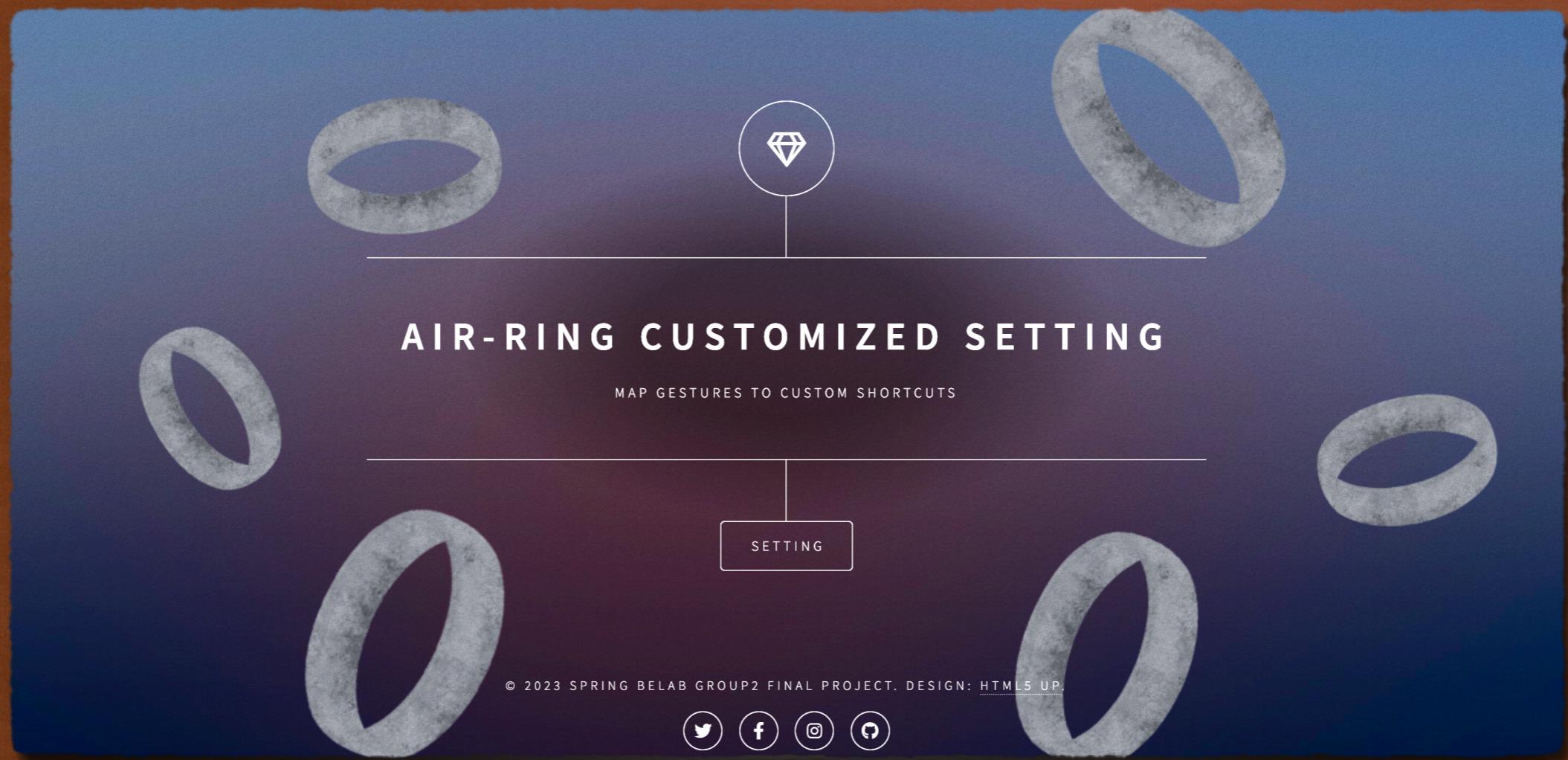


# 生醫實驗 DEMO

AIR-RING: GESTURE RECOGNITION,  
IMPROVING WORKFLOW WITH SHORTCUT KEYS  
讓手指再次偉大

B08901210 陳祈安, B07901149 柯岱佑, B08901009 翁證騏

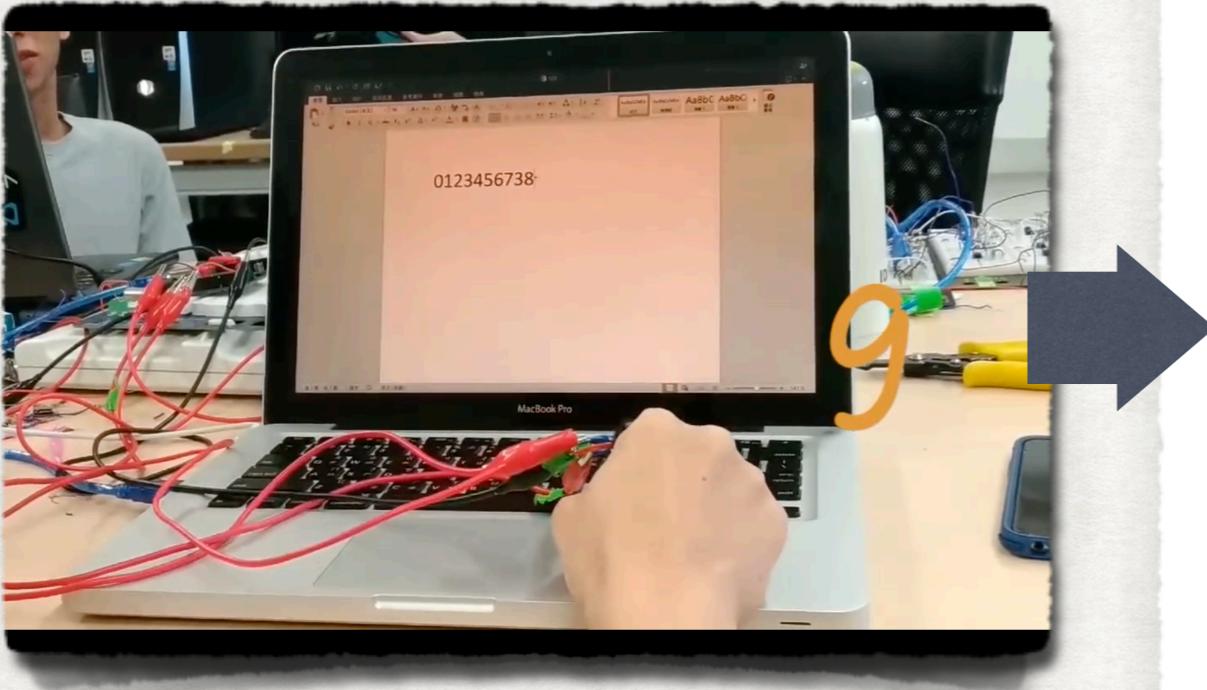


# OUTLINE

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- 前情提要
- 整體流程說明
  - Data collection
  - Preprocessing/ Data Augmentation/ Model
  - Real-time Algorithm
- Demo 影片
- Q & A

## 前情提要

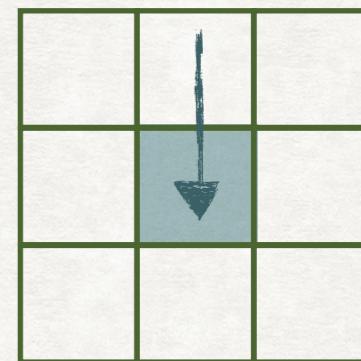
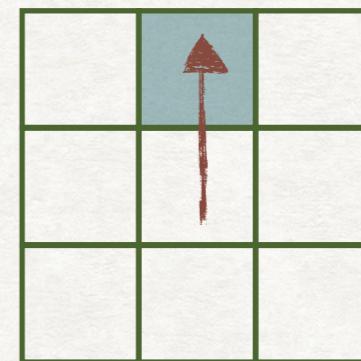
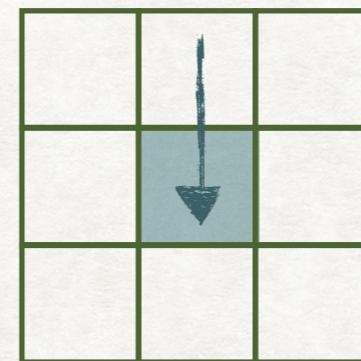
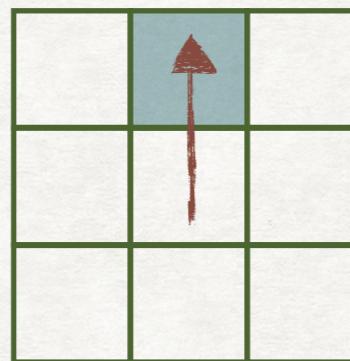
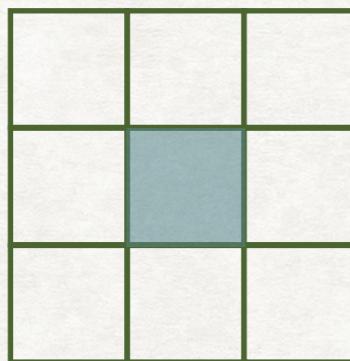


**AirRing**  
**把按快捷鍵的時間  
省掉吧。**

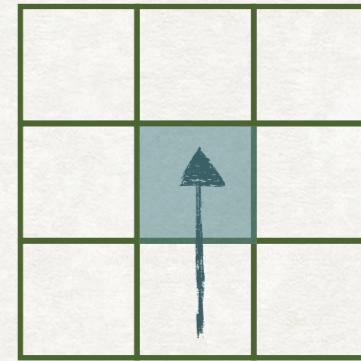
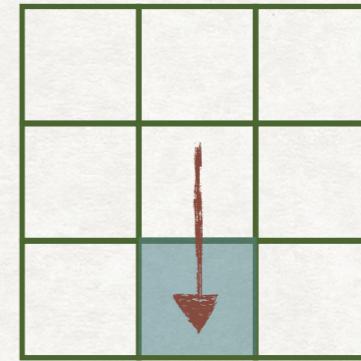
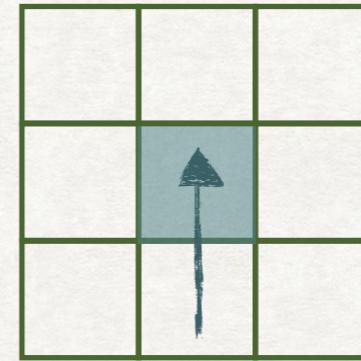
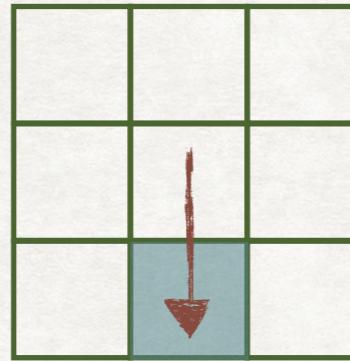
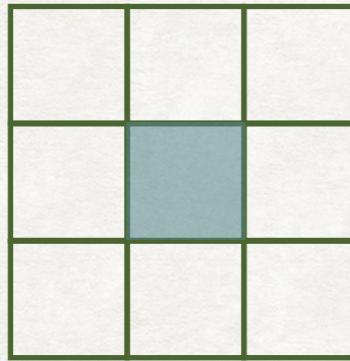
參考學長姐的專題，使用手勢辨識進行鍵盤控制  
從僅提高手勢辨識成功率，到更完整的應用

# 手勢說明 (UP/DOWN)

Up

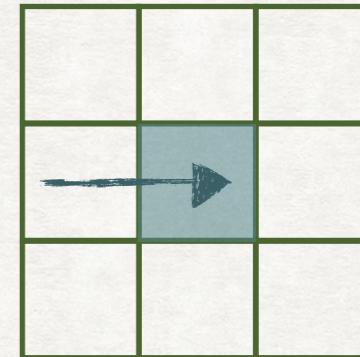
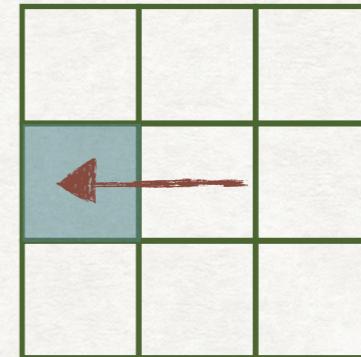
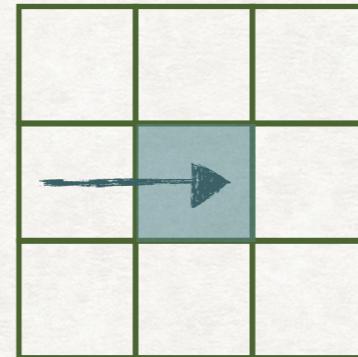
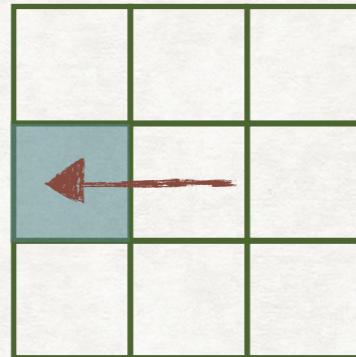
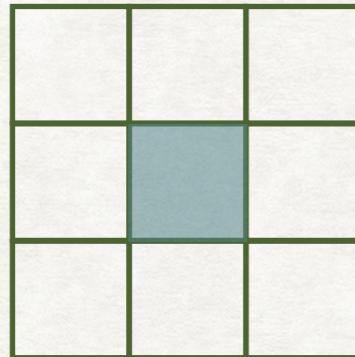


Down

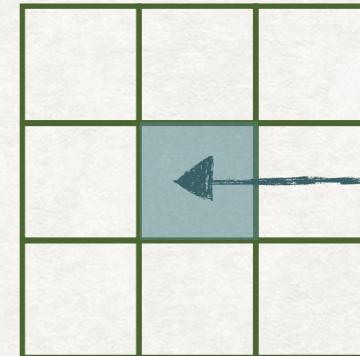
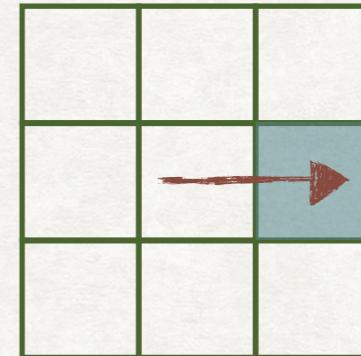
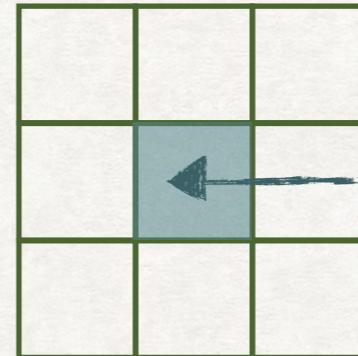
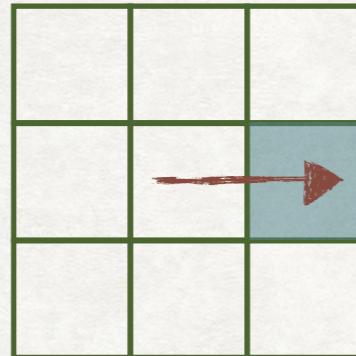
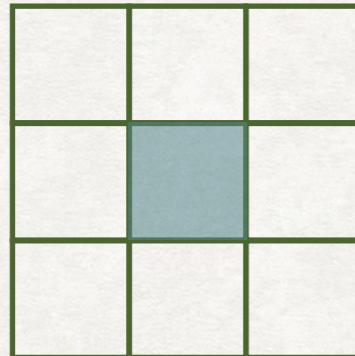


# 手勢說明 (LEFT/RIGHT)

Left

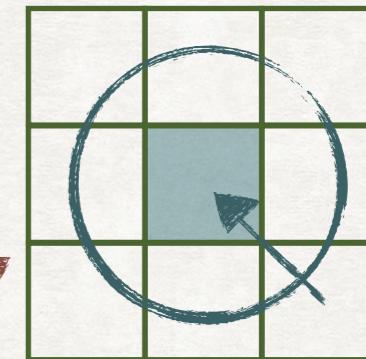
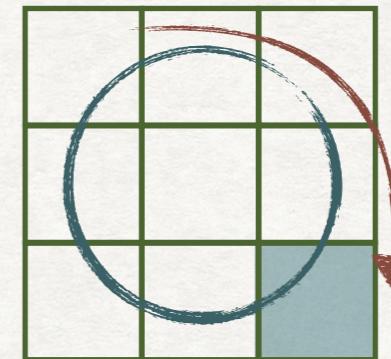
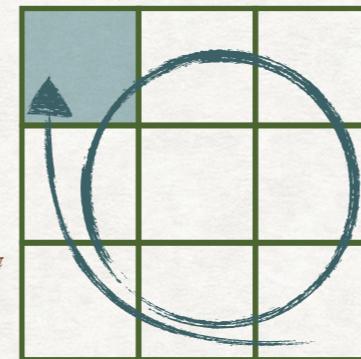
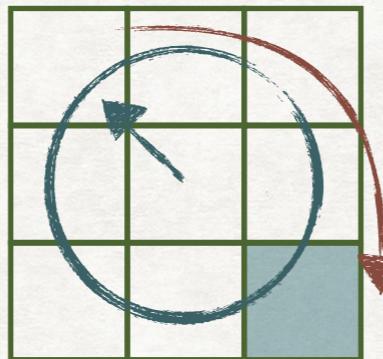
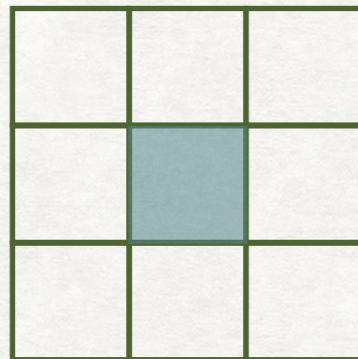


Right

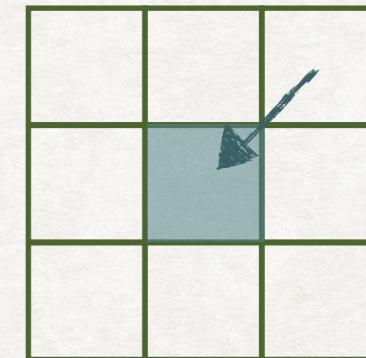
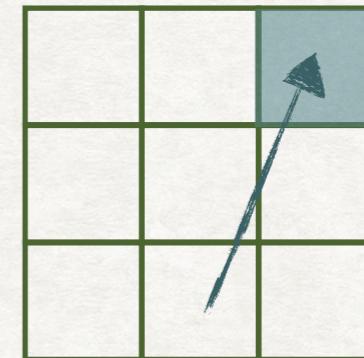
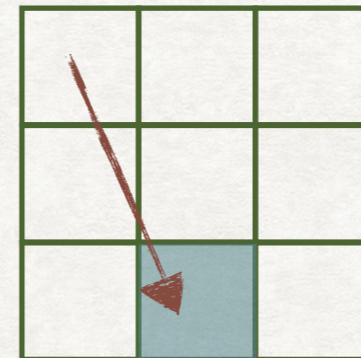
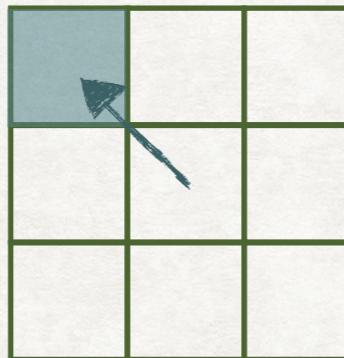
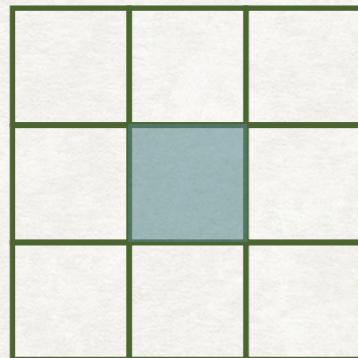


# 手勢說明 (O/V)

O

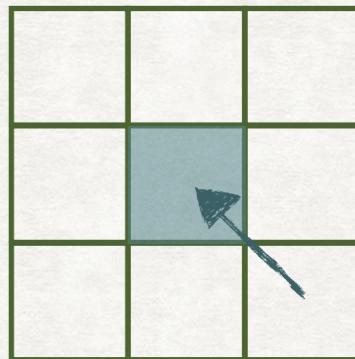
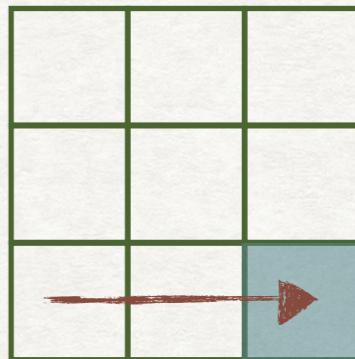
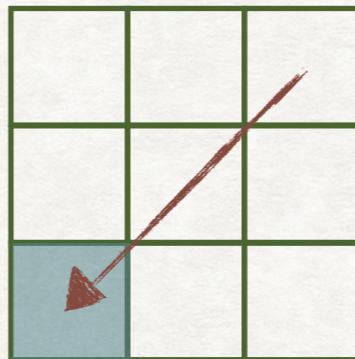
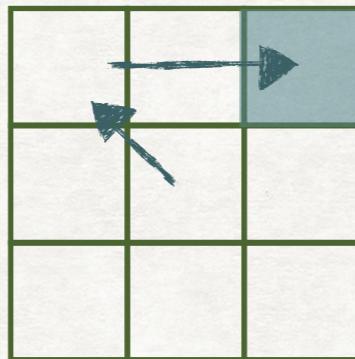
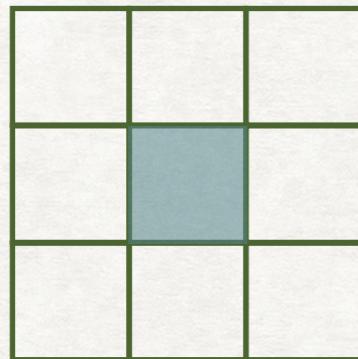


V

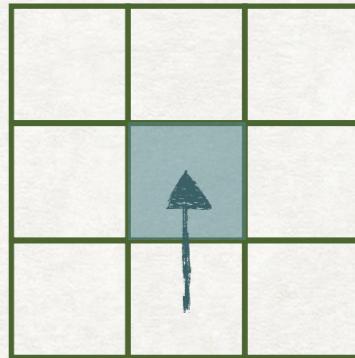
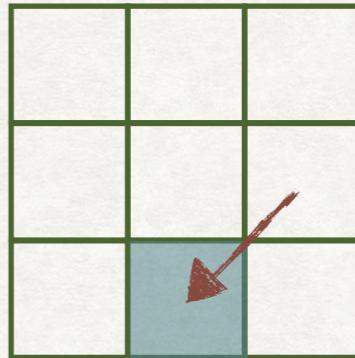
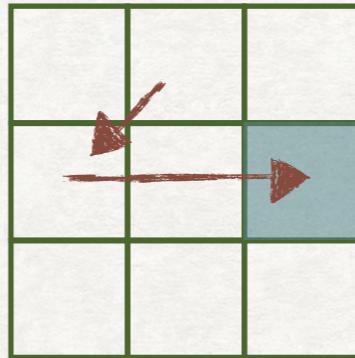
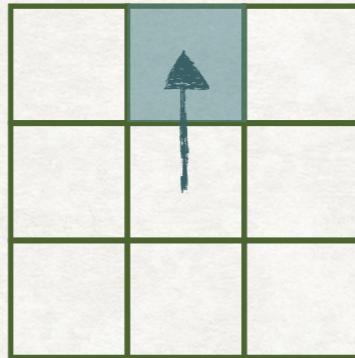
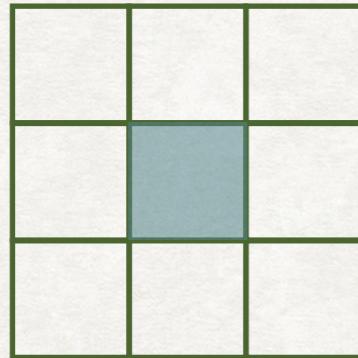


# 手勢說明 (Z/N)

Z



N

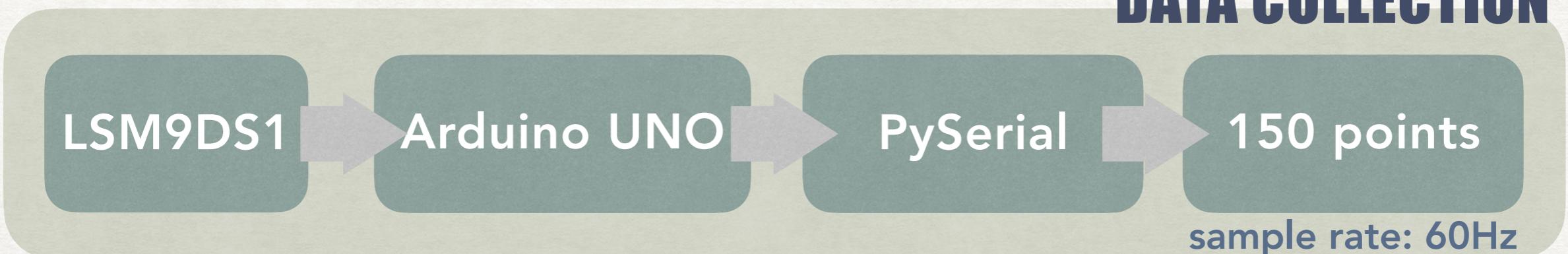


# 手勢說明 (DEMO)

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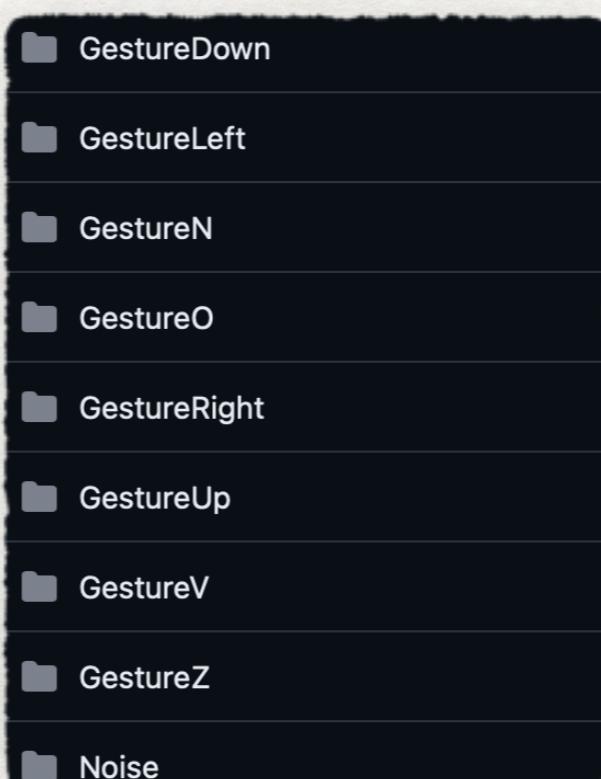
# DATA COLLECTION



[https://github.com/sparkfun/SparkFun\\_LSM9DS1\\_Arduino\\_Library](https://github.com/sparkfun/SparkFun_LSM9DS1_Arduino_Library)



新的裝置配戴方式



Each gesture: 450  
Noise: about 1000  
Total: about 5000

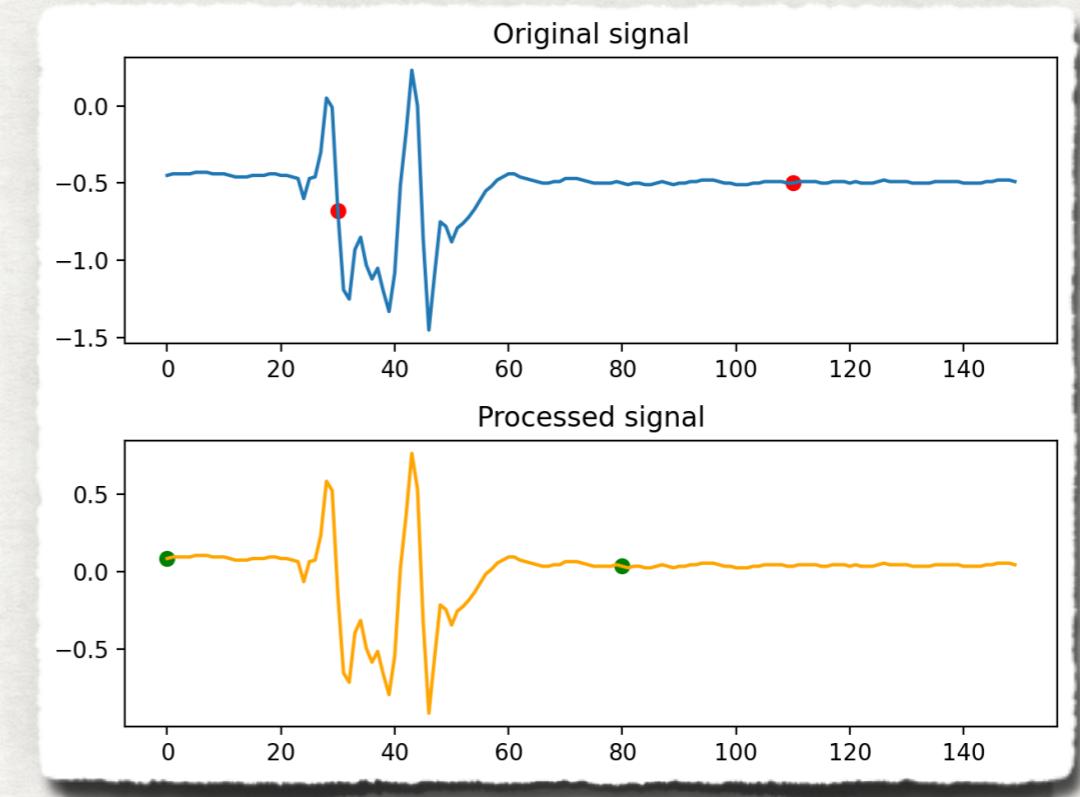
# PREPROCESSING

Normalize to zero mean

Extract data by power ( $150 > 80$ )

- Preprocess
  - Extract meaningful signal, reduce input size from 150 points to 80 points
  - Normalize to zero mean (orange line)
  - Find 80 point interval with largest power (green dot)
  - Randomly add noise to each training data
- Feature
  - Time domain
  - Discrete wavelet transform

$$Power = \sum_{i=0}^{79} signal[i]^2$$



selected 80 points,  
Up: original, Down: normalized

# DATA AUGMENTATION

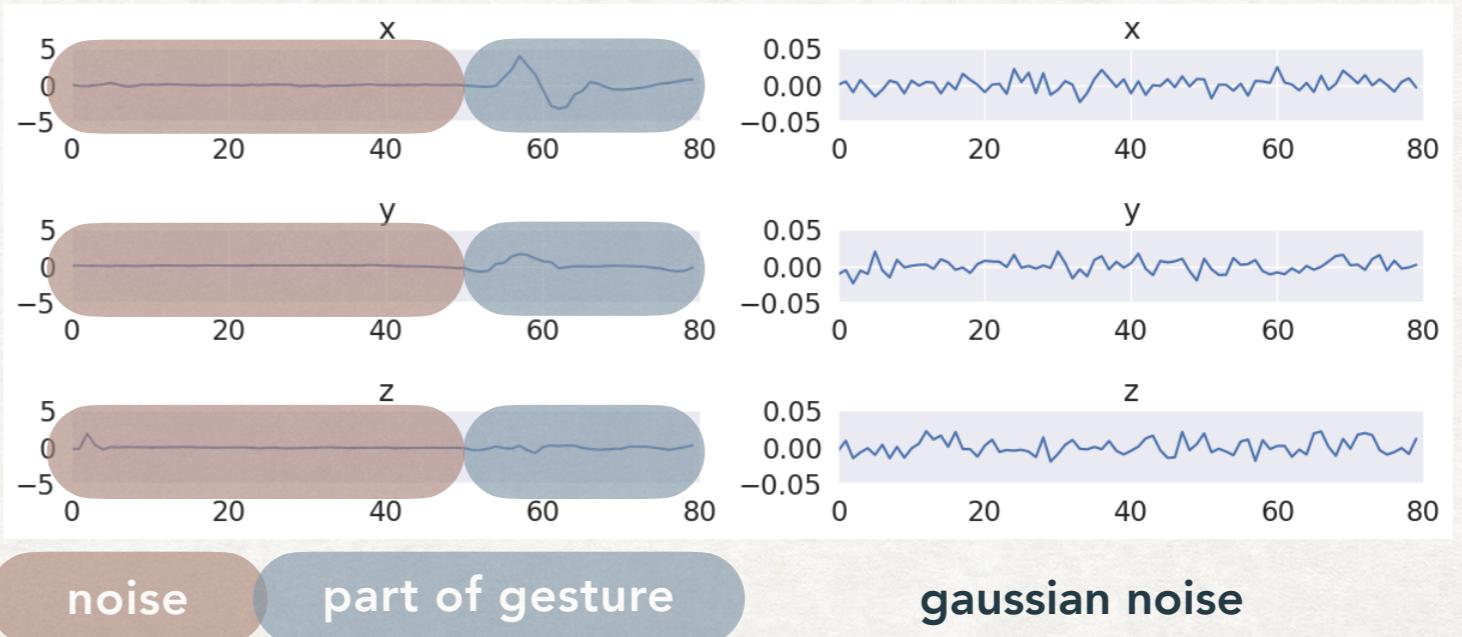
Extract part of gesture

DATA AUGMENTATION

Concat noise to it,  
and label it as noise

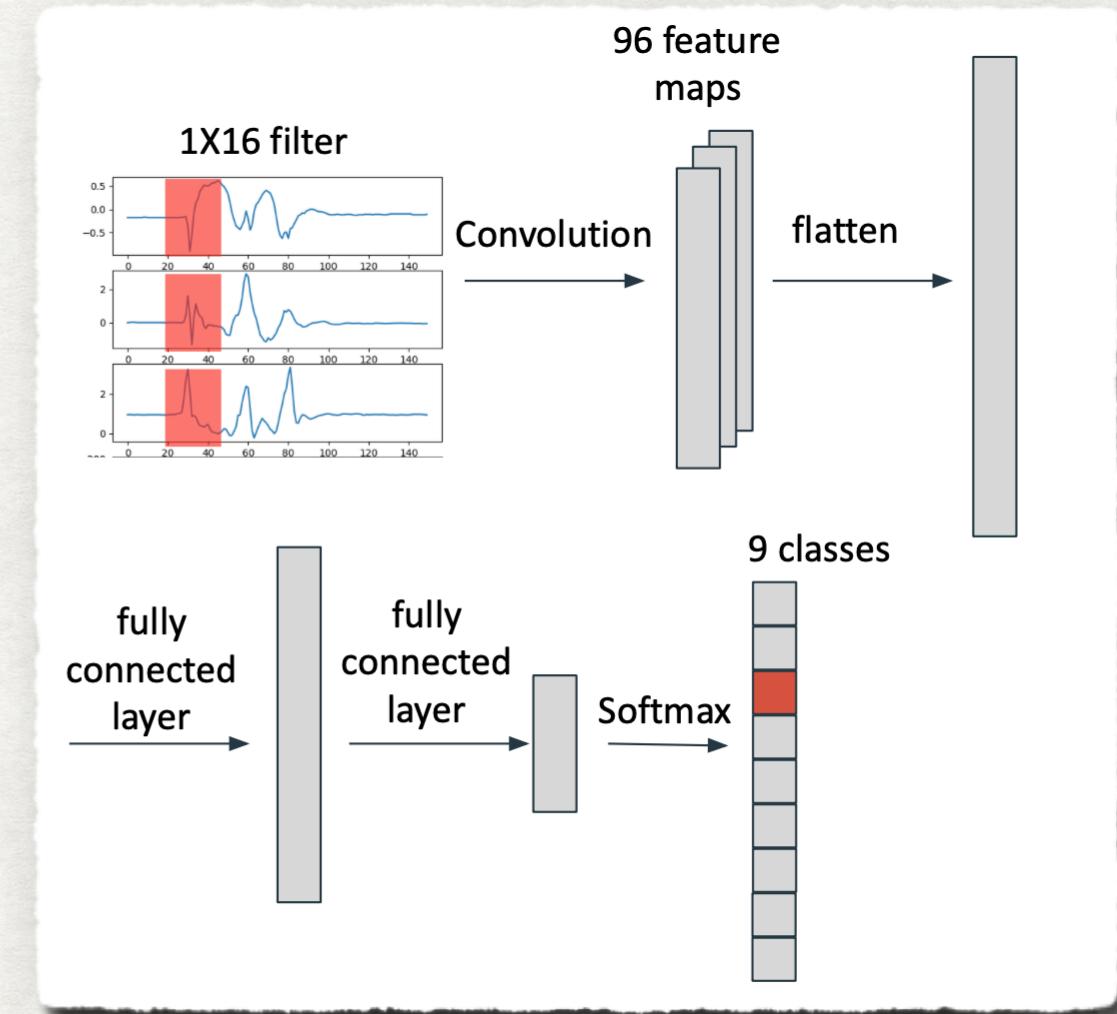
To achieve real-time classification, we collect various types of noise to discriminate gestures from noise.

- typing, using track pad
- Gaussian noise: motionless
- Collected noise concat with part of gesture signal: Avoid classify signal mainly with noise to wrong classes.



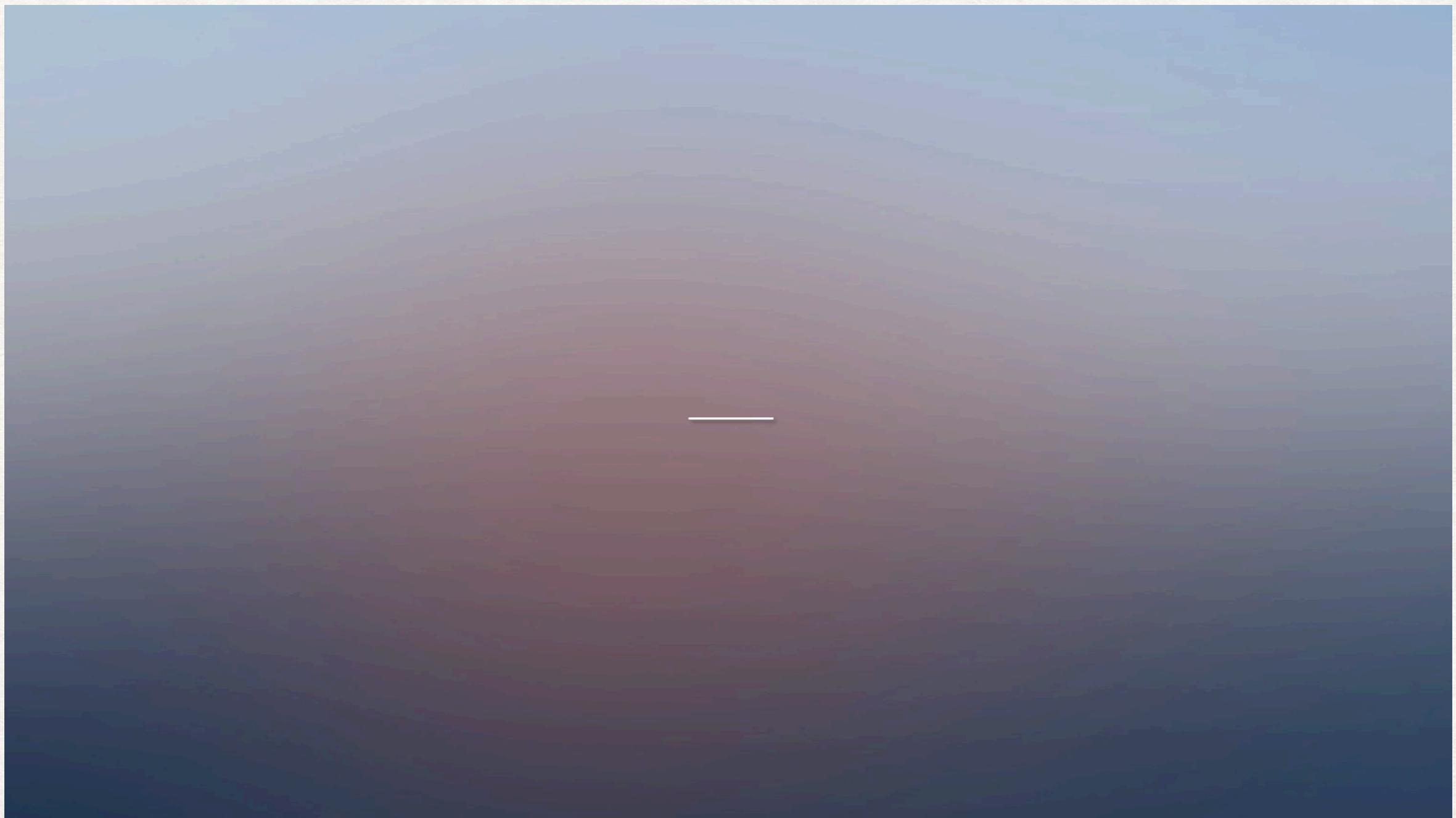
# MODEL

- **CNN model**
  - Time domain Acc = 97%
  - Discrete wavelet transform Acc = 94%
  - Adam optimizer
  - Batch size = 10
- **SVM**
  - Acc = 84%
  - (with PCA, Acc = 45%)



# PHOTOSHOP DEMO

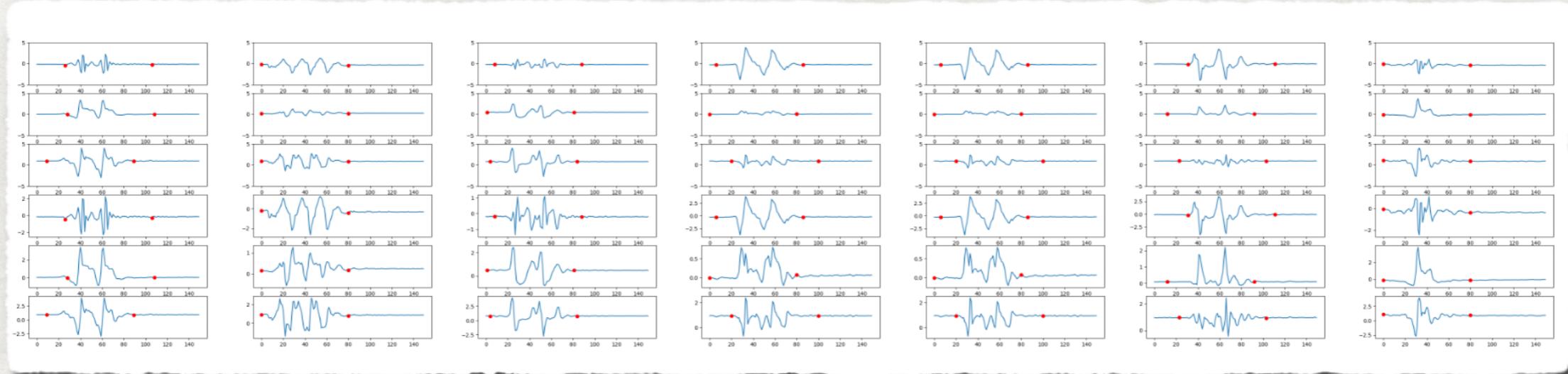
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# REAL-TIME RECOGNITION ALGORITHM

## Basic Concept:

- 150-point sliding window (2~3s)
- Procedure:
  1. find the segment of length 80 that has the maximum power
  2. Feed this segment into model for prediction
  3. If the result isn't noise, conduct the shortcut action accordingly



length 80 that has the maximum power, marked by the red points

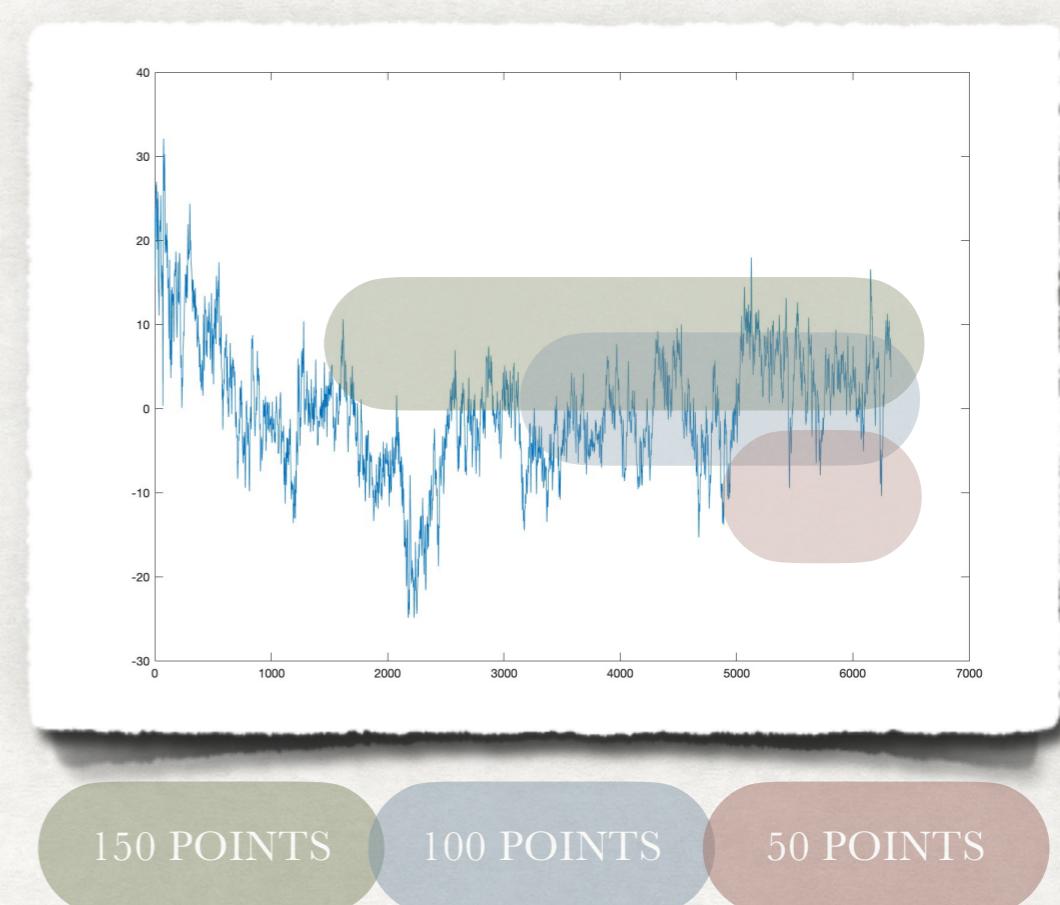
# REAL-TIME RECOGNITION ALGORITHM

## Further Consideration:

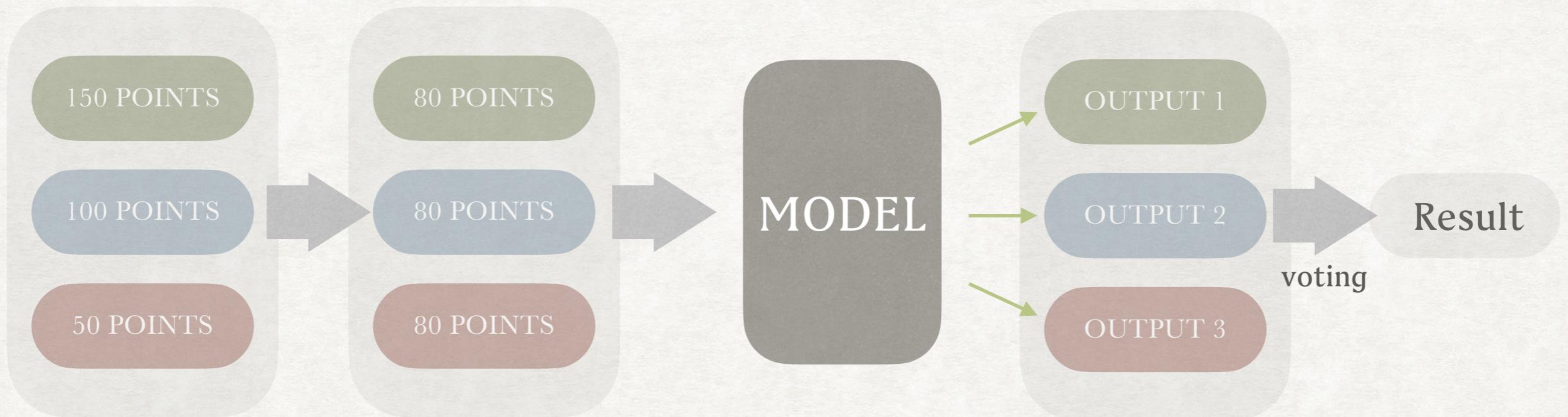
- the variation of the speed of gesture among different people

## Approach:

- For the 150-point sliding window, we further take the last 150, 100, 50 points.
- For the last 150, 100 points, find the segment of length 80 that has the maximum power
- For the last 50 points, resample the 50 points to 80 points



# REAL-TIME RECOGNITION ALGORITHM



- Feed those data into model respectively
- Final result is returned via vote among the predictions that aren't noise
- If a non-noise result:
  - set current window data to all zeros”  
> avoid repetition of the same shortcut action

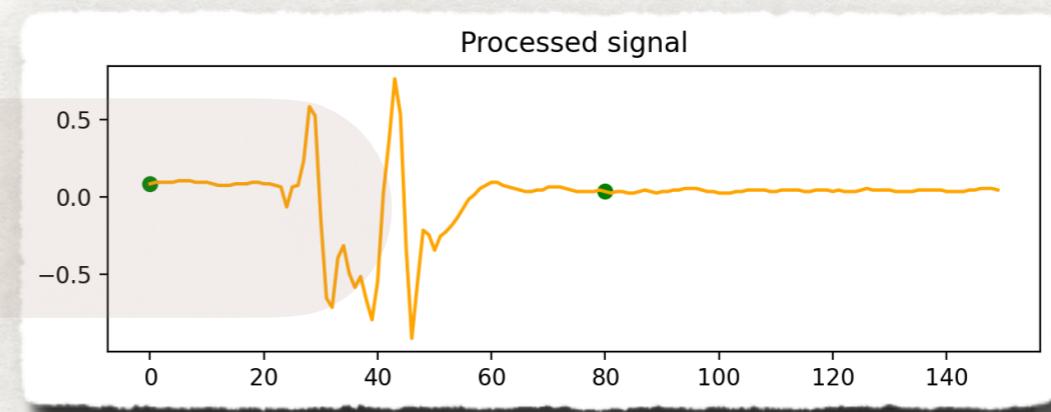
# REAL-TIME RECOGNITION ALGORITHM

## Issue 1: Incomplete Gesture

- real time
- incomplete gestures may be classified to a wrong gesture.

## Solution

1. Add incomplete gestures to training data labeled as noise.
2. Don't feed into model if the selected segment is one of the last 5 segments (balance between correctness and speed, by experiment)



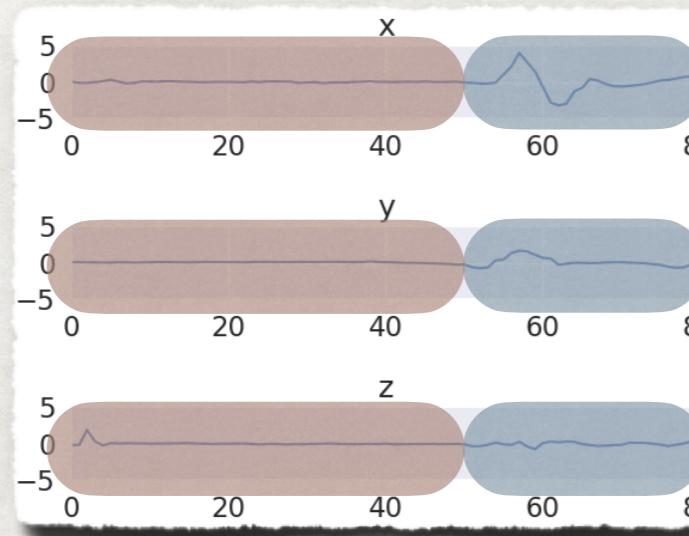
# REAL-TIME RECOGNITION ALGORITHM

## Issue 2: Minor finger movements

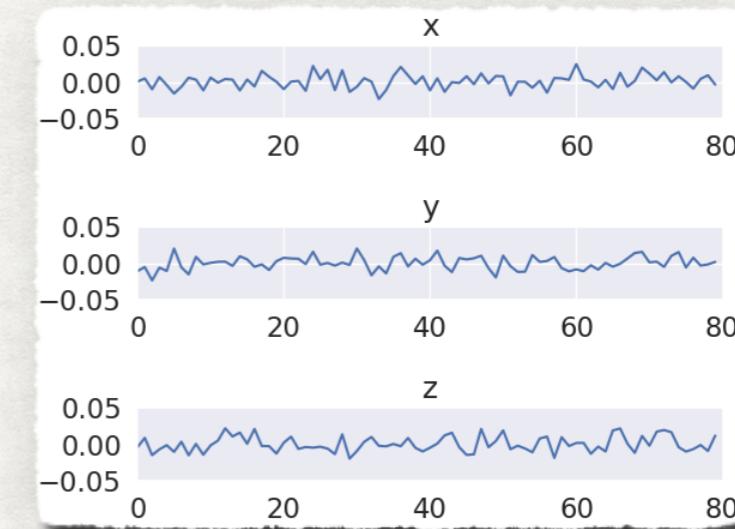
- Small movements (typing) may incur false recognition.

## Solution

- Add minor finger movements to training data labeled as noise
- Set a power threshold
- also utilize resources efficiently
- Total power of the selected data > power threshold



noise  
part of gesture



collected noise

# REAL-TIME RECOGNITION ALGORITHM

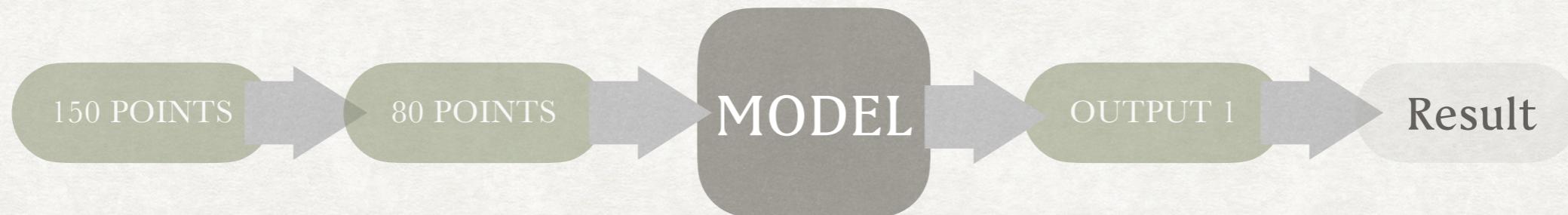
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## Issue 3: Data Resampling

- Resampling the last 50 data points to 80 points often incurs false recognition

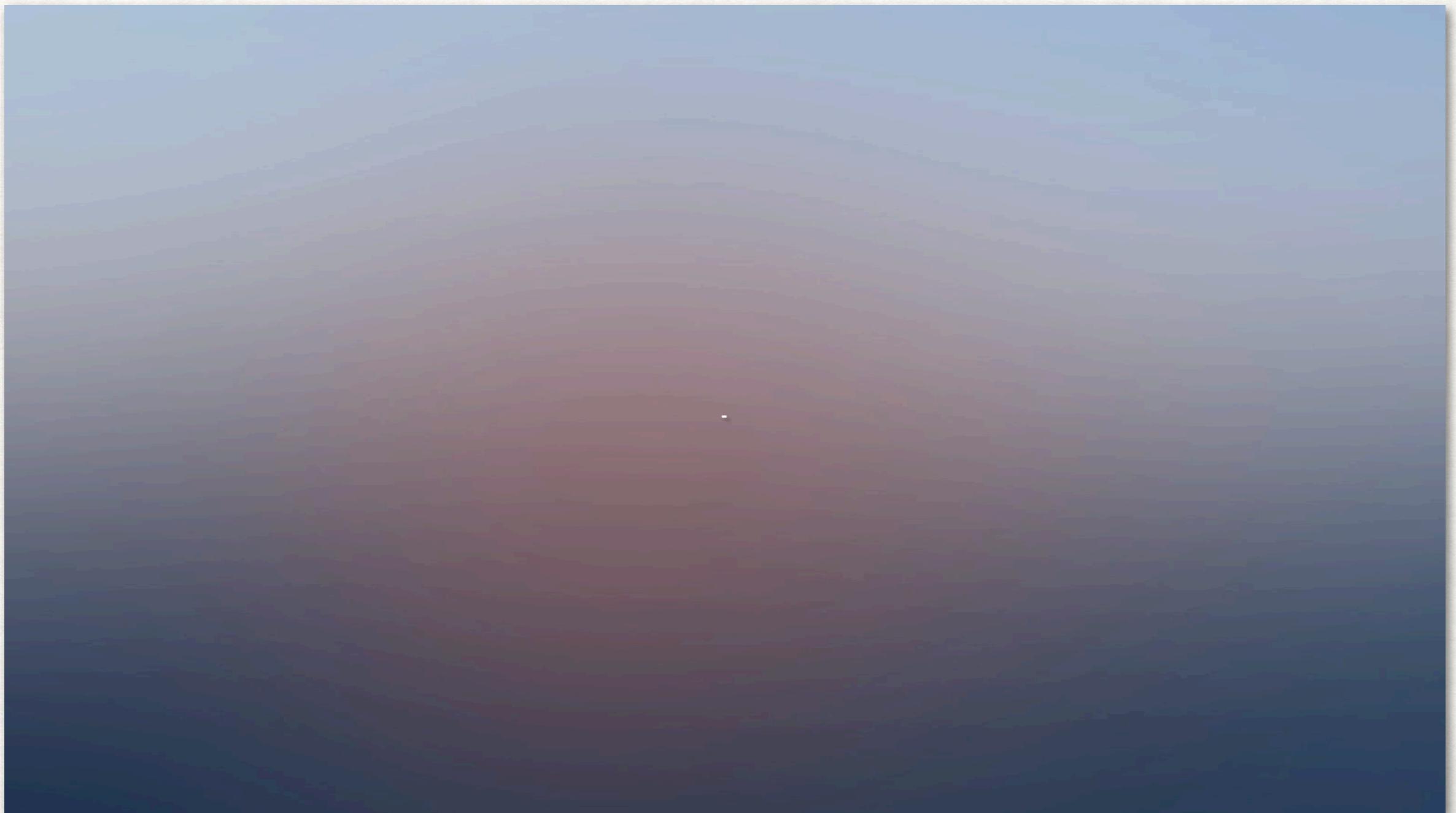
## Solution:

- From our experiment, we conclude it's not necessary to take 150, 100, 50 data points.
- 150 points of data have great enough accuracy.



# REAL-TIME RECOGNITION ALGORITHM DEMO

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# 參考資料

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- [http://cc.ee.ntu.edu.tw/~ultrasound/belab/term\\_project/Group7/final\\_reprt\\_G7.pdf](http://cc.ee.ntu.edu.tw/~ultrasound/belab/term_project/Group7/final_reprt_G7.pdf)
- <https://learn.sparkfun.com/>
- <https://www.biometricupdate.com/201801/this-ring-uses-gesture-recognition-to-write-words-and-numbers>
- [https://github.com/adafruit/Adafruit\\_ADXL345](https://github.com/adafruit/Adafruit_ADXL345)
- [https://github.com/sparkfun/SparkFun\\_LSM9DS1\\_Arduino\\_Library](https://github.com/sparkfun/SparkFun_LSM9DS1_Arduino_Library)
- [https://swf.com.tw/?p=1188&fbclid=IwAR3kguoYJDWyzA7fybZRm8fOZz0lmJnv13t9mzQMa4MRST8QOaOa\\_P16QXk](https://swf.com.tw/?p=1188&fbclid=IwAR3kguoYJDWyzA7fybZRm8fOZz0lmJnv13t9mzQMa4MRST8QOaOa_P16QXk)
- <https://www.sciencedirect.com/science/article/pii/S1568494617305665>
- [https://link.springer.com/chapter/10.1007/978-3-319-27707-3\\_19](https://link.springer.com/chapter/10.1007/978-3-319-27707-3_19)
- ChatGPT

Q & A