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Design and Implementation of Pneumatic Motion Base for 4D Home Theater

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Abstract

Home Entertainment system is recently being offered by Home Theater & Smart TV with contents service. Also, console game is being played in the media like in TV. The usage of 4D as the main technology in entertainment industry has mostly been limited in Theme Park, Amuse Park, Theater, and contents for Movie and Animation. Some simulation systems for game has been developed but they were made mostly by using electric or hydraulic motion system which cause high power consumption and have a restriction of place for install. The paper is attempted to build Home Entertainment system which makes users feel realistic contents by developing 4D systems for Home Entertainment rather than before. 4D control S/W in which user can insert and edit 4D effects on contents of all areas such as game, movie, and broadcasting is developed. Also, built-in pneumatic cylinder in 4D system which can be easily controlled and managed in home is developed.

***Keywords**: 4D, Home Entertainment, 4D Home Theater, Pneumatic Motion Base*

1. Introduction

The recent home entertainment system has been establishing the content services around a home theater and a smart TV, and a console game is also being provided on the TV as its medium. In addition, there is an increasing interest in the augmented reality, the virtual reality and the game contents along with a declining interest in the 3D video and a more attention paid to the 4D system which makes it possible to deliver a sensory experience [1][2].

The 4D industry is what is produced by adding the realistic vitality to the 3D industry and is most commonly used in a theme park, an amusement park, and a theater. However, the development of a home entertainment system where the realistic contents can be experience is being demanded in accordance with an individualizing social characteristic and a technological enhancement [3][4].

This study has its purpose on developing a 4D Home Theater system which is different from the method

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that accepts the 4D contents that are already made by the existing manufacturers as it can operate with the 4D effects inserted by users. Furthermore, it is designed and simulated to be advantageous in terms of noise, power consumption and management compared to the electric and hydraulic systems by simulating the motion effects in a pneumatic method.

The structure of this study is as follows. The chapter 2 discusses the major technologies of the 4D cinema system, and the requirements to design the home 4D system are dealt with in the chapter 3. Then, the chapter 4 looks at the home 4D system software suggested in this study and the home motion base development, followed by the chapter 5, which concludes this thesis.

2. Technological factors for 4D cinema simulation

The technological factors required to simulate the 4D contents are largely divided into the imaging technology, the sound technology, and the physical effect generation technology. The imaging technology includes a 3D stereoscopic image simulation technology, a large screen for theater, and a three-dimensional monitor for a game machine. The sound technology which is to play music and sound effects simulates a 3D stereophonic sound. By using a physical generation technology, users' senses can be stimulated through vibration, smell, and light. Generally, 4D effects are comprised of motion, vibration, air and light as shown in the Fig. 1.[2][4]

Fig. 1. 4D system effects

The actuator controlling the movement of a seat needs to perform a stop, rotation and reciprocation motion that often happens while operating a motion platform. The motion control system is categorized into the axis 3, 4, and 6 depending on the number of motors which decide a driving axis. More axes enable a more elaborate motion but cause a difficulty in a cost and its simulation.

Actuators are categorized into pneumatic, hydraulic, electric and a method using special materials such as memory alloy [5]. The 4D motion base is composed of a motor type, a pneumatic type, and a hydraulic type, and the motor and pneumatic types are mostly common for a theater.

The pneumatic type is a method where the compressed air is pushed in and pulled out of the enclosed cylinder. The hydraulic type works in a way that a cylinder is pushed by the high-pressure oil. The hydraulic type needs a separate pipe and container to collect and hold the draining oil. As for the driving power, a hydraulic type is more than five times as powerful as a pneumatic type. The response speed of a hydraulic type is faster than a pneumatic one, and the slip phenomenon caused as a reaction to an object does not

happen in the hydraulic type [5]. The pneumatic type has it over the hydraulic and motor type in terms of noise and power consumption, and is more appropriate to product a small scale of motion platform. The table 1 shows the strengths and weaknesses of each 4D simulation method [6][7].

The process where the physical technology is simulated according to an image is carried out automatically through a seat controller and a video signal. The final version of an image includes signals to simulate the physical technologies and these signals are inserted through a programming process. The latency should not occur in a process where a controller interprets and delivers a signal to a device, and the image and the physical effects have to be in an exact sync.

Table 1. Implementation methods comparison of 4D motion [4-6]

Items	Motor Operation Method	Hydraulic Method	Pneumatic Method
System Durability	Excellent	Good	Good
Maintainability	Regular Lubricant Input	Oil Refilling Replacement	Nozzle Checking Safety
Accuracy	Excellent	Good	Average
Composition	Power Supply Motor Driver	Pump, Pipe Compressor Servo Valve	Compressor Pipe Servo Valve
Fusibility	Used in Various Equipment	Construction Machine, Machine Tool, Industrial Robot	Pneumatic Hand Train Door

3. Description of 4D home theater

Along with the development of the Home Theater Infrastructure, a need to develop a 4D system to experience the realistic contents at home has been on the rise. As the recent home entertainment system has been established around a home theater and a smart TV, a console game is also being provided through the TV as its medium. Accordingly, there has been a demand for a home system which can provide realistic and sensory contents in accordance with the increasing individualizing social characteristics and the technological enhancement. The Fig. 2 illustrates the areas, which can be combined with a home 4D system of the home entertainment system [8-10].

Fig. 2. 4D system and home entertainment

The 4D home theater requires a function which makes it work by inserting the 4D effects to a general home theater function as it needs to combine with the existing home entertainment video images or games. Also, in comparison to the existing methods for a theme park and a theater, the effective power, size and weight lightening as well as maintainability is required. It is also needed to simplify the effects such as motion, vibration, air, and light which simulate 4D effects [11].

A development range of the 4D home theater is as follows. Firstly, it needs to be designed as a pneumatic motion base which is advantageous in terms of noise, power efficiency, and management. Secondly, it has discrimination from the method that accepts the existing 4D contents which are already manufactured. Thirdly, it should be able to make an overall simulation of the contents play and the 4D effects including a 4D server, special effects, and a 4D motion base. The Fig. 3 presents the home 4D system environment.

Fig. 3. Environment of 4D system for home entertainment

4. 4D Home Theater Simulator

The purpose of this study is to establish the home entertainment service which enables a sensory experience of the contents at home through the 4D system development. The Fig. 4 shows the 4D simulator components that include a 4D server, a controller, a 4D motion base, and the special effects. The 4D server is in charge of a control program operation, a display and a data communication. The controller is located within the 4D server and the 4D motion base, and is responsible for a control and communications. The 4D motion base and special effects are responsible for the output of each effect through the reception of a control signal from the controller.

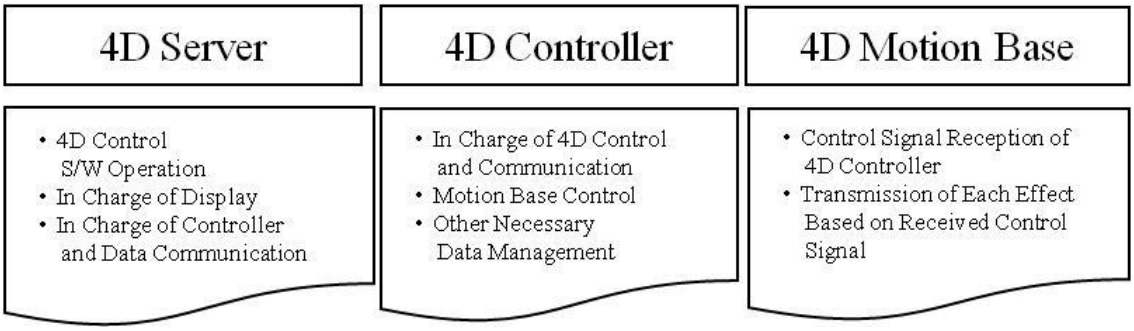


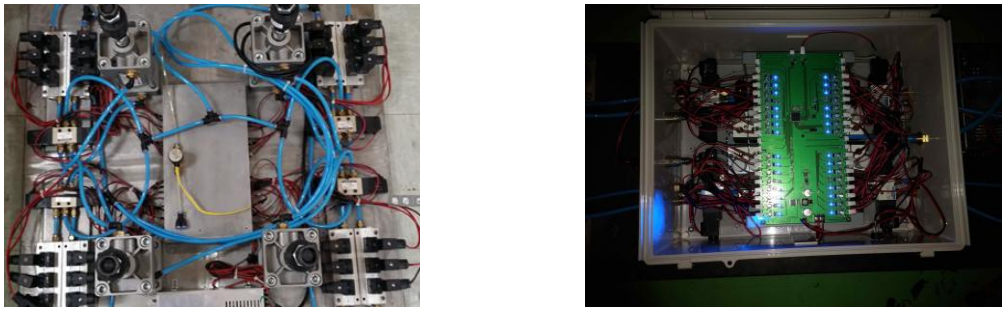
Fig. 4. Diagram of the 4D Simulator Components

4-1. Pneumatic Motion Base

The Fig. 5 shows a simulated pneumatic motion base. The motion base is developed as an integral type with four axes and structured as an enclosed type from the existing open structure with the visible interior. In case of maintenance, the motion base only can be separated and replaced.

Fig. 5. Pneumatic Motion Base

While for the motion of the existing pneumatic method, two pneumatic pipes were needed for the main air IN and the air OUT, it was developed through a modification to operate by comprising only the main air IN. The proposed motion base reduces a cost for the pipe installation and maintenance by modularizing motion base and removing an air OUT pipe. In addition, it was structured to be proper for home by equipping the air valve within the motion base with a noise reduction part and thus, reducing noise from the emitting air due to the reciprocating motion of a cylinder. The Fig. 6 illustrates the proposed pneumatic motion base.



(a) (b)

Fig. 6. Pneumatic actuator (a) Existing Motion Base, (b) Motion Base Modularized

The existing method which used the air pressure had a limit in the motion such as a detailed adjustment. The proposed method can simulate a detailed motion as a result of the development of a control system that makes a progressive adjustment of the amount of the input and output air. This enabled a simulation of a swing motion which is based on the detailed motion. Also, the improved speed control ability relatively reduced a sense of fatigue caused by a rapid motion change.

4-2. 4D Effect Edit Software

The 4D contents that meet various users' preferences are demanded in order to invigorate a home 4D system. This program has its purpose on developing a program where users can control all the motions and effects which are 4D components. The program was developed using the Window 7 O/S based Visual C++ MFC. This simulated an intuitive content play which does not require coding of users and a 4D seat motion,

as well as the input and edit mode of the special effects such as light and air.

The major characteristic of the program is that an independent communication protocol was structured to individually control the user-input external special effects and the seat motion effect code. This made it possible to check and respond to only the relevant part when a problem happens with the simulation of each function. Furthermore, the generality was expanded through a possible recognition and compatibility even when the 4D system update and special effects are added or deleted. The Fig. 7 shows the 4D effect-editing program which is composed of a display part showing an image, a control part, and a timeline based effect input/edit part.

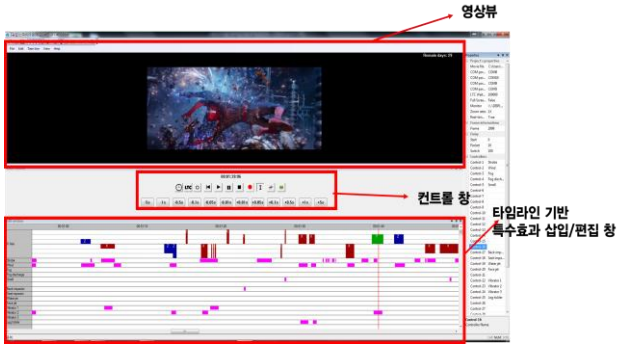


Fig. 7. 4D effect editing program

The Fig. 8 presents a diagram of the air control among the 4D effects. The air effect control data is comprised of an ID to verify a right message, a board ID to verify an arrival at a right place, an 'Effect ID' to differentiate the characteristics of special effects, and a 'Motion Intensity' to distinguish a strength and a weakness of special effects.

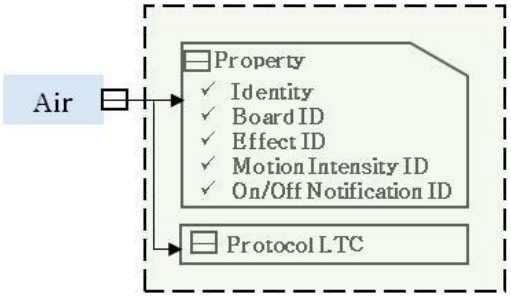


Fig. 8. Schema diagram of Air Type device command

5. Conclusion

The 4D system proposed in this study was designed and simulated around weight, power, noise and user's convenience considering that it is used at home. The pneumatic system design which is excellent in terms of weight, power and maintenance was suggested so that users can easily enjoy the 4D contents at home, and the user-centered program was proposed where the 4D effects can be controlled. The motion effect in the suggested system which is a pneumatic simulation is excellent in noise and power consumption compared to the hydraulic and electric methods, and beneficial in terms of home management.

In addition, it is different from the method which accepts the existing 4D contents in that it provides an

input and an edit mode for the content play, 4D seat motion and all the motions of special effects like light and air, and makes an instant response (synchronization) to a user's input. This increases the number of cases in choosing the 4D contents, and enables users to experience a unique and individualized 4D by manufacturing customized content unlike general content.

The recent home entertainment system has been establishing the content services around a home theater and a smart TV. The proposed home sensory simulation device and software is expected to improve the accessibility to the 4D contents. A further research and affiliation is required to establish a platform of the 4D seat base which can generally control the seats with various designs. Also, the requirements to manufacture the 4D contents need to be adjusted by evaluating the usability of the 4D control programs made by the existing content manufacturers.

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References

[1] J.D. Huh, J.K. Yun, and H.W. Oh, "Trend of Multimedia based Realistic Contents Delivery System," *Electronics and Telecommunications Trends*, Vol. 26, No. 6, pp.180-191, 2013.

[2] Jae-Kwan Yun, Min-Gi Kim, and Jong-Hyun Jang, "Design and Implementation of the 4D-Media Broadcasting Service System in a Smart TV Environment," *Journal of IEMEK*, Vol. 7, No. 1, pp. 9-15, 2012.

[3] Min-Gu Kang and Jean-Hun Chung, "Research for the component of perceptible video content," *Art and Media*, Vol. 10, No. 2, pp. 119-128, 2011.

[4] SooTae Kwon, GwangShin Kim, SoYoung Chung, SunWoo Ko, and GeunHo Lee, "The Analysis of Physical Effects on Presence in the 4D Attraction Film using the Data Mining," *International Journal of Software Engineering and Its Applications*, Vol. 9, No. 2, pp. 163-170, 2015.

[5] Cho H., Kim H.K., Jeon W.J., and Kim K.H., "Technology Trends of Virtual Reality based Motion-Platforms," *Electronics and Telecommunications Trends*. Vol. 29, No. 1, pp. 31-40, 2014.

[6] M Zupan, MF Ashby, and NA Fleck, "Actuator Classification and Selection-The Development of a Database," *Advanced Engineering Materials*, Vol. 4, No. 12, pp. 933-939, 2002.

[7] Schilling Robert, *Fundamentals of robotics*, 2013.

[8] Yongmun Park, Bumsuk Choi, Hankyu Lee, and Kyung Sung, "A Framework of Sensory Information for 4-D Home Theater System," Appl. Math 6.1S, pp. 201S-207S, 2012.

[9] K.R. Yoon, B.S. Choi, E.S. Lee, and T.B. Lim, "4-D broadcasting with MPEG-V," Proceedings on Multimedia Signal Processing (MMSP), pp. 257-262, 2010.

[10] J.S. Han, J.K. Yun, J.H. Jang, and K.R. Park, "User-Friendly Home Automation based on 3D Virtual World," IEEE Transactions on Consumer Electronics, Vol. 56, No. 3, pp. 1843-1847, 2010.

[11] SooTae Kwon, GwangShin Kim, SoYoung Chung, SunWoo Ko, and GeunHo Lee, "A Study on the Physical Effects in 4D," *Advanced Science and Technology Letters*, Vol. 77, pp. 9-13, 2014.

[12] Byung-Wan Han and Sung-jun Lim, "A Study of Video Synchronization Method for Live 3D Stereoscopic Camera," *The Journal of The Institute of Internet, Broadcasting and Communication*, VOl. 13, No. 6, pp. 263-268, 2013.