Ethical and Environmental Analysis

Year: 2022 Semester: Fall Team: 12 Project: RACHEL

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Assignment Evaluation:

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| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Environmental Impact** |  | x6 |  |  |
| **Ethical Challenges** |  | x6 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

Comments:

*Comments from the grader will be inserted here.*

1. Environmental Impact Analysis

Our project is embodied by multiple modules – a consumer grade projector, camera, and laptop, and our PCB and associated interfacing. This includes our microcontroller, a USB-to-Serial interface, and analog filter components and sensors. The PCB is enclosed by a machined polycarbonate case. There, of course, are environmental concerns for all parts of our product life cycle – manufacturing, normal use, and disposal.

PCB manufacturing contaminates water with heavy metals, creating wastewater [1]. Unfortunately, that is the nature of electronics manufacturing. Harmful metals involved, such as manganese and chromium, can cause DNA breakdown and instability in living things exposed to them [2]. Though, this waste can be collected with efficiency as good at 98.5%, however, at the cost of producing cyanide and ammonia [2]. We still need to follow these manufacturing measures to create safe and reliable electronics. Thus, to create the smallest environmental impact, we should produce the smallest PCB possible for our use.

Production of microcontrollers, and other chips, like the USB-to-Serial interface, have significant impacts in abiotic depletion, global warming, and aquatic ecotoxicity as well [3]. But, as we continue into the digital age, nearly every new discovery or development requires some sort of computation device. In a similar light to PCB production, it is our duty to be as efficient as possible in our design and minimize the number of integrated circuits on our board. As such, we only incorporate our microcontroller, a linear regulator, USB-to-Serial interface, and 2 operational amplifiers on our device.

Our polycarbonate enclosure for the PCB is one of the most environmentally friendly produced plastics we could have chosen. It is non-toxic and can easily be recycled [4]. Though, plastics are still not a great resource; they are made of petroleum, a non-renewable resource. More problematic, while they usually can be recycled, they can not be destroyed. Polycarbonate takes nearly 400 years to decay, and as such, plagues landfills [5]. Though recycled polycarbonate does not tend to be as strong as newly created polycarbonate [4], it is enough for our circumstance, and we could opt to only design our case from recycled plastics.

In our normal use stage of the device’s life cycle, not many environmental concerns arise. Our only device that is likely to not last a significant time (> 5 years) is our piezoelectric sensors. If properly cared for, their mean time between failure is 12 years [6]. Though, if improperly set up, or continuously detached and reattached, they may break, as they are fragile [7]. Research shows that fixing a cracked piezoelectric sensor is not easy, and not worth the time [8]. Thus, we will have a note in our construction manual that insists the piezoelectric sensors be placed only once and be handled carefully. As they are attached on the underside of the table, we do not foresee frequently broken devices, if left alone.

When our device’s life is over, we should do our best to recycle its components for other uses. The polycarbonate casing can be reused, as mentioned above. To recycle the PCB, we can use a similar process as mentioned to reduce the waste metals produced. But this still produces other harmful chemicals. Though, the dangerous byproducts like cyanide can be used as an intermediate for other household items, like paper [9]. This process allows us to produce other products and allows us to retrieve most of the heavy metals from the PCB, which are not easy to collect, nor are a renewable resource. In this case, we must choose the “worst of 2 evils”, in which we leave the PCBs to sit in a landfill, or we try to retrieve its useful parts first, though perhaps causing more harm in doing so.

Many integrated circuits and other general components, like resistors, can also be reused in other devices, if they continue to work properly [10]. Though, this raises issues in the fact that “old” components are built into a “new” device and cannot be truly considered a “new” device. Such components are perfect to be sold cheap and used by hobbyists, as many projects will be short-lived and often as a budget. Using “old” components for a consumer-grade product may be concerning, unless it may be offered as a budget version of a popular device. Though, then, the company will expect them to break faster, warranting complaints from consumers. But, as the consumer opted to buy the “cheap” version, should they be subject to warranties?

1. Ethical Challenges

As our device does not have any particularly “dangerous” components, such as motors or high-voltage circuitry, we do not have severe safety concerns with our product, the main ethical challenge we will face. However, as with all electronics, there still exist hazards. Of course, our device will be packaged as safely and isolated from the elements as possible, but that never removes the potential for human contact with electricity. A majority of the device runs on 3.3 V DC, which poses little threat, since all lines that are most likely for the user to accidentally contact are GPIO pins, with output currents limited to 25 mA [11]. This still would require damage to the device for human contact to be made.

For the safest possible packaging, we will have no exposed circuitry, only allowing the user to directly interface with the keypad matrix, and any cables that must be connected to other devices. This requires a closed casing for the PCB and button matrix, with an IO shield for its connections to the piezoelectric sensors and the above device for camera processing. Of course, the sensors and the overhead camera and projector system also need a similarly designed package. For added physical security and reliability, these cables will have a locking connector system that keeps the connections secure and disallows any accidental user contact, such as that of a USB socket.

For maximal harm prevention, we will include a notice label on all packages included as part of our product. These will outline the dangers of electricity and tampering with the device. For any electrical problem that arises, the user will be recommended to contact the company to resolve the issue, to assist in prevent the customers from tampering with the device and possibly hurting themselves.

More notably, we must ensure the over-table subsystem is properly mounted by the customer. This is a process that is intended to be laid out in the user manual for said product and is a safe method to reliably secure the camera and projector on the ceiling of one’s home, above the ping pong table. A notice label will also be added for this process, mentioning that if the user does not follow the outlined method to secure the overhead system, that they are subjecting the device, their table, and themselves to danger.

Designing this process requires significant testing. We need to create a package that can be mounted to the ceiling, easily and safely, and that provides safety. The difficulty is that not all ceilings are the same, and we would need multiple methods for varying ceiling styles and heights. It may need to be suspended if the ceilings are higher than average. For tables on a lower level of a house, we must ensure that any large forces above, such as jumping up and down or dropping a large object are not enough to potentially cause the integrity of the mount to fail. Testing for extreme cases should be done as well, such as under the forces of a typical earthquake.

A growing use for ping pong tables is to play “beer pong” [12]. This puts the table and devices at risk of getting wet, if not removed, which poses a threat as electronics are present. To reduce likelihood of safety hazards through such use, the electronics casing has been made of waterproof polycarbonate, as a backup safety feature. Of course, the safety labels should also mention the danger of wet electronics to prevent this use case.

3.0 Sources Cited

*Throughout this and other papers, use of the IEEE citation style should be used. Use of embedded hyperlinks for all web-based sources is required. A reference to the IEEE citation style format is provided* [*here*](http://www.ieee.org/documents/ieeecitationref.pdf)*.*

[1] PubMed, “Environmental risk assessment of wastewaters from printed circuit board production: A multibiomarker approach using human cells,” 6-Nov-2016. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/27829507/#:~:text=Since%20the%20production%20of%20printed,abundant%20were%20copper%20and%20iron. [Accessed 12-Nov-2022].

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[9] CDC, “Facts About Cyanide,” 4-Apr-2018. [Online]. Available: https://emergency.cdc.gov/agent/cyanide/basics/facts.asp#:~:text=In%20manufacturing%2C%20cyanide%20is%20used,vermin%20in%20ships%20and%20buildings. [Accessed 12-Nov-2022].

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[11] STMicroelectronics, “RM0091 Reference Manual,” 6-May-2022. [Online]. Available: https://www.st.com/resource/en/reference\_manual/rm0091-stm32f0x1stm32f0x2stm32f0x8-advanced-armbased-32bit-mcus-stmicroelectronics.pdf. [Accessed 12-Nov-2022].

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