Assistive Touchscreen Device

GNG2101 (Summer 2019)

Team Z4

Joydeep Gill,
Ali Gulamhussein,
Faye Lin,
Harisan Karunakaran,
July 25, 2019

Abstract

Over the course of this semester, we have been working with our client Gary to develop a product that allows him to use his phone properly. Since Gary has Parkinson's disease, he often has hand tremors (he experiences shakiness in his hands), which makes using smartphones a challenge. To combat the tremors Gary takes some medication daily. This medication is temporary and wears off. We were asked to develop a product that would allow Gary to use his phone when hand tremors would otherwise make it a challenge.

Table of Contents

List of Figures

List of Tables

1. Introduction

Parkinson’s is a disease that affects the nerves and brain. Among many other symptoms, it leads to hand tremors. These tremors are a huge hindrance to those afflicted with Parkinson’s. Simple tasks like writing on a piece of paper, or using a screwdriver become extremely time-consuming and complicated. That makes using a smartphone understandably difficult. For a person without Parkinson's, accidental taps or multiple taps are already a problem due to the sensitivity of modern smartphone screens. For a person with Parkinson's, these problems are amplified. Multiple accidental taps are a constant occurrence. Using smartphones then become both an irritation and liability. At our first meeting with Gary (our client), he mentioned how he would not be able to use his phone in an emergency because of his hand tremors. The convenience of a smartphone is not something people can sacrifice and so we were tasked with developing a solution.

We looked at all possibilities when ideating a solution and eventually settled on the design we currently have. This is the best option currently available since it is significantly cheaper than all others. It is a simple design that allows Team Z4 to continue its development by listening to users feedback and making improvements. The Stylus we have developed is not only superior due to its low cost, but also due to the group manufacturing it. Team Z4 is committed to hearing all the feedback from users and clients in order to create the most ideal and effective products.

The product that we ended up developing was a simple and functional stylus which allowed Gary to better utilize his smartphone. For the final prototype we made 3 styluses, each with varying spring strengths. The varied spring strength was included for different individuals preferences and different degrees of hand tremors.

2. Engineering Design Process

We utilized the Agile Design Process. We figured it would be the best to use since it was something which studied and reviewed in class, in addition to this, it was a process which all group members were familiar with as well. During this process, we had to come up with several different solutions, constantly receive client feedback and re-iterate our solutions/prototypes based on the client feedback that we received. Since this whole process was constantly changing based on our client feedback, it was best to adopt the agile design method.

3. Need Identification & Product Specification

3.1 Problem Statement

Design a compact device which made it so that it was easier for our client to use his smartphone.

3.2 Target Specifications

Original target specifications of the product

1. Length: < 30 cm along the largest side
2. Mass: Must not exceed 1 pound(0.5 kg).
3. Work for at least 1 hour on a single battery charge.
4. Suppress tremor at frequency 2-5 Hz
5. Suppress tremor of amplitude at least 1 cm in all directions.
6. Support for capacitive touchscreens.

Updated and revised target specifications

1. Length: < 30 cm along the largest side
2. Mass: Must not exceed 1 pound(0.5 kg).
3. Support all capacitive touchscreens.
4. Suppress tremor of amplitude at least 3 mm in all directions.

Why we modified target specifications

Following our first client meeting, we began the design process. We started with identifying the need statements and determining our target specification. Following the second client meeting, a few team meetings and some reflection we determined that some of the target specifications are not measurable by individuals with our qualifications. With this in mind, we re-evaluated our position and made sure we set ourselves lofty, but achievable goals.

3.3 Metrics

1. Mass: g
2. Dimension: cm

4. Conceptual Designs

A total of fifteen designs were created. Since many designs were very similar, we have chosen the best design from each team member to include in this report.

4.1 Stylus (Joydeep)

This idea implements a thicker version of a stylus (see Figure 1 below) that is used by our client experiencing hand tremors. Many different styluses are out on the market nowadays (e.g., Apple Pencil, Galaxy Note Pen, etc), however, they are all very thin in shape and form. This becomes troublesome when experiencing hand tremors since a thin stylus will not have much grip, so there is nothing to hold onto when the tremors take place. Making a much thicker stylus would provide a much better grip in this type of situation.

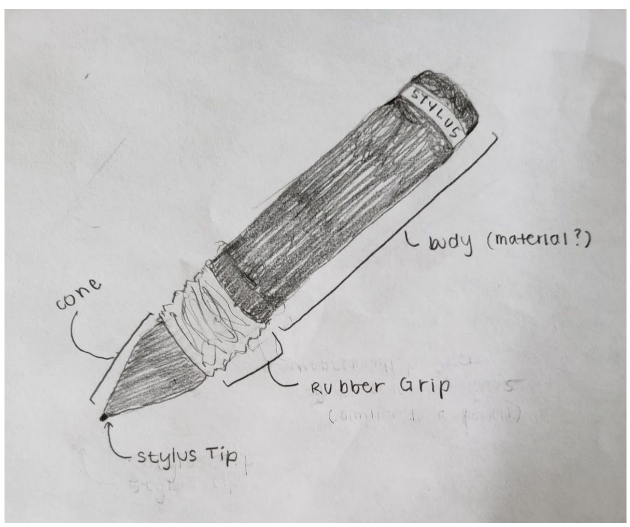

Figure 1. Stylus Concept

4.2 Exoskeleton (Ali)

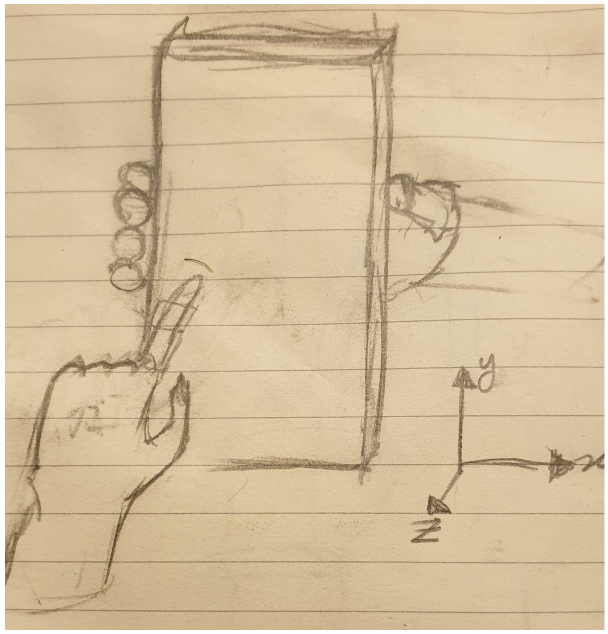

Figure 2. Exoskeleton Concept.

This design idea is wearable device that allows our client to move his fingers freely in the X and Y axis but limits his fingers movement to two heights in the Z-axis. The lower of these heights will be in contact with the screen while the higher will not be. In doing this we can eliminate the errors caused by multiple taps on the screen. To do this we would have a stiff cover (but not totally unbendable) over Gary's finger. The cover will have a magnet which will correspond to one on the inside of his hand.

4.3 Stylus with flywheels on springs and with magnets (Dima)

Figure 3. Magnetic Stylus

This idea is based on the fact that flywheels are able to translate rolling motion around one axis to another axis. The two perpendicular flywheels on a spring can provide the desired partial stabilising effect along the x and y-axis while allowing for hysteresis along the z-axis. This may require very complex spring/springs to allow for rotation. It cannot stabilize along the x and y-axis simultaneously effectively (only one axis at a time), as there will be 2 dead angular sectors along which motion is not inhibited. To overcome this limitation it may require a more complex construction with bearings along the z-axis and a larger number of flywheels.

4.4 Stylus with retracting tip (Faye)

This design is inspired by mechanical pencils that have “unbreakable” tips. Normally, an inner tip made of non-conducting material extends beyond the outer layer. When the stylus’ tip is pressed against a surface and enough pressure is applied downwards, the tip retracts into the stylus. Then the conducting part on the outer layer makes contact with the screen. The inner tip immediately pops out when the downward pressure is released. Alternatively, this design can use a button on the side of the stylus to retract the tip.

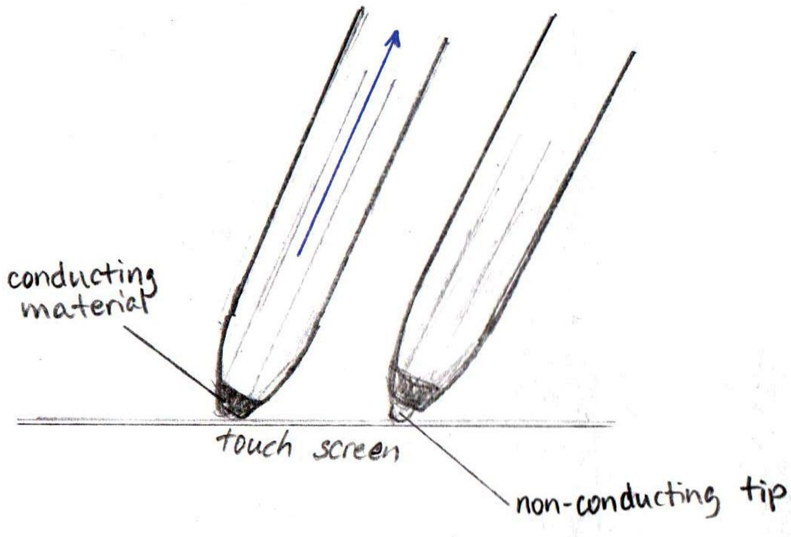

Figure 4. Stylus with Retractable Tip

4.5 Magnetic glove + stylus (Harisan)

Using magnets attached to gloves and a stylus the grip to the stylus can be modified. Strong magnetic interactions with the glove and stylus will force a tight grip with the hand which will counteract hand tremors. For when the client feels weaker tremors the force of the magnet can be adjusted with a switch which lowers the distance between the magnets in the stylus relative to the glove.

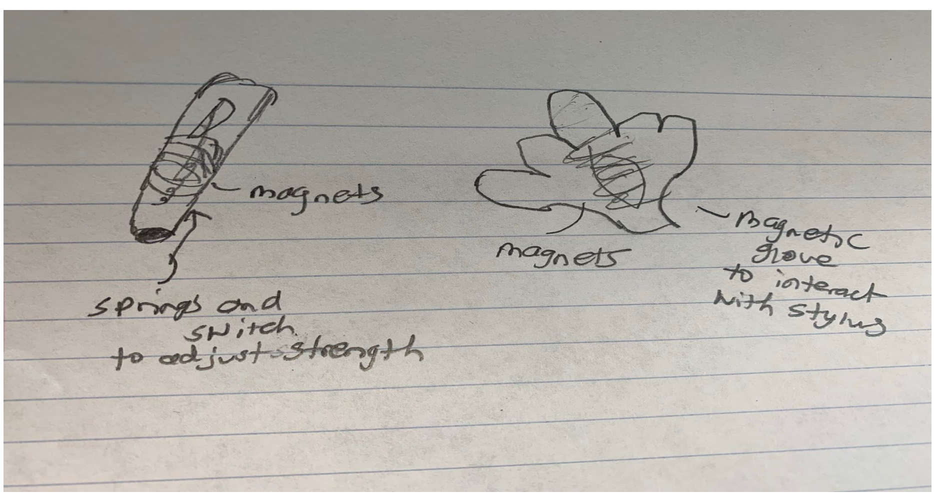

Figure 5.

5. Project planning and feasibility study

From the concept generation phase we eliminated any ideas that were not feasible due to the complexity of the design, practicality in use, meet the minimum customer requirements, target the problem statement or satisfy the time and money constraints (duration of this course and $100 budget). After this screening process was complete, the remaining 5 concepts were scored using a weighted decision matrix then selected based on which concept best fit our selection criteria.

Table 1. Weighted decision matrix

Selection Criteria	Weight	Stylus		Keyboard		Gyrogloves		Exoskeleton		Magnetic stylus	
Portability	20%	9	1.80	10	1.00	7	1.40	6	1.20	7	1.40
Simplicity	10%	10	1.00	9	0.90	4	0.40	7	0.70	5	0.50
Cheap to manufacture	10%	10	1.00	7	0.70	2	0.20	5	0.50	4	0.40
Easy to manufacture	5%	8	0.40	3	0.15	3	0.15	7	0.35	3	0.15
Durability	15%	6	0.90	8	1.20	9	1.35	7	1.05	7	1.05
Functionality	30%	9	2.70	6	1.80	9	2.70	8	2.40	8	2.40
Aesthetics	5%	7	0.35	4	0.20	8	0.40	6	0.30	7	0.35
Ease of use	5%	7	0.35	5	0.20	6	0.30	4	0.20	2	0.10
Total Score		8.50		7.20		6.90		6.70		6.35	

5.1 Feasibility Study (TELOS Analysis)

Technical

Our team will build the stylus using the technologies that are available to us (such as a 3D printer). Not everyone in the group has a lot of experience with 3D printing. However, with the guidance of the TAs and people who work at the institution (such as the TAs and employees at the makerlab).

Economic

We opted to go for something simple enough to use by the client that we can build with the resources around us. One of our goals was to spend the least amount of money as possible, while maintaining functionality. Overall, our First Prototype is within the given budget constraints provided.

Legal

There are no legal issues with releasing the solution to the general public. We are basing the general design of our product off of thick pencils and styluses that are currently in the market. A similar design would be the BIC ReAction Mechanical Pencil. It has a very thick outer shell, making it simple and easy to grip. We are also planning to use a thick encasing (but designed differently than this one -- see Figure 8 from Section 6). In addition to this, our stylus will not be used for writing like the mechanical pencil but will instead be used for interacting with the smartphone screen by the client.

Operational

There are a few skills which some of the team members are not entirely familiar with (such as 3D printing and soldering). In order to learn these skills, we would have to utilize the institutions' resources in the makerLab, such as 3D printers. We would need the help and guidance of the PM and/or the TAs and staff that is employed there. As of right now, there is no cost related to money (since the first prototype does not use any money), but there is time involved in learning how to use these tools and technologies.

Scheduling

Throughout this project, we have utilized the Gantt Chart, as well as Trello (used to keep track of who finished what tasks) just to stay on track. In addition, we also kept track of the tentative due dates for deliverables on brightspace since these dates tend to change from time to time due to certain circumstances. We finished creating the final working (high-fidelity) prototype on time (however, we have yet to show our client the final product, we ran into a few scheduling issues and there was some miscommunication).

5.2 Project Plan

Throughout the course of this project, we utilized Trello just to keep track of who worked on what specific part of the Deliverables. In addition to this, we also used a Gantt Chart to keep track of all of the Deliverables and their due dates. However, from time to time, due dates are subject to change depending on external circumstances, hence we also consulted the Course Syllabus to see any changes regarding the Deliverables.

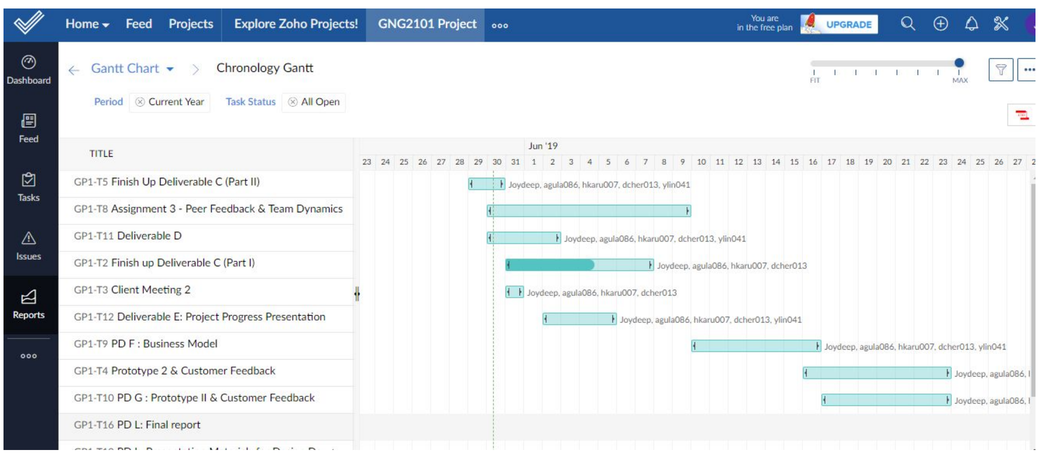

Figure 6. Gantt Chart

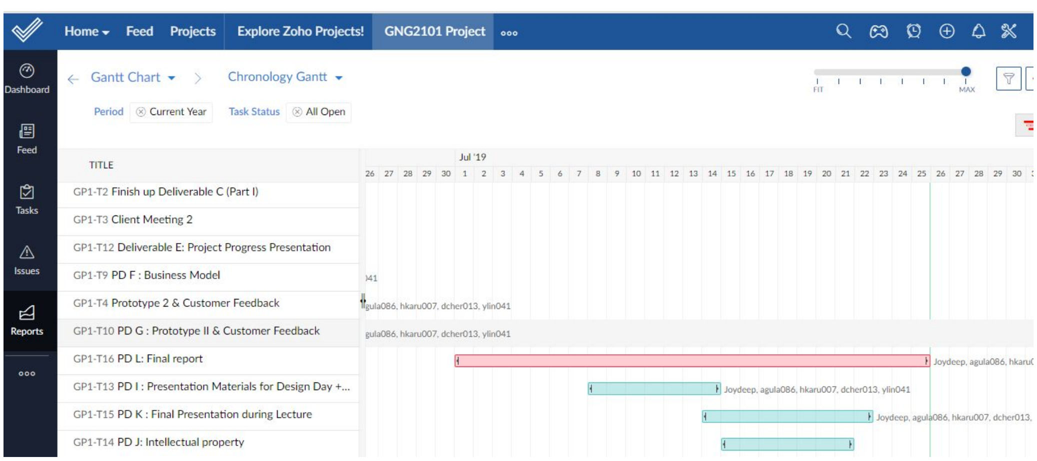

Figure 7. Gantt Chart

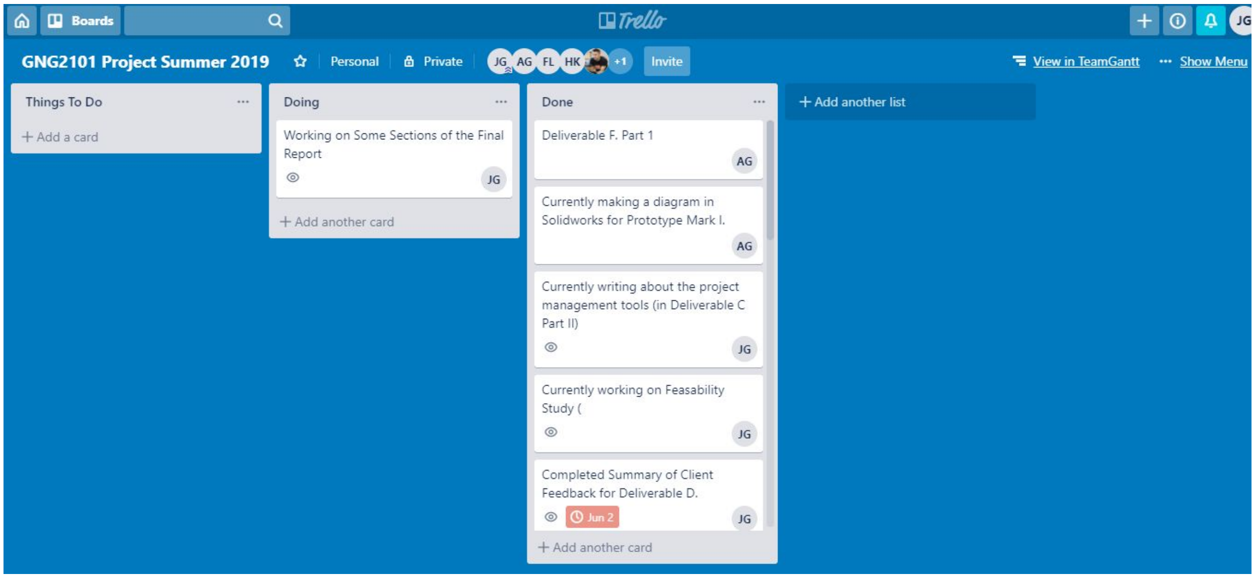

Figure 8. Trello Board

6. Technical Analysis of Design

No formulas, calculations, simulations or quantitative data collection was used in the development of our prototype. This may not be the case for future iterations of our product.

7. Prototyping, Testing and Customer Validation

Chosen Solution

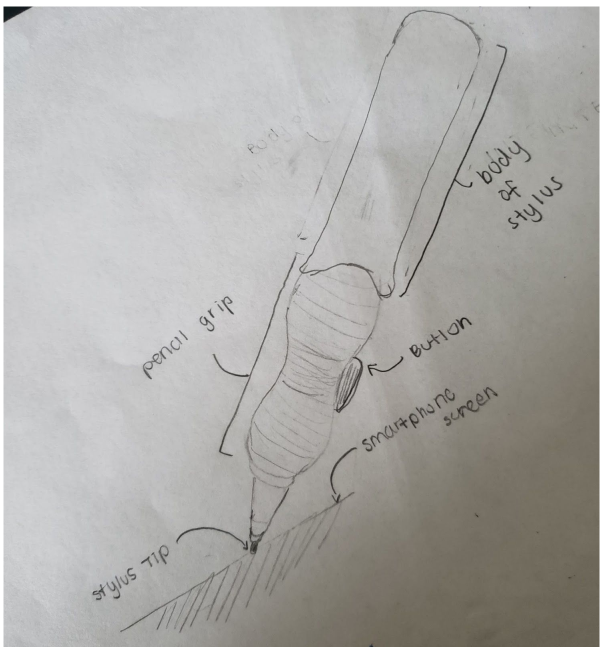	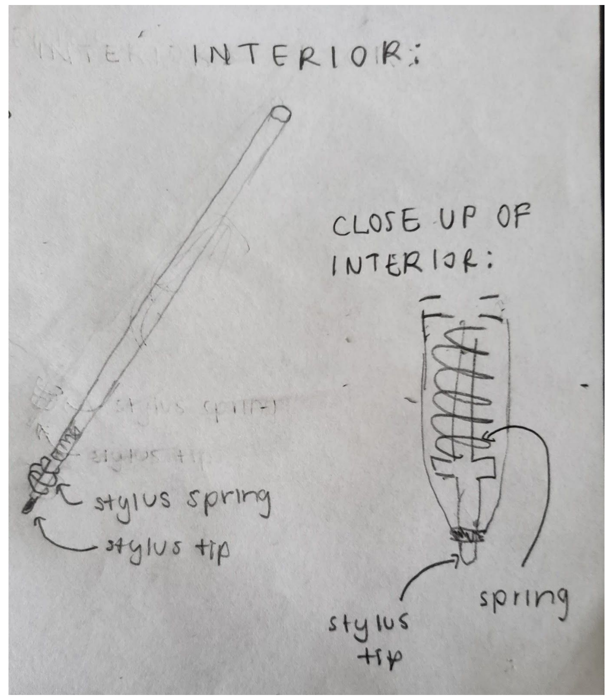
Figure 9	**Figure 10**

Description

The stylus tip will be a retractable tip connected to the spring. Only when the tip is pushed completely into the encasing does the phone register the tap. The additional button on the side may be as a camera capture button or something else the client may ask for. The design is set to be tip heavy which will induce more control from the user. The large diameter of the stylus grip is also intended to help with reducing the effects of the tremors.

Physical Prototype 1

Figure 11 - Physical Prototype

Figure 12 - The prototype disassembled

Table 2: Feasibility text of Physical Prototype 1 with Old Target specs

Target Specification	**Comments**
Length: < 30 cm along the largest side	The use of a stylus dictates that the product does not exceed the specified length of 30cm. (A stylus of length greater than 30cm would be absurd.)
Mass: Must not exceed 1 pound(0.5 kg).	Once more the use of and size of a stylus

	makes the probability of having a product with a weight exceeding 1 pound, highly unlikely. The first prototype we made weighed about 10 grams.
Suppress tremor of amplitude at least 3mm in all directions.	Will require further testing with a more substantial (higher fidelity) prototype.
Support all capacitive touchscreens.	Does not work on capacitive touchscreens.

Physical prototype 2

Figure 13. Physical Prototype 2

Figure 14. Physical Prototype 2 disassembled.

The mechanism used in this iteration is the same as in prototype 1. The wooden skewer acts as a buffer between the black stylus tip and the phone. The length of this stick was adjustable depending on how much the top half of the pen was screwed on. This also adjusted the amount of force required to register a tap when the stylus was brought into contact with the phone. Using this, we determined the ideal length of the part protruding from the pen and the ideal force required to register taps.

Customer Feedback to Physical Prototype 3: (First working prototype)

Firstly, and most importantly, our client Gary stated that he really liked the prototype we presented him with. The following are some notes from the client meeting:

The client was impressed with Prototype II

- He really enjoyed holding the stylus
- He also liked the thickness of the second prototype (loved the way it felt while holding it in his hand)

Table 3: Feasibility test for Physical Prototype 2

Target Specification	**Comments**
Length: < 30 cm along the largest side	The use of a stylus dictates that the product does not exceed the specified

	length of 30cm. (A stylus of length greater than 30cm would be absurd.)
Mass: Must not exceed 1 pound(0.5 kg).	Once more the use of and size of a stylus makes the probability of having a product with a weight exceeding 1 pound, highly unlikely. The first prototype we made weighed about 10 grams.
Suppress tremor of amplitude at least 3mm in all directions.	Allowing Gary to use and test this prototype, we can determine that the effects of the hand tremors are reduced to within the given constraints.
Support all capacitive touchscreens.	Supports all capacitive touchscreens.

8. Final Product

Description

The final product works with an identical mechanism to that of the previous prototypes. This prototype is a more refined version with better materials that make the product life longer and provides a better user experience. It consists of a 3D printed cap connected to the spring that attaches to the plastic coated skewer. Attached to the stylus is rubber gel grip to make the grip diameter thicker.

Figure 15. Final Product

Table 4. Feasibility test for final Physical Prototype:

Target Specification	**Comments**
Length: < 30 cm along the largest side	The final prototype is 13.8 cm long.
Mass: Must not exceed 1 pound(0.5 kg).	The final prototype weighs about 10 grams.
Suppress tremor of amplitude at least 3mm in all directions.	The final product is similar enough to the previous iteration that it satisfies this specification.
Support all capacitive touchscreens.	The final prototype works on all smartphones and tablets.

Table 5. Bill of Materials

Item No.	**Part Name**	**Description**	**Quantity**	**Unit Cost**	**Extended cost**
1	Stylus Shaft	The shaft to which the cap, conductive tip and grip are attached	1	*	*
2	Spring	Spring from pen	1	*	*
3	Conductive Tip	A tip that will register taps on the phone	1	*	*
4	Interior shaft holder	Piece connecting the interior shaft to the spring	1	$1.83 *Includes Stylus shaft spring and conductive tip	$22.05 Includes Stylus shaft spring and conductive tip
5	Plastic coating	Plasti Dip coating applied to the interior shaft to prevent	1		$16.97

		screen damage			
6	Interior shaft	A wooden stick that separates the phone from the conductive tip	1	$0.03	$3.00
7	Cap	3D printed part at the top of the shaft that connects to the spring	1	$0.30	$0.00
8	Grip	Rubber grip attached to the stylus shaft to increase comfort	1	$0.00	$0.30

9. Business Model Canvas

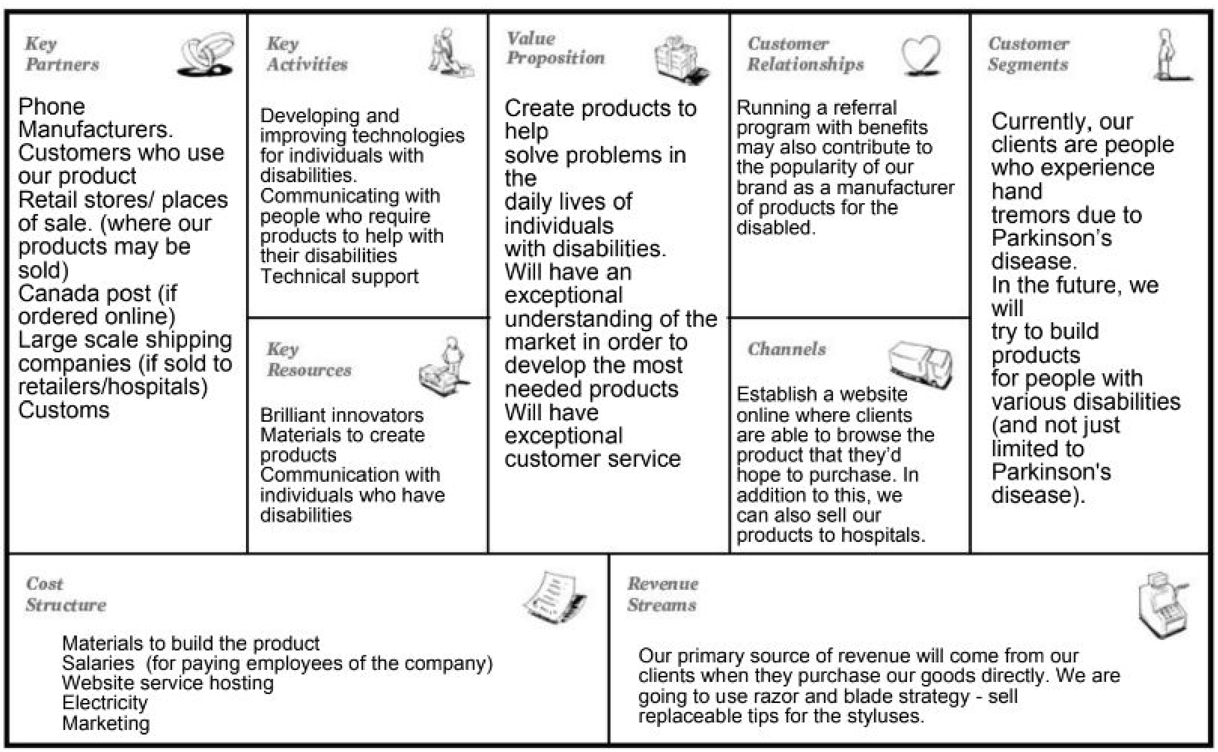

Figure 16. Business Model

10. Economic Analysis

Table 6. Potential business costs

Cost	Estimated spend ($/year)	Type of cost
Warehouse/factory rental	8,000	Fixed
Material Supplies (ie. springs and pens)	1,500	Variable
Electricity	5,000	Semi-variable.
Overhead	2,000	Indirect
Labour/salaries	30,000	Direct
Total	46,500	

Table 7. Three-year income statement

Sales: (2000 products sold per year **x** $26 per product **x** 3 years)	$156,000
Cost of goods sold: ($23.25 per product **x** 2000 products sold per year **x** 3 years)	$139,500
Operating Expenses: **Marketing and Promotion** **Administration (ie. insurance and legal support)** **Referral discounts** **Investment in prototyping future products**	 $3,000 $2,000 $2000 $5,000
Operating Income	$4,500

Break-even point:

Fixed costs = rent + operating expenses
= 8,000 + 12,000
= 20,000

Contribution margin per unit = sales - variable cost

= 26 - 23.25
= 2.75

Assume we sell 2,00 units in every year, and r = 30% compounded yearly.

Table 8. Break-even analysis

Year (t)	Fixed cost in PV $\frac{20000}{(1.3)^t}$	Contribution Margin in PV $\frac{2000t \cdot 2.75}{(1.3)^t}$
1	15,385	4,231
2	11,834	6,509
3	9,103	7,510
4	7,003	7,703
5	5,387	7,407

We will reach the break-even point at year 4.

11. Conclusions and Recommendations for Future Work

We learned that an effective product does not need to be complicated or overengineered. A simple, functional stylus which achieves the customer needs and satisfies the problem statement is sufficient. The focus of this product was to design for functionality and usability. We had to make the best use of our limited resources and target the core of the problem. The limited time and money constraints were satisfied and most importantly, our client, Gary was pleased with the results. Utilizing the lessons learned and success of the product we plan to pursue future endeavors with the government and hospitals to directly target individuals with Parkinson's disease and possibly branch out to indirect clients such as smartphone companies who are interested in implementing our design into their existing styluses. Furthermore, the simplicity of the stylus allows for many modifications to the existing design such as a button to adjust the length of the tip and a switch to compress or expand the length of the spring to better satisfy individual needs of the user.

12. Improvements

One of the things that we could have improved is that, we should have came up with a more concrete and qualitative testing method/plan, in addition to the client meetings where we consulted with our client in order to see our prototypes and provide us with feedback.

In the future we will ensure that we conduct extensive testing to ensure our product functions at its best and solves the problem effectively. To do this we would present our product to a large group of people with Parkinson's. We would then get them to use our product for a certain amount of time. While they use our product we would monitor them to see how many errors they make (with regards to multiple taps). We would then compare these error numbers to the number of errors they would make without our stylus.

APPENDICES

APPENDIX I: User Manual For Current Product

The Team Z4 stylus is designed for preventing multiple taps. On the makerepo link for our product, we have the 3D sketch for the top part of our stylus, nicknamed The Nail. In the same link, we have pictures of the structure of the internal workings of the product. The simplicity of the design allows for the interior of the product to be detailed in a single picture.

Instructions

To use the stylus, press down on the stylus until the black conductive rubber is pressed against the surface of the touchscreen.

The stylus is not intended to be used at a large angle with the smart surface. Improper usage could break the tip of the shaft or the body of the stylus

Maintenance

Maintenance of the product is similar to that of a pen in that it requires little to no maintenance but, must be replaced often. When using the stylus, the user should not apply too much force, or the stylus may be prone to breakage. The product is not waterproof or resistant due to the 3D printed and wooden component

Safety Guidelines/Precautions

All the standard things; don't chew on the pen, don't stab people with it, sharp object warning and whatnot

Due to the interior shaft being very small and thin, it can be a danger to individuals. The sharp nature of it may be a danger to someone improperly uses it (ex: if it gets too close to the individuals eye, it can cause serious harm).

Young children should not be using this stylus. They may accidentally end up causing harm to themselves if they accidentally end up breaking apart the stylus and end up swallowing one of the stylus components. If this occurs, they should be taken to see a doctor immediately. Hence, people must exercise extra precautionary measures when using the stylus around young children.

Troubleshooting

If the rubber coated non-conductive tip breaks, they can either discard the stylus or they can purchase [component] from another supplier/retailer (such as Amazon, for example).

APPENDIX II: Design Files

All design files related to this product can be found on makerepo:
https://makerepo.com/Joydeepgill30/gng2101-group-z4-assistive-touchscreen-device