

浙江大学

边缘计算开发实践



题目 _____ Cough Detection _____

姓名 _____

学号 _____

浙江大学实验报告

专业： 电子科学与技术

姓名：

学号：

日期： 2023/10/23

课程名称： 边缘计算开发实践 指导老师： 皇甫江涛 成绩：

实验名称： Cough Detection

一、 实验目标

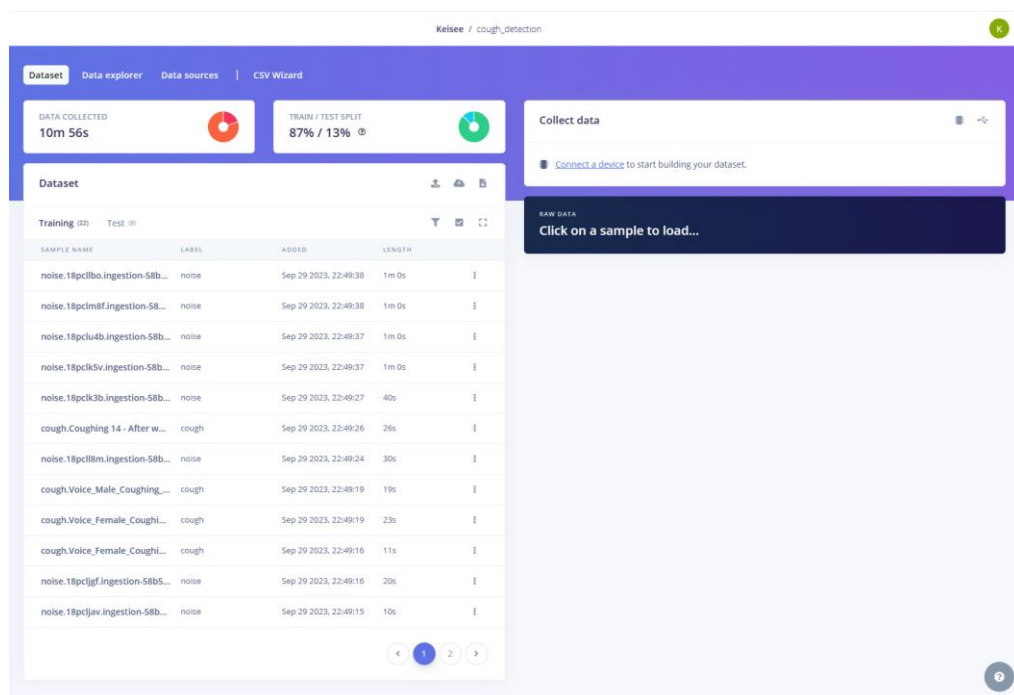
利用 Arduino 区分噪声和咳嗽声。

二、 实验任务

1. 获得[数据集](#)，并导入到 Edge Impulse 的工程中。
2. 在 Edge Impulse 中对数据集进行机器学习训练。
3. 将训练好的模型上传到 Arduino 上，进行模型测试。

三、 实验内容

1. 数据集的获取与导入
 - a) 从 <https://cdn.edgeimpulse.com/datasets/cough.zip> 下载数据集，解压。
 - b) 在 Edge Impulse 的 Dashboard 界面进行 upload existing data，导入结果在 Data acquisition 界面查看：



2. 在 Edge Impulse 网站进行模型训练

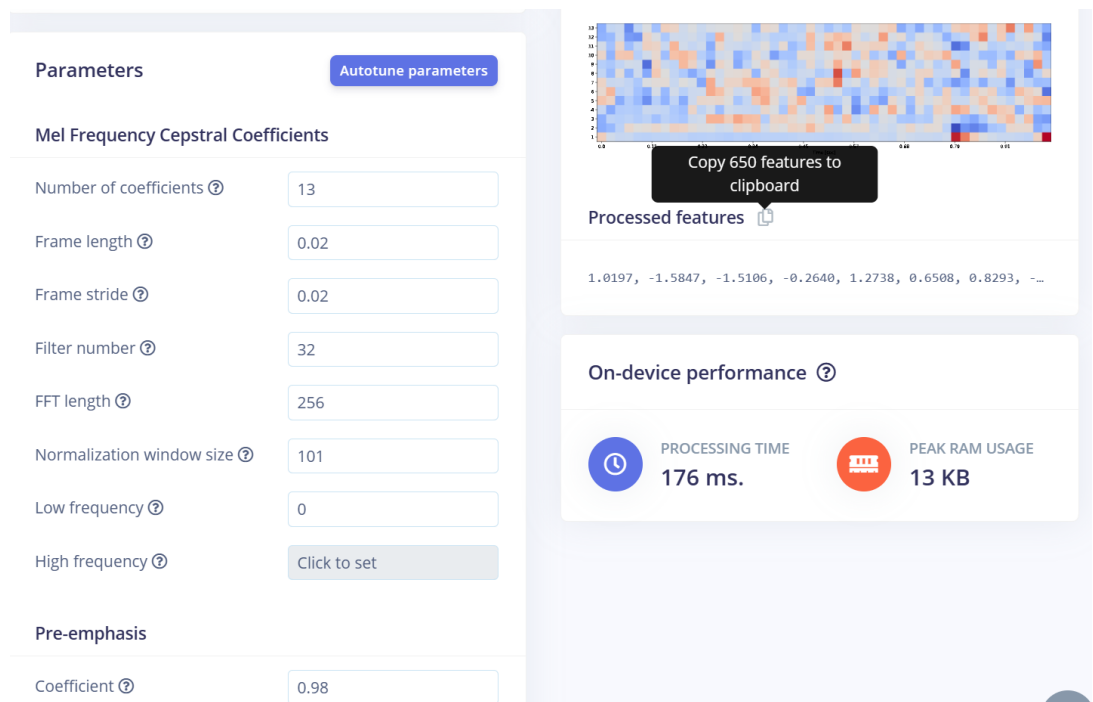
a) Create impulse

选择窗大小为 1000ms，每次增加的大小为 500ms；声音特征提取算法为 MFCC；learning block 为分类（classification）。

b) MFCC 特征提取

实验仅需对环境和人声作区分，因此 MFCC 的系数 13 个足矣。

具体参数如下：



The screenshot displays the Edge Impulse configuration interface. On the left, the 'Parameters' section is expanded, showing 'Mel Frequency Cepstral Coefficients' with the following settings: Number of coefficients (13), Frame length (0.02), Frame stride (0.02), Filter number (32), FFT length (256), Normalization window size (101), Low frequency (0), High frequency (Click to set), and Pre-emphasis Coefficient (0.98). On the right, a spectrogram visualization is shown with a tooltip that says 'Copy 650 features to clipboard'. Below the spectrogram, the 'Processed features' section displays a list of numerical values: 1.0197, -1.5847, -1.5106, -0.2640, 1.2738, 0.6508, 0.8293, ... At the bottom right, the 'On-device performance' section shows 'PROCESSING TIME' as 176 ms and 'PEAK RAM USAGE' as 13 KB.

由上图可知一条音频提取了 650 个特征。如果特征不够，可以增大 FFT length；本实验较为简单，650 个特征已经足够。特征提取结果：



可见经过 MFCC 处理后两种音频的特征有了明显的分簇，有利于后续的训练。

c) Classifier

神经网络的构建代码如下：

```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, InputLayer, Dropout, Flatten,
Reshape, BatchNormalization, Conv2D, MaxPooling2D, AveragePooling2D
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.constraints import MaxNorm
# model architecture
model = Sequential()
model.add(InputLayer(input_shape=(X_train.shape[1], ), name='x_input'))
model.add(Reshape((int(X_train.shape[1] / 13), 13, 1),
input_shape=(X_train.shape[1], )))
model.add(Conv2D(10, kernel_size=5, activation='relu', padding='same',
kernel_constraint=MaxNorm(3)))
model.add(AveragePooling2D(pool_size=2, padding='same'))
model.add(Conv2D(5, kernel_size=5, activation='relu', padding='same',
kernel_constraint=MaxNorm(3)))
model.add(AveragePooling2D(pool_size=2, padding='same'))
model.add(Flatten())
model.add(Dense(classes, activation='softmax', name='y_pred',
kernel_constraint=MaxNorm(3)))
# this controls the learning rate
opt = Adam(lr=0.005, beta_1=0.9, beta_2=0.999)
# train the neural network
model.compile(loss='categorical_crossentropy', optimizer=opt,
metrics=['accuracy'])
model.fit(X_train, Y_train, batch_size=32, epochs=9,
validation_data=(X_test, Y_test), verbose=2)
```

模型结构设计：

Layer (type)

Reshape

Conv2D

Pooling (Average)

Conv2D

Pooling (Average)

Flatten

Dense

训练结果：

Model

Model version: ?

Quantized (int8) ▼

Last training performance (validation set)



ACCURACY
96.9%



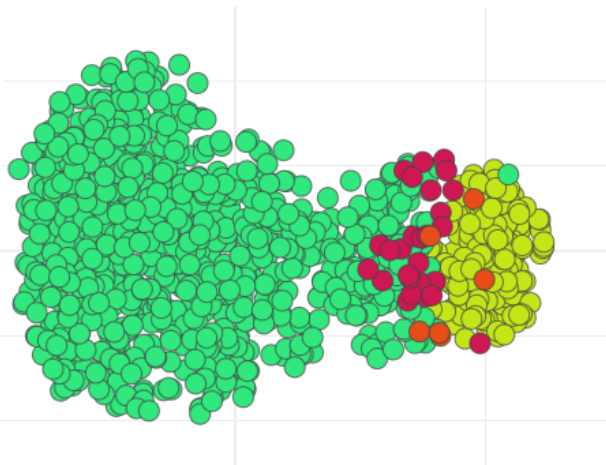
LOSS
0.08

Confusion matrix (validation set)

	COUGH	NOISE
COUGH	86.0%	14.0%
NOISE	0.6%	99.4%
F1 SCORE	0.91	0.98

Data explorer (full training set) ?

- cough - correct
- noise - correct
- cough - incorrect
- noise - incorrect



可见训练的准确度比较高，对于 Cough 信号，有少量概率被检测为 Noise 信号；但 Noise 信号不易被判断为 Cough 信号。

3. 在 Arduino Nano 33 BLE sense 上测试

a) 在 Edge Impulse 上部署模型，烧录到 Arduino Nano 33 BLE sense。

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```
C:\Windows\system32\cmd.exe
找不到操作数。
You're using an untested version of Arduino CLI, this might cause issues (found: .34.2, expected: 0.18.x)
Finding Arduino Mbed core...
arduino:mbed_nano 4.0.2 4.0.8 Arduino Mbed OS Nano Boards
Finding Arduino Mbed core OK
Finding Arduino Nano 33 BLE...
Finding Arduino Nano 33 BLE OK at COM5
arduino:mbed_nano 4.0.2 4.0.8 Arduino Mbed OS Nano Boards
Device      : nRF52840-QIAA
Version     : Arduino Bootloader (SAM-BA extended) 2.0 [Arduino:IKXYZ]
Address     : 0x0
Pages       : 256
Page Size   : 4096 bytes
Total Size  : 1024KB
Planes      : 1
Lock Regions : 0
Locked      : none
Security    : false
Erase flash

Done in 0.000 seconds
Write 295760 bytes to flash (73 pages)
[=====] 100% (73/73 pages)
Done in 12.412 seconds
New upload port: COM5 (serial)
Flashed your Arduino Nano 33 BLE development board.
To set up your development with Edge Impulse, run 'edge-impulse-daemon'
To run your impulse on your development board, run 'edge-impulse-run-impulse'
请按任意键继续. . .
```

b) 打开命令行，输入 `edge-impulse-run-impulse` 命令，Arduino Nano 33 BLE sense 开始工作。测试结果如下，测试者发出声音时 `cough` 的概率提高至 0.87 以上；而不发声时，则是 `noise` 的概率接近于 1。综上，模型训练和测试的效果均好。

```
C:\Windows\system32\cmd.exe - "node" "C:\Users\11097\AppData\Roaming\npm\node_modules\edge-impulse-cli\build\cli\run-impu...
Starting inferencing in 2 seconds...
Recording...
Recording done
Predictions (DSP: 131 ms., Classification: 58 ms., Anomaly: 0 ms.):
  cough: 0.87109
  noise: 0.12891
Starting inferencing in 2 seconds...
Recording...
Recording done
Predictions (DSP: 131 ms., Classification: 58 ms., Anomaly: 0 ms.):
  cough: 0.32422
  noise: 0.67578
Starting inferencing in 2 seconds...
Recording...
Recording done
Predictions (DSP: 131 ms., Classification: 57 ms., Anomaly: 0 ms.):
  cough: 0.01172
  noise: 0.98828
Starting inferencing in 2 seconds...
Recording...
Recording done
Predictions (DSP: 131 ms., Classification: 58 ms., Anomaly: 0 ms.):
  cough: 0.95703
  noise: 0.04297
Starting inferencing in 2 seconds...
```