Exploring serpentine as a wearable

A Self-Powering Deformable Cord Sensor

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Vision of COSMOS

The vision of COSMOS speaks about ***computational skins*** *and objects that weave themselves into the fabric of everyday lives.*

Vision of COSMOS

Such **materials** should be able to:

- Do interesting things (***Be interactive***)
- **Sense** and Actuate
- Harvest their own **power** to perform the above
- Low cost
- Easily manufacturable

Literature review

- Design of organic interfaces and vision of claytronics.
- Alternate interaction techniques with wearables (tapskin, watchout, whoosh, watchout)
- Flexible interfaces (paperphone, Foled, flex stylus, morphees, Bendflip)
- Interactions for rollable displays, Foldable interactions
- Sensing technologies
- Research methods
- Prototyping techniques
- Evaluation procedures
- Serpentine

Serpentine

Serpentine is a highly stretchable self-powered sensing material that can recognize human input based on deformations of its shape.

- Easy to **manufacture** with readily available materials
- Can **sense** human gestures
- **Self-powering**
- **Flexible** and can be embedded into various objects
- Cylindrical shaped cord allows several **intuitive** and playful interactions.

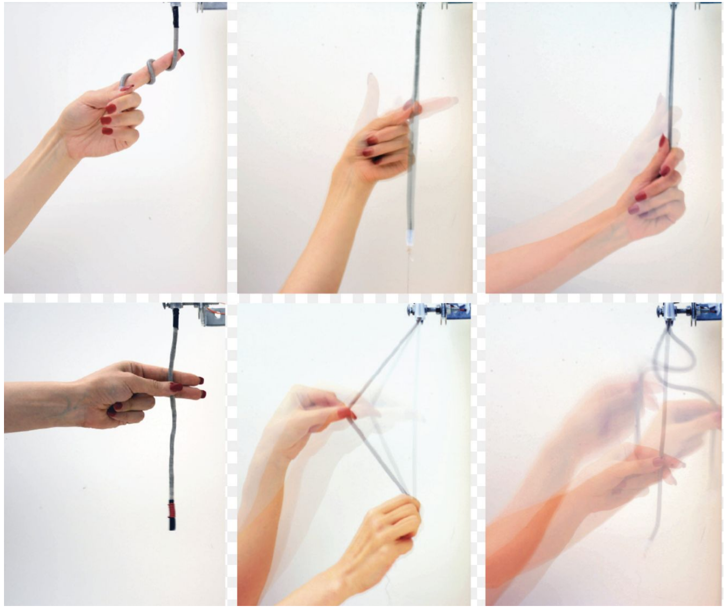
Past work

Physical operating principles of the sensor

Description of how to manufacture the Serpentine sensor inexpensively.

Testing six gestures and prototyping simple application of them.

User study



Initial Brain-storming

Form/Device	Ends Fixed	Scenario	Tasks	Input	Output	Possible interactions	Users

Research questions

1.

How can serpentine be used as a wearable or be a part of the wearable?

- What are the most intuitive and natural gestures for a use case?
- What contexts does it fit in?
- What form factors due users prefer/comfortable with?

2.

What interactions can be detected when worn on body?

- Currently focussing on wrist-worn contexts

Data collection

What interactions can be detected when worn on body?

The aim of this step was to collect sensor data while users interact with the sensor and analyse the collected sensor data to determine the capabilities of the sensor.

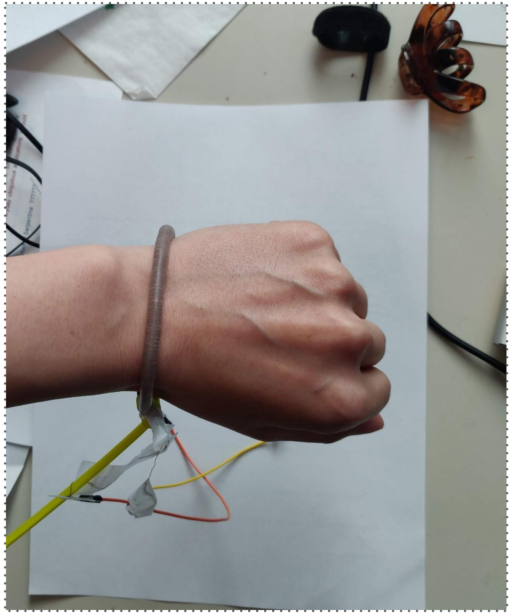
Context: Wrist-worn wearables

Data collection

The setup

2 different setups

Simulated setup
4 users, 6 gestures

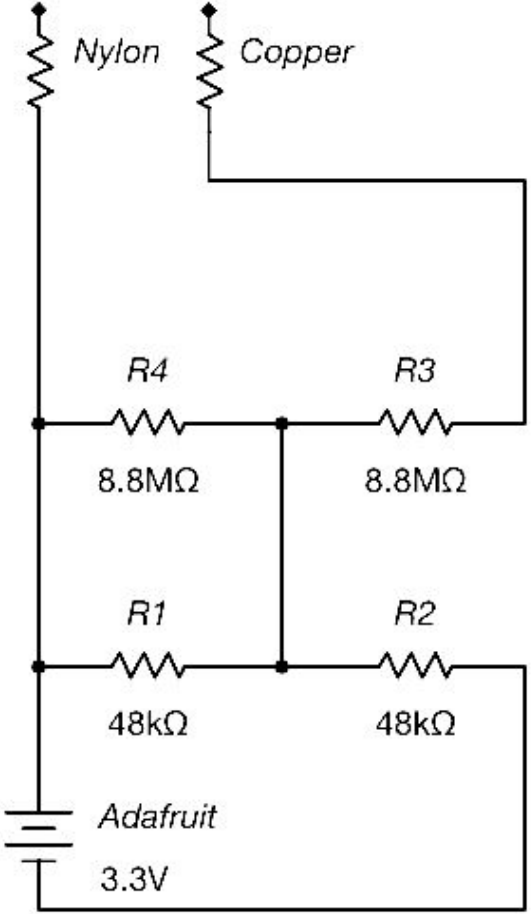


On user's hand
2 users, 6 gestures

Data collection

Data Pipeline

Any gesture performed on the sensor result in signals across the copper and silver-coated nylon electrodes. The signals pass through an amplifier circuit which uses a wifi module (Adafruit) to send them to the laptop and collect.



Data collection

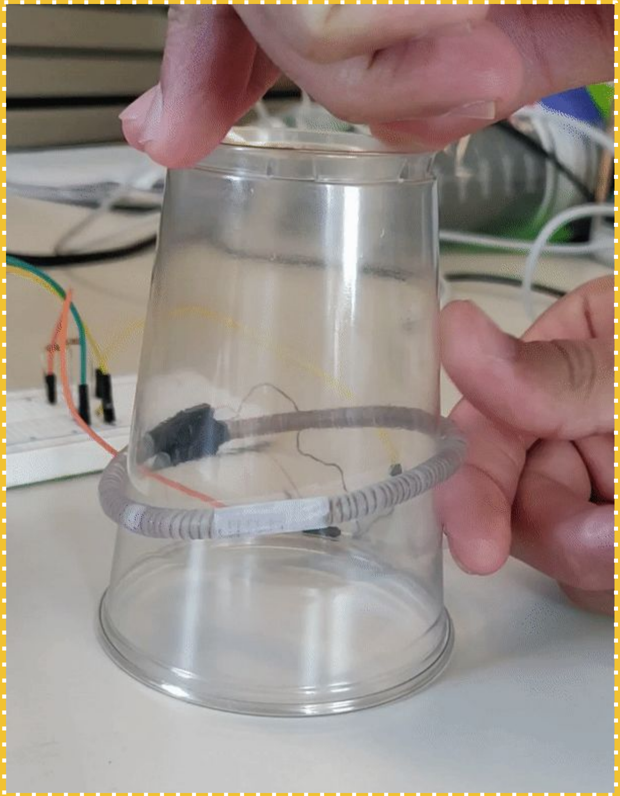
Gestures

Ideated and experimented with about 12 unique gestures.

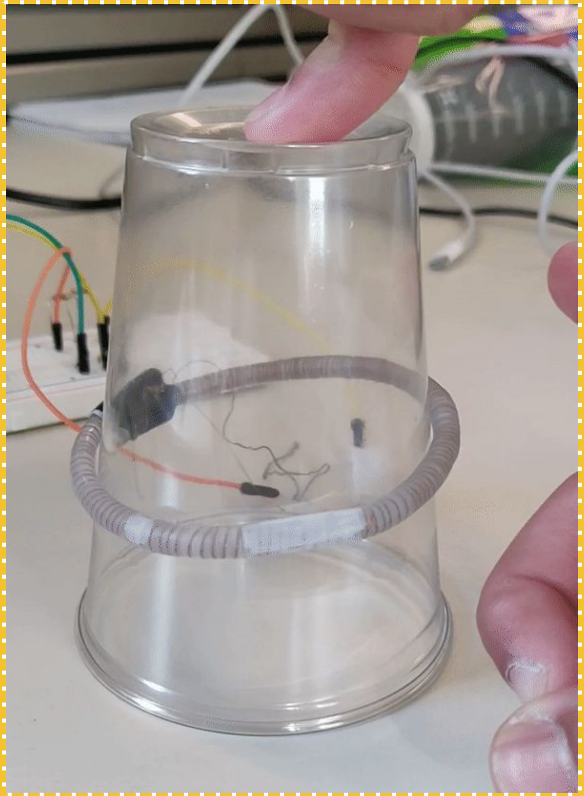
However, eight of them showed a clear difference in the shape of the signal and six of them gave an higher voltage output.

Pluck
Stretch
Tap
Double tap
Pinch
Double pinch
Slide
Twist
Bend
Roll
Roll and leave
Knot

Gestures



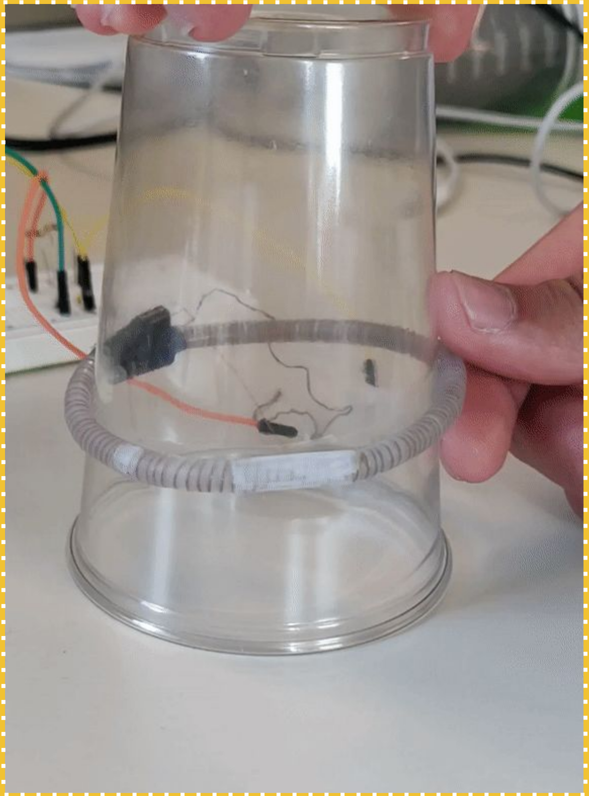
Roll and Leave



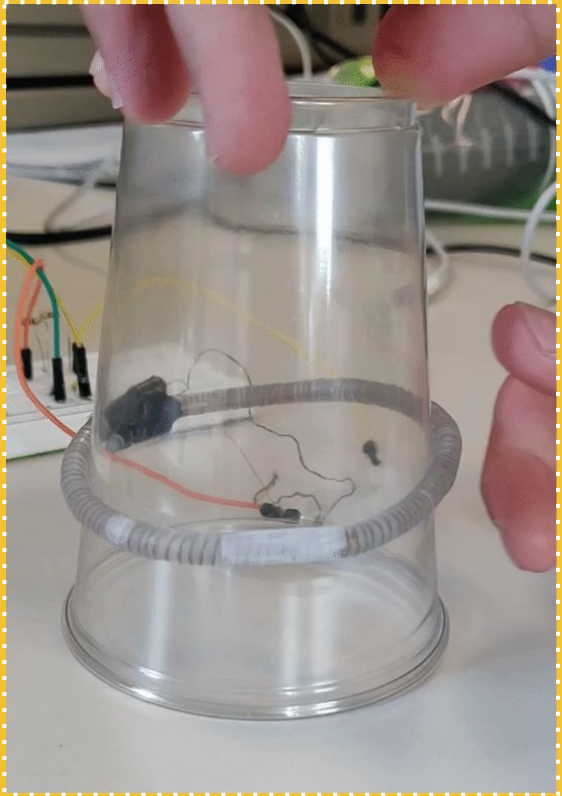
Double Tap

Pluck

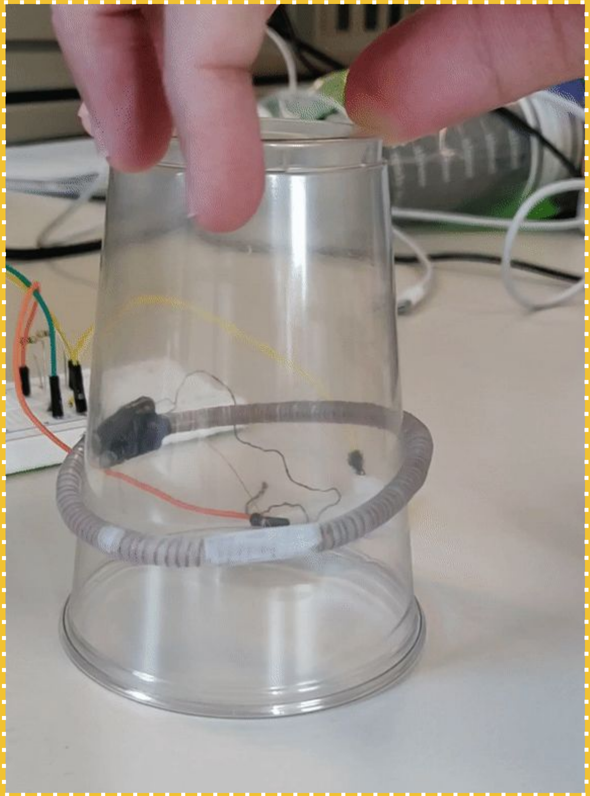
Gestures



Stretch

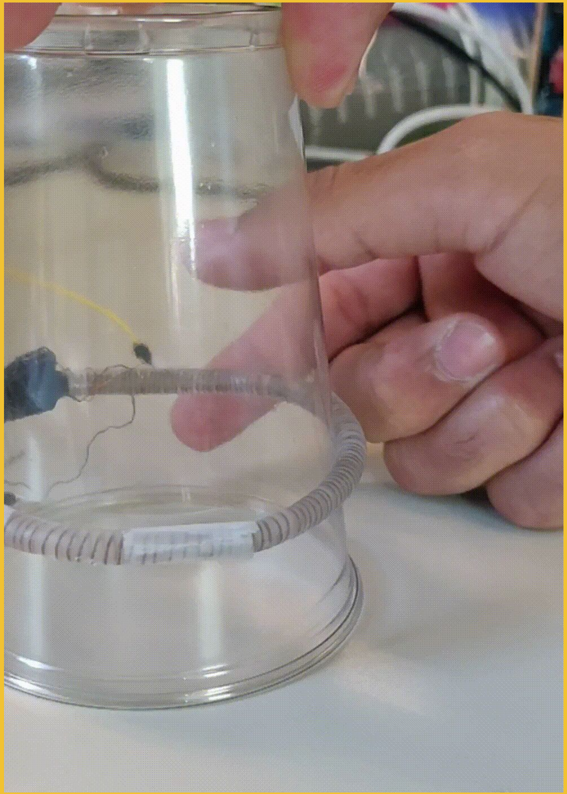


Pinch



Double Pinch

Gestures



Slide

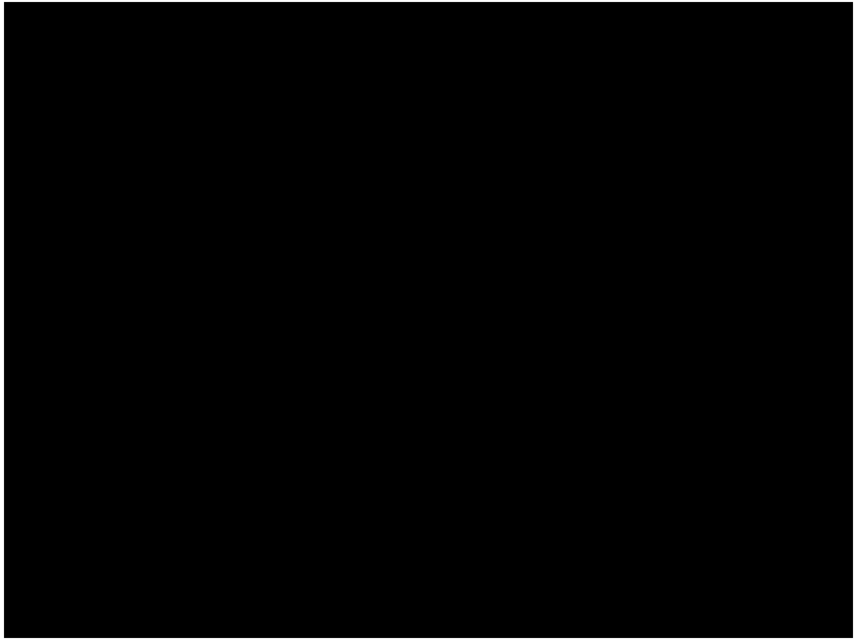
Roll

Bend

Data collection

Gestures

Participants were required to perform n (n = 10,20) sets of these six gestures. These gestures were performed in a random order while a GUI informed participants what gesture to perform.



Gesture recognition

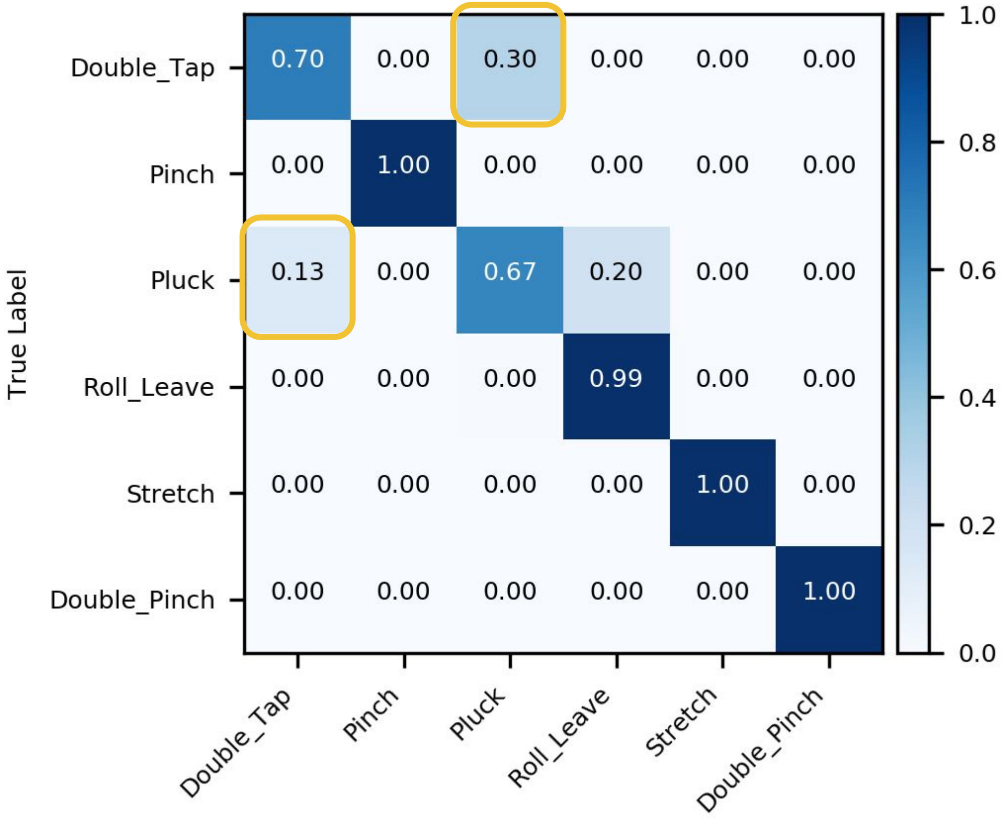
6 gestures
4 participants

The collected data was analysed by sending it to a classifier which used a stratified K-fold cross validation method.

User dependent accuracy scores and confusion matrices were plotted which helped to analyse the sets of gestures that can be used together.

Confusion Matrices

Simulated setup
User 1



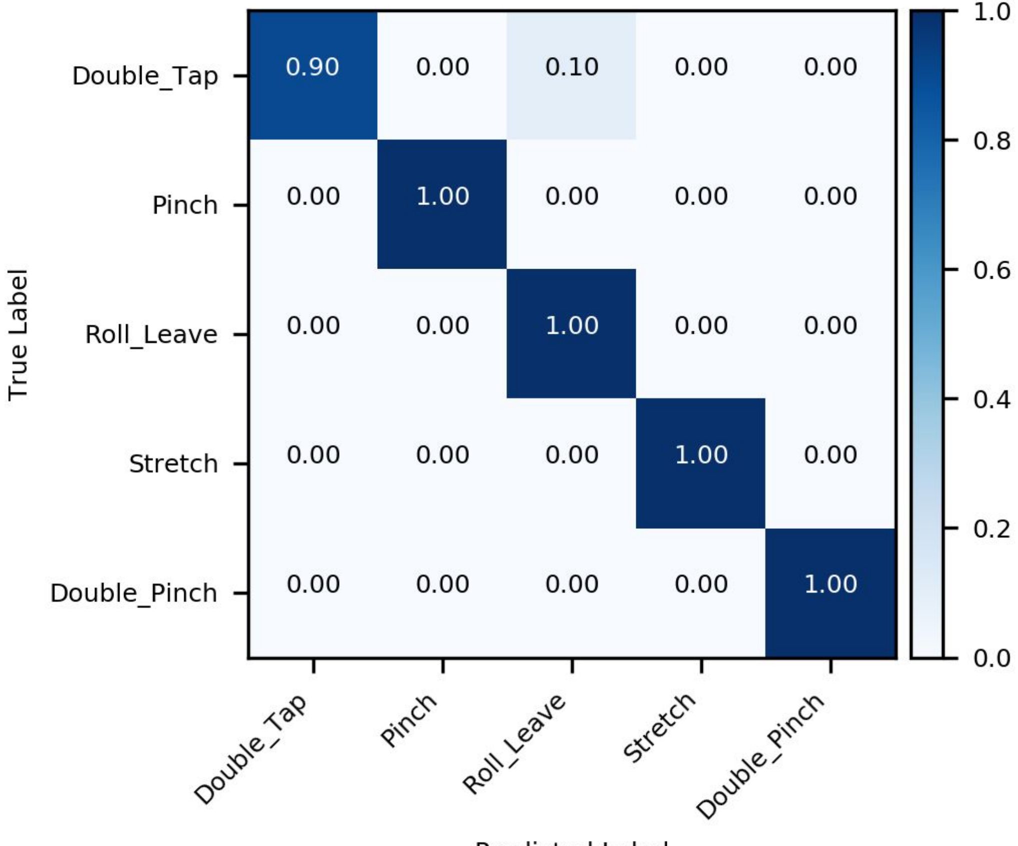
(b)

6 gestures
10 per gesture

Confusion Matrices

Simulated setup
User 2

Removed "pluck"



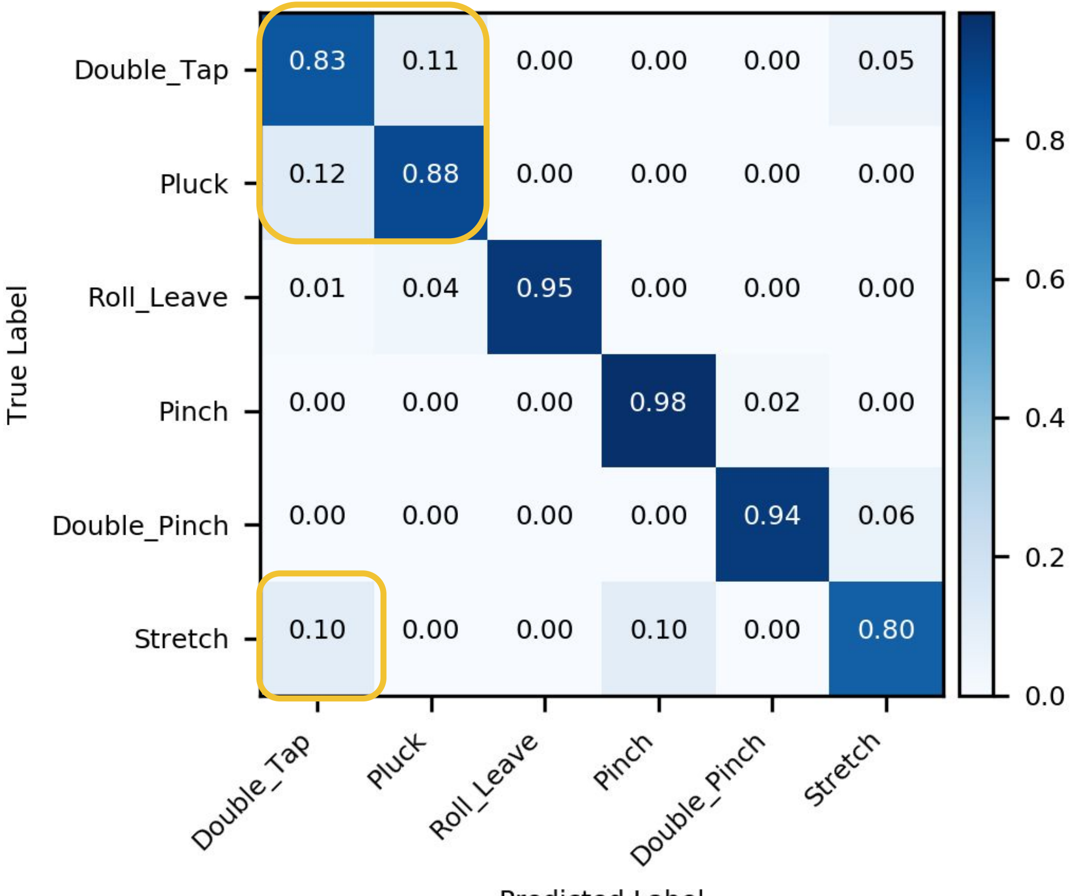
(b)

5 gestures
10 per gesture

Confusion Matrices

Simulated setup
User 2

Accuracy score: 91.41%



(b)

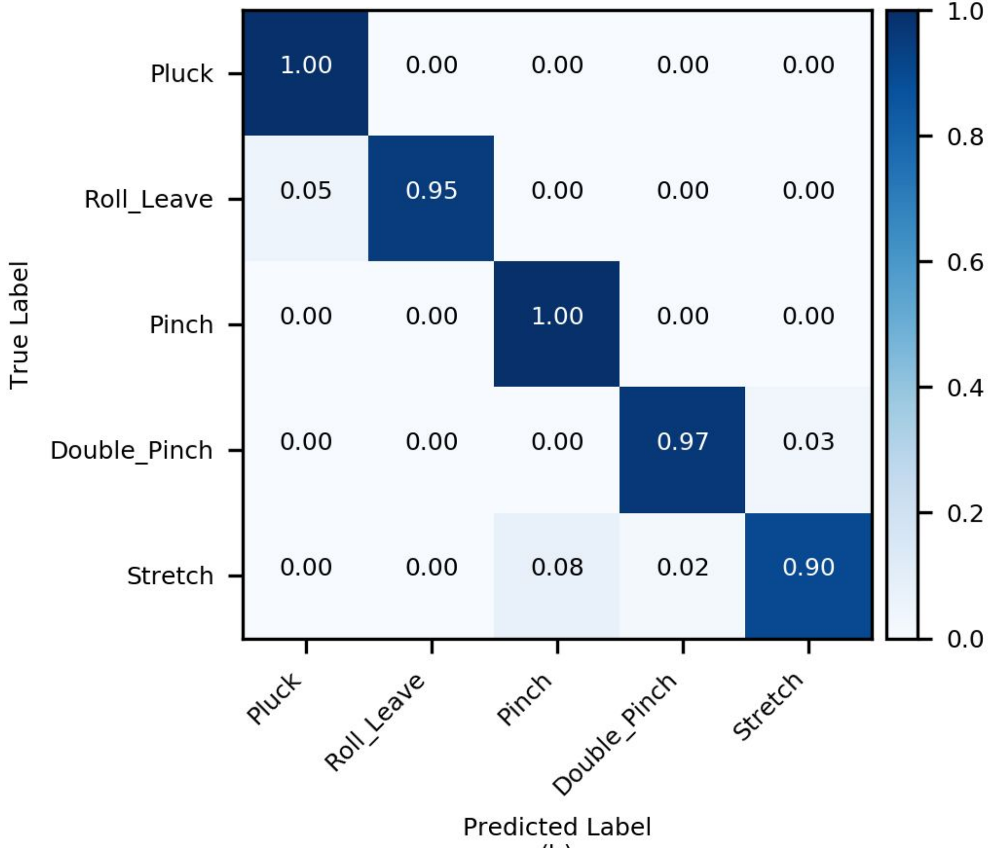
6 gestures
20 per gesture

Confusion Matrices

Simulated setup
User 2

Accuracy score: 95.54%

Removed "double tap"



(b)

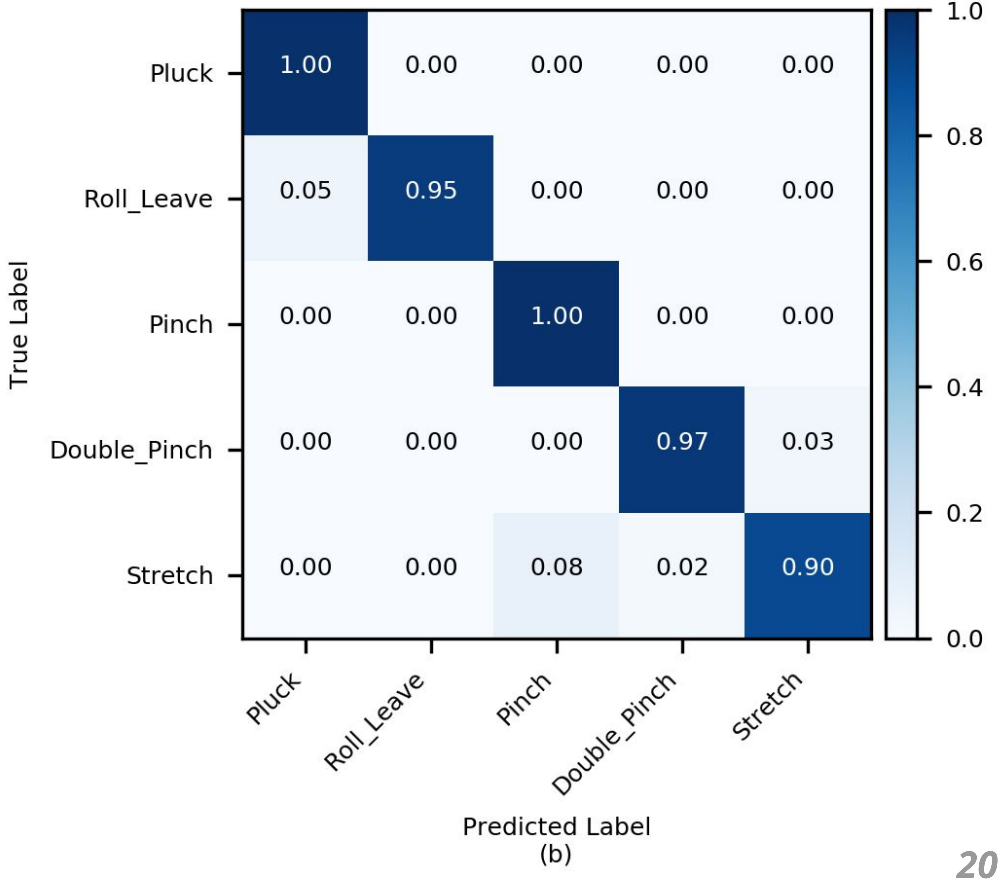
6 gestures
20 per gesture

Confusion Matrices

Simulated setup
User 2

Accuracy score: 95.54%

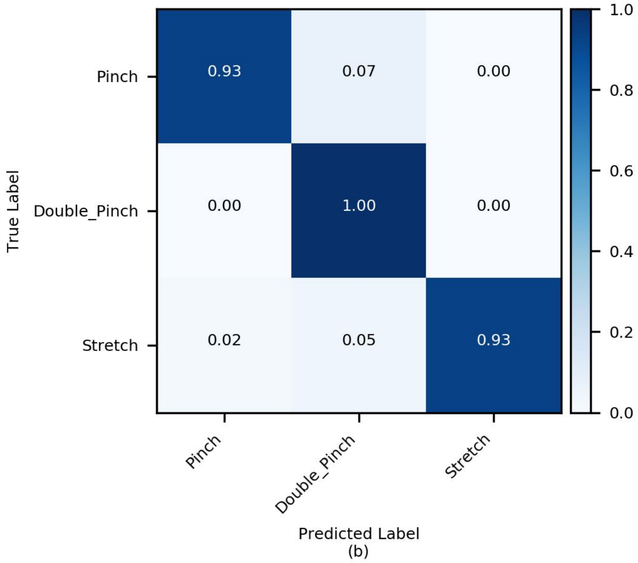
Removed "double tap"

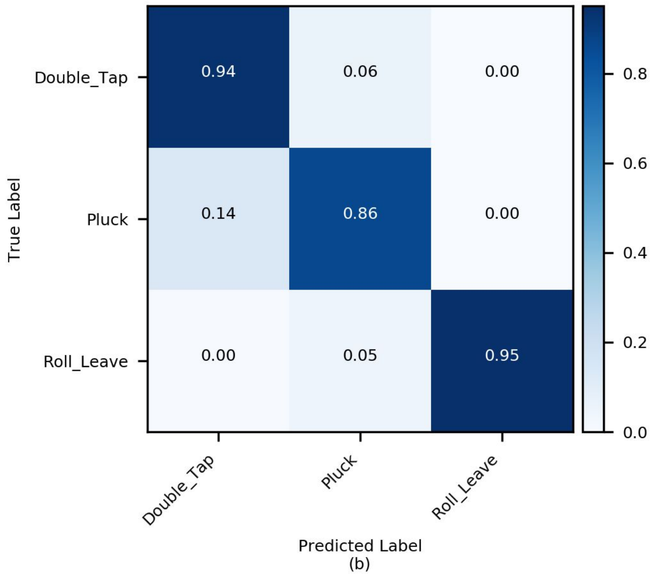


6 gestures
20 per gesture

Confusion Matrices

Sets of gestures



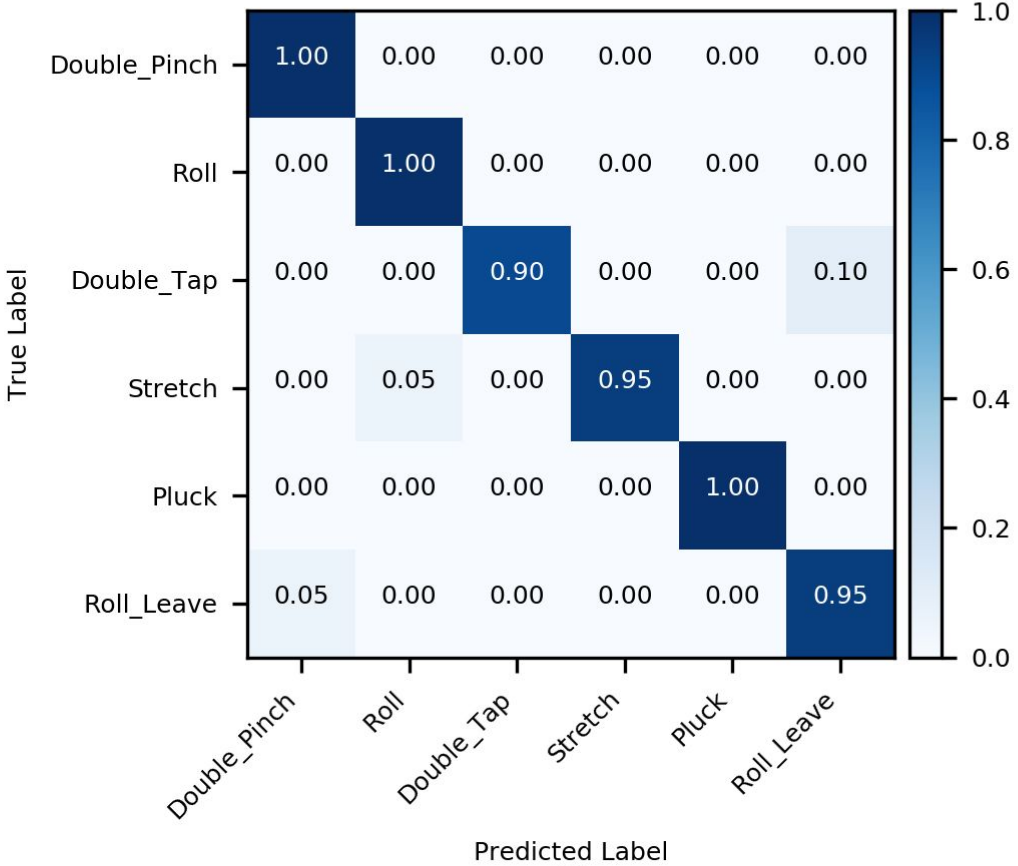


2 sets of 3 gestures
20 per gesture

Confusion Matrices

Wrist worn
User 1

Accuracy Score: 96.96%



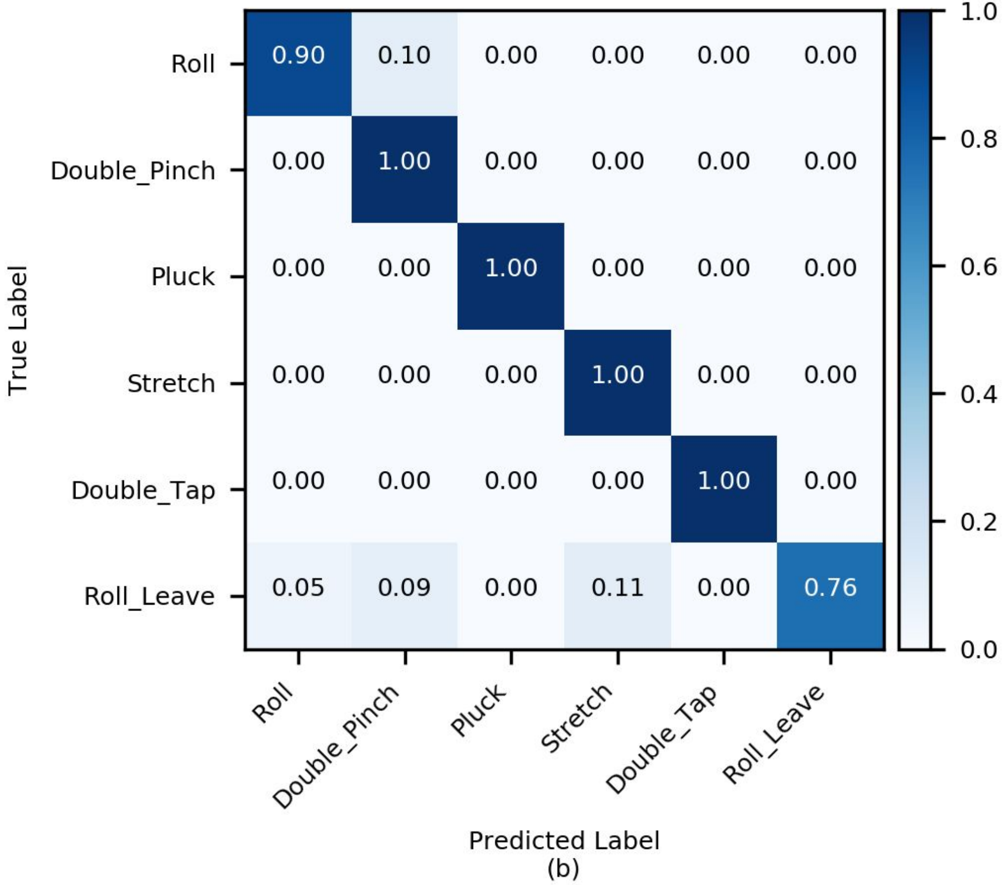
(b)

6 gestures
10 per gesture

Confusion Matrices

Wrist worn
User 2

Accuracy Score: 94.16%



6 gestures
10 per gesture

Insights

Simulated contexts
Double and Pluck were confused the most and not advisable to use them in a set.

Wrist worn contexts
Pinch did not generate any significant signal in a wrist-worn context.

The gesture roll and leave was not intuitive to 2 out of 4 participants. They were unable to perform the gesture with ease and confidence. Three users demonstrated low dexterity while performing the gesture.

"This is not intuitive at all."
Can you show it to me once again?"
"I am unable to do this."

Insights

Pluck, Stretch and Roll were seen and playful interactions, easy and natural to perform.

These gestures might have very interesting applications.

Double tap, Double pinch were intuitive to perform.

Interest Areas

Accessibility esp. Visually Impaired

Hands Free Interactions

Co-design/ Focus Group

How can serpentine be used as a wearable or be a part of the wearable?

The aim of this co-design exercise is to see how users naturally interact with a cord shaped sensor of different sizes and understand the form factors they are most comfortable with. Through this exercise, I also aim to observe and map intuitiveness of gestures to perform a certain task.

How do you think you can interact with the sensor? Probe: Remember, any physical deformation or touch interaction can be detected.

In what situations do you think you will use it? You can brainstorm as a team and list down your responses.

Consider the use case of <activity>.

a) Can you individually think of a solution of how it can help while <activity>? (5 mins) Note: You can use a combination of interactions to come up with a solution.

b) Can you as a group discuss your solutions and come up with one single solution? (10 mins) Can you explain your solution?

Roadblocks

Easily wears and certain gestures could not be tested due the risk of breaking it.

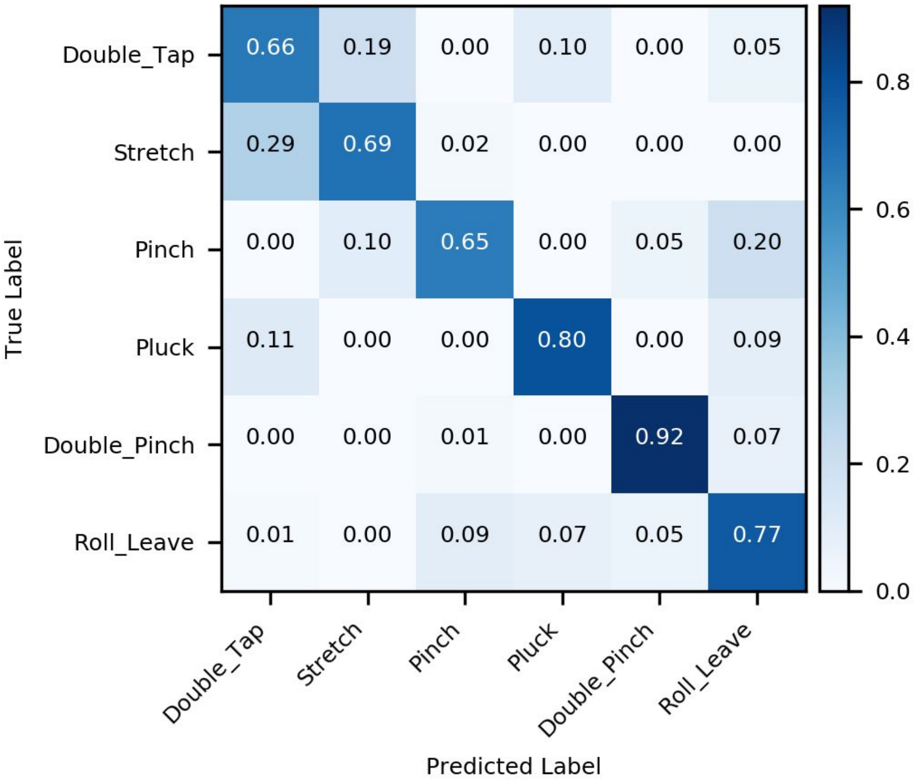
Working with single sensor

Making a new sensor is time consuming and requires an expensive polymer.

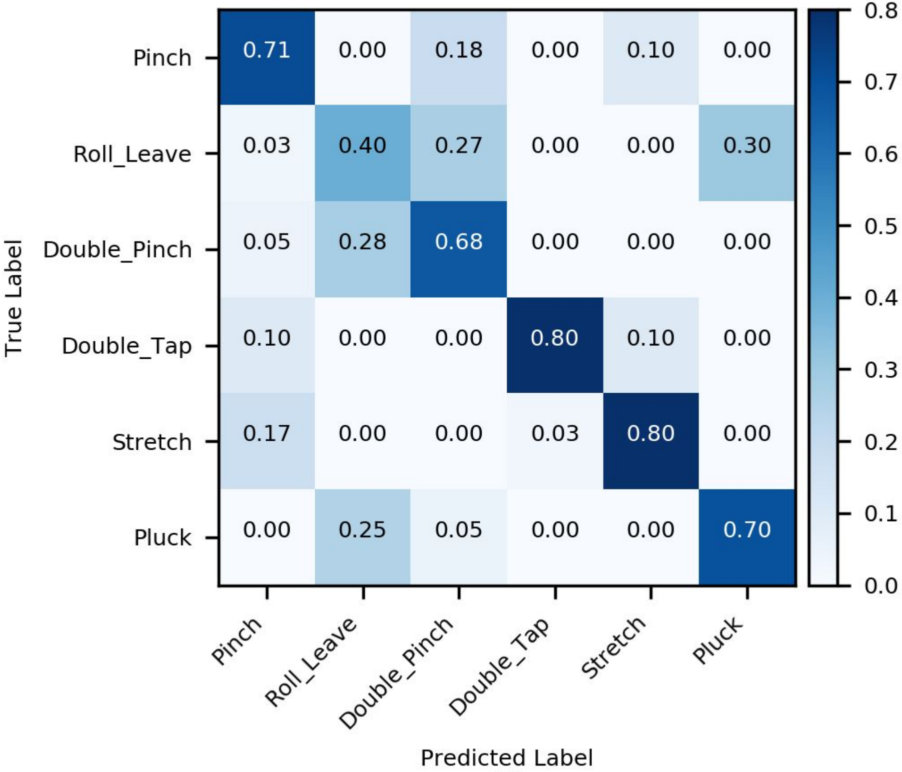
Thank you!

Mentors:
Fereshteh Shahmiri, Shivan Mittal

Appendix


True Label
Double_Tap
Stretch
Pinch
Pluck
Double_Pinch
Roll_Leave
0.66 0.19 0.00 0.10 0.00 0.05
0.29 0.69 0.02 0.00 0.00 0.00
0.00 0.10 0.65 0.00 0.05 0.20
0.11 0.00 0.00 0.80 0.00 0.09
0.00 0.00 0.01 0.00 0.92 0.07
0.01 0.00 0.09 0.07 0.05 0.77
0.8
0.6
0.4
0.2
0.0
Predicted Label

(b)


True Label
Pinch
Roll_Leave
Double_Pinch
Double_Tap
Stretch
Pluck
0.71 0.00 0.18 0.00 0.10 0.00
0.03 0.40 0.27 0.00 0.00 0.30
0.05 0.28 0.68 0.00 0.00 0.00
0.10 0.00 0.00 0.80 0.10 0.00
0.17 0.00 0.00 0.03 0.80 0.00
0.00 0.25 0.05 0.00 0.00 0.70
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Predicted Label

(b)