Umistick: Developing a Blow-Based Joystick Using Arduino Sensors and a Printed Circuit Board

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***Abstract*—Different approaches have been applied in the monitoring of physiological signals for blow detection. This paper presents the development process of a printed circuit board for the *Umistick*, a joystick that allows the execution of control commands of digital games based on the humidity variation generated by the blowing act. For this, processes and hardware schemes of the generated circuit board are described, a small analysis of the logic defined for the generation of keyboard commands is presented, and obtained results through preliminary gameplay and operation tests of the finished circuit are explained. As a result, a simple and inexpensive circuit board was obtained, capable of providing satisfactory performance and playability, as well as representing a new approach for the execution of exercises applied in speech therapy.**

***Keywords*-joystick; arduino; umistick; printed circuit board;**

I. Introduction

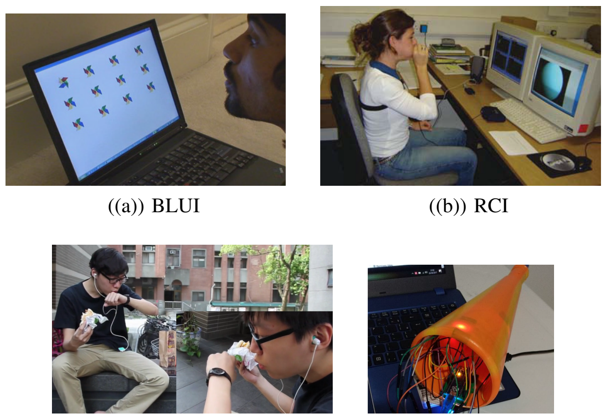
Speech therapy promotes the treatment of muscular and functional orofacial alterations of patients in general [1]. It applies stimulant exercises during therapy sessions that are, in most cases, repetitive, tiring and monotonous, especially for children.

Digital games have emerged as a worldwide trend for health-related purposes, extending the use of serious games in new approaches for the treatment of existing syndromes and diseases [2]. Moreover, considering the acquisition and processing of physiological signals, digital games offer a promising approach for the user to interact in a natural and intuitive way with computing environments [3].

This paper presents the development process of a printed circuit board for the *Umistick*, a joystick that allows the execution of control commands of digital games based on the humidity variation generated by the blowing act. It aims to provide, through the processing of player's blowing signals detected by Arduino sensors, an alternative gameplay for serious games applied in health, in this case for speech-based therapies.

II. Related Work

Some approaches have been applied in the monitoring of signs related to human breath. As an example, *BLUI* [4] provides an interface that interprets the act of blowing on a laptop or computer screen to directly control some interactive applications (Figure 1(a)). A Respiratory Computer Interface (RCI) prototype was also developed with success [3], which was evaluated by a mini-game where players participated in a race to blow up virtual 3D balloons (Figure 1(b)). *Blowatch* [5] provides an input method for smartwatches that uses blowing and gestures to invoke various device operations, such as adjusting the music volume, taking a picture, or answering a phone call (Figure 1(c)). Finally, *Cornestick* [6] introduces the development of a digital joystick that captures directional and blowing movements on a cornet through Arduino sensors (Figure 1(d)).



((a)) BLUI ((b)) RCI

((c)) Blowatch ((d)) Cornestick

Figure 1. Developed technologies based on the blowing monitoring.

III. Methodology

A. Umistick Prototype

For the development of an initial Umistick prototype, some electronic components were used to guarantee the player interaction with a running game:

- 1 temperature and humidity sensor (*DTH11*), to capture data related to the player blow;

- 1 directional axis module, to perform movements in the games where the joystick is applied;
- 2 push buttons of different colors, to execute player actions in the game; and
- 2 different colored LEDs, to demonstrate the usage status of one of the buttons according to DTH11 data.

Based on these components, a functional prototype of the Umistick was implemented in a *protoboard* (Figure 2). The components organization in the prototype takes into account the design of classic joysticks, applying the directional axis on the left side, status indicator LEDs in the middle, and command buttons on the right. The humidity sensor was placed between the directional axis and the LEDs, in order to facilitate the simultaneous usage of all components during a game.

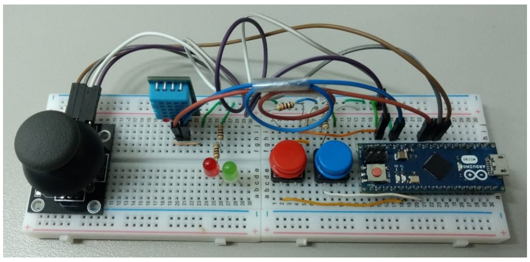


Figure 2. Illustrative image of the Umistick functional prototype.

Regarding the modules and interaction components, they are controlled by the Arduino *Micro R3 ATmega32u4*. It allows player interaction data to be received, processed, converted, and sent in the form of keyboard commands via the *Keyboard* library to the connected device. As an example of component control, by the DTH11 sensor data, a measurement range of approximately 80% to 85% humidity is used to activate or not one of the push buttons on the joystick. The 2 LEDs indicate this status of using or not the push button during a game, where the green LED on indicates "button on" and the red LED on indicates "button off".

B. Printed Circuit Board

After completing the Umistick prototype, a development process was defined to the production of an equivalent printed circuit board, which aims to eliminate the wires among components connections, as well as to facilitate the joystick usage for distinct players as a whole. In this sense, some extra electronic materials were required for fixing the prototype components on a circuit board:

- 1 phenolite plate, to implement the tracks that will be responsible for feeding and connecting all joystick components;
- 2 capacitors with 100nF capacitance equivalent, responsible to eliminate the mechanical noise caused by the two push buttons;
- 2 resistors of *330 Ohms*, for the electric current control that arrives in the LEDs; and
- 2 other *10K* resistors for the push-buttons.

Kicad [7] was used for the development of the whole electric scheme, track design, plate dimensions, spacing between components and others. It is a set of open source multiplatform programs (Windows/Linux/Mac) for 2D and 3D visualizations of schematic capture, drawing and design of printed circuit boards.

As a first step, an electric scheme was assembled based on established links in the protoboard prototype. This diagram represents the connections between the components on the circuit board (Figure 3). It defines *VCC* and *GND* power connections, together with the interconnections of the sending and receiving pins in the Arduino.

Analyzing the electrical diagram, it is possible to find on the left side the connection pins for the directional axis and the DTH11 sensor. On the right side, push buttons connections, with their respective capacitors and resistors, together with the status LEDs can also be found. In the middle, two connectors were applied to integrate each of these components to the Arduino processor. As a result, each joystick component will be powered and operated by the Arduino, according to its initialization and processing logic. For a better understanding, Table I shows the circuit pin mapping between the Arduino and the other electronic components.

Table I
PIN MAPPING TABLE ON ARDUINO.

Component	Pin Mapping
VCC	6
GND	4
X Axis	Analog 4
Y Axis	Analog 3
Push-Button (directional)	Analog 5
Data (Sensor)	Analog 2
Green LED	Digital 9
Red LED	Digital 8
Button 1 (left)	Digital 4
Button 2 (right)	Digital 2

After finishing the circuit board electrical scheme, together with the addition of resistance and capacitance values, it is necessary to perform the *footprints* selection for each board component. This step is important to define the shape and dimensions of each component so that they can be fixed to the board correctly. As a result, Figure 4 illustrates the obtained model and associated results, which corresponds to the final scheme of modeling and construction of the Umistick printed circuit, according to the following specifications:

- **Dimension:** 10 x 5 cm
- **Spacing:** 1cm on the edges
- **Track size:** 1mm
- **Lane size:** 0,60mm/0,40mm

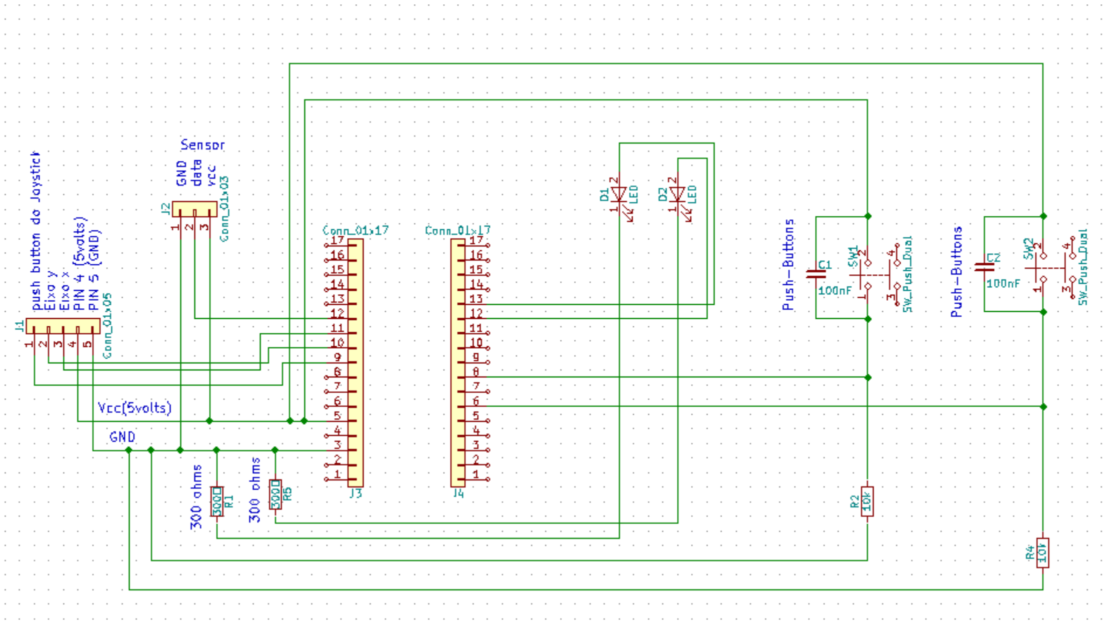


Figure 3. Electrical schematic for the Umistick board.

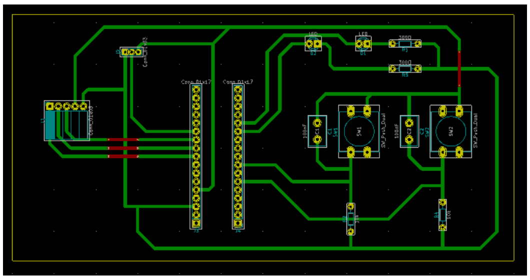


Figure 4. Footprints associations.

After completing the entire modeling and specification process, Figure 5 illustrates the obtained circuit board, with some modifications on the power and data tracks. All indicated components, such as resistors, capacitors, LEDs, sensors and others, were welded to the circuit board, completing as a result a final Umistick model capable of replacing the initially assembled prototype.

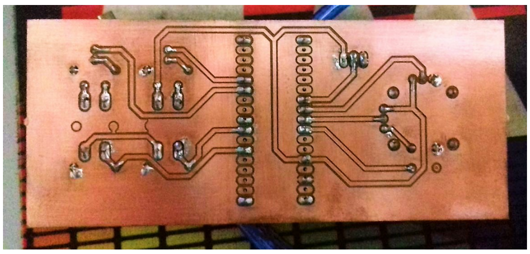


Figure 5. Final Umistick printed circuit board.

IV. Results and Discussion

Regarding the assembly of the initial prototype and the printed circuit version of the Umistick, both have been relatively simple, being designed on the Arduino platform with electronic components widely available to the community, so that they can be easily validated and replicated by third parties. Moreover, a survey of material costs for the printed circuit implementation established an average value of R$ 45.00 (Table II), that is below than the average values offered by traditional computer joysticks (R$ 60.00 - R$ 80.00).

Table II
Cost table for Umistick implementation.

Component	**Average Value**
Phenolite plate	R$ 6.00
Arduino Micro	R$ 20.00
2 LEDs	R$ 0.90 (per unit)
2 Buttons (12mm)	R$ 1.00 (per unit)
Directional Axis	R$ 6.00
DTH11 Sensor	R$ 4.00
4 Resistors	R$ 0.90 (per unit)
2 Capacitors (100nf)	R$ 0.80 (per unit)
	Total: R$ 45,00

Regarding the Umistick applicability in blow-based therapies, it can be used with existing classical games or can direct the production of specific serious games. For classic games, it is necessary to take into account the physiological limitations of interaction in the act of blowing, such as the number of possible blowing repetitions that a player can perform in a minute. For the production of serious games, it is necessary to adapt game dynamics to the joystick limitations, such as the maximum time the sensor stays above 85 % of humidity, the time required for the sensor to reach a value above 85%, among others.

Considering the initial tests performed on the Umistick circuit board (Figure 6), they consist of evaluating gameplay and joystick usability in a classic *shoot'n up* style game available on the web [8]. During this stage, some matches with approximately 5 minutes duration each one were perfomed, allowing the verification of performance, response time and usability details. As a result, the goal of bringing fun and interaction with the player during the gameplay was successfully achieved by the Umistick. However, it has been realize that there is still a need to make software changes to improve the response time in the detection of physiological signals and in sending Keyboard library commands to the connected device.

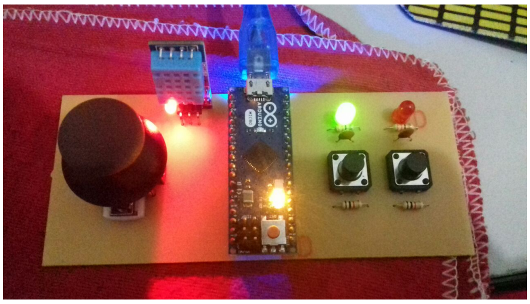


Figure 6. Printed board test for the Umistick.

A new perspective for the Umistick usage was also evaluated in this work, through the addition of temperature sensors in order to increase the joystick functionality. A feasibility study was done in 3 sensors, the *KY-013* analog temperature sensor, the *KY-028* digital thermistor, and the current DTH11. Based on performed tests with the KY-013 and the KY-028 sensors, it is possible to affirm that a little temperature variation was detected by both sensors only after a great player blowing effort. The DTH11 was able to successfully detect the blow temperature variation without a great player effort, but consuming a long period of time to return to the original ambient temperature values, making it impossible to capture the blowing act in short time intervals. As a result, it is possible to affirm that the temperature values of the DTH11 sensor are viable for future joystick functionalities, but only for games where "extra features" are obtained and applied after long and periodic intervals of time.

V. Conclusions and Future Work

This paper presents the development process of the Umistick, a joystick that allows the execution of digital game control commands from the humidity variation provided by the blow. For that, the prototyped hardware scheme was described in conjunction with the development process of the final circuit board.

Initial evaluations of applicability, usability, cost and integration (with 3 different temperature sensors) possibilities were also performed. As a result, Umistick has proven to be a viable solution for the use of blowing in existing game dynamics, as well as a possible driver for future digital games that want to exploit such resource in new game dynamics, rather than just using it as a substitute for classic game controls currently available.

As future work, it is intended to carry out the development of specific games for a better use of the Umistick functionalities and physical limitations. An ergonomic design is also required for the Umistick to provide more comfort to the player during the gameplay. Finally, patient usability tests along with gain tests in speech therapies will also be conducted in the future, through partnerships with professionals and speech-language clinics interested in using it.

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