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Versatile, Low-Cost Interface Device for Keyboard and Mouse Emulation

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***Abstract*—This paper presents the design and fabrication of a versatile, low-cost interface device capable of emulating both keyboards and mice. The device is based on various types of buttons, including capacitive and mechanical ones, which can be constructed using low-cost materials such as laser-cut acrylic sheets and aluminum foil or 3D-printed using conductive PLA. A key feature of this work is the web-based configuration tool that allows users to assign different functionalities to each button. For example, buttons can be used as keyboard shortcuts, creating a switchboard where each button is linked to a specific application shortcut, enabling full control over that application. The simplicity, versatility, and affordability of both the buttons and the electronics make this device an accessible solution for individuals with motor disabilities, offering a highly adaptable platform for various use cases.**

Keywords— Assistive technology, adaptive aids, motor disabilities, human interface device (HID), keyboard emulator.

I. Introduction

The ability to interact with technology through input devices like keyboards and mice is fundamental in modern life. However, for individuals with motor disabilities, these standard devices can present significant challenges. The one-size-fits-all approach largely driven by mass production often leaves users with limited options, failing to effectively address the varying degrees of mobility challenges.

While commercial assistive devices exist, they tend to be rigid in design and do not adequately adapt to the diverse needs of users. The high costs associated with these devices further exacerbate the problem, making them inaccessible for many individuals who would benefit from them. Furthermore, most assistive technologies are available primarily in high-income countries and are difficult to acquire in the local markets of low-income countries. This leads to a lack of information about existing technologies and insufficient technical support in those regions. Purchasing assistive devices from abroad being unable to test them before, risking their inadequacy, with no local support, and facing not only the high costs of the technology itself but also substantial shipping fees, makes access to assistive technology in low-income countries exceedingly limited. According to the World Health Organization (WHO) and UNICEF Global Report on Assistive Technology (2022) [1], in some low-income countries, as few as 3% of people who require assistive products have access to them, compared to 90% in some high-income countries. Make use of assistive technology is essential for daily life, as it allows people with disabilities to access basic rights like working and studying, engage in recreational activities, and, in some cases, even communicate. Therefore, to comply with the Convention on the Rights of Persons with Disabilities, governments are recommended to develop local research capacity [2]. The WHO also elaborates a Priority Assistive Products List (APL) [3] which highlights the necessity of products like keyboard emulators, as addressed in this paper, which are essential for many users and is one of the least ergonomic/easy-to-use interfaces [4].

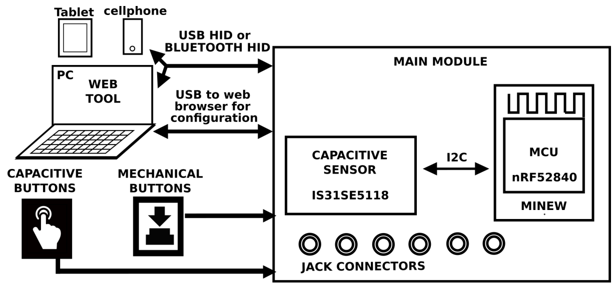

Fig. 1. General diagram of the proposed and implemented device.

This situation has prompted various academic efforts, not only proposing novel interfaces but also focusing on the development of low-cost [5], versatile systems, some of which follow the principles of Open-Source Hardware and Software [6]. Specifically, academic research has proposed human-computer interfaces utilizing buttons or special keyboards [7-9], accelerometers and/or gyroscopes [10], cameras for gesture recognition [11] or eye-tracking [12, 13], electromyographic (EMG) signal sensing [14, 15], electroencephalogram (EEG) signal sensing [16], sensing the tongue motion [17, 18], as well as systems that combine multiple types of sensors [19, 20]. Nevertheless, the issue of access to assistive technology persists, and many challenges remain for these academic developments, such as achieving sufficient robustness and quality to enable the transition of proposed devices from alpha-stage to pilot prototypes [6].

This paper introduces a low-cost, highly adaptable interface device capable of emulating both keyboard and mouse functionality. Its main architecture is presented in Fig. 1. The device utilizes capacitive and mechanical buttons, which are connected to the main module through standard 3.5 mm jack connectors, offering flexibility in design as the buttons can be easily swapped. Two types of buttons were proposed and implemented: 1) using laser-cut acrylic sheets and aluminum foil, and 2) using 3D printing with conductive PLA, making the devices easy to customize and affordable to produce. Additionally, the standard grips compatible with GoPro and ¼ inch camera mounts enhance the versatility of these buttons, allowing them to be securely attached to various surfaces such as tables and wheelchairs. This design consideration not only improves usability but also empowers users by providing multiple interaction options based on their specific needs.

To further enhance usability, a web-based configuration tool allows users to assign specific functions to each button, offering a high degree of customization. For instance, users can create a switchboard with multiple buttons, where each button acts as a shortcut to specific applications. This level of flexibility enables users to interact with various applications in ways that are tailored to their needs, providing a powerful tool for improving accessibility.

This paper is organized as follows. First the main module which includes the electronic circuits is described in section II. The web-based configuration tool is presented in section III, and the mechanical implementation of buttons, cases and grips is addressed in section IV. Finally, the main conclusion of this work is drawn in section V.

II. Main module

The core of the main module is the Nordic nRF52840 microcontroller housed within a Minew module, which includes a Bluetooth antenna. This setup allows the device to connect to a PC either wirelessly via Bluetooth, or through a USB, presenting itself to the operating system as a Human Device Interface (HID). The microcontroller's native USB HID and Bluetooth HID enables straightforward connectivity to the PC, tablet, or cellphone, without requiring any dedicated software, facilitating a seamless user experience.

Additionally, the main module features six female jack connectors, which enable easy interfacing with the capacitive and mechanical buttons. This standardized jack connector allows for the use of existing buttons available in the market, promoting versatility and reducing costs for users.

The main module includes an 8-channel programmable capacitive touch sensor IS31SE5118, which enables the control of capacitive buttons and enhances the responsiveness of the system.

Figure 2 shows the circuit schematic while Fig. 3 presents a picture of the fabricated printed circuit board (PCB) including all the previously described features. The filtering capacitors in the power supply lines are used to reduce electromagnetic interference (EMI), and, like the other components depicted in Fig. 2, follow the recommendations

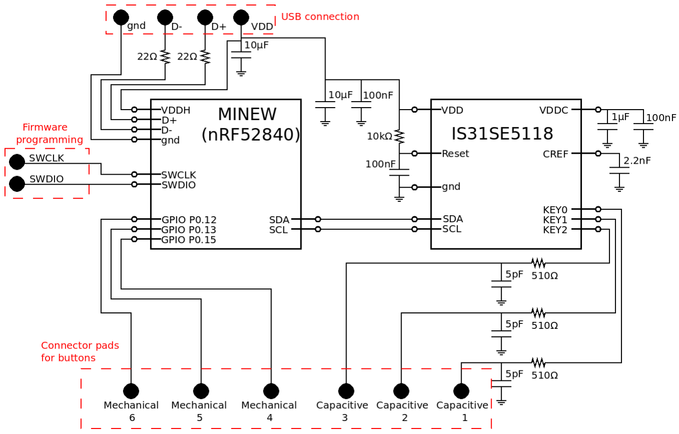

Fig. 2. Schematic of the main module.

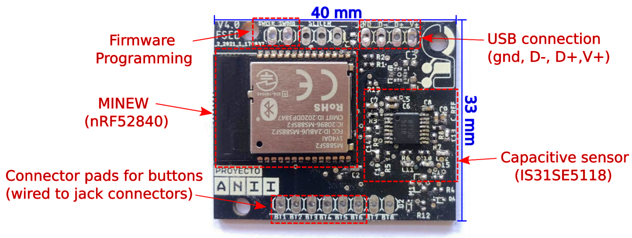

Fig. 3. Fabricated printed circuit board (PCB) for the main module.

from the datasheets of the MINEW module and the capacitive module (IS31SE5118). The pull-up resistors suggested by the capacitive module were not included in the PCB, as they are already integrated in the MINEW module.

For the firmware implementation, we used the software development kit (SDK) provided by Nordic Semiconductor, which includes examples for mouse and keyboard (HID) functionality over both Bluetooth and USB, and combined them. Additionally, the “usbd” library from the Nordic SDK was used to establish a connection with the computer via a COMx/ttySx serial USB port, enabling configuration through a web browser, as described in the next section. The “fstorage” library (Nordic SDK) was also employed to store the firmware and the configured actions for each button in the available flash memory (348.5 KB used out of 1 MB available). Finally, the I2C interface for the IS31SE5118 capacitive module was implemented from scratch, based on the module's datasheet. Basically, the value of the 'Key Status Register' of this module is checked by polling to detect the active button(s).

III. Web Configuration Tool

The web configuration tool is an essential component of the system, enabling users to customize their device's functionality according to their individual preferences. To use this tool, users must connect the device to a PC via USB, open a Chromium-based web browser (which supports USB connections), and load the configuration URL, as shown in Fig. 4. This USB configuration connection to the web does not interrupt the HID (Bluetooth or USB) connection, so the user can adapt the functionality themselves through the same device they are reconfiguring. Using the web configuration tool, users can easily assign different functions to the buttons,

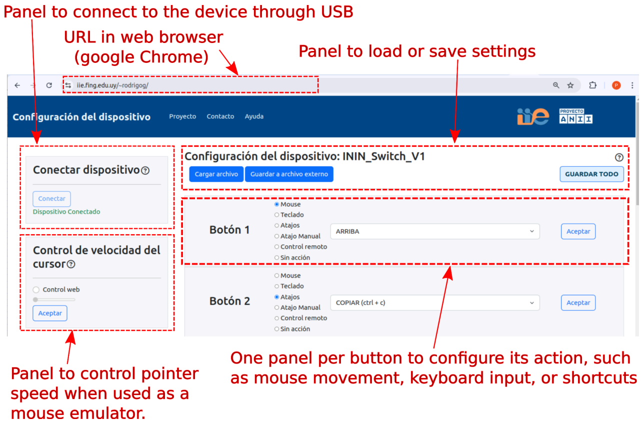

Fig. 4. Web page designed to configure the buttons actions.

such as any keyboard character, shortcuts, or mouse actions (movement in four directions, scrolling, and clicks). For example, a user can create a switchboard with multiple buttons, where each button acts as a shortcut to a specific application, enabling streamlined control of the desired software. Additionally, users can modify the speed at which the cursor moves through the web interface when the device is configured as a mouse.

The tool also allows users to save their configurations to a file, enabling easy reloading of settings. This functionality ensures that users can quickly switch between different setups, further enhancing the versatility and user-friendliness of the device. Once the configuration is loaded into the device, it is saved to flash memory, ensuring the settings are retained even after disconnecting/unplugging the device. This enables the device to be configured once and used on multiple computers afterward.

Using a web browser offers two main advantages: 1) No dedicated software is required to configure the device, and 2) updates can be done on the fly. For instance, predefined shortcuts for interacting with common platforms such as social media and streaming services can be included, and these shortcuts can be updated as needed in a way that is seamless for the user.

The web was programmed on javascript and HTML using the vue framework. To support the USB connection a Chromium-based web browser is required.

IV. Buttons

The button interface is designed for versatility, utilizing both capacitive and mechanical buttons to meet various user preferences. These buttons can be constructed by stacking 3 mm laser-cut acrylic sheets with an aluminum foil, or by using 3D printing with conductive PLA.

Figure 5 shows the 3D designs created using Blender software, along with photos of the fabricated prototypes made from laser-cut acrylic sheets. Through this fabrication process, we built a case for the main module, which houses the PCB shown in Fig. 3, six female 3.5 mm jack connectors, and a USB connection cable. Additionally, we designed and fabricated a capacitive button using 100 µm aluminum foil and a mechanical button using a standard 12 mm x 12 mm tactile switch. In the bottom-right corner of Fig. 5, the top acrylic layers are made transparent to reveal the flexible acrylic layer that acts on the tactile button embedded inside. The flexibility is achieved by removing material from the center of one layer as shown in the picture. A central piston attached to this flexible layer transfers the pressure applied to the top acrylic layer of the button to the tactile switch beneath.

Each button is equipped with a GoPro-compatible grip and a standard ¼-inch camera mount, as shown in Fig. 6 and Fig. 7, respectively. This design allows users to utilize a wide range of commercially available mechanical grips, making it easy to securely attach the device to tables, wheelchairs, or other surfaces.

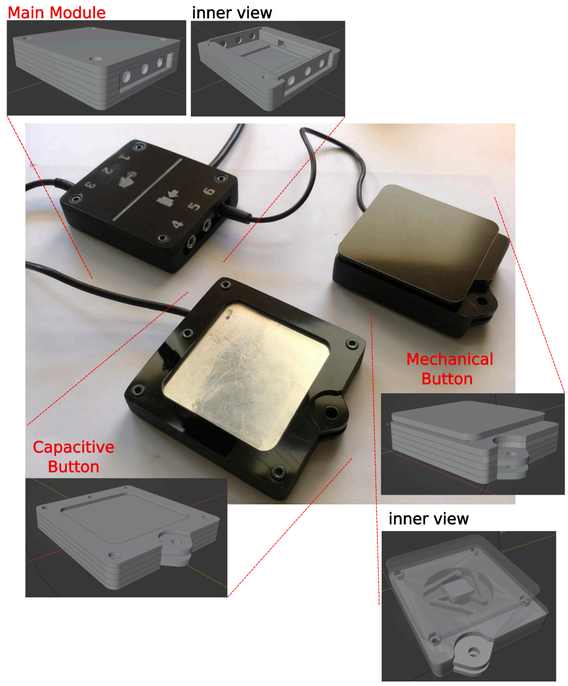

Fig. 5. Fabricated case and buttons stacking 3 mm acrylic layers.

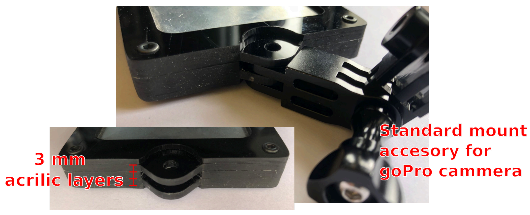

Fig. 6. Implementation of GoPro grip using 3 mm acrylic layers.

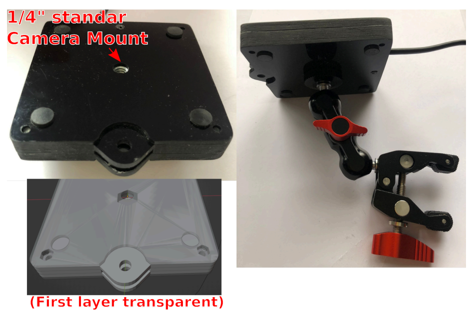

Fig. 7. Implementation of ¼ inch mount point using 3 mm acrylic layers.

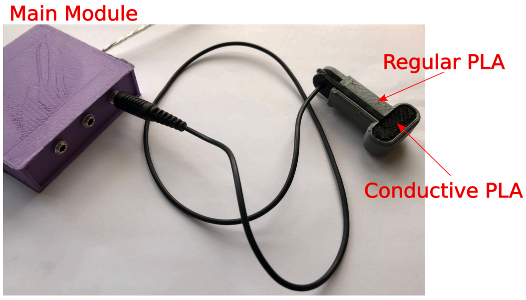

Fig. 8. Capacitive button implemented using conductive PLA.

Capacitive buttons can also be implemented using conductive 3D-printed PLA. Figure 8 shows a prototype of a capacitive button combining non-conductive traditional PLA (gray) and Proto-Pasta conductive PLA filament (black) [21]. The resistance of the conductive PLA parts can reach values in the kilo-ohm range, preventing the normal operation of the capacitive sensor used. When a button made using this fabrication technique (conductive PLA) is connected to the capacitive module (IS31SE5118), the 'Signal Register' for that channel indicates its maximum value of 255, meaning the sensor is detecting noise on the channel. However, when the conductive PLA is touched, the value of this register drops below 255. Therefore, detection was implemented by polling the 'Signal Register' of each channel, triggering the corresponding action when noise is no longer detected on the channel (i.e., when the signal value differs from 255).

V. Conclusions

This article presents the design and implementation of a mouse and keyboard emulator based on capacitive and mechanical buttons. The design is versatile, as the buttons can be easily swapped via 3.5 mm jack connectors and configured through a web interface, allowing different actions to be assigned to each button, such as mouse, keyboard, or shortcuts. No dedicated software is needed for use, as the device is recognized by the operating system as an HID, nor for configuration, which is done through a web browser. The system's compatibility has been confirmed across Windows, Linux, Android, and iOS. Two button fabrication techniques are presented: laser-cut acrylic sheets and 3D printing, both offering easily customizable, low-cost solutions. The proposed designs are robust as required by the application and compatible with conventional mounts to ensure proper fixation

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