Towards the development of Junkyard Hacks: Networked Robotics Applications

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ABSTRACT

In this paper, we outline the ongoing development of a hackathon designed to raise awareness of electronic-waste, alternative uses for it, and what can be done to mitigate the damage caused by it. Nonfunctioning electronics are brought in for participants to salvage functioning parts out of for use in projects. An upcycling hackathon will be the focus of the event, which is designed to encourage STEM educational engagement and sustainability focused cultural development. An example project in which broken Roomba vacuum cleaner robots were repaired and modified for use in a swarm robotics application is also detailed. The expected outcomes are enhanced student engagement in STEM educational technology; awareness of the sustainability issues related to e-waste; and enhanced accessibility of educational technology as a platform for application innovation, development, research, and discovery.

Keywords

Educational Robotics, Roomba, ROS, Raspberry Pi, Hackathons

1. INTRODUCTION

1.1 E-Waste

E-waste, or electronic waste, is a term for garbage generated in the form of discarded electronic devices. This includes, among other things, household appliances, home computers, and cell phones. E-waste management is a growing problem around the world. According to the EPA [2], the United States alone produced over 2.3 million tons of E-waste in 2009. Worldwide e-waste production was 44.5 million metric tonnes (49.3 US tons) in 2016[3]. As a form of pollution, E-waste provides major challenges. Electronics commonly contain heavy metals such as tin, copper, lead, and gold, along with other potentially dangerous substances, including flame retardants and the contents of batteries. [1]

In additions to the materials themselves being toxic, the methods commonly used to process E-waste for recycling can result in further contamination of the environment. E-waste is often shipped to developing countries for recycling, where the common practices involves the use of acid baths and even open air burning of the waste to recover valuable metals. This results in further exposure to potentially toxic substances for the workers.[2]

Due to the difficulties posed by recycling E-waste, we have decided to instead focus on the second of the three R's from the old slogan "reduce, reuse, recycle" -- we are looking at ways of reusing functional components of discarded electronics, rather than stripping them down to their component materials.

1.2 Educational Robotics

Educational robotics is the application of robotics to education. This is most commonly used in STEM education, both as a means of introducing students to fundamental scientific, engineering, and computing concepts, and for teaching robotics as a subject in its own right, but the term is broad enough to also apply to educational techniques which merely make use of robots for teaching some other subject.[7]. In their review of educational robotics platforms, Karim et al identified three broad classes of educational robot: what they called "brick based robot assembly kits," exemplified by the ubiquitous Lego Mindstorm kits; what they called "Modular Robotic Kits," which are designed to be assembled from common off the shelf components, and strike a balance between cost and the flexibility of Lego Mindstorm and its immediate competitors; and pre-assembled robots, such as the E-puck and the iRobot Create. [7], which tend to be smaller and less individually expensive, but also less flexible than robots from either of the other categories. Most of the designs which are currently in use are wheeled ground robots, but there are exceptions, such as the Nao, a humanoid robot from Aldebaran Robotics.[8]

Educational robot platforms are in use at all levels of education, from early childhood clear through post-secondary. At the lowest levels it can act as an engaging extension activity, particularly for math lessons. At intermediate levels robots provide a convenient means for engaging students with concepts of programming and introductory engineering topics. At the post-secondary level, uses range from something similar to the above, to use in actual robotics research.[4][5][7][8]

2. Junkyard Hacks

Junkyard hacks is a concept for a hackathon focused on sustainability and e-waste reduction. Planning is currently in a highly preliminary The basic idea is to provide participants with a selection of broken and discarded electronics, and to task them with creating something from the working components. This could be anything from individual sensors and motors up to the entire device, depending on the reason the original owner discarded it. Equipment, such as workbench power supplies and 3D printers, should be available, and a reasonable supply of batteries and basic electronics components (such as resistors and capacitors) should also be available. Partnerships with recycling centers and manufacturers should be considered, but donations from the community, and even items listed as “for parts” or “as is” on online retailers might be potential sources of broken or otherwise non-functioning electronics for the hackathon. The remainder of this paper will focus on a robotics project that itself serves as an example of the kind of project which participants in the hackathon might create.

3. REPURPOSING DISCARDED ROOMBAS FOR NETWORKED EDUCATIONAL ROBOTICS APPLICATIONS

3.1 Why Roombas?

The iRobot Roomba is an automated vacuum cleaner meant for home use. When purchasing new equipment, the iRobot Create, a robot built on the same platform but explicitly designed for use in educational robotics, may be a better choice, but when acquired used, the Roomba has quite a few reasons for recommendation, beyond the obvious reasons of price and availability.

For starters, all but the earliest models have a serial port which gives access to all functions of the robot, including motor control and sensor data.[6] The Create uses the same port with a slightly expanded set of features, but the point here is that the Roomba already provides an adequate interface for applications outside of their primary function as robotic vacuum cleaners.

Figure 1. The serial port on a 500 Series Roomba

Further, the platform itself is robust -- both mechanically reliable, as it is designed to be always on, automatically cleaning a room at scheduled intervals and autonomously returning to its charging base, and large enough to carry a heavier payload than many smaller entry level robotics kits, such as the GoPiGo from Dexter Industries. Even units produced before iRobot introduced the serial interface have these advantages, and my be of interest for hackathon participants looking to control the motors directly, but the additional work involved in getting control over that has thus far precluded their use in the current preliminary work.

Finally, as a home appliance, there is extensive documentation available online for repairing nearly any problem a given unit might have. Odds are if something is wrong with a roomba, somebody else has already encountered the problem, figured out how to fix it, and made a text or video guide for others with the same problem. This is useful both in the case that a specific unit has an actual problem, and as a source of documentation for the inner workings of the robot in the case that an extension of functionality is desired.

3.2 Current Progress on the Project

Work has progressed at a glacial pace this semester due to various bureaucratic and logistical issues unrelated to the project itself, but some work has been done towards building a functioning prototype. Four Roombas were acquired from ebay, all listed as non functioning units being sold for parts or repairs, at a price of about $50 a piece -- a significant savings over a new iRobot Create 2, at $199.99. Of these, two turned out to be 500 series roombas, one turned out to be an older model that is still new enough to have the serial port, but unfortunately uses a different battery from the 500 series, and thus has not yet been tested, and the third was an even older, pre-serial port model, which takes the same kind of battery as the third Roomba.

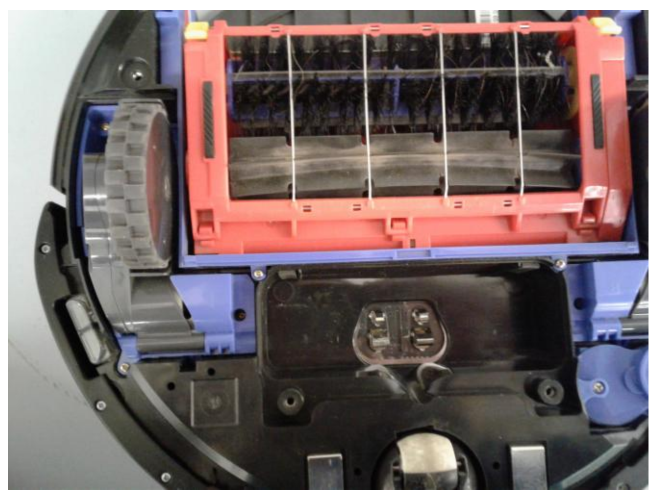

Figure 2. The battery compartment of a 500 series Roomba, with cover plate removed

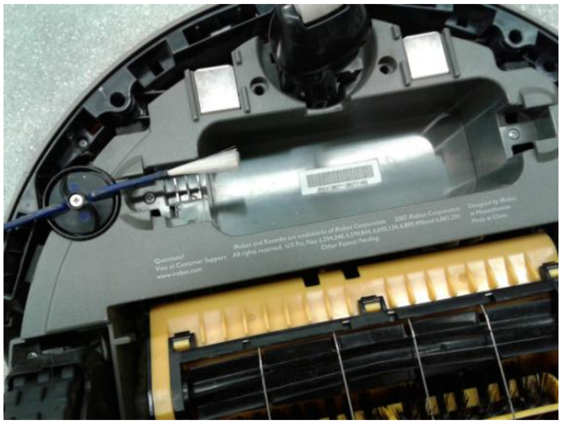

Figure 3. The battery compartment on a pre-500 series Roomba.

Of the 500 series roombas, one turned out to simply need its battery contacts cleaned and a new battery slotted in. Once this was done, the unit started right up and proceeded to work as designed, vacuuming the floor of the lab. The other one had a damaged bump sensor in addition to needing a new battery, causing the unit to think one side of the robot is always in contact with an obstruction, but it should be possible to control over serial even without the use of this sensor, and if time and resources permit, instructions are available on the internet for the repair and replacement of the sensor. Unfortunately, at present time control via the serial port has not been tested, but doing so is the immediate next step.

3.3 Future Work

The immediate next step in the research process is, as mentioned above, connecting a computer to the serial interface and ensuring that everything on that end is working. The plan is to initially use the GPIO pins on a Raspberry Pi microcomputer for this task, moving to more powerful (and expensive) hardware only if necessary. Once the physical connection and serial logic are confirmed to be working, the next step will be to move from Raspbian to ROS as the operating system on the pi. ROS, short for Robot Operating System, is an open source operating system designed specifically for controlling robots, and is used on a wide variety of platforms, and comes with a driver for controlling Roombas. Using ROS will also allow us to leverage previous work done by members of the research group on networked applications involving an in house mesh network and a different robotics platform, the GoPiGo. Keeping things on ROS should, in general, allow us to transfer the higher level aspects of the work done with this platform to other robotics platforms should a reason to do so arise. Once this has been done, the plan is to connect the robots in a mesh network, and start adding additional sensors, such as ultrasonic sensors, accelerometers, and LIDAR, and use the data collected to make decisions within the swarm. Eventually, a set of classroom activities could be developed for educational use.

4. CONCLUSION

In conclusion, e-waste is a growing problem which needs to be confronted. We believe that the planned hackathon could result in ideas for novel ways of dealing with it. The example project above could be one such method; at the very least, it provides the genesis of an interesting alternative to more expensive educational robotics platforms.

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