Hand Gesture Recognition Wristband Based on Resistance Sensing

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Outline

- Introduction
- Methodology
- Exploration of Materials
- Experiments
- Results
- Conclusion
- Q&A

Introduction

- Motivation
- Related work–EMG
- Related work–flex sensor
- Related work–CapBand
- Thesis statement
- Contributions

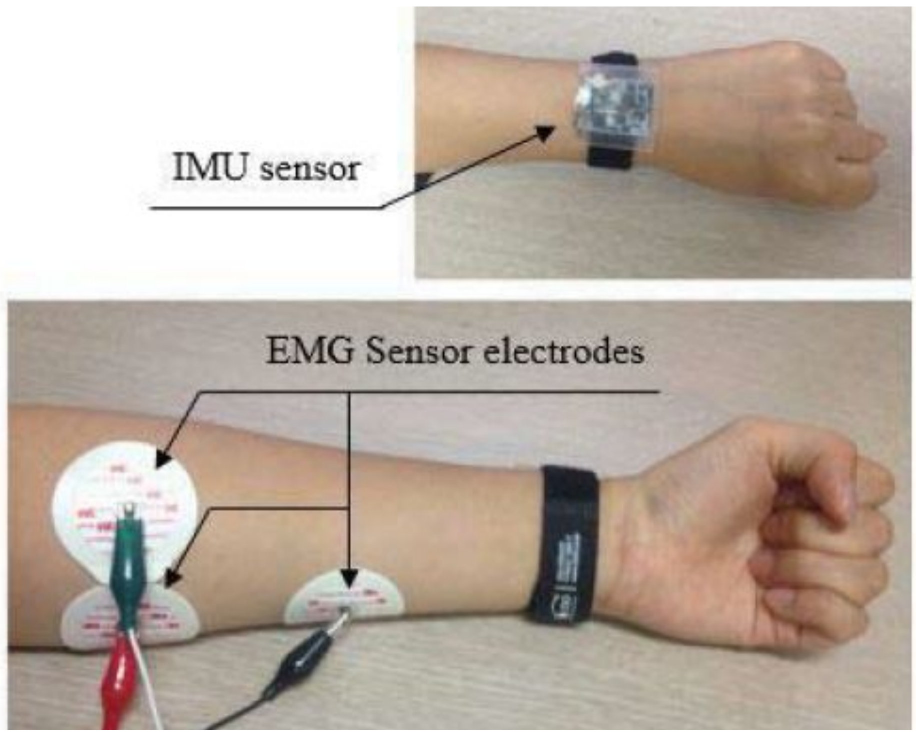
Motivation

Why are current hand gesture recognition systems not suitable for everyday use:

- Vision based:
  - Privacy
  - High compute capacity needed
- Wireless signal based:
  - Low gesture resolution
  - Room-scale recognition
- Wearable devices:
  - Not wearable enough

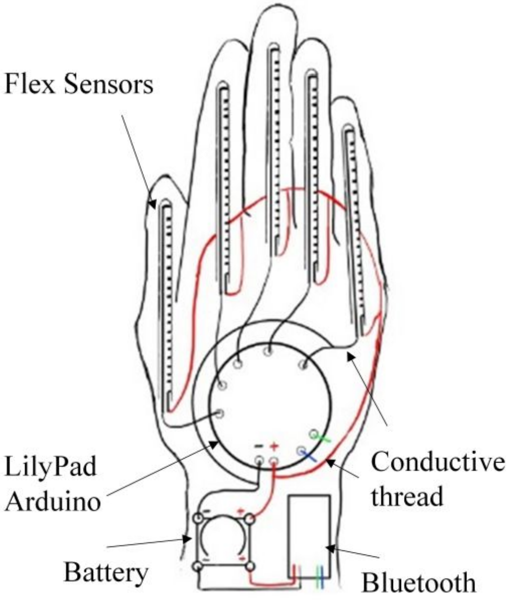
Related Work–EMG[1]

- Sense the neural signal produced by our brain
- Need to attach electrodes on users' skin surface



Related Work–Flex Sensor[2]

- Glove-like system
- Detect the curl and extension of fingers



Related Work–CapBand[3]

Wearable hand gesture recognition wristband

- Capacitance sensing
- Recognize gestures by wrist contour
- Down side:
  - Costly
  - Tight
  - Hard

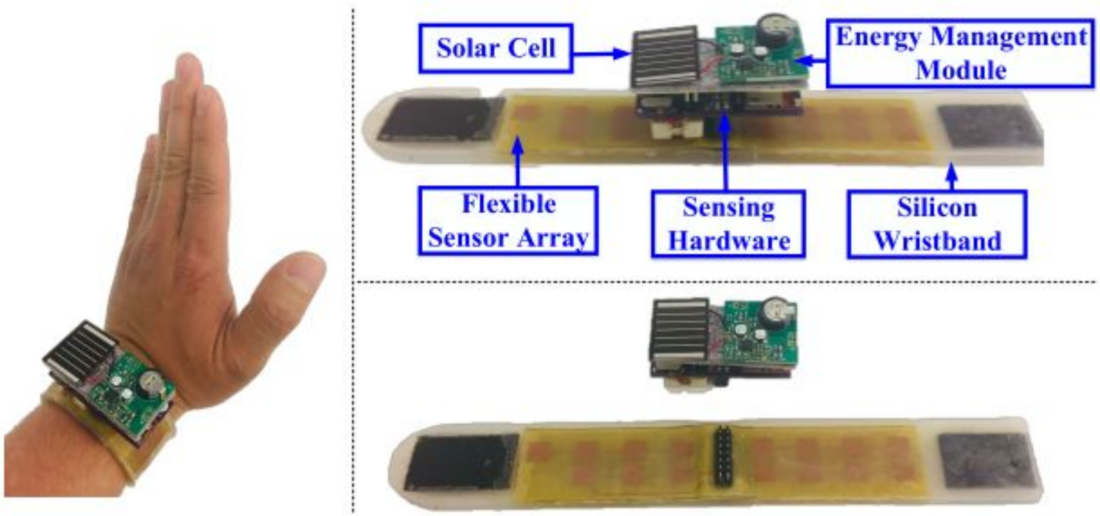


Figure 11: CapBand prototype

Thesis Statement

Goal: a CapBand-like wristband but with lower cost and more comfortable

How:

- Recognize gestures by wrist contour
- Use soft material to make the wristband
- Make wristband with cheaper and simpler structure
  - Denim fabric
  - Conductive rubber cord

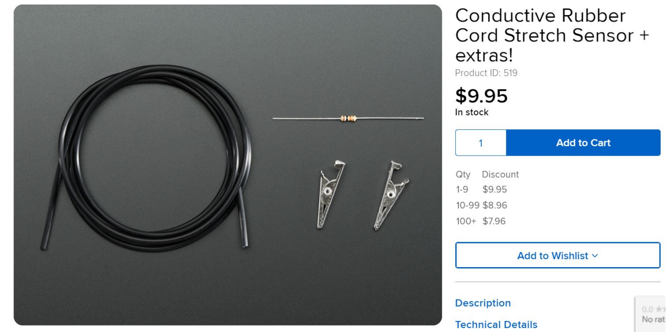
Contributions

- Find a material suitable for sense the length change
- Build a model between the resistance value and length of conductive rubber cord
- Make a wristband using conductive rubber cord

Methodology

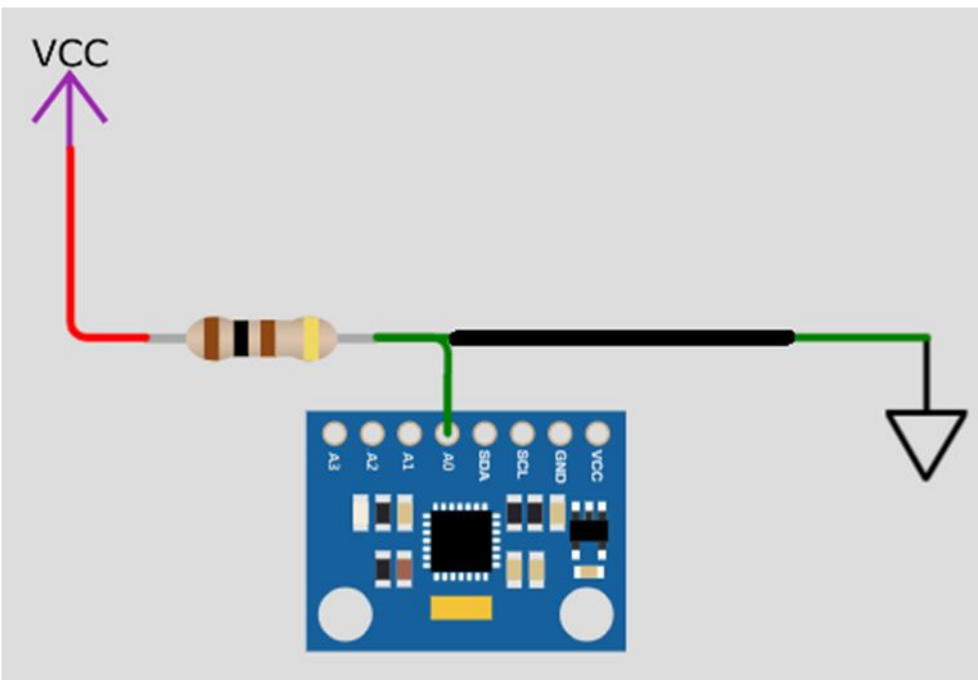
- Conductive rubber
- System overview
- Measurement of conductive rubber cord
- Wristband design
- Recognition flow

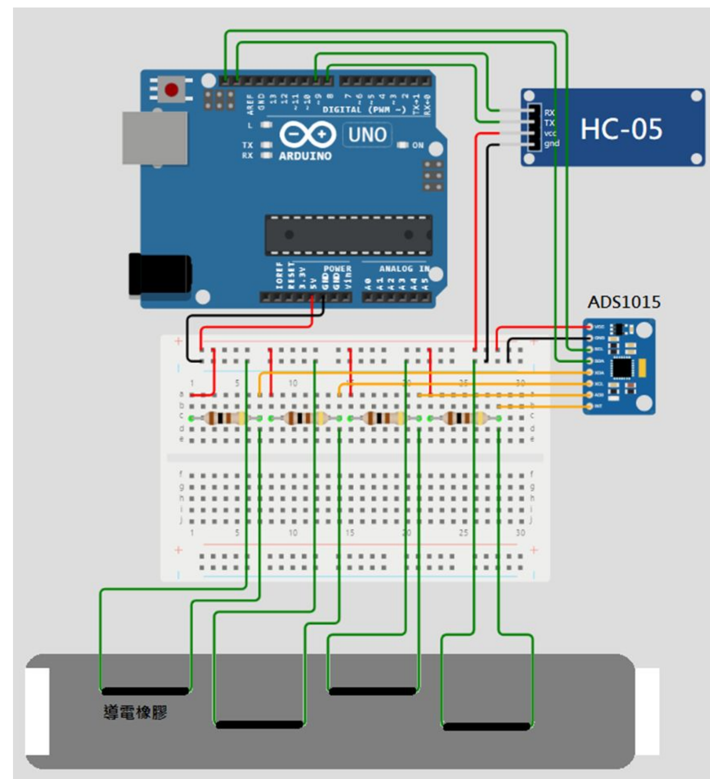
Conductive Rubber



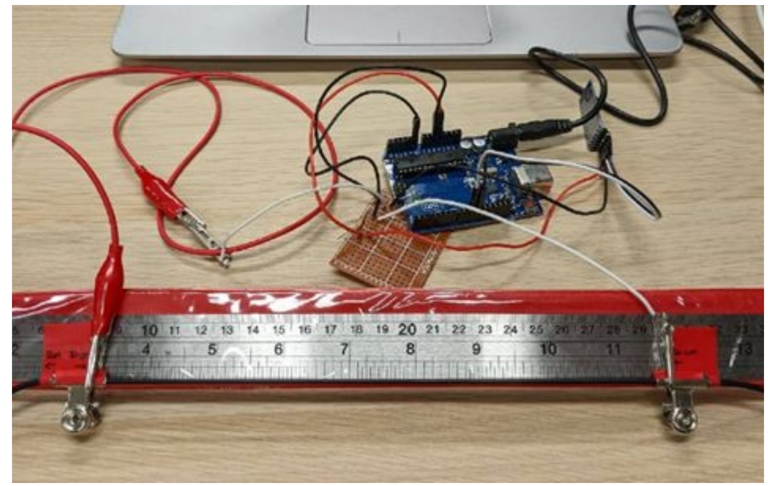
- Carbon black filled rubber
  - Soft
  - Elastic
  - Conductive
- Resistance becomes higher when stretched
- Non-linear stretch sensor
- Conductive rubber cord
  - Commercial product bought from Adafruit
  - 140-160 ohms per cm

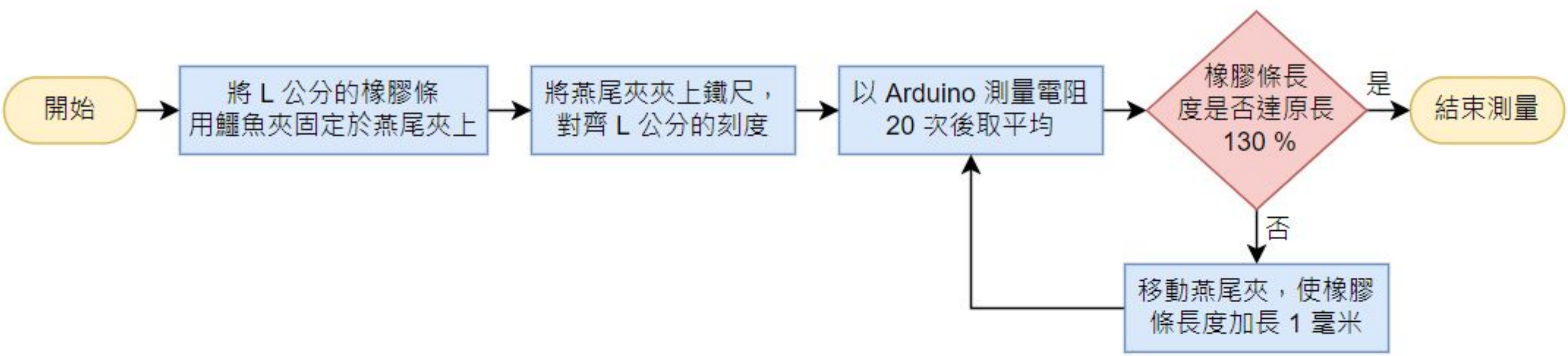
System Overview–Hardware





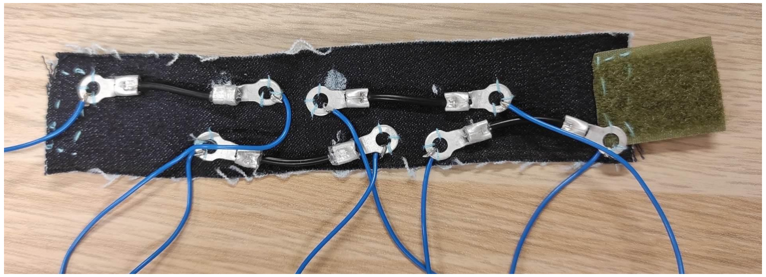
Measurement of Conductive Rubber Cord

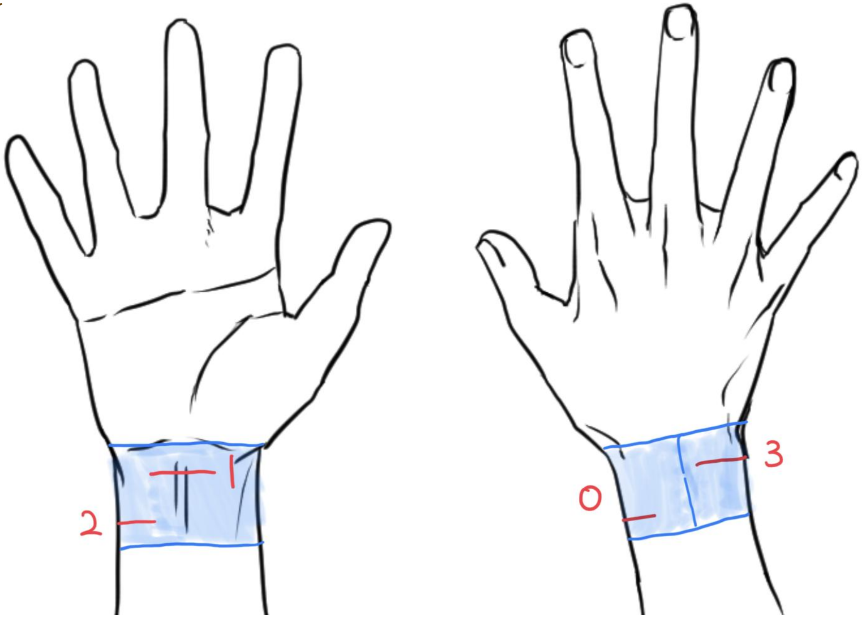




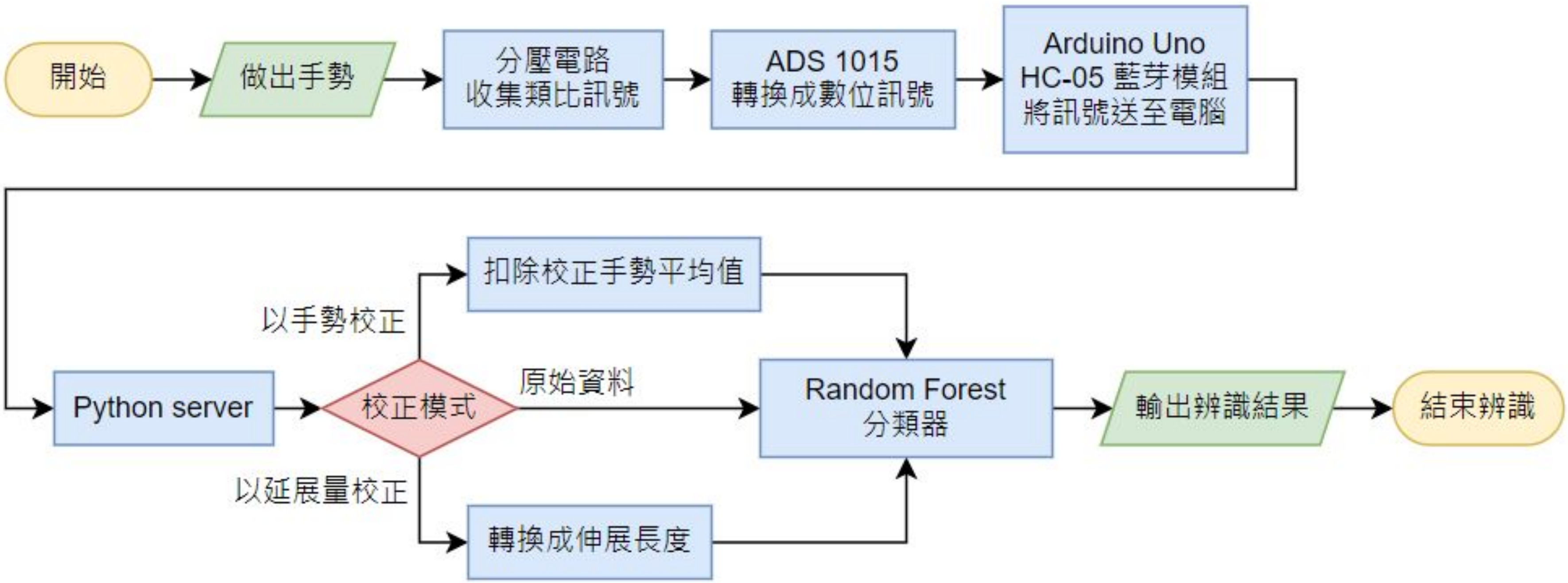
Wristband V4

- Denim fabric
- 4 conductive rubber cord
  - 2 cm each
  - Wrap around the wrist





Recognition flow

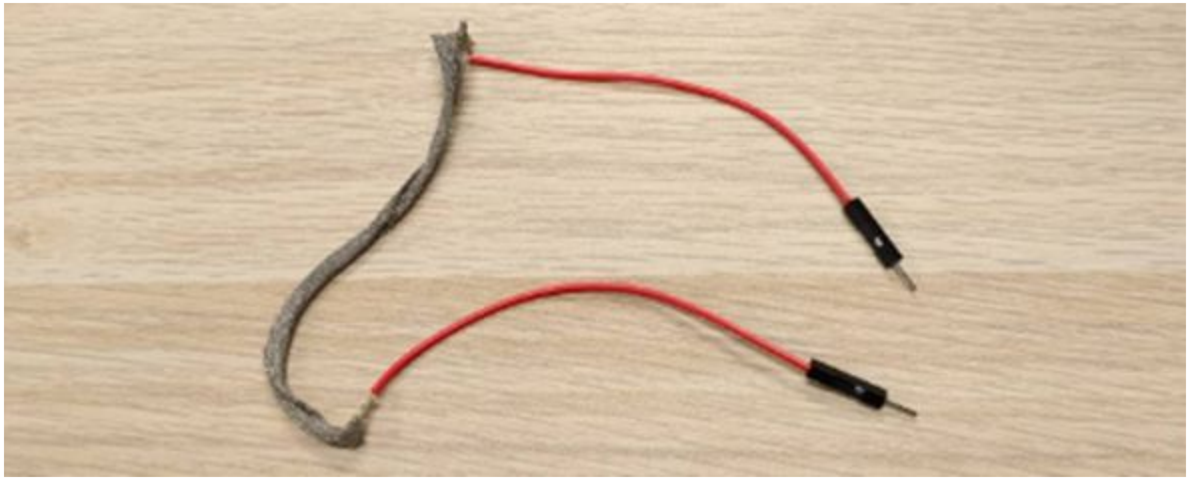


Exploration of Materials

- Adafruit Woven Conductive Fabric
- Adafruit Knit Jersey Conductive Fabric
- Adafruit Conductive Rubber Sheet
- Adafruit Conductive Rubber Cord
- Length-Resistance Model of Rubber Cord

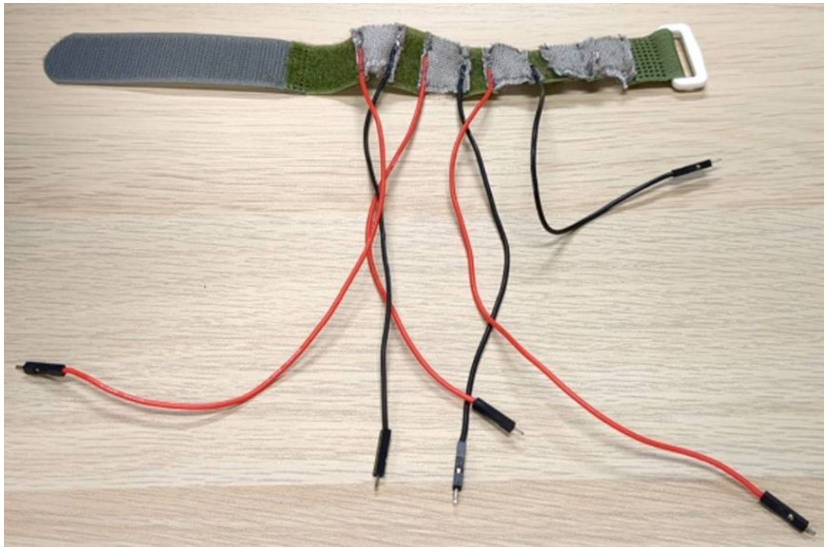
Adafruit Woven Conductive Fabric

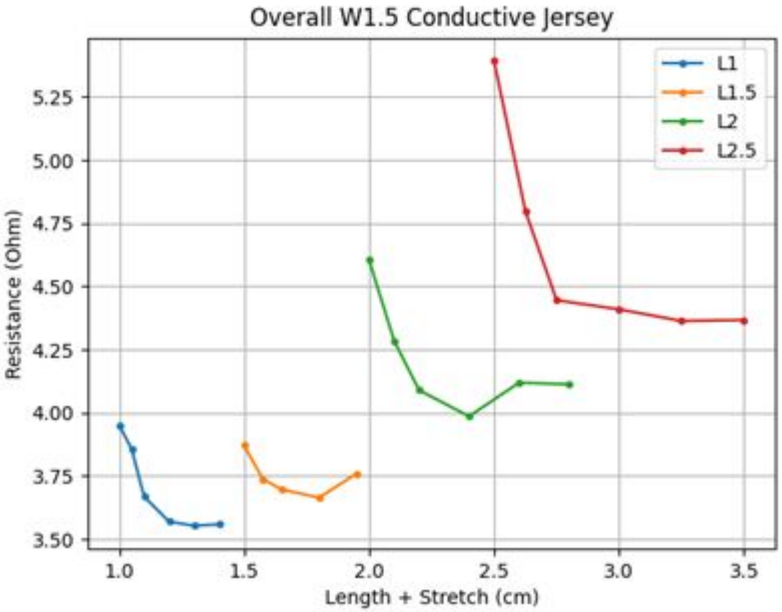
- Made of Copper+Nickel-plated polyester
- Non-elastic



Adafruit Knit Jersey Conductive Fabric

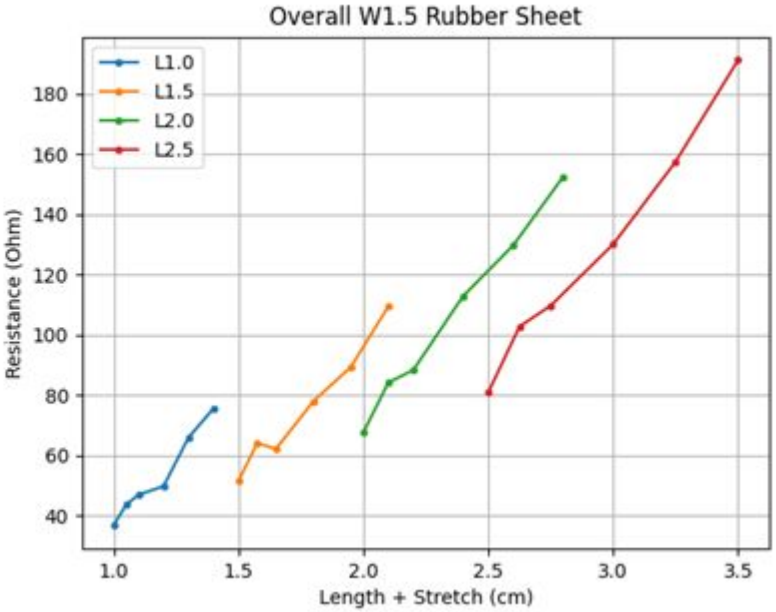
- 63% cotton, 35% silver yarn and 2% spandex
- Elastic but with low resistance value





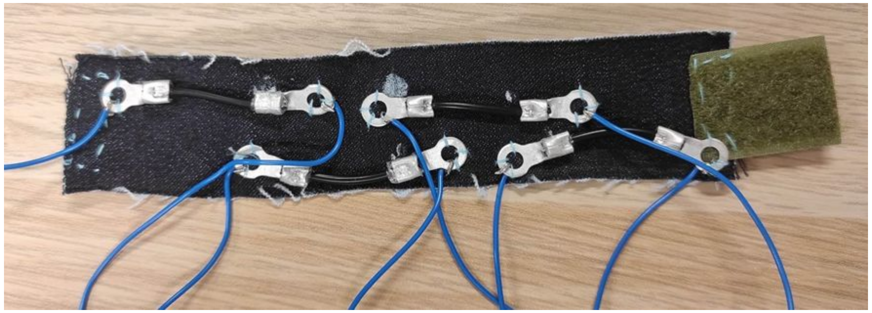
Adafruit Conductive Rubber Sheet

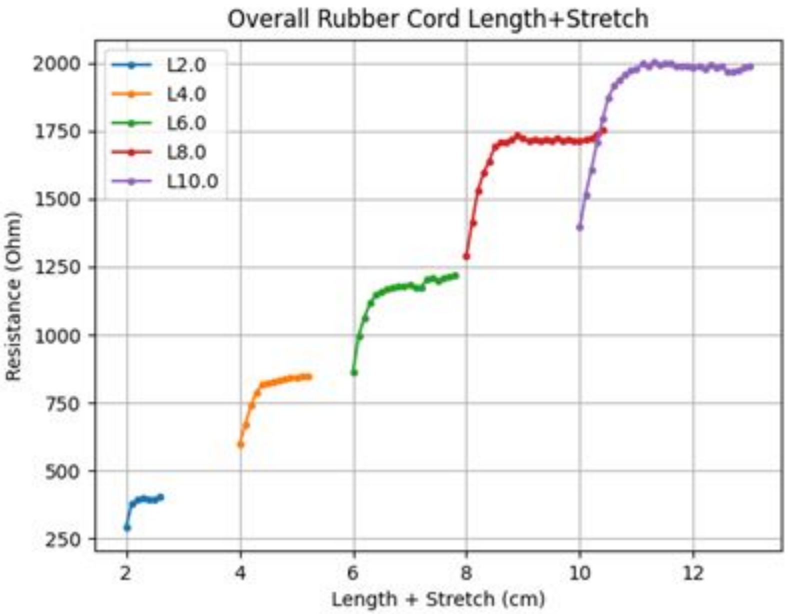
- Made of carbon-black impregnated rubber material
- Take long time to recover after stretched
- Not durable enough



Adafruit Conductive Rubber Cord

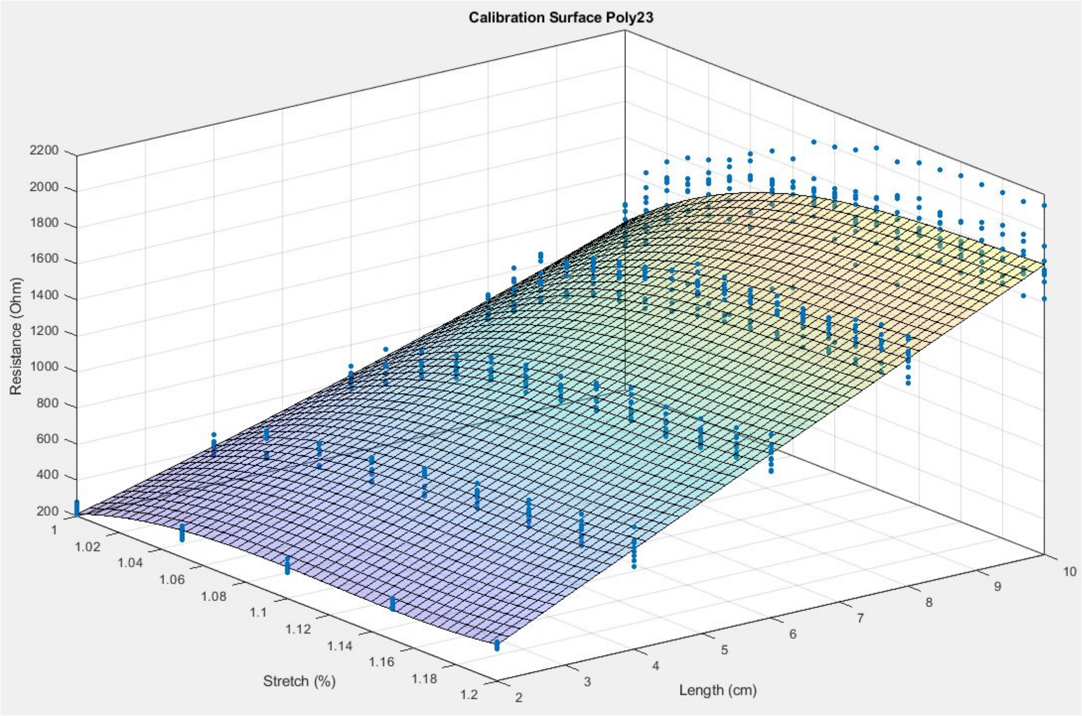
- Made of carbon-black impregnated rubber material
- Resistances rise fast when slightly stretched





Length-Resistance Model of Rubber Cord

- Matlab fit with fit type poly23
- Data size: (5 + (2 + 4 + 6 + 8 + 10) * 2) * 10 = 650

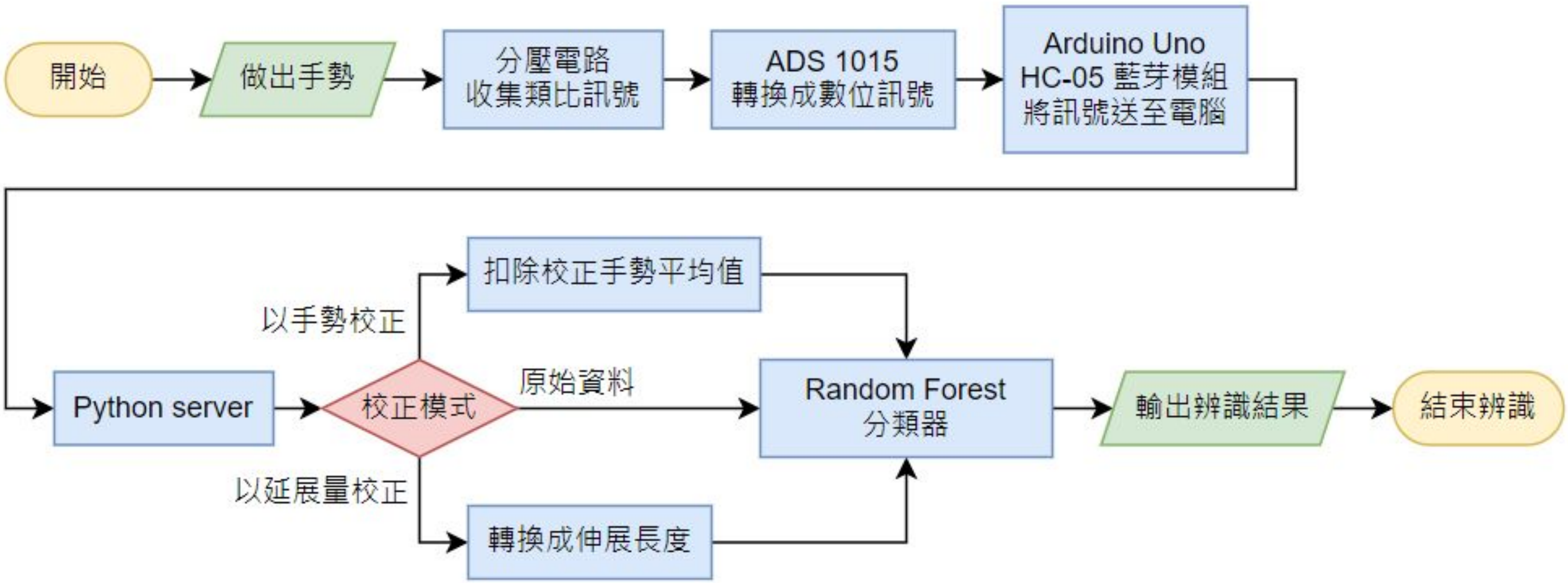


Experiments

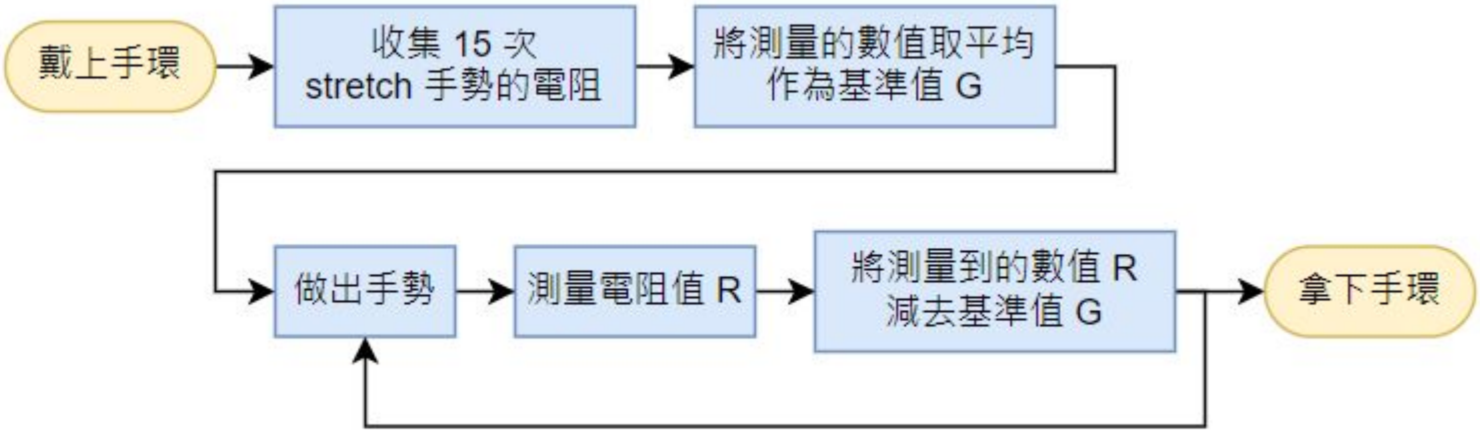
- Gesture set
- Calibration with gesture
- Calibration with length
- Length-Resistance Model for Calibration
- Random forest classification

Gesture Set

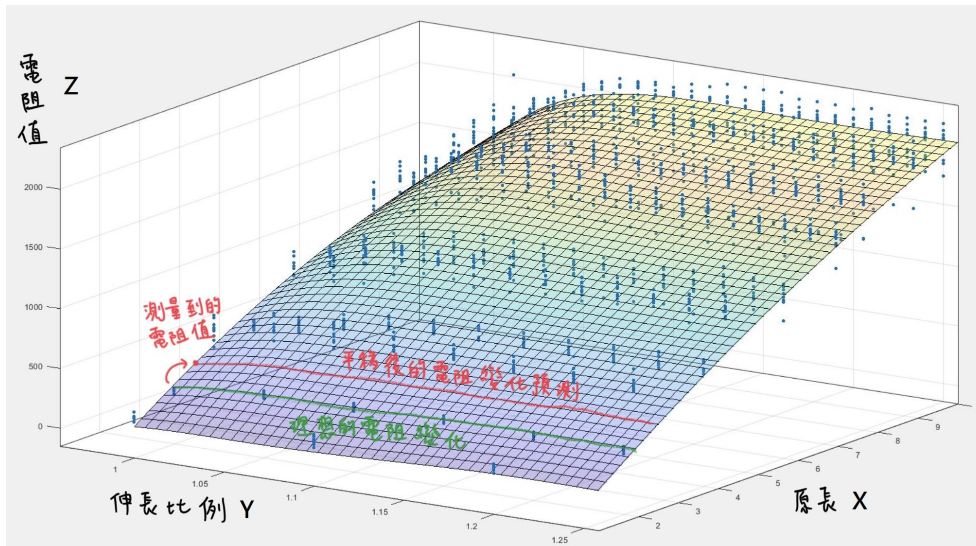
Recognition flow

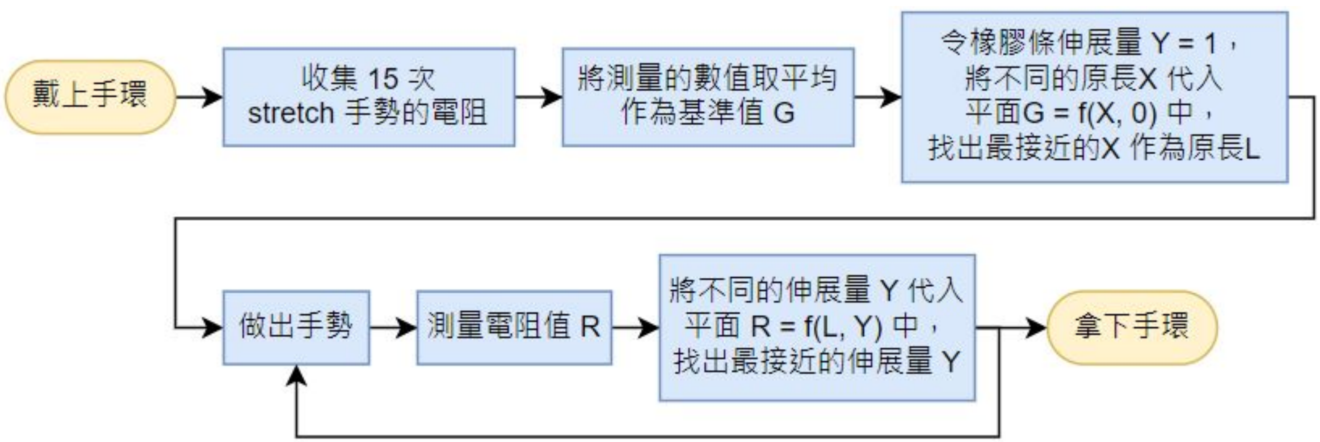


Calibration with Gesture



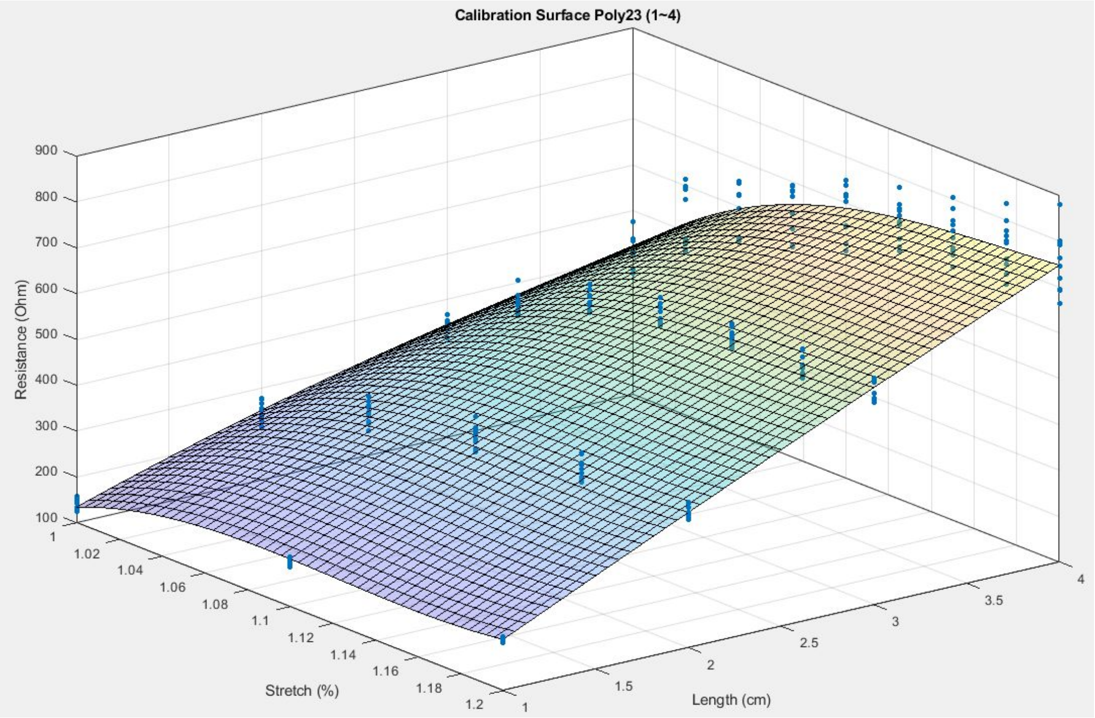
Calibration with Length





Length-Resistance Model for Calibration

- Matlab fit with fit type poly23
- Data size: (4 + (1 + 2 + 3 + 4) * 2) * 10 = 240



Random Forest Classification

Dataset:

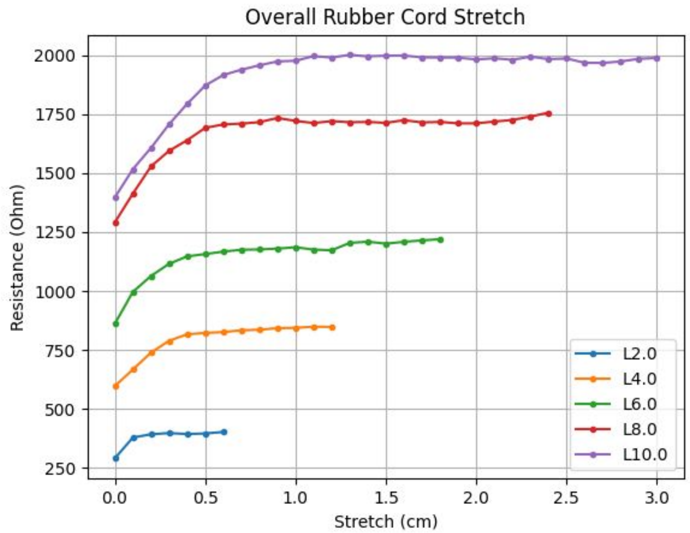
- Training: (15 + 105) * 2
- Testing: (15 + 35) * 1

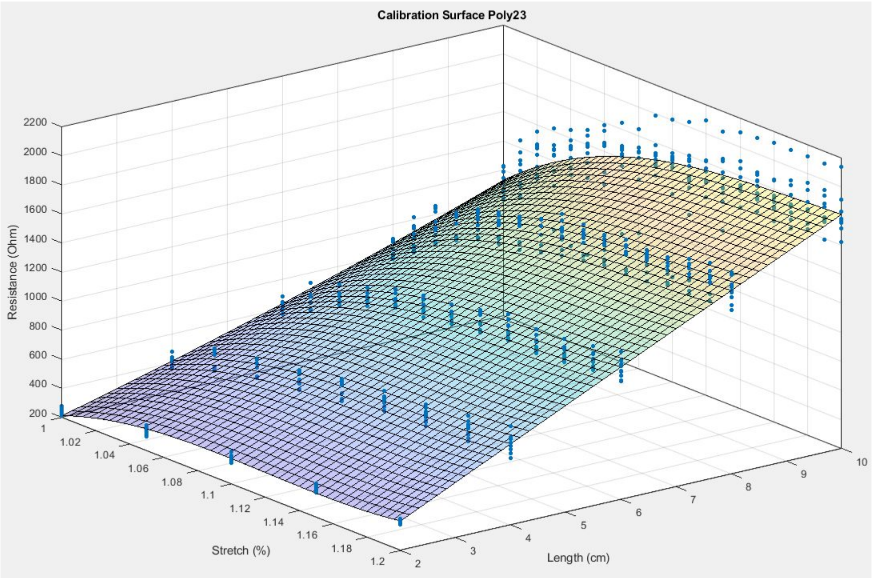
sklearn.RandomForestClassifier

Results

- Resistance results
- Recognition results

Resistance Results



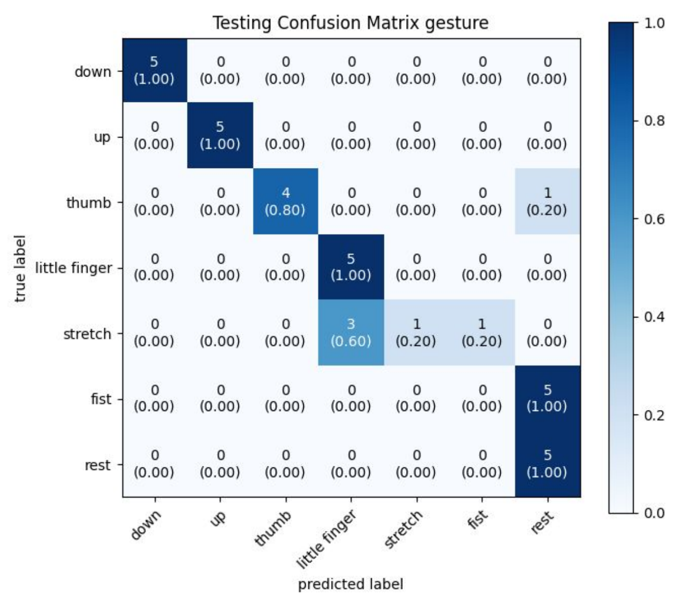


Recognition Results

```
calibration with gesture
[0 1 2 3 3 6 6 0 1 2 3 3 5 6 0 1 2 4 4 6 6 0 1 2 3 5 6 6 0 1 2 3 3 6 6]
train:  0.7936507936507936
test:  0.7428571428571429
calibration with length
[0 1 2 3 3 6 6 0 1 2 3 3 5 6 0 1 6 4 4 6 6 0 1 2 3 5 6 6 0 1 2 3 3 6 6]
train:  0.8095238095238095
test:  0.7142857142857143
calibration with raw data
[6 1 4 2 4 6 6 0 1 6 4 5 5 6 3 1 5 5 5 6 6 3 1 5 5 5 6 5 0 1 5 5 5 5 6]
train:  0.6825396825396826
test:  0.4
```

Discussion

- Certain gestures are hard to recognize
- Decreasing resistance value
- Unstable calibration values between rounds



Conclusions

- Resistance Sensing gesture recognition wristband
  - Using conductive rubber cord to build the wristband
  - Dealing with non-linearity of conductive rubber cord
- Hand gesture recognition wristband
  - Privacy
  - For everyday use
  - Cheap

Q&A

References

[1] Seong-Og Shin, Donghan Kim, and Yong-Ho Seo "Controlling Mobile Robot Using IMU and EMG Sensor-based Gesture Recognition"

[2] Wei-Chieh Chung, Wen-Jyi Hwang, Tsung-Ming Tai, De-Rong Huang, and Yun-Jie Jhang "Continuous Finger Gesture Recognition Based on Flex Sensors"

[3] Hoang Truong, Phuc Nguyen, Qin Lv, Shuo Zhang, Nam Bui, Kaushik Chowdhury, Tam Vu, Ufuk Muncuk, Anh Nguyen, Thang Dinh "CapBand: Battery-free Successive Capacitance Sensing Wristband for Hand Gesture Recognition"