

Customizing conventional computer peripherals in the benefit of low income individuals with disabilities: Step by step procedures to make by yourself

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Abstract—Aware of the gap that exists between the social rights protected by laws and its full enjoyment, a multidisciplinary team composed of engineers, educators and brazilians students, joined to develop assistive technology products that contribute to the inclusion of people with disabilities, especially those low-income people. This paper presents a successful experience of this team on the development of valuable technology assistive products with low-tech. Construction procedures that describe how to transform conventional computer peripherals such as mouses and keyboards in custom devices for people with physical disabilities will be presented in details. These procedures were conceived in order to design functional, durable and low-cost products. The group uses the Internet in order to publicly disseminate their knowledges and projects.

I. INTRODUCTION

Brazilian citizens with disabilities are living a historic moment of great social advances. In 2011, the government of Brazil, through Decree No. 7,612, established the National Plan on the Rights of Persons with Disabilities [1] - *Viver sem Limites* (Living Without Limits Plan). Its plan is in compliance with the terms of the International Convention on the Rights of Persons with Disabilities and its Optional Protocol [2]. The guidelines of *Viver sem Limites* plan ensures the rights of persons with disabilities to an inclusive education system. It is worth noting that the plan, among other guarantees, ensures that public education materials will be available to support people with disabilities and the network of health care for persons with disabilities will be expanded with qualification.

In this scenario, the benefits provided by government policies and social changes are allowing persons with disabilities to exercise their citizenship with dignity, as the case of Luiz Augusto de Oliveira Castro, 7 years old, Werdnig-Hoffmann disease, happy and intelligent. See his photo in Figure 1.

Luiz Augusto attends public school in the city of Betim since 2011. Currently he attends the 2nd year of a regular primary school located in the neighborhood your home. Once Luiz has specific demands associated to his disease he receives support from a specialist teacher in his school that identifies, plans and proposes appropriate educational techniques and materials to him.

Pedagogical support for the inclusion of persons with disabilities is complex and requires multidisciplinary knowledge. Fortunately educators from regular schools in the municipality of Betim can receive support from reference centers in inclusive education. The entity CRAEI-RV [3] is linked to the municipal board of education of Betim that support special education.



Fig. 1. Luis Augusto C. de Oliveira - 2nd grade/primary school.

The educational system just described is real and effective. However its model is far from being practiced equally in the reach of the whole national territory considering the extreme social, economic and cultural differences of our nation.

Sensitized, motivated and fundamentally aware of the enormous challenges involved in issues related to promoting the rights of persons with disabilities, the authors of this study get joined with the common goal of contributing through their knowledge, creativity and workforce on the following issues:

- Train professionals and staff who work at all levels of inclusive education to understand clearly and confidently the technology and operational principles of Assistive Technology Products.

Demystify the constructive complexity of assistive products can improve people skills to compare technologies in the important moments of decision making. Basic knowledge, as soldering a simple broken wire can minimize the disorder caused to users of faulty pedagogical resource, besides reducing considerably the maintenance costs.

- Teach people how to design and produce low complexity solutions in the area of Assistive Technology based on techniques of Product Reuse [4], handworks and criativity.

These techniques will be presented in this paper and the new products will be produced from the transformation of manufactured products and/or raw materials that are accessible to our domain.

The transformation of commercial manufactured products into custom products can be very attractive considering that this techniques makes possible the conception of alternative or innovative products. The solution designed may be economically attractive, durable, fast production, custom to the user needs and full functional despite its features are subject to criticism.

- Promote technical and humanitarian formation of undergraduate students, especially engineering students, in order to ensure that assistive technologies become more accessible to the persons with disabilities, both cost and availability, and that the products developed are robust and suited to their real demands.

Our main goal is on development of assistive technologies with low or medium complexity. The focus is high demand products that can be produced with our technologies and technical-scientific knowledges with low or moderate costs. We also aim to develop flexible products that suit the demands of persons with disabilities so that they can to reach their fullest potential.

In the following we shall present design procedures that make possible transform conventional computer peripherals in peripherals adapted for people with physical disability. It will also be shown how to build switches devices for use with the developed peripherals. Figure 2 shows a set of products made by educators in a workshop promoted by our team.



Fig. 2. Handmade alternative input devices for computer accessibility.

II. HOW TO BUILD ALTERNATIVE ASSISTIVE DEVICES

Changing lives with the transformation of computer peripherals summarizes the essence of this work.

We shall start showing how do build switches devices. Switches are very low complexity products that allow persons with disabilities to interact with computers. Despite the simplicity of the switches those are key elements for accessibility

of persons with physical disabilities such as persons with cerebral palsy.

Switches devices in conjunction with mice, keyboards and assistive softwares represent the keys to the *El Dorado*. The keys that enable one to open the gates to a wonderful world of possibilities.

The following constructive procedures were developed to be accomplished even by people without technical training. The reference [5] shows the basic fundamentals for soldering and building electronic circuits.

A. The Construction of Switches Devices

Figure 3 shows the build stages of the switches devices.

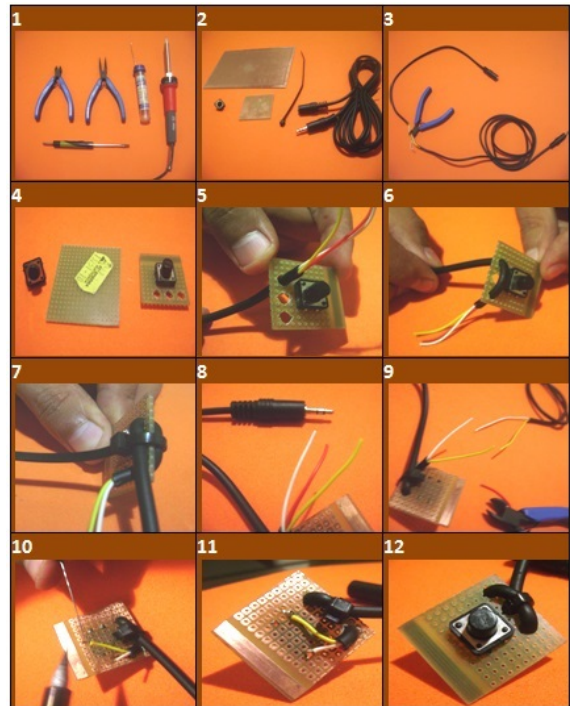


Fig. 3. Building steps of switches devices.

Before starting we need to get the tools and materials. Picture 1 illustrates the tools set needed: screwdrivers, pliers and soldering iron. Consumables are shown in Picture 2: universal prototype Printed Circuit Board (PCB); self-locking nylon cable ties; stereo headphone audio extension cable 3.5mm 3 feet and tactile push button for PCB. All these material are easily found on electronics stores even webshops.

Start cutting the audio cable (60cm length) on the male connector side. Keep the female connector for future use on mice or keyboards. Cut a square (4cm side) on the universal prototype PCB and make three 3 holes (5mm diameter) on the board as depicted in Picture 2. Now, using the self-locking nylon cable ties, trap the cable on the PCB passing through the holes as shown in Pictures 5-7. These techniques make the product robust with high traction resistance. Once we are using stereo cable, because they are easier to find and cheaper than mono cables, we can eliminate one of the three wires. In order to keep compatibility with comercial products, the middle wire are not used. A simple continuity test with LED or buzzer

enables us to discriminate the wires on the connector. Finishing the product we must solder the wires on the diagonal terminals of the push-button switch as depicted in Pictures 11 and create a cover. We suggest the use of Ethylene Vinyl Acetate (EVA) sheets for soft touch finishing.

B. Adapted Mouse

The procedures shown in Figure 4 enable to transform a conventional optical mouse on a mouse adapted for use with switches devices. This intervention lets the left-click function to be hit externally by switches.

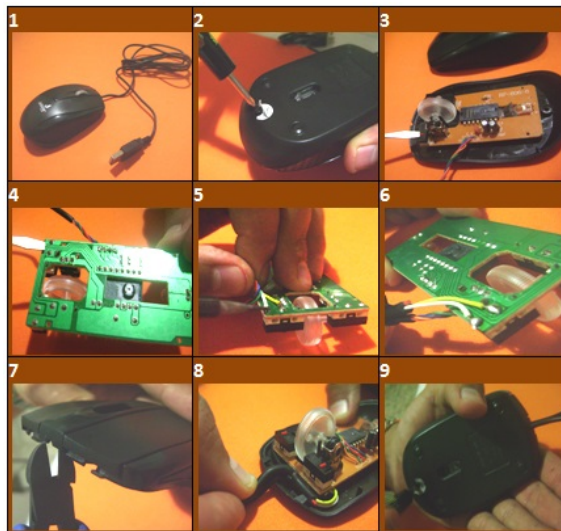


Fig. 4. Building steps of an adapted mouse.

Start disassembling the conventional mouse using a screw-driver. Identify the responsible switch for the left-click and its contact terminals as shown in Picture 3-4. Solder the wires of the stereo cable with female connector as depicted in Picture 6. Enlarge the holes for passing all cabling together or make a new hole on the plastic housing to pass the cable. In the finishing process it is very important to ensure that the cables will be trapped to resist traction efforts. Use the self-locking nylon cable ties to trap the cables preventing them from rupturing. Reassemble the mouse certifying that it continues full functional for normal use.

C. Adapted Keyboard

Similar to the mouse transformation, the procedures shown in Figure 5 enable to 'hit' Enter Key, or any other desired key, through external switches. This transformation requires more manual dexterity for welding yet can still be made by laymen.

After disassembling the keyboard identify the keys that must be accessed externally through the switches devices. The Picture 5 highlight the Enter and Space Bar electric contacts. As depicted in Picture 6 one can use a continuity test to identify the contacts that are closed when a key is pressed. Pictures 7-8 shows the contacts identified that we need to solder the audio cable with female connector. A steel wool may be used to let the terminals cleaned and prepared for welding. One or more cables can be soldered to map different keys. Usually two keys are sufficient. Reassemble the keyboard in



Fig. 5. Building steps of an adapted keyboard.

a more compact plastic housing certifying the cables are well fixed.

III. DEVELOPING A CUSTOM MOUSE FOR A FRIEND

Luiz Augusto, the kid mentioned at the beginning of this article, uses a trackball mouse in your school to record his activities. Using the methodology proposed by Joy Zabala, the SETT Framework [6], the specialist teacher who assists Luis was very successful in defining this technology according to Luis needs and skills. Unfortunately Luis and many other people in a similar situation don't have such device for use at home, either for issues related to low income or even due to difficulties to find the products for sale in the national market.

Using a conventional mouse, a deodorant roll-on ball, a light switch and a good dose of creativity we create a custom mouse for Luis. Figure 6 shows the stages of the development while Figure 1 shows Luis with his custom mouse.

The great challenge in this project was to solve the problem of drag-and-drop operations but the 2-state light switch saved us.

The Luis's mother reported he is enjoying to use the custom mouse at home to do his homework and to play soccer games on computer. We are equally happy!

IV. A TEAM PREPARED TO GO FURTHER

This work is supported by a group of teachers and students at Pontifical Catholic University of Minas Gerais. We are organized as follows: Recently we formed the SIGHT PUC MINAS and we are very proud to be part of the IEEE team. We have a research group GEPETA at CNPq in the area of assistive technology and extension activities in the course of Engineering of Control and Automation with the project Developing Accessible Assistive Technologies.

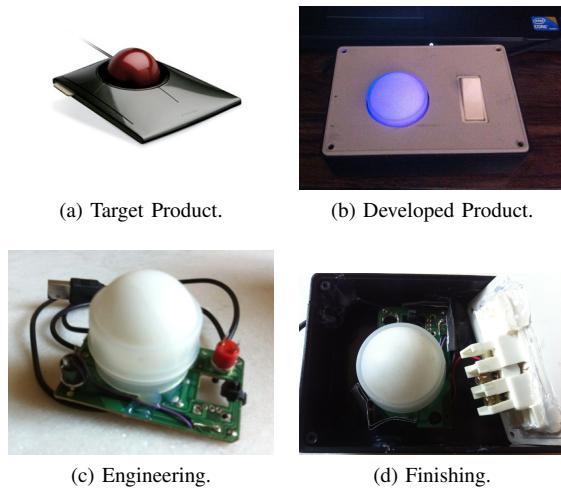


Fig. 6. Development of a Custom Trackball mouse based on a conventional optical mouse and a deodorant roll-on ball.

We maintain the PITANE website [7] with informations about assistive technologies and a online group GATA [8] for sharing information and open source projects.

The team interests are not limited to the techniques of product reuse as presented in this paper. Currently we have projects on assistive technology in the area of automation and control focusing on solutions of low to medium complexity and high demand. Figure 7 shows major projects developed by our engineering students. Here we have simple projects as the custom toys and more complex ones as the inertial mouse based on embedded systems [9].

V. CONCLUSION

In this paper a design methodology based on product reuse has been proposed as an alternative to build assistive technology devices. Handmade procedures to transform conventional computer peripherals into adapted assistive peripherals were presented in details. These procedures were conceived to

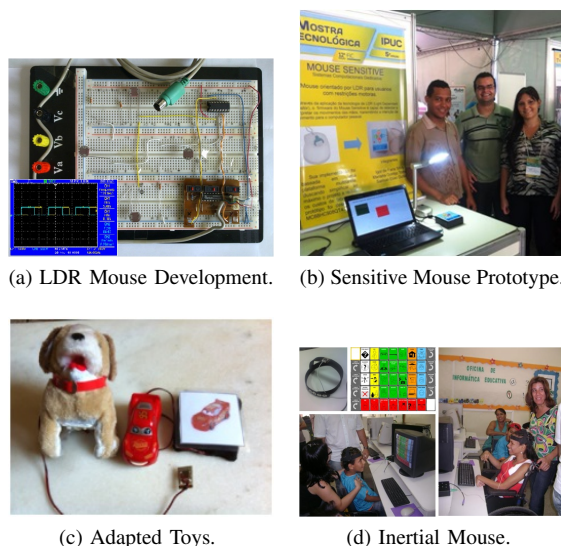


Fig. 7. Projects developed by our students.

be performed with minors efforts even by people with no specialized training.

The products presented in this work are offered in the national market but the costs are prohibitive. One can buy a switch device from a supplier indicated on the National Catalogue of Assistive Technology Products [10] with cost of R\$ 200,00 Reais (\$ 85). The switch device developed in this work has a cost about R\$15.00 (\$ 7) which represents impressive savings.

The authors believe that its work goes further than material contribution to low income persons with disabilities: i) the work contributes to demystify the idea that assistive technology imply high technology and that its small scale production justifies high costs; ii) the work encourages the participation of family and all staff involved on the training of people with disability. It gives those people the opportunity to experiment high quality learning not only at school environments but at home; iii) last but not at least, the work contributes to the social inclusion of people with disability destroying social prejudices, recognizing the potential of the assisted individuals, promoting the training of undergraduate students and recruiting workforce to the battle.

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