That is, it can be seen that there is a statistically significant difference between the two sides. Comparing the average performance time of functions means that the method using virtual reality is significantly superior to the actual product in all functions (Fig. 15) (Fig. 16).

Table 2. Difference between task execution time of real product and virtual product

Assortment	Task 1		Task 2		Task 3	
	Real product	Virtual prodct	Real product	Virtual prodct	Real product	Virtual prodct
Mean	9.75	9.1	5.57	4.49	4.25	3.32
SD	1.67196	1.50853	2.01760	1.62291	1.56512	1.54971
P-value	0.24355		0.27057		0.21573	

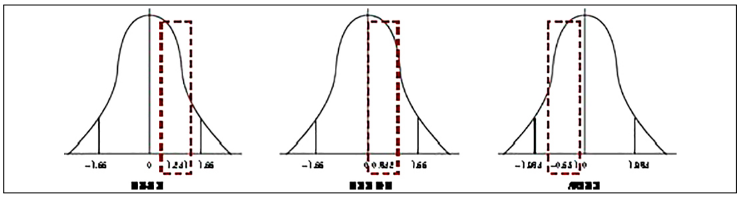


Fig. 15. Acceptance and rejection of the null hypothesis of usage errors

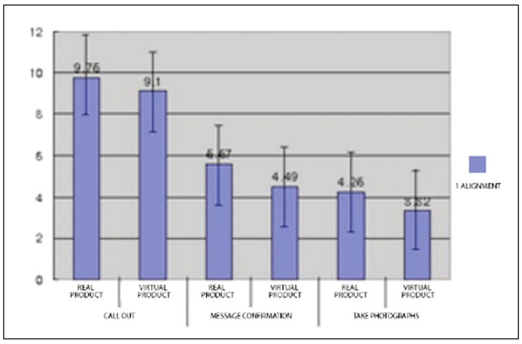


Fig. 16. Average execution time

In addition, the null hypothesis was adopted between the two evaluations in the analysis result of the number of usage errors. However, when comparing the average of usage errors, virtual reality products showed fewer usage errors than actual products (Fig. 17). This also proves the effectiveness of the usability evaluation of virtual reality. When comparing the average completion time for each target function and the average number of errors in use, it was found to be easy in the order of turning the power on, the Play button, and the Next button (Fig. 18). This is the result that was expected before the experiment, and it is understood that the function of the next button has more tasks to be performed, and it is understood that an error occurs to the user because the press of the next button is ambiguous (Table 3). As such, in this study, it was found that the virtual product has a slight advantage in execution time or usage error between the real and the virtual model, but the statistical difference is almost similar. In other words, it can be used as an effective method for usability evaluation using virtual reality.

As a result of this experiment, usability evaluation using virtual reality can save cost and time compared to existing real products, and usability evaluation using cost and time can save money and time compared to existing real products. Was found to be an effective way to obtain.

Table 3. Flatness and standard deviation for usage errors

Assortment	Task 1		Task 2		Task 3	
	Real product	Virtual prodct	Real product	Virtual prodct	Real product	Virtual prodct
Mean	10.77	9.1	7.34	5.98	5.39	3.81
SD	3.10378	2.25173	2.01760	1.62291	3.01585	2.19237
P-value	0.38331		0.35095		0.38291	

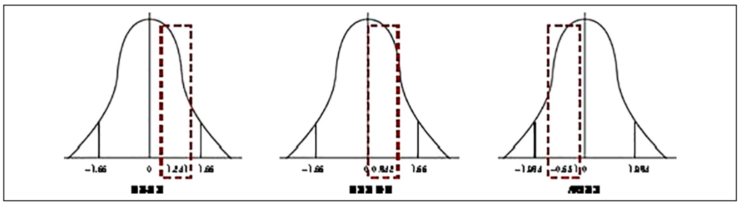


Fig. 17. Acceptance and rejection of the null hypothesis of usage errors

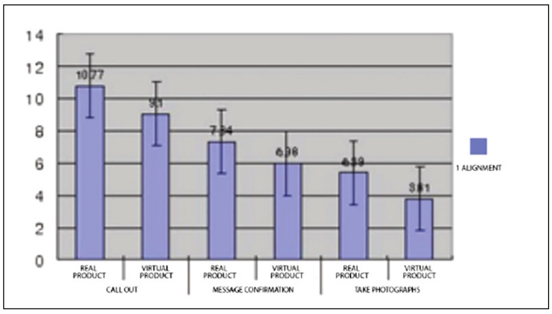


Fig. 18. Number of usage errors

5. Conclusion

Today, due to the digital revolution and various external causes, products are gradually becoming highly functional, multifunctional, and systemized. In addition, microprocessors are installed in products to make them smaller and more intelligent. Due to the black box of products, usability is emerging as a very important decision-making factor for products. In addition, research on design methods considering usability from the product development stage is being actively conducted.

In particular, by reducing time and cost in the design stage and synchronizing the product development process, it provides better services and satisfies user needs through various libraries.

In the existing method, the experiment-based usability evaluation method, which calls the user directly to observe and record usage, is a method that can derive laboratory facility construction costs and unnatural usability evaluation results.

In this study, to solve this problem, an experiment was conducted on a simulation-based usability evaluation method using virtual reality using the AV Player. This method has been proven through experiments that it is an efficient method to reduce the time, effort, and cost required to perform usability evaluation. Also, usability evaluation on the web can be performed. The usability evaluation on the web can reduce the derivation of unnatural usability evaluation across unfamiliar environments. Furthermore, it was confirmed that it is an efficient method in usability evaluation because it can help reduce the cost of building a laboratory by using a camcorder to observe and record the user's behavior.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

Choi, J. M. (2005). A Study on PDA Phone Display Usability Evaluation, Hanyang University, Master's thesis. Samsung SDS IT REVIEW, Understanding Virtual Reality.

Doumas, J. et al. (2004). Usability Test Guidebook, Book Publishing House, Som Media.

Hackos, J. T. et al. (1998). Redish, User and Task Analysis for Interface Design, John Wiley & Sons.

Kang, T. H. (2001). A Study on Effective Texture Expression Methods in Virtual Reality and Web3D, Dongmyung University of Information and Technology, Master's thesis.

Lee, H. Y. (2002). Multi-Centered Ease of Use Evaluation Method, Hanyang University, Master's thesis.

Lee, J. W. et al. (2004). A Study on the Validation of VR Simulation in terms of Interface Evaluation, Digital Design Studies.

Lee, S. H. (1998). Establishment of the vehicle development technology base to shorten the development period of new cars, Ministry of Commerce, Industry and Energy/Ministry of Science and Technology.

Park, S. J. (2005). Design and Implementation of Product Manual Using Turntool, Chungwoon University, Master's thesis.

Pressman, R. S. (1992). Software Engineering: A Practitioner's Approach, McGraw-Hill.

Seo, H. S. (2002). A Study on Usability of Digital Design. Chung-Ang University, Master's thesis.

Vince, J. (1998). Essential Virtual Reality, Spring-Verlag.
Won, J. H. (2000). Designing a 3D VP Simulator for User Interface Improvement, Chung-Ang University Master's thesis.
http://blog.naver.com/webagaci/80011312437.
www.viewpoint.co.kr (2009.1013).
www.turntool.co.kr (2009.1013).