International Journal of Engineering & Technology, 7 (3.24) (2018) 636-641

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Study of Multi-changeable Control Module Applicable to Physical Void Display

[1]Hyun Yi Jung, [2]Bumseok Seo, [*3]Sungdae Hong

[1]*VR Future Fusion Center*, Seogyeong-ro, Seongbuk-gu,*02717 Republic of Korea*
[2]*DasconInc*, 188-11 Wonjuam-gil, Gwacheon-si, Gyeonggi-do, Republic of Korea,*13820 Republic of Korea*
[*3]*Dept. of Film and Digital Media of Seogyong University*, Seogyeong-ro, Seongbuk-gu, *02717 Republic of Korea*
**Corresponding author Email: sungdaehong @gmail.com*

Abstract

Background/Objectives: This study is to develop a control module for multi-changeable physical display hardware to maximize the visual effect compared to the existing physical display to stimulate the emotion of people and express more various contents.
Methods/Statistical analysis: Designed a daisy chain structure and a PMW type void control unit that can be applied to a multi-changeable void display system for various image expressions, and developed a module that can simultaneously perform linear rotation motion for various types of display. Module with an arm structure was developed so that the rotation and linear motion can be performed at the same time for more variety of display forms and expression of contents.
Findings: The high-speed control unit converges the advantages of the Daisy chain method and the PWM servo control method to increase the data transmission bitrate speed up to 38400 bps/sec, and it is designed to be strong against magnetic field or other RF noise using optical communication. Also, the development of the arm type mechanism enables simultaneous function of the rotation and linear motion which movement divided into 256 steps are possible to express 256 shades according to the direction of the motion and the step.
Improvements/Applications: Expected that it will become a useful display system for the outdoor advertisement market by studying the form and material of the actual module surface after advanced testing in the future study.

Keywords: *digital signage, physical display, Kinect display, module, mechatronics technology*

1. Introduction

Daniel Rozin's [1] 'wooden mirror' series or IART's 'Mega Faces', WHITEVoid's 'Living Shapes' are Kinect type display works that use the physical power of motors. Such display is an aesthetic aspect of display that approaches to people emotionally and is gaining popularity nationally and internationally [2], and the demand for physical display in the digital signage market is also increasing. Mechatronics technology, the base of physical display, has been applied for a long time in the physical display part by converging element technologies such as electronics, mechanical design, control, embedded system, SI and others [3]. Recently, mechatronics technology limited to physical display has been integrated with ICT technology and the number of new patents is increasing. Furthermore, it is possible to express various aesthetic expressions using physical media or materials, which goes beyond the current two dimensional flat display method of LCD or OLED, and is acknowledged as a method that provides an emotional and new experience by organically connecting space and people, people and media. Related to this matter [4], there are an increasing number of application technologies that are capable of artistic expression on existing displays. The physical display industry has high added value due to the fact that it can expand its artistic expression, and it continues to grow as it serves the role as a new digital signage [5]. However, most of the existing displays used to have a limit in displaying different images in real time because the module moves only in one direction or the operation is slow. Therefore, it is necessary to develop a physical display control board and module that are suitable for media contents composed of various colors and images, rather than the simple assembly process module that can only express limited images on the current Kinect type display. In other words, if the operation mechanism for driving the void display is modularized so that it can move the linear motion and the rotary motion at the same time, and the image can be transmitted fast without delay, the display will have competitiveness as a display that is capable of storing various and rich contents.

The object of this study is to develop a control module for multi-changeable physical display hardware to maximize the visual effect compared to the existing physical display to stimulate the emotion of people and express more various contents. The high-speed control unit converges the advantages of the Daisy chain method and the PWM servo control method to increase the data transmission bitrate speed up to 38400 bps/sec, and it is designed to be strong against magnetic field or other RF noise using optical communication. In addition, a module with an arm structure was developed so that the rotation and linear motion can be performed at the same time for more variety of display forms and expression of contents. The developed module and control method can be applied regardless of the display form or material; therefore it was devised so that it can be expanded to a void display for various purposes.

2. Void Display Control Unit

First, the overall configuration of the control unit is shown as in

Figure 1. Each control board has a linkage structure with 4 servo control boards and each servo control board can control at least 64 servo modules, therefore it was designed to control a total of 256 modules.

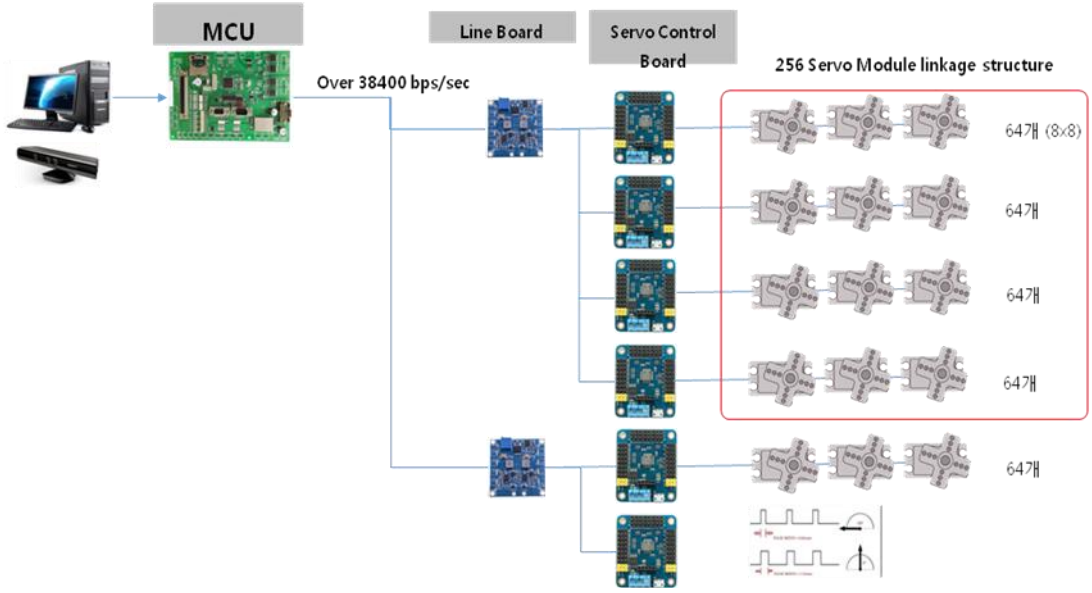


Figure 1:.Module linkage Structure

The overall configuration is divided into a transmission module for analyzing the video image to create each address and encode the data into 8-bit data to transmit the data. At this point, when the data is transmitted, the circuit is duplicated to form a closed-loop to secure data stability. As shown in Figure 2, the sent data is compared with the received data to compare the zero-defect of the data, which compares the received data with the corresponding address, extracts the necessary data, and transmits the next data. This loop structure improves stability greatly because the transmission can be switched between sending and receiving even if one transmission line is cut off. Since this equipment is connected using optical communication, it has an advantage that it is also strong against magnetic field or other RF noise.

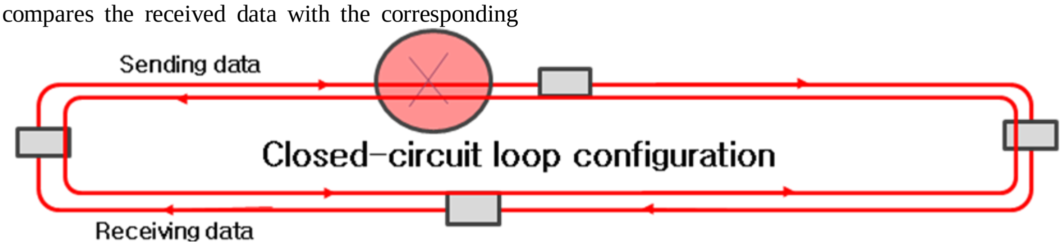


Figure 2: Closed-circuit loop configuration

Daisy chain [6] is a commonly used communication control method. The communication connection method that is applied to the void display was also developed by directly connecting Daisy chain method to the control unit. When applied, the Daisy chain method enables 1:1 direct processing and simplifies product construction or configuration, which increases scalability. However, the problem is that as more Daisy chains are applied, the speed decreases [7]. In order to minimize the speed reduction of the Daisy chain method, the number of Daisy chains is limited to 8 and the number of Daisy chains in the receiver is managed to prevent the speed decrease. The overall configuration of the control unit is as shown in Figure 3.

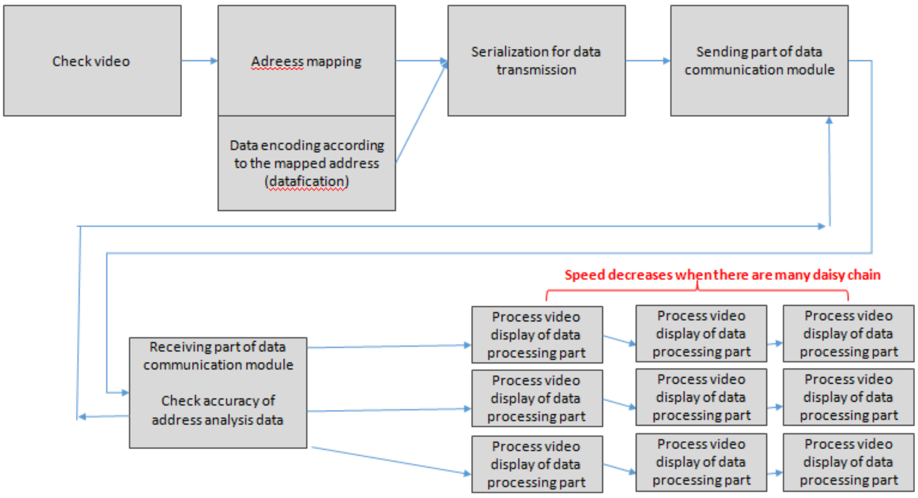


Figure 2:.Overall configuration of the control unit

In the case of the servo control board design, the PLC system is widely used for industrial use. However, since it requires a high-grade server and high priced communication unit, the increase of product cost and the difficult developing environment made it an inappropriate method [8] as this study's object is to materialize the design. Therefore, it was designed to control 256 servo modules by applying PWM [9] method with a relatively simple circuit and low product cost. In the servo control board function shown in Figure 4, 256 depth values of binary data are pulse-converted from data 0 to 256 by FPGA signal conversion.

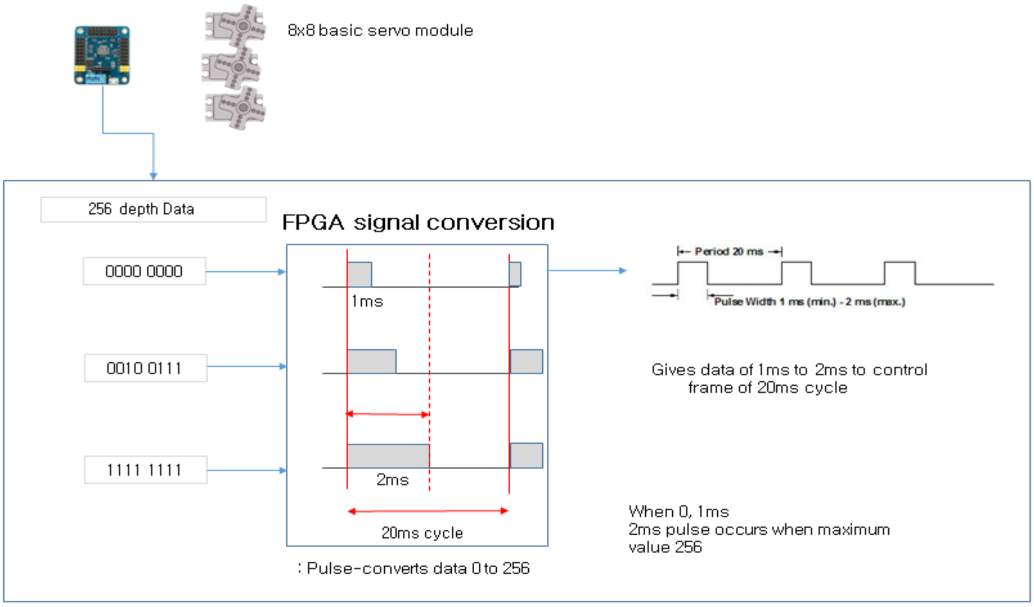


Figure 4:.FPGA signal conversion.

In case of 0, the pulse is 1ms, and when it is the maximum value, 256, 2ms pulse is generated. That is, a data of 1ms to 2ms is given to the control frame of 20ms period. Figure 5 shows the operation method when the data is '0' and the maximum data '256'. Figure 6 shows the actual control board.

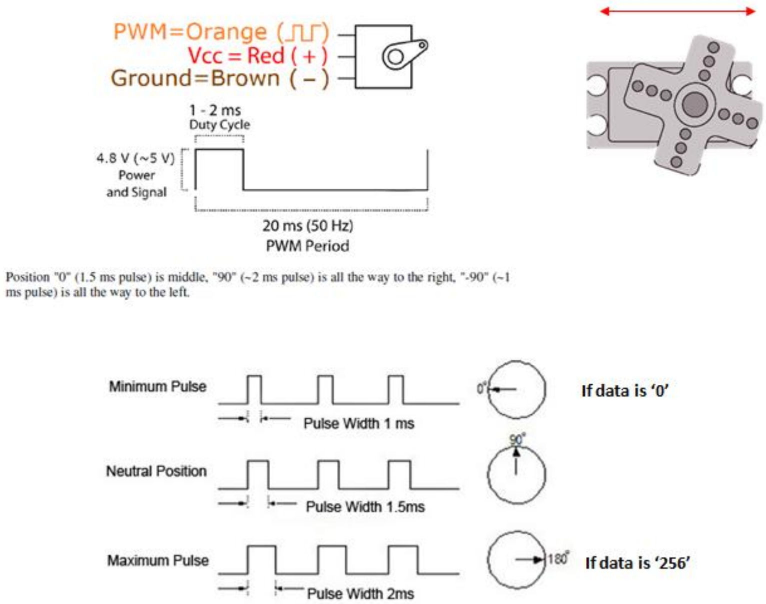


Figure 5:.Operation method of servo

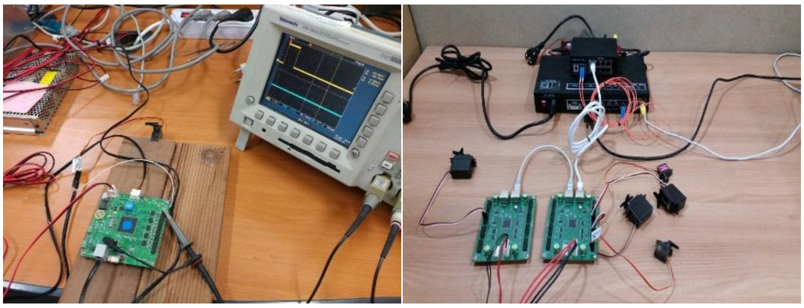


Figure 6:.Actual control board.

3. Void Mechanism

It is a mechanism part that drives the servo according to the pulse control signal from the control board and is composed of a module structure that simultaneously performs the linear motion and rotational motion. The current Kinetic type physical display operates only in one direction, which led to limitations in implementing images such as various forms or colors. Since the resolution of the image that is confirmed through the naked eye is low, it is difficult to implement various sizes, forms, and images. However, as shown in Figure 7, the development of the arm type mechanism enables simultaneous function of the rotation and linear motion [10].

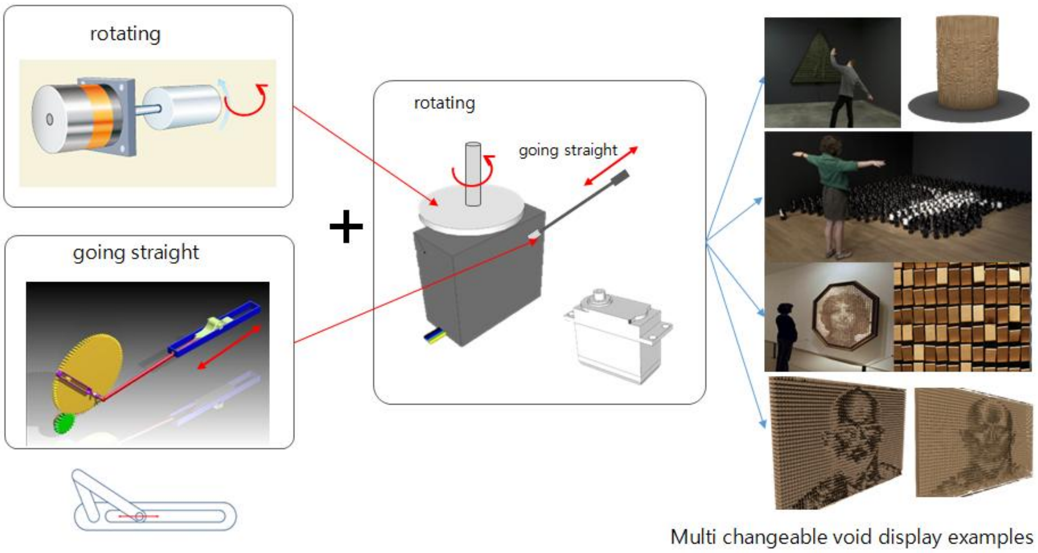


Figure 7:.The development of the arm type mechanism

The movement of the straight line and rotation and the module movement divided into 256 steps are possible to express 256 shades according to the direction of the motion and the step. This technique can express a richer image color representation or form as shown in Figure 8.

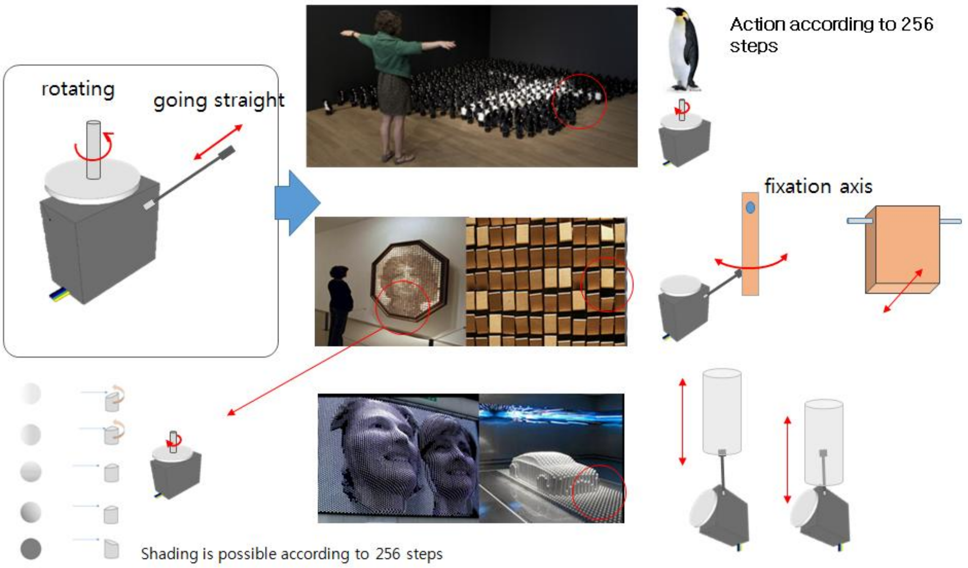


Figure 8: Arm type mechanism express to256 shades

As shown in Figure9, the motor box design drawing shows the arm structure that induces the rotational motion in part 1. The role of part 2 shown in the figure removes the rotational motion of the force and fixes it in a pipe shape so that it can go straight, finally transmitting the direction of the wire in a straight line. At this point, the piano wire can be moved to transmit the force without warping.

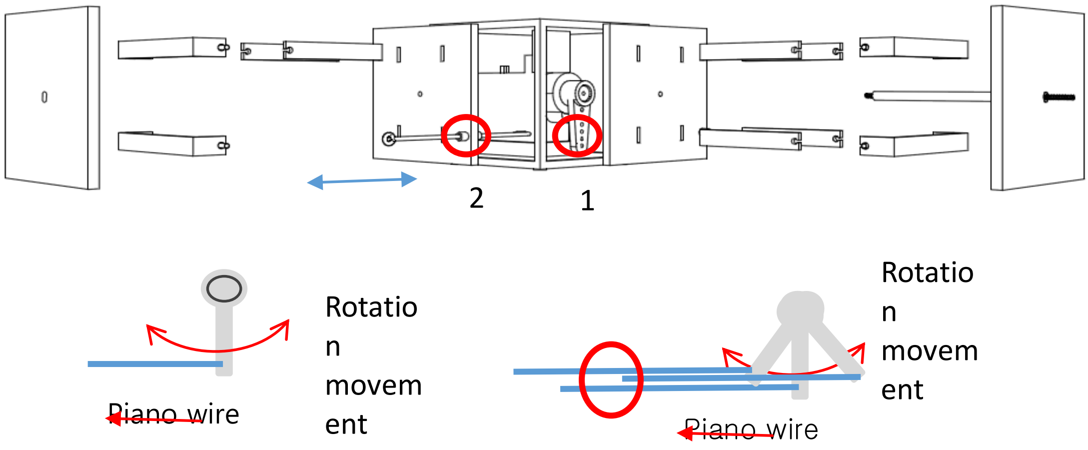


Figure 9: Arm structure and two-way movements

The motion of the arm structure is lost as it goes towards the end of the arm structure, therefore the motion of this part needs to be compensated. In other words, due to the nature of rotational motion that it performs radian motion, the motion of the linear motion becomes smaller as it goes to both ends. To check the scope of loss of the motion in accordance with the pulse control signal, as shown in Figure 10, if the data is 0 and the data is 256, it is compensated for the loss of linear motion by giving more motion, and when the data is 90, it is compensated equally on both ends by giving less motion. As a result, when converting data 0 to 255 to PWM, it is necessary to transform this pulse to obtain a standardized linear motion during a linear motion.

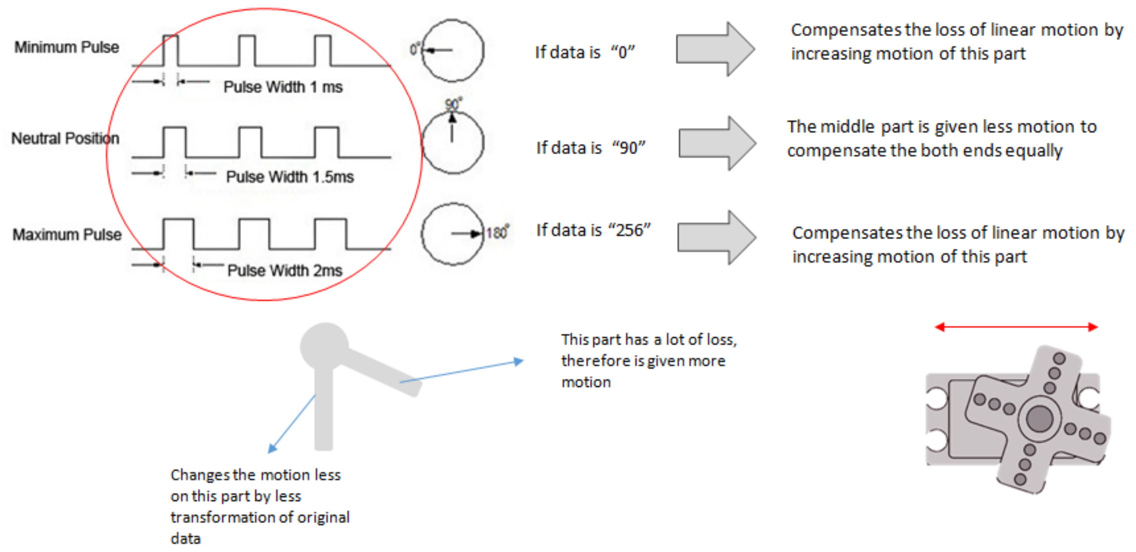
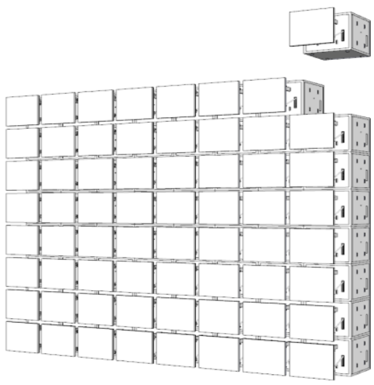


Figure 10:.The scope of loss of the motion in accordance with the pulse control signal

A completed module is modularized as shown in Figure 11 so that modules can be formed successively from small to large size, and it can have a multi-changeable structure that can be formed into a form capable of linear and rotary motion. The completed module is shown as in Figure 12.



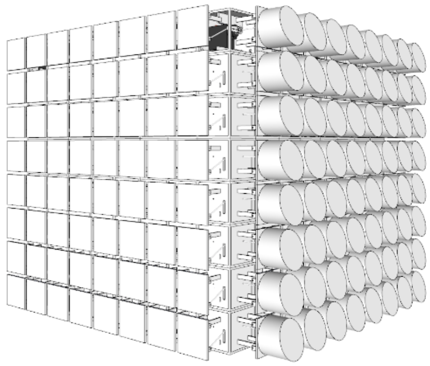


Figure 11:.8x8 a multi-changeable structure and straight, rotation mixed composition example

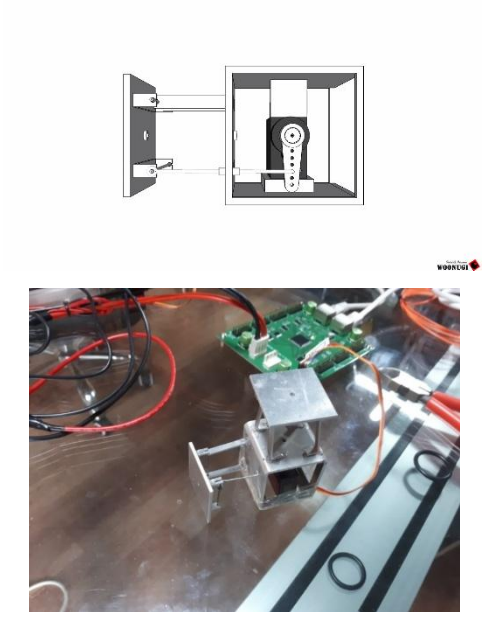


Figure 12:.Actual module image

4. Conclusion

In this study, we designed a daisy chain structure and a PMW type void control unit that can be applied to a multi-changeable void display system for various image expressions, and developed a module that can simultaneously perform linear rotation motion for various types of display. A module capable of simultaneous linear motion for various types of displays has been developed. Video image is processed into 256 data and transmitted to the control unit. Dual closed-loop configuration was used to increase stability and speed was greatly improved to 38,400bps/sec. Since the developed module is capable of linear motion and rotational motion, the aesthetic expression has been extended due to clearer resolution and dynamic form. In addition, because the module can be manufactured in a desired size, it is possible to overcome the limitations of existing physical displays. It is expected that it will become a useful display system for the outdoor advertisement market by studying the form and material of the actual module surface after advanced testing in the future study.

Acknowledgment

This research is supported by Ministry of Culture Sports and Tourism (MCST) and Korea Creative Content Agency(KOCCA) in the Culture Technology(CT) Research & Development Program 2017.

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