PRODUCT SPECIFICATION

TITLE	DATE	REV
Product Requirements	26 Sept 2018	0

Discovery Center Gesture Control Robotics Exhibit

Product Requirements

U of I Discovery

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Document History

Rev Number	Date	Modified By	Reason
0	26Sept2018	A.S. Watson	Initial Release
0	26Sept2018	C. Kim	Initial Release
0	26Sept2018	A.Stratigakes	Initial Release
0	26Sept2018	Z.Wang	Initial Release

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1 Objective

The objective of this document is to document the requirements regarding the Discovery Centers Gesture control Robotics Exhibit, Robotic Arm configuration.

2 Scope

The scope of this document is to define the requirements that are needed to satisfy the client, and designers vision for the project. By using details derived from the Trossen Robotics website, and designer insight into the project, this document should be able to explain most, if not all of the requirements needed to complete this project, to satisfy the clients requirements.

3 References

3.1 Cited Documents

IP Rating Chart. (n.d.). Retrieved September 26, 2018, from http://www.dsmt.com/resources/ip-rating-chart/

PhantomX Robot Arm Kit. (n.d.). Retrieved September 20, 2018, from https://www.trossenrobotics.com/widowxrobotarm

UL - 1004-6 Standard for Servo and Stepper Motors | Standards Catalog. (n.d.). Retrieved September 25, 2018, from https://standardscatalog.ul.com/standars/en/standard_1004-6_2

3.2 Acronyms

DOF Degrees of Freedom
POC Proof of Concept

4 Functional Requirements

4.1 User Interface Requirements

The operator shall not be required to apply any use of force, or touch to the Leap Motion Sensor. The Sensor should be calibrated to react to movements taking place within the “Given Dimensions,” of the overall exhibit. The user, shall be accompanied by an adult if below the age of 10, for personal safety, and for overall durability of the system. Only a single operator should be allowed at the exhibit, at a time, though I know this will be unachievable, for general safety, due to the fact that the robotic arm is a piece of machinery, it should be treated with respect, as it is available for use to several individuals at the Discovery Center of Idaho, daily.

4.2 What it should do

The Trossen Robotics PhantomX Arm should be able to withstand extended uses for a 5-7 hour period, 7 Days a week. This use, will cause a durability issue over time, which will lead to required maintenance, though this durability value, cycle-wise is yet to be known, due to the lack of testing at this point within the project. This will be taken into account, and discussed before the project is finalized. The Robotic Arm, shall be able to transport foam blocks, from a general spot within the exhibit, to a fabricated target, that will be formed to fit the given shape within

the robotic arms grasp. This action shall be done through the act of the user's arm placement over the "Leap Motion" Controller, which will transfer the information, at a rapid pace, which has yet to be specified for the ATMega644p Microprocessor, that is available on the given setup.

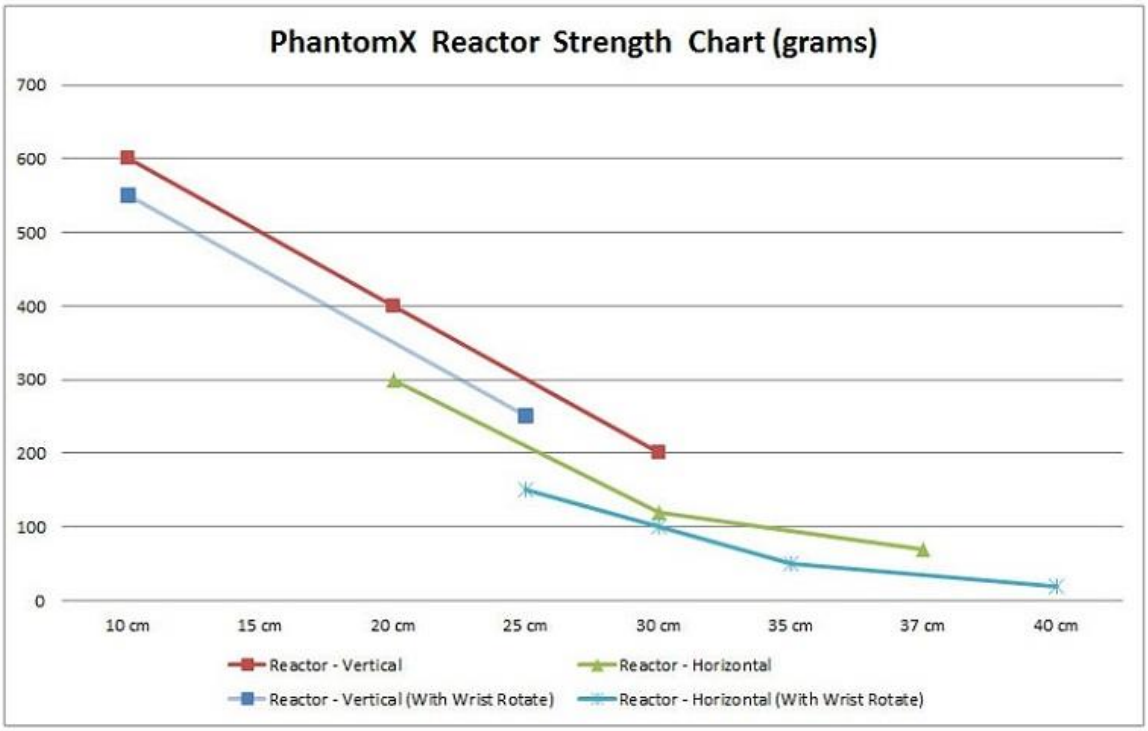
5 Mechanical Requirements

5.1 Strength Requirements

The design shall be able to carry a static load of 500 grams, and should be able to take the static load, and place it accurately, and precisely within a given target, that has notable tolerances for fitment. By adding the wrist rotation to the device, the overall strength decreases about 50 grams to that

Vertical Strength w/ Wrist Rotate: For 10 cm of reach, approximately 550 grams, 20 cm, approximately 350 grams, 25 cm of reach, approximately 250 grams, which for all intents and purposes is plenty, for the given mass of a foam block.

Horizontal Strength w/ Wrist Rotate: For 25 cm, approximately 150 grams, 30 cm, approximately 100 grams, 35 cm, approximately 50 grams, which is great for the current application of the robotic arm. The gripper strength, according to Trossen's website, is that it is 500 grams, without any specification, regarding the uncertainty, +/- a specific range of values. The wrist lift strength is 150 grams, with the given wrist rotation set up.



Trossen Robotics PhantomX Reactor Strength vs. Extension graphic

5.2 Spatial Requirements

The Robotic Arm & Corresponding Electronics shall fit within the following:

- Length < 80 cm
- Width < 80 cm
- Height < 80 cm

The Robotic Arm Extension Capacity

- Vertical ~ 55.5 cm
- Horizontal ~ 43 cm

The Robotic Arm Strength

- 200 grams w/ 30 cm of extension
- 400 grams w/ 20 cm of extension
- 600 grams w/ 10 cm of extension

*Note this will change based upon the extension of any parts of the arm, for viewing purposes. As of now, the encasement for the robotic arm is the last priority.

5.3 Weight/Mass Requirements

The total system shall weigh no more than 4536 grams, or approximately 10 lbs, with the Robotic Arm, Base, Computer Set up, and any targets that may be included for use within the exhibit. The mass of the Robotic Arm is 1430 grams. This will be adjusted, as further knowledge on the setup becomes available from the design team, and the Discovery Center.

5.4 Mounting / Interface Requirements

The Robotic Arm shall be attached to the base provided by Trossen Robotics, which holds the Robotic Arm in place. The Robotic Arm will retain the ability to be modified for any reason necessary, in regards to the design, and its feasibility. The base is three tiered, for maintenance ease of access.

5.5 Appearance Requirements

The final product should retain a black/metallic finish, unless otherwise stated by the client. This has yet to be determined, as we haven't discussed in full detail what the arm should look like. The appearance is also dependent upon the replacement of 3D printed parts, and the colors available for customization. The final product should be satisfactory to the Discovery Center and shall represent the University of Idaho, with a great looking, quality product.

5.6 Durability Requirements

The system shall be designed to operate for 210 hours, or approximately one month, without any scheduled maintenance. By using dual servos within each moving joint of the robotic arm, the overall life of the servos should be greater than that of single servo-actuated parts. The Robotic Arm should be analyzed, and tested thoroughly enough, to satisfy these requirements. With further testing, this information should become more accurate within the future.

5.7 Reliability Requirements

All components, including servos, and circuit boards shall have 90% reliability. The Robotic Arm should be able to actively be in motion, for 7 to 8 hours daily, besides Sunday's, when the Discovery Center's hours shift to a 5 hour working period.

6 Electrical Requirements

6.1 Operational Voltage

During operation the voltage should remain at 12 V, with the ability to allow 5 amps of current through the system.

6.2 Operational Power Capability

During operation, the Battery pack shall be capable of delivering or absorbing power per the table below:

6.3 Energy Storage Capacity

The Robotic Arm shall be able to work on a given charge capacity supplied from an Arduino or Computer Power Supply.

7 Software Requirements

7.1 Functionality

The software shall be able to withstand constant use over a 5-7 hour period. This will include any abuse that it will encounter during the work day, with children ranging from 4-12 being the main focus, and adults. The code that is used for the interface should be able to safely allow the robot to move according to given hand(s) gesture input, without destroying the entire system, if a malfunction is encountered. The arm should be able to grab small foam blocks and move/place them, within a given range, based on the users movements, at the very least. The resolution, and reaction times will be found during testing, and will be depicted within this document throughout the ongoing design process.

7.2 User Interface

The Leap Motion device, will be securely fastened to the working exhibit, on a horizontal surface, with ease of access by the specified user. Depending on future installments to the overall "system structure," if another Leap Motion device is used, each will be labeled/marked with specific numbering, to coincide with which robotic arm is being controlled by which user. The user should be able to simultaneously move the robotic arm with their hand movement on a Leap Motion device. The movement of the robotic arm should be visible physically to the user as they move their arm over the Leap Motion.

8 Environmental Requirements

8.1 Temperature

The Product is expected to have full operational capabilities in environments with ambient room temperatures between 16°C and 27°C, or approximately 60.8°F to 80.6°F.

8.2 Environmental Sealing

All electrical components shall be at least IP50. This standard means that the components will be protected from limited dust ingress, but will not be protected from liquids. Though, if this is an important feature, needed for the design, this can be increased.

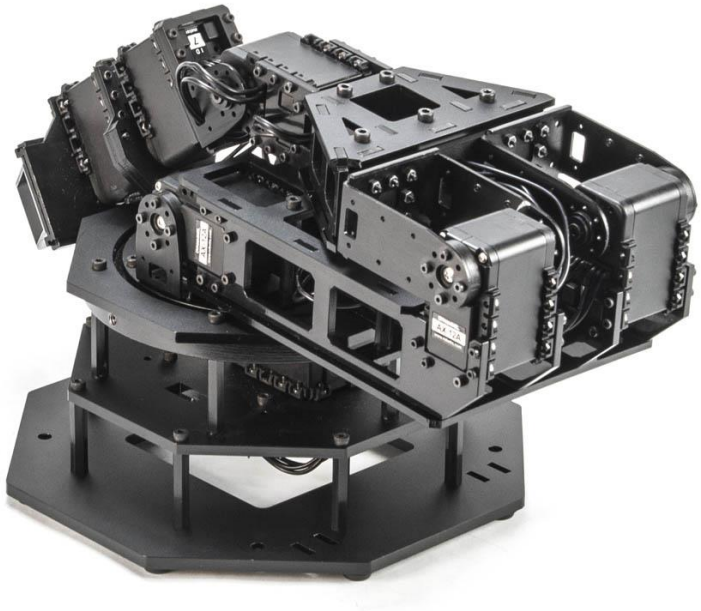
9 Regulatory Requirements

9.1 UL Requirements

The Servo and Stepper Motors, shall comply with the UL 1004-6 Standard. This standard is an accountable certification that is depicted in the documentation from Underwriters Laboratories.

9.2 Shipping Requirements

The Robotic Arm should be stored, and padded with protection during shipment. The arm should be encapsulated in a foam pellet, or bubble-wrap set up. Below, is the envisioned storage for the arm, with the current dimensions from Trossen Robotics.



10 Cost Requirements

10.1 Prototype Cost

Cost to build a POC prototype shall not exceed $1500 as of now. Based on design reviews, the overall budget may increase, depending on the wants from the client, Dr. Ralph Budwig, and the Discovery Center of Idaho.

10.2 Production Requirements

Estimated annual volume of the product will potentially be 1-unit total, unless the client or Discovery Center of Idaho want another, within the given time frame of the project.

Projected cost for a single robotic arm, will approximately be < $1000

11 Schedule Requirements

The following are the major Project Milestones:

- Approval of Requirements Sept. 30, 2018
- Concept Design Review Nov. 30, 2018
- EPO of long lead parts Dec. 8, 2018
- Detailed Design Review Feb. 9, 2019
- ER of drawing package March 2, 2019
- Complete Prototype build April 5, 2019
- UI Design EXPO April 26, 2019
- Final Report / Drawings May 4, 2019