CircuitBrush: An Autonomous Toothbrush Designed for Individuals with Cerebral Palsy

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Scan to view full process/instructions

Problem Statement

Moderate to severe arm impairment from Cerebral palsy can make brushing one's teeth challenging, and in some cases, impossible without external assistance. This poses a significant threat to quality of life, jeopardizing both physical health and independence.

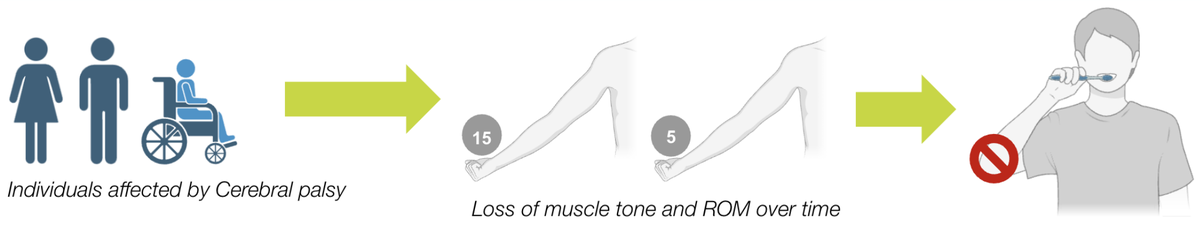


Figure 1: The effects of Cerebral palsy and its impacts on tasks such as brushing teeth.

Process/Methodology

Step I: Initial Prototyping

1

Design 1: in which (for each jaw) a single loop covers all three faces of the teeth – 2 tracks total

Figure 2: Overhead view of Design 1

Design 2: in which (for each jaw) three tracks run on each of the faces of the teeth, respectively – 6 tracks total

Figure 3: Side view of Design 2

2

Design 3: in which (for each jaw) one loop runs around the front/back faces of the teeth, and one track runs on the top face – 4 tracks total

3

Figure 4: Overhead view of Design 3

Step II: Materials Procurement

Involved obtaining *timing track, NEMA17 Pancake Motor, Triplebristle brush heads, and a DRV 8825 motor Driver*

Step III: Materials Production (CAD)

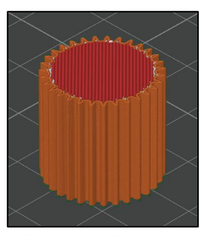


Figure 5: Track gear

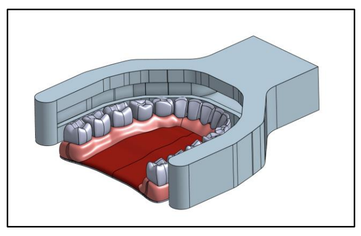


Figure 6: Retainer casing CAD

Step IV: Assembly

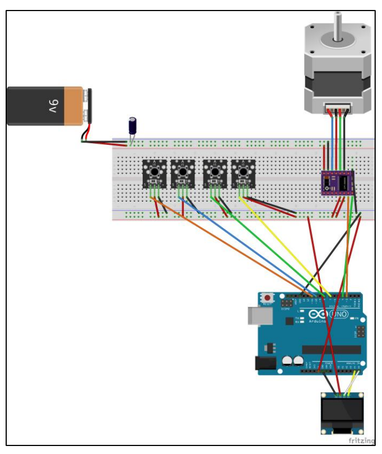
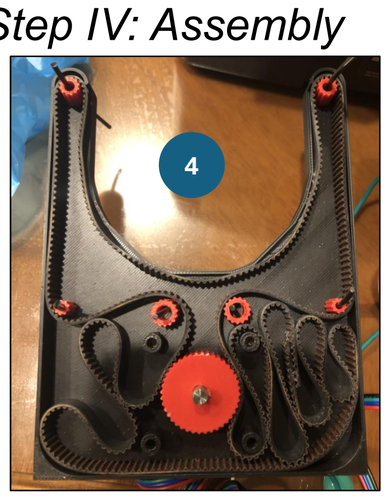


Figure 7: Wiring diagram



4

5

Figure 8a & 8b: Retainer case + timing track + gears in two iterations – we finalized the second design (5)

Analysis/Conclusion

The results of the Motor Speed test suggest that the CircuitBrush will be able to handle oscillatory motion. To minimize user interaction, we aim to make this function autonomous instead of button-controlled. In a similar vein, the brush is also capable of being customized through speed. Further research is required to determine how this will be implemented without the use of hands. Lastly, the water resistance of the PLA case suggests that the CircuitBrush will function properly in clinical use, when it is forced to come in recurrent contact with water.

Engineering Statement

To create a *retainer-based toothbrush* that uses moving brush heads to simulate traditional toothbrushing. Client X should be able to operate the CircuitBrush without the use of their hands and without the aid of a Personal Care Assistant (PCA).

Table 1: Level I Requirements

Requirement	Type	Weight
The device will be able to clean with the effectiveness of a traditional toothbrush.	Functional	10
The device will be able to be operated with the assistance of a wall mount (hands-free).	Functional	10
The device will be waterproof.	Physical	8
The device will be food safe.	Physical	9
The device shall include design documentation.	Documentation	10

Design Study I:

Motor Speed

Goal: To determine whether the motor is capable of speed modulation.
Result: The OLED display (Figure 9) gives the delay in microseconds, which is inversely proportional to speed. As the delay decreased, we observed the motor spinning faster, which would correlate to a faster brushing speed when implemented in the CircuitBrush.

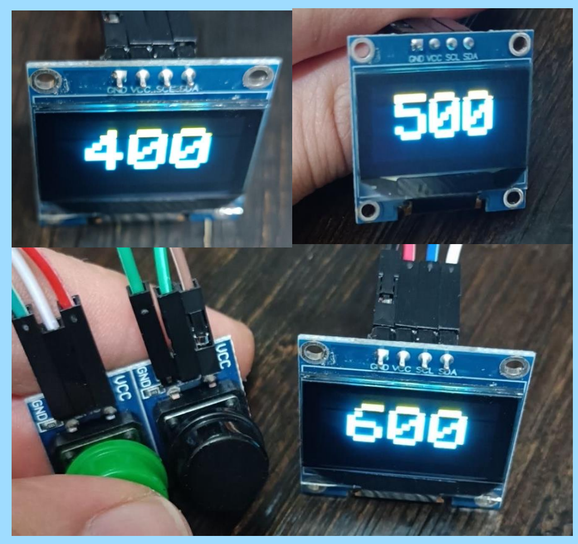


Figure 10: OLED screen displaying delay between each step in microseconds.

Design Study II:

Track Functionality

Goal: To determine whether the motor + gear will move the timing track – with a brush head attached – in a way that simulates the motion of traditional toothbrushing.
Result: The track is able to oscillate between positions by switching direction when told to do so. During testing, this motion was created by button input in order for us to test its efficacy. In the CircuitBrush, the track is programmed to continually move back and forth as though the user were brushing their teeth with a manual toothbrush. Additionally, we noted that the grooves of the timing track fit well into the gears' teeth.

Design Study III:

Waterproof

Goal: To determine whether the CircuitBrush is safe for use with water.
Result: None of the components that contact water during use – various faces of the retainer casing itself – degrade, warp, or react in otherwise unfavorable ways when exposed to water over repeated 2-minute intervals.

Future Steps

- Implement automatic oscillation system
- Refine toothpaste delivery system
- Implement pressure sensitivity using FSRs (Force Sensitive Resistors)
- Improve brush/retainer cleaning system
- Iterate design several times