A SYSTEM FOR CONTROLLING A COMPUTER PRESENTATION USING GESTURES

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Abstract: This paper focuses on the design of a device and gestures for contactless control of the computer presentation. The key elements for this work are the development board ESP32 and IMU sensor BNO055. The goal is to connect the board, sensor and power supply on a printed circuit board and develop an appropriate software in Arduino IDE containing the Bluetooth communication between the microcontroller and the computer. In this paper, the general overview of the solution is presented as well as the communication and two gestures which has been already implemented. The results are evaluated and future improvements are discussed.

Keywords: Contactless control, gesture, presentation, sensor, ESP32, BNO055

1 INTRODUCTION

Nowadays, in the world full of modern technology, it is possible to encounter a large number of smart devices for contactless control of computers, robots or any other software. In recent years, the devices, such as camera or different types of sensors are mainly used for recognizing the gestures of individual limbs, face or straight the whole body, which is then converted into signals or is image-processed and then sent to a computer as an instruction. Companies around the world are also developing various types of gloves or other devices with a gyroscope, accelerometer or similar types of sensors which make it no longer necessary to use cameras, but the data is read directly from the moving limb, sent wirelessly to computers and subsequently processed. One of the device which this work was inspired by, is the DigiTouch system represented by a QWERTY keyboard implemented to the glove, so the user can easily tap the fingers, whereas each phalanx represents one key on the keyboard [1]. Another system from biomedical sphere using similar components as this work is [2], which uses sensors detecting the bend of the fingers in combination with gyroscope, accelerometer and Arduino Nano board as the automatic translator of the sign language.

Earlier, the user had to perform various types of non-natural movements with the above-mentioned devices. In case of longer operation of the device, this type of control could be very inconvenient fot the user. Although many gestures are intuitive and simple, even the best devices still contain many bugs and limitations from the external environment that need to be considered during development and not omitted.

Undoubtedly the most used computer accessory is a mouse and keyboard. However, during the presentation, the user may need to control the computer even from its immediate vicinity. That could be solved by using a presenter or a device that will send instructions to the computer based on the hand gestures of the user in the form of signals. With such a device, the user would be able to control the presentation remotely without the need for any other accessories, just a hand and the device itself.

The aim of this work is to design a device that will allow the user to wirelessly control the mouse cursor on the screen, open a presentation and use appropriately designed gestures to switch individual slides in the presentation.

2 REALIZATION OF THE DEVICE

The device uses ESP32-DevKitC V4 development board in combination with the Adafruit BNO055 IMU sensor. The power bank that is used as the power supply is connected to the ESP32 via a mini USB port and provides an output voltage of 5 V. However, this implementation is used for development purpose only and Li-Ion or Li-Po battery will be used for the final version of the device. The BNO055 sensor is then powered from the ESP32 development board via its 3v3 pin with output voltage of 3.3 V. The development board with the IMU sensor, which provides input data from the gyroscope and the accelerometer, communicate with each other via the I2C bus, specifically via SDA and SCL serial data lines. This position data are represented by signals obtained from hand movement with the attached sensor. The signals are then algorithmically processed in ESP32 and transefered to an instruction which is sent to a computer using a Bluetooth module.

The ESP32 has a dual-core Xtensa LX6 processor running at 160 MHz. The main advantage of ESP32 is the integrated Bluetooth module version 4.2 with the BLE (Bluetooth Low Energy) function. ESP32 also includes a WiFi module with support for WPA and WPA2 security in the 40 MHz band. The baud rate of 115200 is used in this work. The BNO055 sensor has a sampling frequency of up to 100 Hz and 9 degrees of freedom (9-DOF). These degrees indicate all possible movements of the sensor in 3D space. Thus, three degrees of freedom can be specified for linear motion, three for rotational motion and the last three are used to collect magnetometric data.

The basic scheme of the device as well as the scheme illustrating the processing of the signal during gesture detection can be seen in Figure 1.

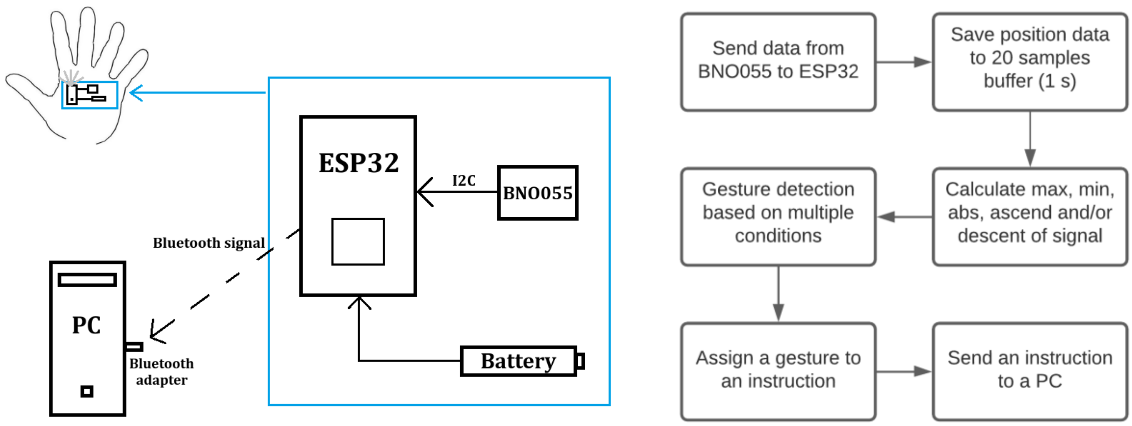

Figure 1: Basic scheme of the device (left) and signal processing (right)

3 GESTURES DESIGN

For intuitive and simple control of the computer and presentation it is necessary to design appropriate gestures that will be easily detectable. However, the algorithm should not swap these gestures with random hand movements. Therefore, during the design of detection logic, great emphasis is placed on the speed and originality of the given movement. Gestures should also be comfortable for the user.

This device has five functions whereas a different type of movement is designed for each functionality. The instruction representing the emulation of keyboard or mouse is send immediately to the computer, so the gestures can be performed immediately one after each other with no time delay. An overview of the proposed gestures and their corresponding instructions can be seen in Table 1.

Table 1: Overview of suggested gestures and instructions

Gesture	Instruction
Move the hand to the sides	Move the mouse cursor
Shake the hand to the sides	Left double-click the mouse
Raise the forearm	Start the presentation (key F5)
Wave the hand from right to left	Move the presentation forward (key N)
Tilt the hand to the right and back	Move the presentation backward (key P)
Pull up the hand to the breast	Take/drop the laser (key Ctrl+L)
Hold the hand at the back	Close the presentation (key Esc)

For the gestures mentioned in the Table 1, there are used either raw accelerometric data or data containing the position and tilt of the IMU sensor in the space for x, y and z axis.

As the example and more realistic idea of the proposed gestures there is shown a gesture for starting the presentation on the left side of Figure 2, where the hand movement of the particular gesture is indicated. The starting point at which the gesture must be started is indicated by a white circle. The orientation of the movement is then indicated by arrows. For correct motion detection, it is necessary to perform the movement in full range, whereas the average length of one movement should be in range within 0.8 – 1.2 s. On the right side of the Figure 2 it can be seen the graphic visualization of data showing the position of sensor in time. The gesture itself is visualized between the red vertical lines.

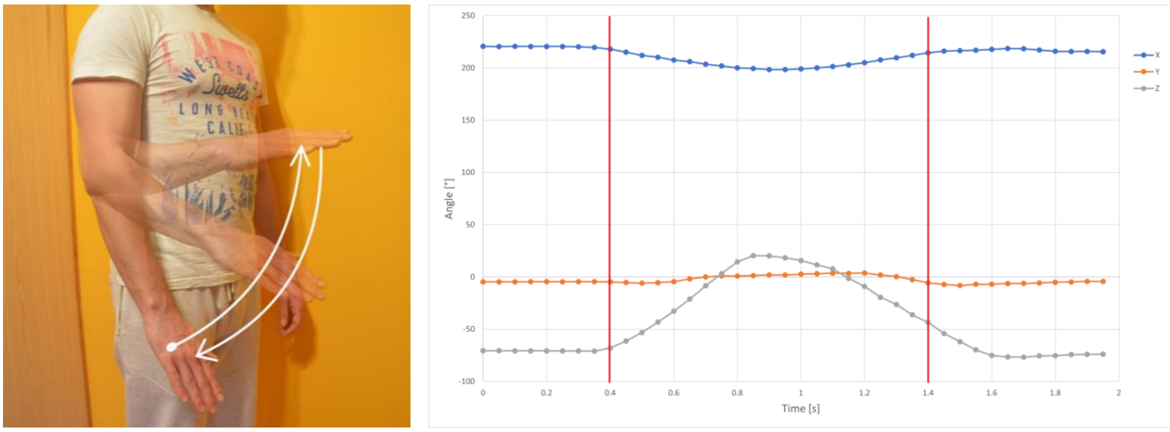

Figure 2: Indication of hand movement (left side) and position data (right side) of the gesture

In order to detect the start of any gesture, the key is the detection of hand movement, which in Figure 2 represents the signal starting at 0.4 s. This detection is based on accelerometric data. Once the hand starts its movement, the buffer begins to fill.

The detection of the particular gesture in Figure 2 involves maintaining the values for x and y axes in experimentally determined band. According to Figure 2 there should be no position deviations greater than 20° in these two axes. In the z axis, the key will be detect the forearm lift represented by a deflection of the sensor by about 90° and the subsequent return to the initial position.

Each proposed gesture has its own original detection logic which was designed based on exploration and data analysis of captured data when designing and performing the individual gestures.

4 RESULTS AND FUTURE IMPROVEMENTS

At this time the functional connection between the microcontroller and sensor with its power supply is designed, as well as the Bluetooth communication between the microcontroller and PC and two of the gestures – moving the mouse cursor and left double-click with the mouse. Although the device occasionally encounters the Bluetooth signal dropouts, the gesture for moving the cursor works very well with 100 % accuracy. The gesture for left double-click works with accuracy of 95 %. Both the gestures were tested by 2 users for 20 attempts in total.

The proposal prototype of the device placed on the hand, which is being used for testing and developing purposes can be seen in Figure 3.

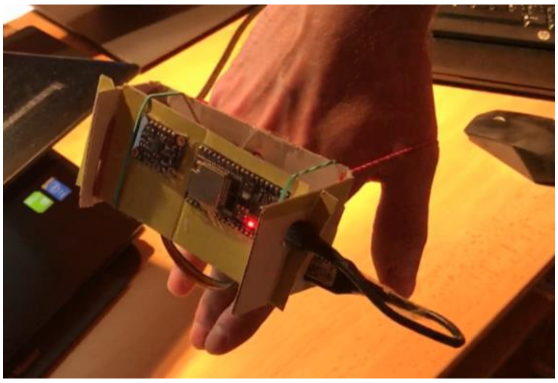

Figure 3: Prototype of the device

The final device should be smaller and lighter. One of the considered components is TinyPICO ESP32 development board, which is 2 times smaller than the ESP32-DevKitC V4 shown in the Figure 3. The aim will be also to design a printed circuit board for connecting the microcontroller and sensor without the need to solder the pins together via cables. Instead of the big and heavy powerbank the small Li-Ion or Li-Po battery will be used. All the mentioned components will be placed in the case, which can be printed on 3D printer.

5 CONCLUSION

The purpose of this paper was to give an idea about developing a new device, which can be used for contactless control of the computer presentation. The components were already successfully connected together and the communication with the computer via Bluetooth module was designed and tested. Five gestures were designed and its belonging signals were processed and explored. Two of the gestures were already successfully implemented.

The aim of the master thesis will be implementation of the remaining three gestures and verification of their functionality in practice. Next step will be designing the printed circuit board with the power supply and finally placing all the components to the case, which can be mounted to a hand.

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