Low Cost, Low Powered Flexible BLE Keyboard

Kirthi Vignan Reddy
ECD
IIIT - Hyderabad
Hyderabad, India
kirthi.vignan@research.iiit.ac.in

Anvesh Reddy
ECE
IIIT - Hyderabad
Hyderabad, India
anvesh.reddy@students.iiit.ac.in

Prof. Aftab Hussain
PatrIoT
IIIT - Hyderabad
Hyderabad, India
aftab.hussain@iiit.ac.in

Mohee Datta Gupta
ECD
IIIT - Hyderabad
Hyderabad, India
mohee.datta@research.iiit.ac.in

***Abstract*—The Keyboard is an essential tool used in all computers, and Keyboard is a bulky rigid device that is difficult to carry in hands and bags. This study presented a flexible keyboard that can type all the characters.Keyboard is a crucial way to communicate with the computer where we code and and give inputs to computer. Many of the available keyboards are bulky, or they are costly. We developed a simple, low-cost, flexible Keyboard based on resistance change due to the touch of finger skin. This system uses the difference in resistance to detect the tap. Based on the keys tapped, we can understand which character is typed. The Keyboard is tested by the time of detecting tap and false taps. This versatile system can be used for other systems where keys are required, for example, the music instruments like electronic drums, electronic piano, and guitar. The use of Bluetooth in the Keyboard helps to connect to the vast variety of devices. Using BLE also simplifies the complex wiring and cable management. The Keyboard works on BLE so the power consumption is very low.**

I. Introduction

We all know the rigorous use of keyboards in this era of computing. The keyboard is used to input the data into any computing device we can think of. Never goes a day without using keyboard on our phone or laptop for various purposes such as for Job, Chat, Querying, etc. But because of the limitations due to the rigid body of an external keyboard, carrying it around is a tedious task. We present the idea & implementation of a Flexible Keypad.Keyboard interface is designed using five buttons [1] with five buttons we can type all the keys and the Key button is similar to membrane available in keyboards [2] with the comb structure we are able to get the resistance change. It is similar to the resistive touch [3]. The proposed system is thin has very less wiring and it is Bluetooth [4].

Due to the 5 key approach it makes typing faster as the user doesn't have to move his hand to type different keys. Ones the user gets acquainted with the key strokes he can type with higher speeds exceeding existing keyboards. We can incorporate a feedback mechanism with haptic motors. Current soft keyboards, however, increase the typo rate due to a lack of tactile feedback and degrade the usability of mobile devices due to their large portion on screens [5].

The Keyboard can also be used as normal switches which have lot of on and off cycles as the switch cycle of the proposed system id very high as it does not have any moving parts that can be weathered due to usage The computer understands the ASCII Value as characters so we need to convert the 5 bit value from the keyboard to the ASCII value so we use a micro-controller to convert the 5 bit value to computer understandable language.Ergonomie devices are often designed to provide more comfort and to increase productivity but they can also help avoid pain and specific injuries. [6] The proposed keyboard reduces the movement of the hand compared to traditional keyboard resulting in better comfort of the users

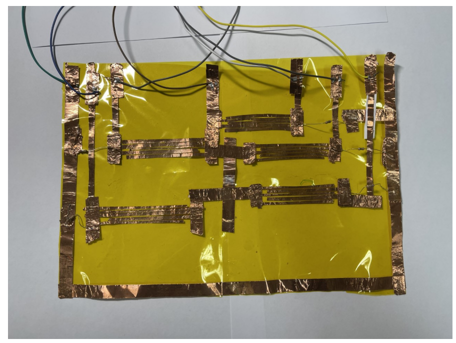

Fig. 1. Flexible keyboard

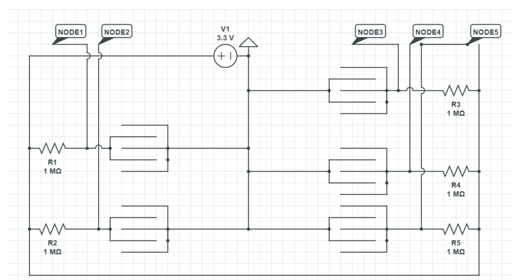

Fig. 2. Schematic diagram of circuit

II. System Architecture

A. *HARDWARE WORKING OF THE FLEXIBLE KEYBOARD*

We developed a flexible Keyboard using Kapton, Copper tape, Resistors, ESP32 Module. Kapton, known for its use in flexible printed circuits because of its flexible and insulating nature. It is stable even at higher temperatures of close to 400 degrees. Due to the thermal stability and other traits, it is considered often in the production of flexible electronic circuits. Copper tape is used as conducting lines in the comb structure of the keys. And resistors of resistance 1M ohm are used in series with the comb structures [Fig 4] across every key. These resistors are used to get the voltage when the comb structure is shorted by placing our fingers on it. The ESP32 Bluetooth module device receives the voltage across the 1M resistor and sends this data to the device which is connected to ESP using Bluetooth. We put a 3.3V across the comb structure. There are 5 such comb structures. Each structure has 5 stripes of copper lines in series with a 1M resistor together form the key. When we touch a key with our fingers, due to the low resistance of human body, the copper stripes will be shorted with our finger as the conducting medium. If not whole, most of the 3.3V is across the 1M resistor. The voltage will not exactly be 3.3V, as our body has some resistance although low. So, some of 3.3V is across our fingers, and remaining across the resistor.

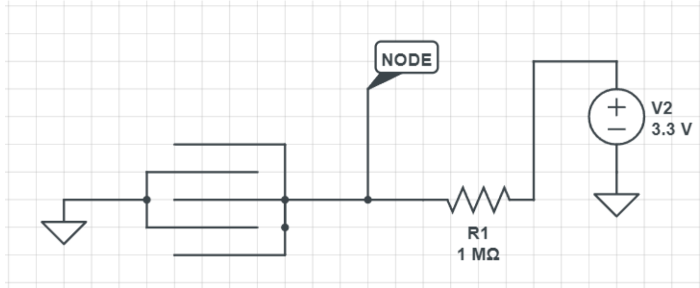

Fig. 3. Individual key

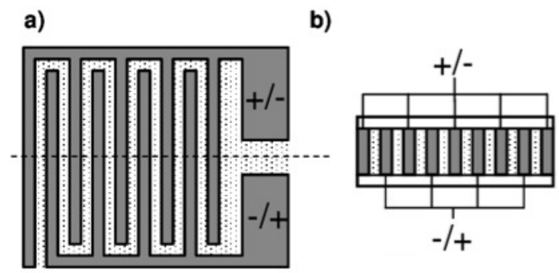

Fig. 4. Comb Structure

The input voltage to the ESP32 pin is taken from the point tagged NODE [Fig 3]. Initially the voltage at NODE is 3.3V and when we press the comb structure, it will get shorted so the voltage then would be 0V. Based on this distinction, we identify the key stroke of a press.

Here we decided to use comb structure because of the large surface area and when we press the comb with our finger, there will be two resistances of the fingers placed in parallel thus reducing the overall resistance of the finger. Ideally, the human finger has resistance of about 100k to 300k ohm. Due to the structure of the comb, it can be reduced to half of it to around 50k to 150k ohm. This reduction in resistance helps us capture maximum voltage across the 1M ohm. We measure this voltage across the 1M resistor by taking the voltage as input to a pin in the ESP32. ESP32 reads the voltages in analog format and uses its inbuilt Analog to Digital Converter (ADC) to map the analog voltages to digital voltage levels ranging from 0 to 4095. Then based on the threshold level we keep, it is defined what range of levels is bit 0 and what are bit 1. For our work, we have taken threshold as 2.5V. We can then program the ESP32 to know when a key is pressed using this level as reference. If we have more keys then we can use multiplexers. If we still want to use more number of keys then we can adopt to polling method. In polling method we poll to each key in a chain then we read the data

B. SOFTWARE WORKING OF THE FLEXIBLE KEYBOARD

Whenever a key is pressed, the copper lines gets shorted and voltage across resistor is collected and sent for programming. A threshold is applied to decide if the voltage is high or low and based on that, we see if the corresponding bit is 1 or 0. We have 5 such keys, so there are in total 5 bits and each bit can either 0 or 1, so we have 32 possible key combinations with these 5 keys. We find the decimal value corresponding to this bit combination by converting it from base 2 to base 10. Based on the value, we assign a character to it that will get printed on the device using ASCII library in the Arduino IDE that is connected to the Bluetooth of the ESP32. Typical characters such as alphabets, space, backspace are all coded in this.

The key is taken as tapped only when its state changes from High to Low this eliminates duplicate keys being registered due to long press. There is a specific time window that is provided in order to take the different combination input which is treated as a single stroke, based on the writer speed we can set the time window. This window helps us to eliminate miss presses and increase the accuracy. We can also incorporate ML to do auto correction of the key and prepare, predict the forthcoming key

The BLE is able to communicate with Mobile devices and work with them without any extra problem of wiring with different types of wires and the accuracy can be increased with prediction. The number of keys can be increased exponentially by just increasing number of keys by one. In future we can keep an extra checking software that can keeps a count of the strokes used and can map the frequently used keys to simple combination of the keys. It can also be used for stenographers where they need to type the words at high speeds instead of mapping one character to each stroke we can map frequently used words to each stroke.

III. Results & Discussions

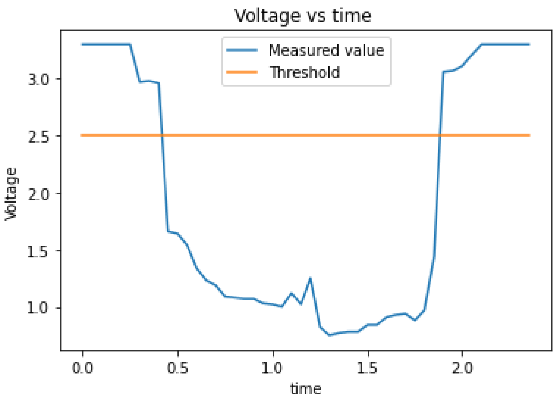

Fig. 5. Voltage vs Time

Based on the experiments we did, it was observed that the minimum bending radius is 3cm. This happened due to the design of resistors on the body of Kapton sheet. While we can roll the keyboard in direction opposite to the body of the sheet, it was not possible to roll in the forward direction as the copper wires got shorted when we did that. [Fig 5] shows the voltage vs time graph for a key stroke. The key was struck at time t=0. We can see the initial voltage being 3.3V as demonstrated in the working of the individual key. Then after a delay of 0.45 seconds, the voltage dropped below our set threshold voltage of 2.5V. So, the response time is 0.45 secs.

We released the finger at 1.6 secs after start of the press. Then it took close to 0.2 secs to get to the original position. There is a delay of about 0.2 secs.

We decided on the 1M ohm resistance by observing the resistance of the hand to be around 100k ohm to 300k ohm. The resistance of the finger keeps changing dynamically but is mostly between 100k and 300k ohm. We want most of the voltage to be across the 1M resistance and not across the finger so we decided to make it big enough that the hand resistance doesn't affect the voltage across the 1M resistance and at the same time we didn't make it much larger keeping in mind the dissipation of heat that happens from the resistance. We tried to make it low energy consuming and low energy dissipating system.

IV. Future Plans

We plan to build this keyboard with 10 keys using 2 hands we can type 2^10 unique strokes in which most of them can be mapped to frequently used words which help us to decrease the typing time significantly. We can include a feedback mechanism which vibrates the kapton sheet which results in haptic feedback that helps in knowing which key is actuated. The type of haptic feedback can be decided by the ML algorithm, which checks the word we want to type and gives feedback based on the correct word. We want to remove the ESP board and include the micro-controller in the Kapton sheet which makes the sheet more flexible.

V. Conclusion

We can use ML to track the key presses and detection any miss keys pressed. At present our system doesn't give a feedback but we can incorporate it by using haptic motors to vibrate the kapton sheet. We can increase the number of characters represented exponentially just by increasing number of keys. We found the reaction time is slightly low we can increase it by using a conducting hand gloves that increases the conductivity inturn increasing the sensitivity and time. Due to less keys, the hand movement is less which is more comfortable to the user and reduces the wrist pains as we don't have to move wrist much in typing. We just have to move the fingers. The placement of the keys can be adjusted based on the requirements of the user. We understood that with proper circuitary we are able to read resistive touch faster.

With increase in use we noticed that the typing speed improves as the user remembers the keystrokes and if we want to improve the speed, we can map the most used characters to simpler strokes.

Acknowledgment

We thank Dr. Aftab M. Hussain,Assistant Professor, PATRIoT Lab, CVEST for his teaching on the subject and Mohee Datta Gupta for helping us in doubts regarding the project.

REFERENCES

[1] X. Yi and C. Liu, ”Design of Keyboard Input Interface in Intelligent Instruments,” 2009 International Conference on Intelligent Human-Machine Systems and Cybernetics, 2009, pp. 266-269, doi: 10.1109/IHMSC.2009.190.

[2] B. Ramsey and D. Harrison, ”Development of paper membrane switches for fully featured computer keyboards,” Proceedings of the 2000 IEEE International Symposium on Electronics and the Environment (Cat. No.00CH37082), 2000, pp. 27-32, doi: 10.1109/ISEE.2000.857621.

[3] J. Calpe-Maravilla, I. Medina, M. J. Martínez and A. Carbajo, ”Dual touch and gesture recognition in 4-wire resistive touchscreens,” SENSORS, 2014 IEEE, 2014, pp. 787-790, doi: 10.1109/ICSENS.2014.6985117.

[4] M. Curic and J. Acosta, ”Keyboard Mouse Glove with Bluetooth Capabilities for the Physically Impaired,” 2019 IEEE International Flexible Electronics Technology Conference (IFETC), 2019, pp. 1-5, doi: 10.1109/IFETC46817.2019.9073770.

[5] U. -H. Kim, S. -M. Yoo and J. -H. Kim, ”I-Keyboard: Fully Imaginary Keyboard on Touch Devices Empowered by Deep Neural Decoder,” in IEEE Transactions on Cybernetics, vol. 51, no. 9, pp. 4528-4539, Sept. 2021, doi: 10.1109/TCYB.2019.2952391.

[6] O. Ciobanu, C. Gavat and R. Cozmei, ”The keyboard remains the least ergonomically designed computer device,” 2015 E-Health and Bioengineering Conference (EHB), 2015, pp. 1-4, doi: 10.1109/EHB.2015.7391585.