Project Portfolio

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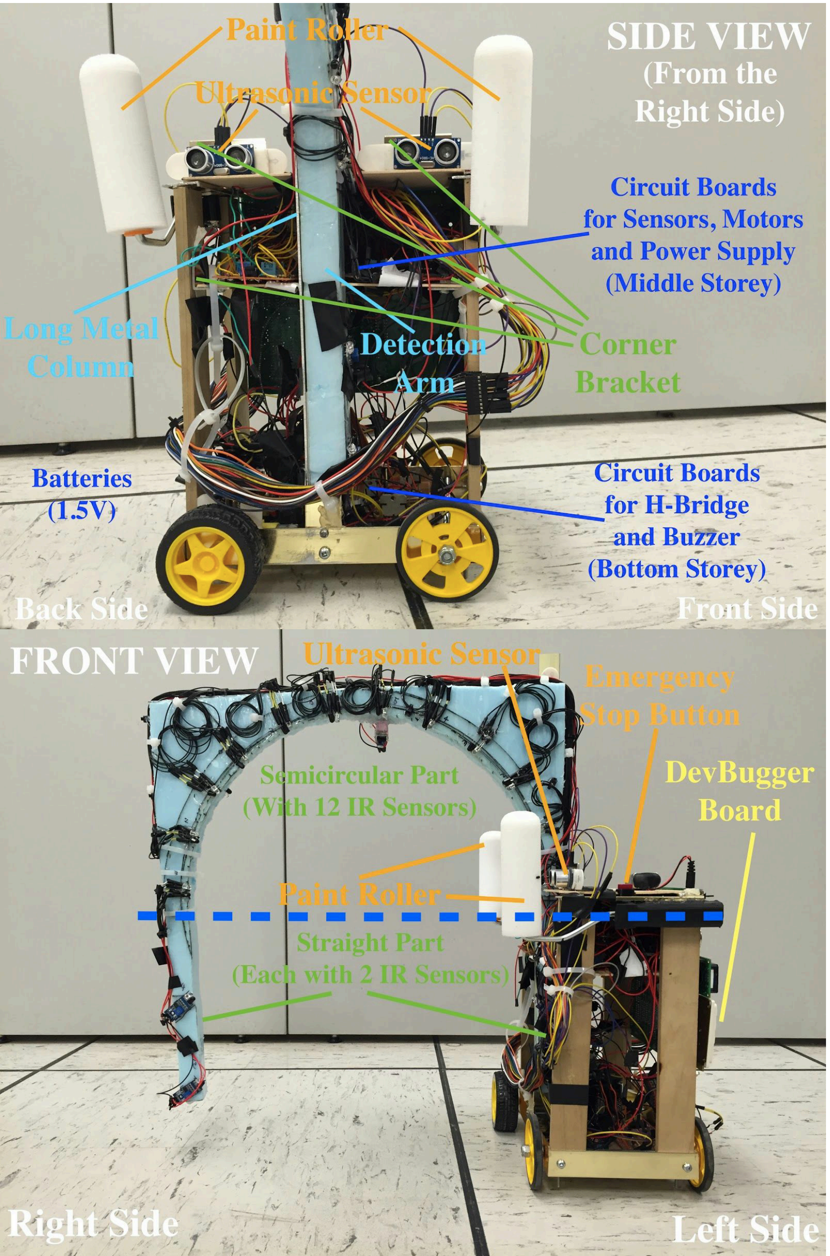
1. Robot Design and Construction (Spring 2016)



In a team of three, we designed and constructed a scale-down, proof-of-concept prototype for a robot that would, in practice, autonomously move around nuclear power plants to inspect their pipelines for potential accumulation of radioactive materials.

The project was divided into three subsystems: microcontrollers, circuits and electromechanical systems. I took charge of the last one, and my responsibilities include: (1) overall structure finalization and fabrication; (2) actuation and transmission mechanism design that reduces the complexity for other subsystems while ensuring functionality requirements; (3) material selection and processing that minimizes cost and weight; and (4) connection mechanism design that guarantees both robustness and flexibility, so that the mechanical structure can not only hold tightly during operation and testing, but also be quickly adapted according to emerging demands.

(Labeled photos of the prototype we designed and built)

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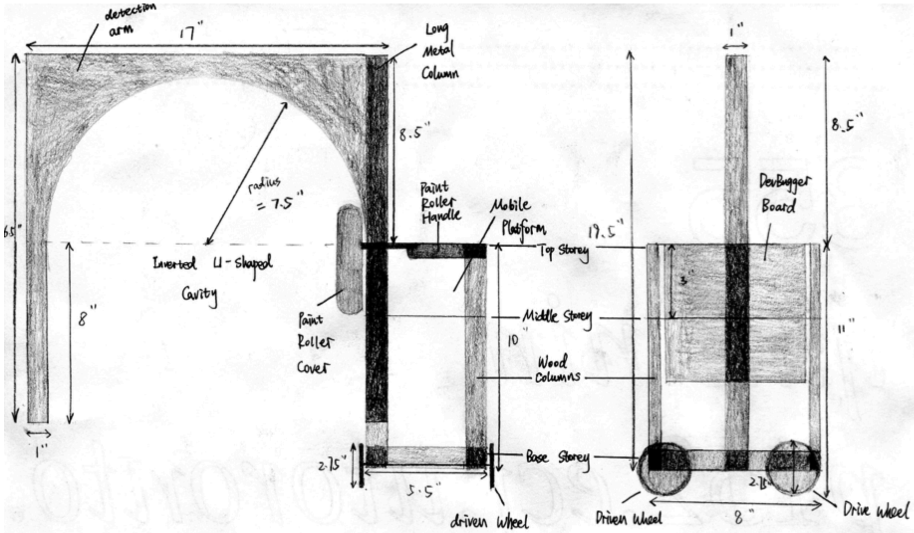
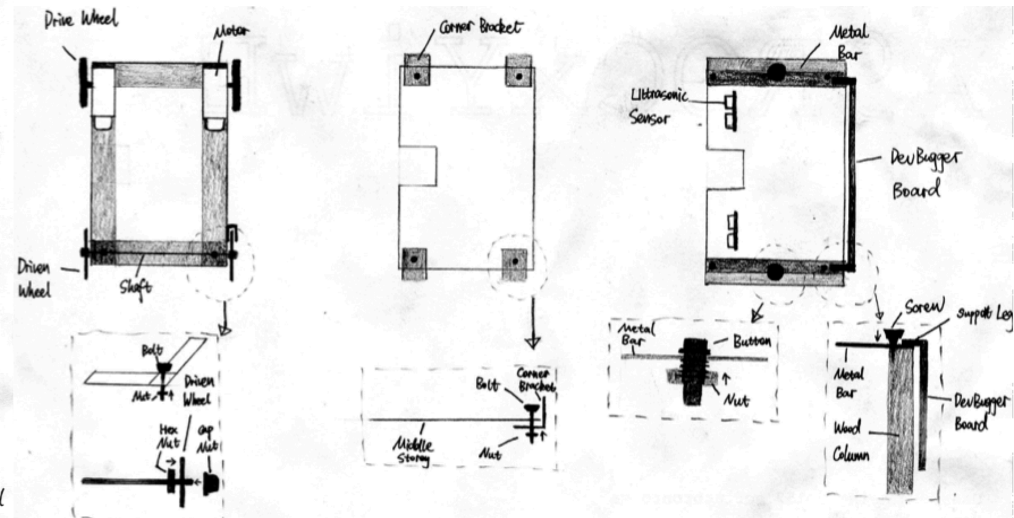
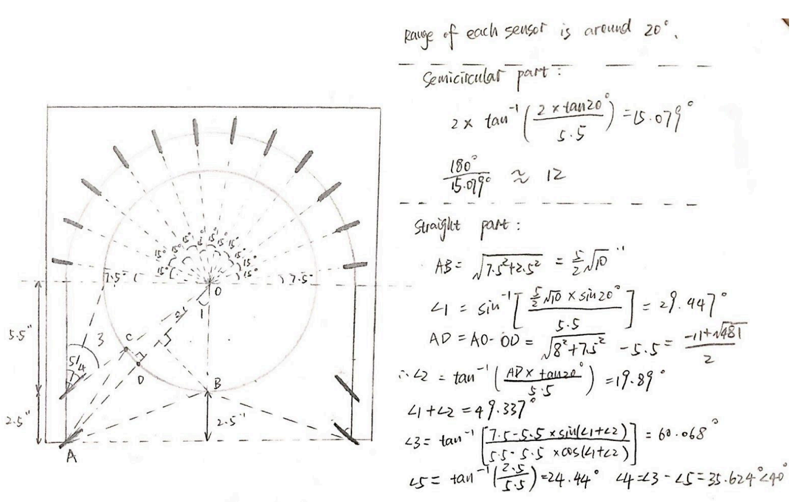






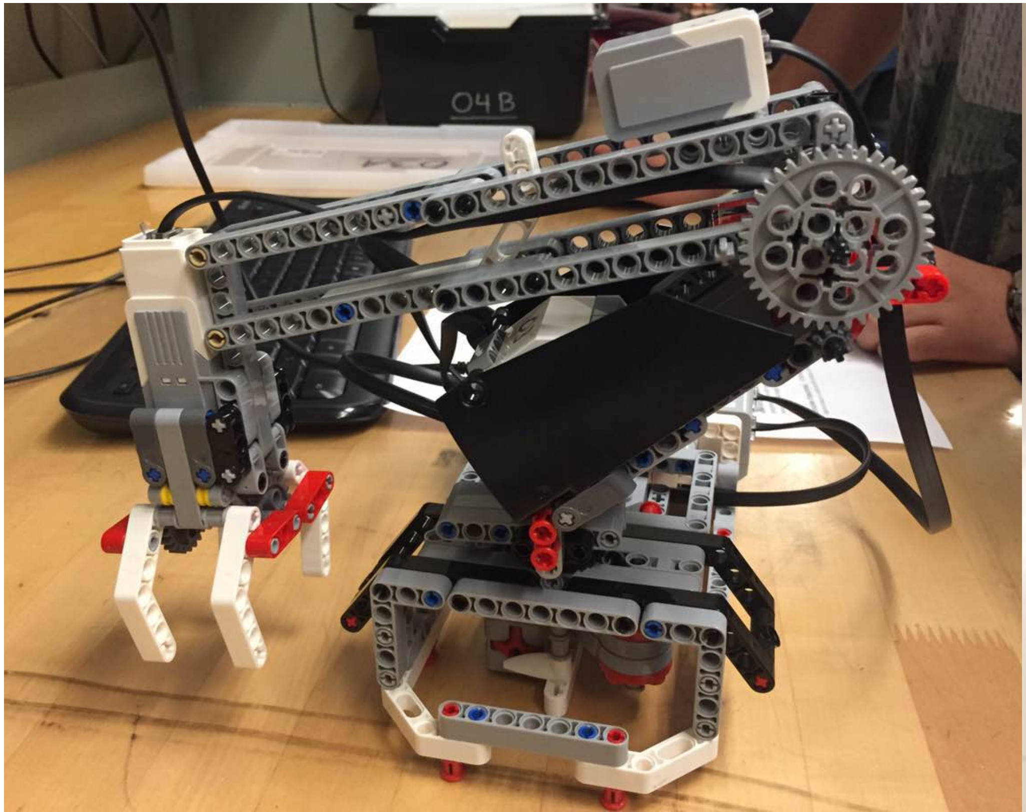
(Sample drawings and calculations)

At the end of the project, our prototype can successfully perform the required tasks: (1) completing all the following operations autonomously after the *start* button is pressed; (2) taking a round−trip along a straight pipe without touching it; (3) detecting, signaling and recording positions of black spots presented over the pipe surface; and (4) termination display of operation time and recorded data.

For me, the most important take-away from this project is how important it is to have good commutations within a team, so that everyone is working hard, helping and encouraging each other, and finding and fixing problems together to achieve the same goal, instead of blaming each other for the smallest malfunction.

2. Lego Robot Programming (In Progress)

In a series of labs, different Lego robots have been assembled and programmed to perform various tasks, such as (1) object gripping, moving and stacking (direct motor control); and (2) path following (using color sensors and PID control). Successful lab completion requires understanding and implementation (in Java) of robotic concepts, mathematical methods and control theories covered in lectures.



3. Equipment Carrying Utility Design for Local Sledge Hockey Players (Spring 2015)

In a team of four, we noticed the need of wheelchair users among local sledge hockey players for well-designed equipment carrying utilities that: (1) ensures safety (keeping hard objects away from users); (2) allows players to carry and access equipment independently (currently it is difficult for some players to come to the stadium without company); and (3) minimizes space taken (since the facilities are not built for sledge hockey players specifically, some areas appear narrow for only the wheelchair). After having approached the players, their families and coaches, we framed their concerns into a Request for Proposal (RFP), which became one of the eight winning ones out of a total of fifty in an engineering design course. Together with another seven teams, we continued to work on developing prototypes satisfying the design requirements and constantly making refinement based on stakeholders' and teaching team's feedback. In the end, our design process and result has been presented at an Engineering Science showcase to interested persons.

(Photo of a player carrying his sledge around his neck, taken during stakeholder engagement phase)

The poster presented at the final showcase to demonstrate design results to teaching team, stakeholders, and the general public

SledgeHammer

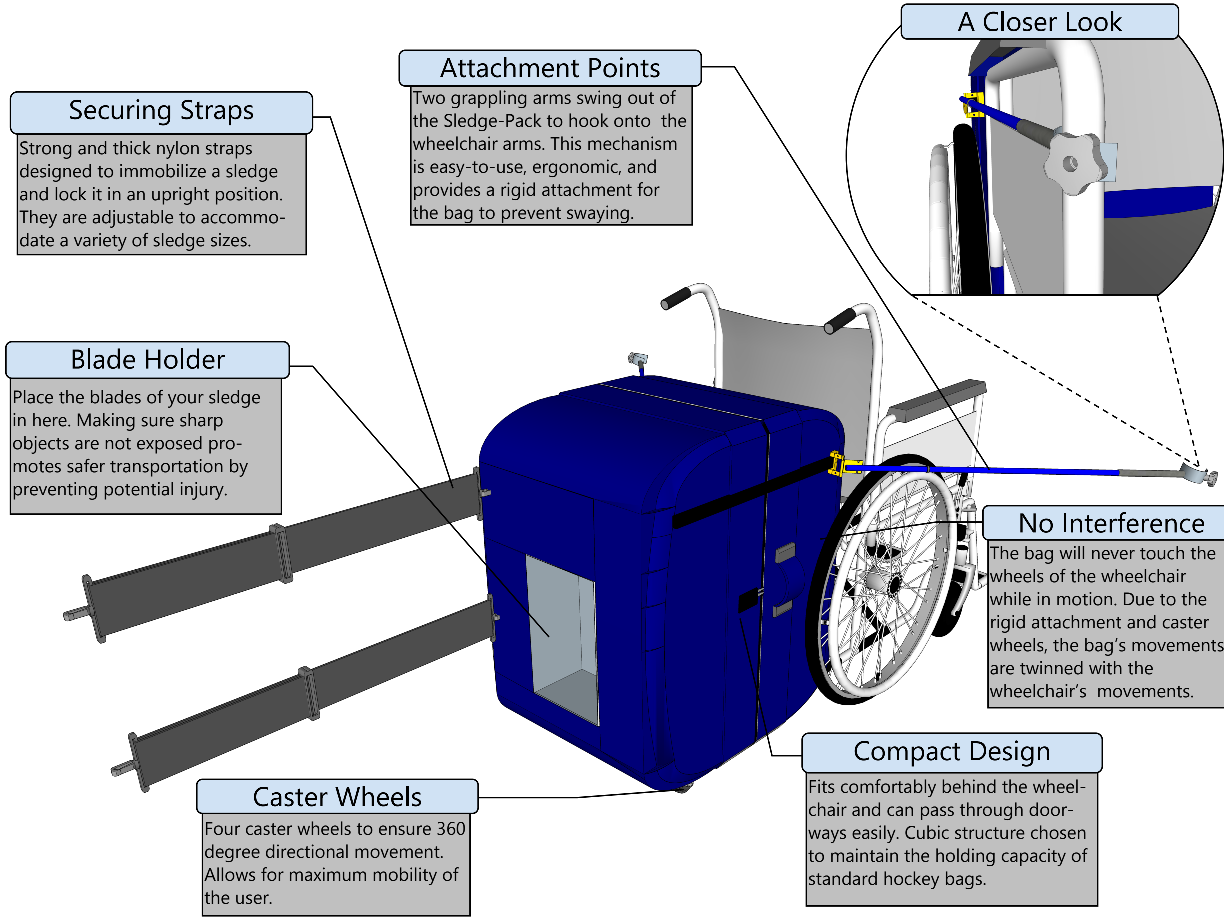
A Transportation Aid for Sledge Hockey Players

The Opportunity

Sledge hockey players who use wheelchairs often carry their equipment with hockey bags designed for able-bodied people. W-05 believes that this is a safety concern, and needs to be addressed.

The Solution

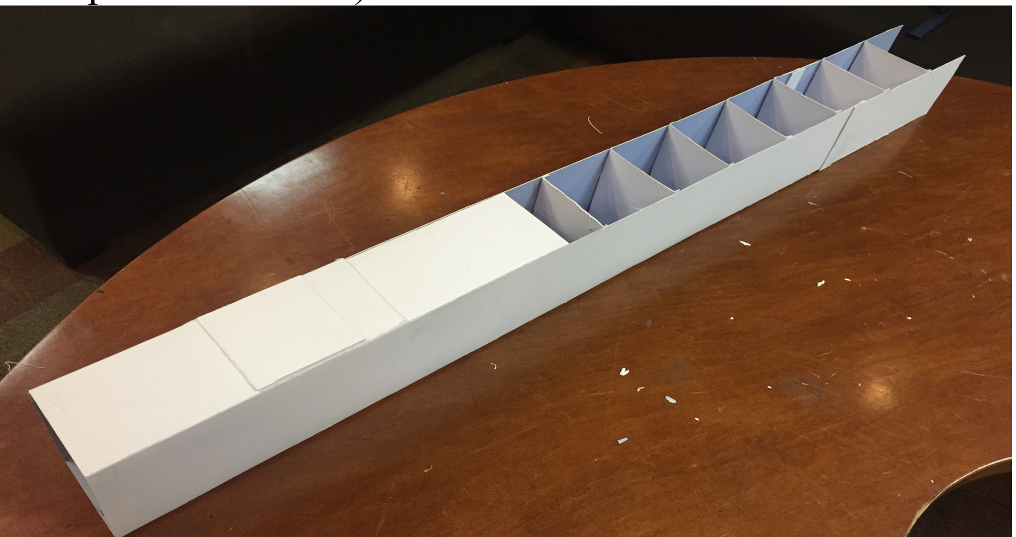
W-05 presents a hockey back specifically designed with wheelchair-users in mind. Sledge hockey players can now safely and conveniently transport their equipment and sledge fitted into a compact package. Take a look at how it works.

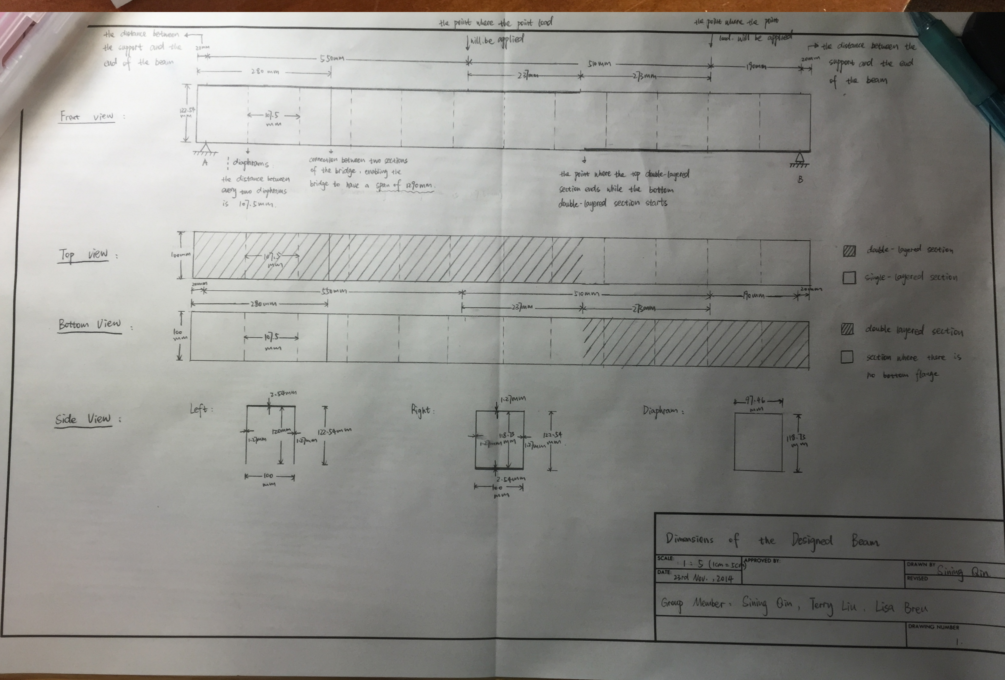


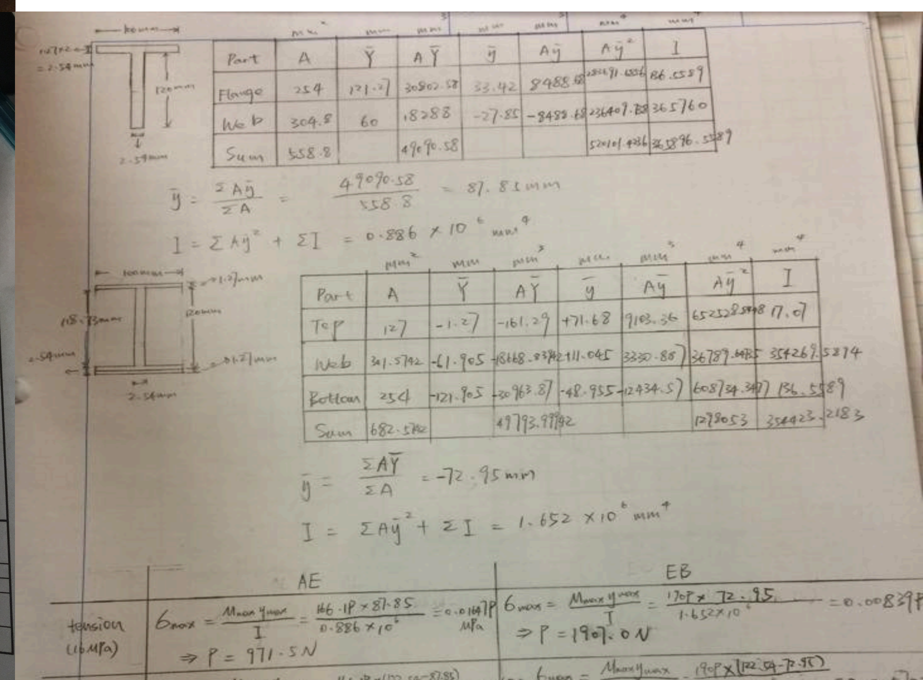
4. Mat-Board Beam Bridge Design (Winter 2014)

(Bottom view of the bridge, engineering drawing, and sample calculations)

In a team of two, we designed and built a beam bridge that, although made of 1.27-mm thick mat-board, could bear a maximum load of around 1000N. This high load capacity was ensured by not only calculations based on theories and equations learned in lectures, but also careful resource planning since only limited amount of raw materials (board and glue) and time was available. It stayed intact after having been tested by wheeled weights moving along and people standing on top of it.







Part	A	$\bar{Y}$	$A\bar{Y}$	$\bar{y}$	$A\bar{y}$	$A\bar{y}^2$	I
Flange	254	121.27	30802.58	33.42	8488.68	[illegible]	86.5589
Web	304.8	60	18288	-27.85	-8488.68	[illegible]	365760
Sum	558.8		49090.58			[illegible]	365896.5589

$$\bar{y} = \frac{\Sigma A\bar{y}}{\Sigma A} = \frac{49090.58}{558.8} = 87.85\ mm$$

$$I = \Sigma A\bar{y}^2 + \Sigma I = 0.886 \times 10^6\ mm^4$$

Part	A	$\bar{Y}$	$A\bar{Y}$	$\bar{y}$	$A\bar{y}$	$A\bar{y}^2$	I
Top	127	-1.27	-161.29	+71.68	9103.36	[illegible]	17.07
Web	341.5792	-61.905	[illegible]	+11.045	3330.88	[illegible]	354269.5874
Bottom	254	-121.905	-30963.87	-48.955	-12434.57	[illegible]	136.5589
Sum	682.5792		-49793.9992			[illegible]	[illegible]

$$\bar{y} = \frac{\Sigma A\bar{Y}}{\Sigma A} = -72.95\ mm$$

$$I = \Sigma A\bar{y}^2 + \Sigma I = 1.652 \times 10^6\ mm^4$$

AE

EB

tension (16 MPa)

$$6_{max} = \frac{M_{max}\,y_{max}}{I} = \frac{166.1P \times 87.85}{0.886 \times 10^6}$$

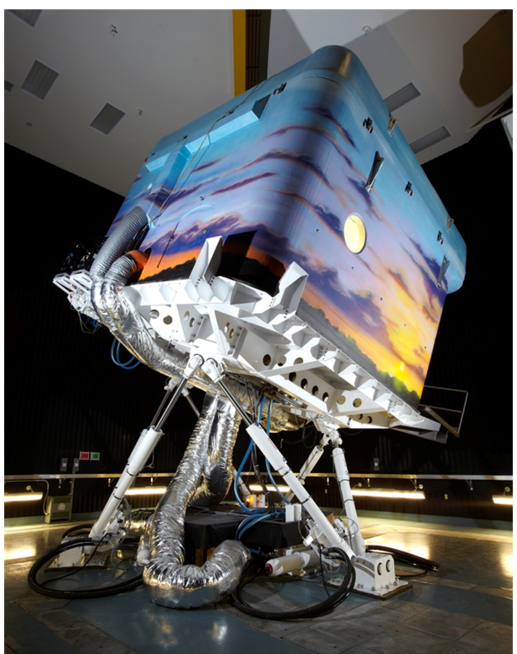
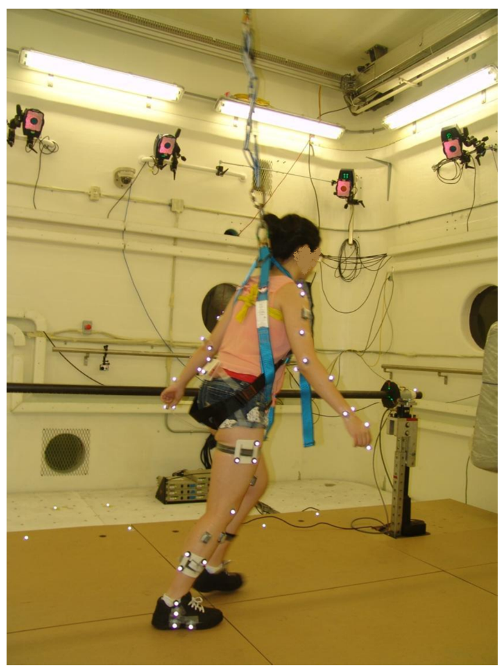
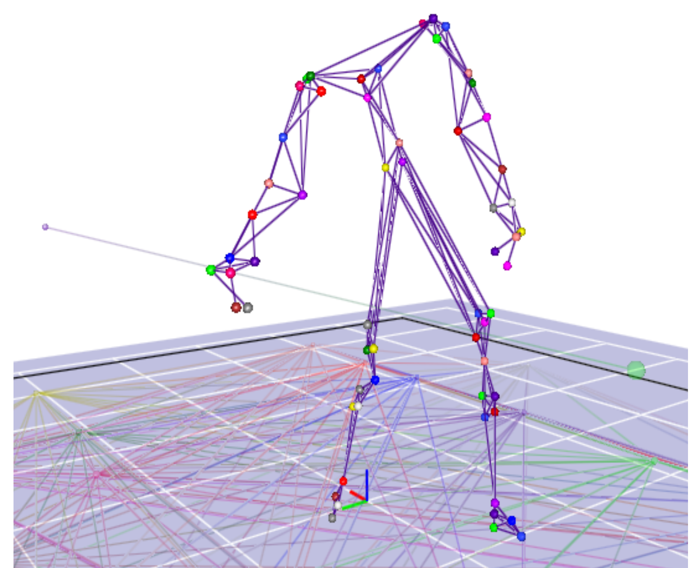
$$\Rightarrow P = 971.5\ N$$

$$6_{max} = \frac{M_{max}\,y_{max}}{I} = \frac{170P \times 72.95}{1.652 \times 10^6}$$

$$\Rightarrow P = 1907.0\ N$$

5. Research Assistant at TRI (Summer 2016)

I spent the summer after my second year working as a research assistant in the Home and Community Team at Toronto Rehabilitation Institute (TRI). Under the supervision of Dr. Alison Novak, my primary project was to help PhD candidate Vicki Komisar investigate how handrail height affects the speed and accuracy of reach-to-grasp balance recovery reactions. This study will provide an evidence base for influencing building codes, accessibility standards and design guidelines on handrail height, and thereby contribute to reducing the risk of falls and falls-related injury. I was involved in different research phases: (1) data collection (with both younger and older adults in the Challenging Environment Assessment Lab at TRI); (2) data processing and analysis (using Cortex, a motion data handling software, and MATLAB); and (3) finding dissemination (presented work within the team and at University of Toronto's research events).

(Exterior and interior of the Challenging Environment Assessment Lab at TRI; sample data displayed in Cortex)

The research poster presented at the University of Toronto's Undergraduate Research Day (UNERD) and Institute of Biomaterials and Biomedical Engineering (IBBME) Scientific Day

(poster presentation at UNERD won first prize in the Mechanical and Industrial Engineering category)

The Relationship between Handrail Height and Speed and Accuracy of Reach-to-Grasp Balance Recovery Reactions

Sining Qin[1, 2, 3], Vicki Komisar[1, 2], and Alison Novak[1, 4]

[1] Home & Community Team, Toronto Rehabilitation Institute - University Health Network; [2] Institute of Biomaterials and Biomedical Engineering, University of Toronto; [3] Division of Engineering Science, Faculty of Applied Science and Engineering, University of Toronto; [4] Faculty of Kinesiology and Physical Education, University of Toronto

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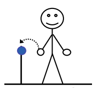
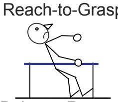
Background and Motivation

- Falls are a leading cause of injury, disability and death in Canadian seniors [1]. Long-term mobility limitations resulting from a fall restrict individuals from living independently.
- Handrails can significantly help people maintain balance and avoid falls when being grabbed quickly, accurately and effectively [2]. Current Ontario building code range for handrail height is 34-38 inches (865-965 mm) [3].
- Our understanding of how specific handrail design features (e.g. height) affect its utility as a balance recovery aid (e.g. speed and accuracy of reach−to−grasp reaction) is limited.

Objectives

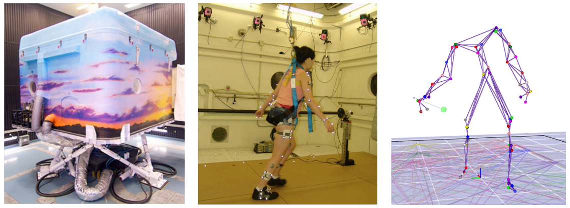
- Investigate how different handrail heights affect the speed and accuracy of the reach−to−grasp balance recovery reactions
- Compare the reaction performances between younger (18-35y) and older adults (≥60y)
- Compare the reaction performances between level-ground walking and 8°-ramp descent


Reach-to-Grasp


Balance Recovery

Methods

Data Collection Methods



- **Participants**: 36 healthy adults, 18 young (18-35y) and 18 old (≥60y)
- **Conditions**: 8 handrail heights within the range of 30"−44"; level ground and 8°-ramp descent
- **Procedure**: Participants walked beside a handrail with arms relaxed, and performed reach-to-grasp reactions to recover balance after walking-surface perturbations
- **Measurements**:
  - Motion: Measured by the Cortex motion capture system, which recorded the position data of a set of reflective markers attached to the participants
  - Hand−to-Rail Contact Time: Measure by a laser device mounted slightly above the handrail

Data Processing and Analysis Methods

- To date, 8 younger adults and 2 older adults have been analyzed; 3 successful grasping trials were averaged to generate each data point
- Motion data were calibrated and cleared up using the Cortex software, and then synced, processed and analyzed with other data using the MATLAB software
- Data corresponding to the following metrics (6 in total) were extracted based on the marker located at right hand's second metacarpophalangeal (MCP) joint:
  - 4 speed metrics: contact time, and the maximum hand speed in the outward, upward, and downward directions; and
  - 2 accuracy metrics: peak hand position and upward overshoot

Current Results

Speed Metrics

- Participants' maximum outward and upward hand speeds overall increase with the handrail height, but there is no trend in the downward speed and contact time
- Younger adults demonstrate faster outward hand movement, whereas in other speed metrics, there is no obvious advantage of one age group over another
- The maximum hand speeds in the outward and downward directions are generally higher in the descent condition than the level one, whereas the upward hand speed is higher for the level ground condition

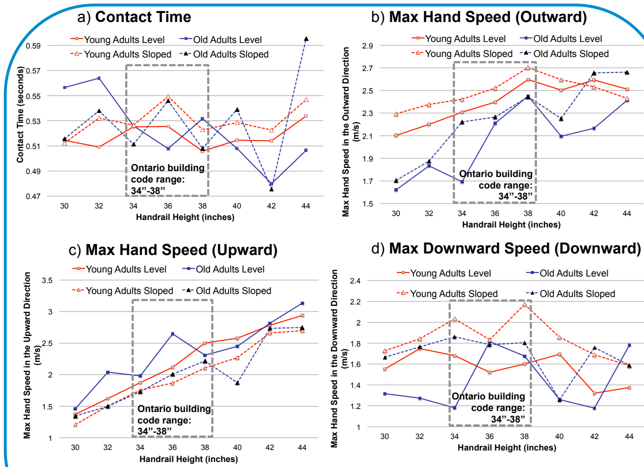


Figure 1: **Handrail height** vs. a) Average hand-to-**rail contact time**; b) Average **max hand speed in the outward direction**; c) Average **max hand speed in the upward direction**; and d) Average **max hand speed in the downward direction**, for 8 younger and 2 older adults in both level ground and 8°-ramp descent conditions

Accuracy Metrics

- Overall, participants' peak hand position rises as the handrail height increases, whereas their upward overshoot drops
- Younger adults perform more accurate reach-to-grasp reactions compared to older adults
- Participants tend to have more accurate hand movement in the level ground condition than the descent one

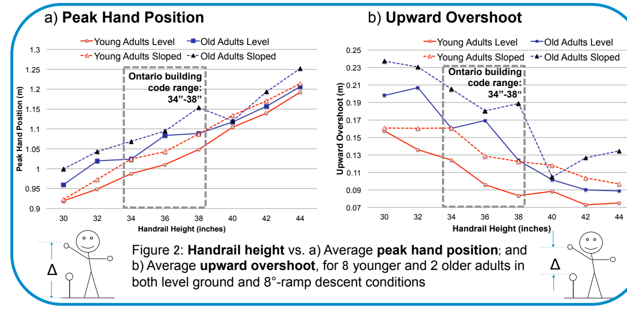


Figure 2: **Handrail height** vs. a) Average **peak hand position**; and b) Average **upward overshoot**, for 8 younger and 2 older adults in both level ground and 8°-ramp descent conditions

Conclusions

- Younger adults' performances are more consistent than older adults' for all metrics; however, this can be a result of the smaller sample size used for the elders
- People customize the speed of their reach−to−grasp reactions according to the various handrail heights present in a scenario, this leads to contact time's independence from handrail height
- For older adults in this sample, contact time approaches its minimum at around 42"
- Participants' reach−to−grasp reactions are generally more accurate in the level ground situation, with younger adults doing better than the older

Future Work:

- Use the speed of participants' center of mass to investigate their speed in the anterior-posterior direction
- Use the electromyography (EMG) signals to investigate participants' latency time

Significance

- Understanding of the handrail heights that promote the most efficient reach-to-grasp reactions can inform current building standards, contributing to a safer built environment by preventing falls

References

[1] Public Health Agency of Canada, "Seniors' Falls in Canada: Second Report", 2014.

[2] B. E. Maki, S. D. Perry and W. E. McIlroy, "Efficacy of handrails in preventing stairway falls: a new experimental approach," Safety Science, vol. 28, no. 3, pp. 189-206, 1998.

[3] Government of Ontario, "Ontario Regulation 332/12: Building Code," 1 January 2016.

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UHN Toronto Rehabilitation Institute

6-8. Extra–Curriculum and Self-Interest Projects

6. A Python Program Helping Me Learn Japanese

During the process of self-teaching Japanese, I found it is hard to associate different kanji (characters borrowed from Chinese, most often have different pronunciation compared to Chinese) with their pronunciations, since one kanji can have multiple pronunciations while one pronunciation can also shared by many kanji. I tried to take hand-written notes, but found it is problematic because as I continuously learn about more kanji and pronunciations, it becomes difficult to append those new contents in an organized manner. Therefore, I wrote a string manipulation program in Python, which (1) takes in an existing text file with unordered (kanji, pronunciations) pairs, (2) allows content updating by directly inputting new pairs into the program, and (3) generates two text files, one with kanji organized according to pronunciations (in alphabetical order) and another with pronunciation(s) corresponding to different kanji, upon completion of the program.

Sample output can be found below. Actual code can be found at my GitHub account: qsnsidney.

```
上	a
会	a
合	a
挙	a
揚	a
遭	a
開	a
明	aka
秋	aki
青	ao
朝	asa
足	ashi
遊	aso	you
新	ata
頭	atama
暖	atatakai
```

```
a	上	会	合	挙	揚	遭	開
aka	明
aki	秋
ao	青
asa	朝
ashi	足
aso	遊
ata	新
atama	頭
atatakai	暖	温
chi	地
cukue	机
cume	冷
dan	段
en	園
gou	号
```

6-8. Extra−Curriculum and Self-Interest Projects

7. A Personal Website (In Progress)

After teaching myself basic web development tools（HTML and CSS), I started to practice my skills by creating a personal website from scratch, which will eventually turn into my comprehensive online portfolio. It is still at its early stage, with basic structures completed but few contents. It can be found at: https://qsnsidney.github.io/.

8. Command and Data Handing (CDH) Subsystem, Space Systems Division, UTAT (In Progress)

UTAT Space Systems is building a 3U CubeSat for the Canadian Satellite Design Challenge happening in summer 2018. The CDH subsystem acts as the brain of the satellite, handling the control of and information exchange between other subsystems such as power, communication etc. I joined the team this September, and is currently familiarizing with work that has already been done on the older version of the satellite, and learning more about microcontrollers and circuitry.