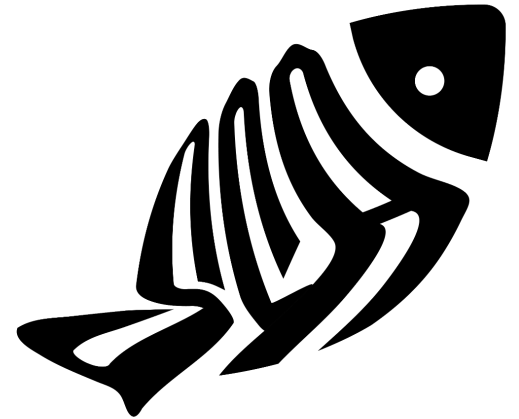


Smart Swim Presentation

Smart Swim (Company 2)
Tim Woinoski (Project Lead)
Kudus Elbo-Iswadi (RT-Systems Specialist)
Kuro Chen (RT-Systems Specialist)
Ethan Cai (RT-Systems Specialist)
Kiran Brar (Software Specialist)
Ray Kim (Software Specialist)



What to Expect...

- Introduction
- Technical Case
 - System Overview
 - Details on system
- Business Case and Costs
 - Market details
 - Running as a business
- Risk Analysis
- Engineering Standards
- Self Reflection

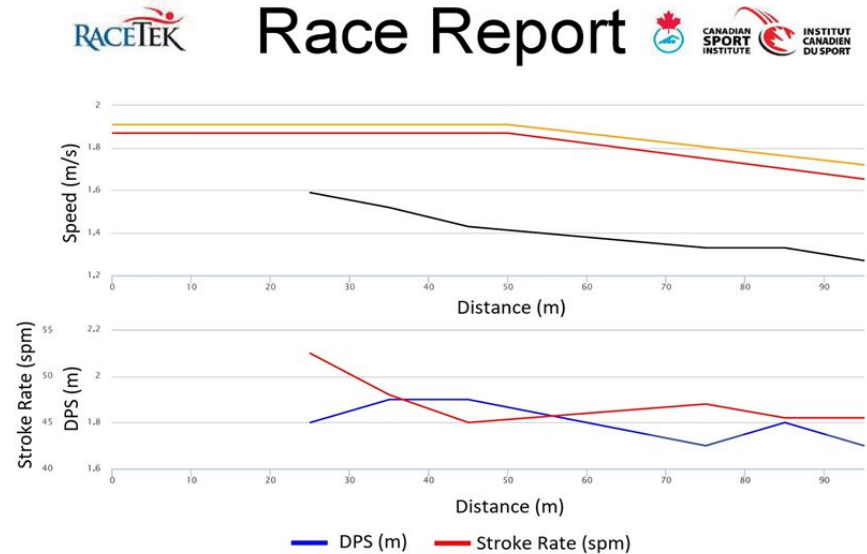
The Problem...

Background

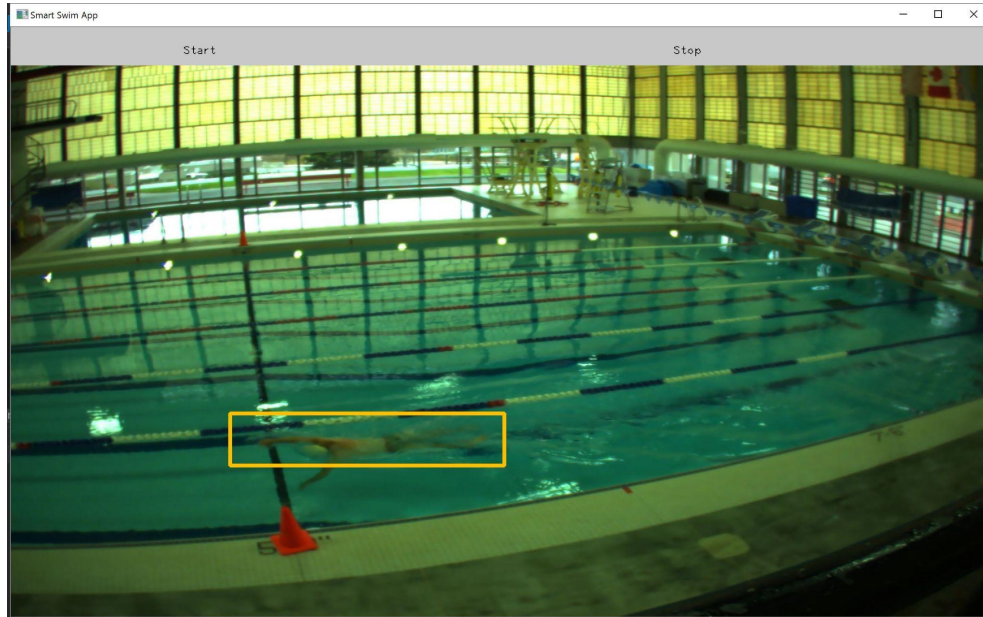
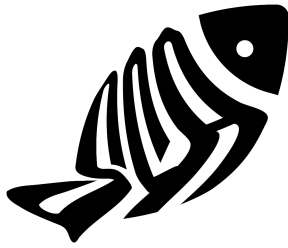
- Automated products not compliant with races
- Race analytics tracked by hand
- Racetek \$14 per race

Motivations

- Efficient budget usage
- Improvements of swimmers

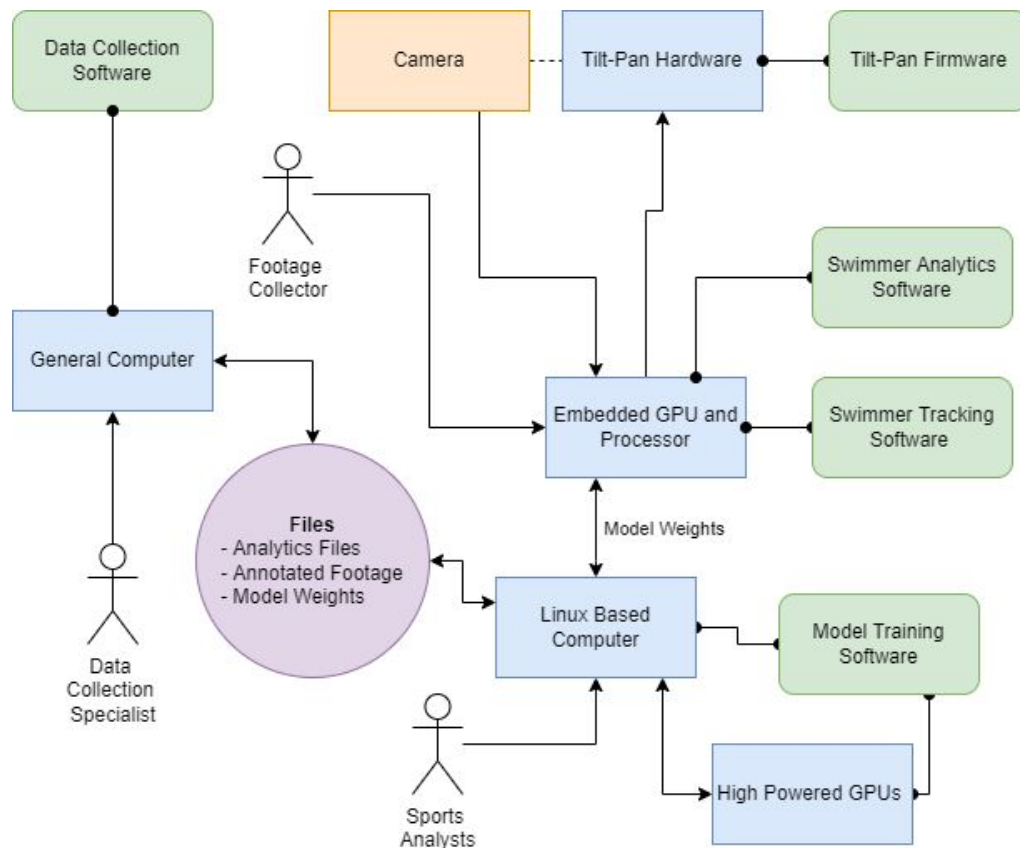


What is Smart Swim



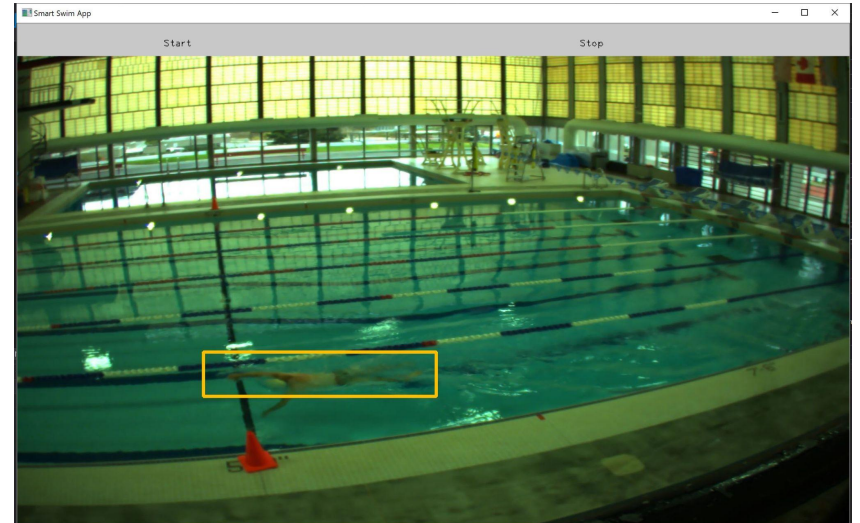
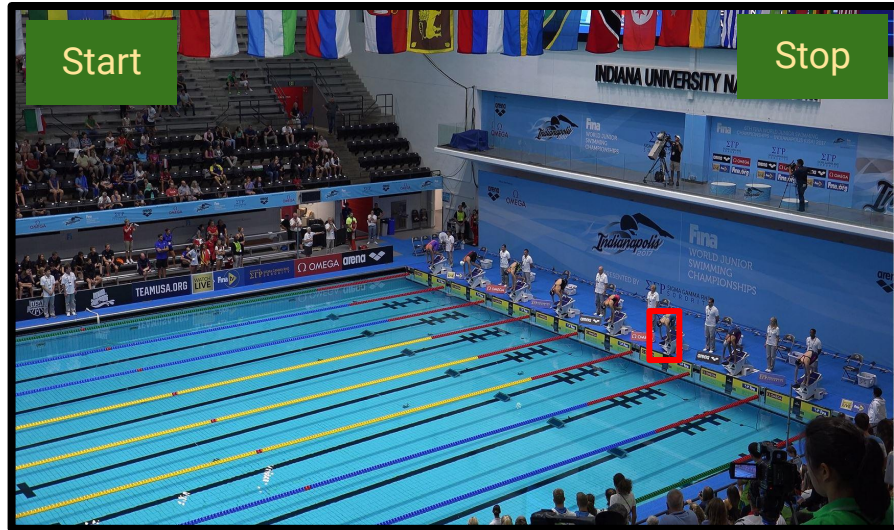
Technical Case

System Overview



Software Overview and Changes

- GUI design change
- YOLOv3-tiny instead of YOLOv3 or YOLOv4
- No calculation of stroke rate, as the processing is not fast enough



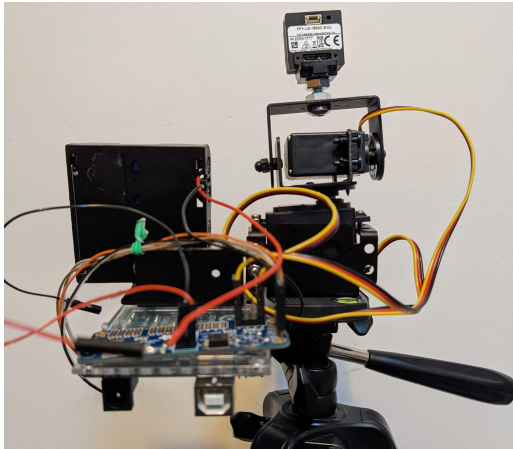
Swimmer Positioning

- Swimmer positioning was dropped



Hardware Overview and Changes

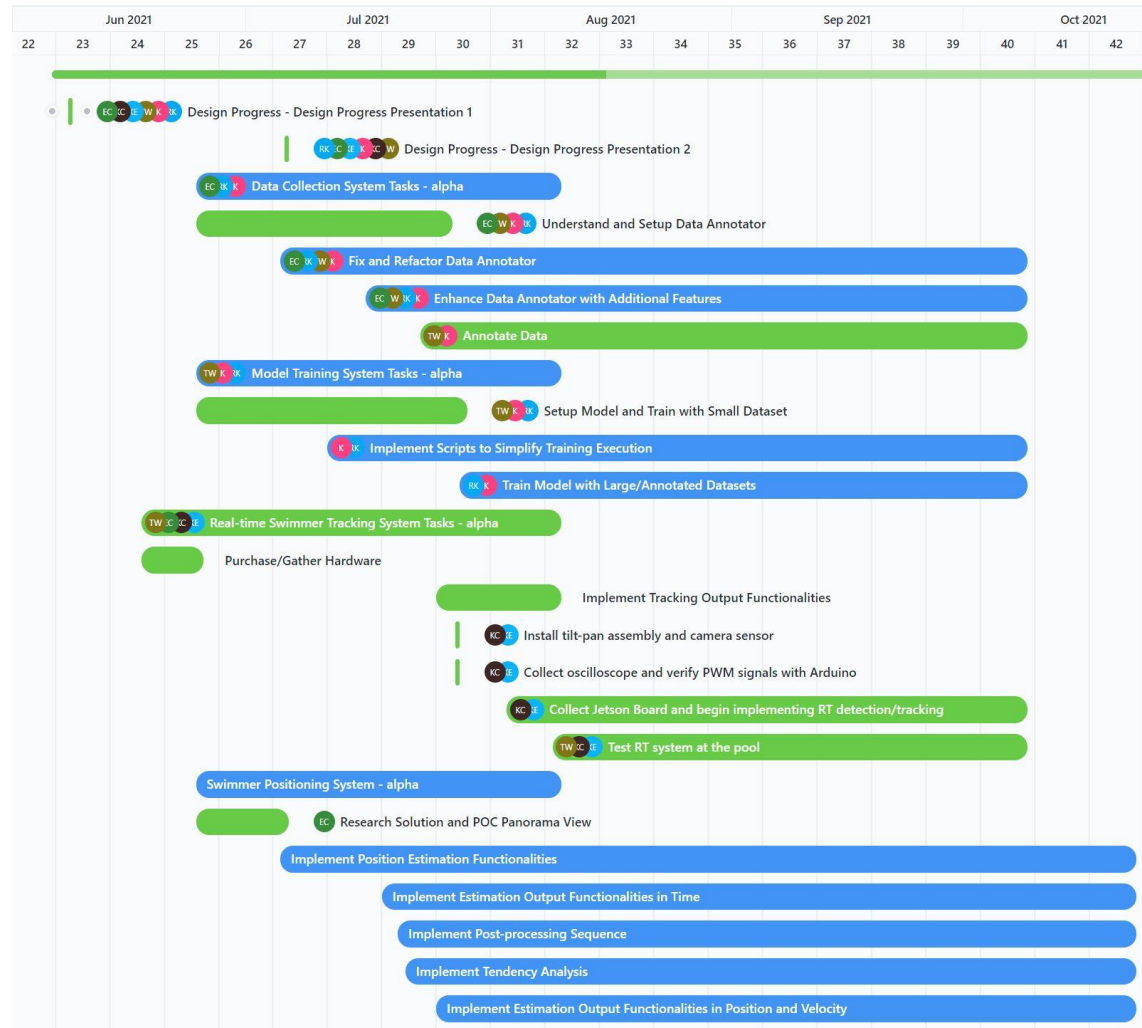
- Raspberry Pi -> Arduino
- Added **powered USB hub** so the tilt-pan is not power by the GPU
- Need to finish tilt-pan assembly design



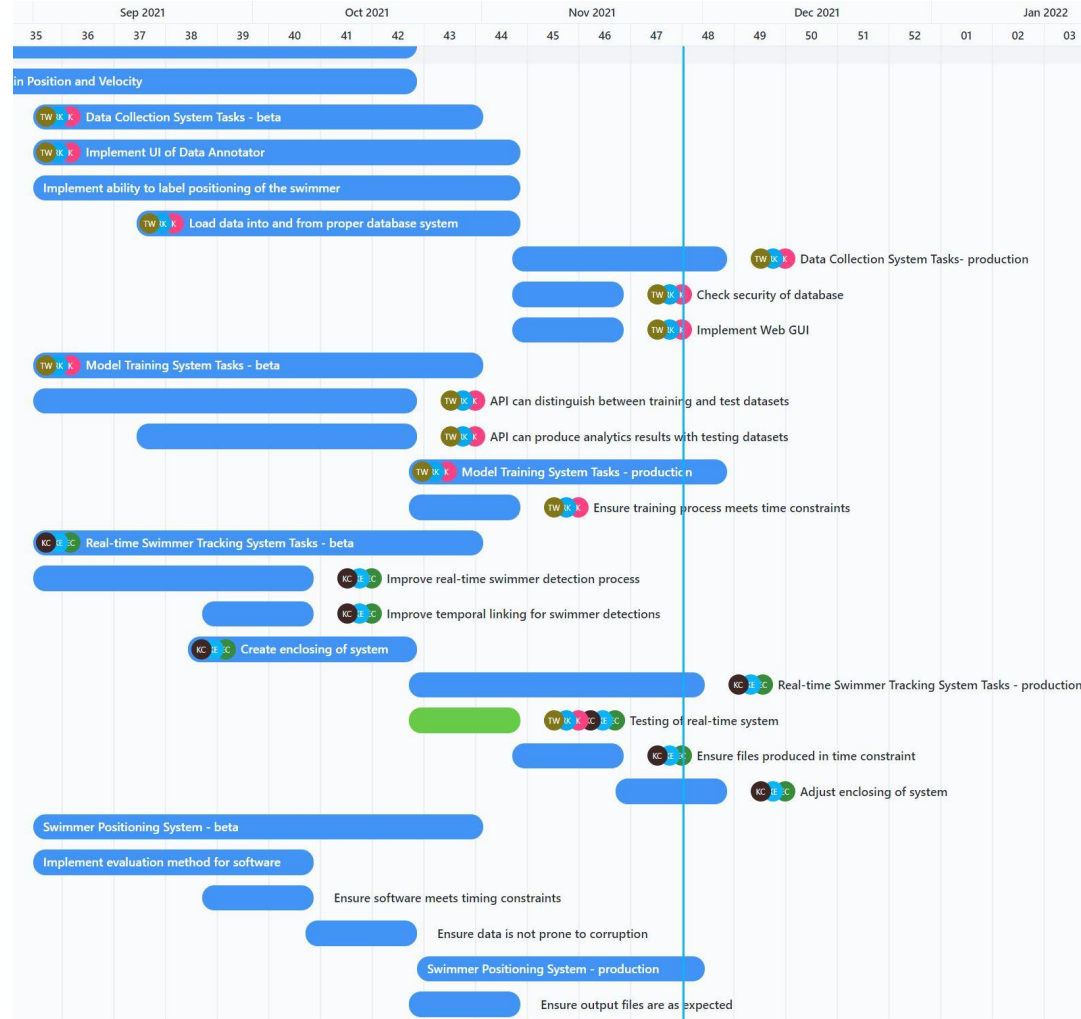
Product Materials and Cradle-to-Cradle

- **Materials**
 - Electronics: Jetson, Arduino, camera, computer peripherals
 - Plastic: tripod
 - Metal: servo holder/bracket
 - Batteries
- **Cradle-to-Cradle**
 - Repurpose/reuse camera, tripod, and, electronics
 - Recycle in case not reusable

Schedule



Schedule



Smart Swim Flow (Progress)

Start-up

1. User click start on desktop (100%)
2. Program "wakes up" Arduino (90% -> 100%)
3. System connects to tilt-pan assembly (95% -> 100%)

User IO

1. Program loop begins (77% -> 100%)
 2. Sub-video created when "Stop" is pressed (90% -> 100%)
- Program Loop (user can...)
- See recorded scene (65% -> 100%)
 - Move camera via "← ↑ ↓ →" (95% -> 100%)
 - Select swimmer to track with mouse (100%)
 - Start/Stop/Cancel automatic tracking (50%->100%)

Finish

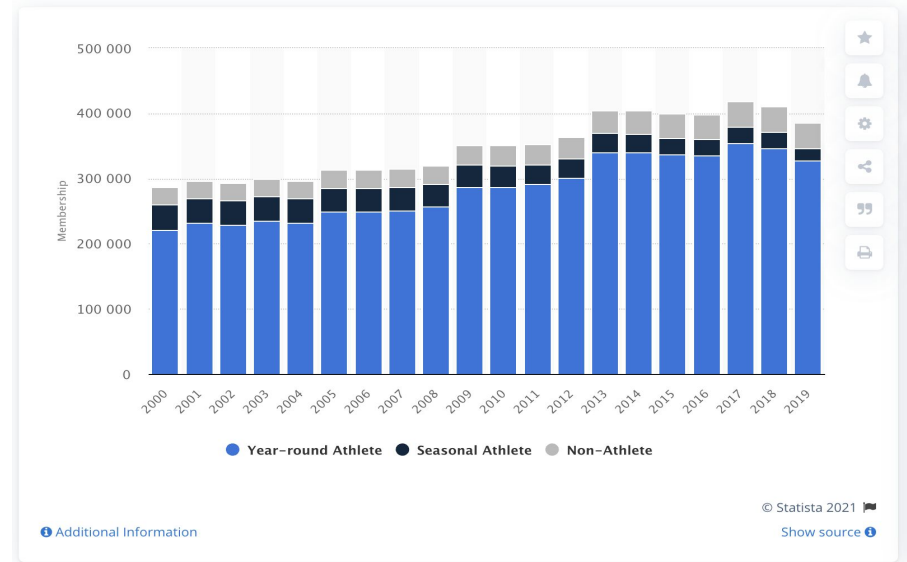
1. System is disconnected from Arduino (95% -> 100%)
 2. Stroke detection model is applied (80%->100%)
 3. Stroke CSV file is created (36% -> ??)
 4. Program terminates (100%)
- Stroke CSV Details
- Time of each stroke in sub-video (90%->??)
 - Average stroke rate given (10%->??)
 - Number strokes taken (10% -> 100%)

Business Case and Costs

Market

- Swimmers and swimmer organizations
- Events and competitions
- USA Swimming memberships increased

USA Swimming number of members from 2000 to 2019



Market in Canada

**RACE PLAN
MODEL
PRICING**

\$29 /Race Plan

**VIDEO RACE
ANALYSIS
PRICING**

\$29 /VRA

**COMPTRAK
MODEL
PRICING**

\$14 /race*



- Estimate that at the least **100 swimmers use RaceTek** for every race
- A swimmer races **roughly 100 races a year**
- Assuming that each race **costs 14\$**

140,000\$ / year

Note: Most clubs do not buy as it is **too expensive**

Costs

- Cost analysis from our Business Pitch Report

	Fixed Costs (\$ CAD)	Variable Costs (\$ CAD)	Selling Price (\$ CAD)	Qeb (per year)
Sell product now	200	1750	2000	1
iPhone Model	140,700	1,900	10,000	18
Subscription Model	179,450	0	100	1,795

Finances

- From business
 - Angel Investors
 - Swim Canada
- Partner with company
 - RaceTek - efficiency
 - FORM Swim

Swimming Canada, "Swimming Canada", Swimming Canada, 2021. [Online]. Available: <https://www.swimming.ca/en/> [Accessed: Nov 19 2021].

RaceTek, "RaceTek," RaceTek, 2018, [Online], Available: <https://racetek.ca/> [Accessed:Nov 19 2021].

Form Swim, "Form,", Swim Goggles with a Smart Display | FORM. 2019, [Online], Available: <https://www.formswim.com/> [Accessed: Nov 19 2021].

Competitors

	Tracking of swimming analytics	System allowed in race environment	Automated tracking
Smart Swim	Yes	Yes	Yes
FORM Swim	Yes	No	Yes
RaceTek	Yes	Yes	No
Omega Timing Systems	Yes	Yes	Not clear

Form Swim, "Form," Swim Goggles with a Smart Display | FORM. 2019, [Online], Available: <https://www.formswim.com/> [Accessed: Nov 19 2021].

RaceTek, "RaceTek," RaceTek, 2018, [Online], Available: <https://racetek.ca/> [Accessed:Nov 19 2021].

OMEGA SA., "Omega, leaders in timekeeping excellence," Omega Timing, n.d., [Online], Available: <https://www.omegatiming.com/> [Accessed: November 11 2021].

Ideal Customers

- Provincial
 - SFU, SwimBC, ...
- National
 - Swimming Canada Nation, USA Swimming, ...
- International
 - Olympics, FINA, ...
- Hard-core individual swimmers
- Competitors
 - Racetek, ...

Swim BC, "Find your greatness", Swim BC, 2021. [Online]. Available: <https://swimbc.ca/> [Accessed Dec 6 2021].

Swimming Canada, "Swimming Canada", Swimming Canada, 2021. [Online]. Available: <https://www.swimming.ca/en/> [Accessed: Nov 19 2021].

USA Swimming, "USA Swimming", USA Swimming Home, 2021. [Online]. Available: <https://www.usaswimming.org/> [Accessed Dec 6 2021].

Ideal Customers by Sales Models

- iPhone model
 - Companies and organizations
 - Clubs
- Subscription model
 - Individual swimmers
 - Clubs (for their individual swimmers)

Risk Analysis and Risk Management

Risk Analysis - Electric Shock

- Analysis
 - Severity: Minimal
 - Probability: Low
- Mitigation Plan:
 - Create housing around Smart Swim components to lower the probability of Shock
- Update
 - No enclosure part of the product yet
 - We have considered “off the shelf” enclosures (by Premier Farnell Limited)

Premier Farnell Limited, “1555WGY Plastic Enclosure, Small, ABS, 59.9 mm, 180 mm, 180 mm, IP66”, Newark.
<https://canada.newark.com/hammond/1555wgy/small-enclosure-abs-grey/dp/97AC9366#anchorTechnicalDOCS> (accessed Nov 18, 2021).

Premier Farnell Limited, “1593HAMARTBU ENCLOSURE, ARDUINO BOARD, ABS, BLU/CLEAR”, Newark.
<https://canada.newark.com/hammond/1593hamartbu/enclosure-arduino-board-abs-blu/dp/58AC5141?st=arduino%20enclosure> (accessed Nov 18, 2021).

Risk Analysis - Blunt Force Trauma

- Analysis
 - Severity: High
 - Probability: Low
- Mitigation Plan:
 - Follow ISO 1222:2010 standards for creating mount point on tilt-pan assembly
 - Give instructions on how to properly install
 - Restricted personnel access during installation and around it
- Update
 - We have designed a connection based on the ISO standards
 - We have a user manual

Risk Analysis Design - Humidity and Temperature

- Analysis
 - Severity: High
 - Probability: Low
- Mitigation Plan:
 - Allowing for the Smart Swim system to be placed in different spaces
 - Create an enclosure for the system
 - Pools are required to have humidity and temperature level well below what the Smart Swim components can handle
- Update
 - The products seem appropriate for the environment.

Acceptable ranges of temperature and relative humidity for comfort
(adapted from *ASHRAE Standard 55-1992*)

Season	Relative Humidity	Temperature
Summer	30%	23°C to 27°C
	50%	23°C to 26°C
	60%	23°C to 26°C
Winter	30%	20°C to 24°C
	50%	20°C to 24°C
	60%	20°C to 23°C

The values apply to people wearing typical summer or winter clothing while doing light, mostly sedentary, work.

Health Canada 93-EHD-166, *Indoor Air Quality in Office Buildings: A Technical Guide*, states that "In most Canadian cities, ideal indoor relative humidity levels are 35% in the winter and 50% in the summer."

For more detailed information on thermal comfort, see *ASHRAE Standard 55-1992* and *ASHRAE Fundamentals Handbook 2001*.

Risk Analysis Design - Humidity and Temperature Cont'd.

- Jetson TX2

Minimum Operating Temperature (°C) ▾	-25
Maximum Operating Temperature (°C) ▾	80

Table 39 Jetson TX2 Reliability Report

Test	Reference Standards / Test Conditions
Temperature Humidity Biased	JESD22-A101 85°C / 85% RH, 168 hours, Power ON
Temperature Cycling	JESD22-A104, IPC9701 -40°C to 105°C, 250 cycles, non-operational
Humidity Steady State	NVIDIA Standard 40°C for 24 hours, then 40°C 90% RH for 96 hours, non-operational

- Teledyne FLIR camera

Operating Humidity	20% to 80% (no condensation)
Operating Temperature	0°C to 85°C (case)

Risk Analysis Design - Exposure to Liquids

- Analysis
 - Severity: High
 - Probability: Low
- Mitigation of Risk
 - Allowing for the Smart Swim system to be placed in different spaces
 - Create an enclosure for the system
- Update
 - No enclosure part of product yet
 - We have considered “off the shelf” enclosures (by Premier Farnell Limited)

Premier Farnell Limited, “1555WGY Plastic Enclosure, Small, ABS, 59.9 mm, 180 mm, 180 mm, IP66”, Newark.
<https://canada.newark.com/hammond/1555wgy/small-enclosure-abs-grey/dp/97AC9366#anchorTechnicalDOCS> (accessed Nov 18, 2021).

Premier Farnell Limited, “1593HAMARTBU ENCLOSURE, ARDUINO BOARD, ABS, BLU/CLEAR”, Newark.
<https://canada.newark.com/hammond/1593hamartbu/enclosure-arduino-board-abs-blu/dp/58AC5141?st=arduino%20enclosure> (accessed Nov 18, 2021).

Engineering Standards

Protocols for Serial Communication

- RS-232
 - Interface between data terminal equipment and data communications equipment using serial binary data exchange
- RS-485
 - Electrical characteristics of drivers and receivers for use in serial communications systems
- Update
 - Utilized in standard Unix software
 - `<termios.h>`

E. I. Association et al., "Eia standard rs-232-c interface between data terminal equipment and data communication equipment employing serial data interchange," International Organization for Standardization, Geneva, Switzerland, 1969.

H. Marais, "Rs-485/rs-422 circuit implementation guide," AN-960 Analog Devices, 2008.

Power Certification

- IEC 60065
 - Audio, video and similar electronic apparatus - Safety requirements
- IEC 60479-1
 - Effects of current on human beings and livestock
- Update
 - Met by using standard power supply and USB for usage in North America

IEC, "Audio, video and similar electronic apparatus – safety requirements," International Electrotechnical Commission, Standard, 2014.

—, "Effects of current on human beings and livestock - part 1: General aspects," International Electrotechnical Commission, Standard, 2018.

Adafruit Industries, "5V 2A (2000mA) switching power supply - UL Listed", Adafruit. <https://www.adafruit.com/product/276> (accessed Nov 18, 2021).

Anker, "Anker | Charge Fast, Live More", Anker. <https://us.anker.com/> (accessed Nov 25, 2021).

Camera Specifications

- European Machine Vision Association (EMVA) 1288-General
- Update
 - We used Spinnaker
 - Follows EMVA standards
 - Implemented its functions to control the camera

Electronics Housing Standards

- IEC 60529
 - Ratings of the resistance of an enclosure against the intrusion of dust or liquids
- IEC 60364-4-42 & IEC 60364-4-41
 - Low-voltage electrical installations
- Update
 - Future work. Our product is not refined enough yet.

IEC, "Degrees of protection provided by enclosures (ip code)," International Electrotechnical Commission, Standard, 2013.

—, "Low-voltage electrical installations - part 4-42: Protection for safety - protection against thermal effects," International Electrotechnical Commission, Standard, 2014.

—, "Low voltage electrical installations - part 4-41: Protection for safety - protection against electric shock," International Electrotechnical Commission, Standard, 2017.

Camera Mount Standards

- ISO 1222:2010
 - Photography — Tripod connections
- Update
 - We use a standard “off the shelf” tripod with a standard connection point to install a camera at a fixed position
 - We use quarter inch threading to secure the tilt-pan assembly

ISO, “specifies the screw connections used between a camera and a tripod or other accessories,” International Organization for Standardization, Standard, 2010.

Amazon.com, "Regetek Camera Tripod Travel Monopod (70" Aluminum Professional Video Camera Mount Leg) Adjustable Stand with Flexible Head for Canon Nikon Dv DSLR Camcorder Gopro Cam& Carry Bag & Cellphone Mount", Amazon.com. <https://www.amazon.ca/Regetek-Professional-Adjustable-Camcorder-Cellphone/dp/B073WCL4NS> (accessed November 25, 2021).

User Interface Design and Software Design

- ISO 9241-61
 - Ergonomics of human-system interaction — part 161: Guidance on visual user-interface elements
- ISOcpp (Standard C++)
- Update
 - Work in progress, our GUI is still being refined
 - Programmed based on the object oriented style

Pool Environment Standards

- CSA Z204-94
 - Guideline for managing indoor air quality in office buildings
- Update
 - This standard is used to determine our products are appropriate, as well as give instructions on what environment the product can be used in.
 - This was discussed in the Risk Analysis

Self Reflection

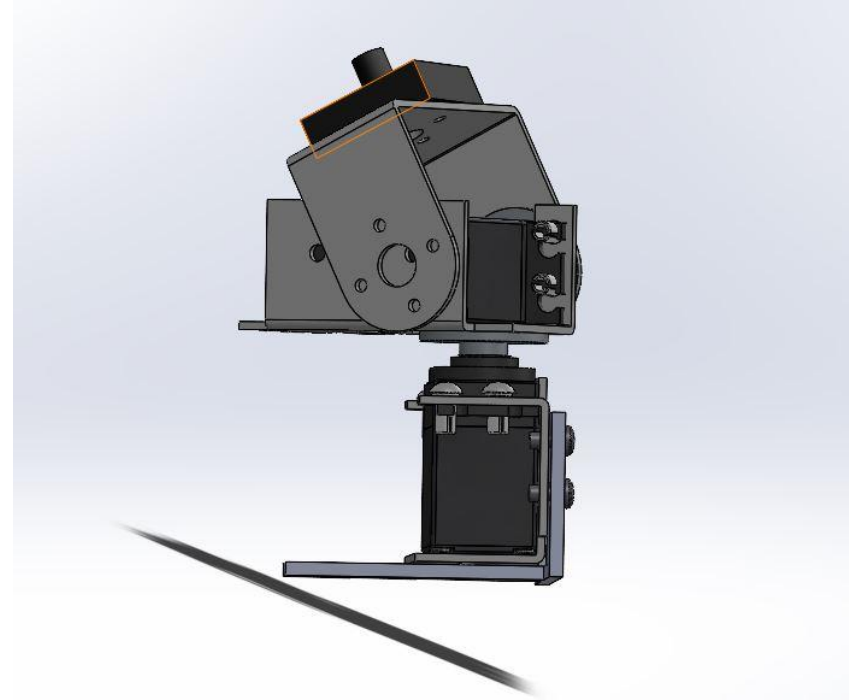
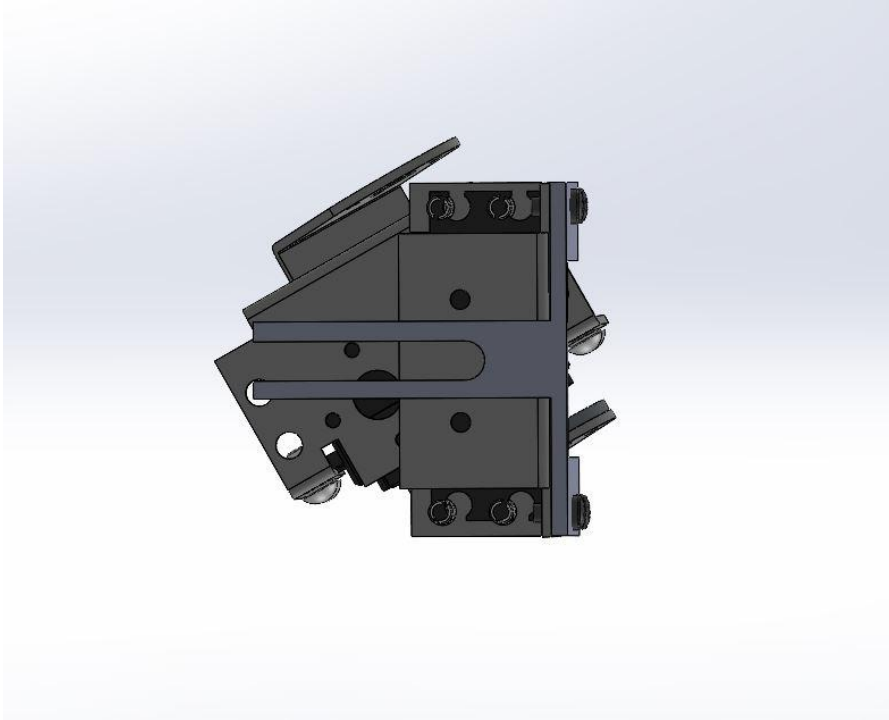
Feedback

- **Feedback: Focus of presentations is not on the right things**
 - Corrections: We focus on showing our work and highlighting the most important aspects based on the main topic
- **Feedback: Document design changes**
 - An example is the change from Raspberry Pi to Arduino
 - Corrections: We ensured to make future changes based on testing (justifies reason for changes). Example: YOLOv3 to YOLOv3-tiny after testing of speed.
- **Feedback: Consider if moisture is a significant risk**
 - Corrections: We found documentation to ensure this is not a risk (included in the risk analysis)
- **Feedback: Make the product more sleek**
 - Corrections: We actually did not have time for this, but we tried our best to make it as sleek as possible

Feedback

- **Feedback: Design the outer casing**
 - Corrections: We worked on finding “off the shelf” products and designing custom components, however it is incomplete. We do have models made however.
- **Feedback: Improve the design to be a slot to be more accessible**
 - Corrections: We updated the models
- **Feedback: Due to tests showing slow results with GPU, have a backup plan**
 - Corrections: We use YOLOv3-tiny instead of YOLOv3
 - Ideal: Stronger GPU, more time on debugging (custom kernel software)
- **Feedback: Demonstrate the work done better**
 - Corrections: Improving our demonstrations in this presentation

Updated Model



Self Reflection - General

- Clickup - use more
 - Sprints
 - Tickets to see (lack of) progress in the beginning
- Mini group meetings > entire group meetings
- Panorama

What was learnt

- What was learnt
 - Tim got to experience being a group lead
 - Managing groups
 - Managing sprints
 - The group got to gain experience with
 - Image processing in C++
 - Detection and tracking algorithms
 - Application of hardware experience for tilt-pan assembly
 - Integration of software and hardware for real-time system

Conclusion

- Product tracks a swimmer at an SFU pool
- Product can produce stroke count results
 - Though this is not as accurate as its optimal level at the moment
- In the future, the product should...
 - Be able to determine the swimmers position
 - Calculate swimmer speed
 - Train with other swimming pools

Acknowledgements

- ENSC 405W staff: Prof. Craig Scratchley, Tim Yu, Shrishti Yadav
- ENSC 440 staff: Prof. Andrew Rawicz, Eric Brace, Chris Hynes
- Prof. Ivan Bajic (provided resources on Deep Learning Systems)
- Tim Woinoski for his previous research and work on this topic
- Taha B. Esmael for his excellent design of the Smart Swim Analytics logo.

Questions?

Logo References

The below are for logos that may appear in images of the product. *We also feature the logo of Regetek (an example of such a tripod can be found at [8]).*

[1] NVIDIA, "Artificial Intelligence Computing Leadership from NVIDIA", NVIDIA. <https://www.nvidia.com/en-us/> (accessed Nov 25, 2021).

[2] Arduino, "What is ARDUINO?", Arduino - Home. <https://www.arduino.cc/> (accessed Nov 25, 2021).

[3] Raspberry Pi Foundation, "Teach, Learn, and Make with Raspberry Pi", Raspberry Pi Foundation. <https://www.raspberrypi.org/> (accessed Nov 25, 2021).

[4] Adafruit Industries, "Adafruit Industries, Unique & fun DIY electronics and kits", Adafruit. <https://www.adafruit.com/> (accessed Nov 25, 2021).

[5] Dell, "Computers, Monitors & Technology Solutions | Dell Canada", Dell. <https://www.dell.com/en-ca> (accessed Nov 25, 2021).

[6] Anker, "Anker | Charge Fast, Live More", Anker. <https://us.anker.com/> (accessed Nov 25, 2021).

[7] Amazon.com, "Amazon.ca: Low Prices – Fast Shipping – Millions of Items", Amazon.com. <https://www.amazon.ca/> (accessed Nov 25, 2021).

[8] Amazon.com, "Regetek Camera Tripod Travel Monopod (70" Aluminum Professional Video Camera Mount Leg) Adjustable Stand with Flexible Head for Canon Nikon Dv DSLR Camcorder Gopro Cam & Carry Bag & Cellphone Mount", Amazon.com. <https://www.amazon.ca/Regetek-Professional-Adjustable-Camcorder-Cellphone/dp/B073WCL4NS> (accessed November 25, 2021).