Project Deliverable G: **Prototype 2**
GNG 2101 – Intro. to Product Dev. and Mgmt. for Engineers
Faculty of Engineering – University of Ottawa

Date: October 31st, 2019
Group number: Group 10
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Introduction

In this deliverable we will define a new design solution with the intent of presenting it on Design Day. By reviewing the client feedback that we received during our third client meeting, we will outline the most pertinent design deficiencies, allowing us to improve our final design. This will be achieved by creating an additional prototype with said design flaws addressed, helping us get closer to creating a final product.

Upon creating out new prototype, we will conduct tests to analyze our products performance by comparing it to our target specifications. By organizing our results in a tabular format, we can further compare our expected results in relation to the actual results. Doing such will allow us to outline remaining design flaws and assure that come Design Day, we may present our client with a verified solution that is effective at treating our problem statement.

1. Summarize the client feedback that you received during your third client meeting for your first product prototype and clearly state what needs to be changed or improved in your design.

Upon meeting with our client for the third time, we were able to present the improved design and prototype we have created. At the time of our last meeting, we presented the client with our original idea of a customizable toothbrush with two degrees of freedom. The client expressed many concerns that caused us to change to our current design.

The client was very pleased with the changes to the original design. He believes that keeping the toothbrush intact and creating a gimbal style support system is definitely more realistic and has a higher chance of functioning within the short timeframe we have. Notably, our client was pleased by the ergonomics our new chosen toothbrush. Due to the physical constraints of our client, a lighter overall product is a very important metric to take into

account. Making this change addressed both weight of our product, as well as decreasing our total found in the Bill Of Materials.

Old Toothbrush	New Toothbrush
Oral-B Vitality FlossAction Electric Rechargeable Toothbrush  331g 29.99$	GUM Daily Clean Sonic Battery Powered Electric Toothbrush  55g 12.99$

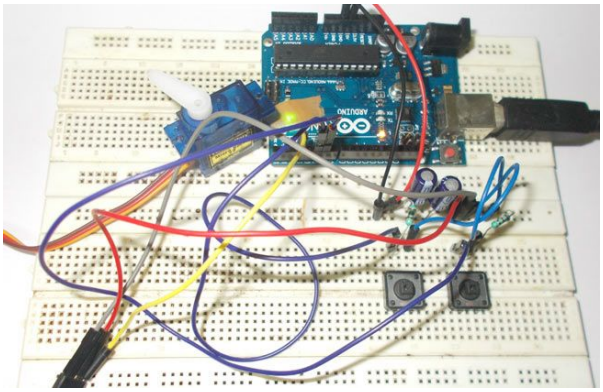
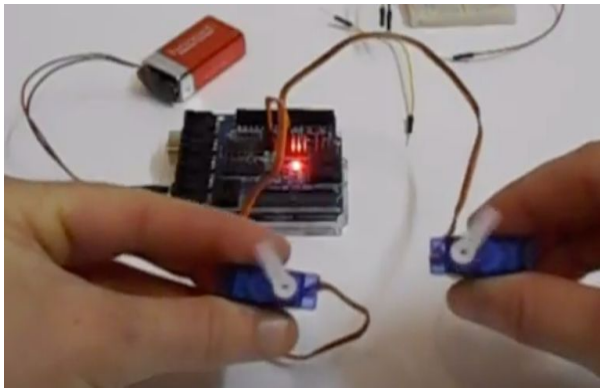
In summary, our client was overall very pleased with how our latest product design. One suggestion that was provided relating to our current design was to use a Sensor Shield V4 Digital Analog Module for Arduino.

An increase in sturdiness of our device was also discussed. As a team, we plan on delivering a product that is of the utmost quality given the time and financial restrictions we face. By refining our design that will maximize the number of uses possible before breaking down, we grow closer to achieving a solution that works efficiently at solving our client's problem.

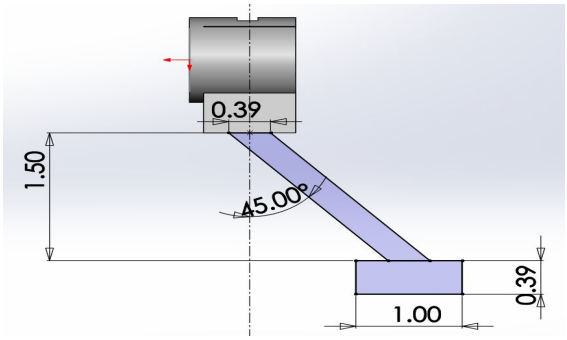
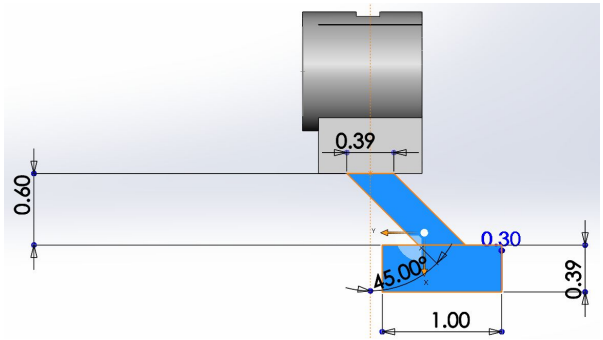
Possible design adjustments for overall ergonomics were also discussed to maximize comfort of our client while operating the device. This included ideas regarding adjustments to the handle of our product appropriately tailored to our clients capabilities.

2 & 3. Based on the feedback, develop a second prototype (or more) which will help you on your way to creating your final product. **Document your latest prototype(s) using as many sketches/diagrams/pictures as required and explain the purpose and function of your prototype(s).**

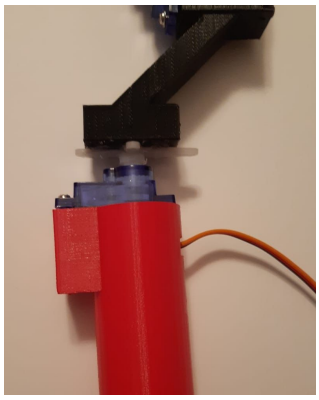
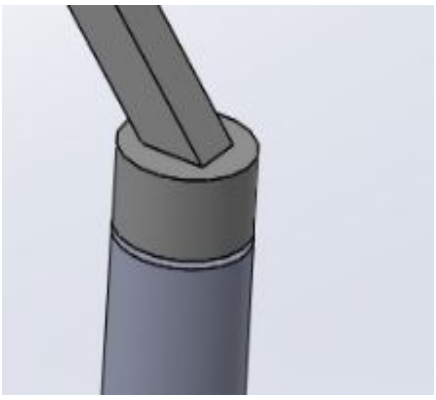
Based on the feedback provided, there are a few adjustments we plan on implementing in our next prototype. As discussed earlier, the use of the Sensor Shield V4 Digital Analog Module will be used to connect the servos to our microcontroller. Our old design incorporated a multitude of wires which would have been connected to a breadboard which would then be connected to the Arduino Uno. By using the Sensor Shield we may increase the overall aesthetics while diminishing the total number of separate parts needed.

Old Design	New Design
	

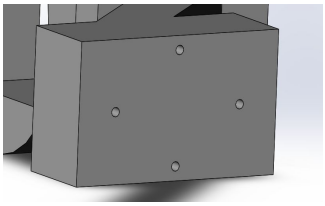
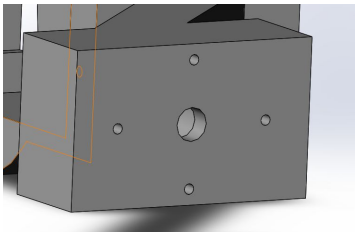
One major insight our team had when testing our previous prototype was that the connection pieces between the servos were unnecessarily long. The oversized arms created no advantage and led to create forces and stresses on the joints. For this reason we changed the length of the connection pieces to allow for a more compact and efficient device.

Old Design	New Design
	

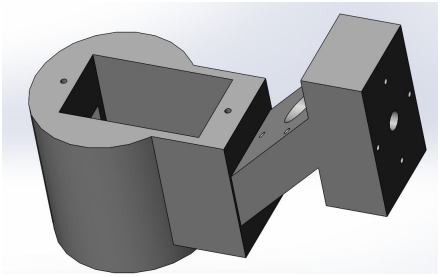
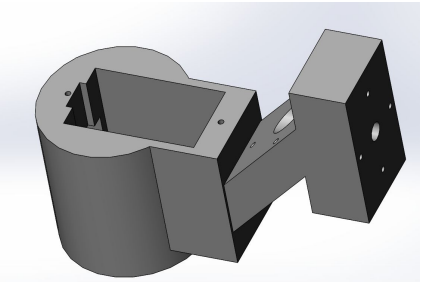
As mentioned, maximizing the structural strength of our device is a great concern of ours as well as our client. We noticed that our current design put a lot of stress on our first joint, found above the handle component. This was found to be a significant design flaw as our product needed to be one that was well built, capable of withstanding stress from daily usage. To solve this issue, we plan on adding a circular collar around both pieces. By doing so, we assure that in the case there is an ample amount of stress in one direction of our first joint, we can prevent further flex by having the collar serving as a stopping agent before the damage is done.

Old Design	New Design (idea)
	

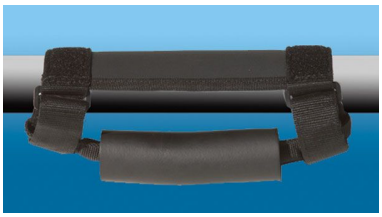
In our previous design, the mounting plate that the driven side of each servo would mount to was missing a feature that would allow us to secure the mounting wing to the servo after the wing had already been attached to the next piece. To fix this design flaw, we have added a bore with a lip for a screw head to sit on to the center of the mounting plate. This will allow the wing to first be attached to the next piece, then a screw can be driven through both the wing and the gimble piece and then into the servo spline. This will greatly improve the integrity of the device as it “sandwiches” all three pieces together with a single screw, in addition to the screws that hold in place the wing to the 3D printed gimbal piece.

Old Design	New Design
	

Another revisment to aid in assembly that we made in response to our previous prototype was slots for wires. In the previous design, the servos fit very well in the spaces designed for them. However, when inserting the servos, a small grove had to be filed in to allow the wires to slide in with servo. To fix this we have designed a small slot that gives the wires clearance to slide down with the servo until they meet the exit port designated for the wires.

Old Design	New Design
	

Upon prioritizing the functionality and structural integrity of our device, we would also like to further increase the quality of our clients experience when brushing their teeth. By refining the handles structure, we will be able to increase our clients grip, facilitating the handling of the device. We're currently in the ideation stage of finding an effective solution for our client. These ideas include adding a shape similar to the handle of a mug. This can be achieved through by 3D printing a new handle or purchase and attach a nylon strap to the handle

Old Design	New Design (ideas)
	 

4. Carry out prototype testing, analyze and evaluate performance compared to the target specifications developed in Project Deliverable B and document all your testing results and prototype specifications. Present your testing in an organized, tabular format that shows expected versus actual results.

Testing Criteria	Expected	Actual
Weight	200g	163g
Adjustments per cycle	6	4
Coefficient of friction on the handle	0.2	0.46
Degree of rotation	180°	360°
Torque provided by the servos	0.005Nm	0.004Nm
Battery life of the power bank	5h	3.4h
Cost Estimate	$64.49	$82.25

Taking advice from our client, we added Sensor Shield V4 Digital Analog Module for Arduino to our bill of material which costs $22.25, making the cost estimate higher than what we had in the original plan. Using our updated gimbal design, now the device is able to achieve a degree of rotation of 360°, which can make the process of brushing the client's teeth more convenient and efficient for her.

As the functionality of our new prototype did not differ much from our previous prototype, we decided to prioritize working on the programming of the arduino. As we are still waiting on certain components to independently use the arduino, we accessed resources provided on campus, this included makerlab. There, we were able to begin the programming process, attempting to get the servos to move in a timely fashion. Without much success, we were still able to do a significant amount of debugging, and got one servo to rotate. Upon further debugging, we plan on developing and implementing the entire sequenced cycle for one session of tooth brushing.

5. Outline what your team intends to present on Design Day and how you intend on verifying that your "Solution Works Really Well".

On design day, our team intends to present a device that effectively solves our client's problems. This device will be one that is easy to use, sturdy and will allow our client to brush all areas of their teeth independently, without the aid of a nurse.

We plan on achieving this by developing a comprehensive prototype used to conduct further tests. By performing a multitude of realistic scenarios our client may experience upon using the device, we are able to collect valuable data regarding the expected versus the actual functionality of our device. This will inevitably minimize the amount of uncertainties that could potentially damage the device, rendering it useless.

Conclusion

This week, we were able to further refine our design solution intended to be presented on design day. Summarizing our client meeting feedback enabled us to address our design flaws, allowing us to further improve our final design. Particularly, alterations in the wiring of the device, structural integrity of the device, as well as user handling were conducted. We organized our results in a tabular format, facilitating the comparison of our expected results in relation to the actual results. We were also able to begin the coding process of our arduino using the required tools provided in makerlab.