Fliperama: An affordable Arduino based MIDI Controller

Rômulo Vieira
Arts Lab in Interfaces, Computers, and Everything Else - ALICE
Federal University of São João del-Rei
São João del-Rei, Brazil
romulo_vieira96@yahoo.com.br

Flávio Schiavoni
Arts Lab in Interfaces, Computers, and Everything Else - ALICE
Federal University of São João del-Rei
São João del-Rei, Brazil
fls@ufsj.edu.br

ABSTRACT

Lack of access to technological devices is a common exponent of a new form of social exclusion. Coupled with this, there are also the risk of increasing inequality between developed and underdeveloped countries when concerning technology access. Regarding Internet access, the percentage of young Africans who do not have access to technology is around 60%, while in Europe the figure is 4%. This limitation also expands for musical instruments, whether electronic or not. In light of this worldwide problem, this paper aims to showcase a method for building a MIDI Controller, a prominent instrument for musical production and live performance, in an economically viable form that can be accessible to the poorest populations. This equipment can be also suitable for teaching various subjects such as Music, Computer Science and Engineering. The outcome of this research is not an amazing controller or a brandy new cool interface but the experience of building a controller concerning all the bad conditions of doing it.

Author Keywords

Arduino Pro Micro, Do-It-Yourself, MIDI Controller, Multidisciplinary, Social Inclusion

CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Human centered computing** → *User studies;*

1. INTRODUCTION

By the mid-1970s, electronic instruments began to appear more often in pop music, particularly in the three major music consuming markets: United States, Europe and Japan. This led the emergence of different manufacturers, with different device models, resulting into a large collection of gadgets and the need of a form of standardization to musical equipment and data transfer between them [13, 20].

It was then, in 1983, that a consortium of synthesizer manufacturers, made up of Roland Corporation, Oberheim Electronics, Yamaha and Korg, created the Music Instrument Digital Interface - MIDI, a protocol responsible for standardizing the physical and logical interconnection of such equipment [2, 3].

NIME'20, June 21-25, 2020, Royal Birmingham Conservatoire, Birmingham, England.

Despite being almost 40 years old, MIDI is still used for the development of new instruments as a feasible way to interconnect devices on the shelf. This is because MIDI is an open protocol and it is accessible to anyone who wants to use it.

The proof of this is that between 2007 and 2014, sales of electronic instruments increased by 25%, with a third of that composed by MIDI Controllers, according to International Music Summit [21].

Even with the popularity of new digital instruments, these devices can still be expensive and inaccessible, especially in underdeveloped countries. Taking into account the socioeconomic situation in Brazil and the difficulties in obtaining musical instruments and research materials, this paper aims to create a low cost MIDI Controller, called Fliperama[1], using techniques from the Do-It-Yourself culture and electrical, computing and music concepts.

Maybe some questions like why to create a new MIDI controller or how to make it in a multidisciplinary way can be done and we intend to present and discusse the motivations and techniques for creating the controller in Section 2. The creation of this interface can be an outcome by itself but we think that it is also necessary to show some technical results obtained from the use of the equipment and its financial viability. Section 3 will bring it up. Section 4 highlights the multidisciplinary of the controller and how the socioeconomic disparities interfere in education and artistic practice. Finally, section 5 presents the lessons learned in the execution of the project.

2. CREATING THE CONTROLLER

In this Section we present the process of creation of our instrument and some questions that probably took our minds during the development of our project.

2.1 Why to create a new MIDI Controller?

According to the latest report of the United Nations (UN) on Human Development, Brazil occupies the 79th position among the 184 countries that make up the ranking, presenting poor results mainly in income distribution and education [15].

These results directly interfere in the music sector, be it in the musical form of expression or in teaching music to novices or to professionals. The influence of poorness in music culture starts with an analysis of the difficulty of obtaining a quality instrument in the country, be it electronic or not. In 2018, it is estimated that 90% of music products sold in Brazil were imported, and in view of the devaluation

[1]Fliperama is how the arcade games like pinball games are commonly called in Brazil. The word is also used to arcade game rooms, places where you can play games using a coins or paying for hour usage.

of the Brazilian currency, the value of instruments increased significantly [19].

It is also worth mentioning the obstacle imposed by the low income distribution. In 2020, the minimum wage in the country is less than US$ 180.00 (data from April 30th, 2020[2]). Thus, most citizens turn their incomes to meet basic needs, causing the consumption of music and other forms of artistic expression to be set aside by a portion of society [8]. These situation create a unbalanced scale summing high cost to import technological goodies, a bad exchange values to our currency and a very low income.

Therefore, the creation of a new model of MIDI Controller, using open-source technologies and low-cost products, can make musical production and creation more accessible.

Beyond the currency value and low income, taxes to import products and the profit of companies make the acquisition of a digital interface even harder and some times unfeasible. Table 1 shows a comparison between the prices of MIDI Controllers sold in the domestic market comparing Brazil and US. The prices were based on international Amazon (amazon.com) and Brazilian Amazon (amazon.com.br).

Table 1: Price comparison of MIDI Controllers.

Product	BRL Price (R$)	US price(U$)
Axiom AIR Mini 32	R$ 1030,00	U$ 162.69
Nektar Impact LX25+	R$ 979,90	U$ 149.95
Akai APC Key	R$ 815,00	U$ 129.00
Samson Conspiracy	R$ 843,00	U$ 211.98
Launchkey Mini MK2	R$1.199,90	U$ 109.64

2.2 How do DIY and multidisciplinarity contributed to the project?

The DIY, an abbreviation for do-it-yourself, is the activity of making or repairing things yourself, especially in your home. This concept is intrinsically linked to art and very important in its diffusion. Records, concerts, promotional material, and now, instruments, are gaining more and more space in this environment, driven by technological resources. There is a relationship here between DIY and the concept of open source, as both prioritize autonomy, low cost of production and free circulation of the means used to create something [18].

This methodology has also gained ground in schools, helping to make learning methods more attractive and encouraging students to develop their own projects based on the theoretical content presented in class. Among the advantages observed in the use o DIY as a learning methodology are the digital inclusion, a presentation to the student of all stages of the project and facilitating the teacher's work [17].

While in rich countries this methodology is linked with the idea of learning, researching and self empowerment, in poor country the DIY is sometimes the possibility to reach and use technology. The difficulties of accessing technology in emerging countries are due to several reasons, such as: lack of infrastructure, authoritarian governments that limit access to information and armed conflicts occurring in the country [11].

In the case of Brazil, this access is restricted by the high price of products and also by the lack of access to the means that produce them. It is in this context that stands out the Maker culture and DIY, with roots in activities involving electronics and technology at low cost, allow the general public access to something previously considered restricted [17, 10].

Another striking feature of DIY methodology is the multidisciplinary ability to cover many different fields of study. In the Fliperama project, there is Electrical engineering, present in the composition and way of communication of the pieces that make up the project, Computer Science, mainly Computer Music, represented by the way the MIDI Controller works together with software and other computer systems, and of course, Music.

The advantages of a multidisciplinary system range from providing students with higher quality learning, to developing problem-solving skills and critical thinking and a taste for learning. It is also very useful for educators, helping them to expand their borders and making teaching richer and more enjoyable [4, 5].

2.3 What kind of MIDI Controller are we intend to create?

Possibilities of creating this equipment are numerous. Because there is no formula to follow, an instrument can and do represent cultural and aesthetic characteristics of the creators, as advocated by Lepri and McPherson [7]. Other than that, a Controller can expand to assist the pedagogical part of music and engineering [9], as well as being an instrument of leisure and fun, stimulating the inventiveness and imaginative use of a digital system by the user [1].

From this project, it is expected that it will be easy to understand and use for inexperienced or lay-technology users. Thus, it was developed to be plug-and-play and easy for computer connection. Users with little knowledge of music are also targeted, so switching from common keys to pianos to joystick buttons makes it easy to execute simple commands.

As the MIDI protocol is present in all Digital Audio Wokstation (DAW), the model shown here is capable of operating on proprietary software such as Ableton Live, Logic Pro and FL Studio, as well as open source software such as LMMS and Ardour. The control to be performed on them is simple, involving binary execution of the notes, that is, once a button is pressed, the sound corresponding to that button is transmitted, otherwise no sound will be made. Instrument and plugin envelopes should also be subject to control.

2.4 Project parts

This project has a fez electrical components. An Arduino Pro Micro played a central role in the operation of the equipment. In addition to performing its basic microcontroller functions, it also made direct conversions between USB and MIDI communication standards, thus eliminating the need for third party software for this. Being an open-source tool also contributed to lower the final price of the product.

CD4067 Multiplexer also played a crucial function for the project. Since Arduino Pro Micro did not have all the outputs required for the project, it was up to it to extend the number of outputs, allowing for greater connection of control interfaces.

As for the control interfaces, two distinct components were used. First of these was rotary potentiometer, which is responsible for adjusting analog functions within the DAW, such as volume control and envelope editing. The second one was the Sanwa joystick buttons. With binary function, they were responsible for replacing the piano keys or percussion pads, common in this type of equipment. This replacement helped to reduce the price of the product and

[2]Conversion made on April 30, 2020, when US$ 1 = BRL 5.44

also attributed a playful character to the instrument. In short, 7 potentiometers were used, each with 10 KΩ and 16 Sanwa buttons.

All of these devices were soldered into a protoboard. The choice of welding, rather than snap connections, was chosen to ensure greater accuracy of the electro-electronic connections and also to increase their protection when transporting the equipment.

Figure 1 shows a schematic drawing of all electronic connections in the project.

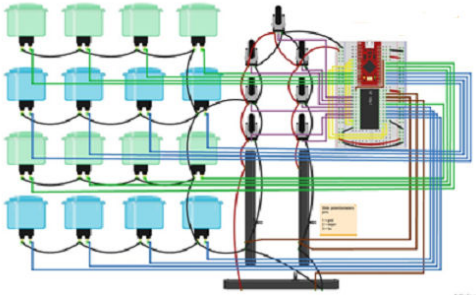

Figure 1: Illustrative image of all MIDI Controller electrical connections.

All programming and code insertion in Arduino Pro Micro was done in its own IDE. Although it is most current version is 1.8.10, the one used for the project was 1.6.8. This is due to the fact that it has two important libraries for the project that were not present in the newer version of the IDE when we looked for it. First of these is the MIDI library, which is responsible for directly converting this protocol to what is interpreted by an USB cable. The second one is the Thread library, which allows multiple commands to be executed simultaneously. Thus, multiple interfaces execute command at the same time, not having to wait for a predecessor command to be terminated before a new statement begins.

Once the connections were finished, they were encapsulated in an acrylic case. A representation is shown in Figure 2 [16].

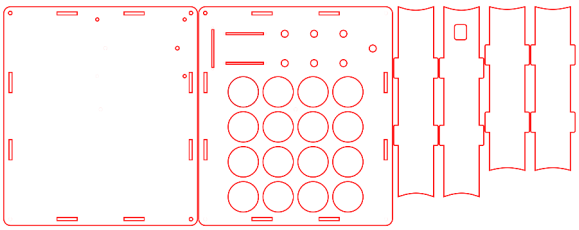

Figure 2: Schematic drawing of the acrylic case.

Weldable protoboard was left outside the acrylic case to facilitate the soldering process, possible replacement of some component and also to facilitate the connection of the MIDI Controller to the computer or other interfaces that accepts this type of connection. To complete the enclosure, drops of silicone were glued to the bottom of the shell to prevent the Controller from moving when resting on any flat surface. Final model it is shown in Figure 3.

3. RESULTS

Once assembled, the MIDI Controller was connected to a DAW to check the functionality and performance of the

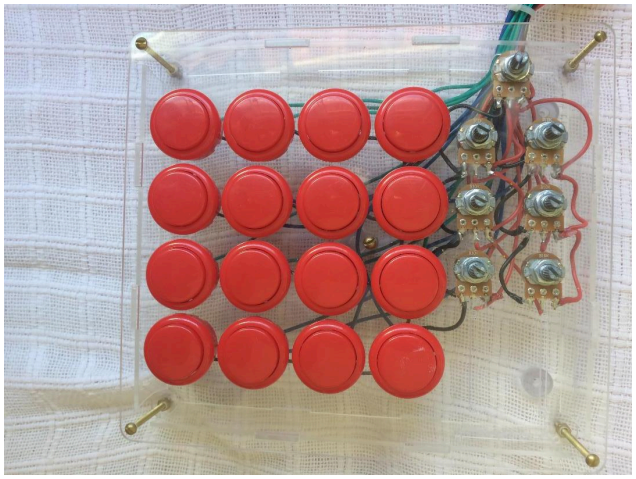

Figure 3: Fliperama MIDI Controller after mounting completed.

equipment. The DAW chosen here was Ableton Live 10.

Despite all the possibilities of mapping, we started with the simple one-to-one mapping each button to a MIDI note message. Since the buttons are just a common push button, there is no dynamic control and the notes are played always with the same MIDI velocity.

Starting with drums, three kits were selected, Kit-Core 606, Kit-Core Stark and Selector Kit Clean. Each of drum set contained 16 parts of a real drum. So, for all 3 options, MIDI Controller was able to act individually on each of these parts. In addition, potentiometers were targeted for volume and note envelope control.

Piano tests were also performed on two simulators: Grand Piano and Tinefull Ambient. Once the simulator was selected, MIDI Controller was already able to play the notes, following a left-to-right order. It was up to the musician only to define which characteristics would be the responsibility of the potentiometers.

3.1 Results from technical performance

The best performance was for the drums. Beyond the fact to the size of the Controller that perfectly matched the tested kits, the latency was 0.3 ms and none of the buttons showed structural damage while in use. This means that besides being useful for studio production, this equipment can serve as a drumfinger in concerts.

For piano samples, the MIDI controller performance was a bit lower compared to the previous test with drums samples. Running pianos' tracks separately, Grand Piano simulator required 10% of the computer's memory capacity. It is also worth that the 64-key condition of piano was not satisfied. Nevertheless, sound quality and functionality of the product were not affected.

For Tinefull Ambient, the memory consumption was lower, around 7%. Again, the main condition was not satisfied, but nothing that would compromise the execution of this simulator.

3.2 Price Comparison

Once functionality of the product is gauged, it is time to check if its price is really below market price, including those with Arduino technology, and to see if this price fits the reality of beginning musicians and students in Brazil. Table 2 shows used equipment, obtained in the local market, and their respective prices, in dollars and in Brazilian currency,

Real[3].

Table 2: Equipment price list.

Product	BRL price(R$)	US price ($)
01 Arduino Pro Micro	R$ 27,50	U$ 5.05
01 Protoboard	R$ 12,00	U$ 2.20
01 Multiplexer CD406	R$ 14,31	U$ 2.63
16 Sanwa buttons	R$ 40,00	U$ 7.32
07 Rotary potentiometers	R$ 9,66	U$ 1.77
AWG wires	R$ 16,90	U$ 3.10
01 Case	R$ 98,00	U$ 18.00
Total	R$ 218,37	U$ 40.07

From the numbers presented, it can be seen that product developed here has a cost equivalent to 21.5% of the minimum wage in Brazil. It also represents 16% of the national average income.

4. DISCUSSIONS

The creation of the MIDI Controller is a multidisciplinary task in view of the technologies used for it. The choice of electronic components, their distribution in a circuit and welding process, refer to basic principles of Electrical engineering. Computer Science is present in the use of programming languages that will determine the behavior of the device, as well as in its integration with the computer and in the transformation from MIDI protocol to USB and vice versa. Music fundamentals are necessary for the use of DAW, control of its properties and good usability of the equipment. The MIDI protocol is the maximum representation of this plurality of fields of study, interacting with all of them.

This characteristic makes the Controller construction also useful for teaching, especially for children and adolescents or those not started in any of these fields. The use of the Arduino platform also contributes to this, as it allows students to create the most diverse projects.

The inheritance of historical events directly interfere with socioeconomic conditions and public policies practiced in underdeveloped countries. This reflects directly on research, education and artistic practice. The lack of investment in research implies the need to import materials, which makes the final product more expensive, making it less and less accessible. In education, the lack of resources does not allow the completion of the academic curriculum, leaving gaps in learning. For the artistic environment, the problems are reflected in the increased value of their work tools, such as musical instruments, for example.

Thus, the creation of new interfaces for musical expressions is not only an alternative for students, scientists and artists from these countries, it is also a need they have to produce their material. The MIDI Controller shown here is capable of meeting all these needs, since it uses low-cost materials, assists teachers and students in learning various disciplines and is still useful for professional musicians or beginners.

5. CONCLUSIONS

Development of this paper has allowed a new approach to creating a MIDI Controller by applying to it multiple concepts, from Engineering to Computer Music and Music itself.

[3]Conversion made on April 30, 2020, when US$ 1 = BRL 5.44

The experience of creating an electronic musical instrument is more than valid because it explores creativity and multiple fields of study unveiling the technology behind the scenes and exposing the DIY culture as a possibility to change the actual situation. From the electronic equipment inherent in engineering, as well as the integration of the system with software and how it applies in concerts and aids in a producer's workflow, requires an intersection between these three areas.

Regarding strengths, this MIDI Controller still had better cost-effectiveness benefit compared to outstanding equipment in the market, including those using the same technology. In addition to affordable and made up of easily accessible parts, the component has a large number of buttons that help musicians from the most diverse genres, both in studio productions as well as live performances. About the structure of the equipment, it is important to highlight that despite using low price components and have an alternative technology, the tests have proven that it has the same functionality and accuracy as the others, covering all the requirements of a musician, producer or student.

Combining the advantages of teaching with DIY and the need to allow technology to be accessible to the poorer classes, creation of electronic instruments, as well as the conscious and sustainable use of these resources[6], should be explored to assist in the teaching and creation of music and other art forms.

We need more experiments with other mapping techniques and some future works include to test different approaches, like one-to-many or even many-to-many mapping possibilities. Probably, we will use some classical arcade combinations to perform these mappings [12].

6. ACKNOWLEDGMENTS

We believe that it is not fair to use the economic situation of our country to justify a paper concerning social issues of DIY methods and make culture. Unfortunately, nowadays, that is our situation, a country that is utterly rich and could be an amazing place to live that is passing through social problems because of wrong political choices and decisions. A few years ago, when our country used to invest in social improvement, science and education, it was not possible to use Brazil to illustrate this paper as an example of places where the DIY culture is more related to poverty than with freedom. That's why we would like to thank president Lula da Silva and Dilma for what they did in our near past. We hope that this paper will not make sense in a near future.

Authors would like to thanks to all ALICE members that made this research and development possible[14]. The authors would like also to thank the support of the funding agencies CNPq, grant no. 151975/2019-1, FAPEMIG and CAPES.

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