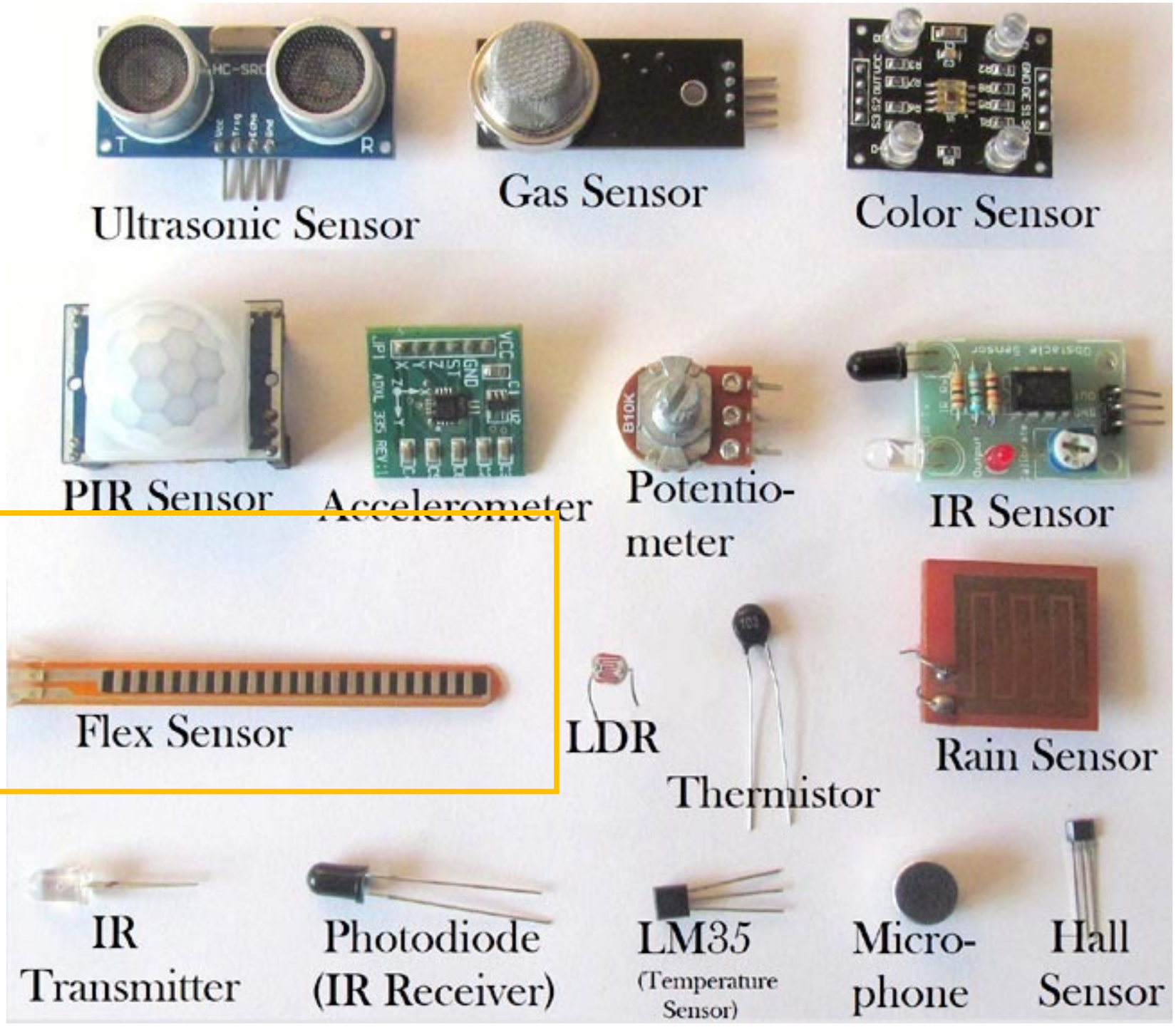
Indirect Sensing and Machine Learning

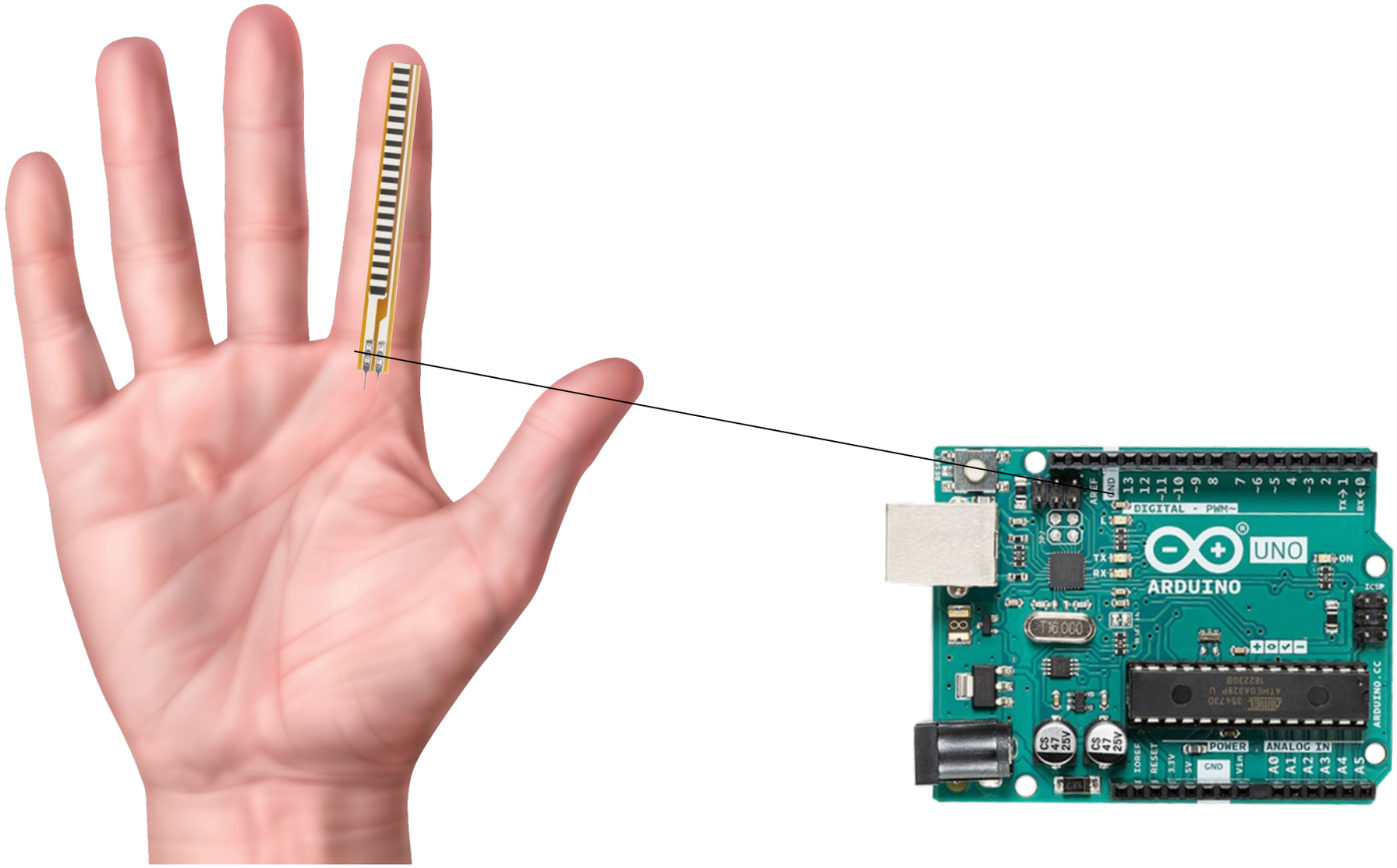
Sai Swaminathan

What is Sensing?

To measure a physical phenomenon and map it to a change in energy.

Sensors

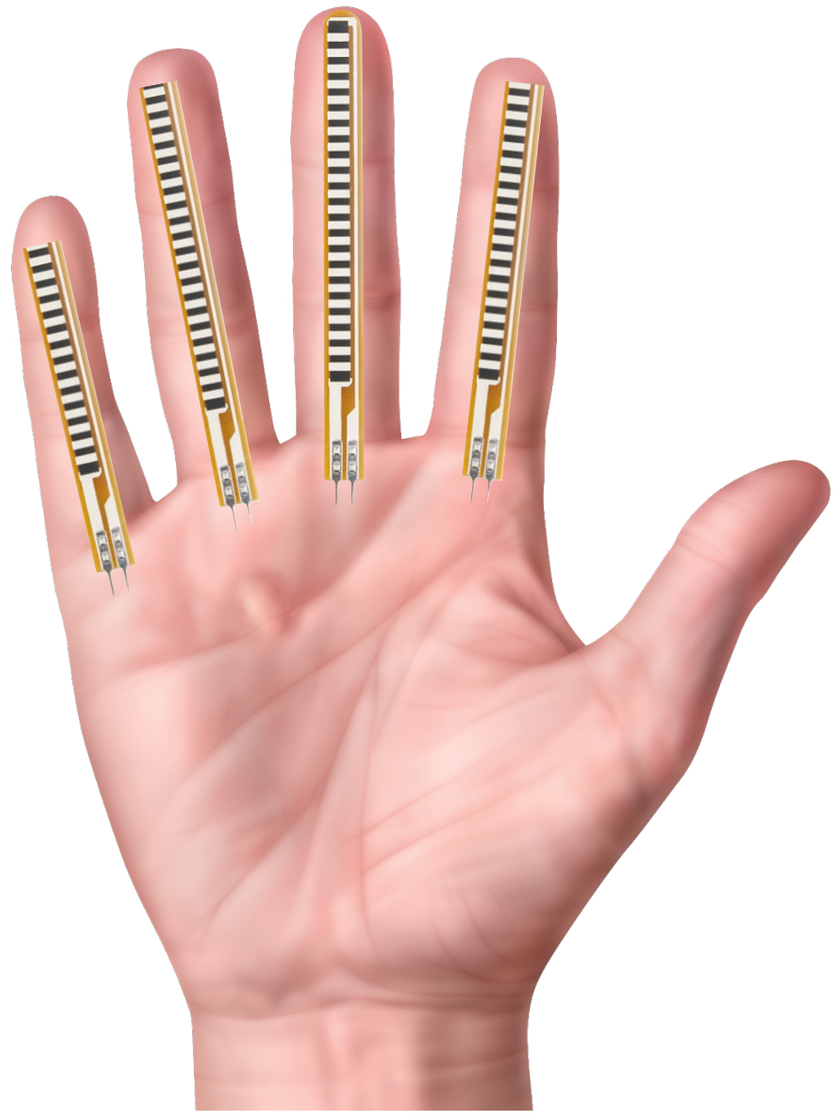

HC-SR0
T
R
Ultrasonic Sensor
Gas Sensor
Color Sensor
PIR Sensor
Accelerometer
Potentio-
meter
IR Sensor
Flex Sensor
LDR
Thermistor
Rain Sensor
IR
Transmitter
Photodiode
(IR Receiver)
LM35
(Temperature
Sensor)
Micro-
phone
Hall
Sensor

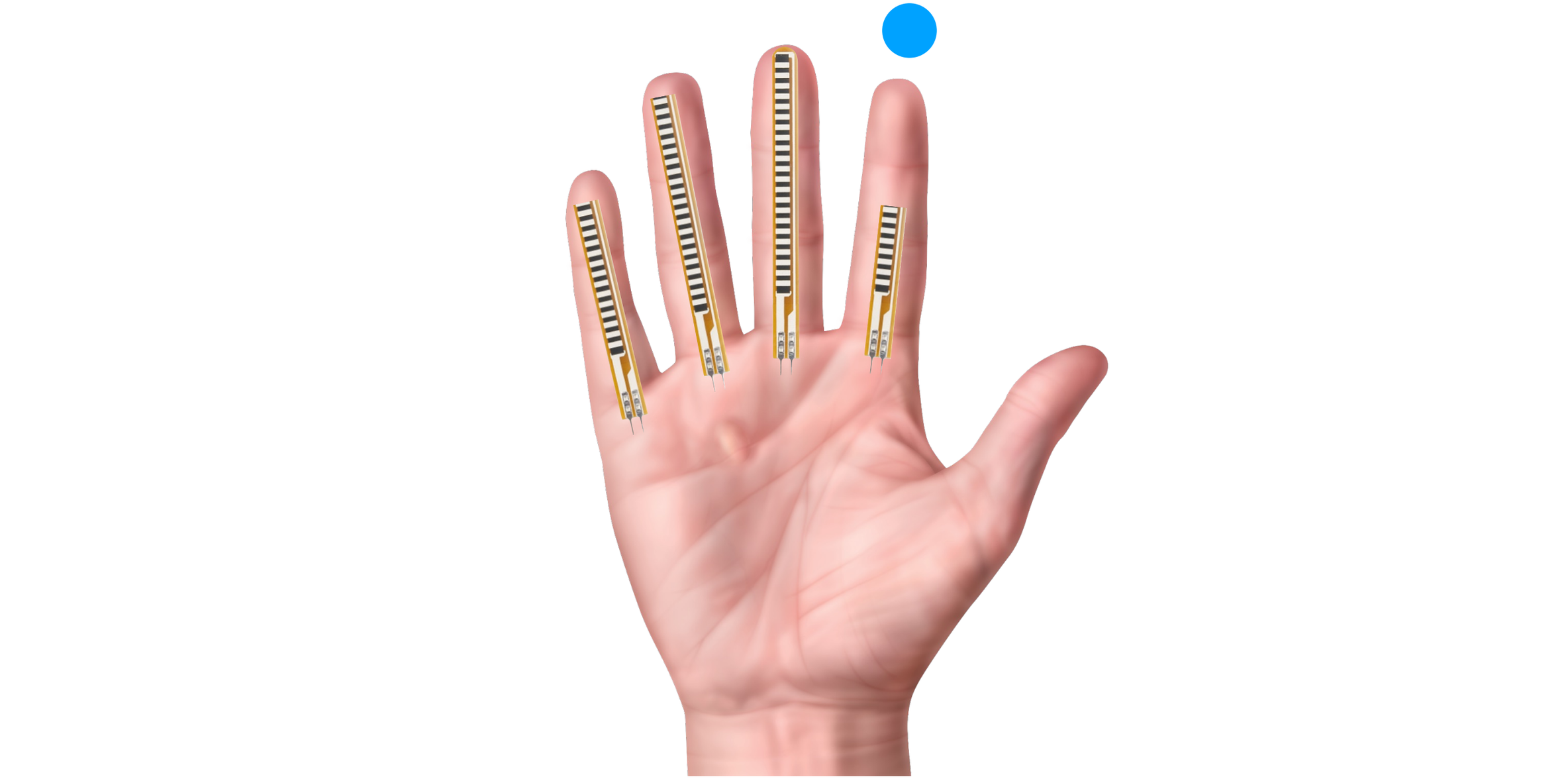

DIGITAL - PWM~
UNO
ARDUINO
ON
TX
RX
POWER
ANALOG IN
GND
ARDUINO.CC

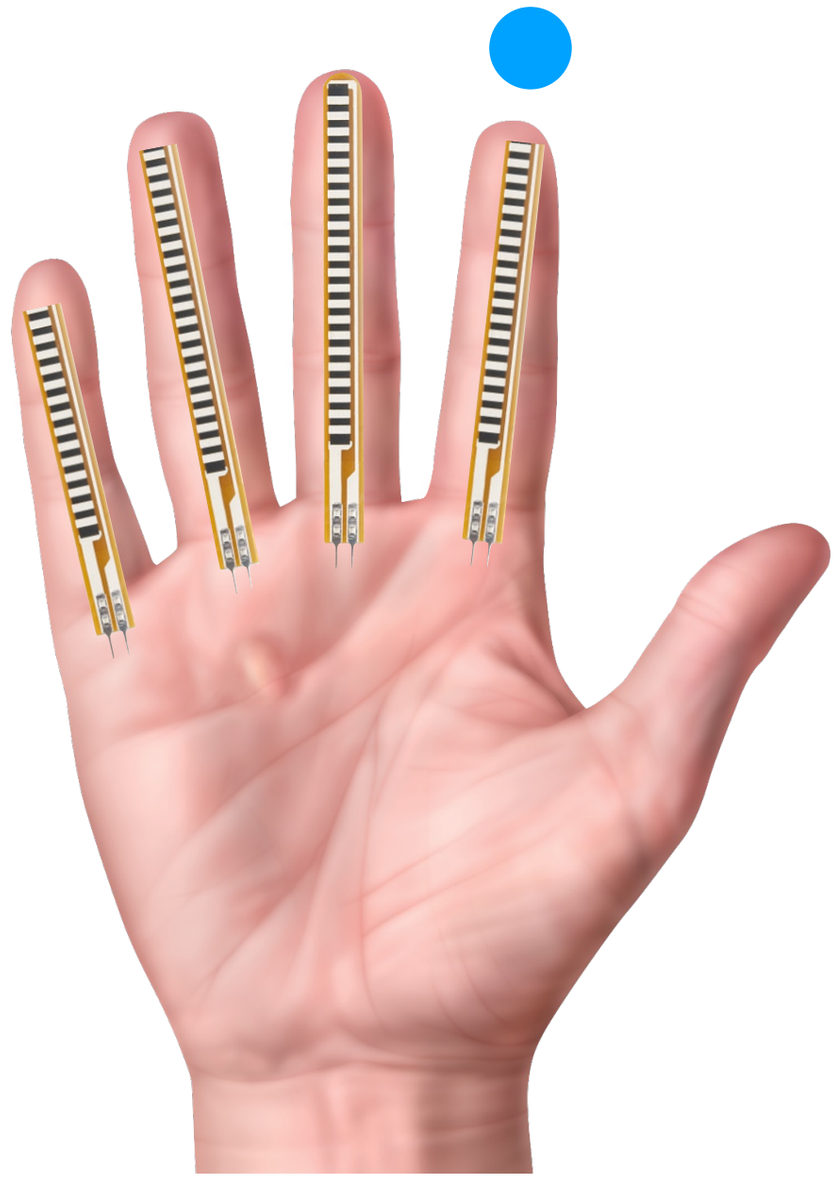
What is Machine Learning?

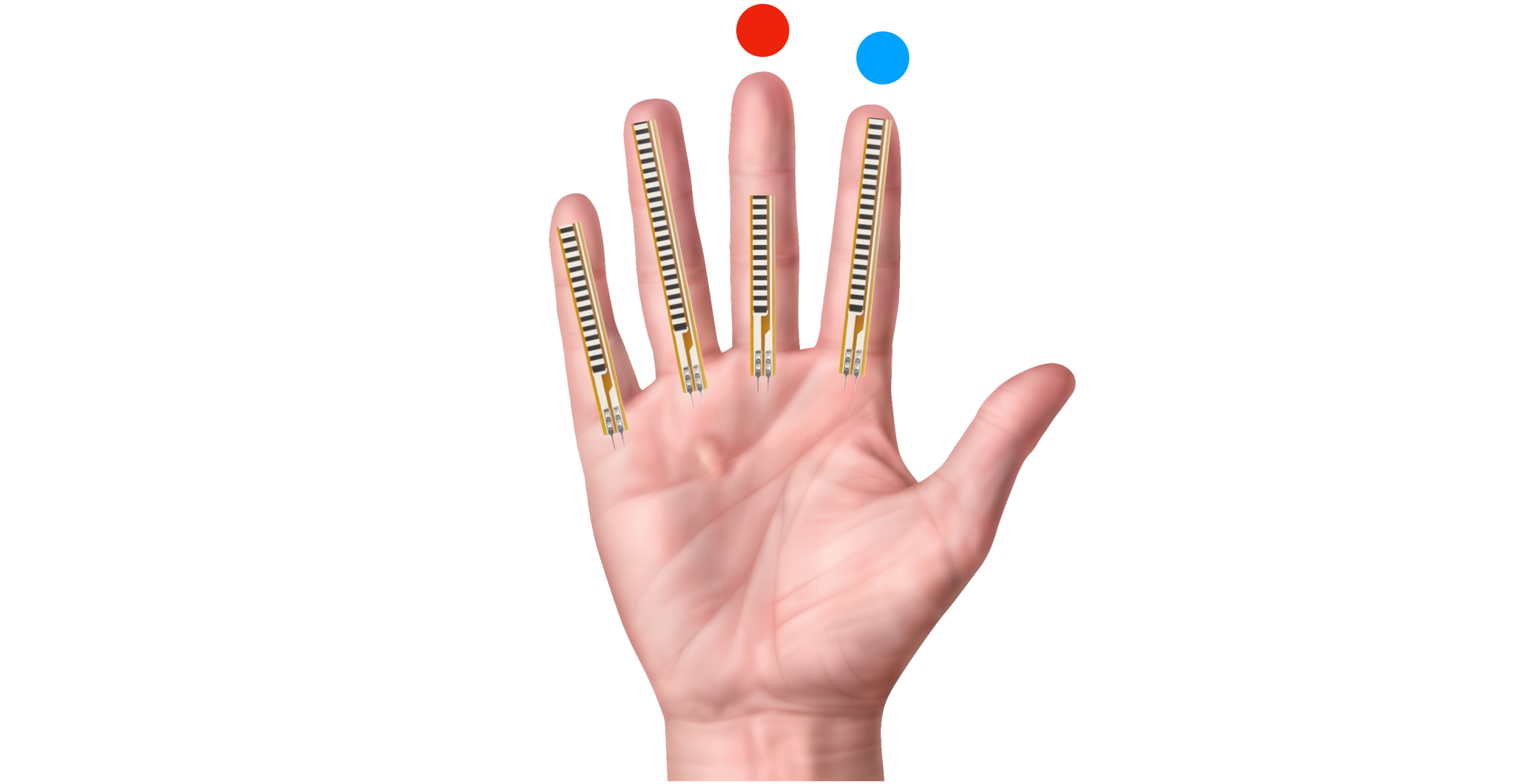
- Teaches a computer a new capability *by example* without explicitly programming

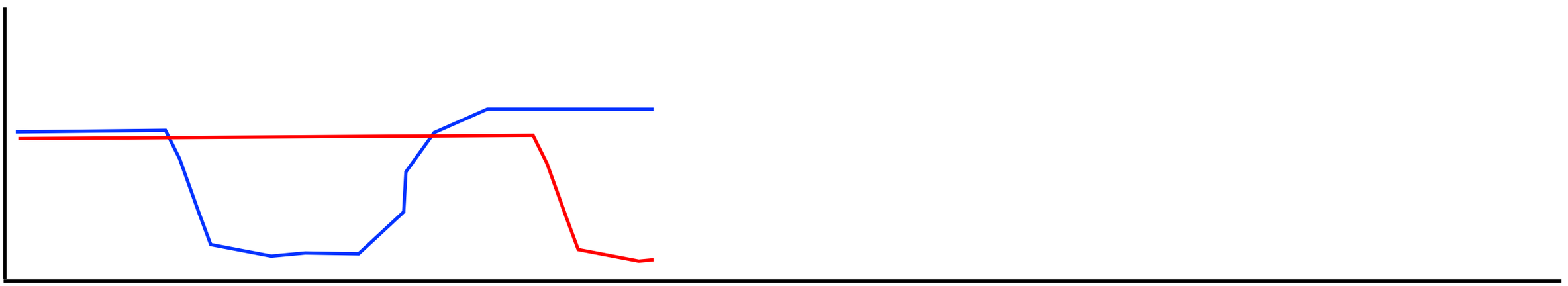
When do we need to combine machine learning and sensing?

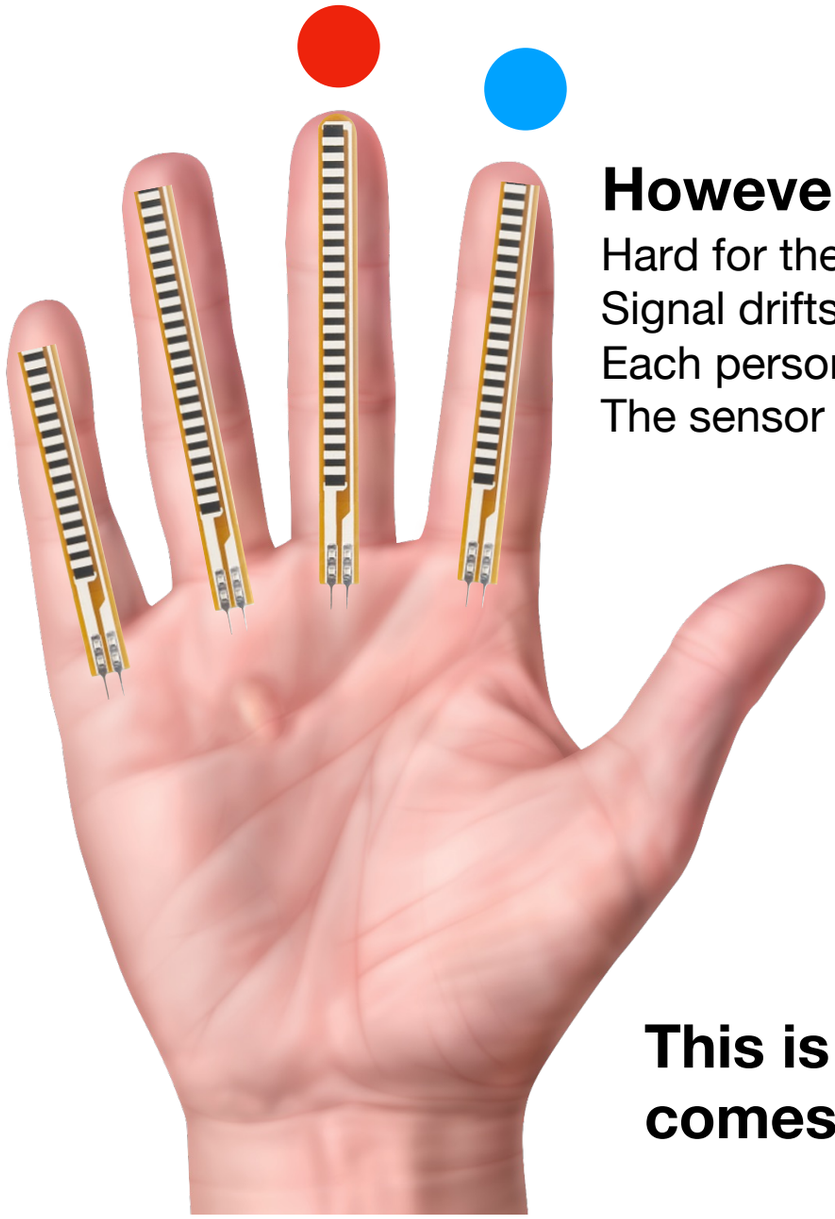








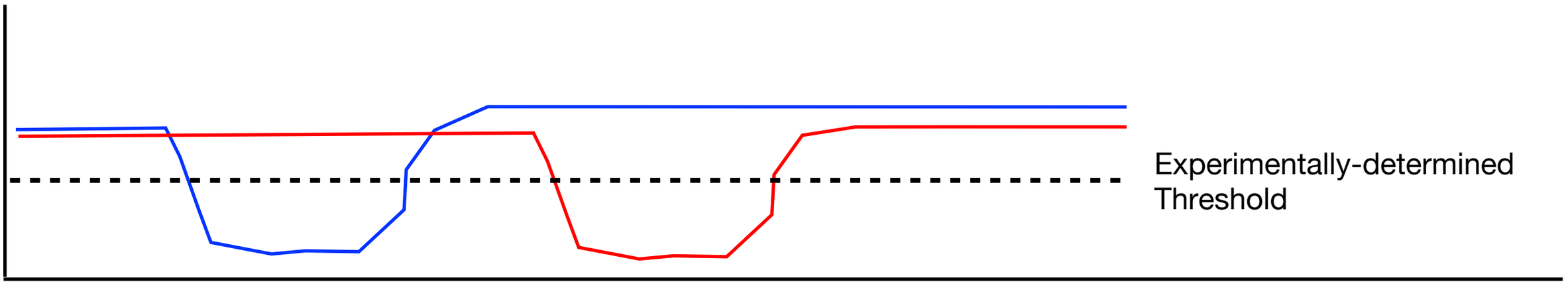


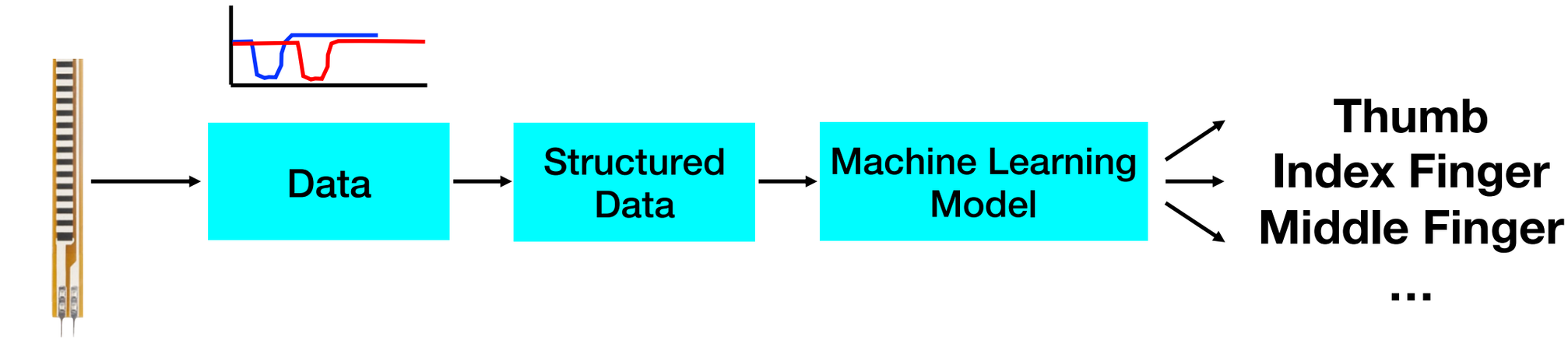


However…

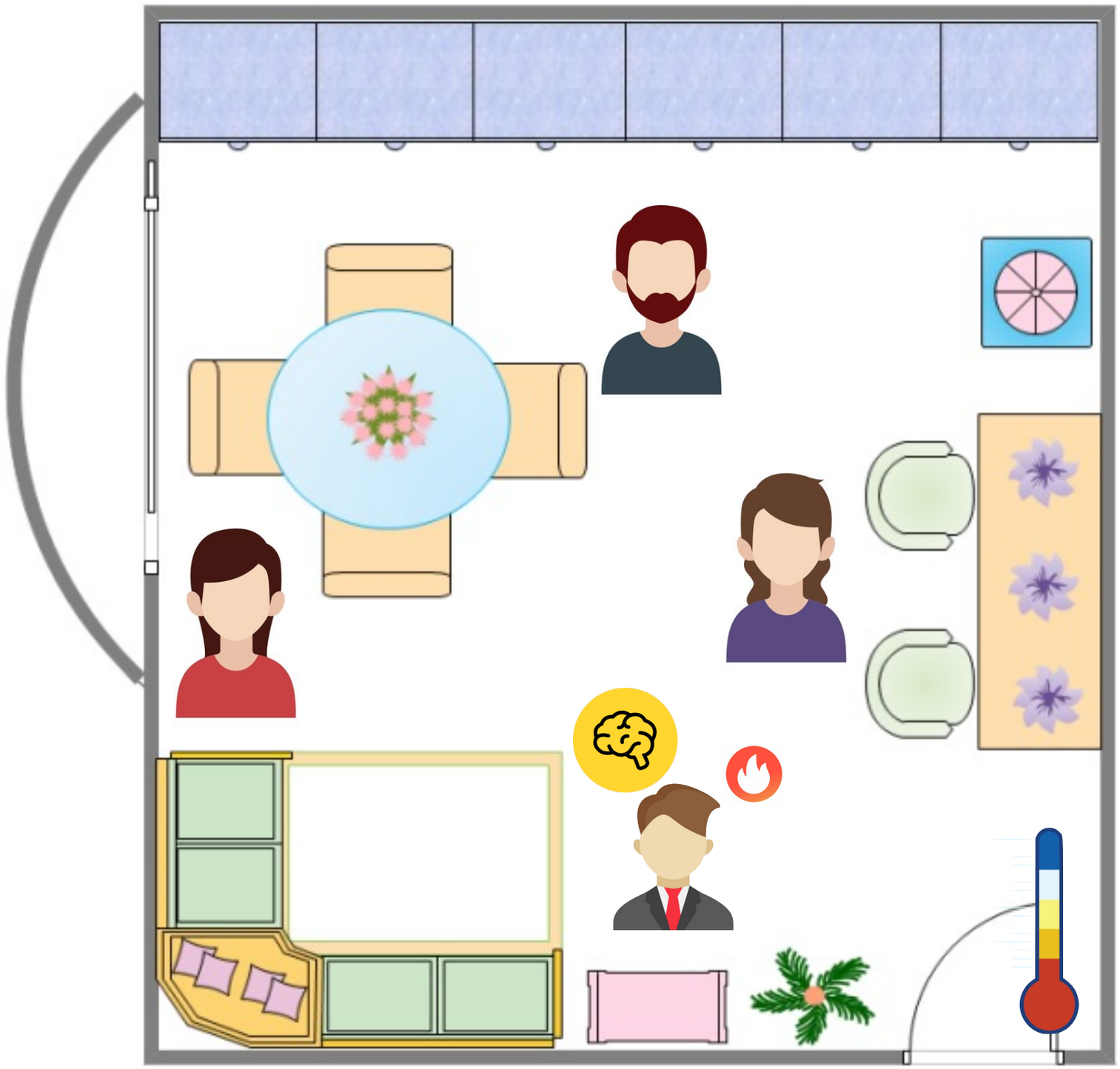
Hard for the fingers to move in complete isolation
Signal drifts over time
Each person will move their fingers a bit differently
The sensor also degrades over time

This is where machine learning comes in




Data
Structured Data
Machine Learning Model
Thumb
Index Finger
Middle Finger
...
Sensor

Another example



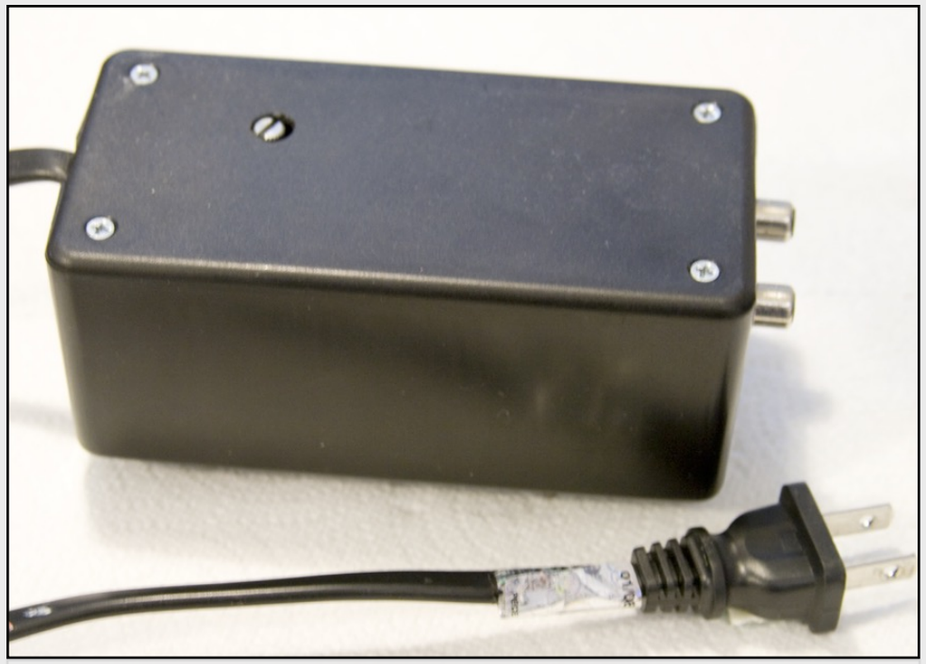
When do we need to combine machine learning and sensing?

- Finding a stable and generalizable threshold is hard

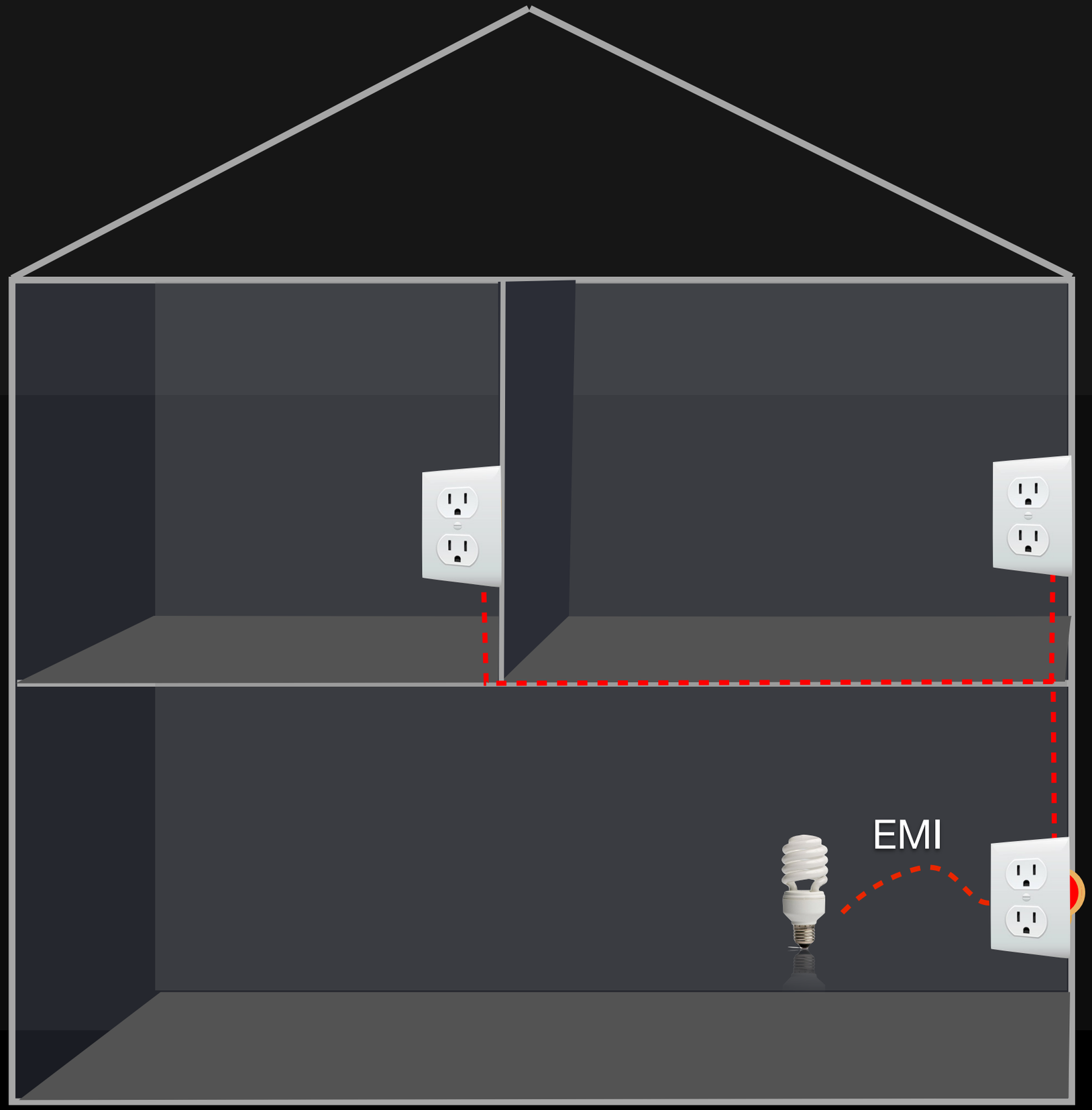
- The sensor is not designed to measure the exact phenomenon


refrigerator
microwave
coffee maker
Froehlich, Gupta, Larson et al.

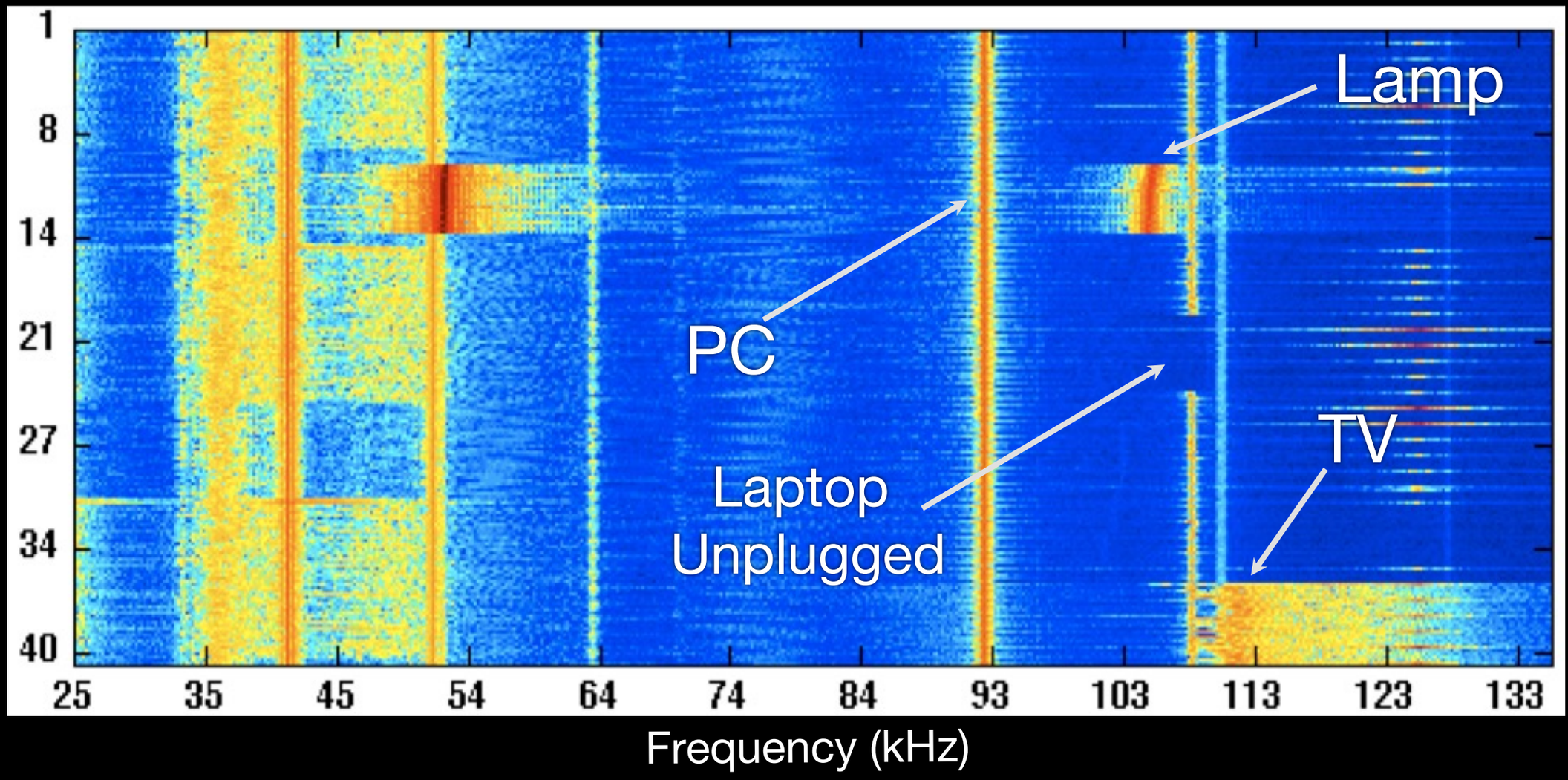
Single Sensor



Froehlich, Gupta, Larson et al.



Froehlich, Gupta, Larson et al.



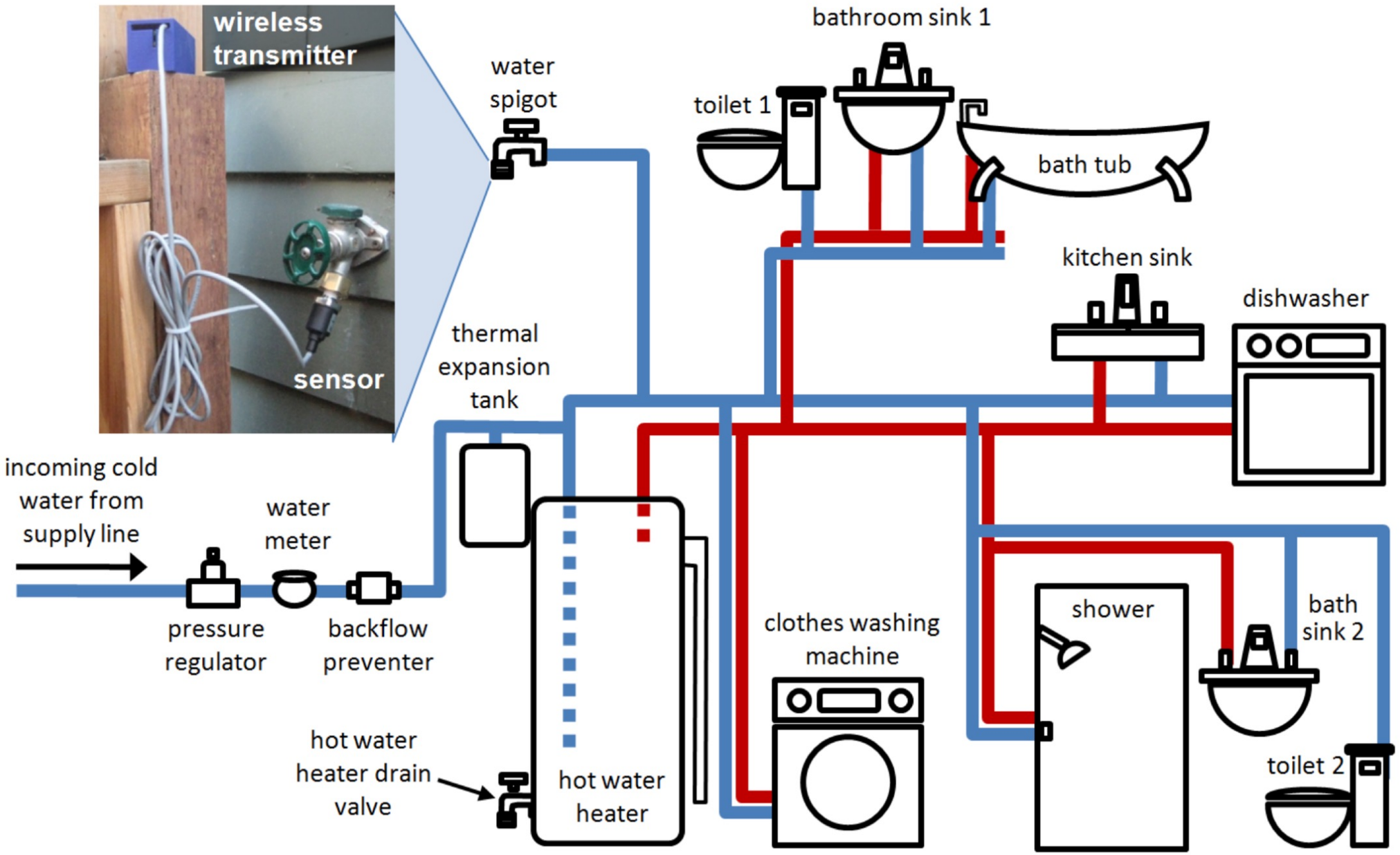
Froehlich, Gupta, Larson et al.

Froehlich, Gupta, Larson et al.

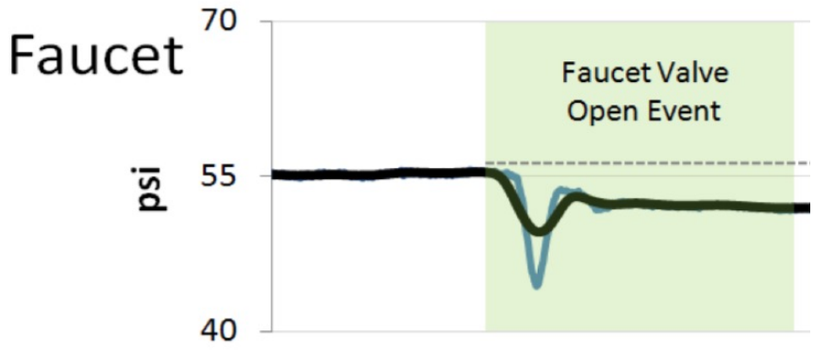
Logistics

- Lecture Video Recording posted
- New TA, Ashley (ababjac@vols.utk.edu)
- Discussion posted
- Office Hours (still deciding)
- Any other?

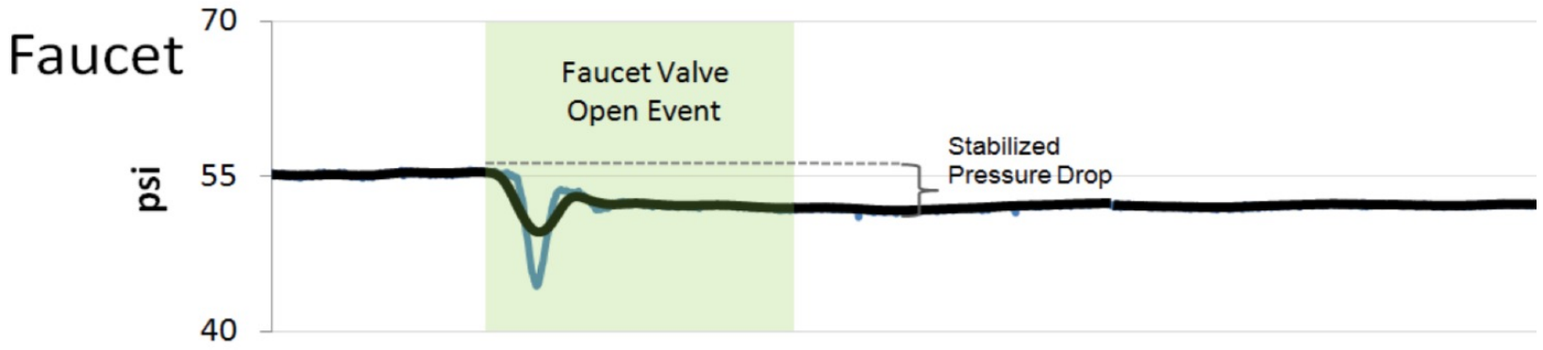
Similarly for water



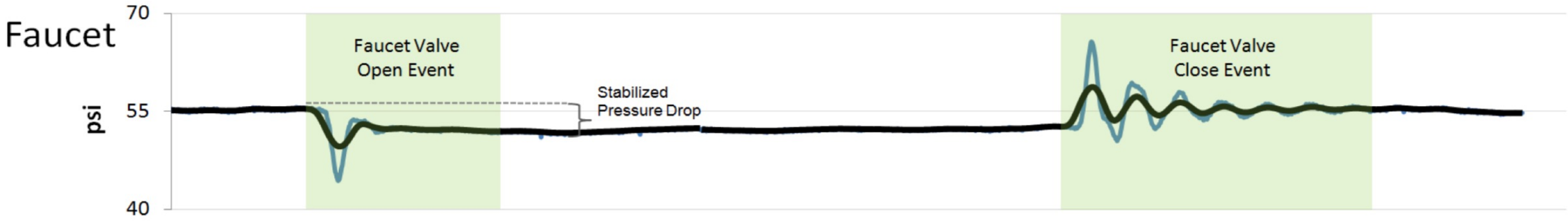
Froehlich, Larson et al.



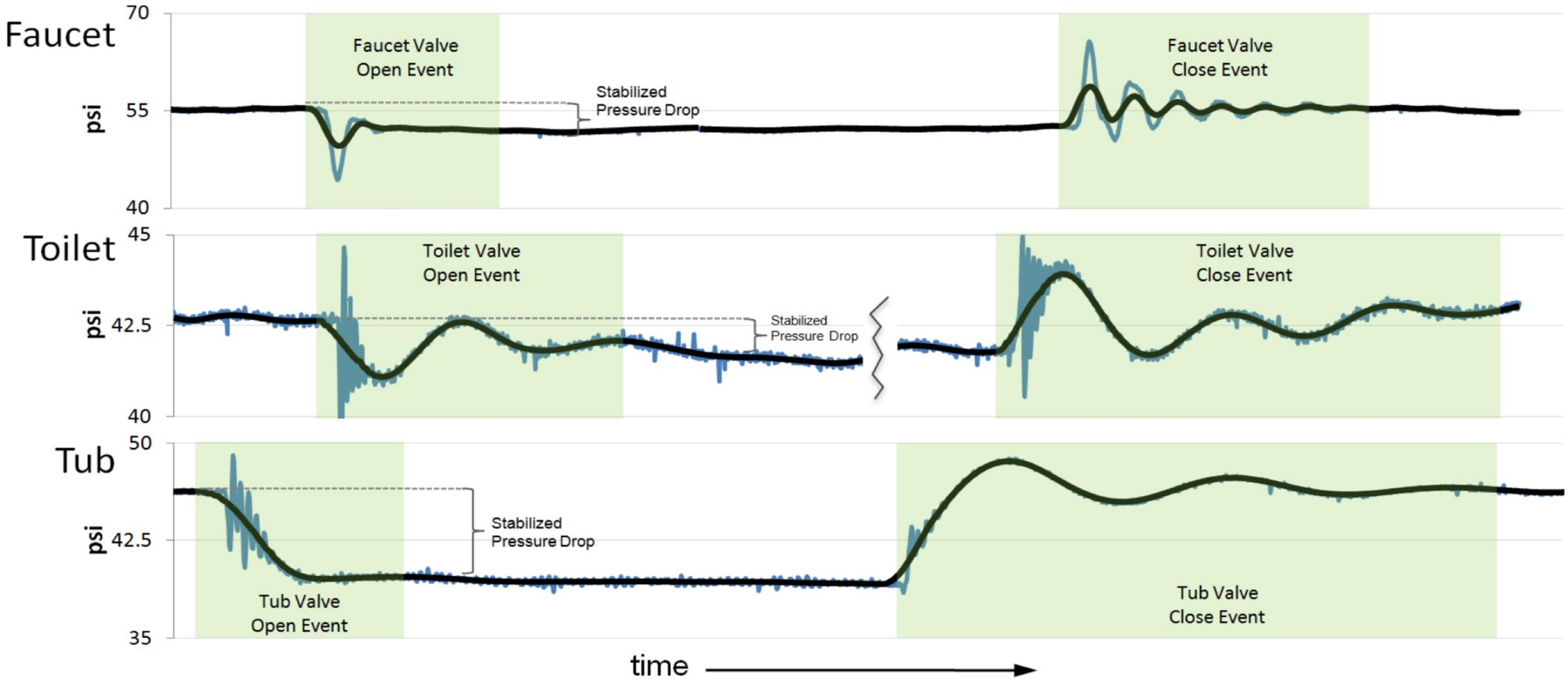
time

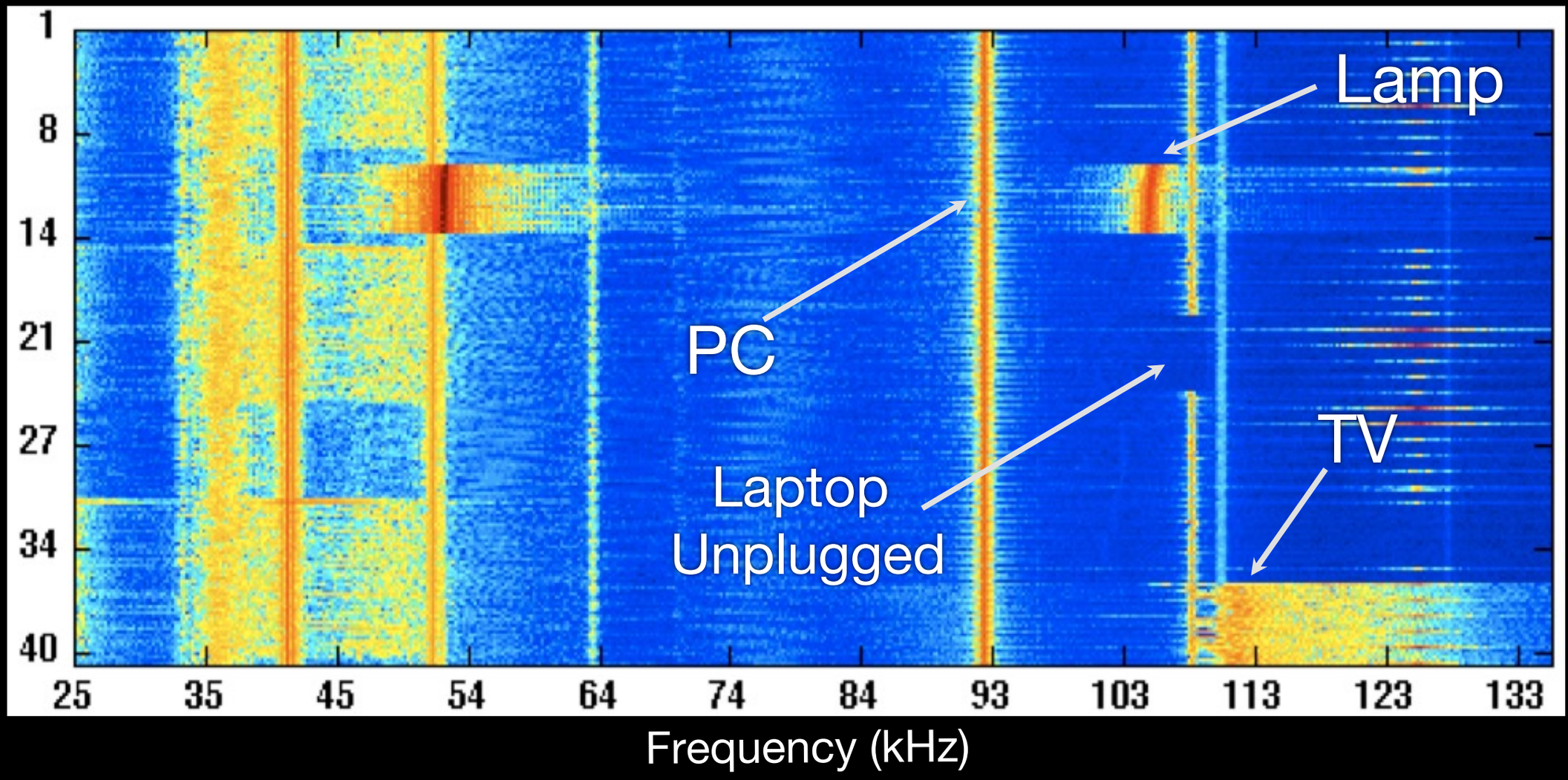

Faucet
70
55
40
psi
Faucet Valve
Open Event
Stabilized
Pressure Drop

time


Faucet
psi
70
55
40
Faucet Valve
Open Event
Stabilized
Pressure Drop
Faucet Valve
Close Event

time


Faucet
70
55
40
psi
Faucet Valve
Open Event
Stabilized
Pressure Drop
Faucet Valve
Close Event
Toilet
45
42.5
40
psi
Toilet Valve
Open Event
Stabilized
Pressure Drop
Toilet Valve
Close Event
Tub
50
42.5
35
psi
Stabilized
Pressure Drop
Tub Valve
Open Event
Tub Valve
Close Event
time



Froehlich, Gupta, Larson et al.

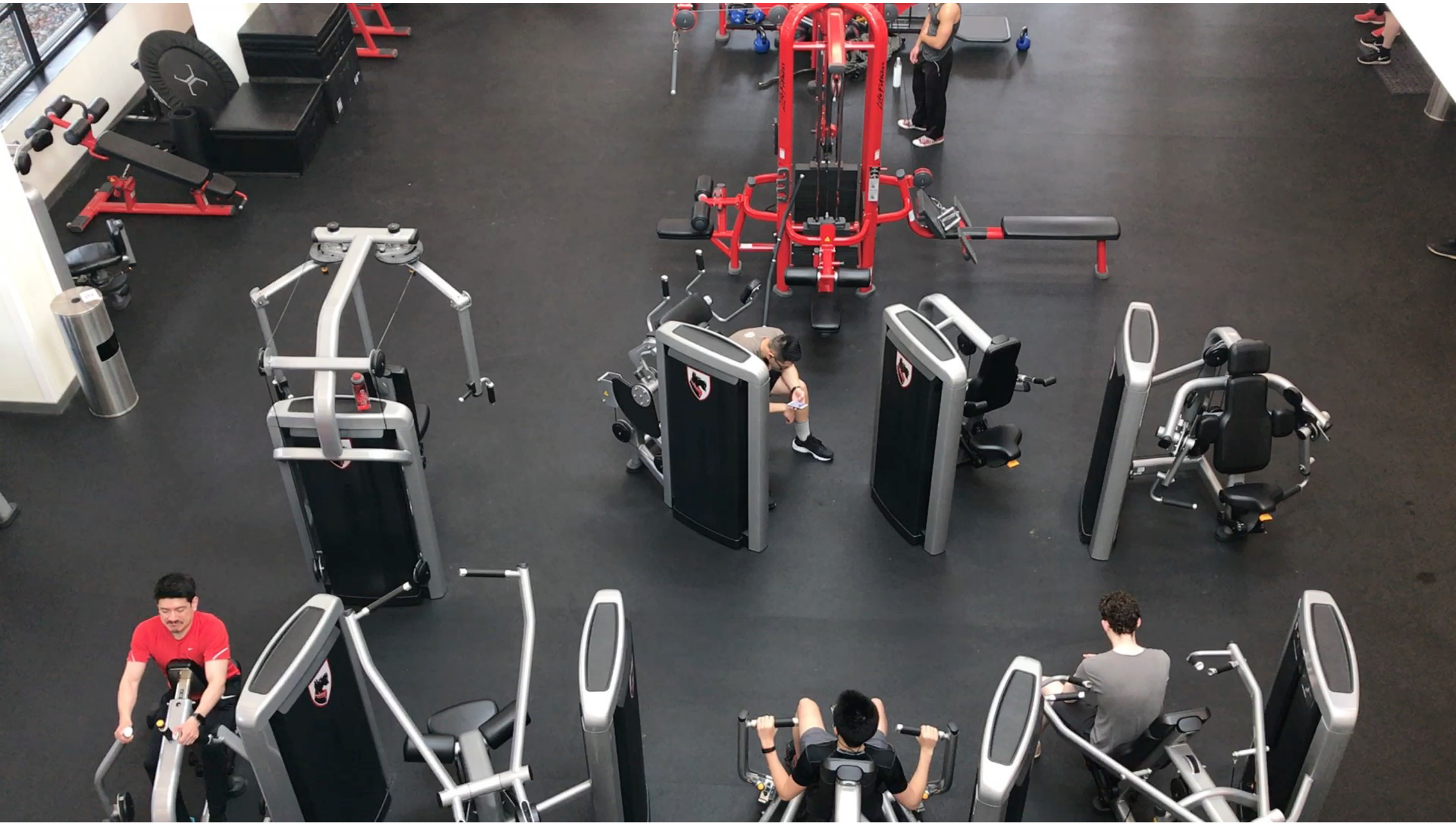
When do we need to combine machine learning and sensing?

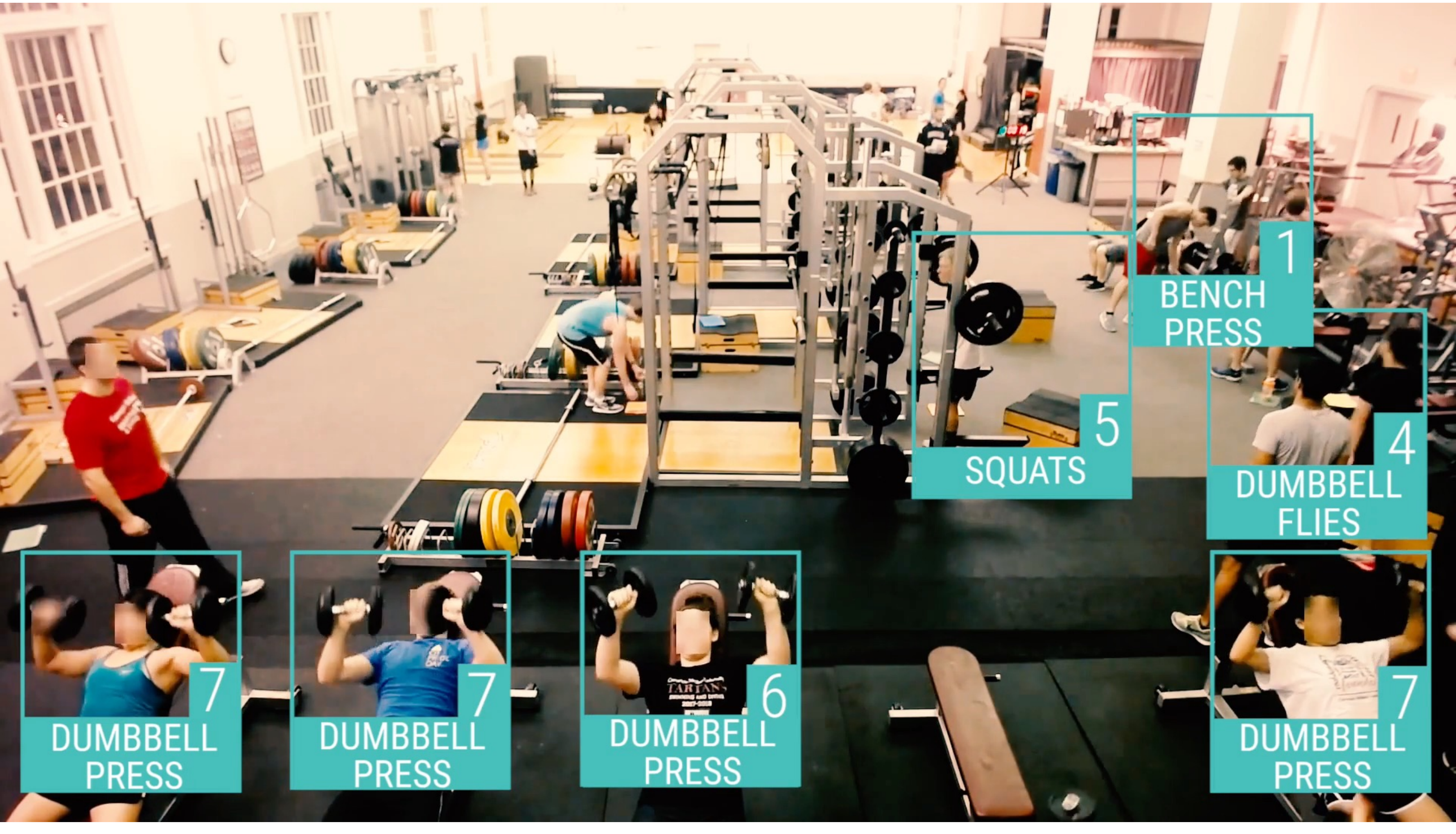
- Finding a stable and generalizable threshold is hard
- The sensor is not designed to measure the exact phenomenon

What are the advantages?

- New capabilities
- Single-point sensing

Single-Point Sensing in the Gym




1
BENCH PRESS
5
SQUATS
4
DUMBBELL FLIES
7
DUMBBELL PRESS
7
DUMBBELL PRESS
6
DUMBBELL PRESS
7
DUMBBELL PRESS

When do we need to combine machine learning and sensing?

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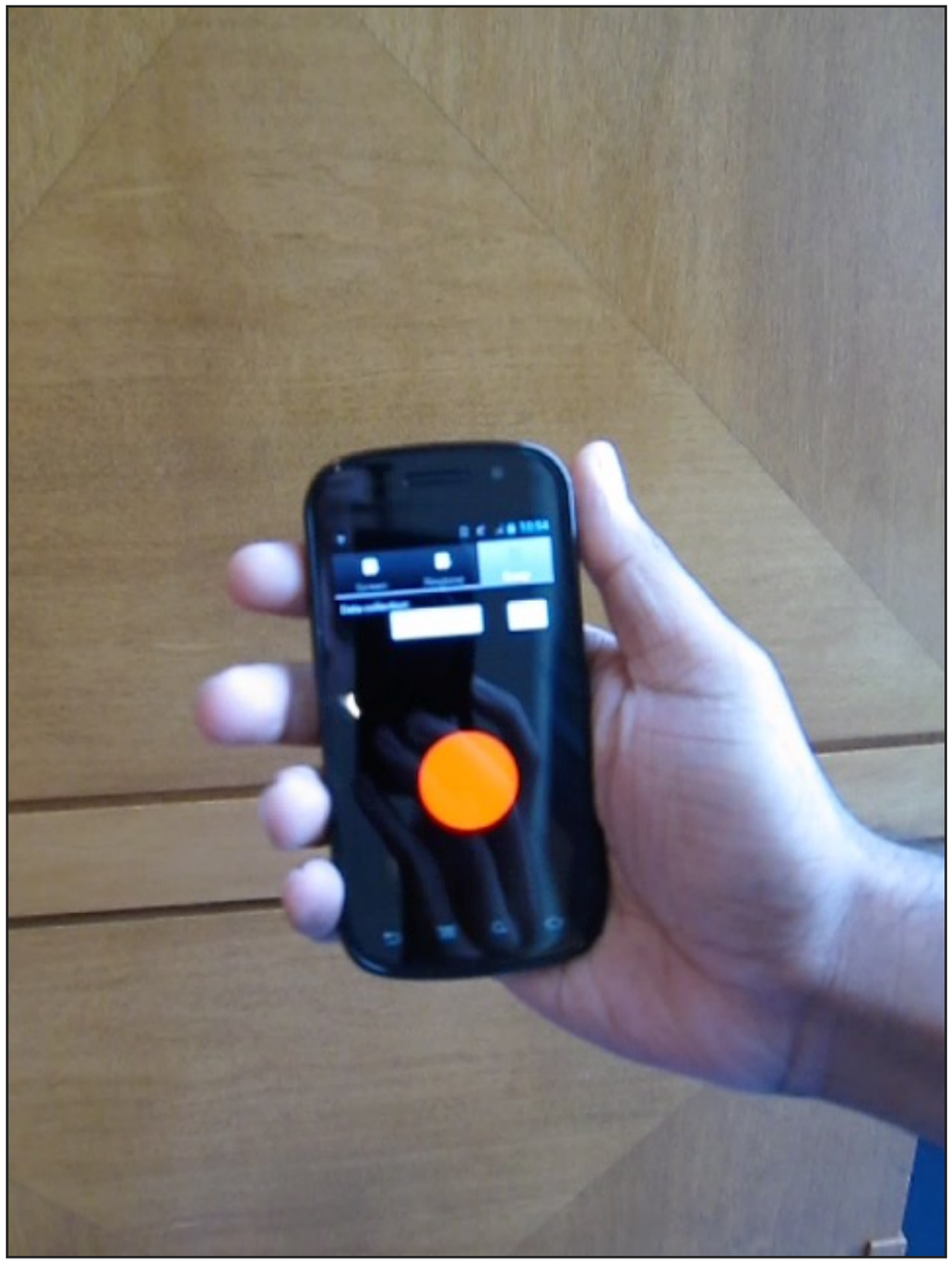
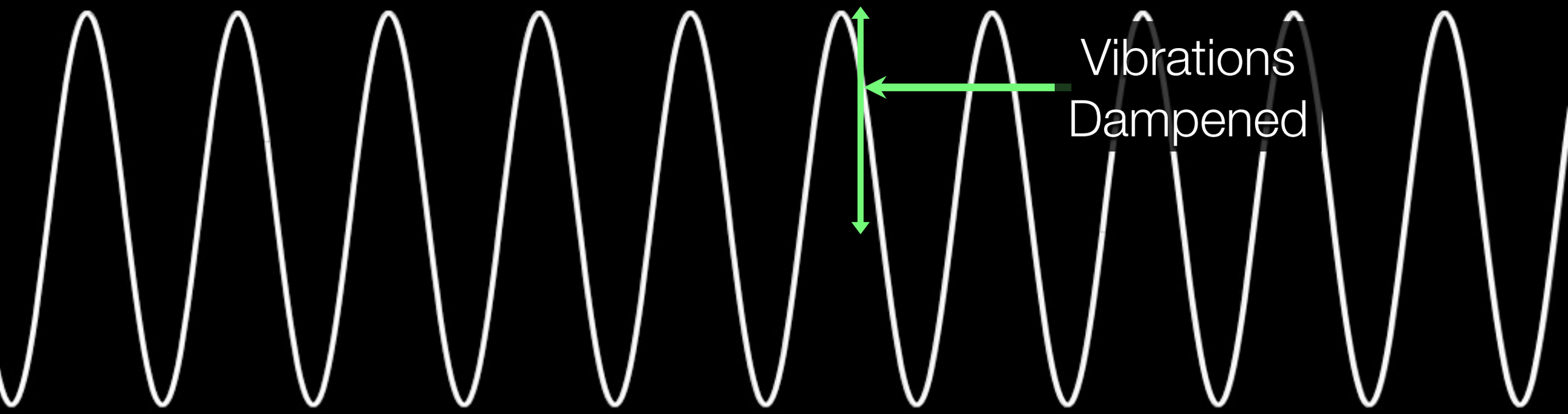
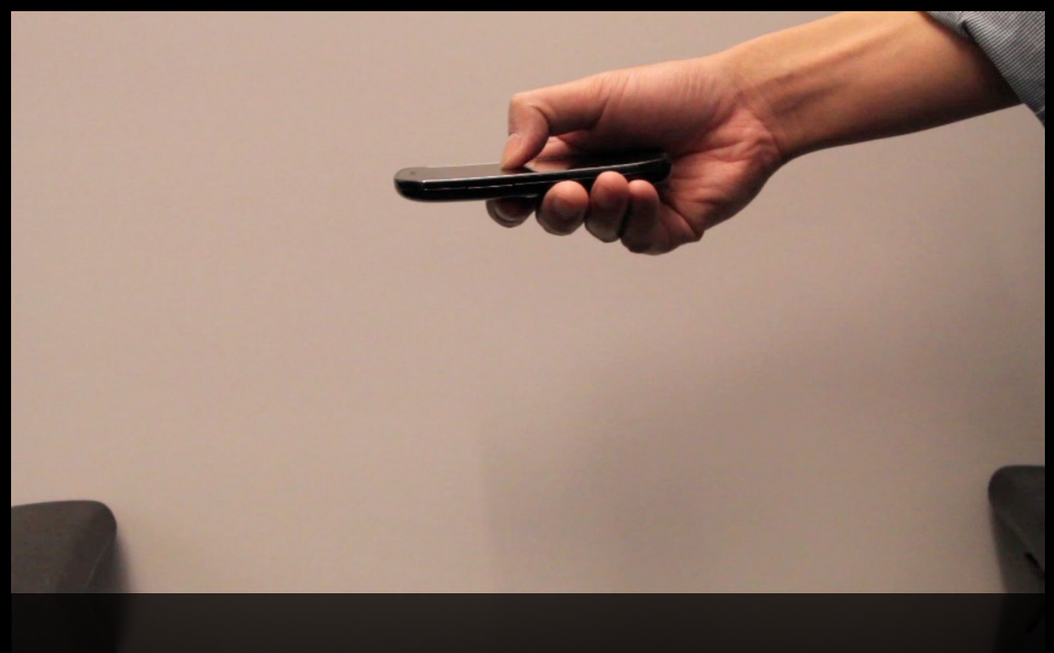
- Single-point sensing
- Ability to use existing sensors



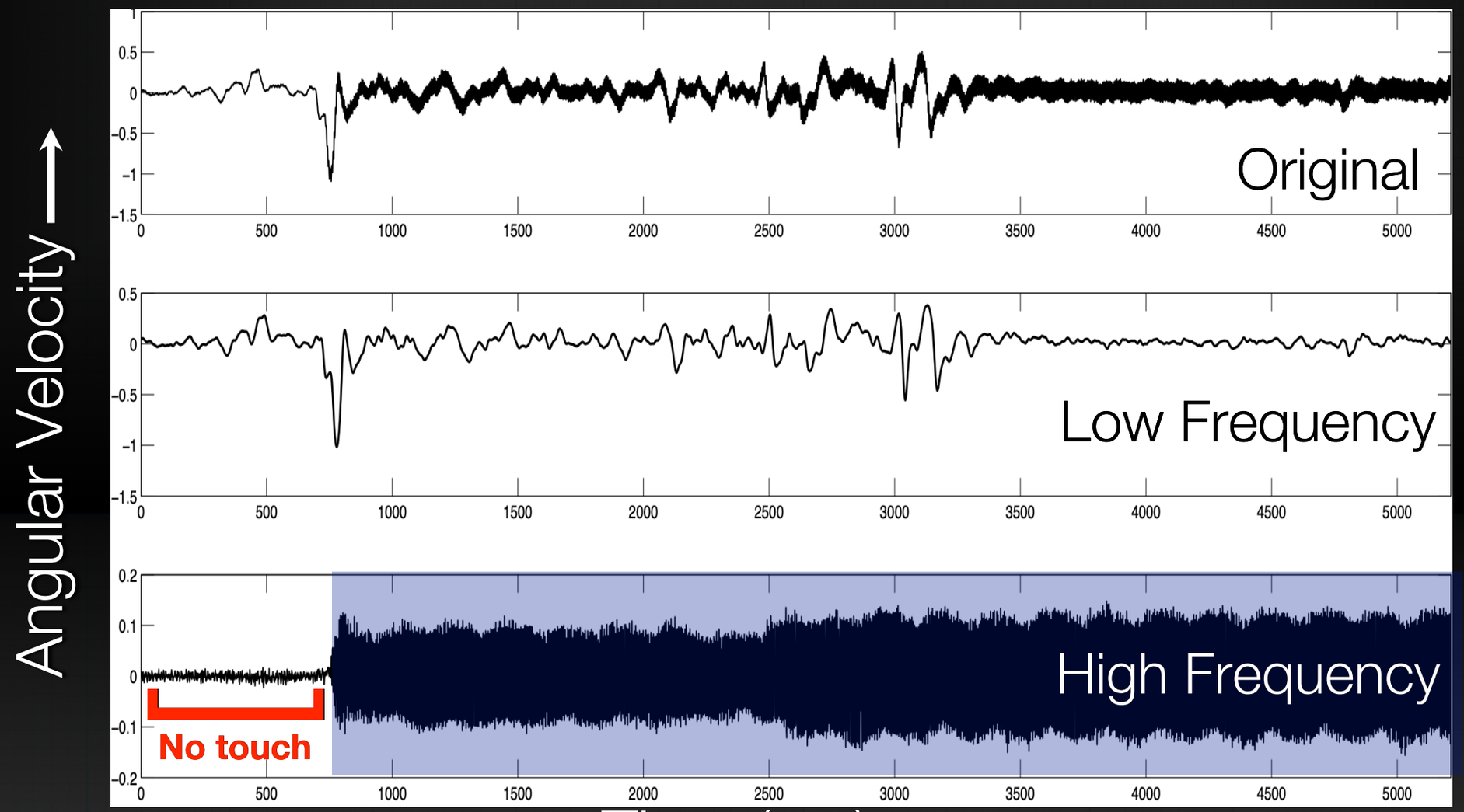
Pressure Detection

Pressure Detection

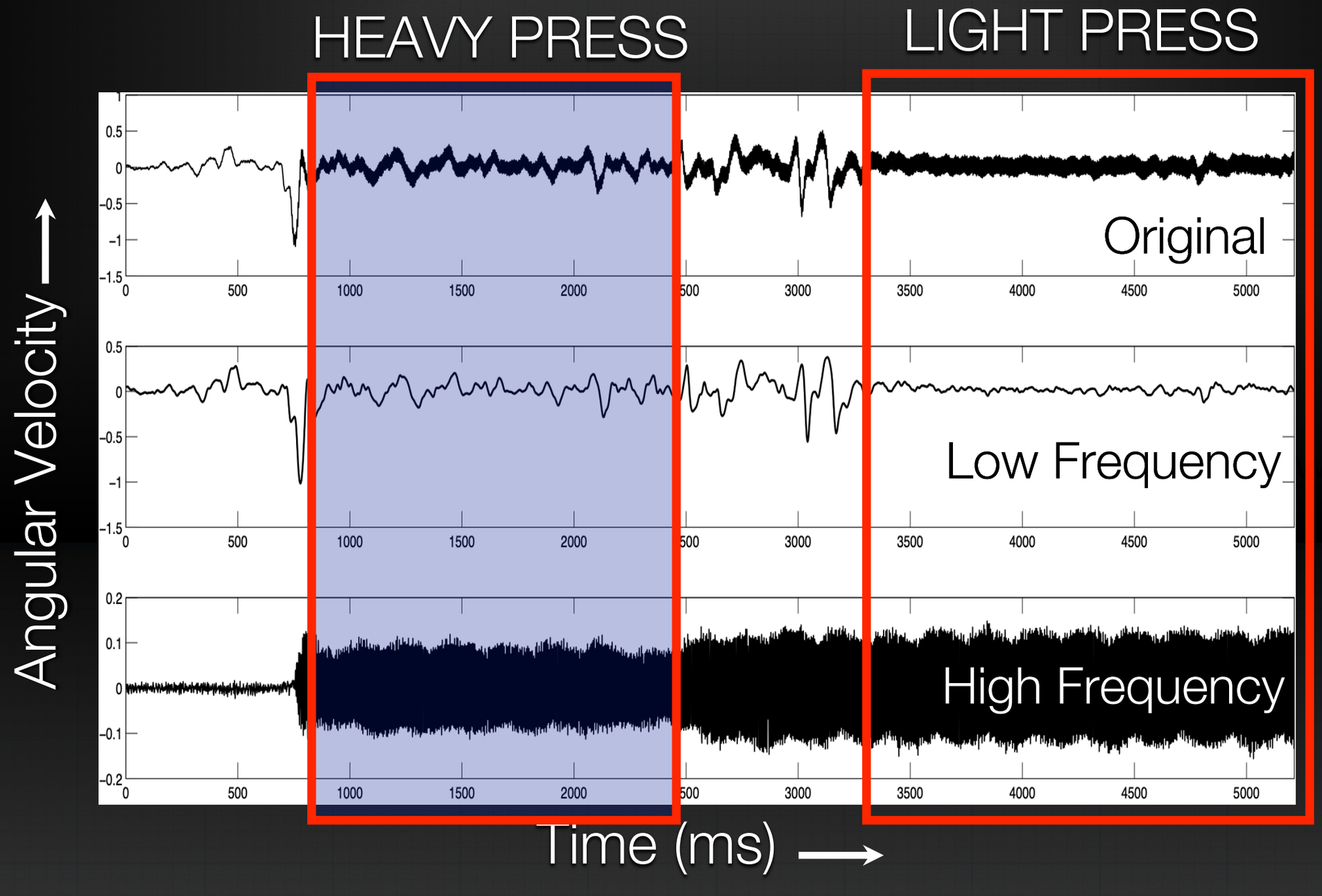




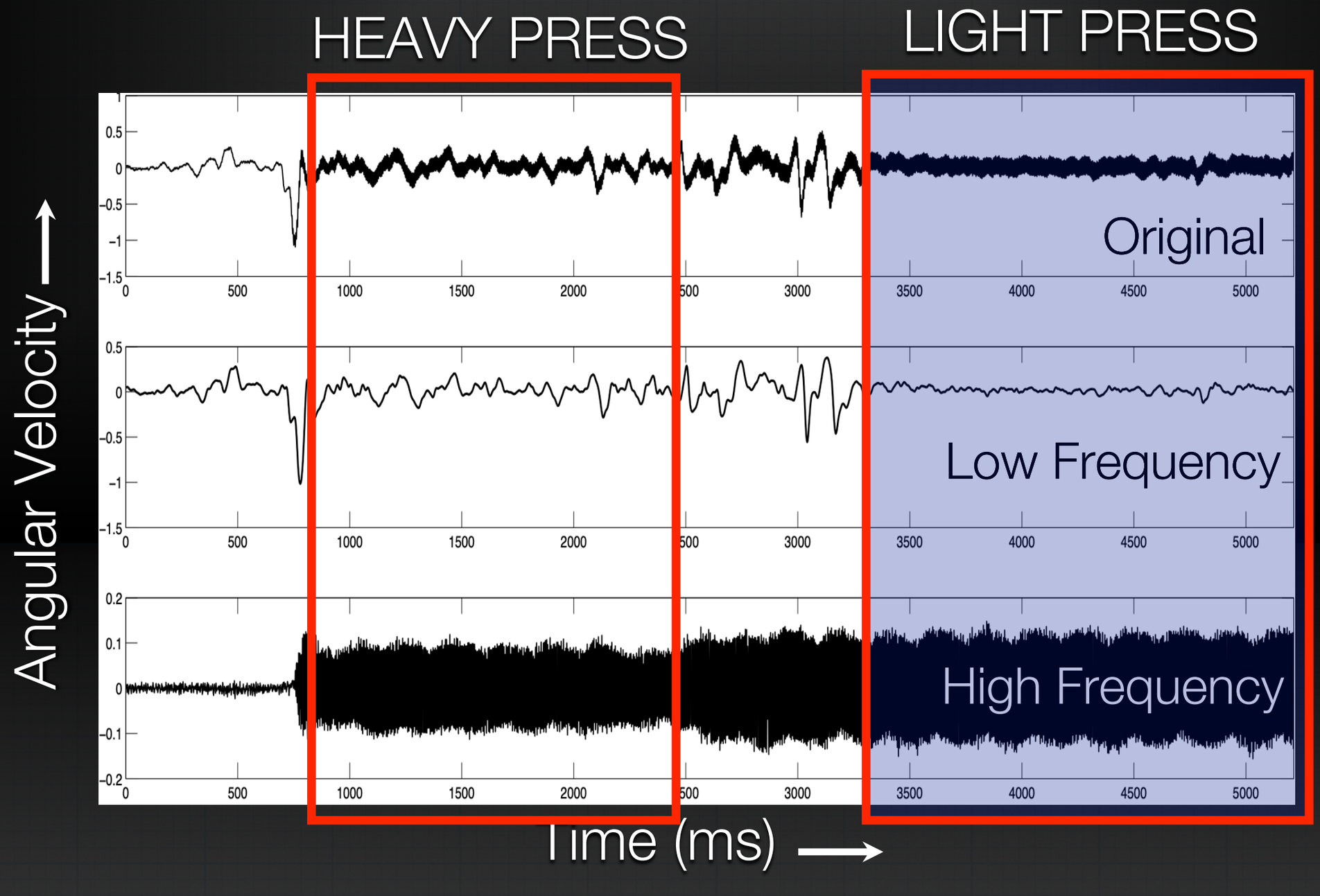
Pressure Detection

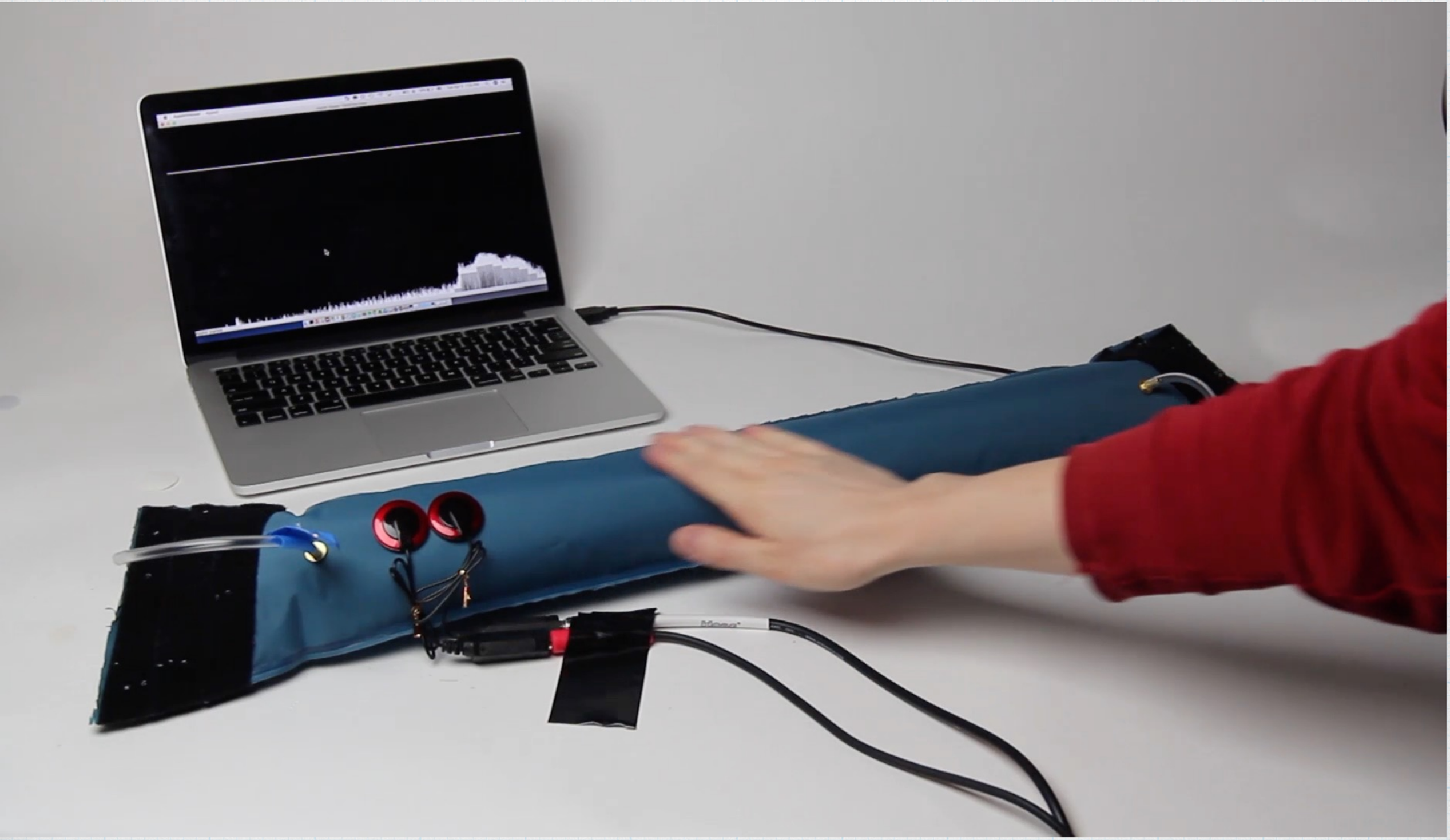


Pressure Detection



Pressure Detection



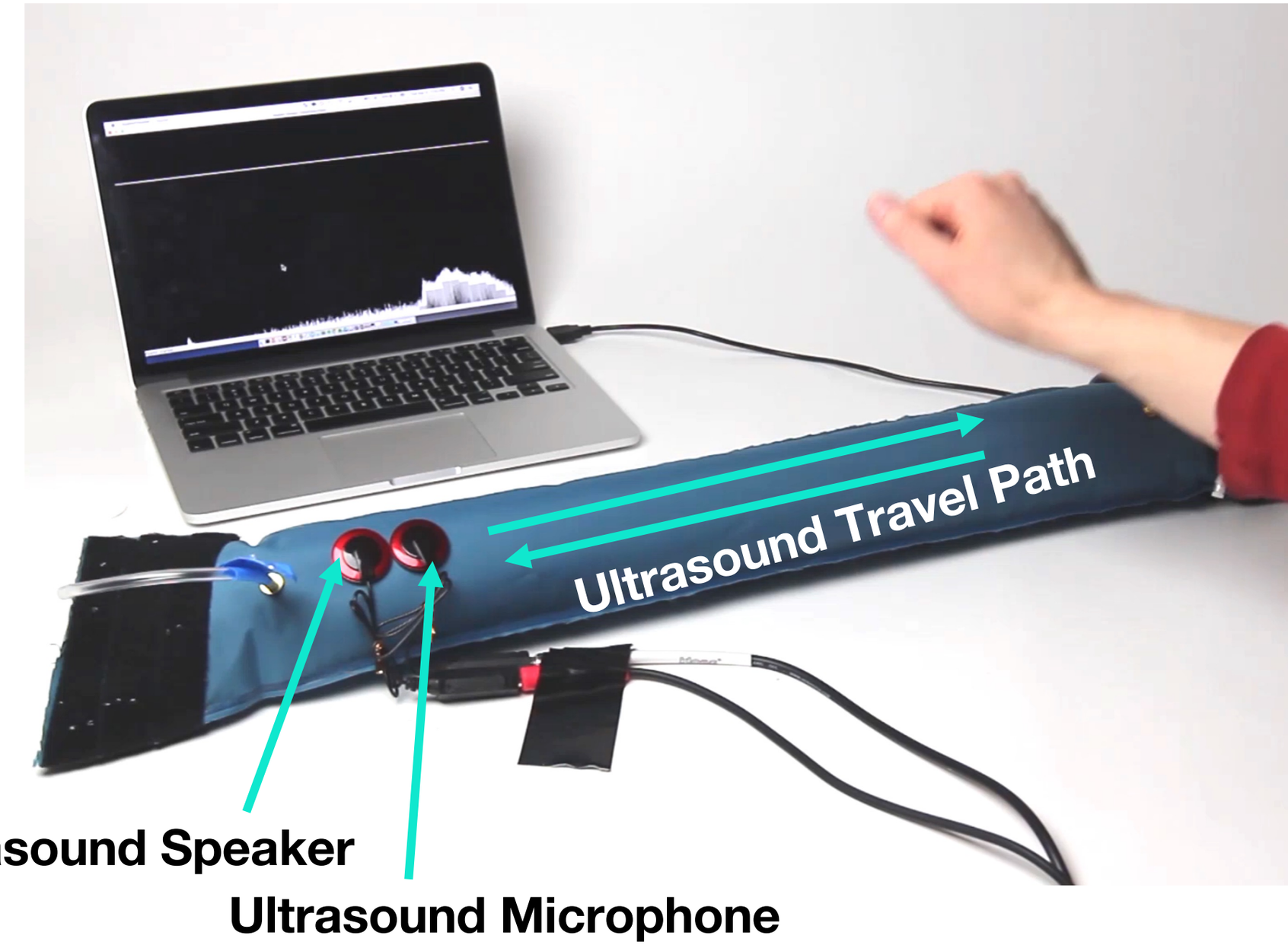


Training AI models on Inflatable Trusses

1. 18-24 kHz ultrasonic sweep from speaker microphone

2. Internal configuration of truss attenuates signal during human interaction

3. Train Classical Machine Learning (AI) models for prediction



Ono et al. 2013

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What are the advantages?

- New capabilities
- Single-point sensing
- Ability to use existing sensors
- Combining multiple sensors