Through Body Communication

CSE 599 N1: Modern Mobile Systems

modernmobile.cs.washington.edu

Content borrowed from Mehrdad, Jon Froehlich, Alex Mariakakis,

Assignment 1: Step Counter

- Collect accelerometer data
- Record it to external storage
- Perform Signal Processing to clean the data
- Count the steps

Tools required

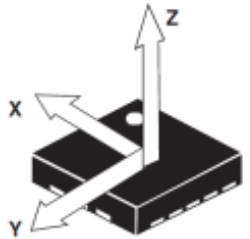
- Android Studio
- Matlab – Use CSE servers https://www.cs.washington.edu/lab/software/matlab

or

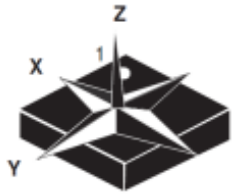
- GNU Octave

Inertial Measurement Unit

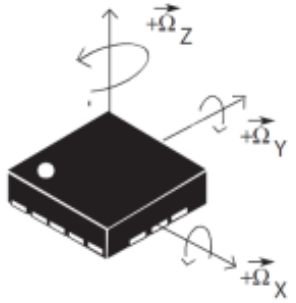
- Accelerometer – Linear Acceleration along the 3 axis
- Gyroscope – Angular rotation along the 3 axis
- Magnetometer – Measure the Earth's magnetic field



Acceleromter



Magnetometer



Gyroscope

1) Collect Accelerometer data

- Setup Android environment

https://developer.android.com/studio/

- Use SensorManager API

https://developer.android.com/guide/topics/sensors/sensors_overview

- Use high sampling rate

- Make sure you have added permissions to access sensors and external storage

Signal Processing

- Sample signal

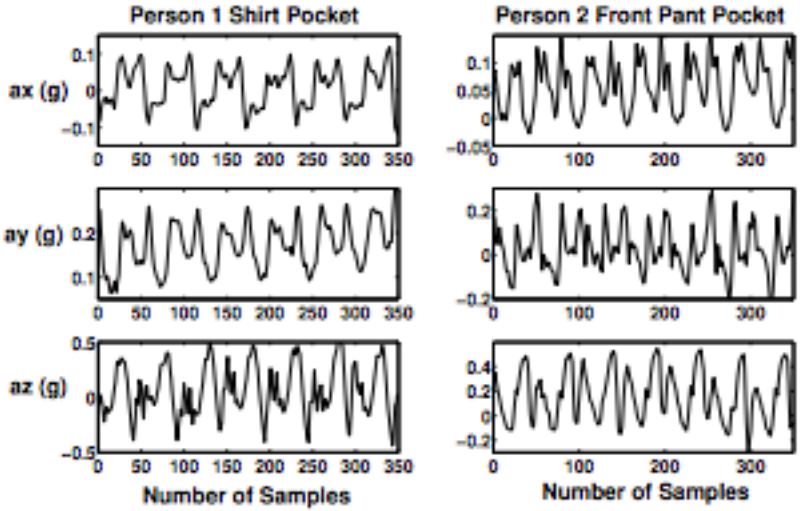
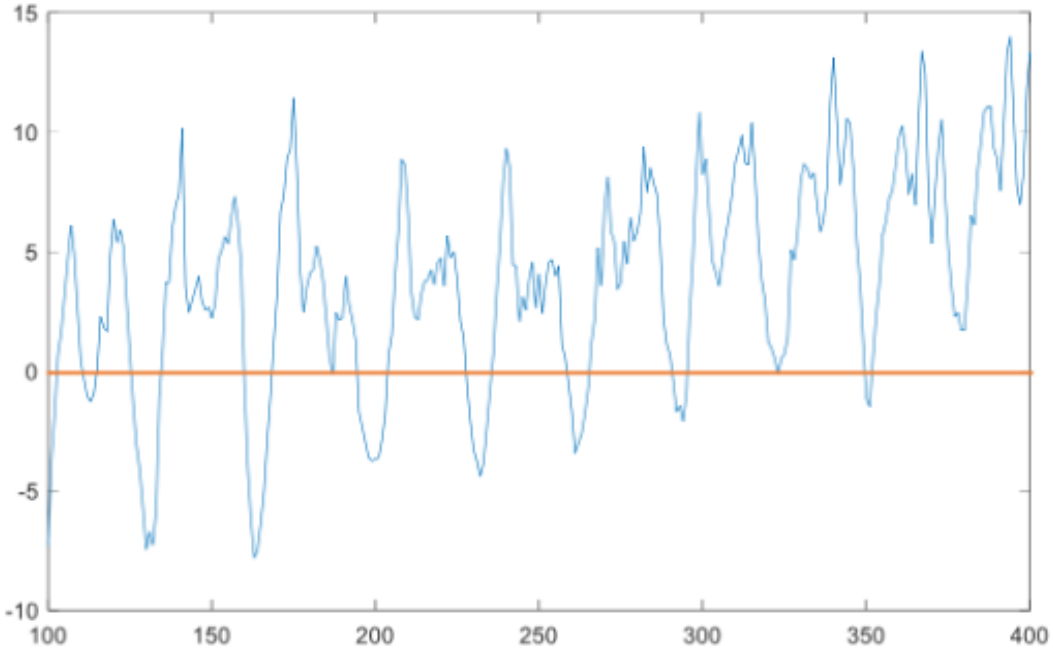


Figure 4: Walking is repetitive

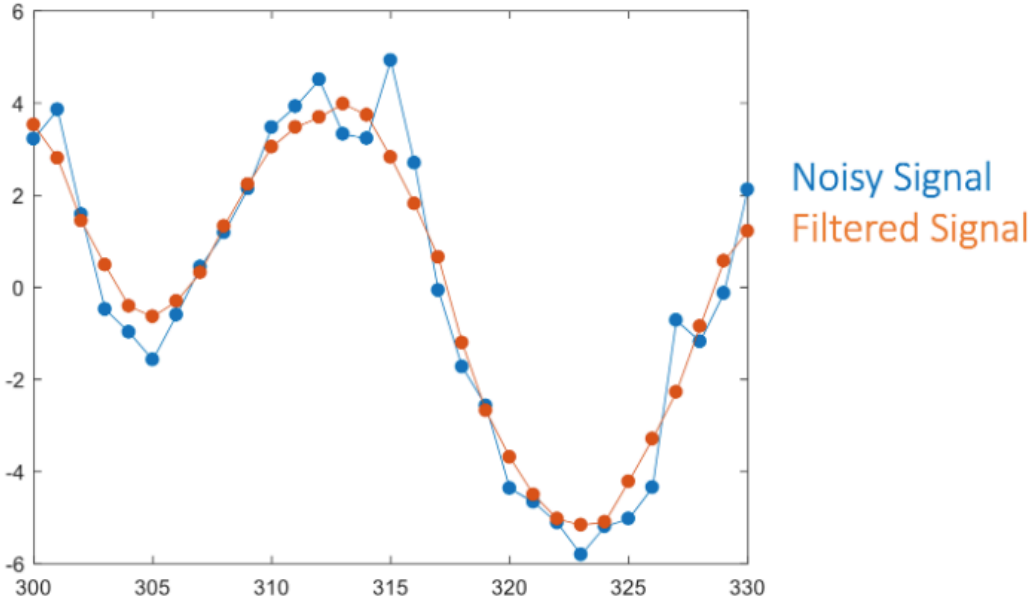
Signal Processing functions

- There will be signal drift.
- Simple zero crossing might not work



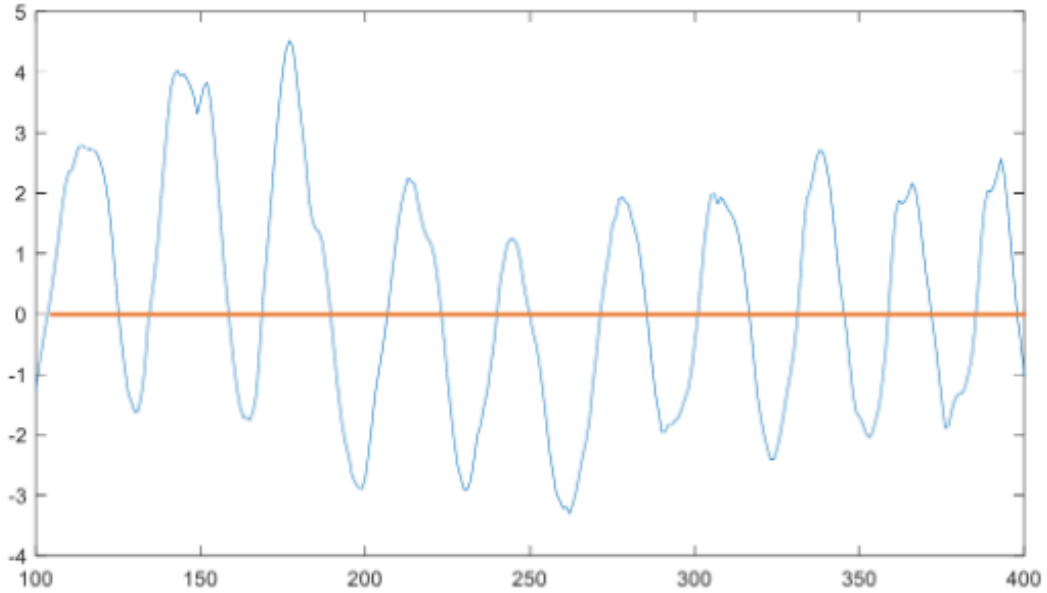
Signal Processing functions

- Signal will be noisy
- Apply Smoothing – moving average filter
- You need to determine the filter window



Apply zero crossing

- After smoothing



Smoothed signal.

Skintrack: Using the Body as an Electrical Waveguide

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Device Setup

Transmitter

Ring transmitting 80 Mhz

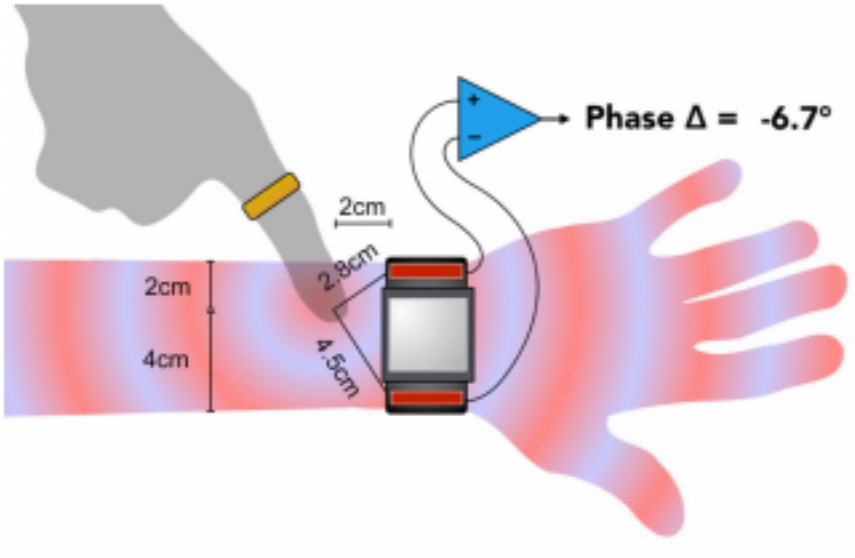
Speed: 7.3 x 10^7

Wavelength: (7.3*10^7)/(80 * 10^6) ~ 91 cm

4 degrees for each cm change

Receiver

Sensor band with gain and Phase comparator chips



Machine Learning

- Step 1: Identify Features
- Step 2: Select Appropriate model
- Step 3: Split training and testing steps

Features

- 4 gain ratios and 4 phase differences
- Differences between each pair of above 8 values
- Mean, median, min, max, std, Sum

Step 2: Select appropriate model

Regression

Maps features to continuous output values

Q: What is the price of this fruit ?

A: 457 cents

Classification

Maps features to categorical output values

Q: Is this an apple or orange

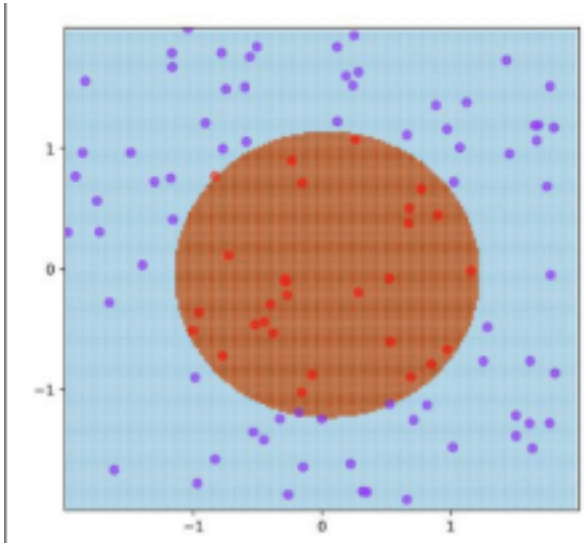
A: Apple

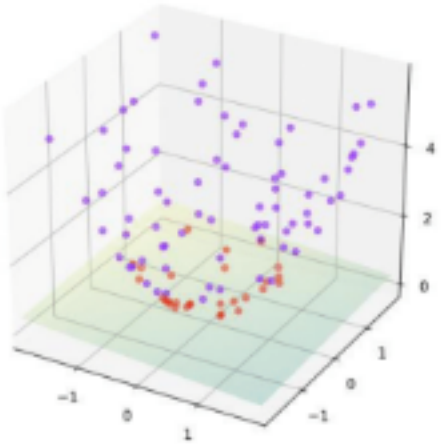
Detecting Touch

- Q: Was there a finger touch ?
- A: Yes or NO

Classification : SVM classifier

Kernel : Radial Basis Function (RBF)

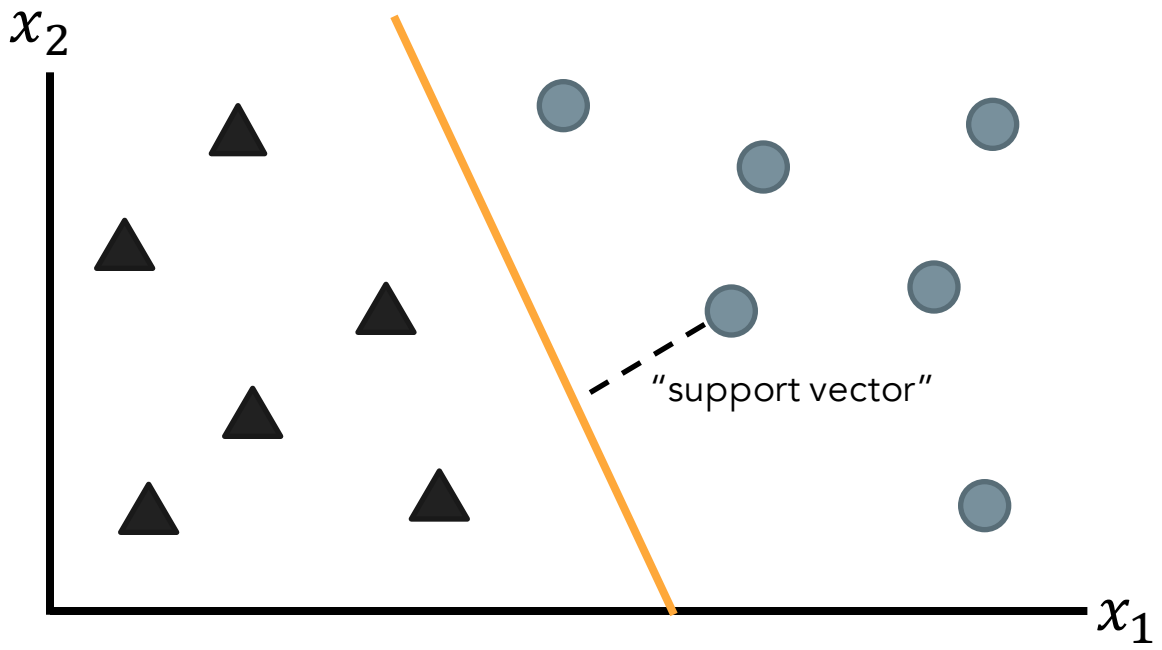




SVM

Separates two different classes with a hyperplane that maximizes separation of classes

$$y \geq w_1 x_1 + w_2 x_2 + \cdots + b$$



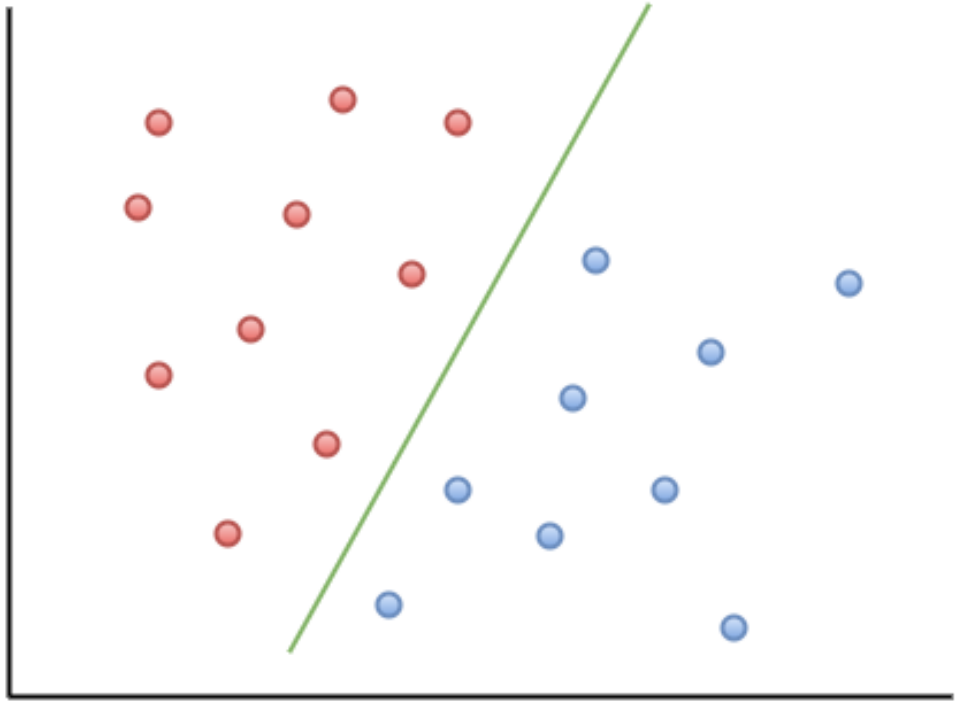
Detecting 2D location

- Q: Where did it touch ?
- A: x,y location

Regression:

SVR – Support vector regression

Kernel – RBF kernel



Skintrack Evaluations

- Stability after removal --- decrease in accuracy
- Cross User --- changes with people
- Level of Training --- more training data better accuracy but are you overfitting ?
- Clothing – does not affect
- Skin moisture --- affects
- Different fingers --- changes the accuracy of touch

Discussions

- Machine Learning vs Signal processing ?
- Pros and cons of the approach
- Compare with other interaction techniques

Enabling on-body transmissions with commodity devices

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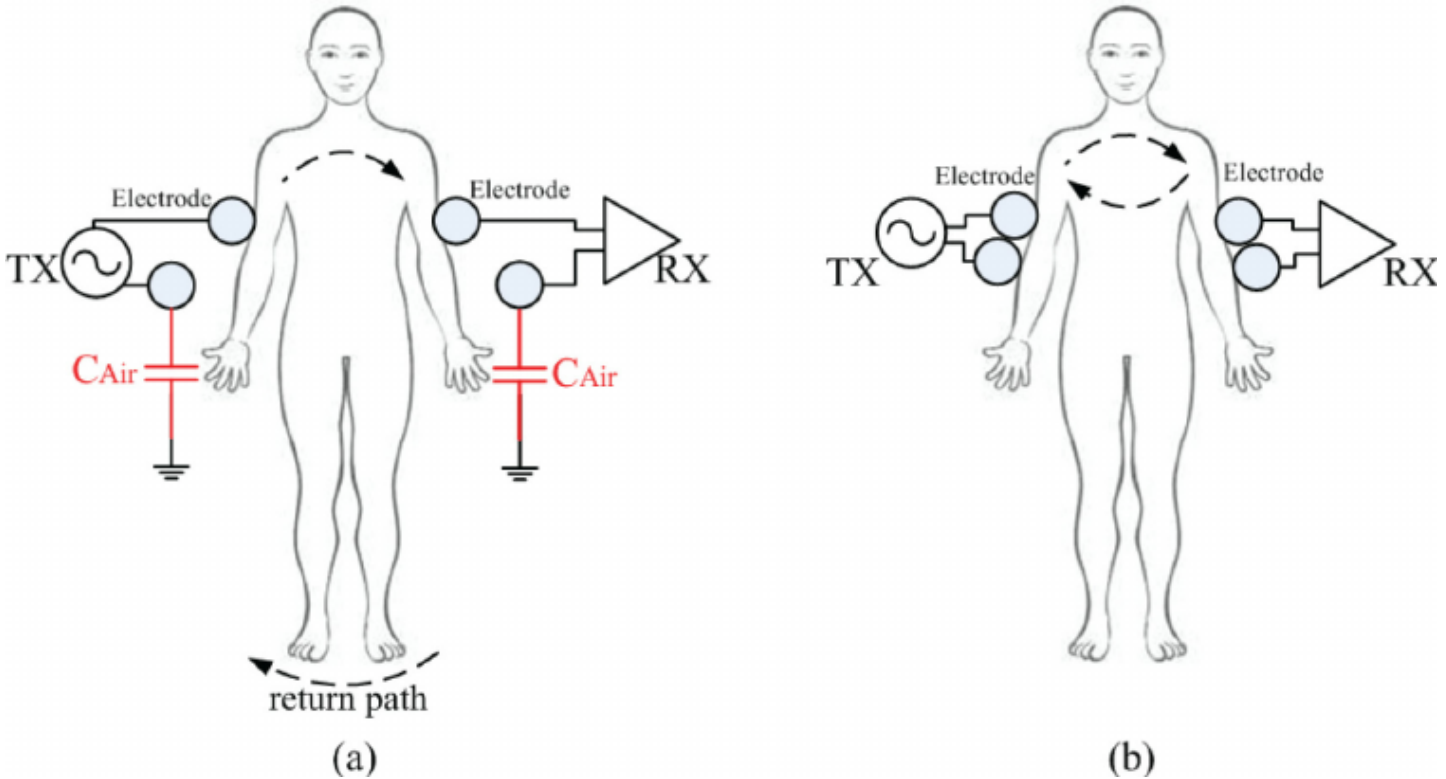
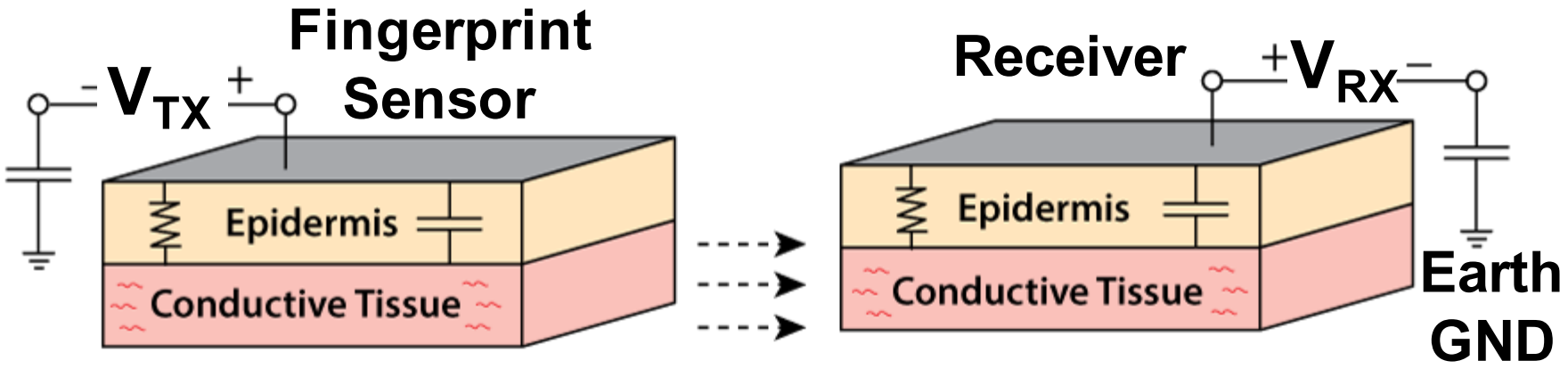
Capacitive Coupling vs Galvanic Coupling

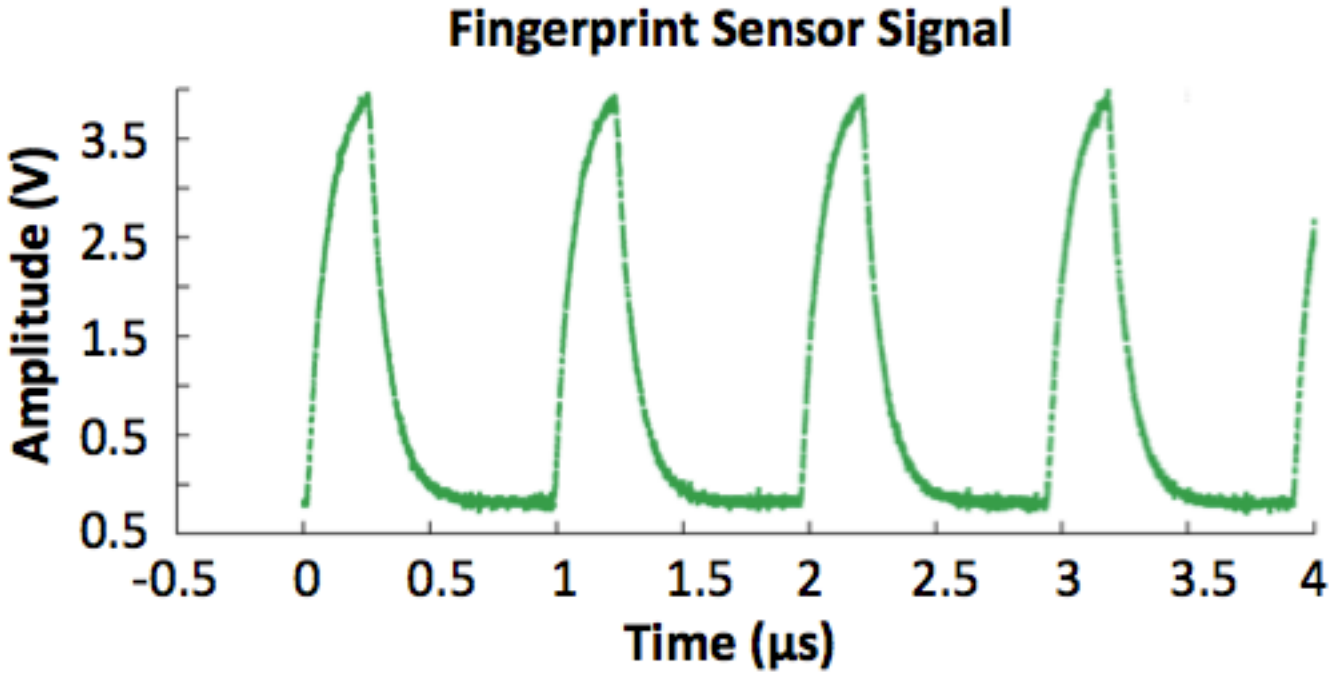


Device setup

Capacitive Coupling

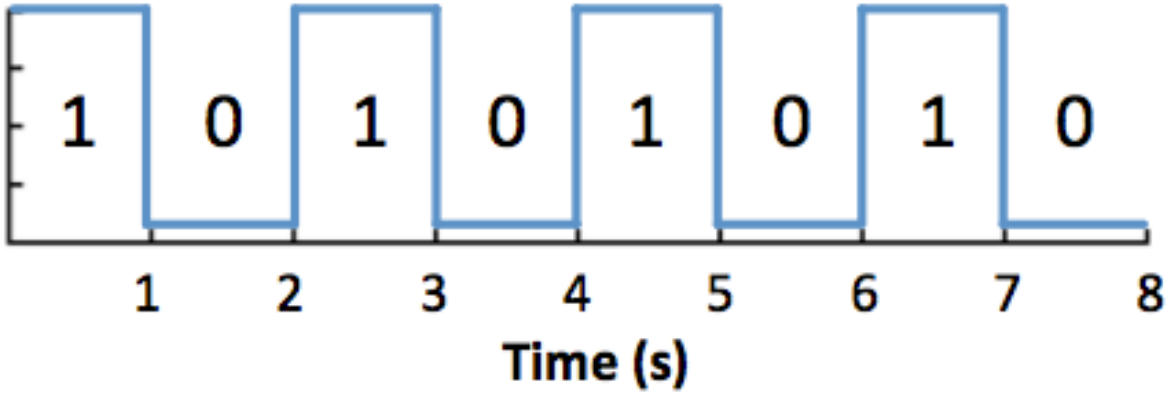


Fingerprint sensors transmit high amplitude signals



Transmitter Design

Modulate data by turning on and off the signal



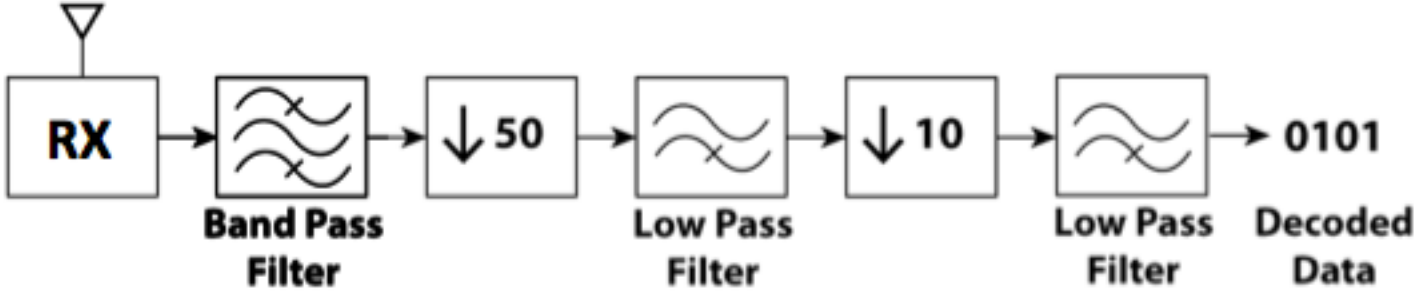
Fingerprint Sensor- Verifi P5100

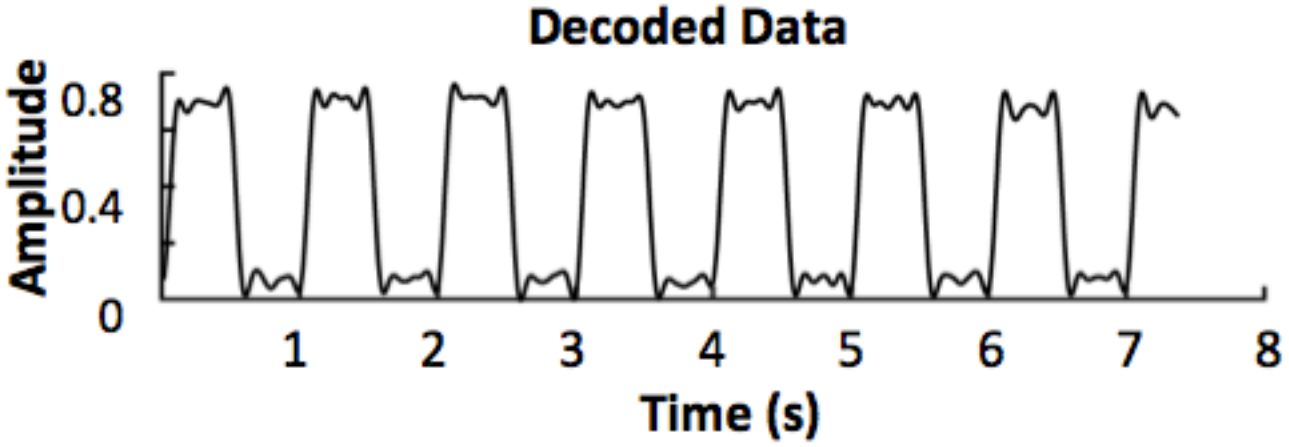
→ Start and stop fingerprint scan

Touchpad- Adafruit Capacitive Touchpad

→ Power cycle the touchpad

Decoding


RX
Band Pass Filter
↓ 50
Low Pass Filter
↓ 10
Low Pass Filter
0101
Decoded Data


Decoded Data
Amplitude
0.8
0.4
0
1
2
3
4
5
6
7
8
Time (s)

Evaluation

- Across the body
- Motion
- Posture
- Height and weight