Article

Umbrella with Lightning Strikes Alarm Function

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Abstract: In recent years, the number of lightning strikes has been increasing in Taiwan. At present, Taipower has a complete lightning detection system, which can accurately monitor lightning data. Therefore, this product was an innovative concept invention and design of an umbrella that predicted lightning strikes, helping users solve the danger of being struck by lightning. Meanwhile, the processing unit, the GPS positioning device, the first wireless transmission device, and the warning light device are placed in the space of the umbrella handle. The processing unit used the radar echo tracking information and the transmission information of the GPS positioning device to calculate the motion vector (TREC vector) of each pixel point on the radar echo image. The principle of this technology was to first divide the radar image into multiple small images of the same size. Then, compared and concatenated the two radar images to calculate the center distance position of the rain gear affected by the fall. The first wireless transmission issued a warning sound and light signal that could be received even without a network, increasing the probability of preventing ordinary people, climbers, farmers, and engineers from being struck by lightning. In the end, the product won the silver award in the 4th Green International Invention and Design Competition in 2022.

1. Introduction

In 2021, there were 12 million lightning strikes around, concentrated in the western coastal areas. In 2019, under the influence of the strong southwest monsoon, thunderstorms on the southern platform were more frequent. Lightning strikes were on the rise in Taiwan. Last year, Taipower detected 40,161 lightning strikes on the island of Taiwan, an average of 4.5 strikes per hour. Since 2005, the number of people killed by lightning strikes in India has been increasing (Zhang, 2022). On average, lightning kills at least 2,000 people across India every year, according to BBC statistics. It increased to 2,885 in 2017 and 2,357 in 2018. The time point was concentrated in the season of May-June. At present, Taipower has established a complete lightning detection system. In recent years, this system has been widely used for lightning strike statistics, including meteorological bureaus, military, airports, and even the operating units of Beishi Maokong Cable Car, which all use Taipower's lightning strike data (Tse Shukmei, 2012). "Lightning strike" should say "electric shock". "Lightning" is an electrical discharge from the cloud base to the Earth's surface. On cloudy or rainy days, umbrellas are used as protection from rain and thunderstorms are frequent (Crawford & Benedetto, 2022; John et al., 2011; Kunkel, 2013; Noah, 2013). However, there is currently no umbrella feature that can notify users in advance of an impending lightning strike. If in the process of an umbrella opening, the user can know in advance that a lightning strike is about to occur, and can determine whether the current location is safe in advance. Therefore, the main innovative design of this product is as follows:

(1) Umbrella with a lightning strike alarm function can avoid the danger of users being struck by lightning.
(2) The umbrella of this product will have a warning message. When lightning was near you 10–20 minutes ago, the information would be transmitted up and down through GPS and the lightning prediction platform's radar echo tracking technology.
(3) Umbrella with lightning strike alarm function, its main structure was a basic umbrella structure. With a transparent handle with a light-emitting element installed inside the handle. A GPS chip was also installed inside the handle. Then, the lightning forecast was carried out through the upper and lower signal modules. The platform's information was combined with GPS positioning to activate the light-emitting element through a signal.

A processing unit, a GPS positioning device, a first wireless transmission device, and the warning lamp device was placed in the accommodating space of the handle. Through the transmission information of the GPS positioning device, the lightning forecast information center predicted the range of the lightning strike. When the lightning strike area was closed, the processing unit transmitted a warning message to the warning lamp device, so that the lamp flashes to give a warning. The processing unit used radar echo tracking information to calculate the motion vector (TREC vector) of each pixel on the radar echo image. The principle of this technology was to first divide the radar image into multiple small images of the same size. Then, compared the two consecutive radar images to calculate the central range of the rain gear affected by the falling thunder. To solve the fatal problem of ordinary people, climbers, farmers, and engineers being struck by lightning outdoors on rainy days (Fig. 1a,b).


(a)   **(b)**
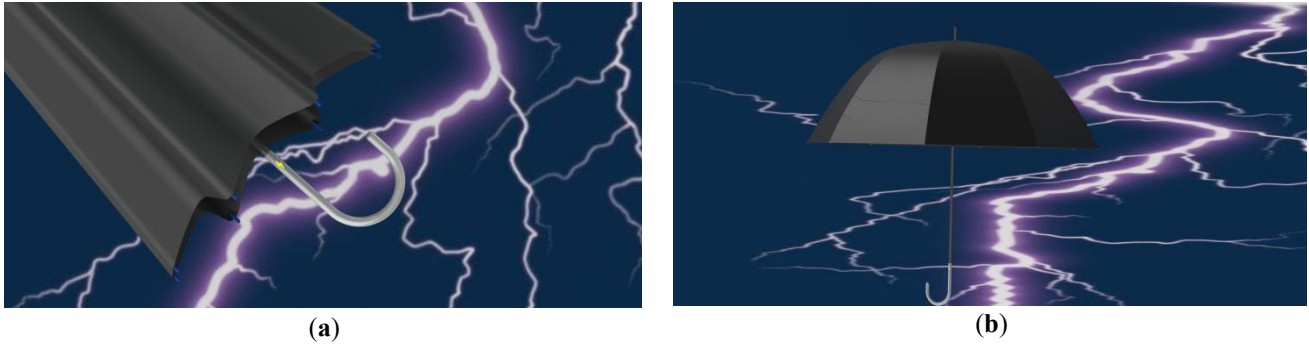
Fig. 1. Product situation diagram. (**a**) The situation diagram of the umbrella when it is stowed, and (**b**) the situation diagram of the umbrella when it is unfolded and used.

2. Materials and Methods

The product has a gradual and predictable economic effect, avoiding the problem of lightning strikes on cloudy and rainy days. Therefore, the development is based on the following three technologies.

(1) Radar echo tracking technology, which calculated the motion vector (TREC vector) of each pixel on the radar echo image. The principle of the technology was to first divide the radar image into multiple small images of the same size. Then, two consecutive radar images were aligned. Based on time A, used the correlation to find the small graph corresponding to time B. After pairing, the position of the two small images in the larger image represented the movement vector of the radar echo during this period, and the center range of the hand-held rain gear affected by the lightning was calculated (Figure 2a).

(2) Combined with the lightning prediction platform through GPS positioning. To achieve that the user could issue a warning signal 10 to 20 minutes in advance when lightning occurred within 1 km of the user's location. There was also possible to transmit messages without an internet connection (Fig. 2b).

(3) The transparent handle of the umbrella emitted flickering signals with vibrations, and users prepared for dodging in advance and improve the probability of avoiding being struck by lightning.

(a)   **(b)**
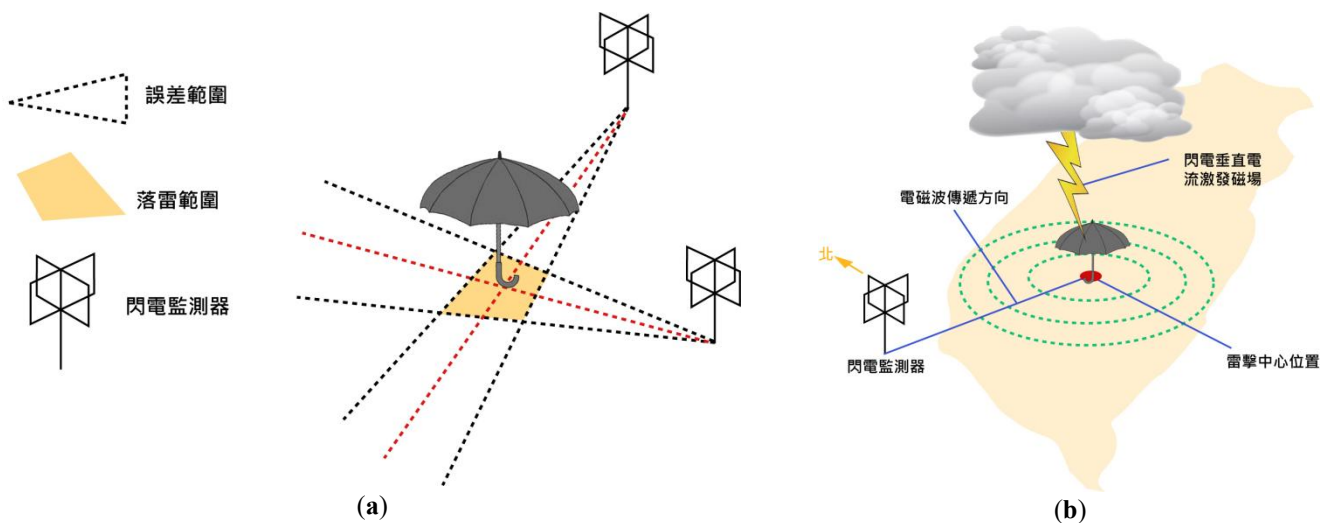
Fig. 2. The Umbrella has a moving vector (TREC vector) technique for the radar echo image. (**a**) Calculate the central area of the hand-held rain gear affected by lightning. (**b**) GPS positioning combined with lightning prediction platform.

3. Results

After checking the patent databases of Taiwan, the United States, and China. Taiwan Patent No. I724561 Smart Umbrella (Huang, 2021), Taiwan Patent No. M529406 Multifunctional Umbrella (Cai et al., 2016). All of them disclosed the installation of GPS positioning devices in the umbrellas, which were intended to facilitate finding the location of the umbrellas and prevent loss. In addition, there was only disclosed that a message transmitter can be installed on the handle to transmit a distress signal, however, the main technical features of the present case were not disclosed at all. The scope of industrial application of this product was the category of general daily necessities, regardless of shape, color, material, function, and market products were significantly different. At the same time, through the radar echo tracking technology, the motion vector (TREC vector) of each pixel on the radar echo image was calculated. The principle of this technology was to first divide the radar image into multiple small pictures of the same size. Then, compared the two radar images. Based on time A, used the correlation to find the small graph corresponding to time B. After pairing, the position of the two small pictures in the larger image represents the movement vector of the radar echo during this period. There were calculated the central extent of the lightning impact on hand-held rain gear. In the hollow of the umbrella, add GPS transmission information to transmit information, and predict the range of lightning strikes through the lightning prediction platform. The transparent handle of the umbrella was light up and vibrate when the range of the thunder was closer. There were received messages even when there was no internet connection. When using umbrellas in the rain, prevent people, climbers, farmers, engineers, and other personnel from being shocked by electric shocks in advance. This product was very simple and convenient in function operation. Therefore, the existing research results of applied academia are combined with the industry's technology. To effectively promote the commercialization of technology, new competitive products were derived in the market to enhance the value of this product (Fig. 3a,b).

(**a**)　　　　　　　　　　　　　　　　　(**b**)
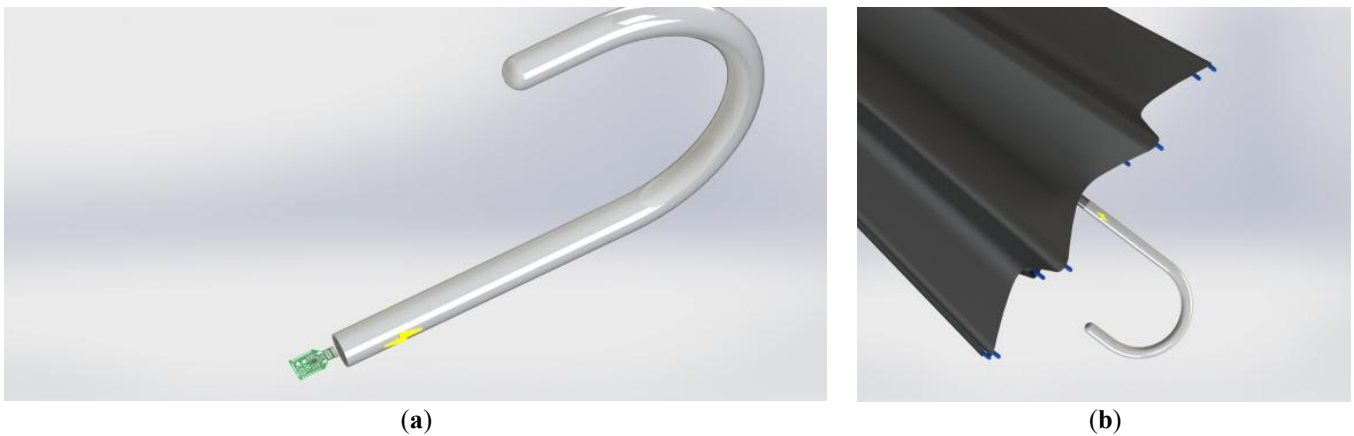
Fig. 3. Umbrella device and display reminder function. (**a**) The GPS positioning device is installed inside the umbrella. (**b**) The transparent handle of the umbrella glows and vibrates.

Description of the schematic symbols of the invention of the umbrella with lightning strikes alarm function.

- Symbol 1: umbrella body, 11: support rod, 12: umbrella rib, 13: umbrella surface, 14: umbrella handle, 141: accommodating space, and 15: handle.

- Symbol 2: Warning module, 21: Light-emitting element, and 22: Speaker element.

- Symbol 3: Operation module, 31: Wireless transmission element, 32: Positioning element, and 33: Processor element.

- Symbol 4: Power supply element.

- Symbol 5: Mobile device and 51: Human-machine interface (Fig. 4a,b).
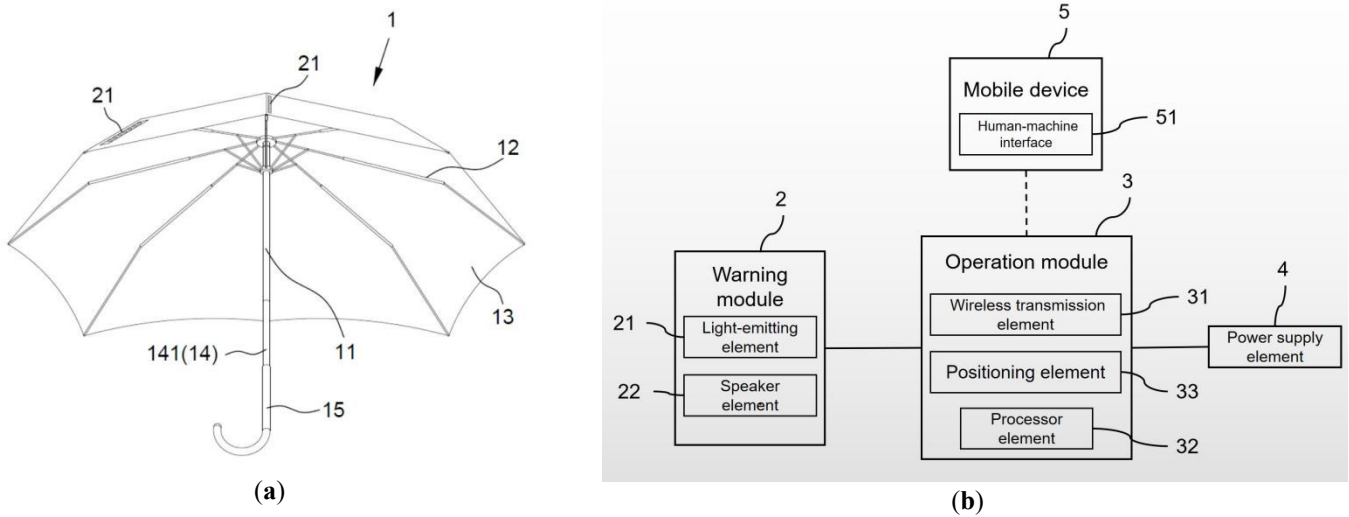
Fig. 4. Schematic description of the umbrella. (**a**) Umbrella physical product, (**b**) Predicting lightning strike platform model.

This product has a physical product and a forecasting lightning strike platform model. The map of northern Taiwan illustrated buildings with a white ball in the upper right. There were indicated by the Wufenshan weather radar station located in Ruifang District, New Taipei City (Fig. 5a). The power of the battery box at the back of the box was turned ON, the lightning chess was moved, and a bright white light appeared in the area that required attention to lightning. When Umbrellas were stacked on top of Raiden, a signal was sent to both Umbrellas. The two umbrellas emitted sound and light alarms (Fig. 5b) to warn the user that they have entered the lightning area and should evacuate as soon as possible.
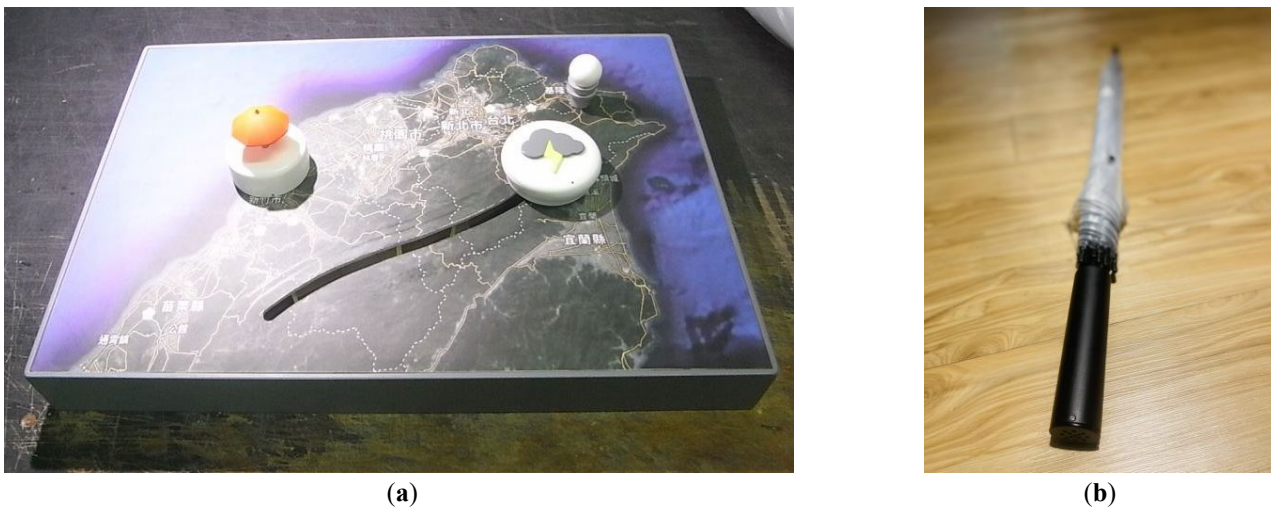

Fig. 5. Umbrella entity product and forecasting platform model. (**a**) Predicting lightning strike platform model, (**b**) Umbrella physical product.

4. Discussion

The product has provided great help and support through the enterprise in design, research development, and sample production. The two parties put forward suggestions and future cooperation directions from the aspects of warning umbrella design, functional research and development, and technology introduction. At the same time, the R&D manpower of the new business of the enterprise was jointly planned, absorbed, and implemented by members of the academic R&D team. The purpose was to use today's technology to implement the results of product development and strengthen the benefits of industry-academia cooperation.

There is known as the Umbrella Kingdom in Taiwan. Therefore, this product also has strong market development potential. According to the data for the past ten years from the Statistics Department of the Ministry of Economic Affairs (unit: 1 dozen umbrellas = 12). In Taiwan, the highest production volume of umbrellas was 6,918 (dozens) in June 2015. This compared to 5,484 (dozens) in July 2017. There were also 5,311 (dozens) in June 2018. The 3,573 (dozens) were produced in the past year in August 2021. In addition, according to sales statistics, the highest sales volume of umbrellas in Taiwan was in July 2016, with a total of

11,157 (dozens). Sales in April 2018 were 7,315 (dozens). The sales volume in May 2019 the following year was 6,674 (dozens). The sales volume in March 2022 this year is also as high as 5,521 (dozens) (Fig. 6a,b) (Ministry of Economic Affairs Statistics Division 2022).

| (a) | (b) |
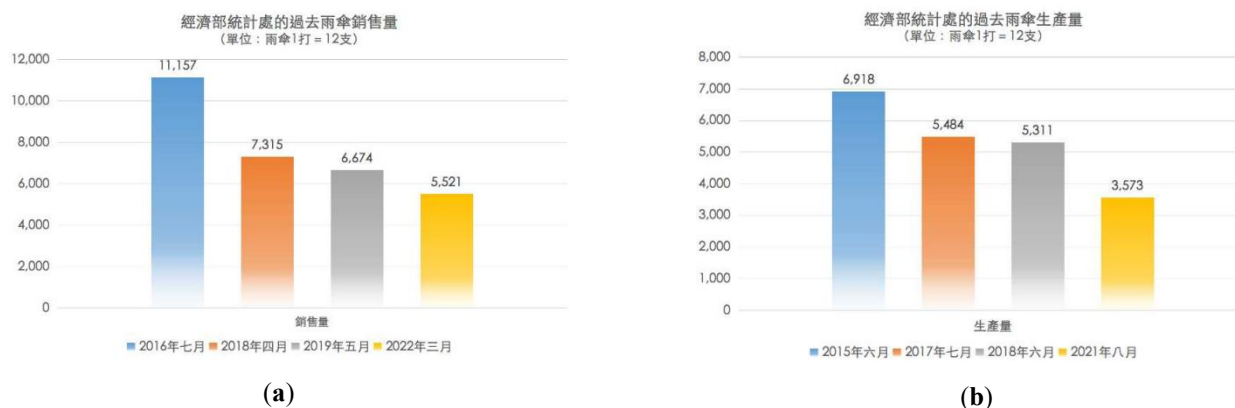
Fig. 6. Statistics from Taiwan's Ministry of Economic Affairs (unit: 1 dozen umbrellas = 12 umbrellas). (**a**) Past sales of umbrellas by the Statistics Department of the Ministry of Economic Affairs, (**b**) Past production of umbrellas by the Statistics Department of the Ministry of Economic Affairs.

The product life cycle is divided into four stages: introduction, growth, maturity, and decline. The introduction period refers to the design, production, market testing, and direct sales of lightning alarm umbrella products to the market (Xu Maolian, 2018). The product is expected to produce 100 units (dozens of units), with sales of 1,000 yuan (TWD) and estimated revenue of about 1.2 million TWD (TWD). When consumers gradually accepted the lightning forecast and warning umbrella products. When the product of the program is purchased in large quantities in the market, it enters the growth period. It is estimated that the sales of this product will reach 500-1000 (dozens), the sales of one product will be 1,000 yuan (Taiwan dollars), and the annual income will be 6 million-12 million (Taiwan dollars). The mature stage is when the technology of the lightning warning umbrella product is stable. When mass production occurs, consumers increase and the market faces saturation. The product will enter the mature stage. It is estimated that the sales volume of this product can reach more than 1,000 units (dozens of units), the sales volume of one product is 1,000 yuan (Taiwan dollar), and the annual income is more than 12 million (Taiwan dollar). After the thunderstorm warning umbrella is aging in the market, sales and profits decline, and the product enters a recession period. The 100 (dozens) a year, with an estimated annual income of 1.2 million (Taiwan dollars), this product will be retired at this time, the design will be improved in the future, and the second-generation product will be launched.

Looking forward to the close cooperation between the design, technology, management, and manufacturing departments of the industry and academia for joint development. Maintain the superior competitiveness of newly developed products in terms of quality, production capacity, and cost, so that technology transfer can expand the field of technology application, create maximum benefits for both parties, and achieve the purpose of technology transfer. At the same time, the developer is entrusted to provide the development and processing funds and remuneration through the patentee's drawings, 3D and product design, and other carrier technical achievements. There is recommended that the authorized target range, with experience in the establishment of a company in the development of rain gear or daily necessities, marketing online or physical business channels, related product development, and technical capabilities, can undertake this product technology. Contact objects for promoting the achievements and research and development of this product, such as rain gear manufacturers, stores, and daily necessities. Because the R&D technology and achievements of this product can solve the fatal problem of ordinary people, climbers, farmers, and engineers being struck by lightning outside on rainy days, and can also bring economic benefits to the general public and other industries.

5. Conclusions

This product has an umbrella with a lightning warning function. The product was in line with ergonomics in terms of holding the handle, opening the umbrella, closing the umbrella, and weight. There was friendly to use, easy to understand gender, and could reduce the possibility of wrong choices for users. Moreover, the user can use the interface of the umbrella through the knowledge has mastered, which was not exceed common sense. When the umbrella made dangerous feedback, there was a prompt for wireless transmission of information to intervene in the system, and the message was also received when there was no network. This product has a complete design aesthetic as a whole, and there was also very convenient in functional operation. The orderly interface icons allowed users to use the umbrella easily and bring people to experience smart life products that were friendly to any gender. At the

same time, before the product encounters lightning, there was predictive feedback of vibration and light. This assists the user to receive information when the perception of the five senses (sight, smell, taste, hearing, or touch) is relatively weak. However, in terms of color friendliness, the product has been matched with neutral colors. The umbrella product interface icon was marked to minimize the user's memory burden. At the same time, the structure of the umbrella interface was clear and consistent, and the style was consistent with the product design style. The promotion of gender-friendly products was expected to be used in mountaineering, agriculture, and engineering fields after mass production in the future. Finally, this product won the silver medal in the 4th Green Idea International Invention and Design Competition in 2022.

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