Ivan Chan

MECHANICAL ENGINEERING | B.ENG

Portfolio

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Underwater Robotic Manipulator

Introduction

MOTIVATION

For our final year project, our team of four decided to design a robotic arm that would integrate with McGill Robotic's RoboSub Autonomous Underwater Vehicle (AUV) to perform various tasks underwater. The RoboSub team designs and builds an AUV every year, competing on an international stage to navigate an obstacle course and complete a series of difficult visual-, acoustic-, and physical-based tasks.

OBJECTIVES & CONSTRAINTS

- Ability to perform previous year's competition tasks (ex. submerge buoys, remove bin covers, manipulating pegs)
- Adaptability for potential new tasks
- Fit within 1ft x 1ft x 2ft box
- Ability to retract within the AUV frame
- Arm extension distance of at least 1ft

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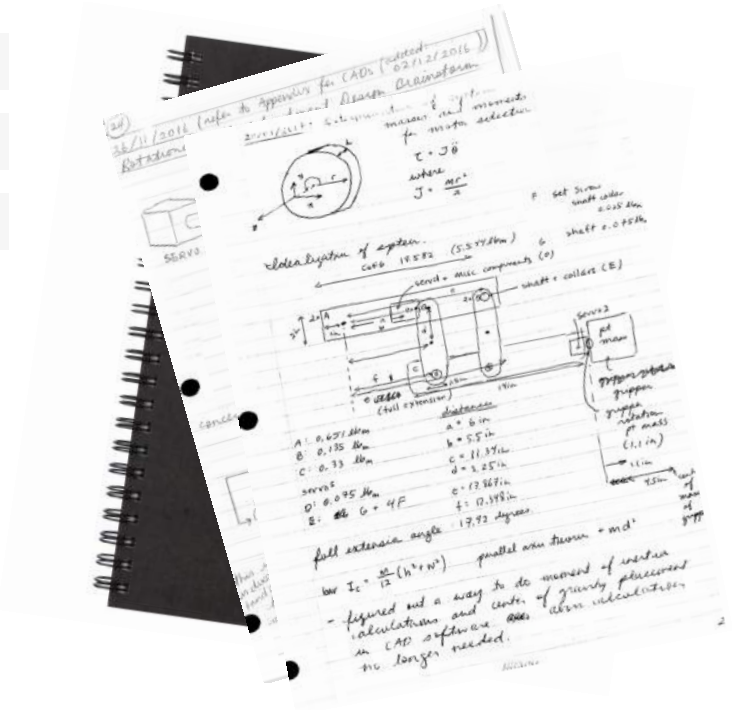
Underwater Robotic Manipulator

Design Process

DESIGN CRITERIA

Functionality	Cost	Robustness
Waterproofness	Speed	Adaptability
Manufacturability	Simplicity	Size



CONCEPT GENERATION

We recognized that the design of the manipulator could be split into essentially independent subsystems- one for each degree of freedom (DoF) of movement. Considering the past year's tasks and keeping in mind adaptability, we settled on having 4 DoFs:

Arm Rotation	Gripper Rotation
Arm Extension	Grip Close/Open

We then went about generating concepts for each of the 4 subsystems. Using a combination of Pugh's decision matrices and morphological charts, concepts were compared using the criteria listed above. From there, an integrated design was selected.

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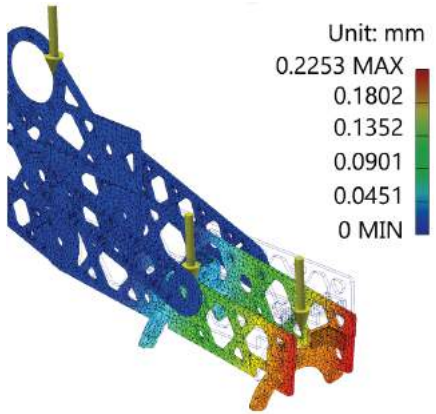
Underwater Robotic Manipulator

Design Process

DESIGN EMBODIMENT

- All mechanical components required for requisite functionality defined at high level
- Combination of hand-drawn sketches and CAD modelling
- Series of design reviews used to critique and guide improved iterations.

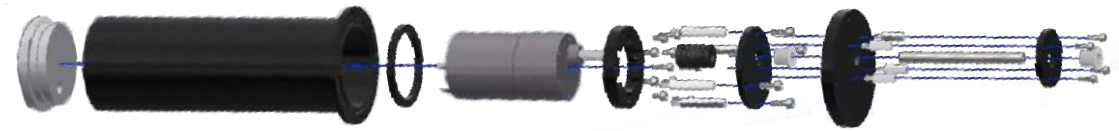


DETAILED DESIGN

- Material selection, detailed component geometry, and off-the-shelf fastener selections
- FEA performed to ensure stress requirements met while shaving off maximum weight
- Another series of design reviews to optimize design

DESIGN CHALLENGE: WATERPROOFING

One of the design challenges we dealt with was making sure the motors and electrical components were effectively waterproofed. Due to the lack of IP-68 waterproof rated motors on the market, we had to design custom pressure vessels sealed using o-rings on both ends. Shaft seals were used around the motor shafts where they exited the pressure vessels. We also ensured the shafts had two points of support- one in front, and one behind- in order to prevent the shaft seals from breaching when under load. In order to keep these pressure vessels compact, conventionally manufacturable, and assemble-able, we had to get our creative juices stimulated!



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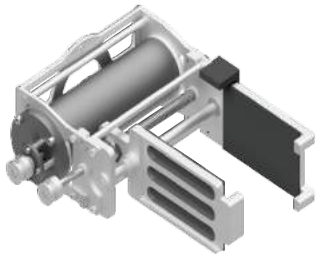
Underwater Robotic Manipulator

Final Design

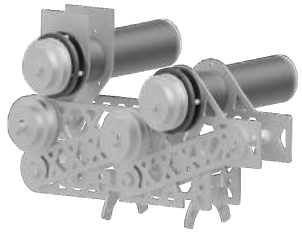


GRIPPER

- Vise Design | Simple, Strong Grip, Robust, Reliable
- DC Motor driven
- Motor Current monitored to estimate applied force
- Gripper Jaw position tracked using Hall Effect sensor
- Rubber Pads for compliance and increased friction

GRIPPER ROTATION

- Stepper Motor driven
- Oppositely-wound torsional springs in series providing self-adjustment of gripper orientation, maximizing grip secureness



ARM EXTENSION & ROTATION

- Dual Linkage System
- DC Motor driven
- Hall Effect sensors for position tracking
- Shouldered shafts with press-fit roller bearings

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Underwater Robotic Manipulator

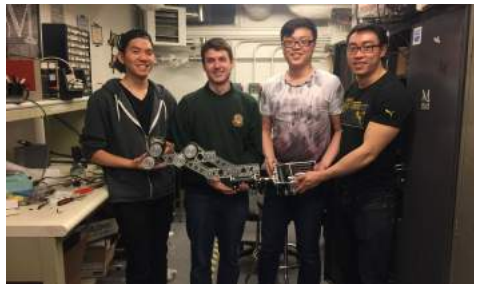
Final Design

MANUFACTURING

Due to the fact that we kept manufacturability of our design by conventional machining methods as one of our top priorities, we were able to not only fabricate most of the components ourselves from stock material using mills, lathes, and drill presses, but also save money and time. Since the rest of the AUV team typically orders a lot of laser cut parts, we piggybacked on their order for a few of our parts. The vast majority of the metal parts were manufactured from aluminum and the plastic pressure vessel components from Delrin.

PERFORMANCE

The arm integrated with the AUV smoothly and performed well during pool testing. The 2017 International RoboSub Competition took place in San Diego in late July, where the AUV was able to reach the second round of semi-finals, out of 37 international teams.



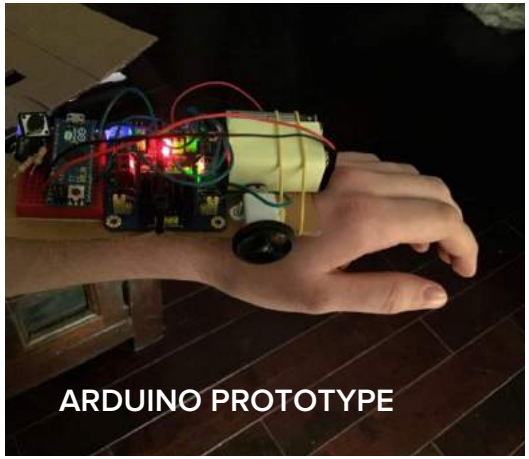
7 Stroke Patient Bilateral Orthoses for Grip Enhancement

MOTIVATION

For Mech 292: Conceptual Design, we were tasked with “solving one of the world’s tough problems” with a budget of $100, including manufacturing costs. Our team of five collectively had experienced the devastating effects stroke can have on family and friends, and so we decided to tackle the problem of grip strength loss due to incidence of stroke.

OBJECTIVE

The objective was to design a device that supplemented human grip. There was a strong focus on cost-accessibility, ease-of-use, compactness, and comfort. Conducting a literature review, we confirmed a need for our device, as existing devices were either too bulky, too expensive (to the tune of thousands of dollars), or only assisted with hand extension rather than flexion.



ARDUINO PROTOTYPE

OPERATIONAL GLOVE

8 Stroke Patient Bilateral Orthoses for Grip Enhancement

DESIGN

Multiple technological options for system signalling such as pressure sensors, EMGs, visual control, and off-hand tapping were considered. Due to our budget, we decided to produce a proof-of-concept using an Arduino/motor system with button control, saving more elegant solutions for future iterations.

In order to stay within budget, a golf glove was used for the glove frame, to which 3D printed structural pieces (as seen on image) are affixed. A series of elastics keeps the hand passively closed continuously, while activation of the motor system pulls the hand open via a series of wires.

PERFORMANCE

The glove was tested using passive hands and performed well in tasks such as picking up objects from mugs to books as well as things like twisting doorknobs.

Moving forward from this project, three of the team members continued on to refine the product for their final year project, and are exploring options to bring the idea to market.

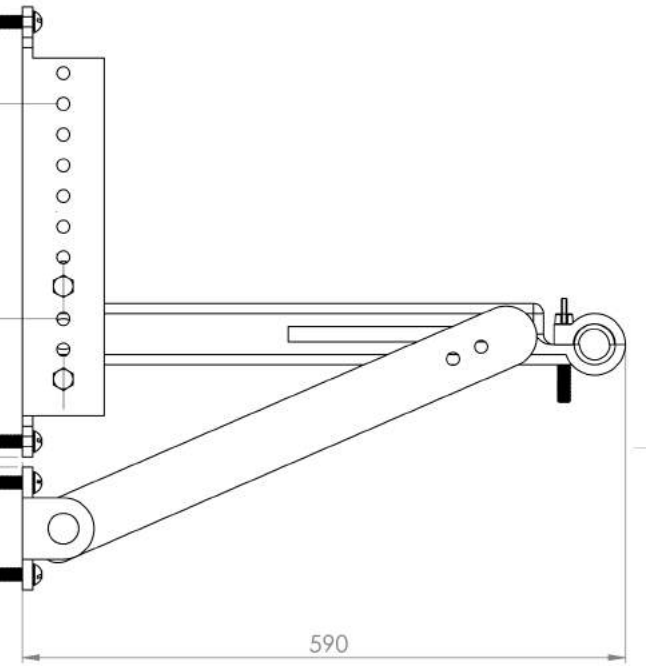
9 Bike Rack

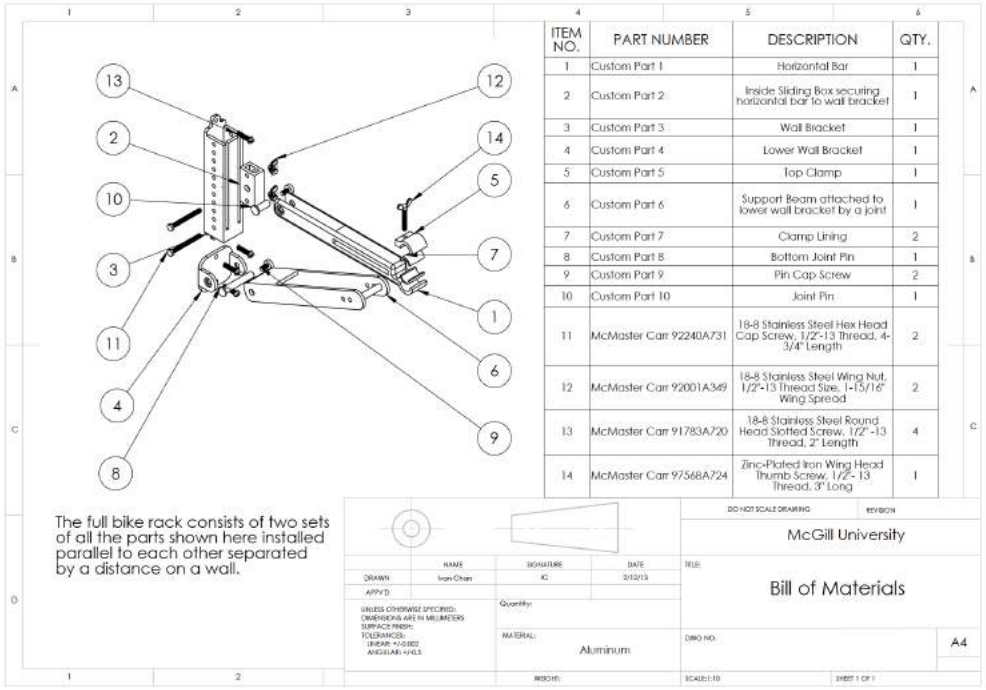
MOTIVATION

For Mech 290: Design Graphics for Mechanical Engineering, we were assigned to design a wall-mounted bike rack to suspend a bicycle for repair work.

OBJECTIVES & CONSTRAINTS

- The rack must be foldable; storage space should not exceed 200mm from the wall.
- A suspended bicycle should be offset from the wall by 600±50 mm.
- The position of the bicycle must be vertically adjustable within a range ±100 mm.
- The rack must be able to rigidly clamp the frame of the bicycle to suspend it vertically or at an inclination. The range of inclination must lie within ±30°.





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Custom Part 1	Horizontal Bar	1
2	Custom Part 2	Inside Sliding Box securing horizontal bar to wall bracket	1
3	Custom Part 3	Wall Bracket	1
4	Custom Part 4	Lower Wall Bracket	1
5	Custom Part 5	Top Clamp	1
6	Custom Part 6	Support Beam attached to lower wall bracket by a joint	1
7	Custom Part 7	Clamp Lining	2
8	Custom Part 8	Bottom Joint Pin	1
9	Custom Part 9	Pin Cap Screw	2
10	Custom Part 10	Joint Pin	1
11	McMaster Carr 92240A731	18-8 Stainless Steel Hex Head Cap Screw, 1/2"-13 Thread, 4-3/4" Length	2
12	McMaster Carr 92001A349	18-8 Stainless Steel Wing Nut, 1/2"-13 Thread Size, 1-15/16" Wing Spread	2
13	McMaster Carr 91783A720	18-8 Stainless Steel Round Head Slotted Screw, 1/2" -13 Thread, 2" Length	4
14	McMaster Carr 97568A724	Zinc-Plated Iron Wing Head Thumb Screw, 1/2"-13 Thread, 3" Long	1

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About Me

CORE COMPETENCIES

MECHANICAL

- SOLIDWORKS
- INVENTOR
- ANSYS
- AUTOCAD
- MASTERCAM

CODING

- MATLAB
- JAVASCRIPT
- HTML
- C

OTHER

- PHOTOSHOP
- WORD
- EXCEL

EDUCATION

Bachelor of Mechanical Engineering – CGPA: 3.82 Sept 2012 – May 2017
McGill University, Montreal, QC

- Dean's Honour List for top 10% GPA in Engineering Faculty (2012-2017)
- Scholarships: J.W. McConnell Scholarship (2013),
  Ram and Durga Panda Scholarship (2014)
  Douglas Macaulay Scholarship (2015)
- Relevant Courses: Conceptual Design
  Machine Element Design
  Design Graphics for Mechanical Engineering
  Solid Mechanics, Mechanics of Deformable Solids
  Principles of Manufacturing
  Applied Electronics and Instrumentation
  Electric Machinery

PROFESSIONAL EXPERIENCE

Mondelez International, Project Engineering Intern May 2015 – Dec 2015

- Repatriated packaging processes of multiple SKUs from co-packers using Lean Six Sigma methodology, yielding yearly cost savings of $600,000.
- Modulated a chocolate line to bypass high error rate equipment resulting in a 40% reduction of total downtime and $38,000/year savings in chocolate waste.
- Overhauled outdated washroom facilities resulting in $23,000/year in water savings.
- Drafted the RFP for the packaging leg of a new $20MM production line. Created decision matrices to aid contractor selection.

About Me

I grew up in a family of engineers and so it was pretty natural that I became one myself. I believe everything is interesting if you dig deep enough. I am passionate about becoming a jack of all trades- seeking continuously to conquer new domains and draw connections between them.

MUSIC

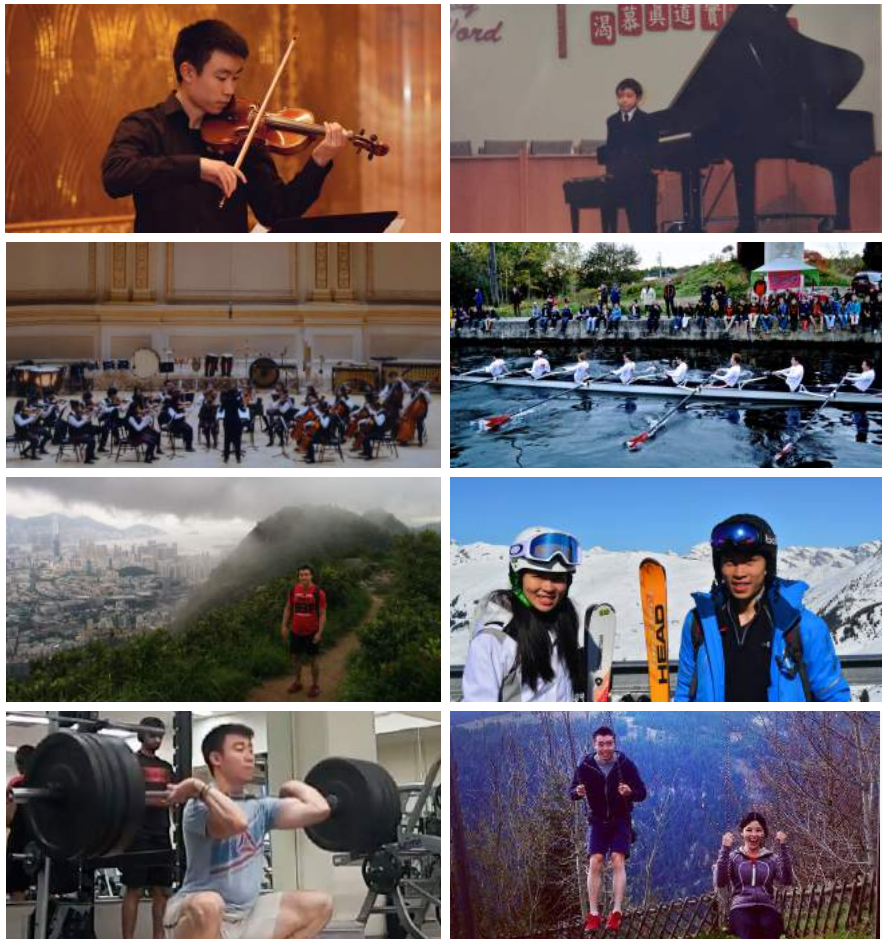
I have been playing piano and violin since the ages of 4 and 6 respectively. What started out as my mom pushing me to take lessons has turned into a passion! I have graduated from the Royal Conservatory of Music with A.R.C.T performance diplomas in both instruments. I have performed in orchestras, duets, quartets, wedding receptions, plays, and even the world-famous Carnegie Hall.

SPORTS

I am an avid weightlifter who has the dream of competing for my country (Canada) at the Olympics. I also love skiing and rock-climbing.

TRAVEL

As an avid traveller, I have visited over 30 countries around the world, mainly in Europe and Asia. I plan to explore South America next! Apart from Canada, I have lived in Hong Kong and Switzerland.



Thank you for viewing my work!

Feel free to contact me at:

ivan.chan@mail.mcgill.ca
+1 (647) 572-5793
linkedin.com/in/ivanpkhchan