Designing the Gateway Remote for a patient with traumatic brain injury

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INTRODUCTION

Traumatic brain injury (TBI) is the designated clinical diagnosis for an individual who incurs “neuropathologic damage and dysfunction” from a head or body trauma. [1,2] The initial injury is frequently followed by a secondary injury, such as hemorrhage, neuroinflammation, or ischemia which can all lead to a variety of neurologic deficits. These include mental deficits (slowed thinking, confusion/disorientation, aphasia) and physical deficits (lethargy, weakness, poor balance, sensory loss) that may or may not resolve itself. [1] Consequently, patients with non-transient, moderate-to-severe TBI require extensive, individualized therapies to recover to the best possible level of function. Rehabilitation engineering is a powerful tool to modify or create highly-specialized technologies for occupational and physical therapies addressing TBI symptoms.

In this case study, rehabilitation engineers in the Assistive Technology (AT) Program at McGuire VA Medical Center innovated a custom-designed television remote for a patient with TBI. The patient has demonstrated an inability to access communication devices and other electronics due to inhibited cognition, right hemiparesis, and ideational apraxia. AT initially provided a single-switch solution for patient to turn the television on and off which proved ineffective.

The AT rehabilitation engineers evaluated the patient’s situation and developed design constraints for the Gateway Remote, a television remote with two switches. Both switches are programmed so that if a user presses a switch to send out an infrared (IR) command, that switch will subsequently be deactivated until the other switch is pressed to issue another IR command. Therefore, the remote can be programmed to separate the television on and off commands and requires the user to make that distinction as well. This project serves to highlight the importance of rehabilitation engineering, an emerging field in medicine, as a resource for addressing challenging clinical situations.

METHODS

Before pursuing a custom design project, the AT rehabilitation engineers trialed an interface with the existing television remote which allowed a single switch to control television power on and off. However, the patient pressed the switch repeatedly (perseveration) and wanted to manipulate the switch roughly. Based on observation, AT staff determined that current adaptive television remotes on the market, such as the Relax remote from Ablenet or the large Wireless TV Remote Control from Enabling Devices, would not be simplified and accessible enough for the patient.

To create a television remote that might better serve the patient’s needs, the AT rehabilitation engineers determined the following design constraints:

1. Make the remote durable and tamper-resistant. The patient is hard on equipment and possesses considerable strength in his left extremities.
2. Power the device using batteries, and make it easy to replace the batteries. A power cable will limit the placement of the remote.
3. Design the remote to be programmable. The remote will be universal so that it can work with any television. The remote will not needed to be modified by AT rehabilitation engineers if the television intended for use with the remote changes.
4. Add two low-profile, tamper-resistant switches for issuing IR commands and space them apart at least five inches. The switches should be very distinct from each other to make remote function as simple as possible.
5. Build in a logic gateway so that a switch is deactivated after use until the other switch is pressed. This condition will require the patient to perform a different action to obtain a different outcome, and it will prevent the patient from turning the television on and off rapidly by pressing one button many times successively.

The AT rehabilitation engineers chose a sturdy project box to encase the remote, approximately 8.6” x 4.3” x 1.75”, made of reinforced ABS plastic. The length of the remote allowed enough room for the switches to be spaced apart, and the width and height provided space to insert a four-cell AA battery compartment and all the internal components. Two arcade-style switches were selected for durability and recessed mounting, making them more difficult to grab onto and potentially damage. These switches also light up when pressed, indicating to a user that the switch is responding to the user’s input.

To prevent tampering, the AT rehab engineers placed the battery compartment and the IR emitter in the front of the remote, facing away from the user. Similarly, the programming components (an IR receiver for programming and a pushbutton to enter programming mode) are recessed into the remote body to make probing impossible with fingers. The pushbutton is not accessible except using a paper clip or writing utensil to press it, mitigating inadvertent programming.

The AT rehabilitation engineers utilized Arduino, an open-source electronic prototyping platform, to drive the electronic components of the Gateway Remote. The Arduino Pro Mini microcontroller board was sufficient for controlling the remote while remaining compact enough to fit inside the case.

RESULTS

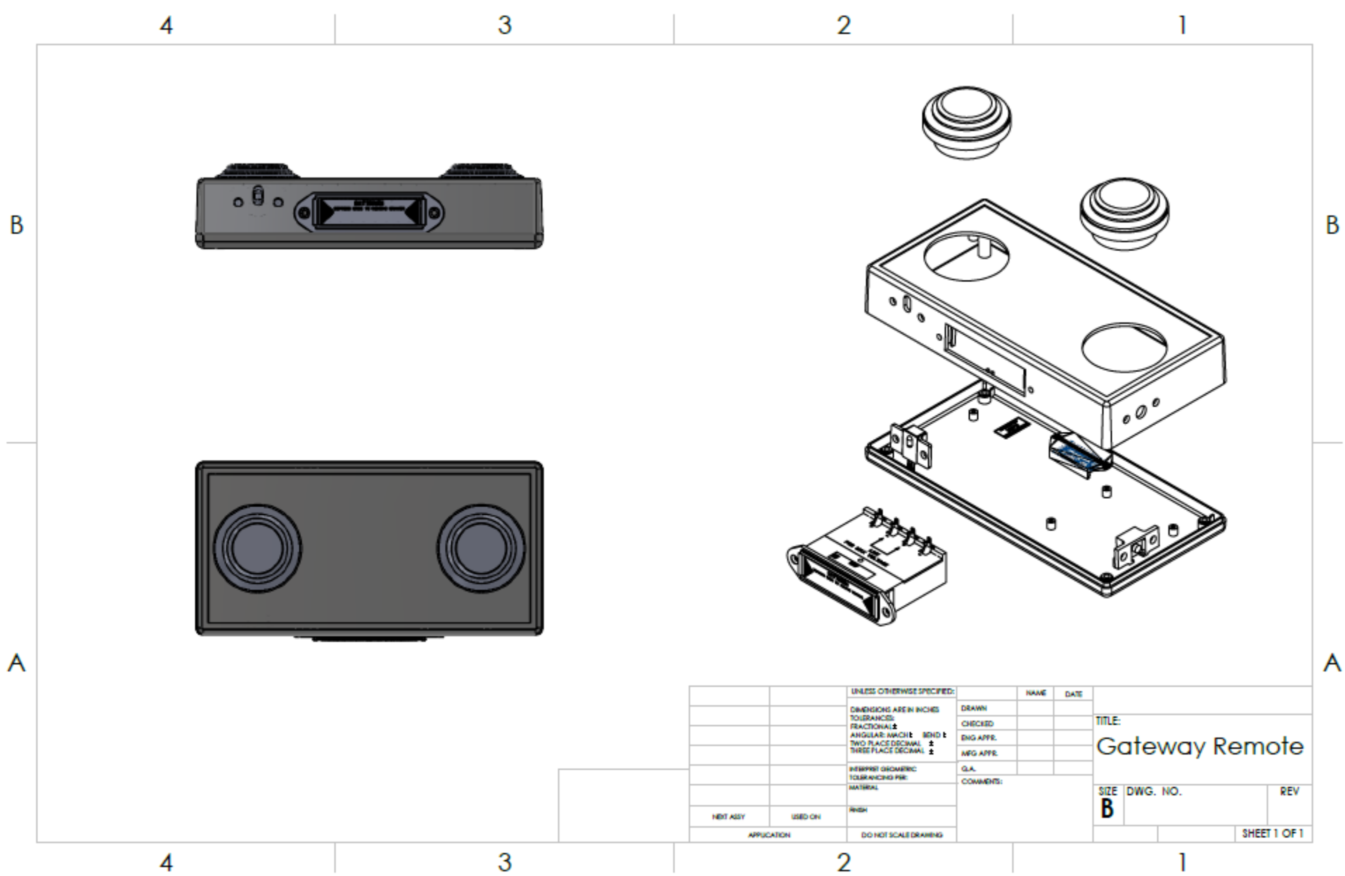

Figure 1. A SOLIDWORKS drawing of the Gateway Remote. The body of the remote contains an Arduino Pro Mini with a mounting bracket, a pushbutton/mounting bracket for entering programming mode on the right side, an IR emitter/mounting bracket in the front for controlling

the television, and a four-cell AA battery compartment in the front to power the device. Two arcade buttons fit into the top of the remote body, one for activating power on and one for activating power off.

The patient initially trialed basic AT solutions which were inadequate to meet the patient's needs.

The AT rehabilitation engineers successfully built a remote prototype using design constraints. The prototype was programmed to activate a demo television in the AT Program laboratory and successfully operated. The prototype allows a user to turn on the television with one switch, which was then automatically deactivated until the other switch was pressed to turn off the television. The AT rehabilitation engineers simulated perseveration by pressing switches rapidly, but the prototype did not respond to excess input and only turned the television on and off when the remote was appropriately actuated.

The build was virtually created in SOLIDWORKS, a 3D CAD (computer aided design) software, to determine any potential issues prior to the physical build. The final build and use with patient will occur once all parts have arrived from vendors.

DISCUSSION

The final product from this project will be immediately useful to the patient as a television remote that may provide him with greater independence. Further observation and evaluation will be crucial to determining whether this rehabilitation engineering project is effective in expanding the patient's independence. If the patient masters the remote, it may also be a learning tool for the patient to begin using more complex technology. The ultimate goal for the patient – as expressed by his family – is to use a communication device, which entails multiple input options. By separating the inputs for television power on and off, perhaps the Gateway Remote will be a stepping stone towards that goal.

The Gateway Remote can also be easily adapted to other technology accessible by IR control, thanks to its programmability. For example, the same patient could learn to turn the lights on and off in his room and avoid the effects of perseveration. Additionally, it could serve as a durable tool for controlling a bed remote to move a hospital bed up and down for pressure relief and comfort. The Gateway Remote could work for any two-way function with an IR-accessible input.

CONCLUSIONS

This case study demonstrates how rehabilitation engineering, a relatively new but growing field, can bridge the gap between what a patient needs to be successful and what exists in the market. The AT rehabilitation engineers observed and evaluated the patient, determined what he would need to increase independence, and set clear, defined design constraints to create a unique device fine-tuned to the patient. Additionally, they utilized an assortment of makerspace technology, from ABS and SLA 3D printing to Arduino programming and electronics fabrication to CAD software.

This process occurs daily at the McGuire VA Medical Center because of the establishment of an Assistive Technology Program that serves the entire hospital. Having the tools to make and create projects "in-house" is not yet ubiquitous in hospitals, but it is a growing trend with an increasing body of work suggesting it is a strong factor in delivering better health care to patients with challenging conditions, including but not limited to TBI.

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