Ethical and Environmental Analysis

Year: 2022 Semester: Fall Team: 05 Project: Metaporter

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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:

1. Environmental Impact Analysis

Metaporter is comprised of an LCD, 4x4 matrix keypad, and synchronized stereo camera. In addition, within our device, we have a PCB soldered with numerous electrical components, a Jetson nano, and an IMU. All parts will be enclosed in an acrylic packaging, and they will be supplied power from a standard wall outlet. Given Metaporter’s extensive list of components, there are several crucial aspects of the production and end-of-life stages that may cause concern for environmental impact.

During the printed circuit board (PCB) manufacturing process, conductive copper traces are etched and laminated onto non-conductive substrate to electrically connect components, and they also typically contain epoxy resin, nickel, fiberglass, iron, and aluminum [1]. The fabrication of PCBs produces wastewater with ferric chloride that is polluted with organic matter and heavy metals, namely copper and iron; therefore, after a 2017 toxicology study of PCB wastewater, it was determined that genome damage and low viability of cells can be caused by contact with this waste [2]. In an effort to reduce the serious environmental impacts posed by this manufacturing process, we can decrease the form factor of our PCB to minimize the amount of waste per product. In addition, utilizing a fabrication facility that carefully disposes of or cleans waste would greatly diminish environmental impact and health risks.

Although LCDs have become widely used and are accredited for being energy efficient, there are numerous environmental concerns with the manufacturing process. Particularly in TFT-LCD fabrication, the processes of thin-film deposition and etching use substantial amounts of silane, phosphine, ammonia, and hydrogen gases; the most hazardous ones used are nitrogen trifluoride and sulfur hexafluoride for chamber cleaning and dry etching, and they are considered to be pyrophoric, flammable, and oxidizing [3]. Considered one of the most consequential greenhouse gases with a Global Warming Potential greater than 10,000, nitrogen trifluoride is capable of damaging the liver and kidneys in addition to corroding components. Likewise, silane causes spontaneous flammability in the bloodstream if above 5 ppm [3]. In order to minimize the health risks and environmental impacts of the LCD manufacturing, we could adjust for a smaller model or an eco-friendlier display. OLED (organic light emitting diode) displays use more organic compounds and may be a cleaner choice for our project.

Acrylic is a petroleum-based plastic that has become a common material with a vast range of uses since it is both durable and inexpensive. Because of this, we chose acrylic for our product packaging; however, this does not come without drawbacks to environmental impact during fabrication. Throughout production, carbon dioxide, carbon monoxide, and formaldehyde are among the many harmful gases substantially emitted [4]. As a means to reduce greenhouse gases and overall environmental impact, we could design an enclosure that minimizes excessive space and requires less material to be used. In addition, using an environmentally friendlier option like polycarbonate could significantly reduce our carbon footprint.

Over two million tons of printed circuit board waste contributes to 40 million tons of global electronic waste [5]. At the end-of-life stage, PCBs must be disposed of and recycled properly as they contain many non-biodegradable and rare materials. PCBs along with their electrical components contain about 40% metals, 30% ceramic, and 30% plastics [1]. Richer concentrations of precious metals like gold and palladium are found in printed circuit boards as well; therefore, it is important that they are carefully recycled as the use of PCBs grows rapidly with technological innovation and the amount of harmful waste becomes insurmountable for the environment. There are numerous methods to recycle PCBs [1]. The first way is mechanically using manual disassembly, shredding, electrostatic separation, and pyrolysis. Manually disassembling components allows for careful examination in order to remove hazardous parts and recover reusable ones. After disassembly, the PCB is crushed and screened to separate the metals from nonmetals. This is done through strong magnetic separators or electric conductivity-based separation techniques. Although the mechanical approach is widely used, there can be fallbacks with energy consumption. Another method of recycling is automatic which involves robots for precise disassembly and image-processing to identify recoverable parts and materials. This would also have a degree of error as most autonomous systems do, and energy consumption would still be an issue. Semi-automatic recycling combines both of these approaches to streamline component and material separation while reducing the error of operation. Although each recycling method requires energy consumption, employing one of these systems would recover numerous reusable components and materials while minimizing waste.

A CCFL backlighting component is needed for each LCD, and these contain 3.5 to 13 mg of mercury which is incredibly hazardous for the environment [3]. If mercury is not disposed of properly, it can end up in drinking water from landfills or in the air by incinerators [6]. There are various waste collection services that will ensure it is safely disposed, so consumers should take care when discarding their devices after end-of-life.

During the end-of-life stage, the acrylic packaging also needs to be disposed of appropriately. Since acrylic is non-biodegradable and would take an exceptionally long time to break down, it is considered very hazardous if it ends up in bodies of water or wildlife habitats [4]. It can, however, be recycled and reused for other purposes; therefore, this is the best method for disposing of the packaging and minimizing environmental impact. While this requires additional energy consumption and gas emissions, it is much more harmful to have bulk amounts of non-biodegradable plastic littering our environment.

While the environmental impacts of the stereo camera, keypad, and Jetson nano were not previously elaborated on, each of these contain components and factors mentioned earlier. The camera and Jetson nano both have PCBs and electrical components with non-biodegradable properties. Consequently, they will need to be separated and examined for recoverable parts the same way as our main PCB. In addition, our keypad is made out of plastic and minute electrical components to achieve its thin form factor and mesh design. This unit will need to be recycled properly to avoid environmental pollution from non-biodegradable material. All of these precautions and recommendations will be provided for consumers’ end-of-life disposal in our user manual.

* 1. Ethical Challenges

As engineers, it is our duty to ensure our products work to the standards we claim and minimize threats posed to consumers. While never intended, products or designs can fail or become misused in certain circumstances; therefore, it is crucial that we disclose any and all plausible hazards. The best way to communicate these precautions is through labels and documentation in the user manual. Metaporter, while not intrinsically unsafe, can pose some risk to consumers.

In order to ensure consumer safety, Metaporter should not be misused or disassembled by users. If tampered with, our product’s power circuit can be shorted with improper rewiring. This could result in device malfunction and possible consumer harm. When shorted, the device can produce high amounts of heat and electrostatic discharge; therefore, bodily harm is imminent when handling the device in this condition. By printing warning labels for the device packaging and cautioning users in the manual, we can guarantee that people are well-informed of this risk to avoid hazardous situations with misuse.

Another circumstance users should be aware of is what happens to the data collected by our device. During the data collection process, snapshots are taken with the stereo camera and saved on the Jetson nano. Afterwards, these images are transferred to the host machine over a local network to be run through VSLAM and compiled into the 3D reconstruction model with NERF. Consumers have a right to know where their data is stored and how it is being used. This can be clearly communicated by displaying a detailed privacy notice on the LCD upon device startup. In addition, data collection should be done over a private and secure network to avoid possible hijacking of user data. On a public and unsecure network, users are incidentally susceptible to numerous cyberattacks. We can warn them of these risks in the user manual and provide recommendations to ensure the safety of their data.

Our device will be powered by a wall outlet using a long cord. As users will be maneuvering around their subject for the reconstruction, they should pay careful attention to their path of movement in order to avoid tripping over the cable and injuring themselves. A warning label will be fastened to the cord along with precautionary tips in the manual.

3.0 Sources Cited

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