CircuitBrush

The Problem

Written by Andrey and Ila || Reviewed by Adel

Our design seeks to address the issues that individuals with motor impairments in their arms have with brushing their teeth independently. Standard handheld toothbrushes require a level of hand mobility that many individuals with disabilities struggle to achieve. The motions that may cause issues when using a standard toothbrush include: difficulties with sustaining the arm in a raised position, difficulty maintaining a firm grip, and issues with the dexterity and fine motor skills required to maneuver the toothbrush in the mouth. Previous attempts to solve this issue and create a hands-free toothbrush have been demonstrated to be ineffective when compared to standard toothbrushes (Niere et al., 2020).

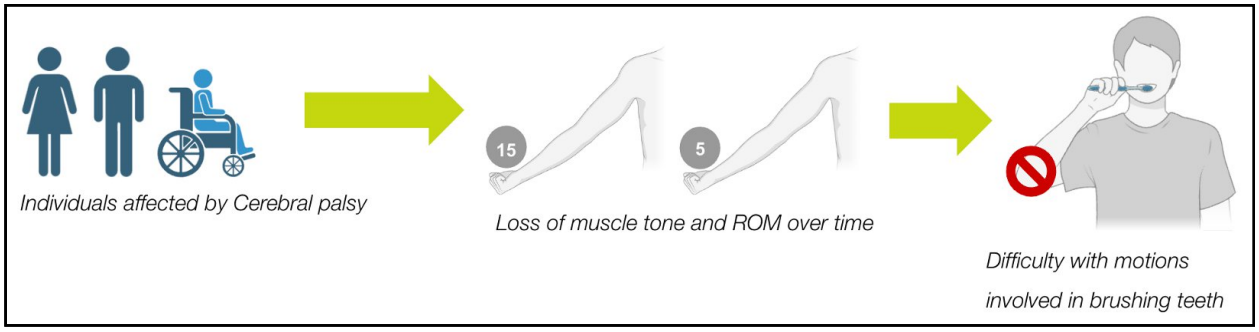

Figure 1: graphical abstract of the problem

Design Description

Previously written by Andrey || Current version written by Grace || Reviewed by Adel || Edited by Ila

We kept the retainer case of the initial prototype, and from there, we removed the belts, which previously caused too much friction. Due to the high friction, the belt was replaced with a design where a belt is no longer needed – instead, a flexible TPU partial gear was implemented, forgoing the need for complicated belt configurations further into the box. Our current design works by having a gear reduction. The gear is a 10-tooth gear and is placed on the stepper motor, which spins the gear to move the brush around the teeth of the user. The 10-tooth gear transmits its torque to a 3D printed 16-tooth gear, which meshes with a 12-tooth gear. The 12-tooth gear, in turn, transmits its angular velocity to a partially cut 62-tooth gear. The partially cut 62-tooth gear is 3D printed using TPU. Due to the firmness of PLA, when the TPU gear comes in contact with the PLA casing, the malleable gear bends in order to travel inside the retainer case. We also used a gear reduction to create an 8.266 times higher torque output to the TPU gear. This ensures

that the TPU gear would spin as the torque that is applied creates a force stronger than the frictional resistance it rests on. Afterwards, a 3-sided toothbrush was attached to the smooth portion of the flexible TPU gear to ensure all 3 faces of the teeth are properly cleaned. A small circular spacer was added to the side of the retainer case to ensure that the TPU would run smoothly to the outside of the retainer case. A smaller PLA piece was added to the top of the retainer case in order to ensure structural integrity. The PLA gear and the spacer are spinning on a dead axle.

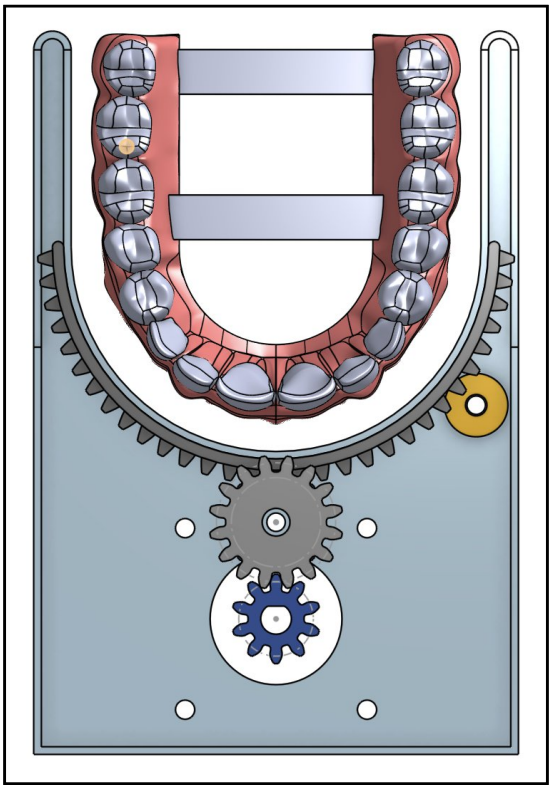

Figure 2: an overhead view of the CAD, as described above

The motor is attached to a DRV8825 motor driver. The driver is connected to an 11.1V battery to power the motor; it also receives signals from an Arduino board to determine its direction and speed. The Arduino determines when to run the motor using buttons.

Figure 3: an overhead view of the final design

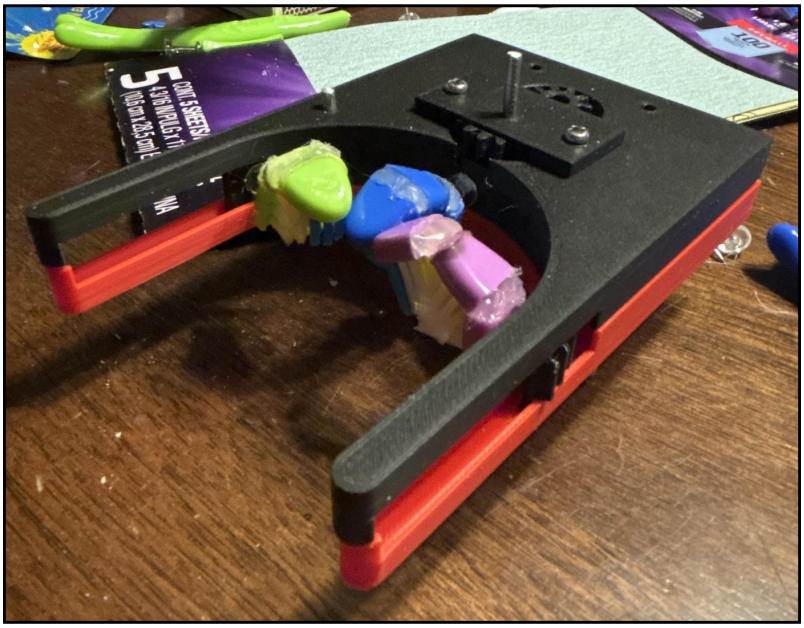

Figure 4: a ¾ view of the final design

Instructions for the Client

Written by Andrey and Grace

Installation:

In order to install the device, the user can simply attach the wall mount to the wall, making sure the screws are tightened so that the device doesn't fall when pressure is applied to it.

Mounting the wall mount to an actual wall requires there to be pilot holes pre-drilled into the wall. Consult the owner of the property before installing this device.

Use:

Written by Andrey and Grace || Reviewed by Adel

The first step is to place a toothpaste capsule into the user's mouth. The capsule should be located on the tray from the wall mount. The capsule can then be broken apart and spread across the user's teeth. In order to turn on the device, the user can use any part of their body to press the button that is located on the side of the device. Pressing the button will initiate a 10-second delay, and then the device will activate. During the 10-second delay, the user should move to place their jaw into the retainer casing, and then hold it there until the bushes stop moving.

Maintenance Instructions

Written by Andrey

For maintenance, it is important for the device to be cleaned at least twice a week to prevent buildup in the retainer. Additionally, the capsule tray needs to be refilled at least once every five days, because it can hold at most 10 capsules. The capsules may also degrade when exposed to open air, so the user should also not leave unused capsules for more than five days because they will lose their potency. The battery should also be recharged once a month to ensure the device continues operating smoothly.

Safety Warning & Care ⚠

Written by Andrey, Ila, Adel

Care & Maintenance:

Written by Ila

The CircuitBrush is waterproof. We recommend rinsing out the bristles and retainer case as often as possible, at least twice a week. Per ADA guidelines, the track unit, which should come with brush heads attached, should be replaced every 3 to 4 months.

Safety Warning:

Written by Ila and Adel

If there are any exposed wires or wires that seem to have been unplugged from the main circuit board, please do not power on the device for both your safety and to minimize the damage done to the device. The fluoride capsules could represent a potential choking hazard, especially for individuals with issues swallowing. Additionally, always be careful to check your chosen

toothpaste or capsules for potential allergens. Being a mechanical device, it is very important to be careful to not get your tongue or other parts of the mouth stuck in the retainer, and if this does happen to stop the device as soon as possible to prevent harm.