EZ-Clean: Smooth Surface Cleaning Tool

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Abstract
The EZ-Clean is a tool that will allow users suffering from limited upper body motion to clean surfaces effortlessly. This tool should fit in at a Laneway House for use by the elderly. This report covers the changes made to the system since the initial in-class prototype demonstration, and our rationale behind these changes. We will go into detail exploring the embodiment we presented in class, considering its strengths and weaknesses. Additionally, we will address the weaknesses in our embodiment that were brought up during the final presentation, and describe the changed that we made to present in the CPSC showcase. Finally, we detail a few ideas that could improve the design of the EZ-Clean.

Author Keywords
Laneway House; cleaning tool; extended reach & motion; tangible user interface.

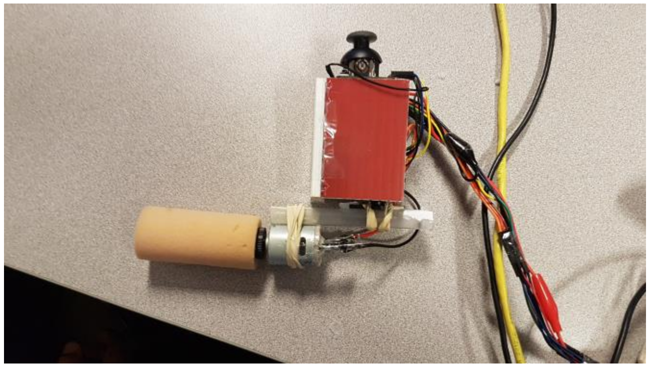

Figure 1: EZ-Clean as presented at the CPSC Showcase

Introduction
Initially our goal in the development of this tool was to create a system that would allow a persona we created to clean her counter tops with ease. Nancy, the persona we created this system for, is an elderly woman who enjoys cleaning but suffers from osteoarthritis. To help Nancy clean, we wanted to create a tool that allowed her to clean smooth surfaces, such as counters, in a way that would be comfortable for her. Since traditional cleaning methods cause Nancy tremendous joint pain, our original plan was to create an automated system that would relieve her from performing the cleaning task altogether, and her only interaction with the system would be a mobile app that would control the machine. We reconsidered our plan after the prototype presentation because, as previously mentioned, Nancy likes cleaning. We did not want to take the participation

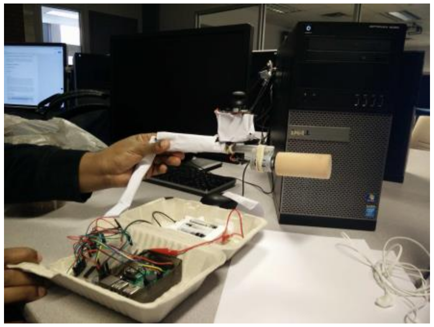

Figure 2: EZ-Clean as presented in the classroom

in the cleaning activity away from her, so we reassessed our designs and decided not to automate the entire cleaning process, and instead we created a handheld tool (figure 1) that Nancy could use to clean. The handheld tool, EZ-Clean, is more maneuverable and versatile than any of the automated options we originally come up with, so its uses extended beyond just counters, to other smooth surfaces such as bathtubs, or tiles.

Implementation & Embodiment

One of our initial project proposals was an extendable arm that would allow Nancy to reach and clean from places far out of her reach, but it had one major flaw: an extendable arm with a weight on the end would require a larger force to move than the weight on its own. Because of Nancy's medical condition, such a design was out of the question.

We then thought of two different automated systems that could completely take over the cleaning process. One was a tool that would be attached to the counter, the other was a small Roomba like device that would roam freely on the counter, cleaning it. We wanted to include a mobile application that would be used to control whichever of the devices we built. These were the two ideas we presented to the class, but one very important issue was brought up: these devices would take the 'cleaning' away from our persona. Additionally it might also not be fair to assume that our elderly user would be familiar with using a mobile device - as many have not/do not use them.

We borrowed from the initial design of the proposed extendable arm, and the automated surface cleaning robot to create a small handheld tool, the EZ-Clean, that utilizes a motorized cleaning head (sponge/brush). The device extends the reach of the user by about one hand's length, and increases their range of motion, as well as lessens the amount of work required to clean a smooth surface. The tool consists three main components (figure 3):

1. A **cylindrical sponge** that is attached to a **DC motor** -this sponge is the portion of the tool that will clean the surface the tool is used on. The motor drives the sponge so the user does not have to manually scrub the surface they are trying to clean.
2. A **servomotor** that rotates the scrubbing sponge perpendicular to the user's palm - this motion allows the user to cover a larger area on the surface they are trying to clean. While the extra range of motion would not help people without joint problems, it could significantly help someone who has trouble moving their wrists.
3. A **thumb joystick** - this acts as a control to the above two motors. A simple press down on the joystick starts the rotation of the cylindrical sponge. Moving the joystick side-to-side allows the user to control the servomotor to create a sweeping motion with the sponge.

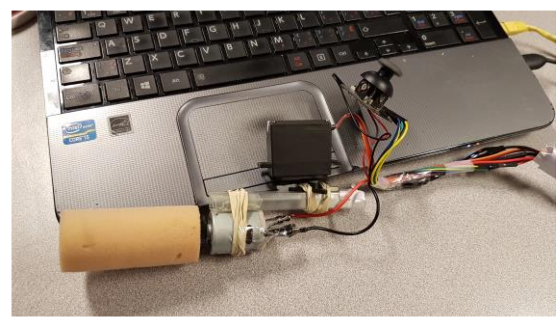

Figure 3: The three main components, as described above

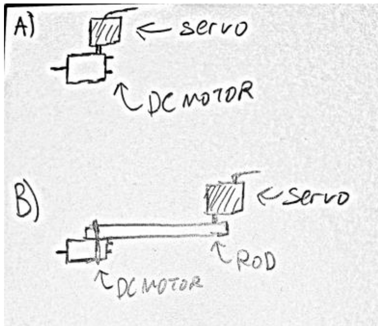

Figure 4: The two servomotor positions we considered

The two motors mentioned above are connected using a plastic rod. We experimented with various placements (figure 4) to find the optimal positioning of the two motors. Placing the DC motor directly onto the servo did not cover the amount of surface area we had hoped for. The placement of each motor at each end of the rod seemed to be ideal, but our servomotor could not create enough force to move the DC motor and sponge while it was on a surface. We decided to compromise between the two positions, and chose to place the servo at the middle of the rod, and the DC motor at the end. This configuration also allowed us to fix many of the loose wires onto the rod, in order to prevent any disconnects during use, as well as improve the aesthetic of the tool.

In addition to the main components listed above, we use a battery pack, raspberry pi, and a breadboard to build the appropriate circuitry and run the code to make the system work as intended. Ideally, we would make all these parts smaller and fit it into the tool so that the entire system is more mobile.

Evaluation & Analysis

Physical Ergonomics and Affordance

The implementation of EZ-Clean we presented in class was a little confusing to operate, as what appears to be the handle was actually a shaft used to keep the wires in place. The actual handle was a little small for most hands so it was difficult to operate with one hand, but using two hands (one to grip the handle, and another to interact with the joystick) alleviated this problem. The joystick itself is easy to use with either a thumb or the palm of the hand.

Limitations

The most apparent critique of the design is its form factor. The EZ-Clean we presented in class didn't make it obvious which part was meant to be held, as a result, the majority of people chose to hold the tool by grabbing, what is perceived to be, the handle. Holding it in this way prevents the servo from functioning as intended, because the servo will turn side to side rather than the sponge. The reason we didn't remove the handle-like structure from the device is because of the number of wires that were used to drive all the motors required a strong enough support, otherwise a number of them would have disengaged from the components they were powering.

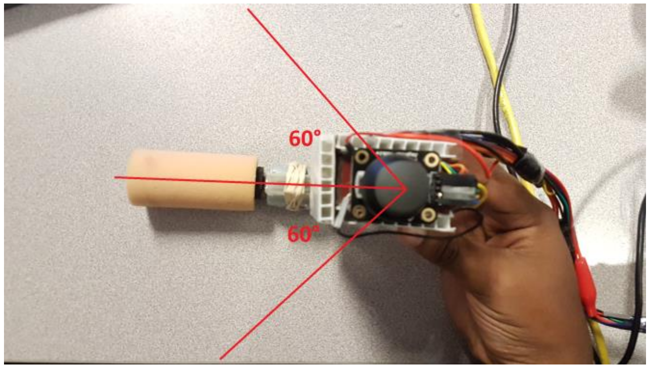

Figure 5: Rotational limit of 60°

A less obvious limitation is that the rotational limit of the servo is set to 60°, so should a user want a wider sweep, they would have to rotate their wrist. While this limitation does inhibit the capabilities of the tool, we decided that the restriction was necessary in our current implementation because of the number of wires that would get in the way. If these wires were minimized and constrained to the holding portion of the device, we could consider increasing the range of the sweep on each side to 180°. A 180° sweep would double the area the user could clean without moving their hands

Showcase Modifications

The main thing we wanted to accomplish in time for the CPSC showcase was to improve the affordance of the EZ-Clean, and make it more comfortable to use. We addressed this by removing the back end of the shaft and raising the joystick, effectively making it sit on top of the handle, to add a more ergonomic hand grip to the device. The handle is used to convey to the user how the tool is meant to be held. The heightened joystick is much easier to maneuver with the palm of the hand (as many people suffering from osteoarthritis can feel pain from bending their fingers), as well as with the thumb if the user is using one hand.

Future Work

There is one main flaw that we were unable to address during the development of the EZ-Clean, mobility. In order to improve the mobility of the device, it would be important to either extend all the wires, and bundle them into one long cord, or miniaturize the controller (breadboard and Raspberry Pi) and constrain it to the handle of the tool (effectively making the tool wireless). Either of these changes would also help solve the issue of mobility because the user would no longer have to carry the box that contains the Pi, battery pack, and breadboard.

Attachments are another suggestion that we could look into implementing. Currently we only have a small cylinder brush that can be used on smooth surfaces, but other extensions could include triangles to reach intro corners, bristled cylinders to clean the insides of cups and bottles, a larger feathered duster, etc. The inclusion of attachments would diversify the EZ-Cleans utility in the home, as well as eliminate the need for additional job-specific tools.

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