

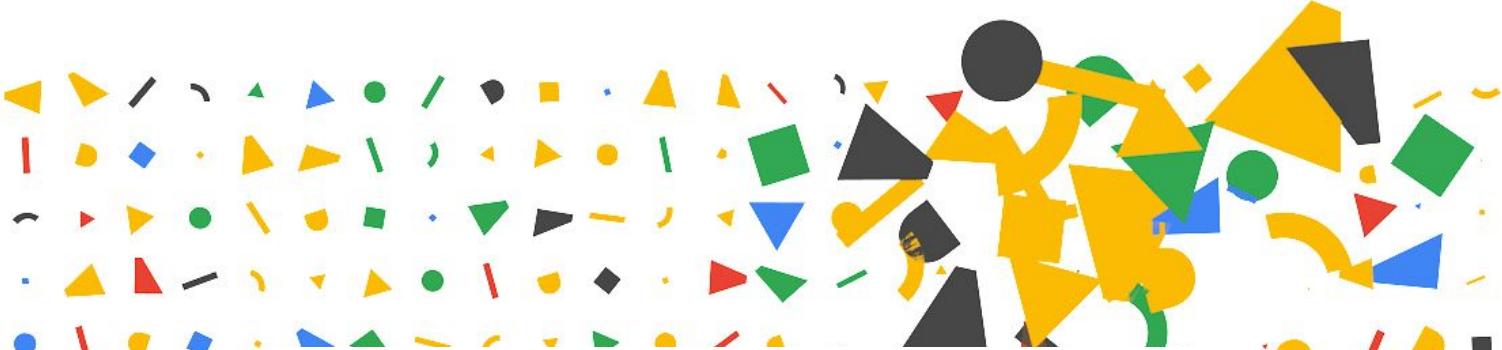
Smart Necklace

Weiching Chen

Motivation

1. Nowadays, there are a lot of wearable device, such as smart watches. I want to make a wearable and fashionable device that can take care of humans.
2. Drinking water can make ourselves healthier.
3. Currently, the only way to detect whether or not you have drank water is using a smart water bottle.



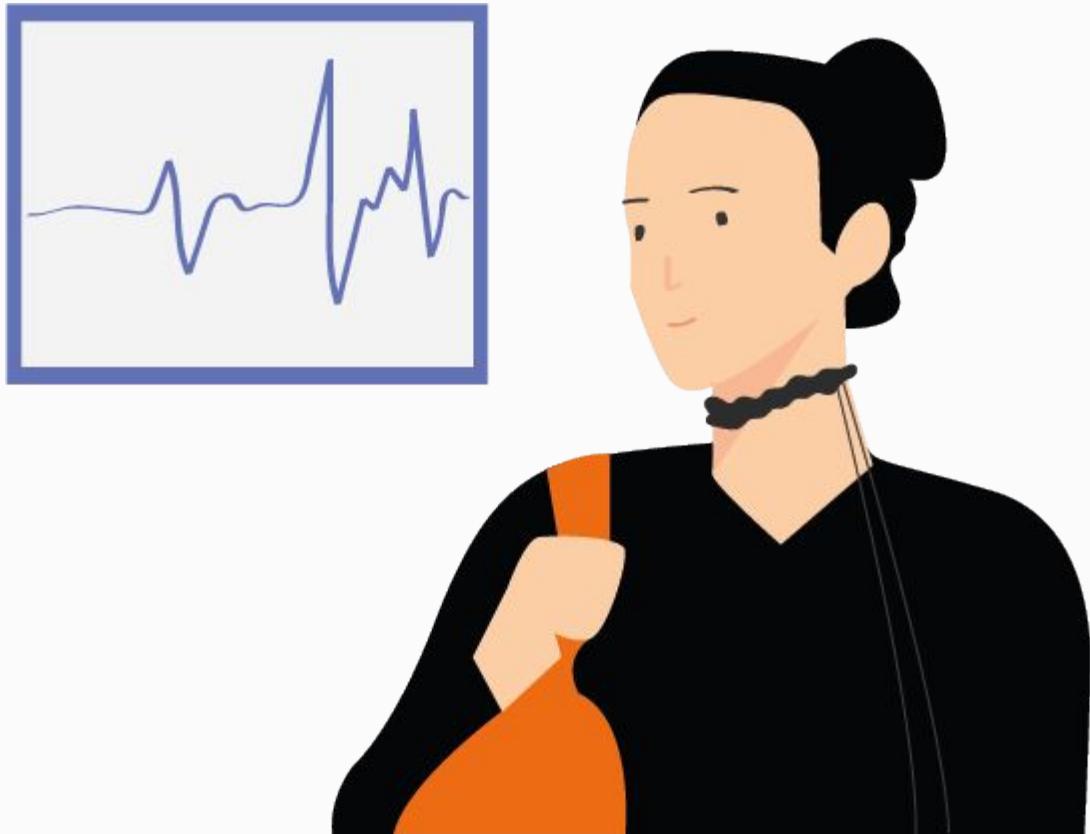


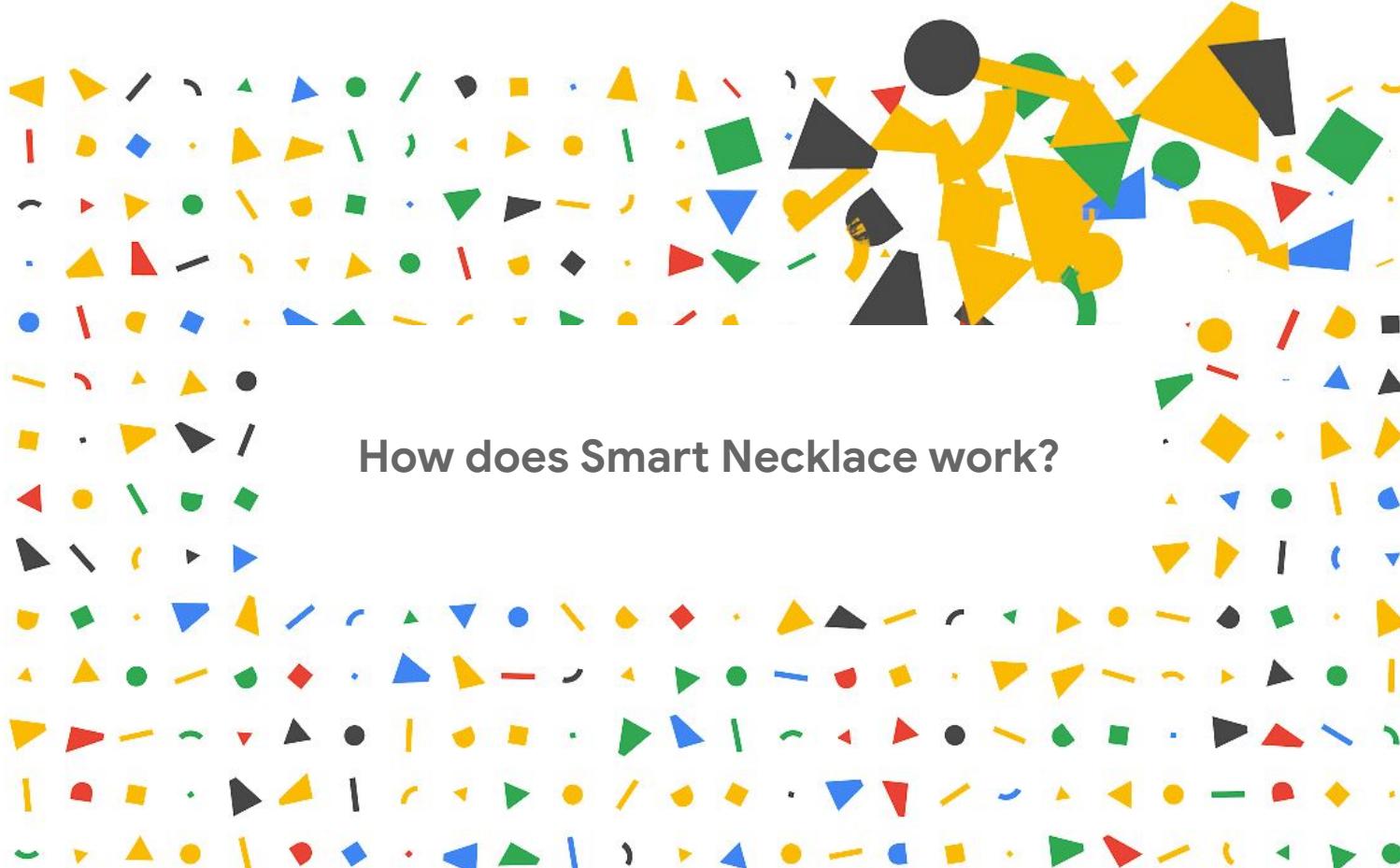
A person wearing a yellow shirt and black pants stands amidst a chaotic arrangement of various colored geometric shapes, including triangles, squares, and circles in shades of yellow, green, blue, red, and black. The shapes are scattered across the frame, creating a sense of motion or a search.

What is my goal?

Objective

1. I want to make it a **functional device**
2. I want to make this device **fashionable**
3. I would like to make this device more **compact** and **consume less power**

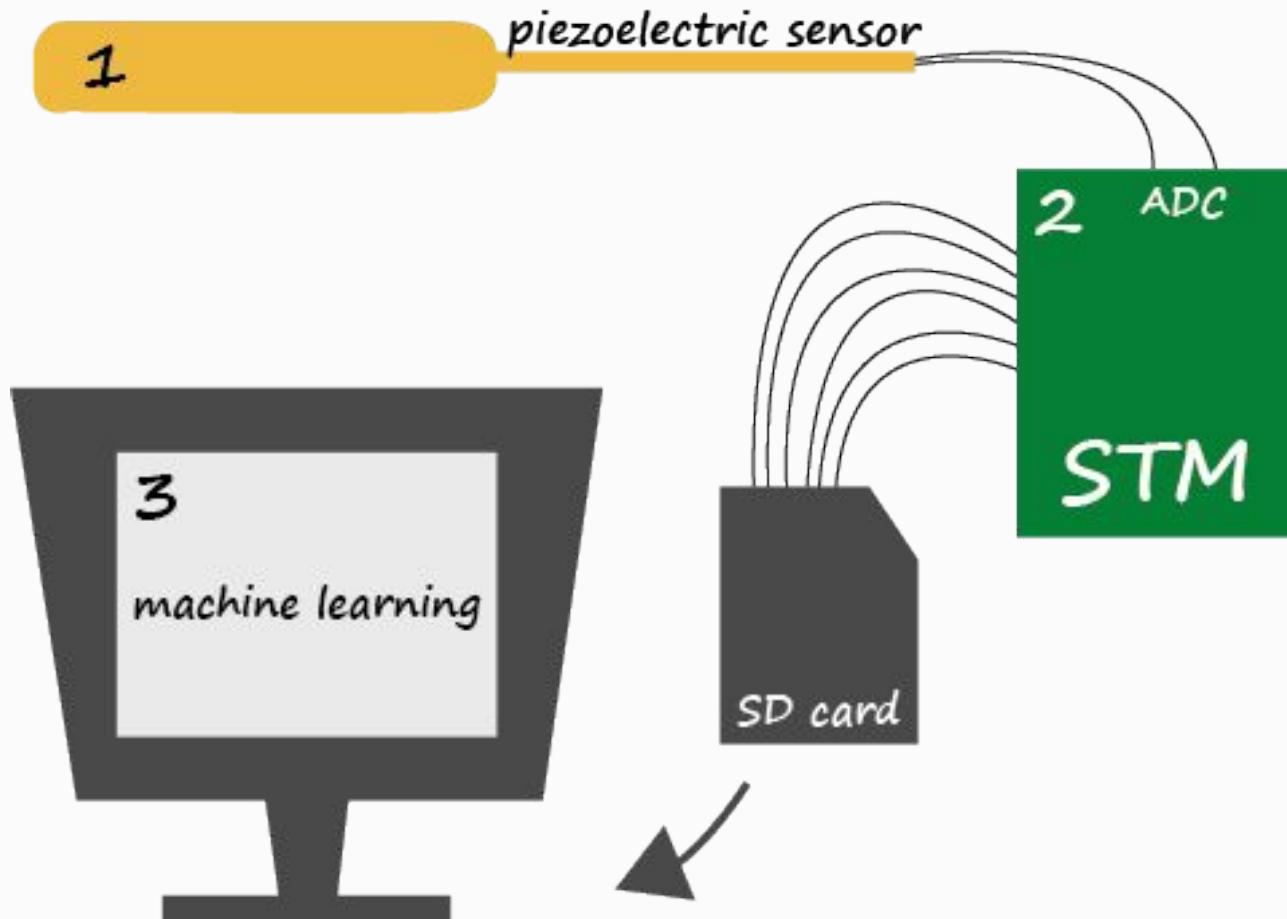




How does Smart Necklace work?

Smart Necklace

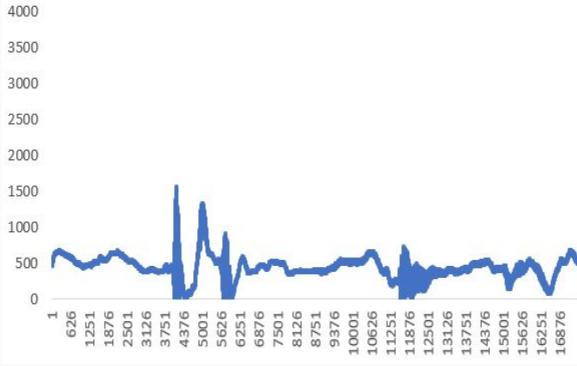
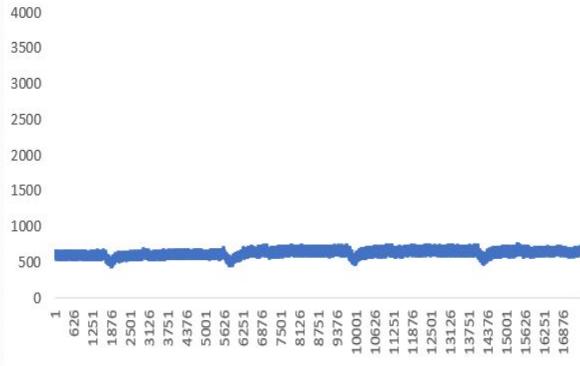
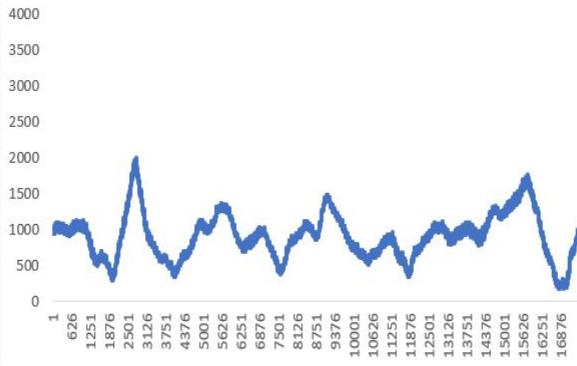
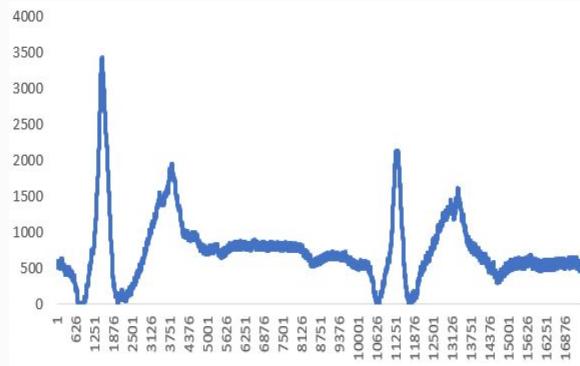
I divided this Smart Necklace into three parts. First, I used piezoelectric sensor to detect different waves. Then, I used MCU to collect data. Last, I used CNN to do machine learning.



Piezoelectric sensor

The benefits of piezoelectric sensor:

1. It is **sensitive** enough to distinguish different movements
2. This sensor requires **no battery**
3. This sensor is **compact** and **thin** enough to make it look like a necklace



Piezoelectric sensor

Piezoelectric Effect is the ability to generate an electric charge from mechanical stress. A power source is not needed for this effect. In the other words, you can transfer the vibration into electricity.

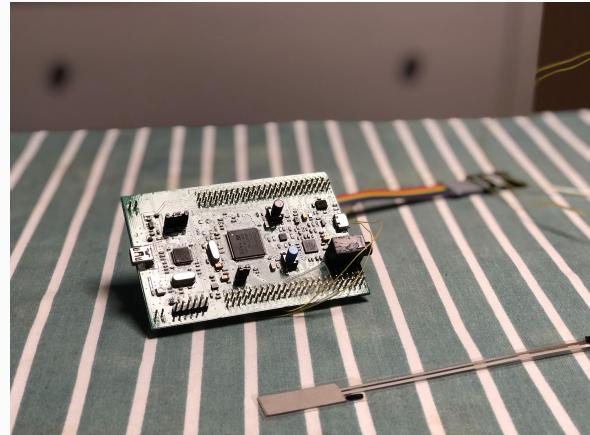
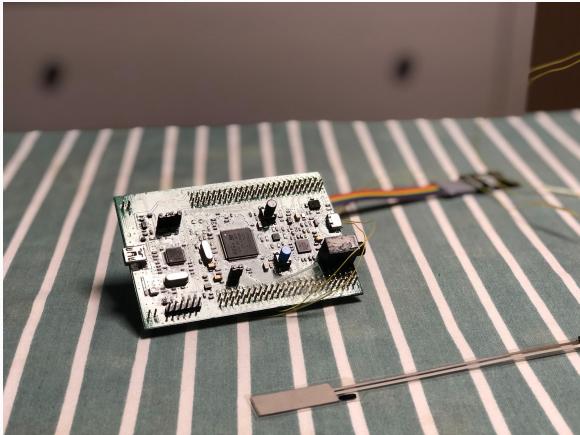
I found that when we drink or talk, the muscles in our neck move. It is during this muscle movement that a sensor is used to generate data. The Piezoelectric film sensor turns these vibrations into tiny electrical pulses, and the data can then be used for machine learning.



MCU+ADC

In the future, this MCU can be replaced by a single chip and it will be smaller. It will have a better power consumption in the future!

I used MCU to collect data and transferred the analog wave into digital signals. So I chose to use STM discovery board since it has its own ADC. The sampling frequency of Smart Necklace is 5,000Hz, and one point is about 2 bytes. Nowadays, the SD card can collect over 32G, which means this device can definitely do long-term collection.



Machine learning: training

Machine Learning is a category of algorithms that allows software applications to accurately predict outcomes without being programmed. The basic premise of machine learning is to build algorithms which have the capacity to receive input data and can use statistical analysis to predict an output.

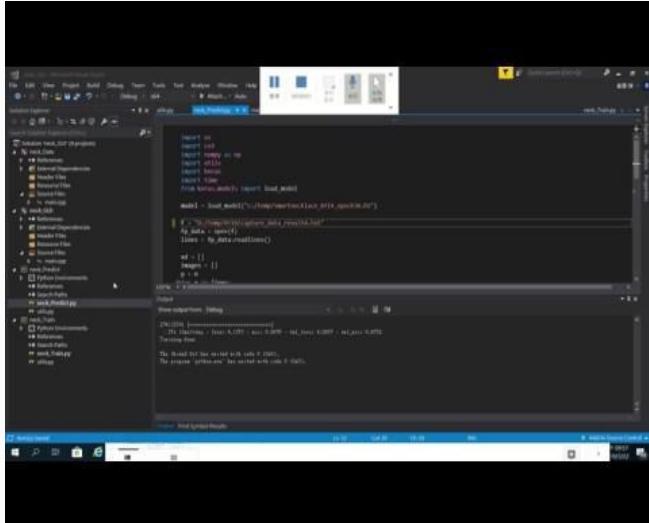
CNN model design: one dimension of convolution will be used in this study, consisting of two 1D-convolution layers followed by a maximum pooling layer. Then, full connection classifier layers consisting of four neural network layers and two dropout layers will be used for classification.

```
Using TensorFlow backend.  
-----  
Layer (type)          Output Shape         Param #  
-----  
conv1d_1 (Conv1D)     (None, 17500, 128)    2176  
max_pooling1d_1 (MaxPooling1D) (None, 2188, 128) 0  
conv1d_2 (Conv1D)     (None, 2188, 256)    524544  
max_pooling1d_2 (MaxPooling1D) (None, 274, 256) 0  
reshape_1 (Reshape)   (None, 70144)        0  
dropout_1 (Dropout)  (None, 70144)        0  
dense_1 (Dense)      (None, 1024)         7128480  
dropout_2 (Dropout)  (None, 1024)         0  
dense_2 (Dense)      (None, 1024)         1049600  
dense_3 (Dense)      (None, 128)          131200  
dense_4 (Dense)      (None, 4)           516  
-----  
Total params: 73,536,516  
Trainable params: 73,536,516  
Non-trainable params: 0  
-----  
Epoch 8/30  
[=====] - 36s 1ms/step - loss: 19.973 - acc: 0.3683 - val_loss: 19.2215 - val_acc: 0.3982  
[=====] - 36s 1ms/step - loss: 18.6397 - acc: 0.8840 - val_loss: 17.9487 - val_acc: 0.8878  
[=====] - 36s 1ms/step - loss: 17.3568 - acc: 0.9168 - val_loss: 16.7013 - val_acc: 0.9388  
Epoch 10/30  
[=====] - 36s 1ms/step - loss: 16.1846 - acc: 0.9296 - val_loss: 15.7526 - val_acc: 0.9178  
[=====] - 36s 1ms/step - loss: 15.0771 - acc: 0.9467 - val_loss: 14.5700 - val_acc: 0.9388  
[=====] - 36s 1ms/step - loss: 14.0653 - acc: 0.9539 - val_loss: 13.6581 - val_acc: 0.9548  
Epoch 12/30  
[=====] - 36s 1ms/step - loss: 13.1096 - acc: 0.9606 - val_loss: 12.7253 - val_acc: 0.9446  
[=====] - 36s 1ms/step - loss: 12.2389 - acc: 0.9683 - val_loss: 11.8622 - val_acc: 0.9752  
[=====] - 36s 1ms/step - loss: 11.4372 - acc: 0.9675 - val_loss: 11.0994 - val_acc: 0.9592  
[=====] - 36s 1ms/step - loss: 10.6563 - acc: 0.9914 - val_loss: 10.3479 - val_acc: 0.9738  
[=====] - 36s 1ms/step - loss: 9.9524 - acc: 0.9788 - val_loss: 9.6399 - val_acc: 0.9665  
Epoch 15/30  
[=====] - 37s 1ms/step - loss: 9.3066 - acc: 0.9788 - val_loss: 9.0517 - val_acc: 0.9767  
[=====] - 37s 1ms/step - loss: 8.6722 - acc: 0.9672 - val_loss: 8.4449 - val_acc: 0.9796  
[=====] - 37s 1ms/step - loss: 8.0988 - acc: 0.9829 - val_loss: 7.9185 - val_acc: 0.9796  
[=====] - 37s 1ms/step - loss: 7.5666 - acc: 0.9898 - val_loss: 7.3659 - val_acc: 0.9810  
[=====] - 37s 1ms/step - loss: 7.0575 - acc: 0.9923 - val_loss: 6.9049 - val_acc: 0.9781  
[=====] - 36s 1ms/step - loss: 6.5947 - acc: 0.9909 - val_loss: 6.4565 - val_acc: 0.9796  
[=====] - 36s 1ms/step - loss: 6.1523 - acc: 0.9942 - val_loss: 6.0227 - val_acc: 0.9810  
[=====] - 36s 1ms/step - loss: 5.7438 - acc: 0.9953 - val_loss: 5.6440 - val_acc: 0.9796  
Epoch 26/30  
[=====] - 36s 1ms/step - loss: 5.3723 - acc: 0.9923 - val_loss: 5.2999 - val_acc: 0.9781  
[=====] - 36s 1ms/step - loss: 5.0225 - acc: 0.9905 - val_loss: 4.9344 - val_acc: 0.9752  
[=====] - 36s 1ms/step - loss: 4.7431 - acc: 0.9741 - val_loss: 4.6649 - val_acc: 0.9621  
Epoch 29/30  
[=====] - 37s 1ms/step - loss: 4.4736 - acc: 0.9668 - val_loss: 4.3781 - val_acc: 0.9723  
[=====] - 37s 1ms/step - loss: 4.1973 - acc: 0.9876 - val_loss: 4.0957 - val_acc: 0.9752  
Training done  
Press any key to continue... .
```

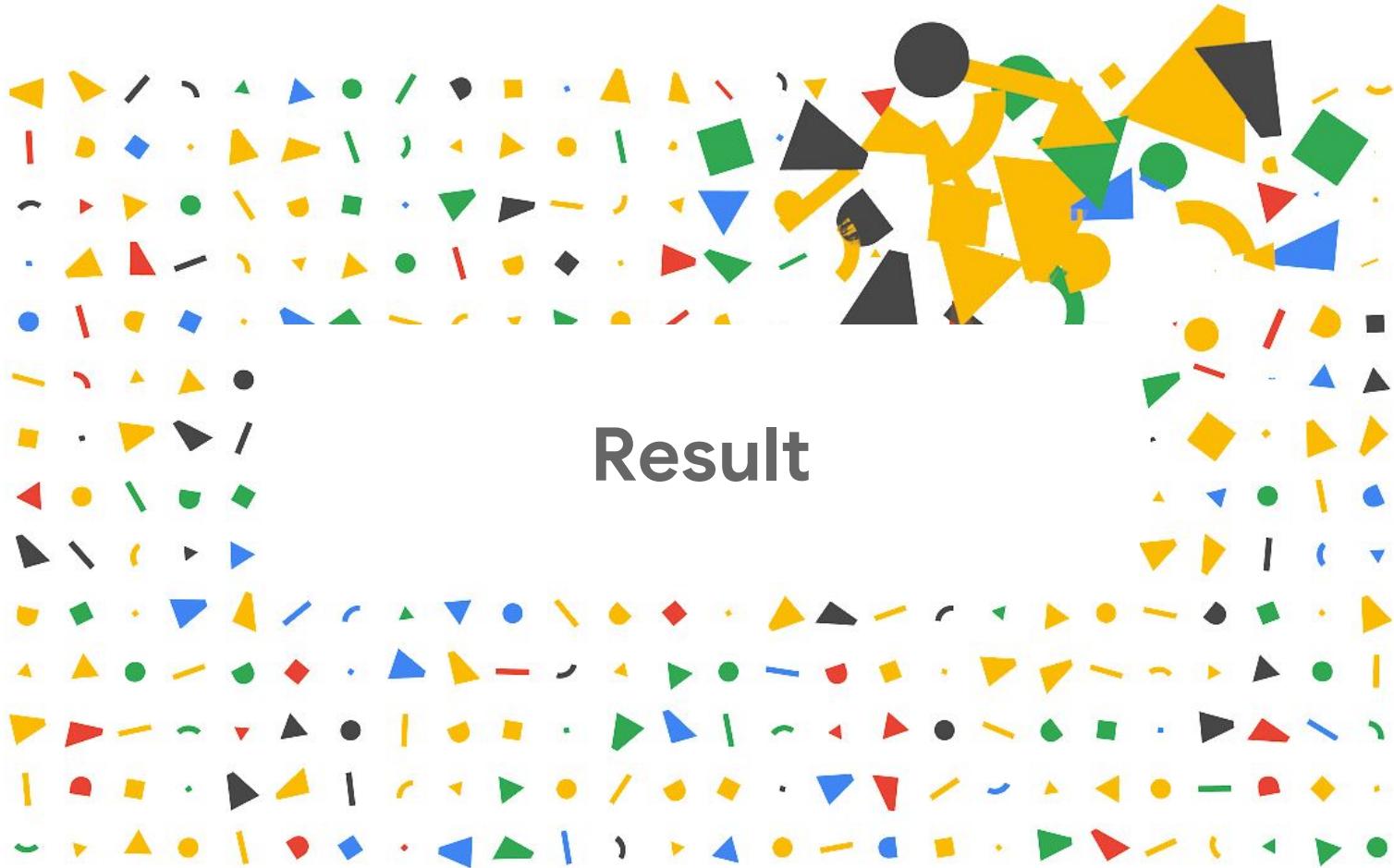
Machine learning: prediction

Machine Learning is a category of algorithms that allows software applications to accurately predict outcomes without being programmed. The basic premise of machine learning is to build algorithms which have the capacity to receive input data and can use statistical analysis to predict an output.

After training, I got a result, and then I used the result to do the prediction of a variety of movements.

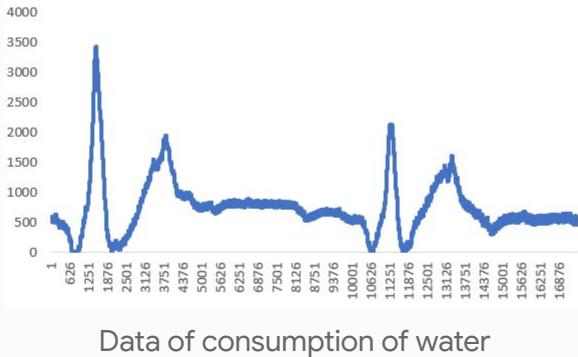


213500	0.002971	0.115357	0.881672	0.000000
217000	0.000084	0.003777	0.996139	0.000000
220500	0.000034	0.000041	0.99925	0.000000
224000	0.000500	0.000061	0.999429	0.000011
227500	0.012400	0.001040	0.079513	0.907047
231000	0.002290	0.000130	0.005938	0.991642
234500	0.000640	0.000028	0.001283	0.998049
238000	0.000600	0.000027	0.000349	0.999024
241500	0.000622	0.000026	0.000185	0.999167
245000	0.002474	0.000141	0.001297	0.996088
248500	0.008556	0.001317	0.989875	0.000252
252000	0.001021	0.996732	0.002247	0.000000
255500	0.003632	0.995007	0.001361	0.000000
259000	0.000050	0.999913	0.000037	0.000000
262500	0.000065	0.999934	0.000001	0.000000
266000	0.000305	0.999667	0.000028	0.000000
269500	0.987749	0.006748	0.005503	0.000000
273000	0.011181	0.000247	0.988571	0.000000
276500	0.001202	0.046372	0.952426	0.000000
280000	0.000022	0.000014	0.999964	0.000000
283500	0.002897	0.000177	0.000638	0.996288
287000	0.005277	0.000464	0.005375	0.988884
290500	0.001817	0.000139	0.000407	0.997637
294000	0.029282	0.004214	0.048111	0.918394
297500	0.015304	0.001892	0.108698	0.874106

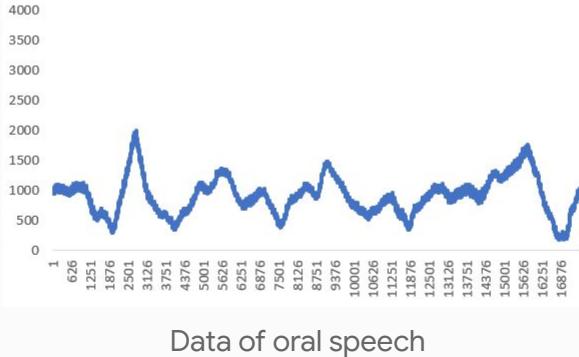


Experiment 1

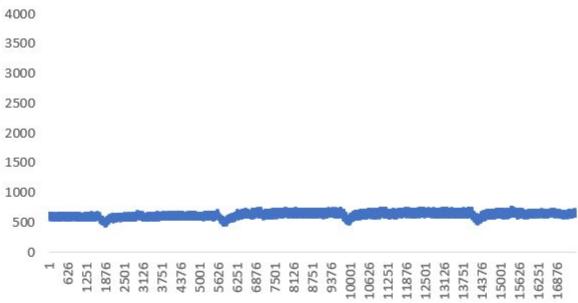
This experiment proved that our neck will create different vibration when doing different movement.



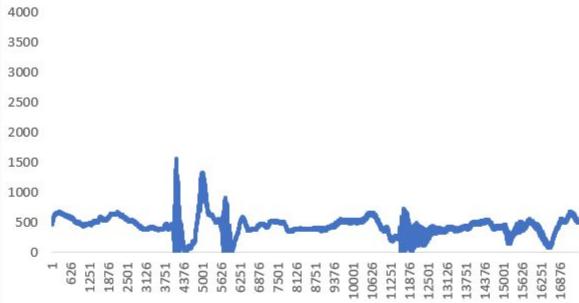
Data of consumption of water



Data of oral speech



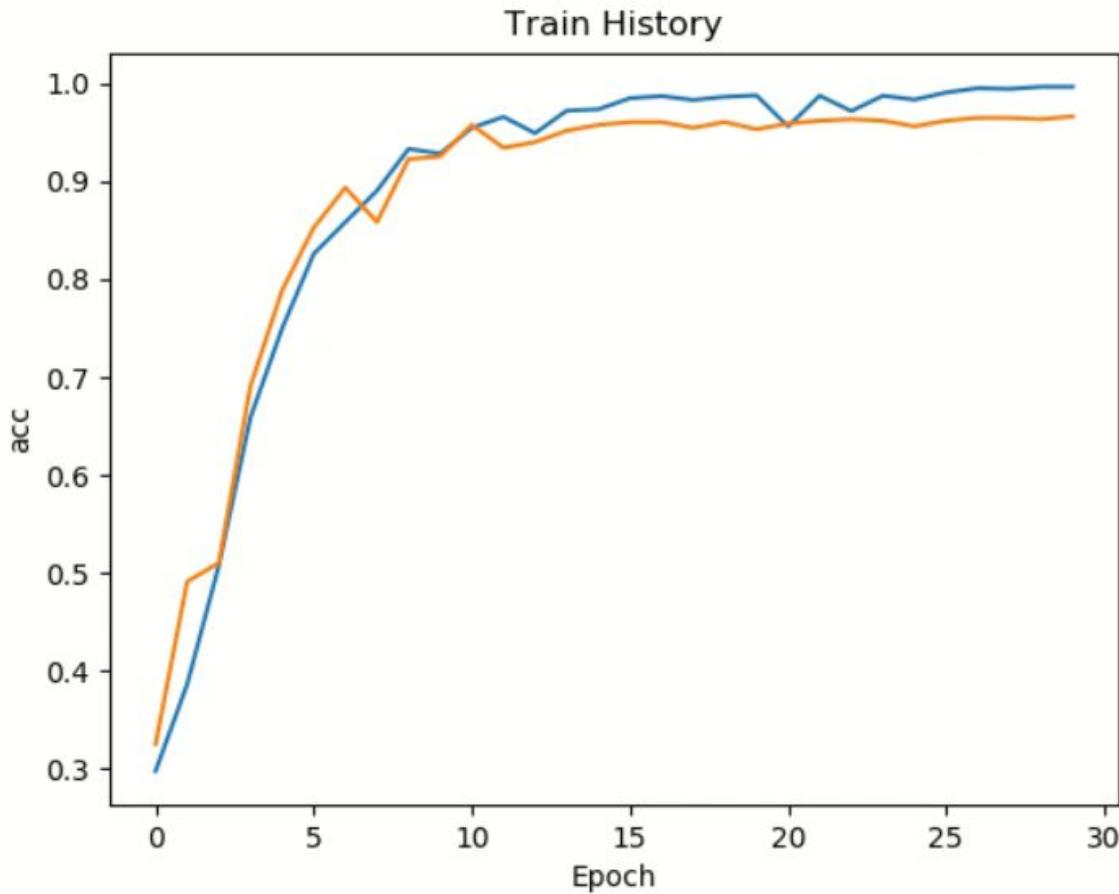
Data of heart rate



Data of coughing

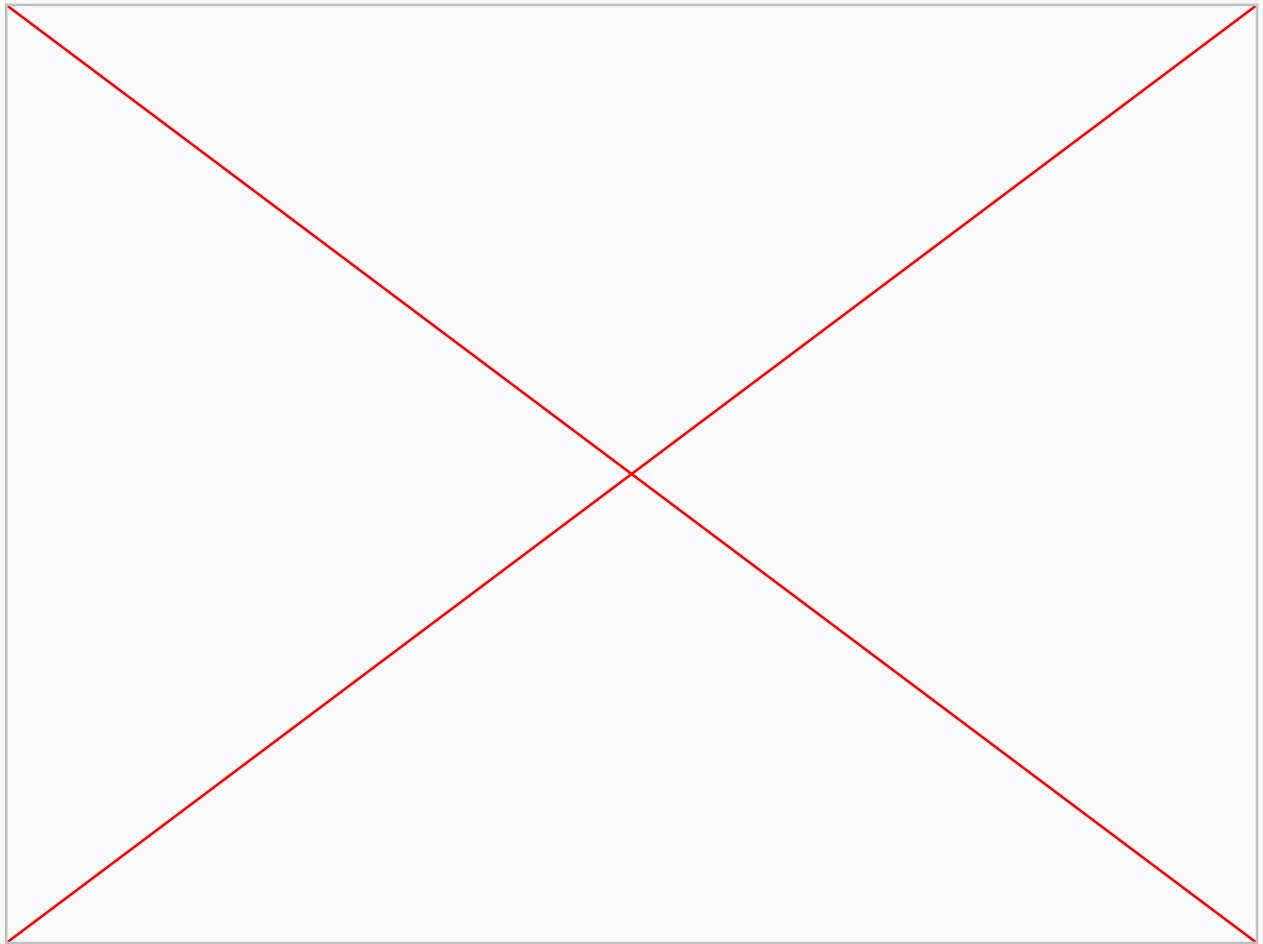
Experiment 2

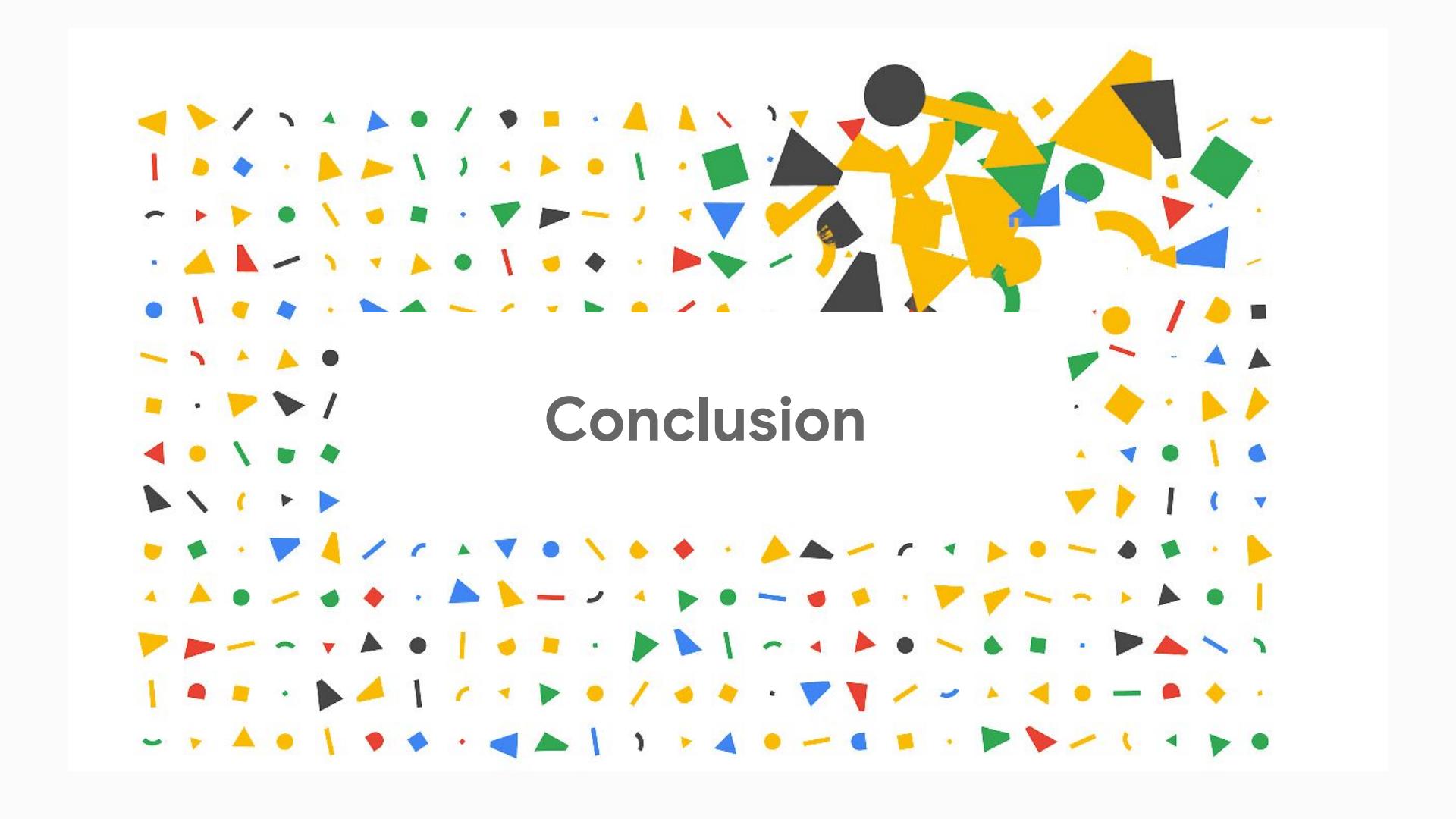
In this experiment, I have trained over 2700 pieces of data. After 30 epochs of training, I got a high accuracy rate, which is about 0.98. The graph beside shows the result.



Experiment 3

In this experiment, I did a variety of movements in 60 seconds. This video shows the result.

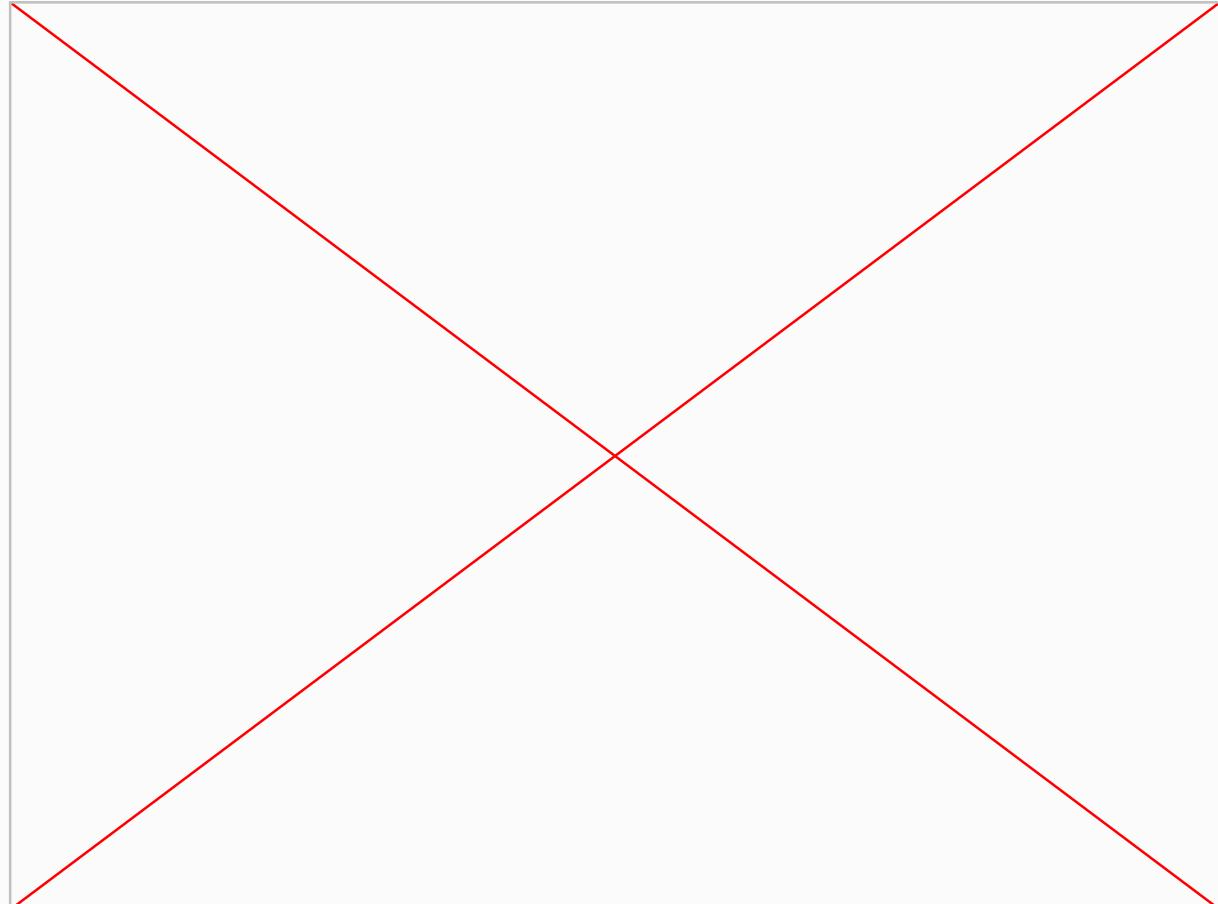




Conclusion

Conclusion

1. The piezoelectric sensor can distinguish different movement
2. This device can truly be used to collect data
3. After training, my device got an high accuracy rate
4. This device can truly collect a long-term data and distinguish the movement that user performs.





Impact

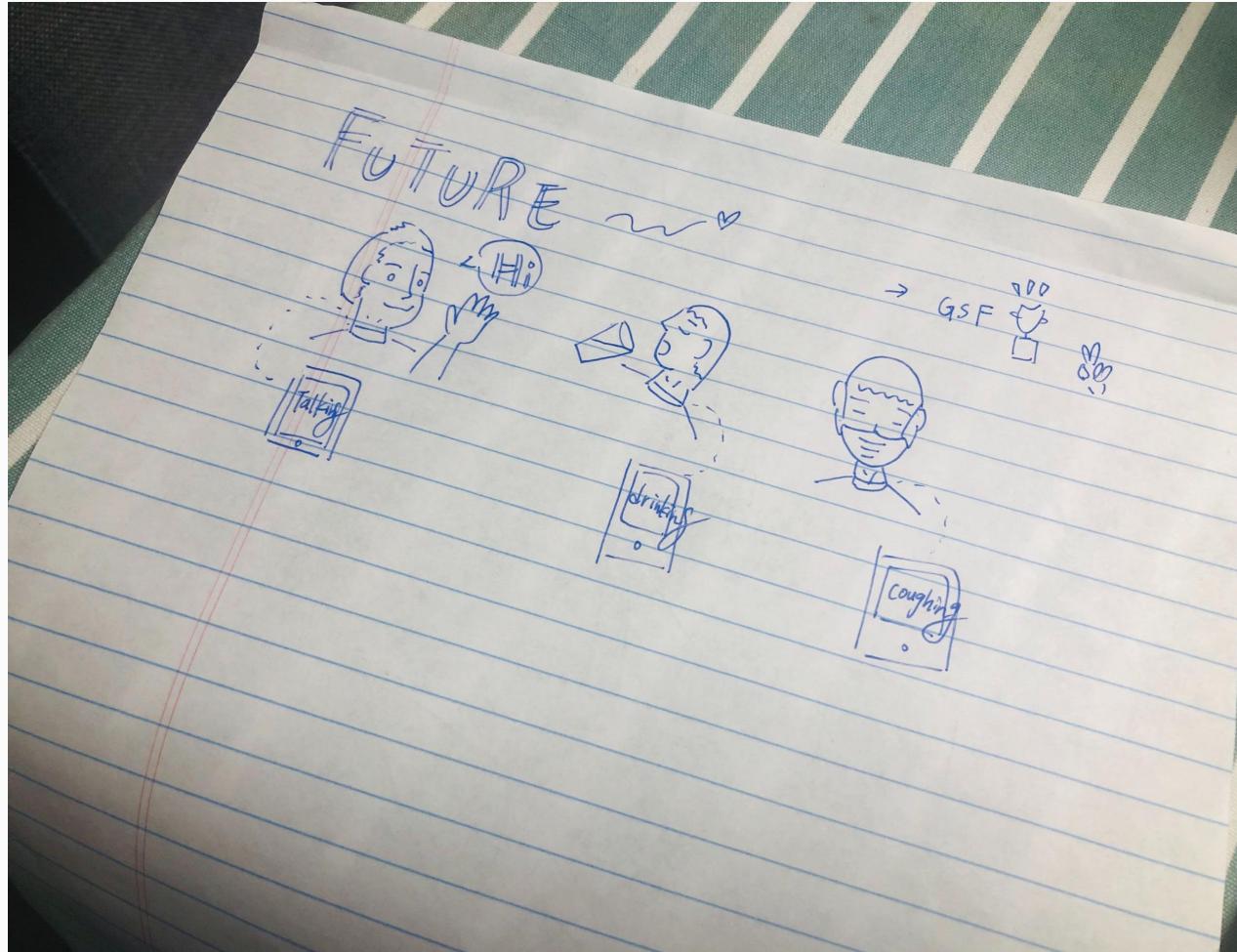
Contribution

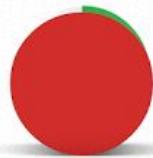
This device is especially useful in terms of helping the elderly. We are now entering the era of an aging society and there are a more and more old people living alone. It can help caretakers know whether the elderly are drinking enough water and also sent out the warning.



Future work

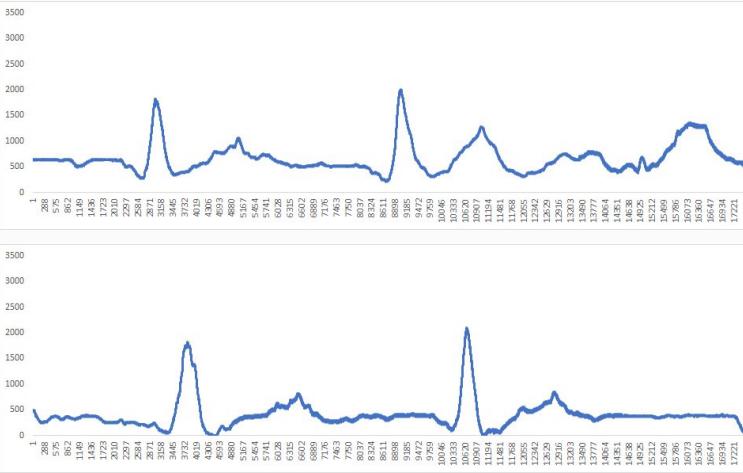
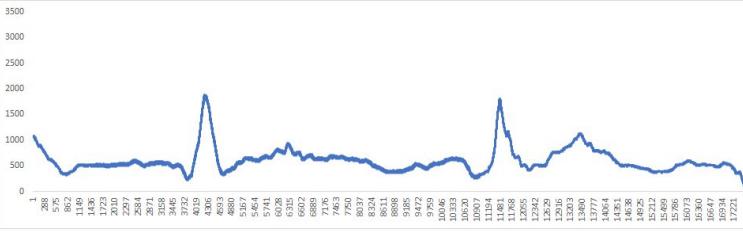
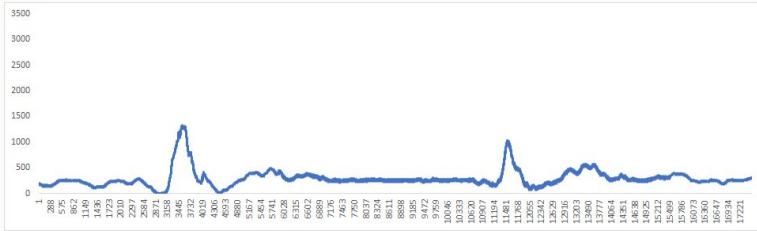
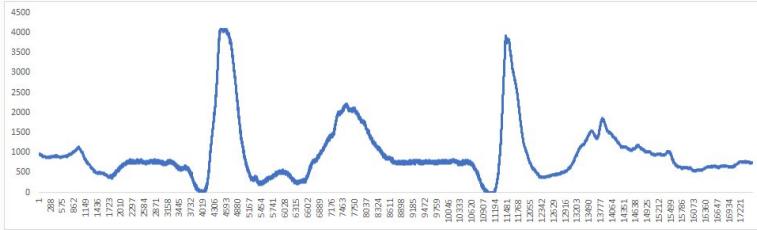
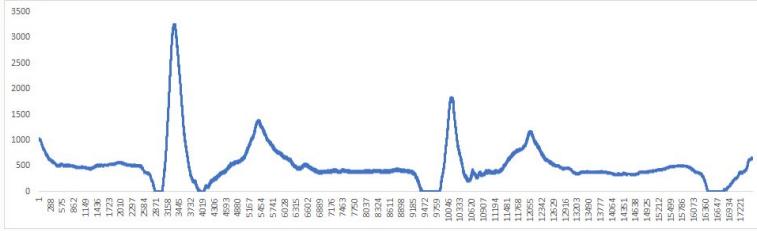
1. I want to make this device more **functional**
2. I will make this device more **compact**
3. I will investigate into **different fashion choices** and user experience in the hope to introduce a more **user-friendly wearable device**
4. In the future, I want to make this device **wireless** and connect it with a smartphone, so the user can check the data in real time



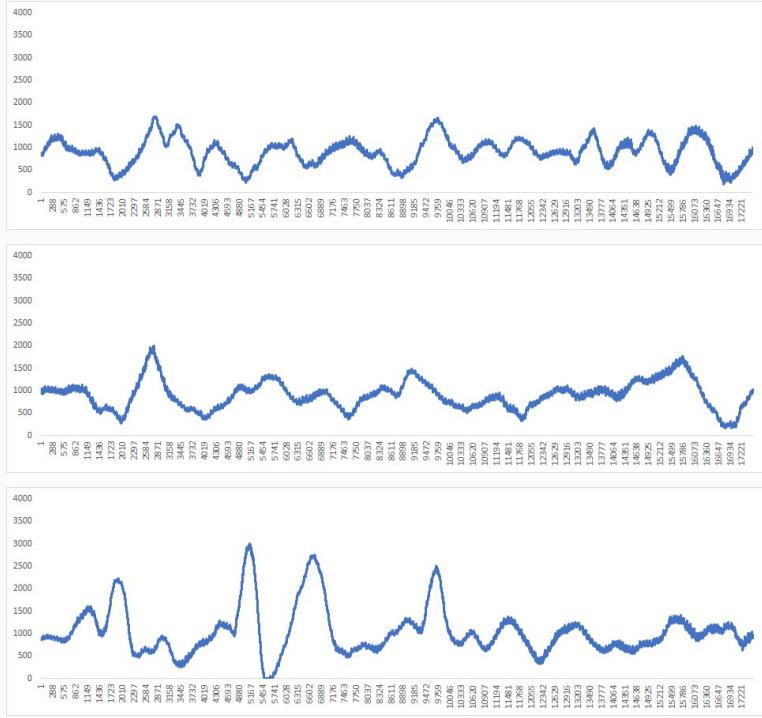
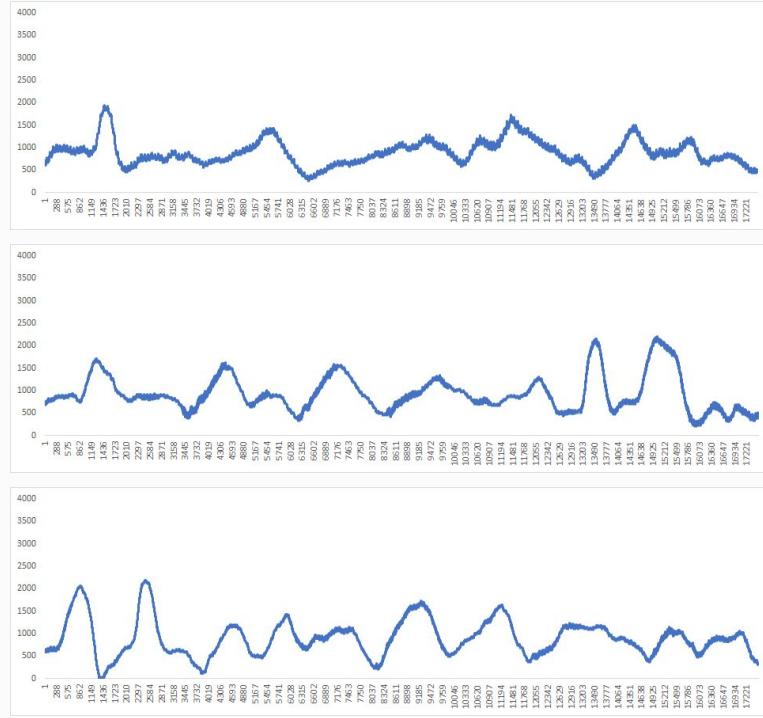


It's Q&A time!

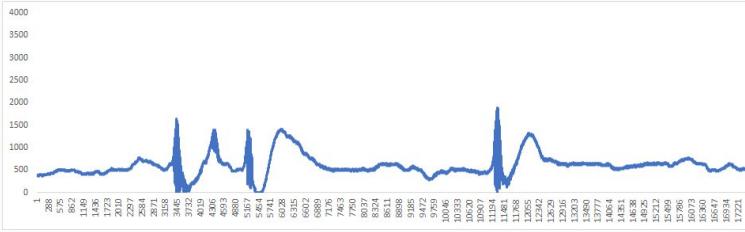
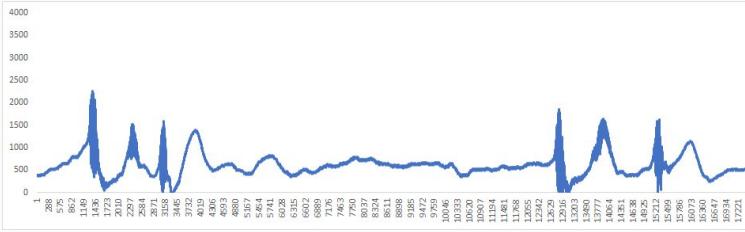
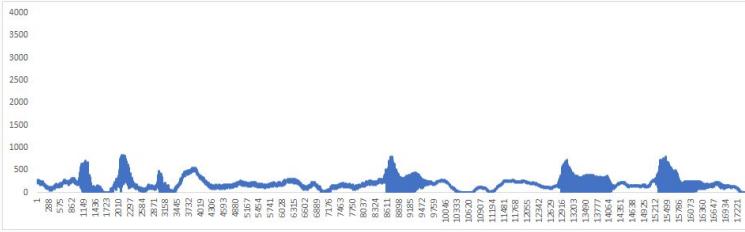
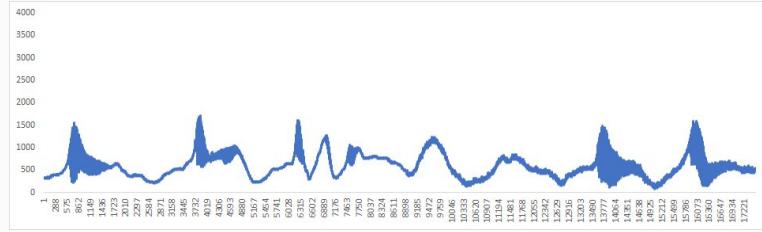
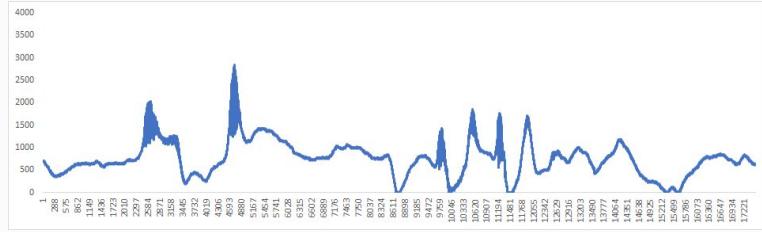
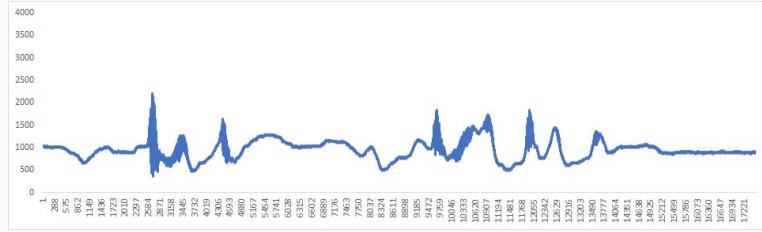
Experiment 1: data of consumption of water



Experiment 1: data of consumption of oral speech



Experiment 1: data of coughing



Experiment 1: data of heart rate

