Anup Sathya Sai Kumar
Master's Thesis Defense

Dr. Huaishu Peng

Dr. Niklas Elmqvist

Prof. Alex Leitch

Introductions

Anup Sathya Sai Kumar

Master's Thesis Defense

Enabling On-Body Computing Using a Track-Based Wearable

Anup Sathya Sai Kumar

Master's Thesis Defense

Can we put a railway system on the body?

Today

Outline

Why?

- Motivation
- Related Work
- Our Approach

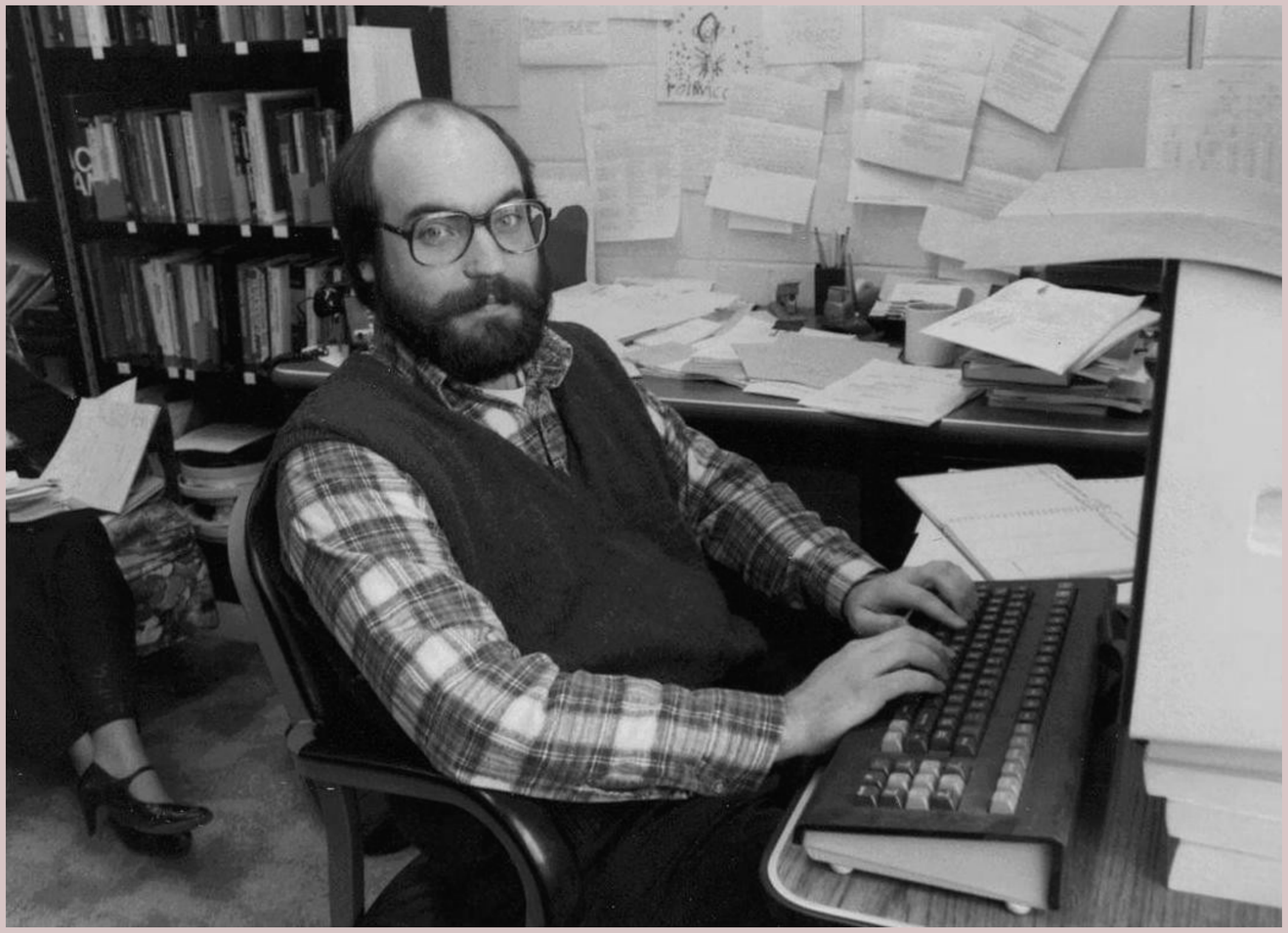
How?

- Process
- System Design

What?

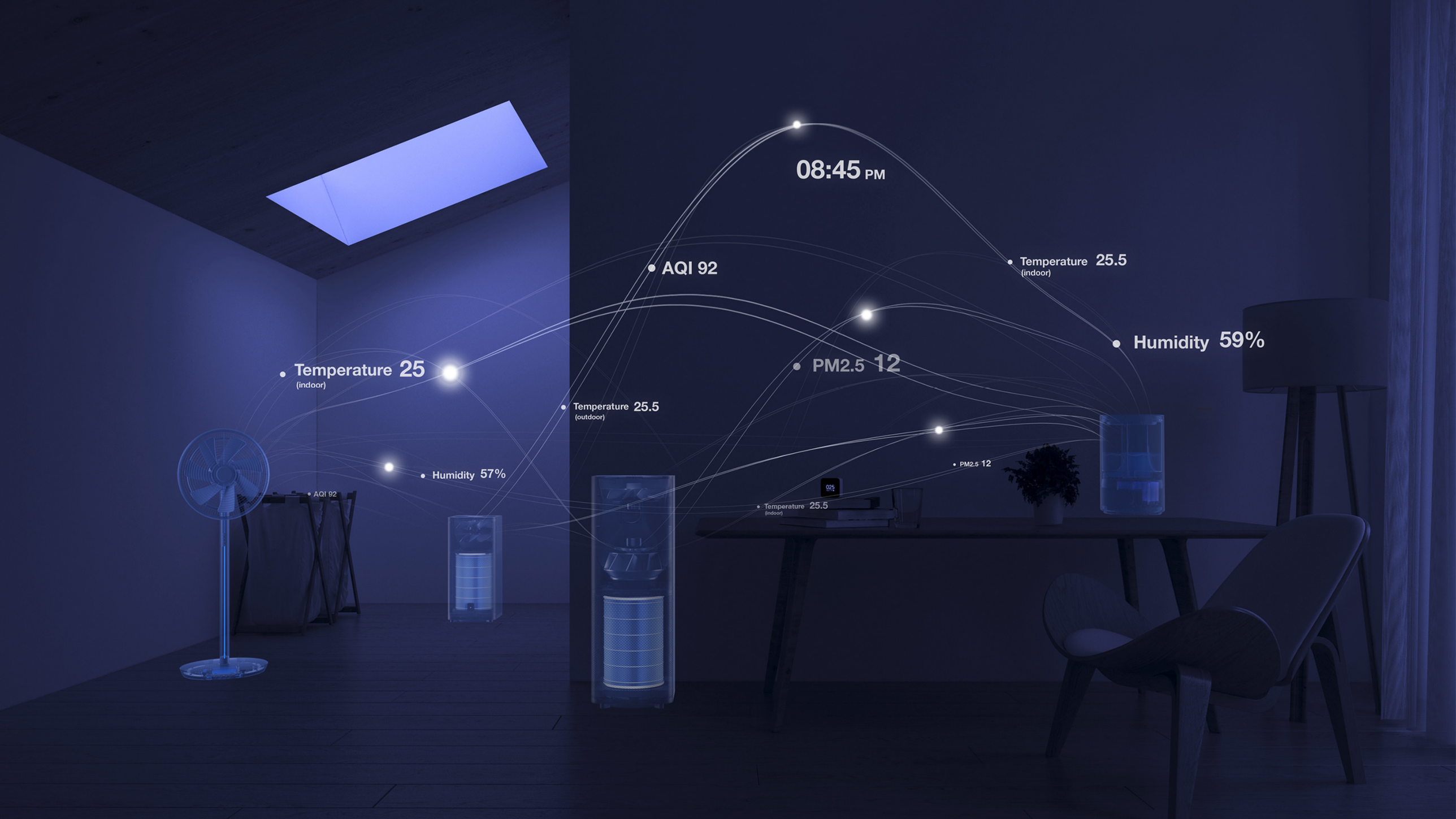
- Performance Evaluation
- Applications

Ubiquitous Computing



“Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives.”

Mark Weiser

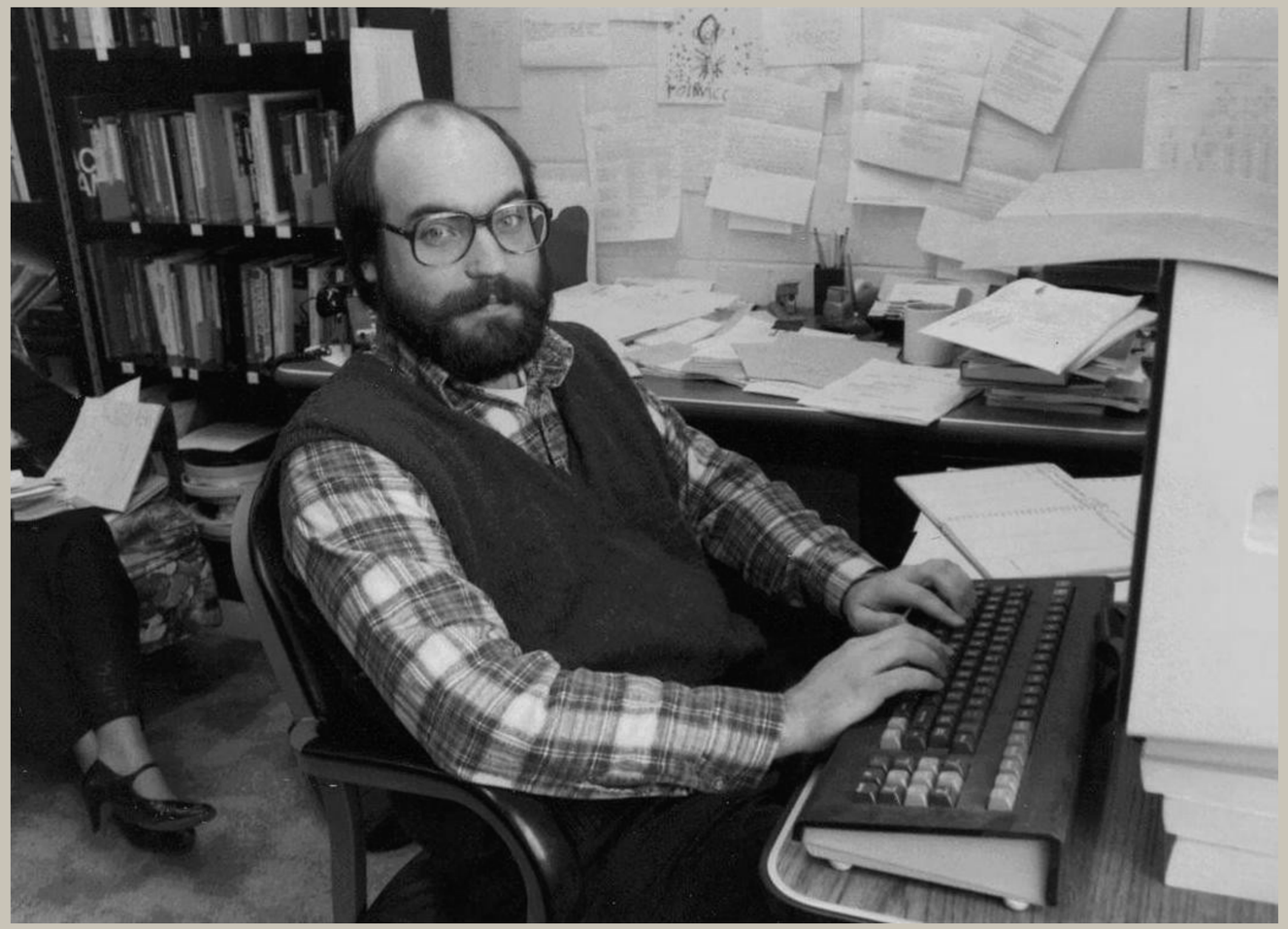

08:45 PM
AQI 92
Temperature 25.5
(indoor)
Humidity 59%
PM2.5 12
Temperature 25
(indoor)
Temperature 25.5
(outdoor)
Humidity 57%
AQI 92
PM2.5 12
Temperature 25.5
(indoor)

19:12
iPhone
Buck Shots
A$AP Rocky–TESTIN

Ubiquitous Computing

“The more you can do by intuition the smarter you are; the computer should extend your *unconscious*.”

Mark Weiser



Where do we wear wearables?

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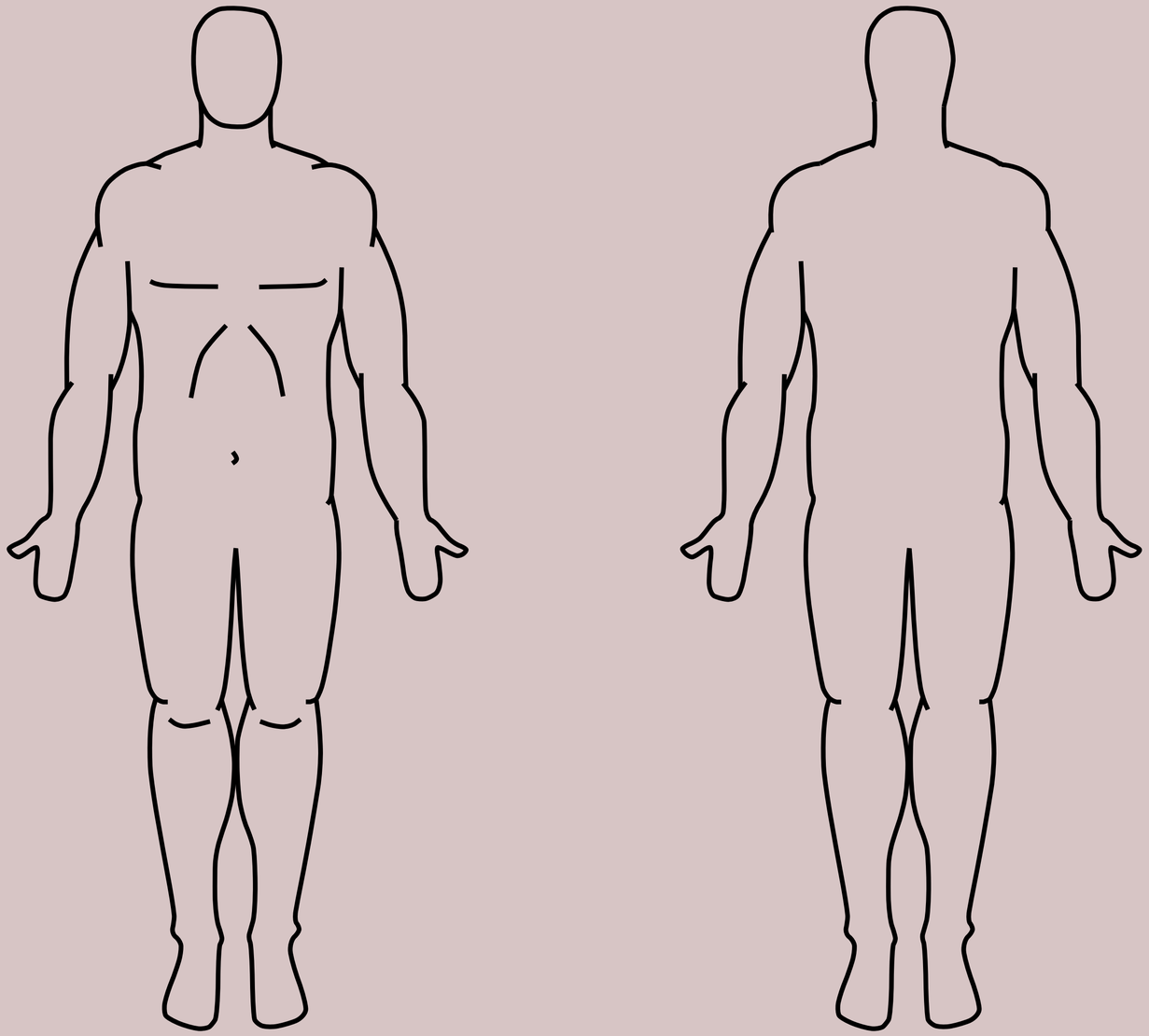

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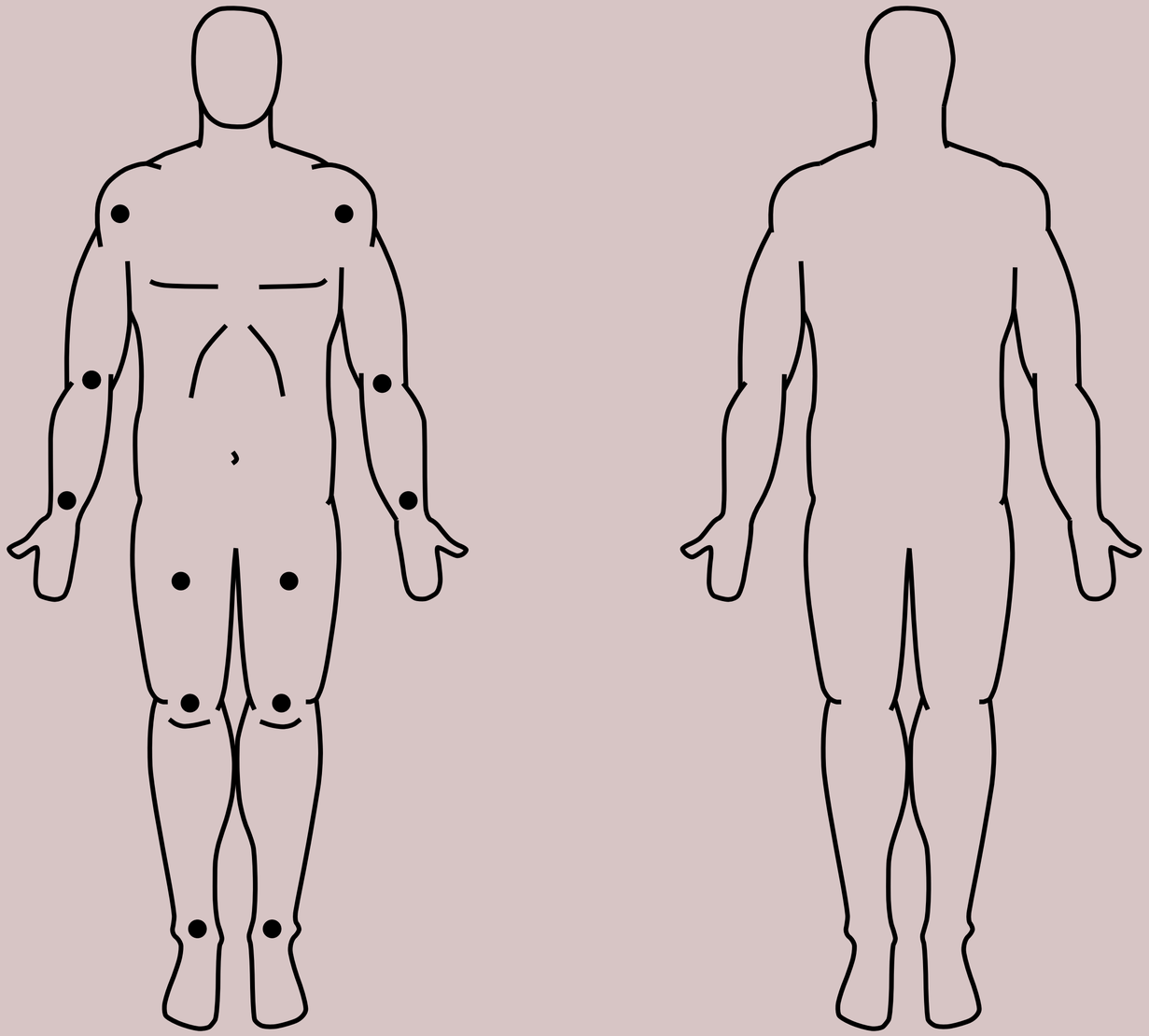
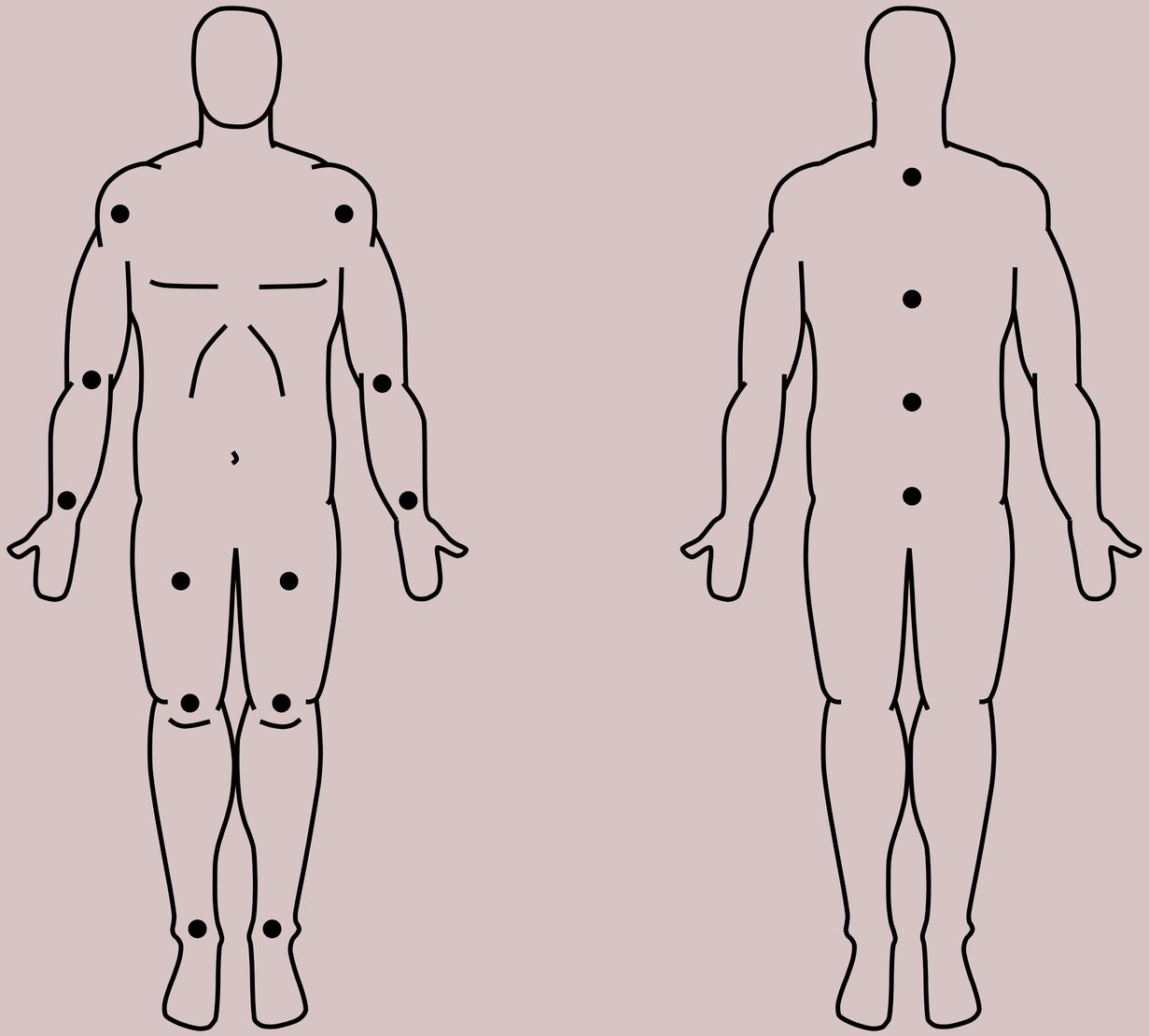


LIMB MOVEMENT

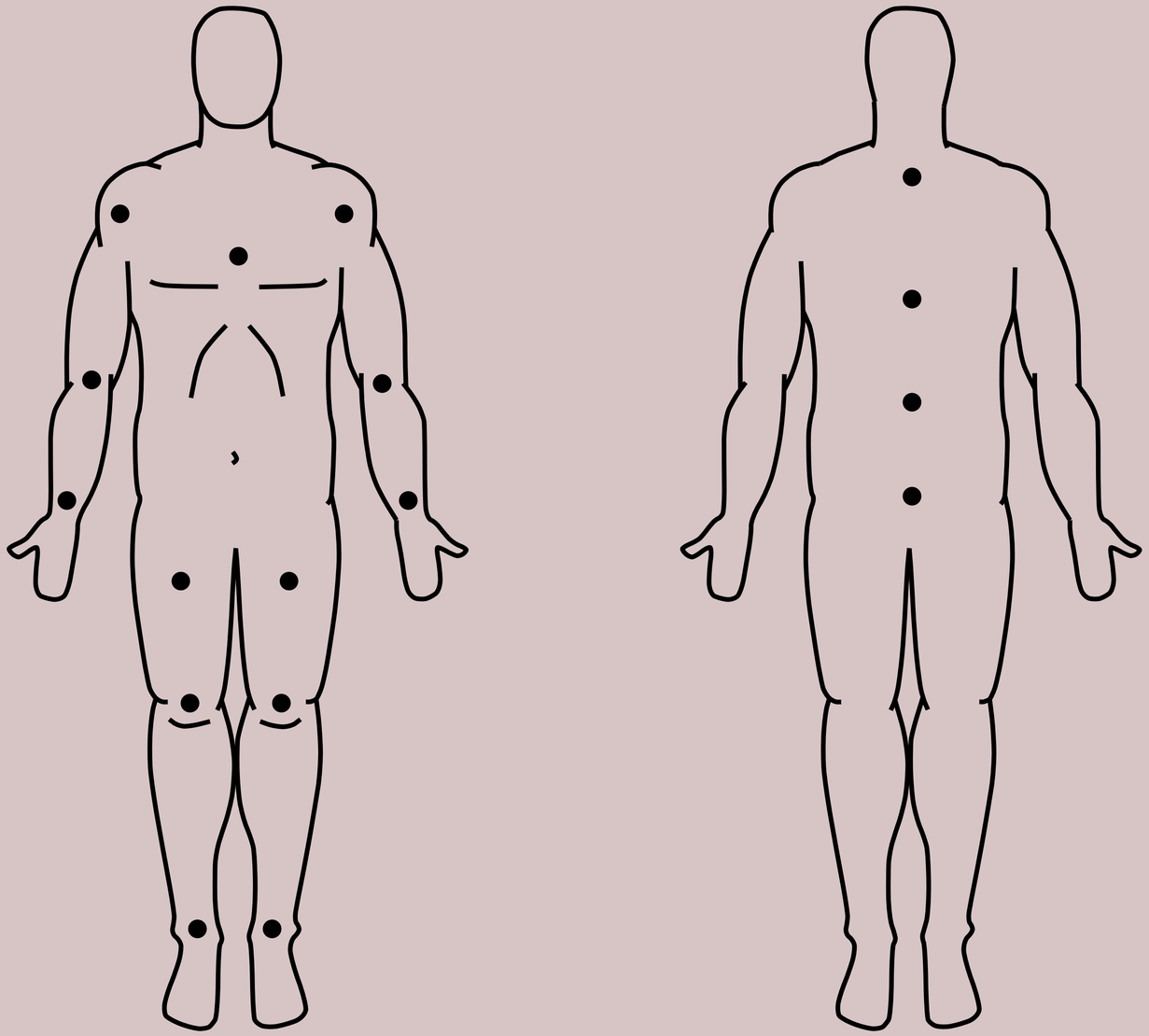
Where do we wear wearables?



LIMB MOVEMENT

POSTURE

Where do we wear wearables?

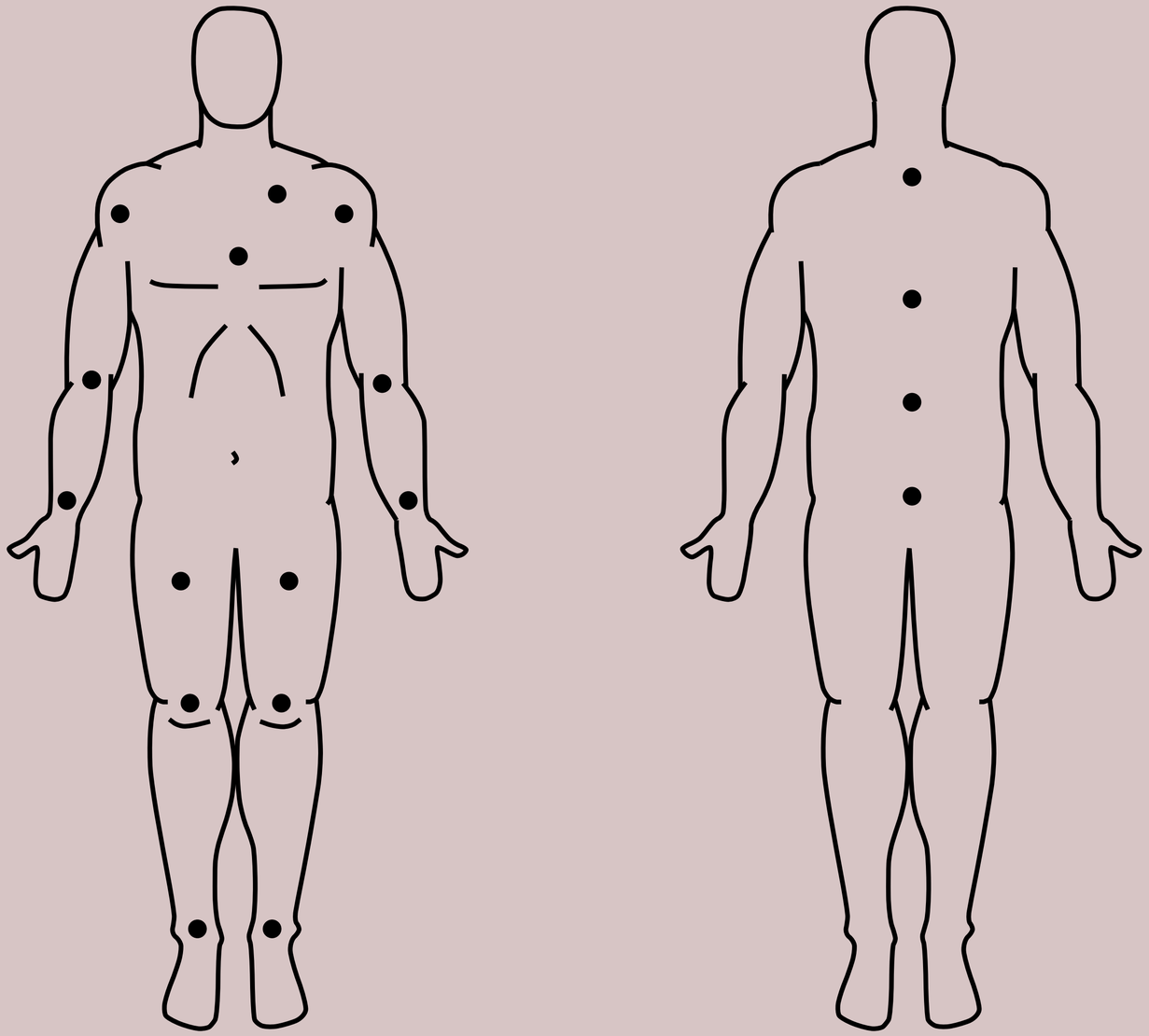


BREATHING

LIMB MOVEMENT

POSTURE

Where do we wear wearables?

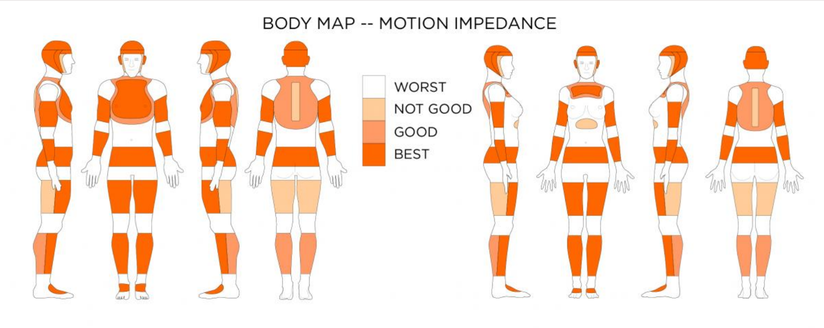


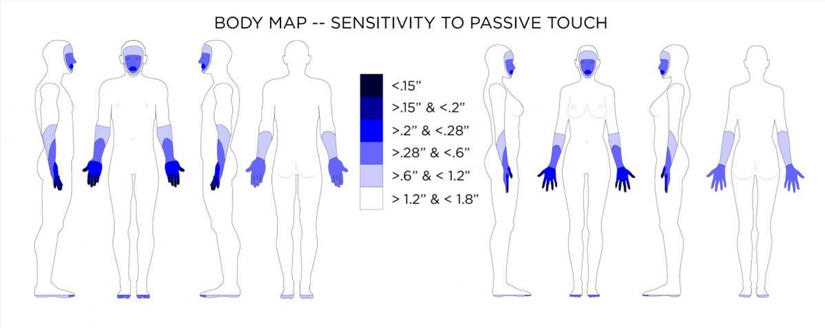
CHEWING

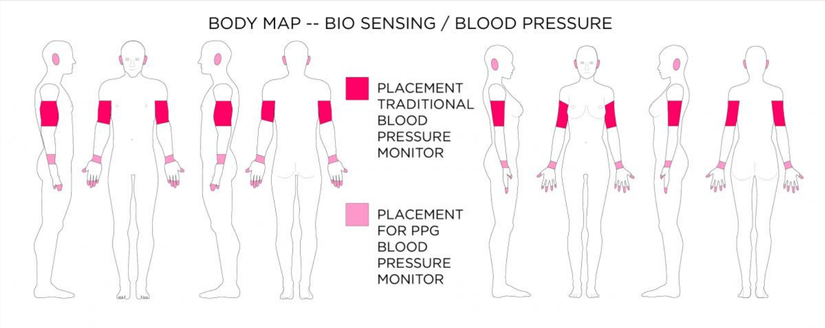
BREATHING

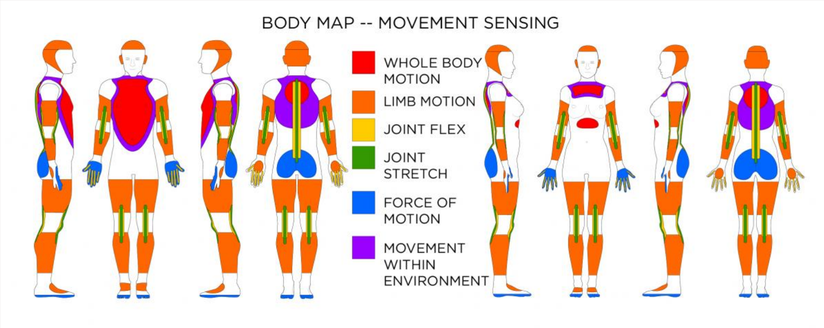
LIMB MOVEMENT

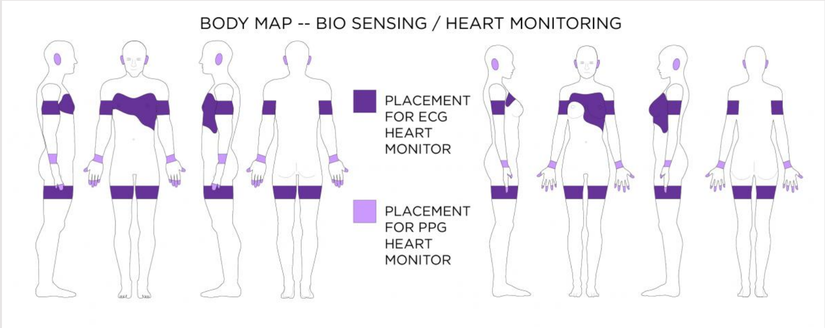
POSTURE

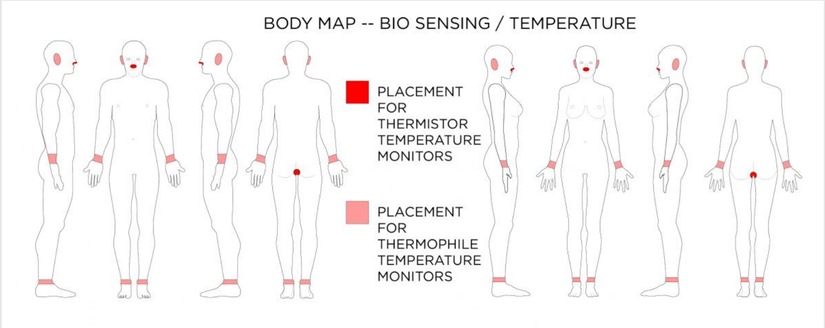

BODY MAP -- MOTION IMPEDANCE
WORST
NOT GOOD
GOOD
BEST

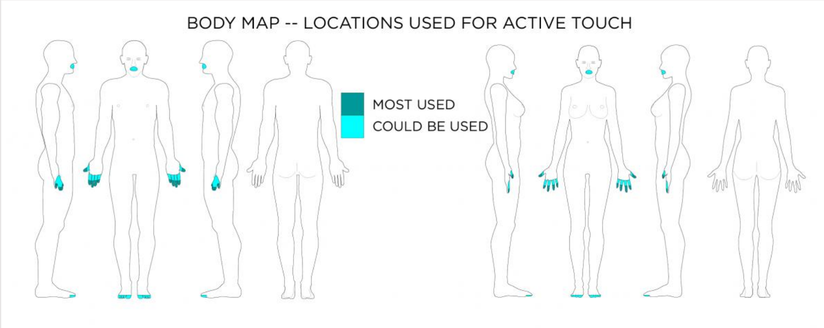

BODY MAP -- SENSITIVITY TO PASSIVE TOUCH
<.15"
>.15" & <.2"
>.2" & <.28"
>.28" & <.6"
>.6" & < 1.2"
> 1.2" & < 1.8"

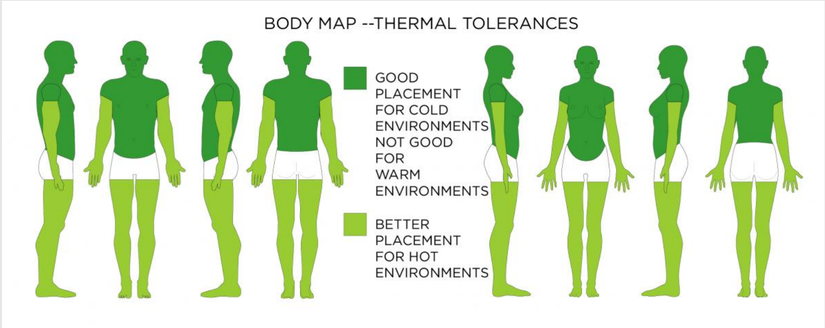

BODY MAP -- BIO SENSING / BLOOD PRESSURE
PLACEMENT TRADITIONAL BLOOD PRESSURE MONITOR
PLACEMENT FOR PPG BLOOD PRESSURE MONITOR

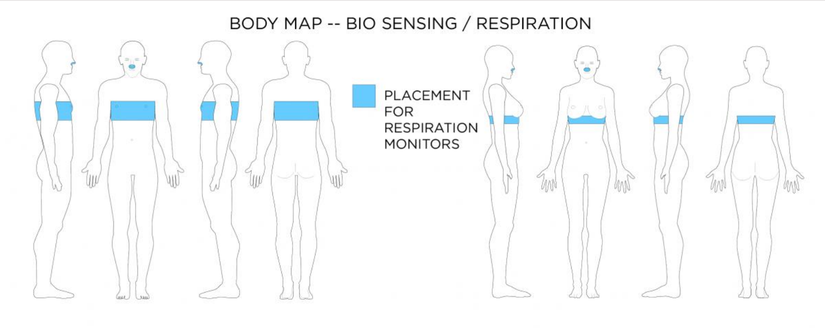

BODY MAP -- MOVEMENT SENSING
WHOLE BODY MOTION
LIMB MOTION
JOINT FLEX
JOINT STRETCH
FORCE OF MOTION
MOVEMENT WITHIN ENVIRONMENT

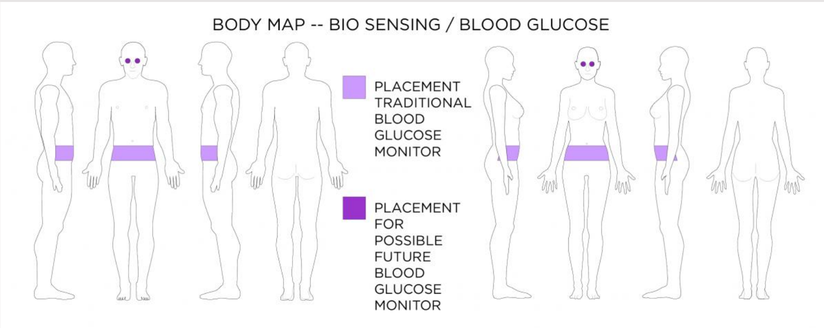

BODY MAP -- BIO SENSING / HEART MONITORING
PLACEMENT FOR ECG HEART MONITOR
PLACEMENT FOR PPG HEART MONITOR

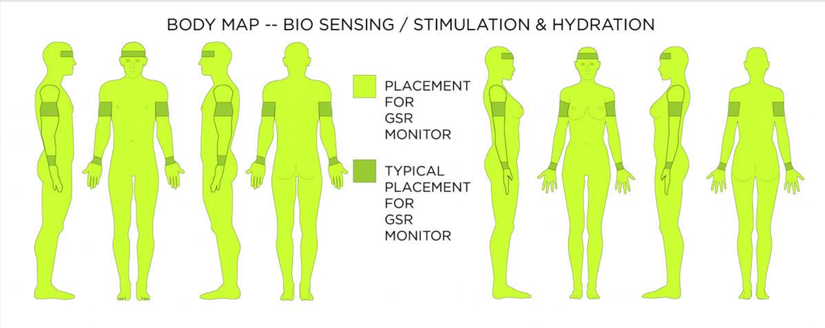

BODY MAP -- BIO SENSING / TEMPERATURE
PLACEMENT FOR THERMISTOR TEMPERATURE MONITORS
PLACEMENT FOR THERMOPHILE TEMPERATURE MONITORS

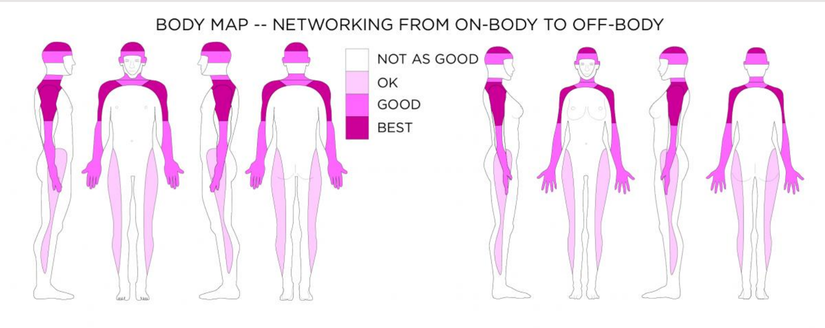

BODY MAP -- LOCATIONS USED FOR ACTIVE TOUCH
MOST USED
COULD BE USED


BODY MAP --THERMAL TOLERANCES
GOOD PLACEMENT FOR COLD ENVIRONMENTS NOT GOOD FOR WARM ENVIRONMENTS
BETTER PLACEMENT FOR HOT ENVIRONMENTS


BODY MAP -- BIO SENSING / RESPIRATION
PLACEMENT FOR RESPIRATION MONITORS


BODY MAP -- BIO SENSING / BLOOD GLUCOSE
PLACEMENT TRADITIONAL BLOOD GLUCOSE MONITOR
PLACEMENT FOR POSSIBLE FUTURE BLOOD GLUCOSE MONITOR


BODY MAP -- BIO SENSING / STIMULATION & HYDRATION
PLACEMENT FOR GSR MONITOR
TYPICAL PLACEMENT FOR GSR MONITOR


BODY MAP -- NETWORKING FROM ON-BODY TO OFF-BODY
NOT AS GOOD
OK
GOOD
BEST

Adding Locomotion to Wearables

Clothbot

Daily Support Robots

Rovables

Issues with a free-moving wearable

Problems

- Slow
- Unreliable
- Localization in 3D is REALLY hard
- Only certain types of clothing
- Uncomfortable
- Can’t carry heavy payloads

3
TFX-37
NL

LAKE DEASE
LAKE KLUAHNE
LAKE CHILKAT
YUKON RIVER
LAKE MCNEIL

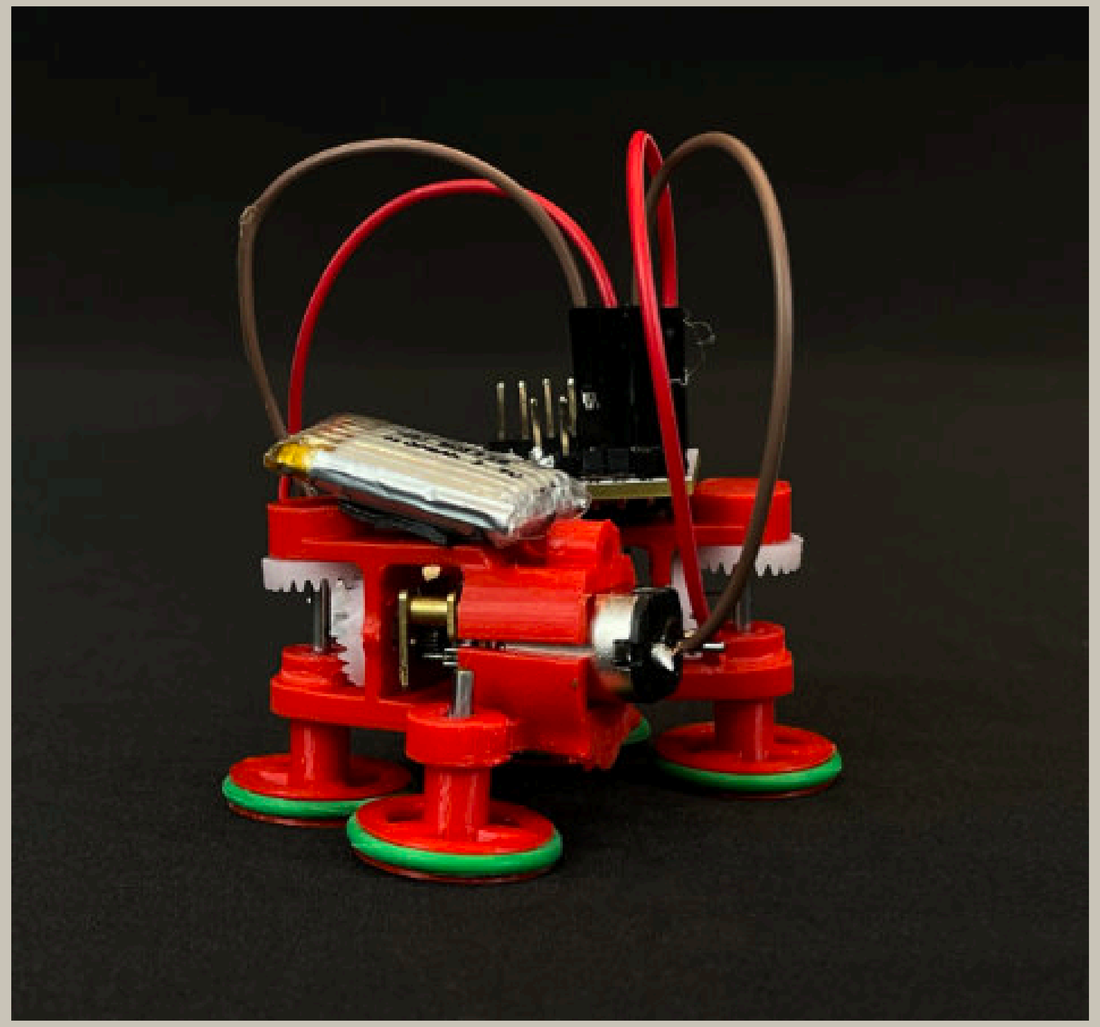
Let’s put a railway system on the body.

Stuttgart Hbf
DB

Calico

The “Train”

Proof-of-concept

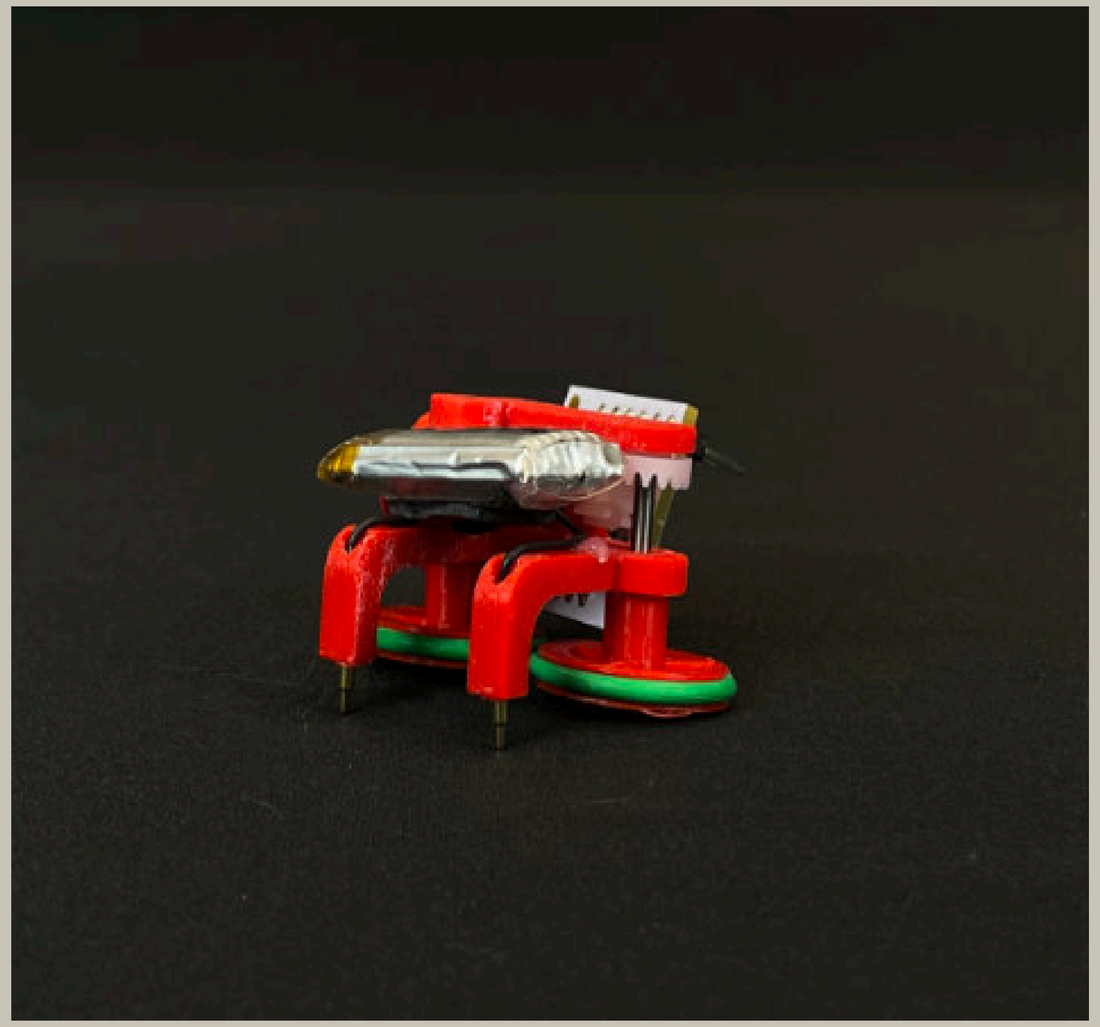


4 wheels

2 large motors

Central Ball-Bearings

1st Iteration

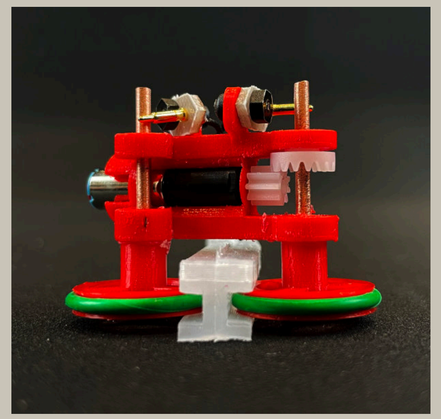


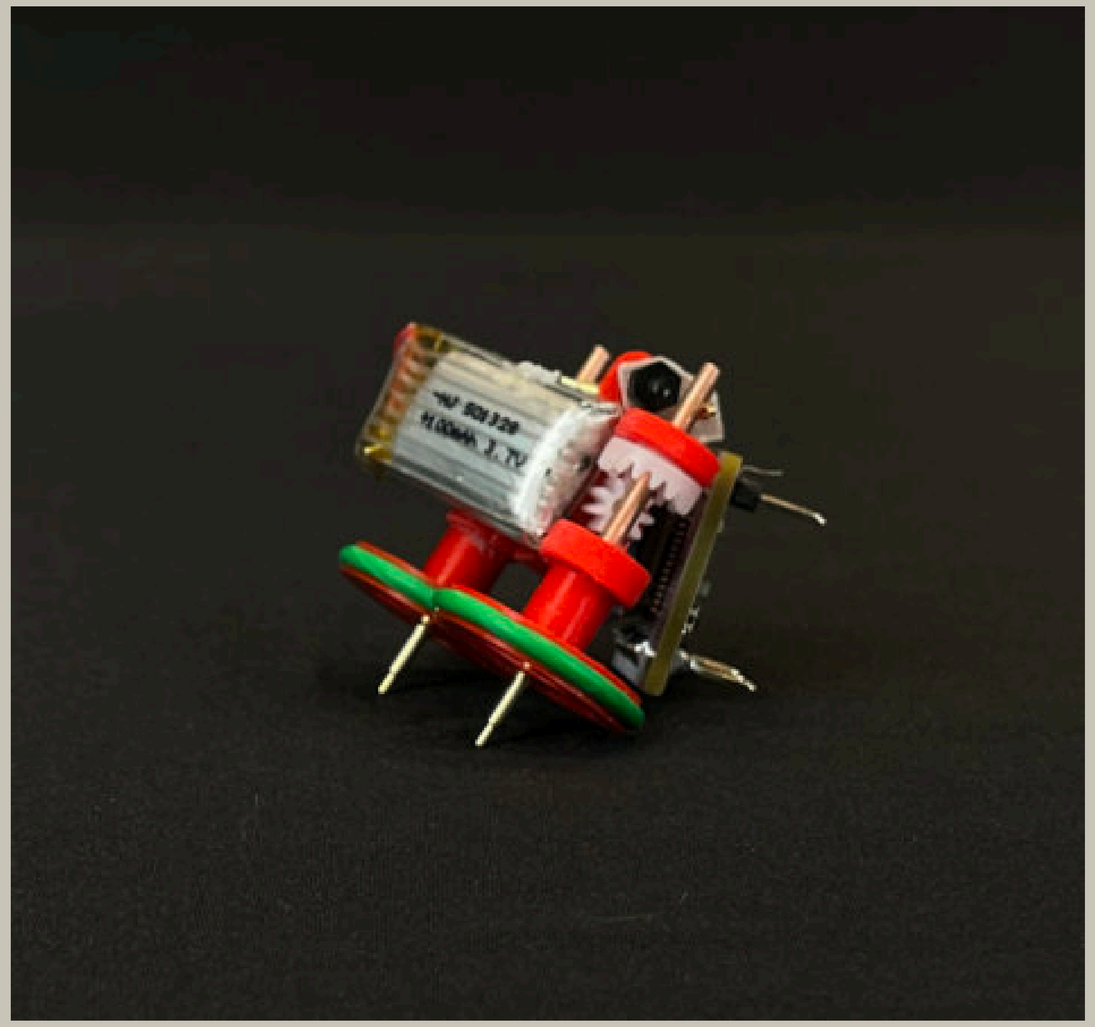
2 wheels

1 motor

Overhangs with pogo-pins

2nd Iteration



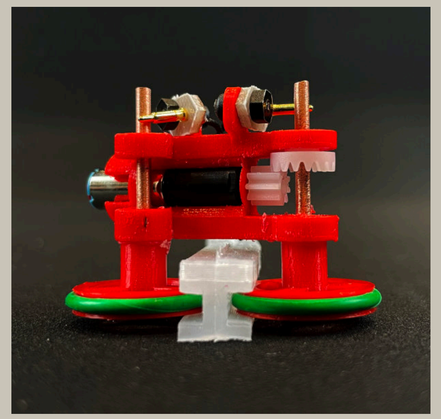


2 wheels

1 motor

Copper shaft with pogo-pin “brush”

Final Iteration



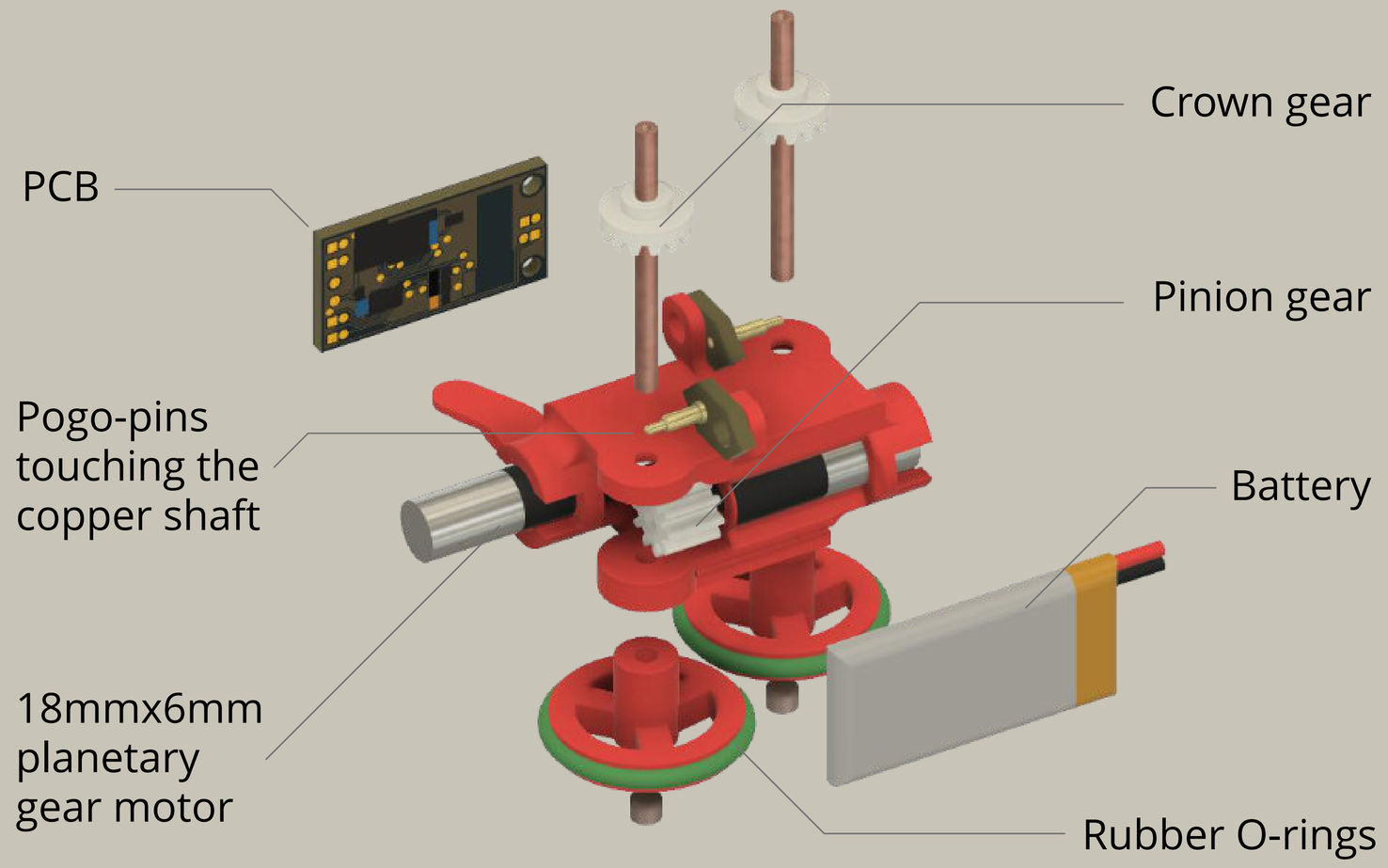
2 wheels

2 motors

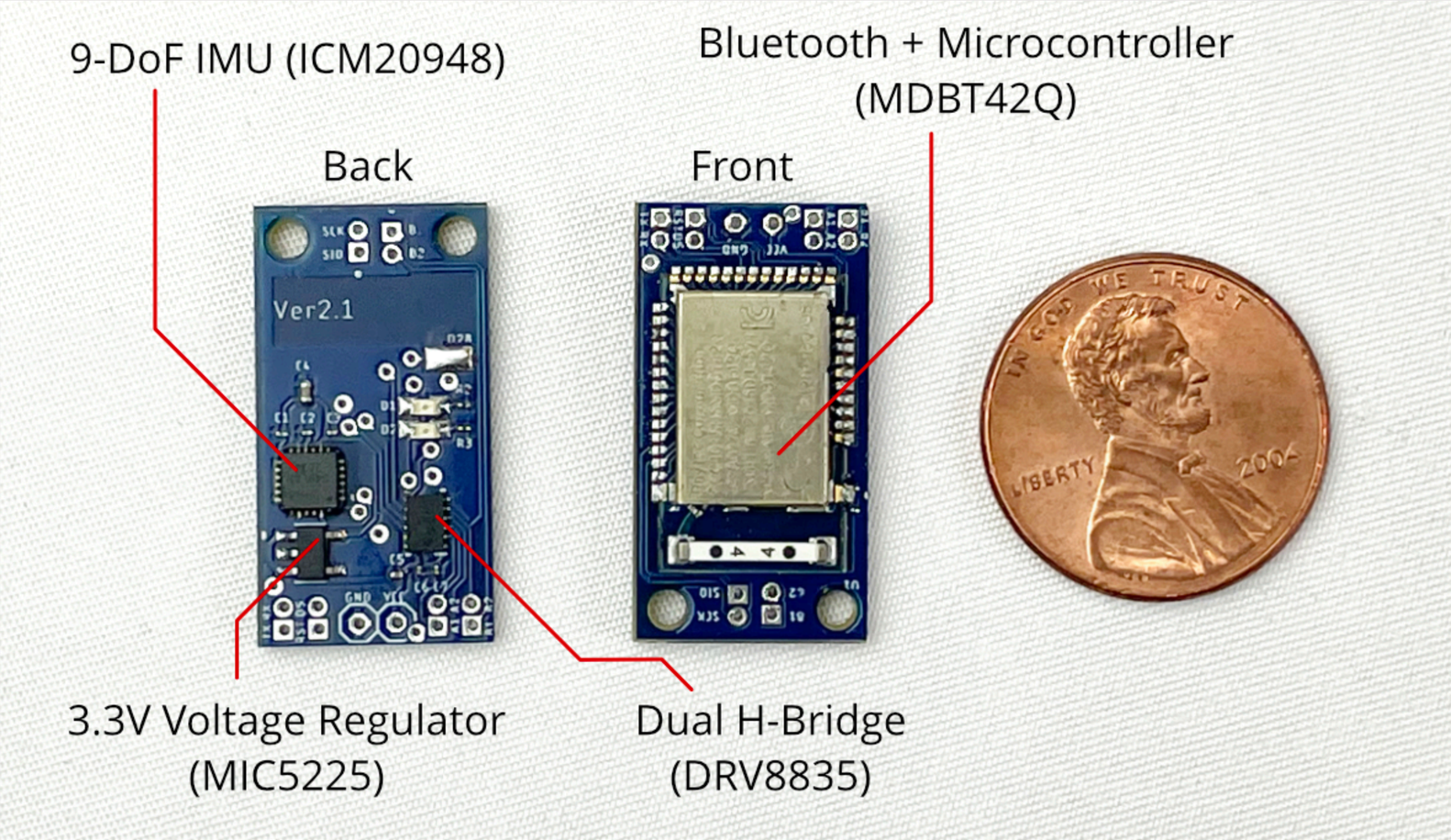
Copper shaft with pogo-pin “brush”

2 Hall-effect sensors at the bottom

Exploded View



The PCB

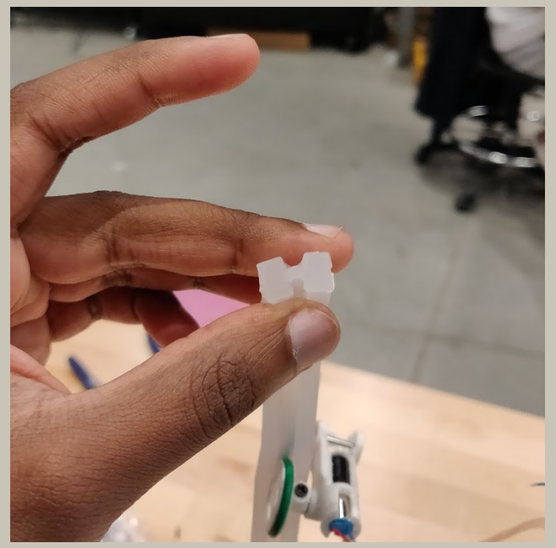

9-DoF IMU (ICM20948)
Bluetooth + Microcontroller
(MDBT42Q)
Back
Front
Ver2.1
3.3V Voltage Regulator
(MIC5225)
Dual H-Bridge
(DRV8835)

The substrate

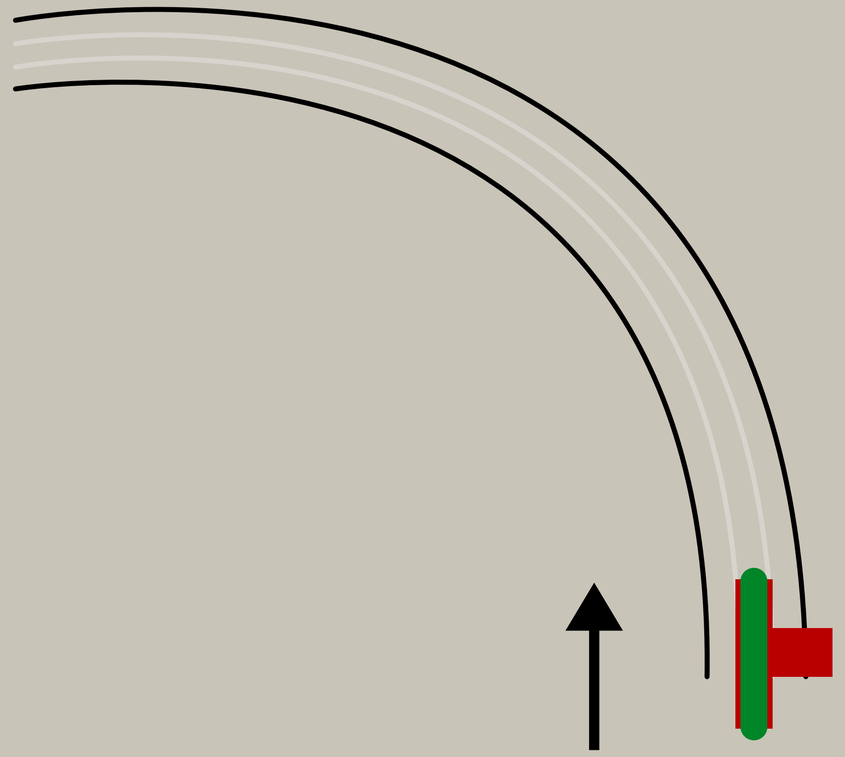
The Track

Making the track better

Urethane Rubber

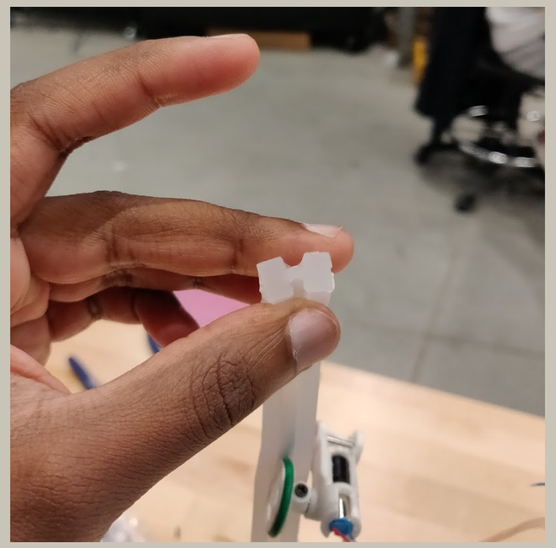


Platinum-cured Silicone

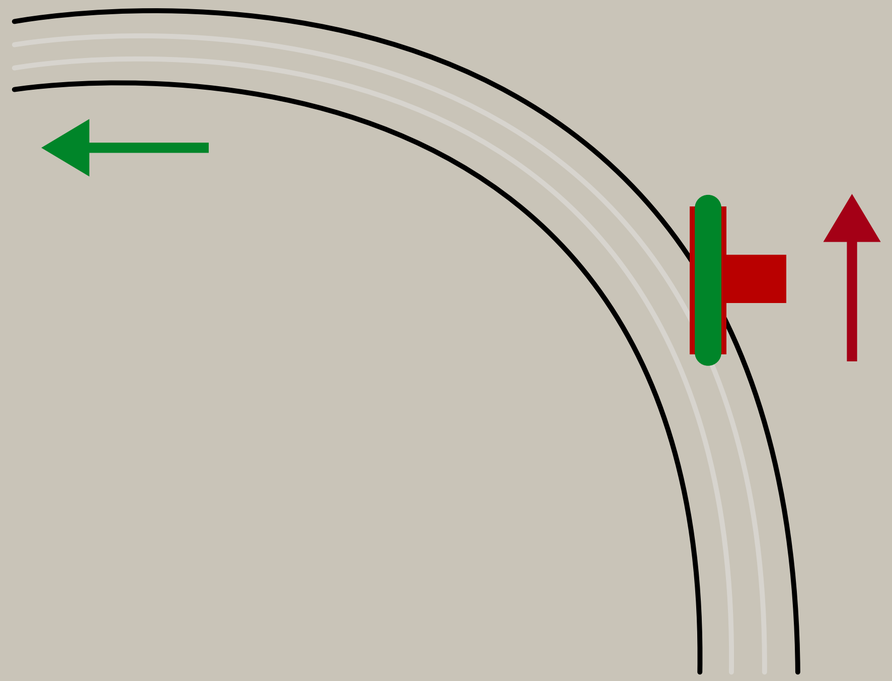


Making the track better

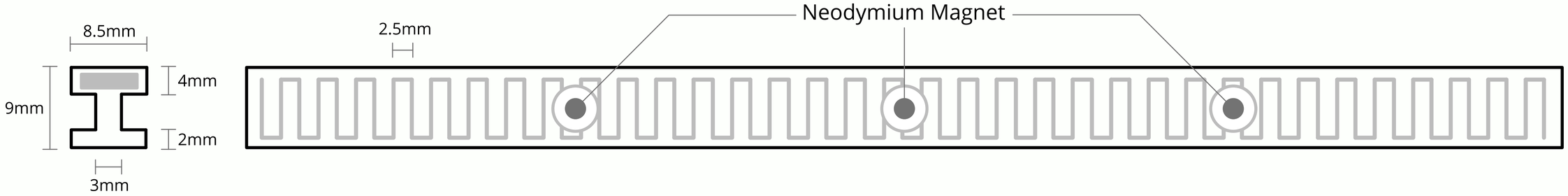
Urethane Rubber

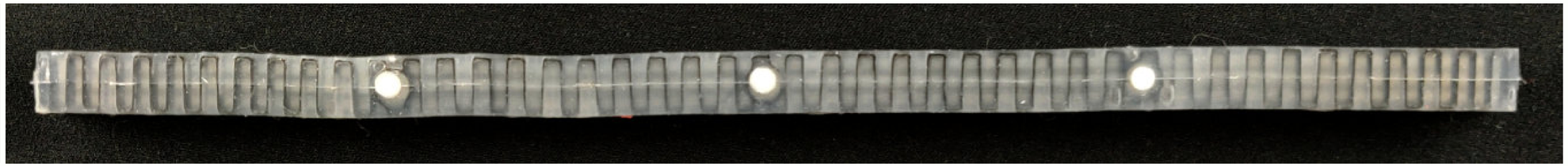


Platinum-cured Silicone



Live-Hinge Pattern



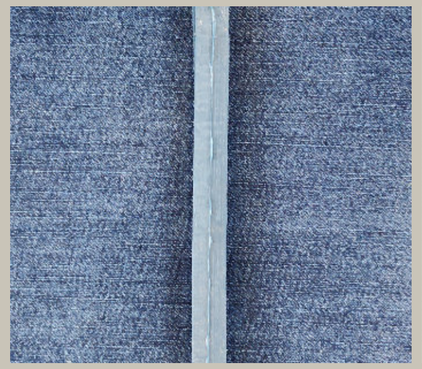


Live-Hinge Pattern

Flexes in both directions but still restricts the wheel

Styling

Denim

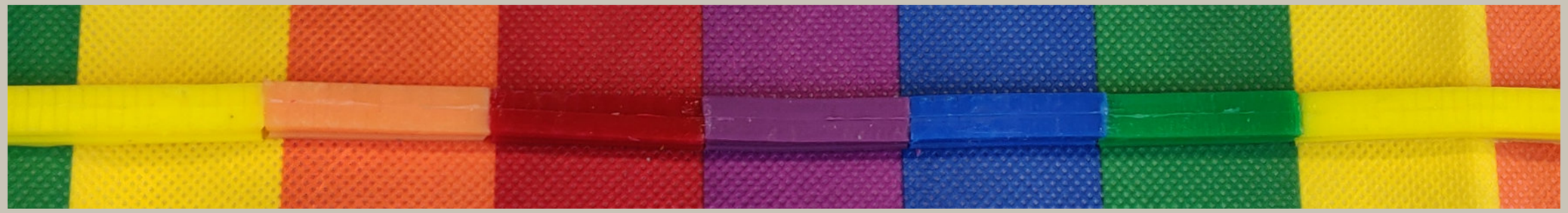


Leather

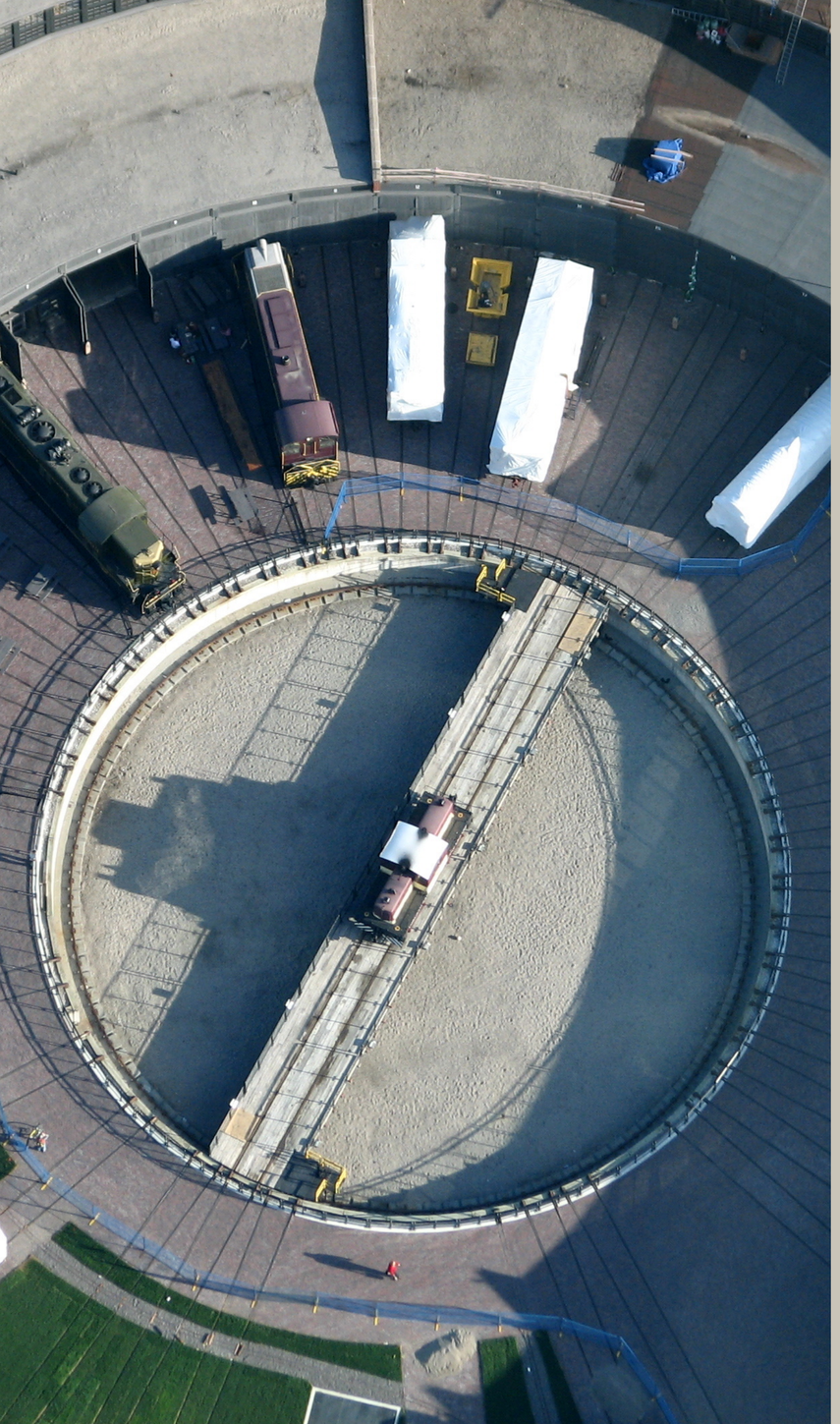
Felt

???

Satin



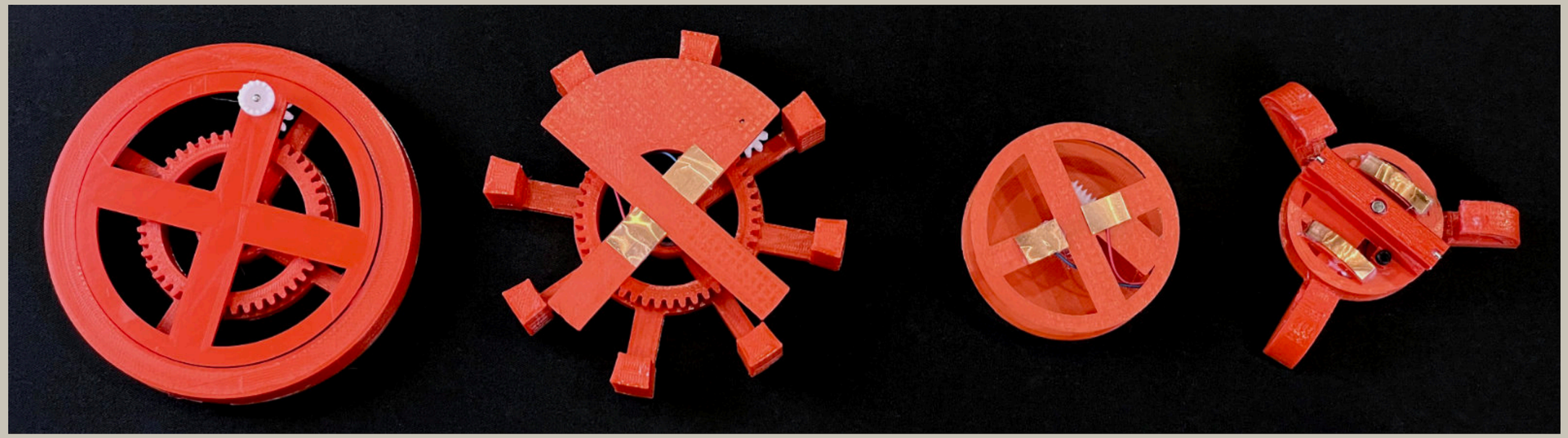
Multi-colored stripes



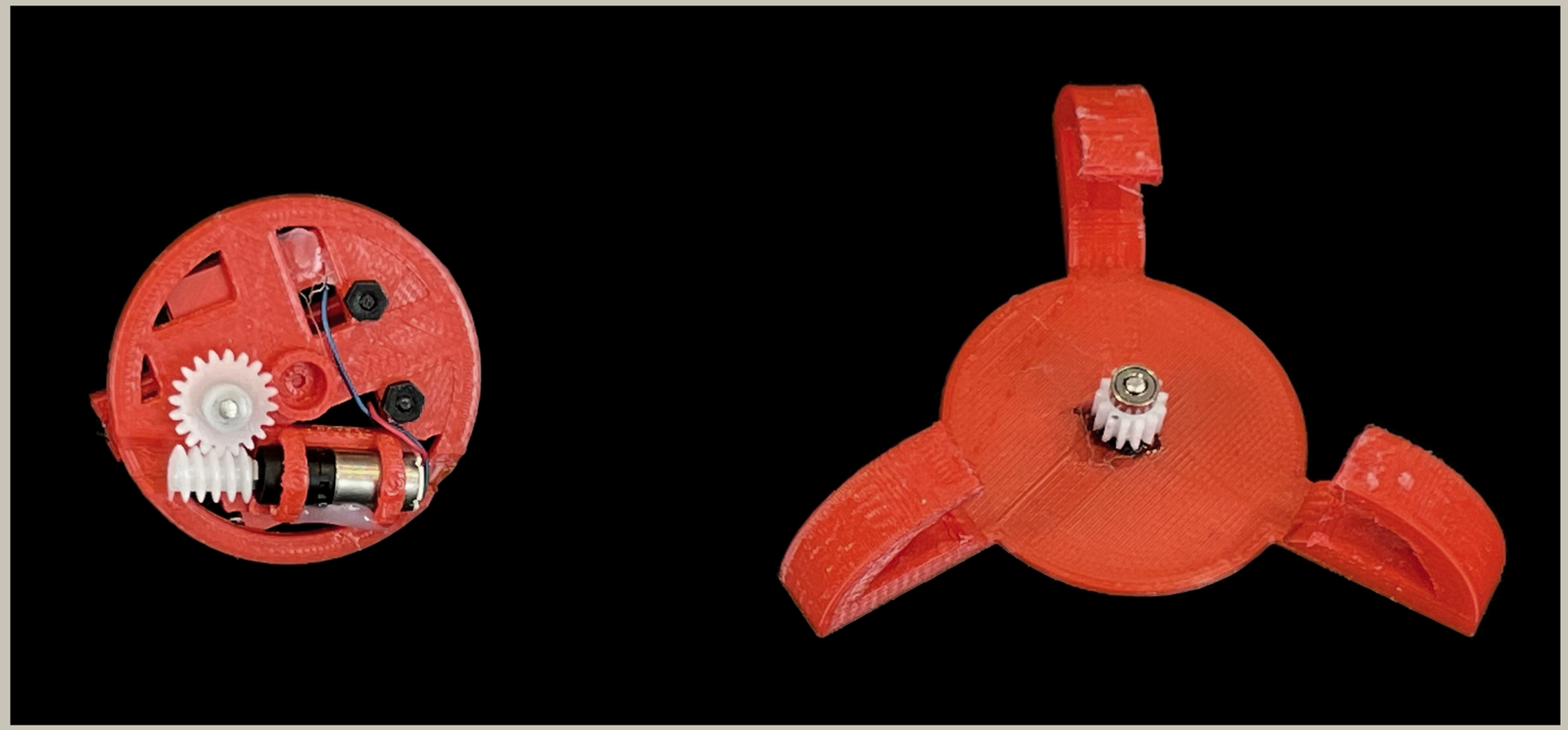
Switching Between Tracks

The Turntable

Turntable design process



Final Turntable



Creating a 2D graph

Calico
Connected
Control Calico and move it around your body.
Home
Personal Companion
Set Current Location
Set Destination

Is it good enough?

Is it fast enough?

How much can it carry?

Can it go around curves?

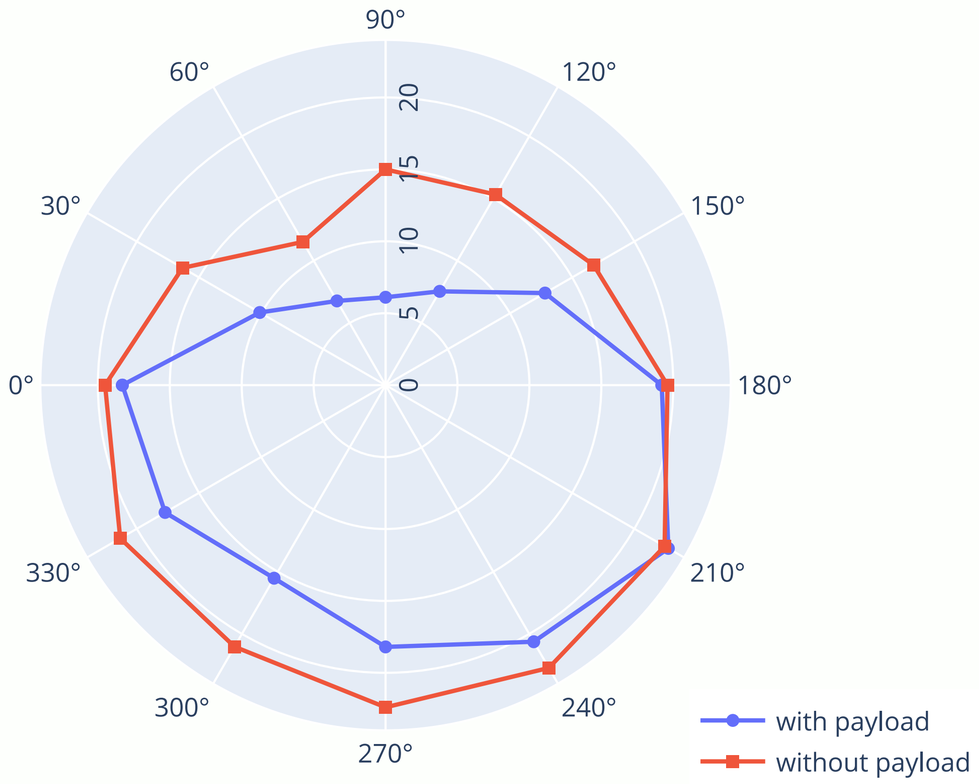
Does it slip?

Is it reliable enough?

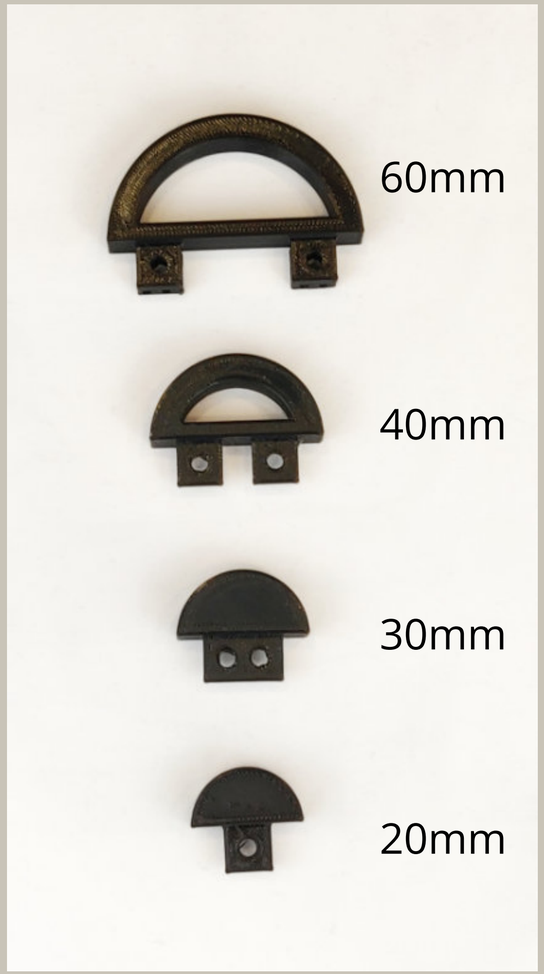
Performance Evaluation

Testing the speed at different angles with and without a 20gm payload

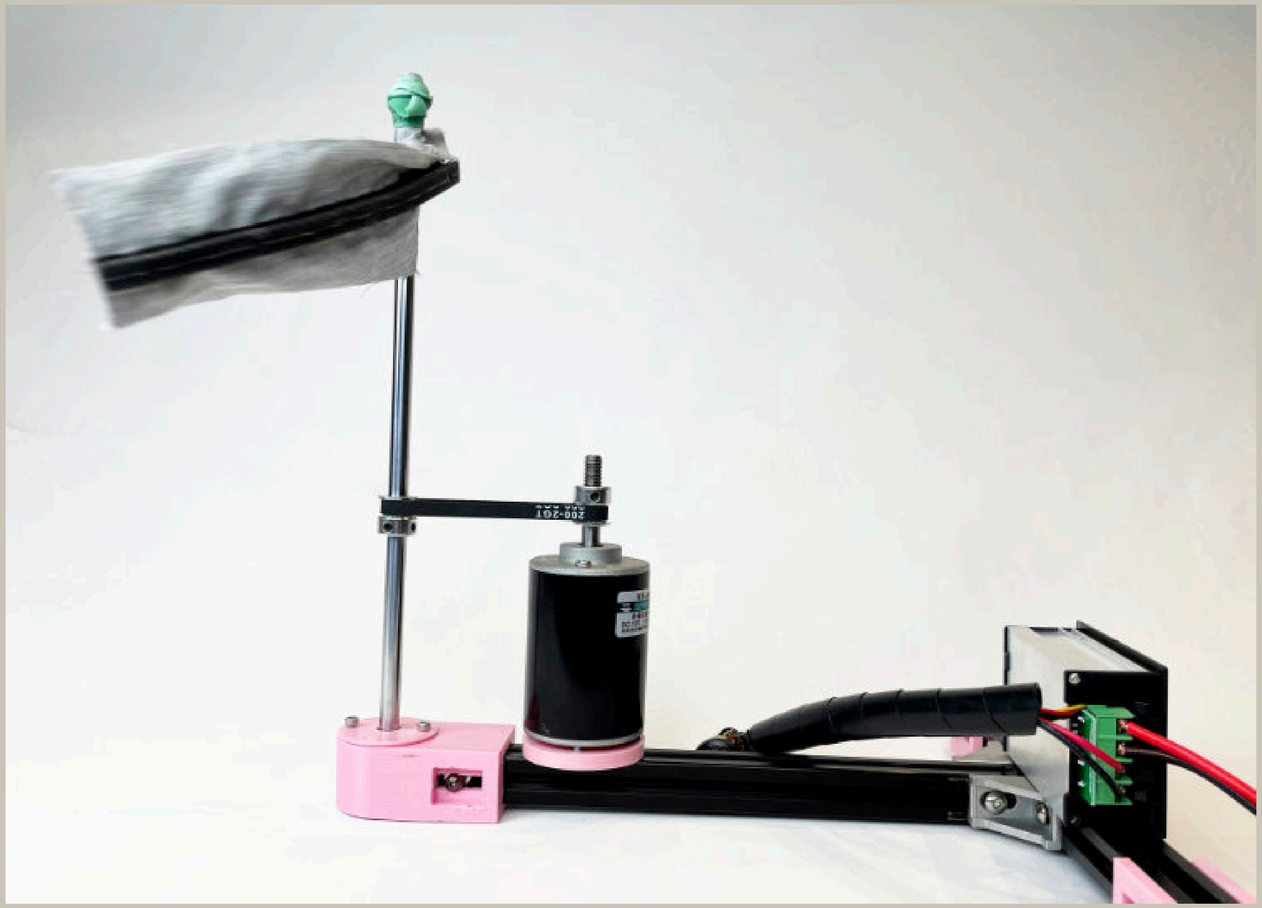
Testing the speed at different angles with and without a 20gm payload



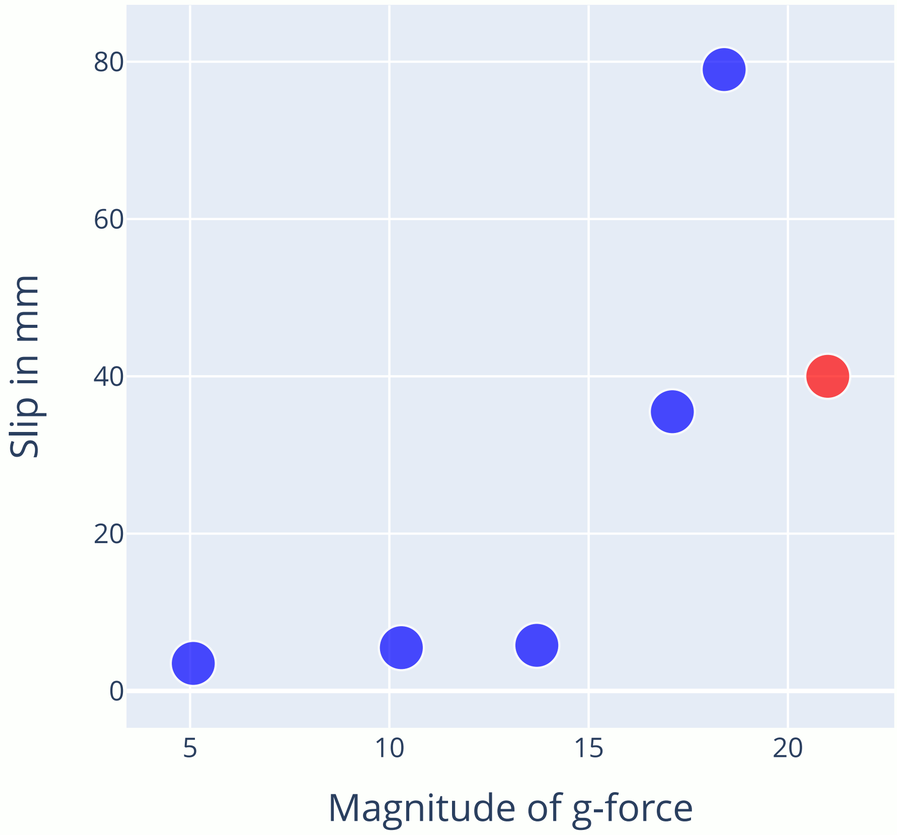
Testing the minimum curvature



Testing the slip under high g-force



Testing the slip under high g-force



Let’s put it to use

Applications

Anup Sathya Sai Kumar
Master's Thesis Defense

Special thanks to

Jiasheng Li

Dr. Tauhidur Rahman

Thank You

Thanks to Prof. Justin Miller for inspiring the design of the slide deck

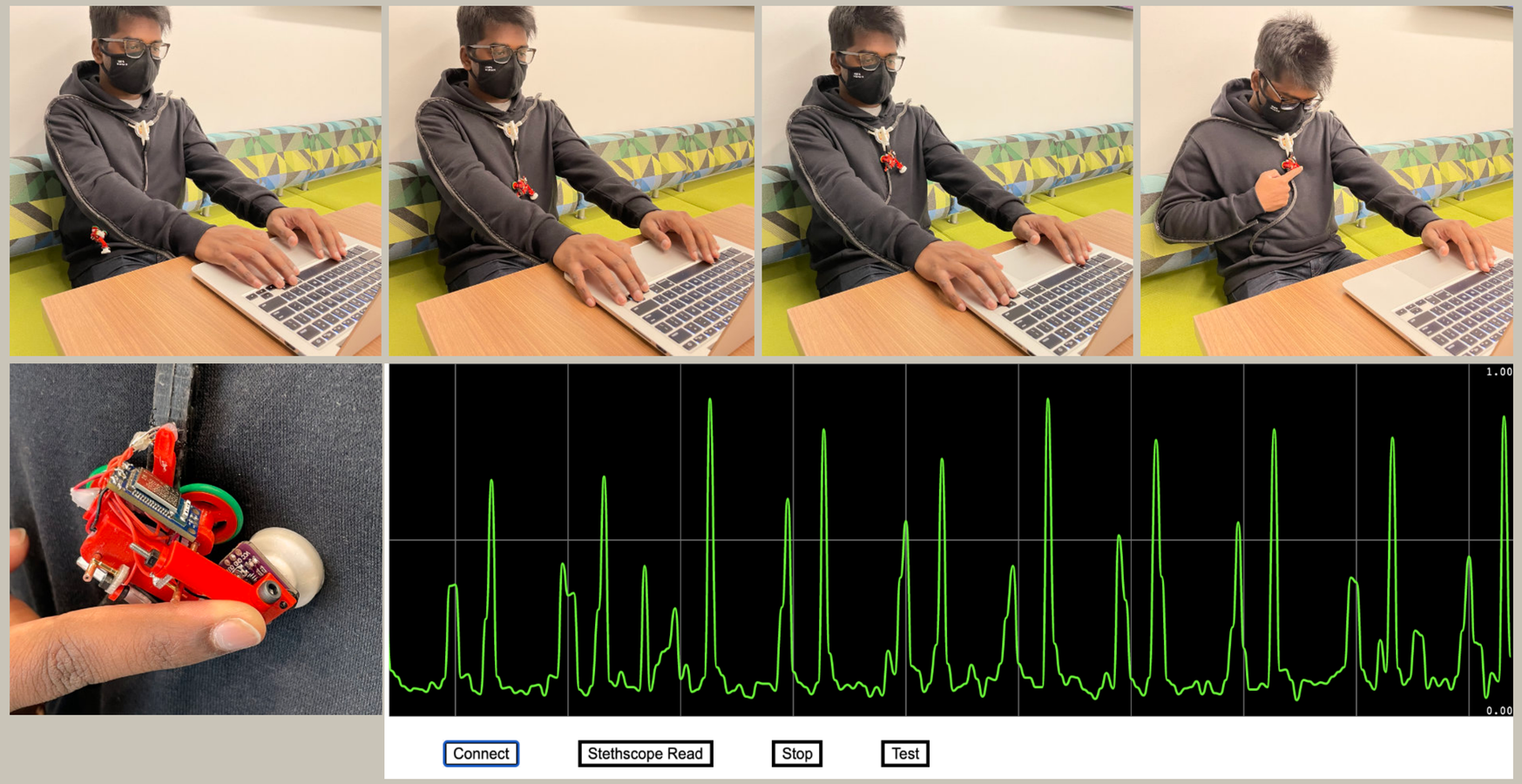
The drainers

Microcontroller	3uA to 1mA
Motors	~160mA
IMU	8uA to 3.11mA
Other	< 1mA

30 minutes with constant movement

8 hours idle

Battery Life

In-the-wild testing

On-demand auscultation