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Design and Implementation of an Innovative Raspberry Pi Auxiliary Device with Mountable Display

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Abstract: The purpose of this study is to develop an auxiliary device that securely supports and stabilizes a display device combined with a Raspberry Pi. To this end, the researcher analyzed existing Raspberry Pi boards, commercially available Raspberry Pi stands, and related public perception using big data analytics. As a result, it was found that most existing products had certain limitations. Especially, there were many shortcomings in terms of convenience when combining a display with a Raspberry Pi. Furthermore, through the analysis of public perception, it was possible to identify various key words related to Raspberry Pi. Based on this information, the researcher designed a new Raspberry Pi stand which is proposed in this study. The developments introduced in this study are as follows. The auxiliary device achieves enhanced stability through specially designed plates and fastening holes. Additionally, it enhances mobility and facilitates seamless connections with other devices via a mobility module and coupling member engagement groove. This innovative auxiliary device not only effectively supports the combination of a display device and Raspberry Pi but also provides invaluable support for diverse educational activities involving the Raspberry Pi platform. In this study, the development of a Raspberry Pi stand was presented, but its effectiveness in real-world applications was not verified. Future research should apply this stand in practical settings and conduct its effectiveness verification.

Keywords: Raspberry Pi, Display Device, Experimental Auxiliary Device, Programming Learning

1. Introduction

Developed by the Raspberry Pi Foundation in the UK, Raspberry Pi is a small single-board computer that is widely used in education and research due to its performance and convenience. It can be connected to various devices via HDMI and USB ports and can access the internet through built-in Ethernet and Wi-Fi. It also uses a Linux-based operating system, enabling it to support various programming languages (including Python and Scratch) that are utilized in maker and software education.

Multiple studies show that Raspberry Pi is an effective tool for elementary school students' programming learning[1] and can be used to set up remote lab environments for high school students' physics experiments[2]. Raspberry Pi is also used as an essential tool in computer science and engineering education for the Internet of Things (IoT)[3]. Moreover, it can be used to set up a digital measurement system that students need to perform actual physics experiments[4]. These findings provide rich examples of how Raspberry Pi can be used in educational contexts and show how it can enhance students' learning experiences and outcomes.

However, the uses of Raspberry Pi remain limited. First, Raspberry Pi is typically used in conjunction

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with external displays—generally small displays in experimental environments. As a result, the Raspberry Pi often protrudes beyond the display, making it difficult for users to check the screen. Second, in certain experiments using Raspberry Pi, such as car control experiments, attaching the display and Raspberry Pi to modules is challenging, and constructing such modules can be time-consuming.

These issues highlight the growing need for auxiliary devices that allow users to easily check and operate a display device screen combined with a Raspberry Pi. Meanwhile, demand for experimental auxiliary devices that facilitate Raspberry Pi-based experiments, particularly experiments like car control, is also growing.

In attempting to address the above problems, this study has two specific goals. First, it sets out to develop an experimental auxiliary device that supports a display device combined with a Raspberry Pi. Second, it seeks to allow users to freely modify the structure of the device to align with the purpose of the experiment. In pursuing these goals, this study aims to enhance user convenience and increase efficiency in conducting experiments. In so doing, it will help Raspberry Pi, with its small size and powerful functionality, more fully enhance students' learning environments and experiences and enable them to develop practical skills in various academic fields.

2. Related Studies

2.1 Research regarding the Educational Applications of Raspberry Pi

As a result of its affordable price, high availability, and versatile applications, Raspberry Pi—a prime example of a single-board computer (SBC)—has been widely used in educational environments. Indeed, its compact size, cost-effectiveness, and flexibility make it a popular platform for experiments and projects across disciplines[5]. Specifically, Raspberry Pi has been recognized as an effective tool in IoT (Internet of Things) education. Undergraduates majoring in computer science have had enhanced learning experiences designing and implementing IoT systems directly using Raspberry Pi[3]. Furthermore, introducing Python programming and Raspberry Pi-based projects to elementary students has significantly improved their problem-solving abilities and creative thinking[1]. Such experiences contribute significantly to nurturing the technological literacy needed in future societies.

Meanwhile, Raspberry Pi has also played a central role in the development of remote laboratories. Particularly during the COVID-19 pandemic, when physical restrictions were imposed on educational sites, remote laboratories that use Raspberry Pi significantly assisted high school students in learning physics[2]. In addition, Raspberry Pi has been used as an essential tool for setting up digital measurement systems necessary for physics experiments. In this way, it enabled students to experience the process of collecting, analyzing, and storing data obtained from physical sensors in real-time, thereby giving them a deeper understanding of the scientific method[4]. Finally, in the field of process control education, the introduction of practical instruction regarding robot design and control using Raspberry Pi has allowed students to enhance their abilities to solve real-world problems[6].

These studies demonstrate the various educational possibilities of Raspberry Pi, suggesting ways to assist students in gaining a deeper understanding and experience of subjects through the integration of technology into education.

2.2 Research on Big Data Analysis and Product Development

Big data analysis has become an essential tool in modern business and research fields, facilitating a deeper understanding of user perceptions and the development of innovative products and services.

For instance, Lee and Bang focused on the utilization of big data in the cosmetics market[7] and successfully developed the concept for the anti-aging cosmetic brand “Logically Skin” by analyzing

SNS data. Their work demonstrated the significant role AI-based sentiment analysis can play in the contemporary market.

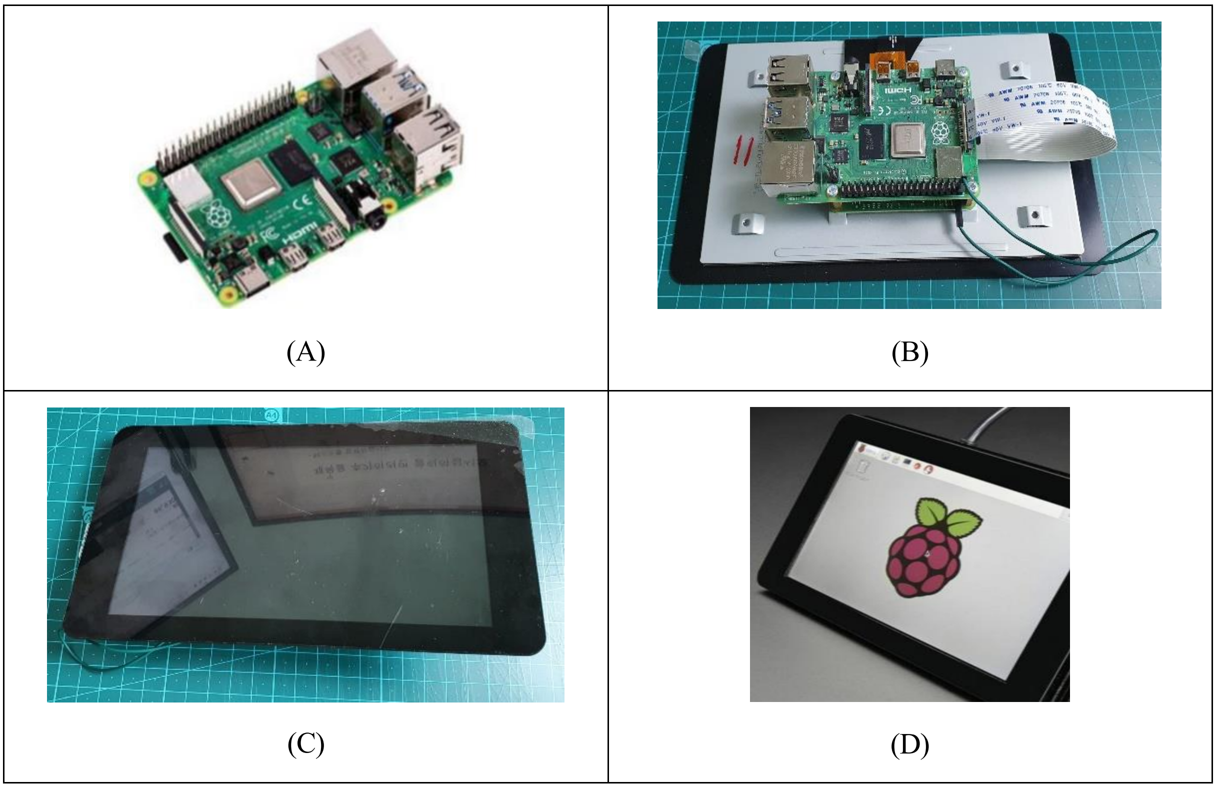
Meanwhile, focusing on the design field, Kim and Nam[8], proposed a method for analyzing user needs and perceptions through online reviews. Specifically, by deeply analyzing reviews of air purifiers, they meticulously extracted users' expectations and requirements.

Such studies illustrate the pivotal role of big data analysis in product development and understanding user perceptions. The current study utilized a similar approach to establish a development direction for the Raspberry Pi holder.

3. Development Process

3.1 Analysis of Problems with Existing Products

This study was conducted to overcome the limitations of Raspberry Pi and associated display devices. The currently sold Raspberry Pi 4B model (Fig. 1(A)) operates by connecting to a monitor via an HDMI cable or using a Raspberry Pi-specific touchscreen (Fig. 1(B)). The most significant issue when using these two devices together is the absence of a method to stably position the touchscreen (Fig. 1(C)). As a result, users incur additional costs purchasing separate devices (Fig. 1(D)) that can mount the touchscreen. These devices also have the disadvantage of being difficult to repurpose for other uses. This study aims to solve these problems and enhance user convenience.



(A) (B) (C) (D)

[Fig. 1] Raspberry Pi and Display Device

(A) Raspberry Pi boards available on the market, (B) The appearance of a display device combined with the commercially available Raspberry Pi, (C) Display devices that cannot stand when combined with a Raspberry Pi, (D) The appearance of purchasing a separate product to stand the display device.

3.2 Analysis of Public Perception

This study set out to develop a stand for the Raspberry Pi to be used in educational activities. To this end, general public perceptions regarding "Raspberry Pi + Education" were analyzed. The required data was gathered using the comprehensive big data analysis solution website Textom (https://www.textom.co.kr). Textom is a web-based solution that collects data from major portal search sites both domestically and internationally, and conducts various analyses[7]. This site makes data collection and refining processes easier and more convenient than traditional methods using R or Python. The search was conducted exclusively with the portal site Naver because Naver has the highest average inflow rate of all domestic portal sites[8], and online posts about particular topics typically appear across multiple portal sites at the same time [9].

Researchers conducted a big data analysis on Textom, focusing on the keywords "Raspberry Pi + Education". The data collection period ran from March 1, 2012, when Raspberry Pi was first released, to May 31, 2021 A total of 5,816 pieces—3,246 Naver blogs, 1,003 news articles, and 1,567 cafe posts—were collected. The total volume of the collected data was 2,209KB.

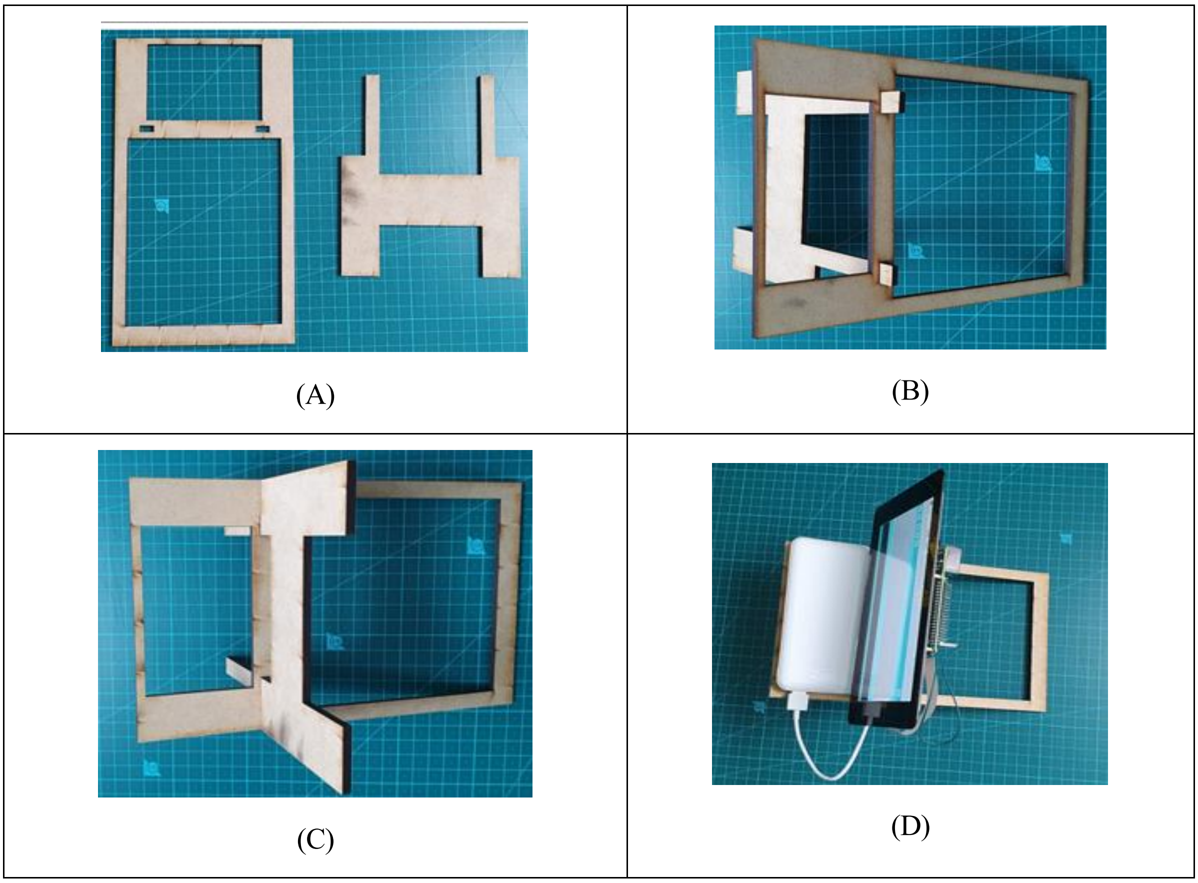
After refining the texts, a frequency analysis was conducted; <Table 1> shows the top 30 keywords. The researcher utilized some of these 30 main keywords as reference materials in the development of the stand. For instance, the 6th ranked keyword "coding (1,028)" and the 7th "students (802)" suggest that students in coding education would be likely to use such a stand extensively. Accordingly, the stand was designed to facilitate easy assembly and disassembly. Additionally, the 11th keyword "project (455)" and the 18th "kit (389)" supported the idea of designing the stand as a kit for easy application in project activities.

[Table 1] Big Data Analysis Results (Frequency Analysis) of “Raspberry Pi + Education”

No	Keyword	Frequency
1	Raspberry Pi	5,624
2	Education	4,254
3	Arduino	1,974
4	Utilization	1,909
5	Computer	1,066
6	Coding	1,028
7	Student	820
8	Development	631
9	Maker	470
10	Board	464
11	Project	455
12	Program	438
13	Internet of Things (IoT)	436
14	Programming	426
15	Python	423
16	United Kingdom	409
17	Progress	406
18	Kit	398

19	Course	388
20	Basic	358
21	Robot	331
22	Software	326
23	Various	323
24	Production	303
25	Artificial Intelligence	287
26	Practical Training	283
27	Foundation	280
28	Technology	267
29	Coding Education	267
30	Scratch	266

3.3 Research and Experiment Process



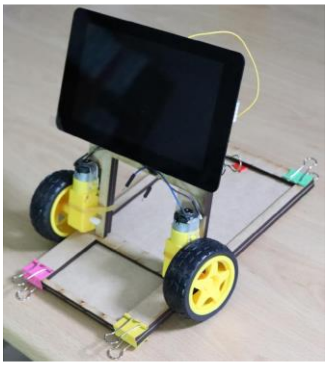
[Fig. 2] Basic Structure of Raspberry Pi Stand

(A) Two MDF boards that can accommodate the display device, (B) Joining process 1 of the two MDF boards, (C) Joining process 2 of the two MDF boards, (D) The appearance of the display device mounted on the stand made by joining the two MDF boards.

The researcher conducted research and experiments based on the public perception insights ascertained through the investigation of existing products and big data analysis. The process was as follows. Initially, various designs and prototypes were designed and improved using a laser cutter and Medium Density Fiberboard (MDF). The process began with simple forms that gradually increased in complexity.

[Fig. 2](A)–2(D) show a stand made using two cut MDF boards. This structure is erected by fitting one board into another.

Using the shown in [Fig. 2], the researcher attached a Raspberry Pi to the display device to develop a basic display device, as shown in [Fig. 3](A). This display device is capable of various modifications. For instance, [Fig. 3](B) shows a basic display device transformed into a car module. In this case, attaching additional parts to the stand makes it possible to transform it into a car that can be directly controlled with a mouse and keyboard, as shown in [Fig. 3](C). A more complex modification example is the car module using four MDF boards shown in [Fig. 3](D). By adding two boards to the initial two boards, the researcher created a space where additional devices such as auxiliary batteries, sensors, and motors could be placed.

 (A)	 (B)

[Fig. 3] Raspberry Pi Stand Utilization Examples

(A) A basic example of a Raspberry Pi mount, (B) An example utilization as a car teaching tool.

4. Results

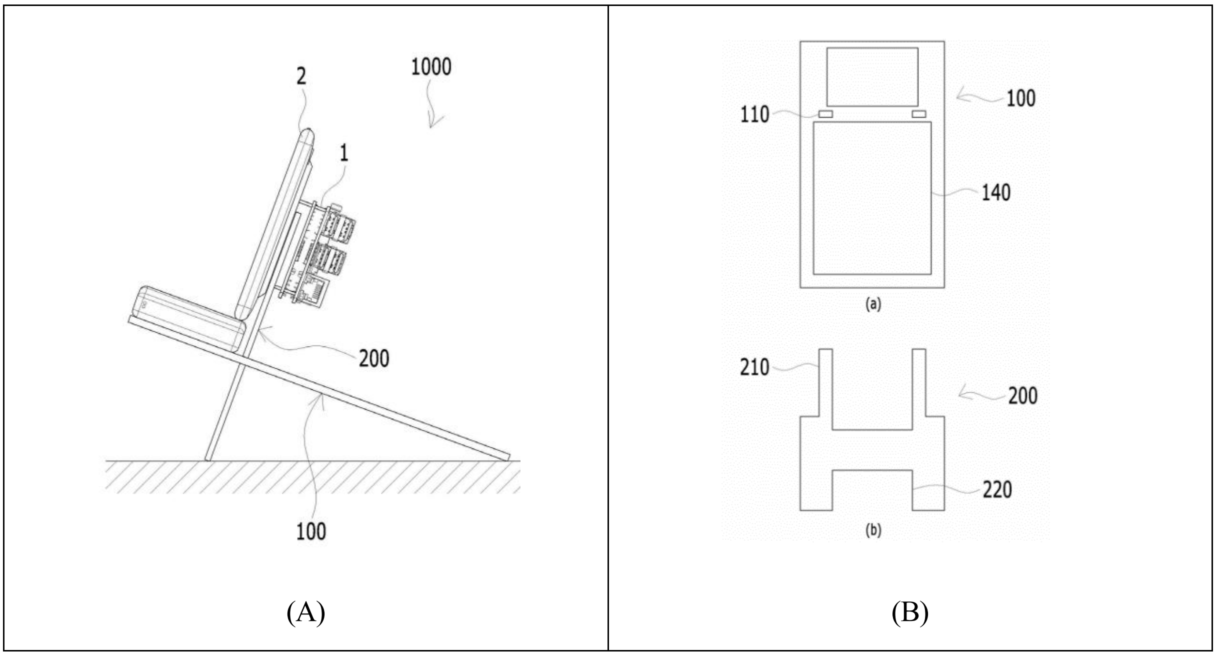
The results of this study are as follows:

First, the researcher developed an auxiliary device to support experiments using a display device combined with a Raspberry Pi (1) (Fig. 4(A)). This auxiliary device includes a first horizontal plate (100) with a first coupling hole (110) formed in the center and a first vertical plate (200) with a first coupling part (210) protruding on one side along its length, which is coupled to the first coupling hole (110). In addition, on the other side of this vertical plate, along its length, a first mounting hole (220) is formed to facilitating the mounting of a Raspberry Pi (1) (Fig. 4(B)).

Second, the auxiliary device includes an additional second vertical plate (400), and this plate has a second coupling part (420) and a coupling projection (430) formed thereon. The first horizontal plate (100) connected to it includes a second coupling hole (120) that can accommodate the coupling projection (430) and a mounting slot forming hole (140) formed in the thickness direction.

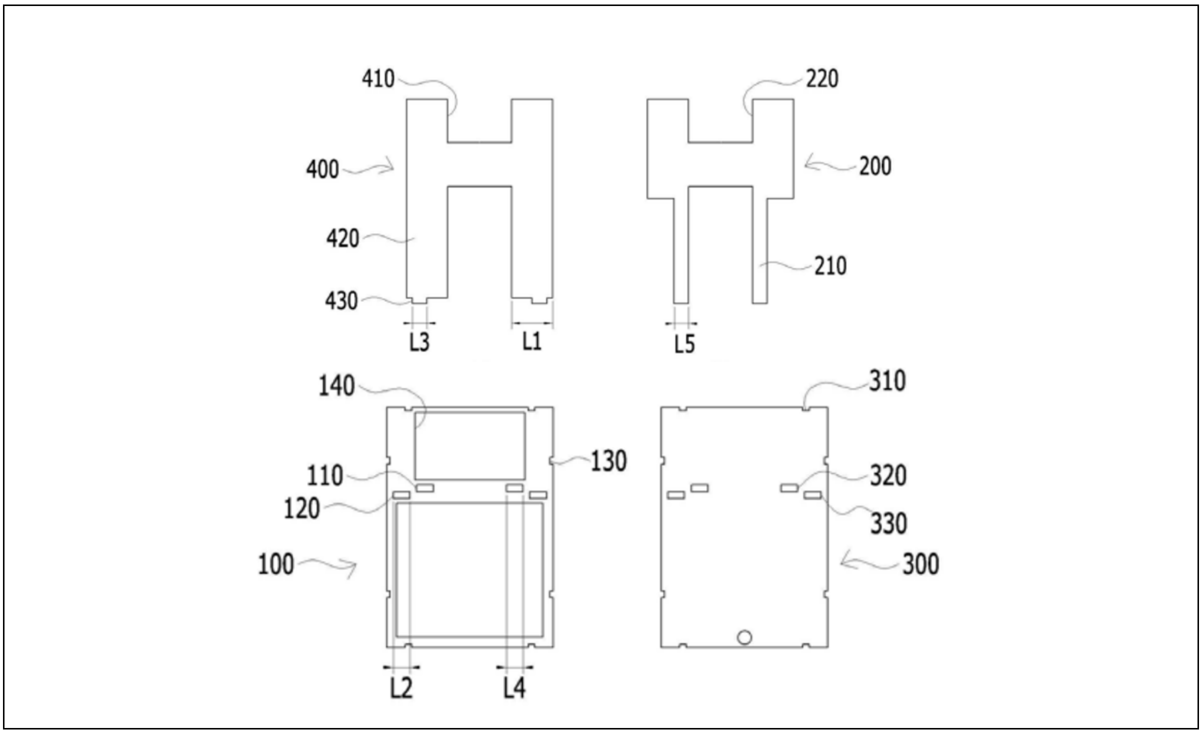
Third, the widthwise length (L1) of the second coupling part (420) exceeds the widthwise length (L2) of the second coupling hole (120), but the widthwise length (L3) of the coupling projection (430) is shorter than the widthwise length (L2) of the second coupling hole (120). Meanwhile, the widthwise length (L5) of the first coupling part (210) is designed to exceed the widthwise length (L4) of the first coupling part (210). These designs enhance the stability of the auxiliary device ([Fig. 5]).

Fourth, a coupling member insertion groove (130, 310) is formed on the edge of the first horizontal plate (100) and the second horizontal plate (300), making it easy to couple the auxiliary device with other devices.



[Fig. 4] Stand Composed of Two Plates

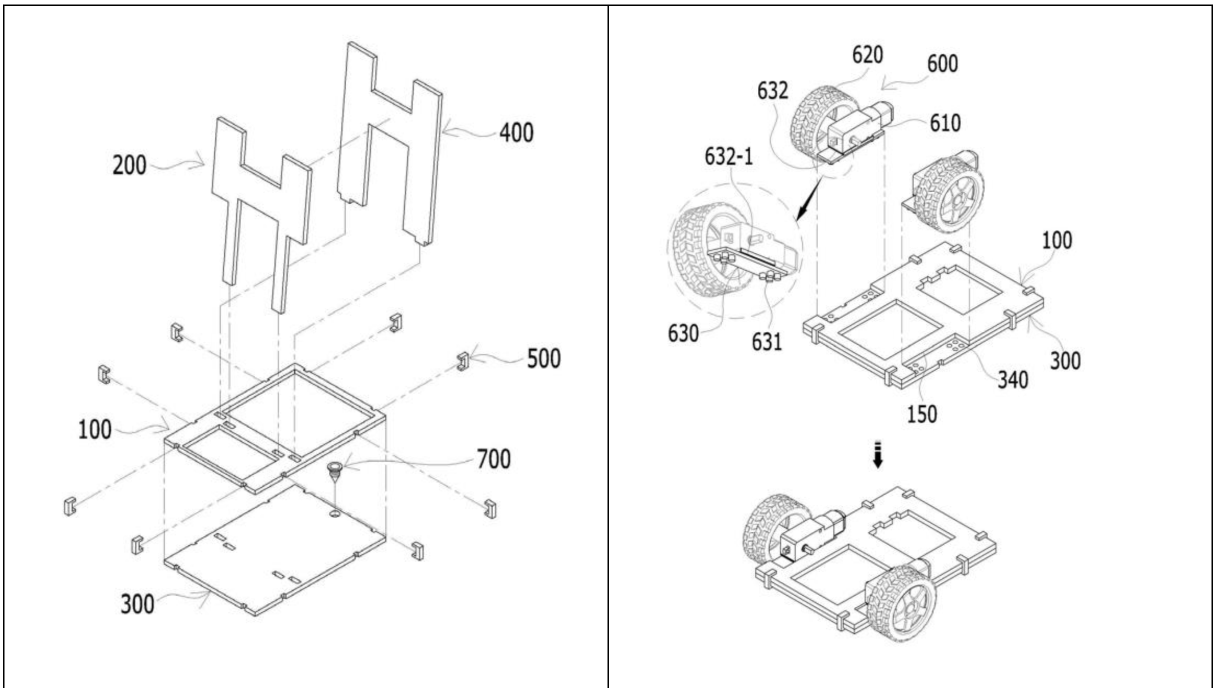
(A) Basic structure of Raspberry Pi mount, (B) Example of the basic board for Raspberry Pi mount



[Fig. 5] Configuration of the Entire Plate

Fifth, this auxiliary device includes a mobile module (600) that can be coupled to either the first coupling part (210), the second horizontal plate (300), or the second vertical plate (400), thereby enhancing mobility (Fig. 6(A)). The mobile module (600) includes a mobile module body (610) with a power device and a gearbox built therein, a wheel (620) rotated by the body, and includes a coupling block (630) with a coupling projection (631) formed thereon (Fig. 6(B)).

Lastly, the auxiliary device developed in this study can mount a display device (2) combined with Raspberry Pi (1) and supports various experiments using such a set up. Significantly, the results of this study establish the design and functional characteristics of the auxiliary device.



(A) (B)

[Fig. 6] Example Car Module Stand Utilization

5. Conclusions

In this study, the researcher have successfully developed an auxiliary device to support experiments using a display device combined with a Raspberry Pi. To achieve this, the researcher developed a mount by analyzing existing Raspberry Pi boards and mounts on the market and conducting big data analysis to understand related public perceptions. Utilizing specially designed horizontal and vertical plates, coupling holes, and coupling parts, this auxiliary device can securely fix various components of the display device combined with Raspberry Pi. The second vertical plate and the mounting slot forming hole make the device suitable for a wide range of experiments. In particular, by adjusting the widthwise length of the coupling part and the coupling hole, the researcher greatly improved the stability of the auxiliary device. The first and second horizontal plates are designed with a coupling member insertion groove, which allows easy connection with other devices. Also, the mobile module enhances the mobility of the auxiliary device, and it includes a wheel with a built-in power device and gearbox as well as a coupling block, facilitating expansion into mobile devices like cars.

In conclusion, the auxiliary device developed in this study can securely mount a display device combined with Raspberry Pi and supports the use of this set up in various experiments. The research described in this paper played a significant role in establishing the efficient design and functional characteristics of the auxiliary device.

6. Acknowledgments

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