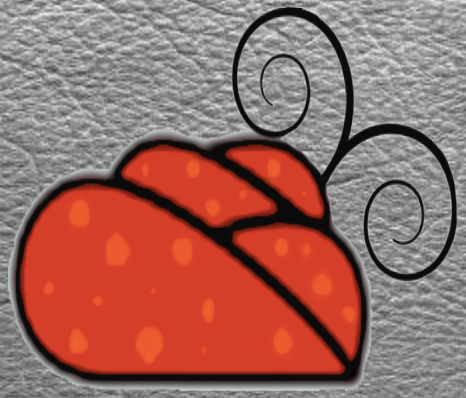

Snail TECH

The Vital Band

A Wristband to Measure Heart Rate and Skin Temperature

Outline

- **Introduction**
- **Snail Tech Team**
- **Project Management**
- **Project Design**
- **Individual Contributions**
- **Testing & Evaluation**
- **Demo**
- **Questions**

Snail TECH

Introduction

- Where did the idea come from?

- Exercise Intensity
  - Heart rate
  - Skin temperature

The Snail Tech Team

Ardavan Kalhori : *Chief Executive Officer*

- Software Design
- Test and Implementation
- Project Management

Sepehr Sheikholeslami : *Chief Technical Officer*

- Hardware Design
- Test and Implementation

SnailTECH

The Snail Tech Team

Amir Kassaian : *Chief Financial Officer*

- Software Implementation
- Research
- Documentation and Finance

Ghazal Saray-sorour: *Chief Operating Officer*

- Hardware Implementation
- Team Coordination
- Documentation and Research

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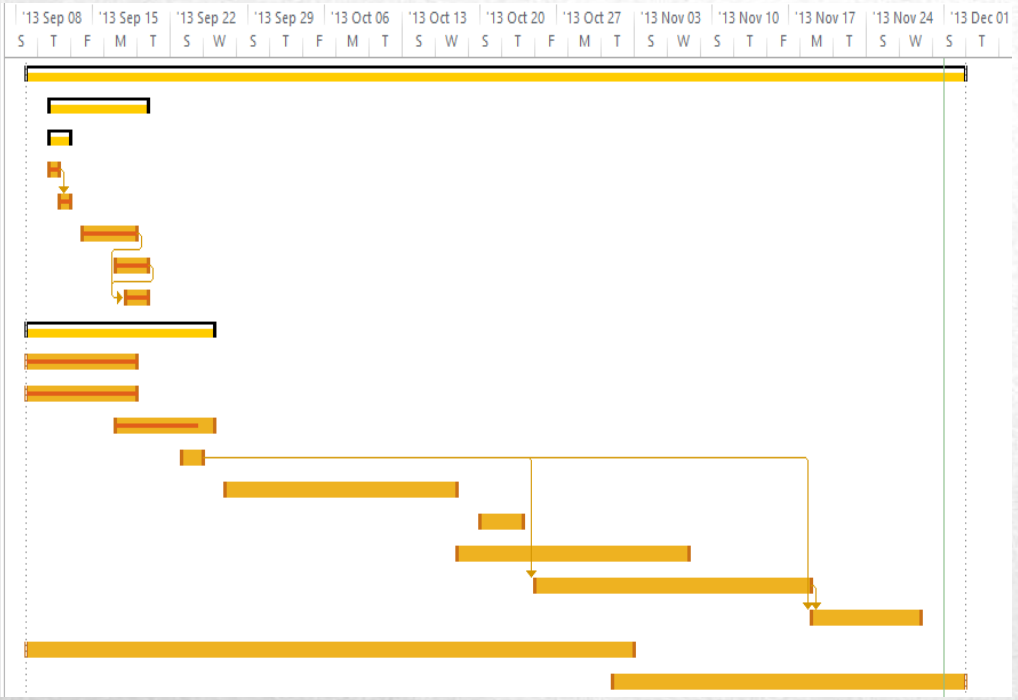
Project Management

Project Management

- Agile
- Risk Management
  - Resources
    - Illness
    - Emergencies
    - Course Loads
  - Parts
    - Malfunctioning
    - Availability

Old Schedule

	Task Name	Duration	Start	Finish
1	**Vital Band**	**62 days**	**Mon 13-09-09**	**Mon 13-12-02**
2	**Funds**	**8 days**	**Wed 13-09-11**	**Thu 13-09-19**
3	**Company Info**	**2 days**	**Wed 13-09-11**	**Thu 13-09-12**
4	Name	1 day	Wed 13-09-11	Wed 13-09-11
5	Design Logo	1 day	Thu 13-09-12	Thu 13-09-12
6	Cost Estimation	4 days	Sat 13-09-14	Wed 13-09-18
7	Solid Work Model	3 days	Tue 13-09-17	Thu 13-09-19
8	Power Point Presentation	2 days	Wed 13-09-18	Thu 13-09-19
9	**Proposal**	**14 days**	**Mon 13-09-09**	**Wed 13-09-25**
10	Research	9 days	Mon 13-09-09	Wed 13-09-18
11	Parts List	9 days	Mon 13-09-09	Wed 13-09-18
12	Proposal Document	7 days	Tue 13-09-17	Wed 13-09-25
13	Order Parts	2 days	Mon 13-09-23	Tue 13-09-24
14	Functional Specification	15 days	Fri 13-09-27	Thu 13-10-17
15	Oral Progress Report	4 days	Sun 13-10-20	Wed 13-10-23
16	Design Specification	15 days	Fri 13-10-18	Thu 13-11-07
17	Integration	17 days	Fri 13-10-25	Mon 13-11-18
18	Debugging & Prototype Modification	8 days	Tue 13-11-19	Thu 13-11-28
19	Meeting Minutes	42 days	Mon 13-09-09	Sat 13-11-02
20	Written Process Report	22 days	Fri 13-11-01	Mon 13-12-02



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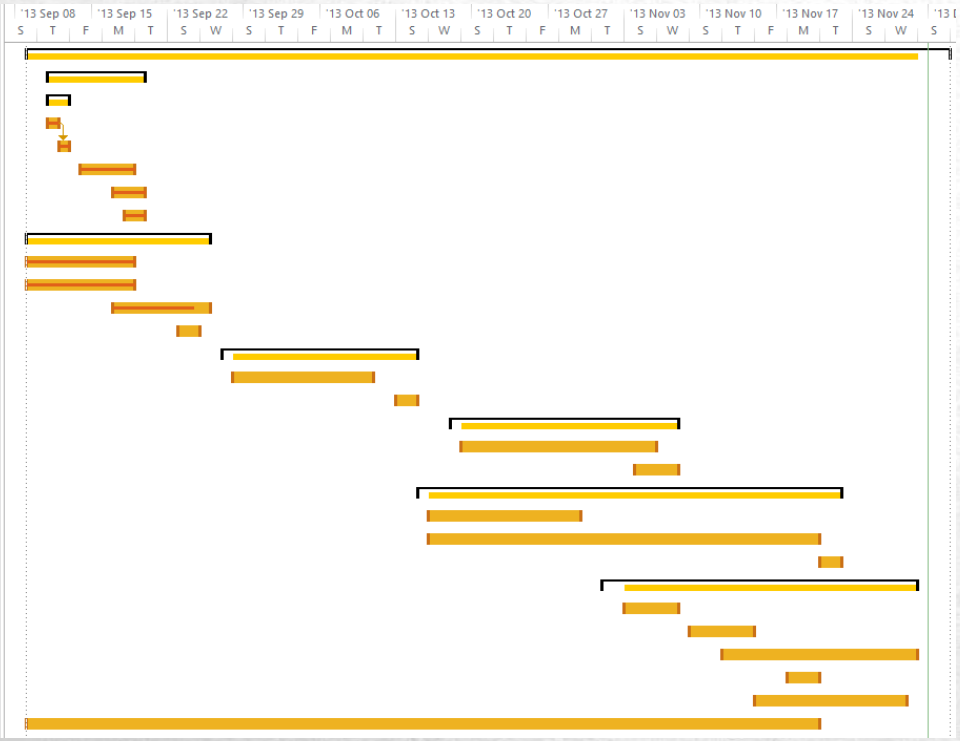
New Schedule

	Task Name	Duration	Start	Finish
1	**Vital Band**	**62 days**	**Mon 13-09-09**	**Mon 13-12-02**
2	**Funds**	**8 days**	**Wed 13-09-11**	**Thu 13-09-19**
3	**Company Info**	**2 days**	**Wed 13-09-11**	**Thu 13-09-12**
4	Name	1 day	Wed 13-09-11	Wed 13-09-11
5	Design Logo	1 day	Thu 13-09-12	Thu 13-09-12
6	Cost Estimation	4 days	Sat 13-09-14	Wed 13-09-18
7	Sample Solid Work Model	3 days	Tue 13-09-17	Thu 13-09-19
8	Power Point Presentation	2 days	Wed 13-09-18	Thu 13-09-19
9	**Proposal**	**14 days**	**Mon 13-09-09**	**Wed 13-09-25**
10	Research	9 days	Mon 13-09-09	Wed 13-09-18
11	Parts List	9 days	Mon 13-09-09	Wed 13-09-18
12	Proposal Document	7 days	Tue 13-09-17	Wed 13-09-25
13	Order Parts	2 days	Mon 13-09-23	Tue 13-09-24
14	**Functional Specification**	**12 days**	**Fri 13-09-27**	**Mon 13-10-14**
15	Research	10 days	Sat 13-09-28	Thu 13-10-10
16	Writing	2 days	Sun 13-10-13	Mon 13-10-14
17	**Design Specification**	**15 days**	**Fri 13-10-18**	**Thu 13-11-07**
18	Research	13 days	Sat 13-10-19	Tue 13-11-05
19	Writing	4 days	Mon 13-11-04	Thu 13-11-07
20	**Integration**	**29 days**	**Tue 13-10-15**	**Fri 13-11-22**
21	Assembling	10 days	Wed 13-10-16	Tue 13-10-29
22	Solid Work Model	26 days	Wed 13-10-16	Wed 13-11-20
23	3D Printing	2 days	Thu 13-11-21	Fri 13-11-22
24	**Debugging & Prototype Modification**	**21 days**	**Fri 13-11-01**	**Fri 13-11-29**
25	LCD Optimization	5 days	Sun 13-11-03	Thu 13-11-07
26	Push Buttons - Debouncing	5 days	Sat 13-11-09	Thu 13-11-14
27	Fix Pulse Sensor Accuracy	14 days	Tue 13-11-12	Fri 13-11-29
28	Fix Temperature Accuracy	3 days	Mon 13-11-18	Wed 13-11-20
29	Hardware Integration & Modification	10 days	Fri 13-11-15	Thu 13-11-28
30	Meeting Minutes	54 days	Mon 13-09-09	Wed 13-11-20



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Prototype Budget

Equipment List	Unit Cost
LCD: Sharp memory display breakout – LS013B4DN04	$40
3D Printing	$150
Skin Temp Sensor – GE M1000	$1
Pulse Sensor	$25
Arduino Pro Mini 3V3	$10
Lithium Ion Polymer Battery 110 mAh	$8
USB/DC Lithium Polymer Battery Charger	$30
Electronics (Push Button, Switch, Schmitt trigger, etc)	$10
Equipment	$40
Shipping	$90
Total Prototype Cost	**$404**
Extra Costs: - Bluetooth Low Energy Module ($65) - IR Temp Sensor ($55)	$120
Total	**$524**

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Marketing

- **Business Approach**
  - Athletes
  - Elderly
  - Clinical Trials

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Competitors

Model/Brand	Price
Polar RC3 GPS Heart Rate	$ 359.99
Polar RCX3M	$ 199.00

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Project Design

Project Design

Heart Rate			
Electrocardiogram (Chest Strap)		**Optical (Finger Sensor)**	
Pros	*Cons*	*Pros*	*Cons*
Continuous Monitoring	More Expensive	Comfortable	Pause before measurement
More Accurate	Uncomfortable	Inexpensive	Less Accurate

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Project Design

Temperature			
Infrared (IR Temp Sensor)		**Surface (Thermistor)**	
Pros	*Cons*	*Pros*	*Cons*
Fast Response	More Expensive	Less Expensive	Slow response
	Large Less Accurate	Small More Accurate	

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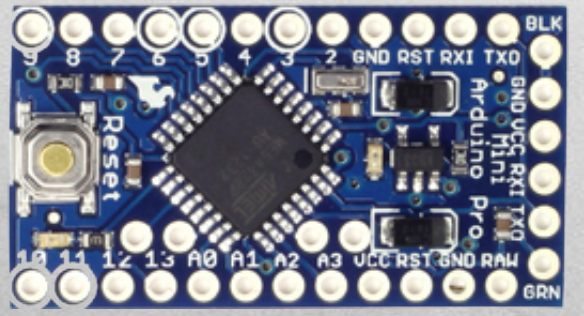
High-Level System Design

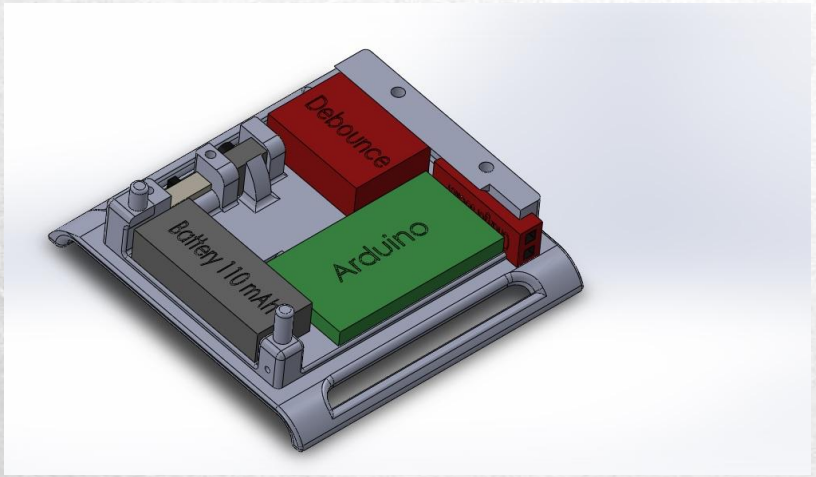
- Sub-systems:
  - Processing
  - Display
  - Pulse Sensing
  - Temperature Sensing
  - Power (Battery and Charger)

Processing

Arduino Pro mini 3V3:

- Open Hardware
- Small
- Inexpensive





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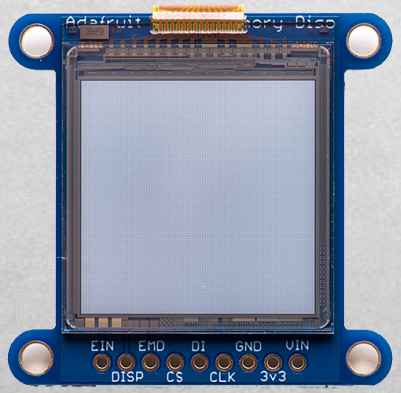
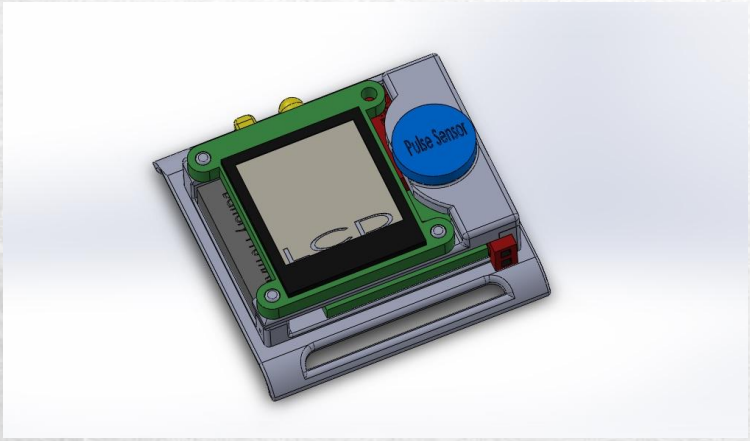
Display

- Sharp Memory Display
- Serial peripheral Interface(SPI) to communicate
- 96x96 pixels LCD – 1.2”
- Low Energy





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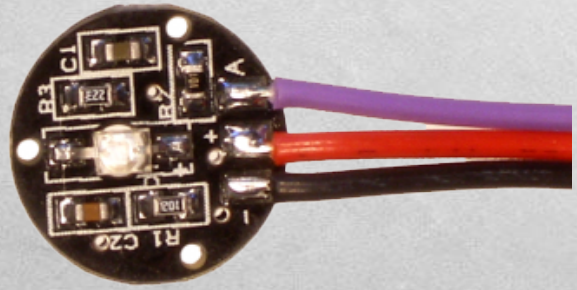
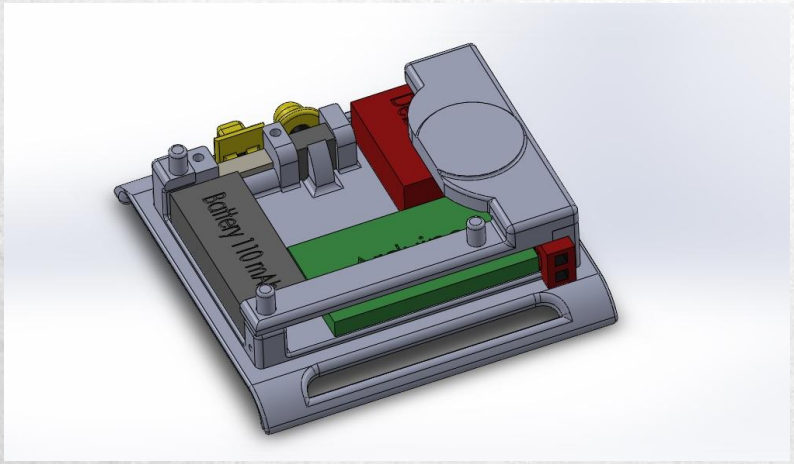
Pulse Sensing

- LED
- Light Photo Sensor
- Filter





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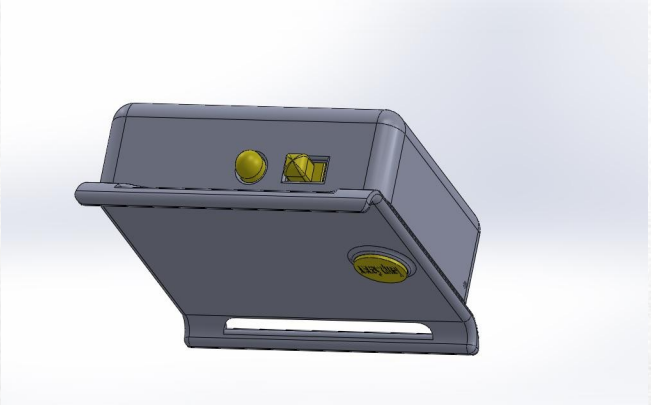
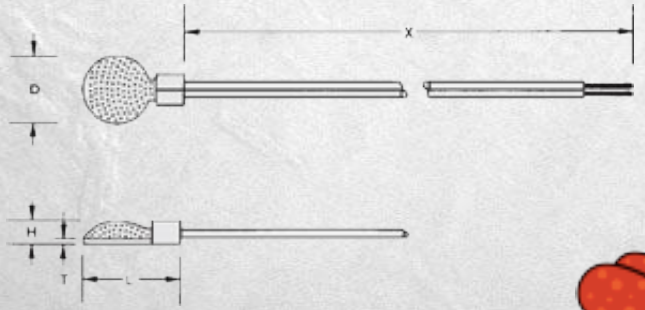
Temperature Sensing

- GE surface temperature sensor
- 5k Ohm (at 25 °C) thermistor
- Accuracy of 0.2 °C in the 0-35 °C range
- Wire:
  - Insulation: Medical grade PVC
  - Gauge: 30 AWG





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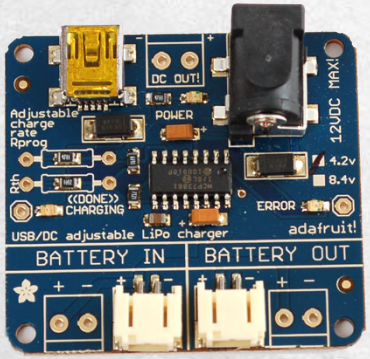
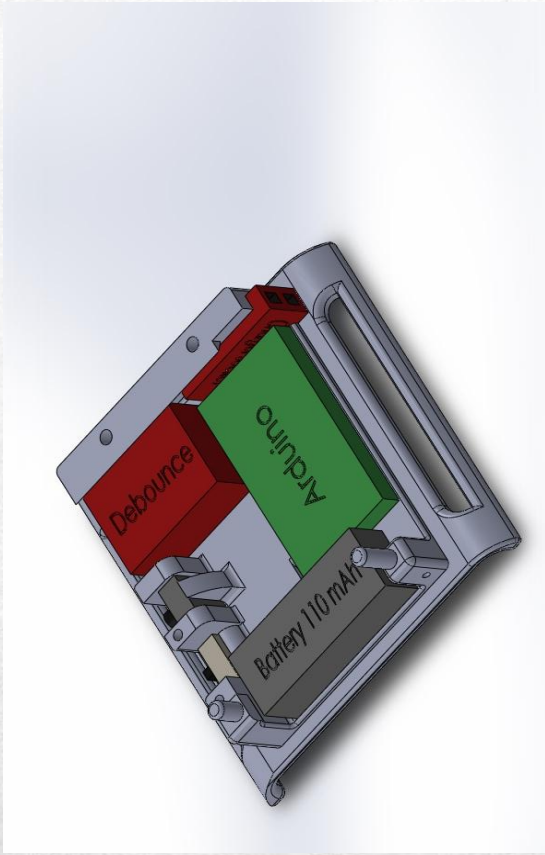
Power

3.7 V Lithium ion battery

- 110 mAh
- 12 hours ON-time
- Small
- Rechargeable





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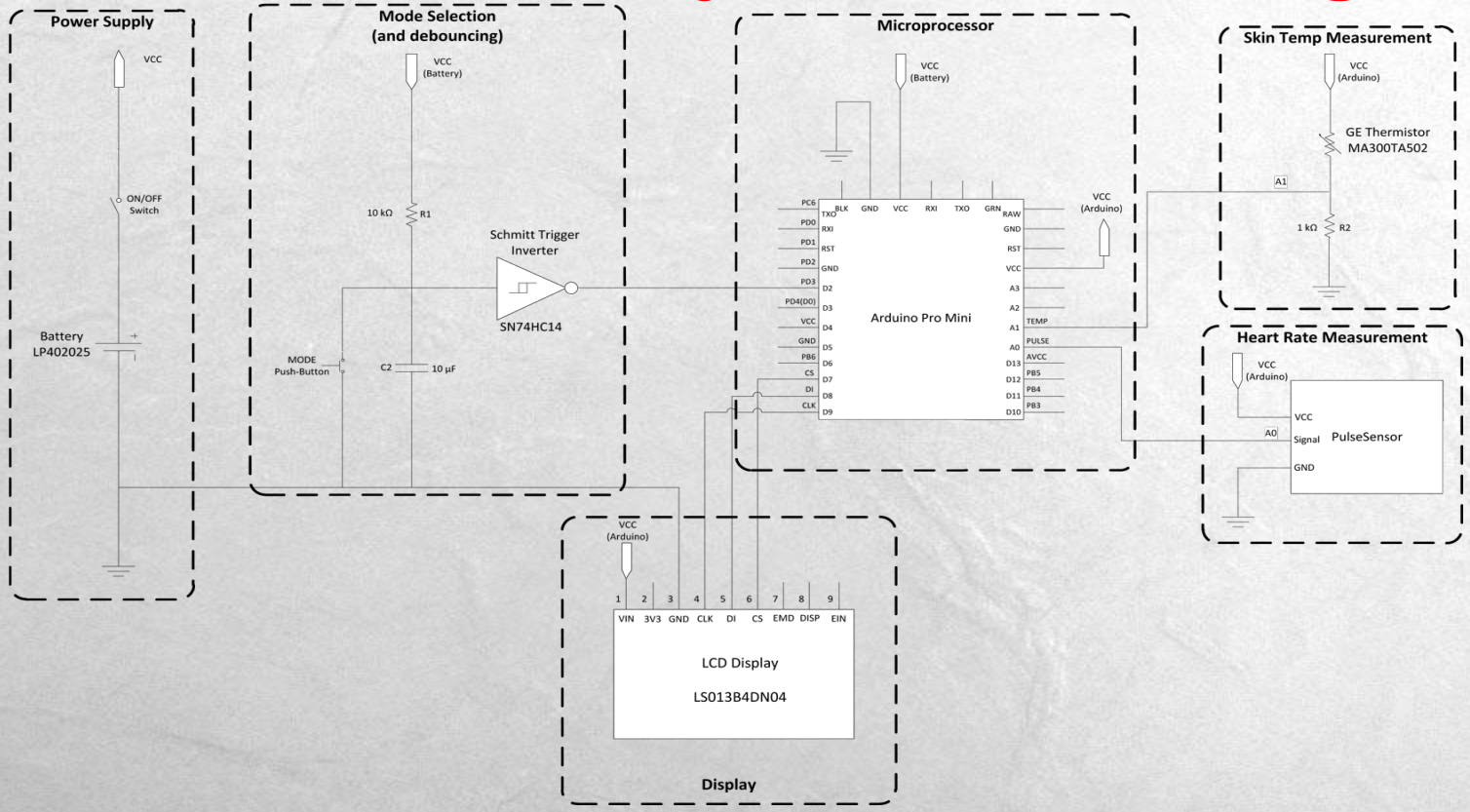
Low-Level System Diagram



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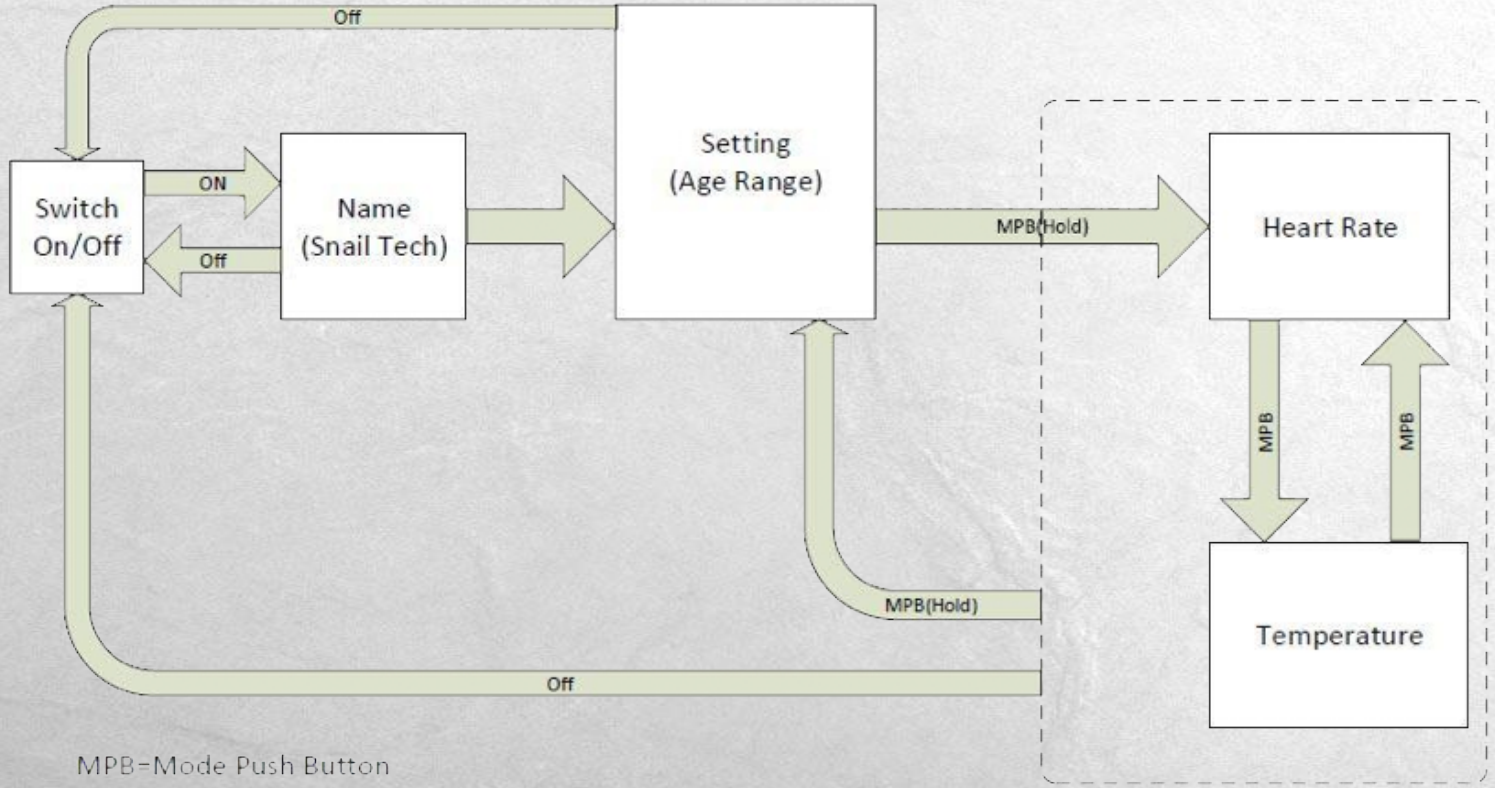
Software Functional Diagram



MPB=Mode Push Button

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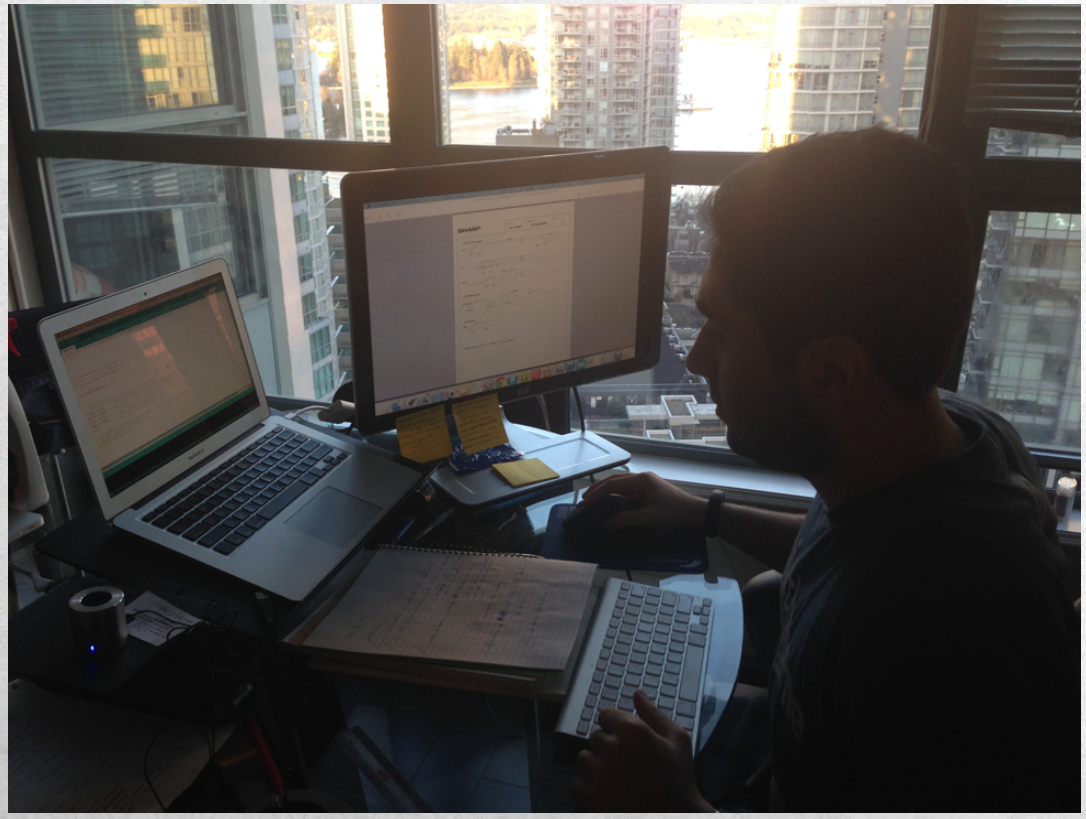
Individual Contributions

Ardavan



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Mode Selection

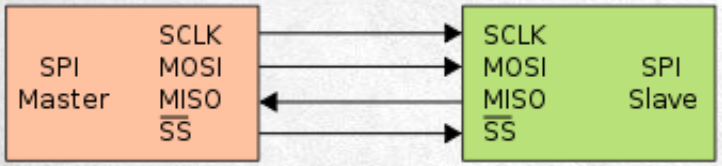
- Initial design
  - 3 push buttons
    - Up
    - Down
    - Select
- Pros
  - User Friendly
- Cons
  - Required more components and space

Mode Selection

- Final design
  - 1 push button for Select, Up, Down
- Pros
  - Less components
- Cons
  - More Complicated Code
    - Interrupts
    - De-bouncing
    - Hold Vs. Press

LCD

- SPI Communication Implementation
  - Self Implementation
  - Open Source Library



- Improved the Library
  - Update few lines instead of the whole screen
  - Found the lowest screen refresh rate to reduce calculations

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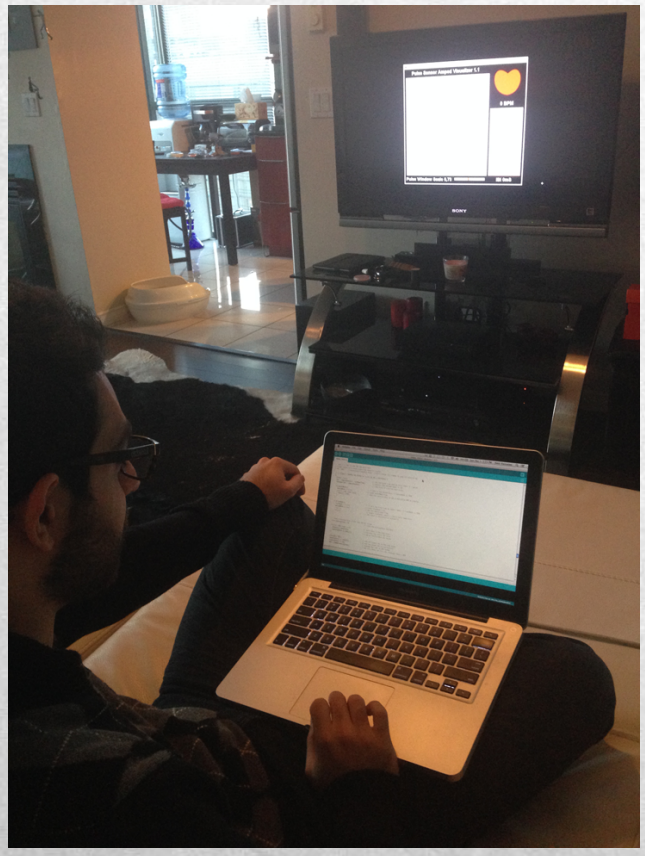
Pulse Sensor

- Sample Sensor Value
  - Main Loop
    - Waste CPU cycles
  - Clock Interrupt
    - Circular Buffer
      - Buffer Overflow
      - Inaccurate calculation
    - Capture and calculate BPM
- Implemented an algorithm for finding the stable BPM

Lessons

- Courses that helped:
  - ENSC 350, 215, 351
  - CMPT 128, 225, 275
- CO-OP:
  - Software Engineer at Alcatel-Lucent
  - Software Engineer at Electronic Arts

Amir



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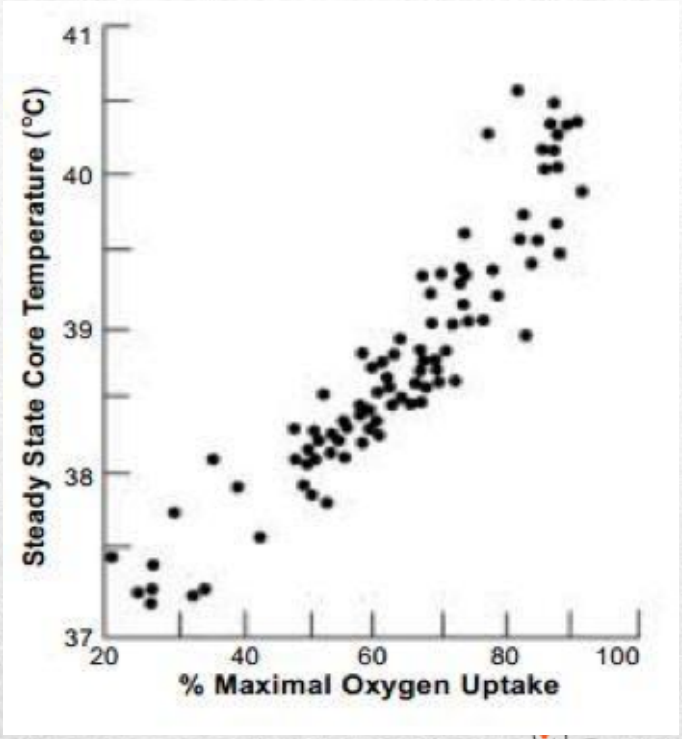
Tasks

- Research
  - Skin temperature vs. exercise intensity
  - Heart-rate vs. exercise intensity
  - Part Selection

- Documentation (editing)



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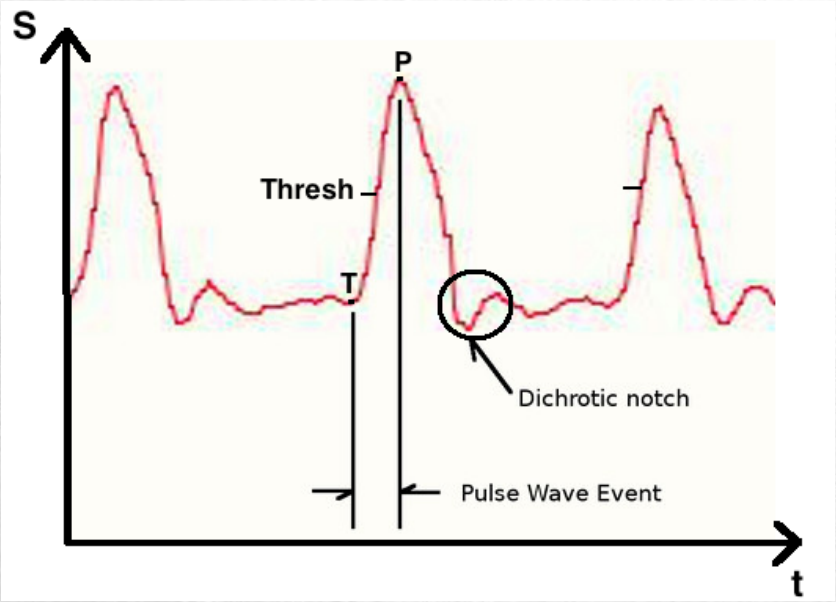
Tasks

- Pulse Sensor Signal Processing:
  - BPM measurement
  - Noise Cancellation
    - Hardware
    - Software
- Testing and

  FMEA chart generation



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Lessons

- Productivity and Workload

- Related SFU courses
  - ENSC387
  - ENSC351

Sepehr

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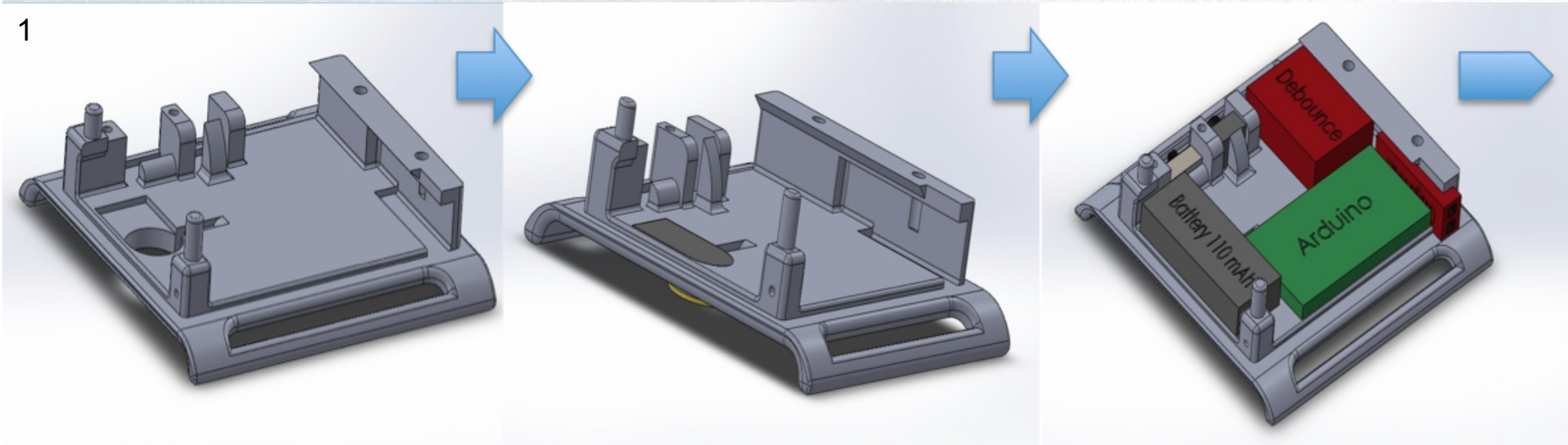
Tasks

- Hardware Design using SolidWorks

1



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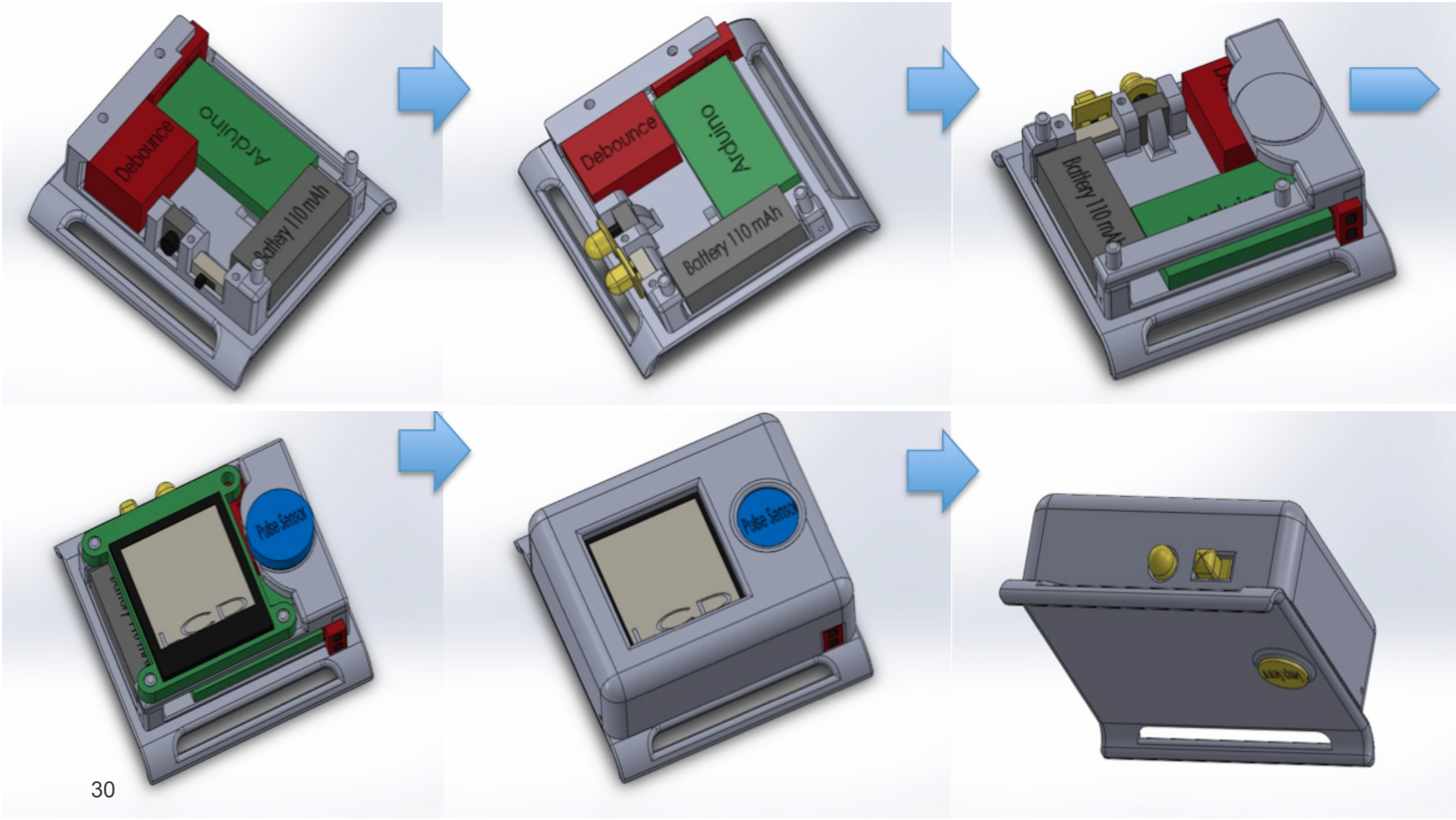
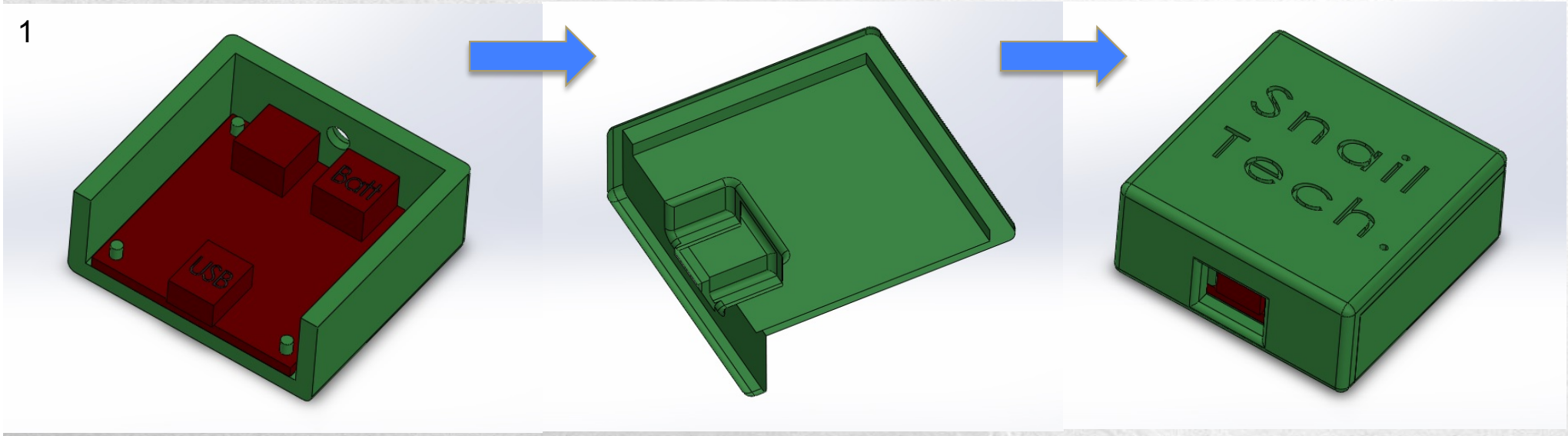

Debounce
Arduino
Battery 110 mAh
Debounce
Arduino
Battery 110 mAh
Battery 110 mAh
Pulse Sensor
LCD
Pulse Sensor
LCD

Charger

1



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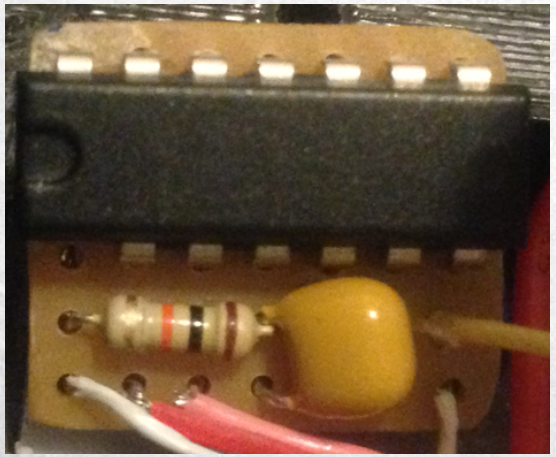
- Hardware Implementation and modification
  - 3D Print modifications (sanding, drilling, …)
  - Soldering
  - Medical grade PVC cables
  - Epoxy Resin (appearance)



- Debouncing Hardware
  - Inverting Schmitt Trigger
  - R= 10k Ohms, C=10 uF
    - So: 0.1 Seconds decay time

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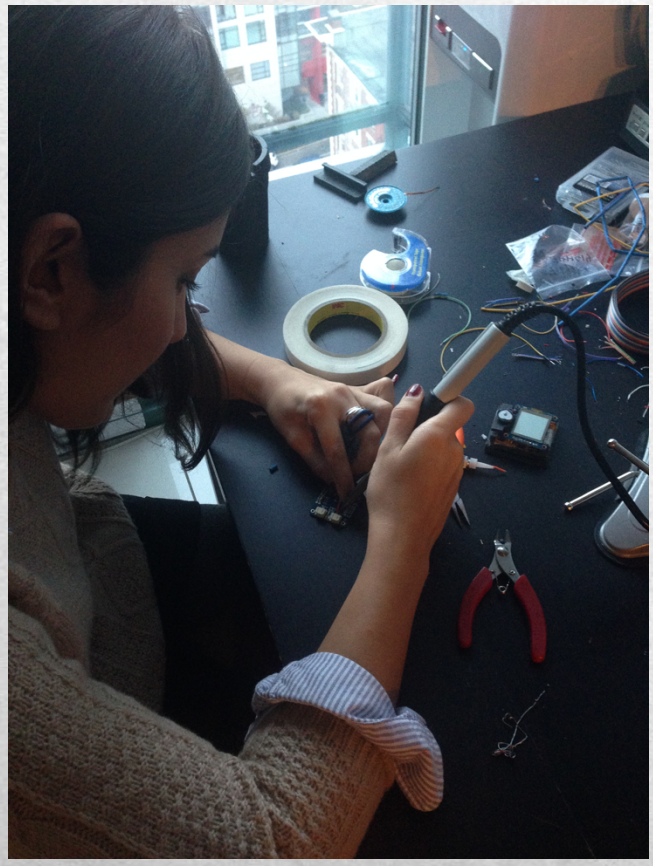
- Productivity and Workload
- Related SFU Studies:
  - ENSC 204, 220, 230, 320, and Co-op

Ghazal



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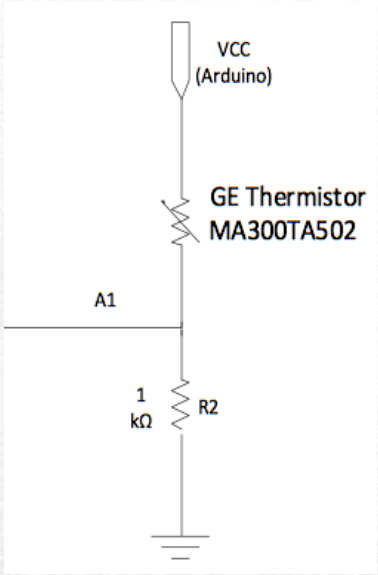
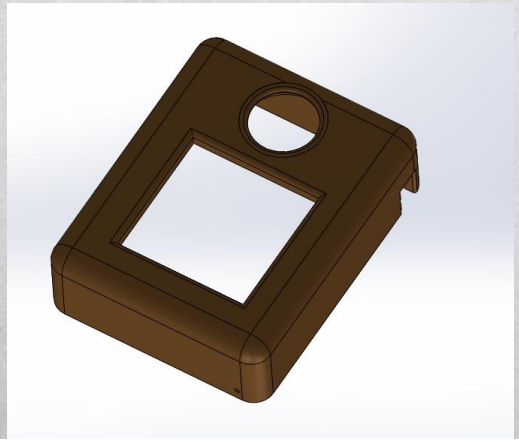
Tasks

- Thermistor
  Temperature () = 0.2446*S -152.22
- Research and Documentation
- Meeting Organization
- Hardware Implementation and Enclosure Design





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Lessons

- Productivity and workload
- Related SFU courses and experiences
  - ENSC230
  - BlackBerry (Beta Software Issue Management)

Testing & Evaluation

FMEA Chart

Component	Function	Failure Mode(s)	Cause	Effect(s)	S	P	D	RPN	Recommended action(s)	S	P	D	RPN
Push Button (+Cap)	Push button selects the mode of the device. It is also used to select age group.	Press/Hold event not registered via the software	Push button bouncing	Failure to switch between modules	8	4	5	160	Implement De-bounce circuit	8	0	5	0
				Failure to save the age group when button is held	8	4	6	192	Implement De-bounce circuit	8	0	6	0
		Fracture	Stress exceeds material strength	Failure to switch between modules	8	1	7	56	No action required				
Sliding Switch (+Cap)	Sliding switch turns the system on and off.	Fracture	Stress exceeds material strength	Unable to turn the system on/off	9	2	6	108	No action required				
ABS Enclosure	Encloses all the materials inside a compact design wearable on the wrist	Bend/Fracture	Stress exceeds material strength due to improper Handling	Device is fatally destroyed and all functionality is distorted	10	2	4	80	No action required				
		Incorrect Pulse Reading	Ambient Light	Erratic BPM values	7	5	5	175	Redesign the enclosure so that the PulseSensor has 2mm distance to the surface	7	2	5	70

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Evaluation

Design Parameter	Desired Value	Actual Value
BPM Accuracy	+/- 5%	+/- 4%
Temperature Accuracy	+/- 0.2 °C	+/- 0.2 °C
Temperature Delay(*)	5 – 60 s	5 – 120 s
BPM Delay	10 s	15 – 20 s
BPM Alarm Accuracy	+/- 5	+/- 5
Weight	100 g	46 g

* The time depends on how long the wristband has been worn

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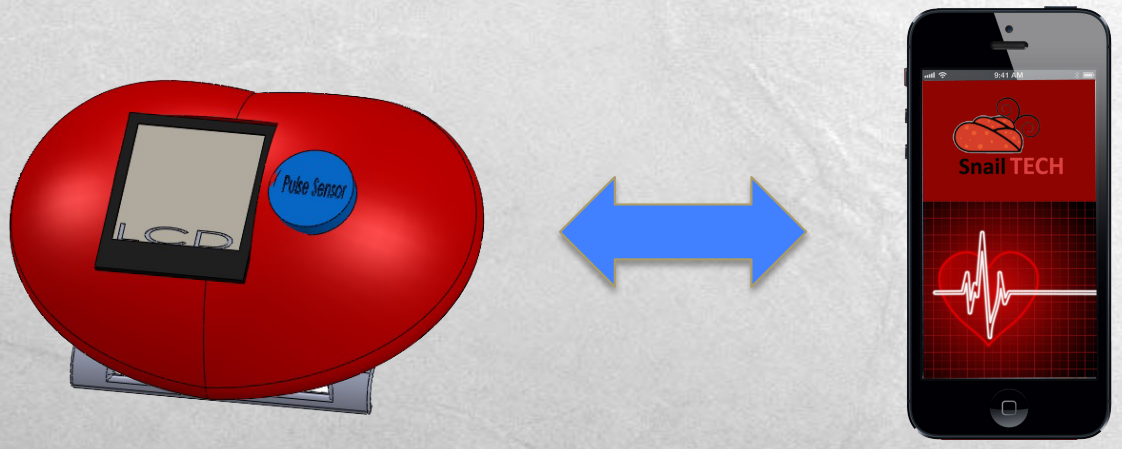
Future Development

- Incorporation of BLE and smartphone application
  - Transfer of data (pulse and temp) continuously during exercise
  - Store data on a server
  - Temperature and pulse analysis



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Final Product Cost

Equipment List	Unit Cost
Monochrome 0.96” OLED graphic display	$15
Enclosure and PCB fabrication (mass-produced)	$20
Skin Temp Sensor – GE M1000	$1
Pulse sensor	$10
ATmega328	$2
Lithium Ion Polymer Battery 110 mAh	$4
USB/DC Lithium Polymer Battery Charger	$6
Electronics (Push Button, Switch, Schmitt trigger, etc)	$3
Bluetooth Low Energy Module	$25
Total	**$86**

SnailTECH

Acknowledgment

- Lakshman One
- Reza Mohammadnia

Lessons Learnt

- Test assumptions
- More communication with team members
- Not to trust the supplier and always prepare for risks

Demo

Questions?