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Oralpunk: High-efficiency and Low-cost Oral Controller

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Abstract:

In recent years, the development of assistive products has significantly improved the lives of people with disabilities. However, for those who are paralyzed or have reduced limb mobility, there are few assistive products on the market that allow them to interact with computers. Existing mouth-controlled devices are often complicated to operate, expensive, and not widely popularized. This paper proposes a low-cost mouth-controlled device called "Oralpunk" that aims to simulate the function of a mouse for people with full body paralysis or limited limb mobility. The device controls the computer through the movement of the user's tongue, teeth, and airflow. This paper details the design, development, and iterative improvement process of Oralpunk, including the control mechanism, motherboard integration, and support structure. The device was experimentally tested for effectiveness and its functions, material texture, ease of operation, and precision of operation were evaluated. The results show that although the cursor movement function performs well, some functions still need to be further optimized. This study shows that Oralpunk is expected to provide a more economical, practical, and flexible solution for people with disabilities to promote their wider participation in social activities through assistive technology.

Keywords: Assistive technology, oral controller, digital fabrication, DIY assistive product

1. Introduction

The development of assistive products has brought great changes to the lives of people with disabilities. "Assistive products (APs), which include physical devices and digital software or any combination of the two, are essential tools that supports the health and wellbeing of over 1 billion people across the world, and enable independence and full participation in family life and society" [1]. For people with paralysis or limited mobility of their limbs, traditional input devices such as mouse and keyboard cannot meet their needs. Therefore, how to provide these people with convenient control methods through other means has become an important research direction of current human-computer interaction technology. As

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a new type of auxiliary input device, oral controllers can be operated through the user's tongue, teeth or airflow to simulate the function of a mouse, so that such people can interact with computers and other electronic devices more conveniently. According to relevant statistics, the number of people with disabilities in China is very large, "with 85 million people with disabilities, or 6.5 percent of the population" [2]. However, the current situation of this group has long been ignored in Chinese society. The stereotypes and public stigma of disability inherited from the old society formalize negative emotions, while the self-stigma of the disabled community themselves "integrates this negative emotion into self-consciousness" [3]. "The existence of social stigma generated by the interaction of these two has led to the marginalization and devaluation of people with disabilities"[4]. Many people with disabilities are reluctant to appear in public, which to some extent exacerbates their social marginalization. This phenomenon not only affects the opportunities for people with disabilities to participate in social life, but also leads to insufficient attention to the needs of the disabled community.

Therefore, relevant computer access technology (CAT) is urgently needed to be developed, "which can reduce social isolation by eliminating physical barriers, facilitating communication, and providing a forum for the exchange of information" [5]. At present, there are some oral control devices on the market to assist people with disabilities in basic computer operations. However, most of the existing devices have a single input method, and use different combinations of the same input method to perform different inputs, which sometimes cannot meet complex operation requirements such as simultaneous operation [6]. In addition, the relatively mature oral controllers on the market are extremely expensive and not widely used, which limits their wide application. There is no relevant product circulation in China, and there is a market gap. Therefore, how to balance and optimize functions and cost performance is a challenge for such products.

Based on this, this paper will propose a new type of oral controller, "Oralpunk", which aims to provide users with full body paralysis or reduced limb mobility with a lower cost but more flexible and comfortable mouse function simulation. This study not only explores the design and implementation of the oral controller, but also evaluates its feasibility and effectiveness in practical applications. Through this study, it is expected to fill the gap in existing products and provide more innovative and practical assistive devices for people with disabilities. The author hopes that through the "Oralpunk" project, the disabled can be better involved in the online social life, while improving the public's perception of the disabled group and the disabled group's sense of participation in social life.

2. Method

Oralpunk is an oral controller designed for paraplegics and people with upper and lower limb disabilities. Its development has gone through several iterative stages. The controller is designed to simulate mouse input, allowing users to interact with the computer only through the movement of the organs in the mouth. The whole process involves concept design, prototyping, user testing and improving the device to ensure its usability for the target audience.

2.1 Concept Design and Development

In the initial design stage, the project focused on designing a device that can replace the need for upper limb input through oral movement, and finally determined three main components: the control part, the motherboard part and the support structure. Each part has been carefully designed and improved many times to improve the functionality and user experience of the device (Fig.1).

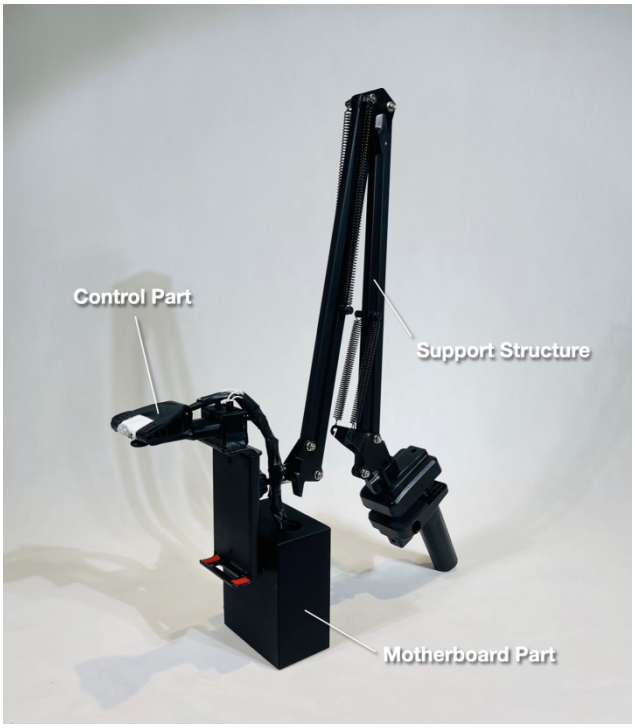

Fig.1 The designed Oralpunk (Photo/Picture credit : Original)

2.1.1 Control part

The control part is mainly composed of a joystick, a three-hole box and a long button. The three are integrated through the corresponding carriers and finally assembled into a whole.

Joystick: The joystick is fixed inside a 3D printed fan-shaped sandwich structure and installed in the center of a

U-shaped bite trainer. The pins and wires of the joystick pass through the sandwich of the fan-shaped structure and are sealed with food-grade silicone. The U-shaped bite trainer is an existing bite trainer used by fitness people to exercise the masseter muscles on the market. It is made of edible latex material. The joystick uses a mini joystick with two functions: pressing and shaking. After testing, the size of the joystick and the amount of force required to move it can be easily used by the user with the tongue.

Three-hole box: The three-hole box is a structure made of multiple original parts, which is made by 3D printing. The rear end of the three-hole box is a square box, one side of which has a wire connected to the main board. There are three holes in the front section, the middle one is large and the two sides are small, which are used to fix an edible silicone hose and two long buttons respectively. The bite trainer is also fixed on the three-hole box, and the three-hole box is fixed on the supporting structure. The box is equipped with an airflow sensor and a button, which are introduced into the user's mouth through an edible silicone hose and an extended cylindrical button respectively.

Long button: There are two buttons on both sides of the joystick, which are made by 3D printing. The interaction of the buttons is located at the left front and right front of the joystick based on the user's direction, respectively, to simulate the left and right buttons of the mouse. When using it, users can interact by pushing the button with the tip of their tongue, and can interact with the joystick at the same time. The button is designed to be slender, and the button body and circuit are in a three-hole box. This structure ensures the output of the two buttons while keeping the circuit part away from the inside of the mouth, thus avoiding safety hazards.

2.1.2 Motherboard part

The motherboard part is based on the Arduino Leonardo microcontroller, which provides the device with mouse simulation function. The shell of the motherboard part uses 3D printing technology to build a more compact and easy-to-integrate shell, making the entire device safer and easier to use. Arduino programming is also optimized for various input methods, including button pressing, joystick movement and airflow detection, ensuring that the device responds quickly and operates accurately.

Button: The button uses a normally open button. When pressed, a closed circuit is formed to transmit the signal. After being transmitted to the computer through the data cable, it is converted into the corresponding mouse button simulation through the special method of mouse simulation.

Joystick: The principle of the joystick itself as a button is consistent with the button part. The values of the X and Y directions corresponding to the joystick when it moves determine the movement of the mouse cursor. Moving the joystick forward based on the user corresponds to moving the cursor upward, and moving the joystick backward corresponds to moving it downward. The left and right movement of the joystick is consistent with the direction of the cursor movement.

Airflow detection: The airflow sensor sends a value to the computer in real time. When there is enough airflow passing through, the value is 0, otherwise it is 1. When the value is 0, call the corresponding method to scroll the page.

2.1.3 Support structure

The support structure is modified from a black metal mobile phone holder, so that Oralpunk can be stably installed on the desktop and adjusted to a suitable position. The support structure is divided into two parts, the clamp and the metal frame. This clamp can adjust the distance between the upper and lower clamps by turning the handle. The maximum width can be opened to about 7.5 cm, which can be suitable for most desktops. There are three holes on the clamp to meet different installation requirements. Four springs are installed on the metal frame to ensure the ductility and stability of the frame. There is a retractable mobile phone holder at the end of the metal frame. For simplicity, the three-hole box part of Oralpunk is directly installed on the edge of the mobile phone holder by screws.

2.2 Interaction Instructions

Cursor movement: Move the joystick with the middle of the tongue, and the cursor will move in the corresponding direction. There are two modes of cursor movement: fast movement and slow movement. When the joystick itself is pressed upward as a button and moved, the cursor will move at a faster speed; otherwise, the cursor will move at a slower speed. This design allows users to quickly move the cursor to the desired position while ensuring that the user can precisely operate the cursor position.

Left and right click: When the long button on the left front of the joystick is gently pushed with the tip of the tongue, the left mouse button is simulated to be pressed. When the long button on the right front of the joystick is gently pushed with the tip of the tongue, the right mouse button is simulated to be pressed. When the button is successfully pressed, the tip of the tongue will feel a slight vibration interactive feedback.

Page scrolling: When the user blows air into the silicone hose in the middle of the three-hole box (directly in front of the joystick) with appropriate force, the page will scroll down. When the user presses the joystick button upward

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with the middle of the tongue and blows air with appropriate force, the page will scroll up. The user's normal breathing will not cause the page to scroll.

3. Experiment

To verify the effectiveness of the device, four testers were recruited to test the final prototype. After being informed of the method of use, the testers used the OralPunk to conduct a free test with the computer for about 3 minutes to familiarize themselves with and use its functions. During the test, the testers were encouraged to interact with the computer in any way and restore the use of the computer in a natural state (Fig.2). After the test, the testers' feedback on the use of the OralPunk was recorded and summarized into the table 1. The table 1 evaluates the three main functions in terms of material texture, difficulty of operation, and operation accuracy.

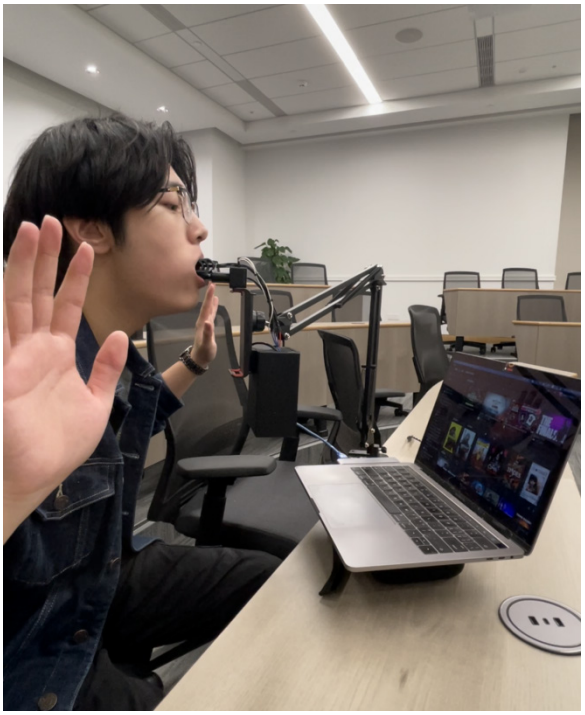

Fig.2 Test result (Photo/Picture credit : Original)

Table 1. Main Functions and Corresponding Features

	Material Texture	Difficulty of control	Control accuracy
Cursor Movement	Very Good	Easy	Good
Left and right click	Poor	Difficult	Very Good
Scroll up and down	Good	Easy	Poor

Functional feedback

The cursor movement has been well received by users because the selected joystick is very light and easy to operate, and its surface coating makes its surface delicate and soft, which enhances the user experience. The two different movement speed switching ensures its operation accuracy, and the specific movement speed can be further customized.

The left and right key click is a part worth optimizing. The choice of button elements and their extended structure materials should be changed. The current buttons use ordinary mini buttons that require a lot of force to press, which can easily cause tongue fatigue. The extension structure is currently made by 3D printing, which is hard and has a small contact area with the tongue, so it will make the user feel uncomfortable when the tongue tip pushes it. In subsequent iterations, a button that is easier to press should be used, and the extension structure should be replaced with edible-grade materials, and its texture should be relatively soft.

The biggest drawback of the up and down page turning function is that its manipulation accuracy is poor, and sometimes users cannot turn the pages up and down completely as they wish. After research, it was found that the main reason is that the position of the edible silicone hose may cause air leakage. In order to avoid normal breathing causing page turning, the airflow required for page turning is set too high, and the sensitivity of the airflow sensor is not high enough, which makes the user's page turning function unstable.

Other feature feedback

Although some users called for the development of a mobile version using Bluetooth connection, the rest of the users expressed affirmation for the design of OralPunk installed on the desktop. Due to the loss of limbs or reduced mobility of the target user, it is difficult for the user to independently take the OralPunk out of the mouth and put it back in the mouth. Therefore, when the OralPunk is

fixed, the user can easily take it out or put it in the mouth by turning the head to meet their own needs, including speaking.

Some users reported that the control part is large in size, which may cause some discomfort for users with small oral contents after long-term use. It is recommended to launch a version with customizable control part size.

At present, more than 70% of the materials in the oral part of OralPunk are edible materials, while the remaining parts are still made of PVC plastics. The waterproof performance of the control part is good, but the waterproof performance during long-term use deserves further testing.

4. Conclusion

In this paper, after a series of development and iteration processes, the author has produced a controller that can interact with the computer by simulating the traditional mouse function through the movement of the organs in the mouth. After testing, it was found that although some materials and functions need to be optimized, this controller can simulate the function of the mouse well. By using this oral controller, people with full body paralysis and people with reduced limb mobility can also interact with the computer easily. In addition, this controller has the advantages of being highly customizable and low-cost, which can allow more users to participate in online social life. In the next stage, the accuracy of the manipulation will be adjusted, and some parts and materials will be replaced to achieve a more comfortable interactive experience.

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