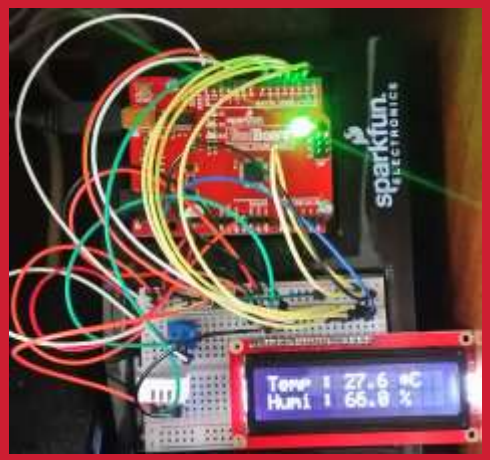


Arduino-IOT

[wk12]

nano33 BLE sensor

T, H, L, P, R, G, B

Visualization of Signals using Arduino, Node.js & storing signals in MongoDB & mining iot data using Python

Drone-IoT-Comsi, INJE University

2nd semester, 2022

Email : chaos21c@gmail.com

My ID

ID를 확인하고 github에 repo 만들기

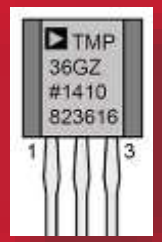
AA01	강대진	AA13	박제홍
		AA14	심준혁
AA03	김성우	AA15	이상혁
AA04	김정헌	AA16	이승무
		AA17	이승준
AA06	김창연	AA18	이준희
AA07	김창욱	AA19	이현준
AA08	김태화	AA20	임태형
AA09	남승현	AA21	정동현
AA10	류재환		
AA11	박세훈	AA23	정희서
AA12	박신영	AA24	최재형

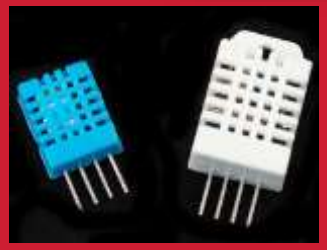
위의 id를 이용해서 github에 repo를 만드시오.

Option: 아두이노응용 실습 과제 – AAnn

Public, README.md check

[Practice]





- [wk11]
  - Data Mining of IoT Data
  - Multi-sensor circuits (cds-dht22)
  - Complete your project
  - Upload folder: aann-rpt11
  - Use repo “aann” in github

wk11 : Practice : aann-rpt11

- [Target of this week]
  - Complete your works
  - Save your outcomes and upload outputs in github

제출폴더명 : **aann-rpt11**

- 제출할 파일들

① iot_csv.ipynb

② iot_ison.ipynb

③ All *.js

④ public/All *.html

⑤ client_iot.html

⑥ public/data/All data (*.csv)

⑦ AAnn_s2000.csv

⑧ Don‘t upload node_modules subfolder

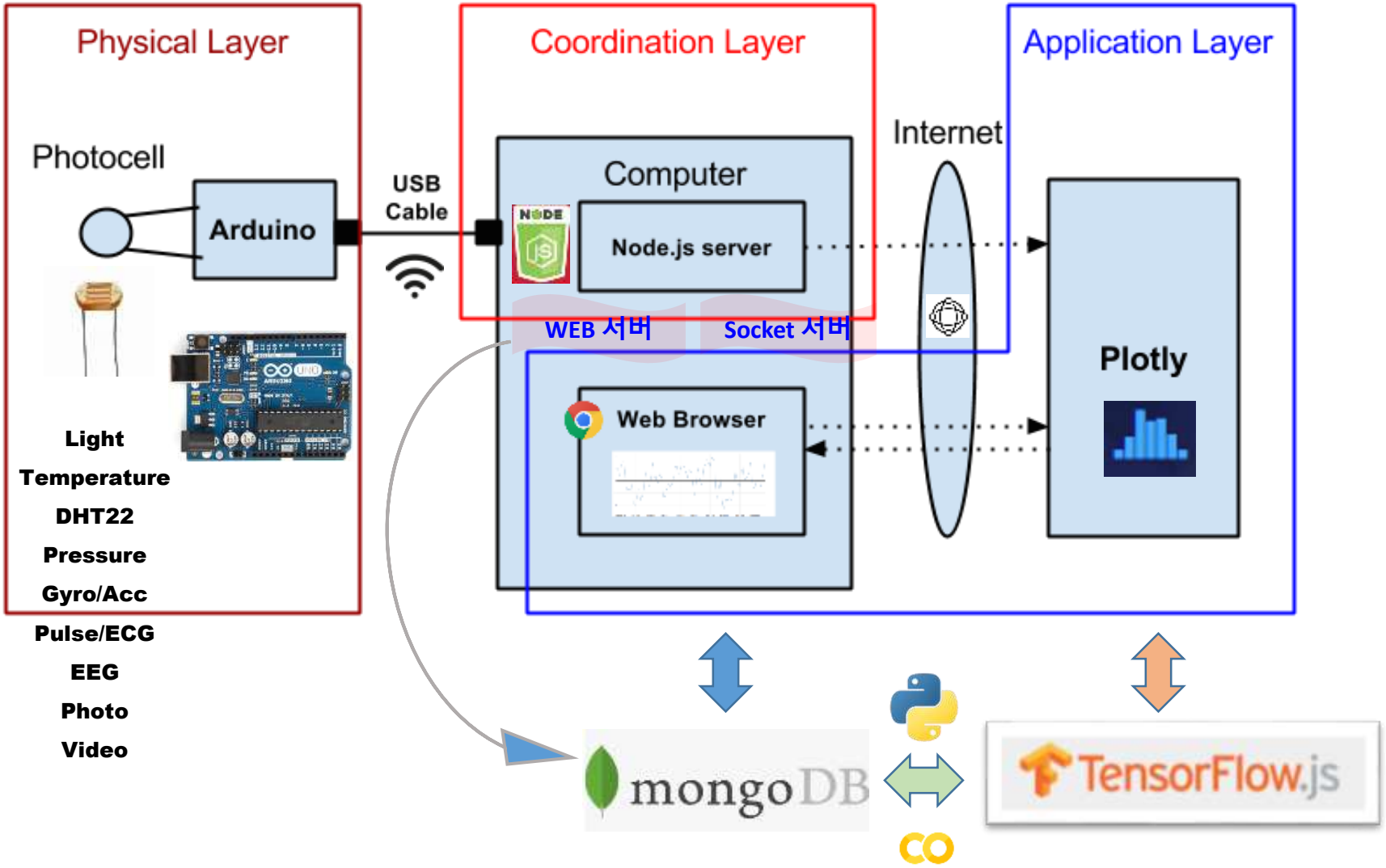
Purpose of AA

주요 수업 목표는 다음과 같다.

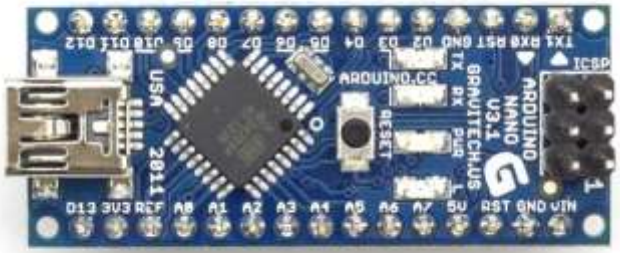
1. Node.js를 이용한 아두이노 센서 신호 처리
2. Plotly.js를 이용한 아두이노 센서 신호 시각화
3. MongoDB에 아두이노 센서 데이터 저장 및 처리

4. 저장된 IoT 데이터의 마이닝 (파이썬 코딩)

Layout [H S C]

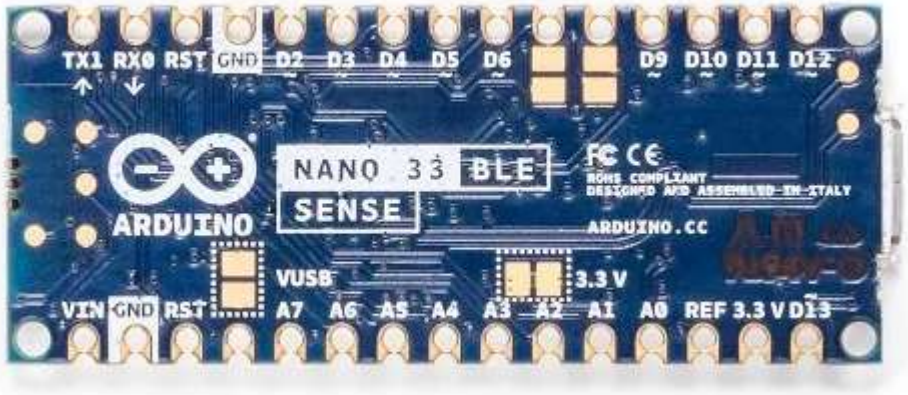

Physical Layer
Photocell
Arduino
USB Cable
Light
Temperature
DHT22
Pressure
Gyro/Acc
Pulse/ECG
EEG
Photo
Video
Coordination Layer
Computer
Node.js server
WEB 서버
Socket 서버
Web Browser
Internet
Application Layer
Plotly
mongoDB
TensorFlow.js

1.2.4 Arduino hardware: nano, nano33



✓ Arduino Pro NANO

· ATmega168/328 microcontroller
· Input voltage: 7~12V
· 14 Digital I/O Pins (6 PWM outputs)
· 8 Analog Inputs
· 16KB Flash Memory
· 16Mhz Clock Speed



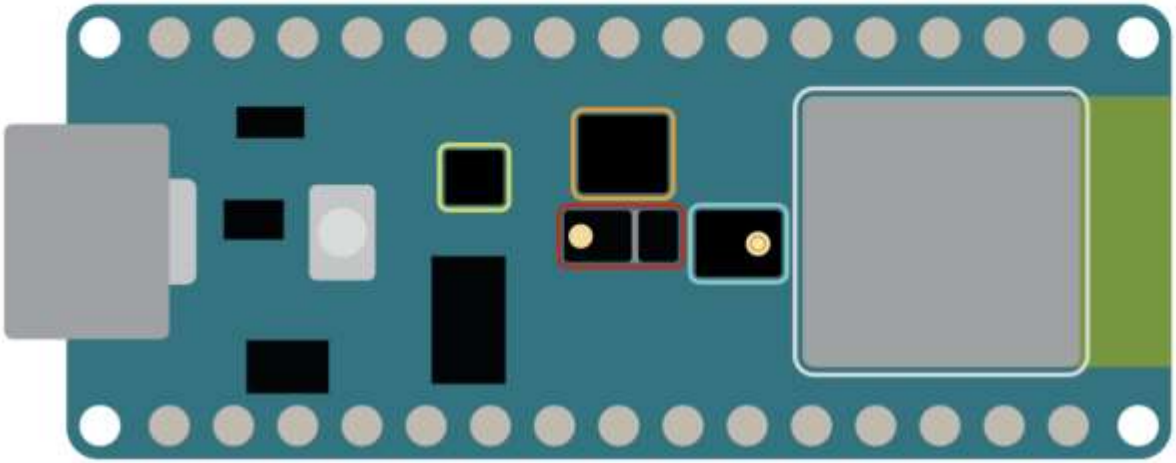
✓ Arduino NANO33

◆ BLE IOT (wifi)

◆ BLE SENSOR

nano33BLE sensor

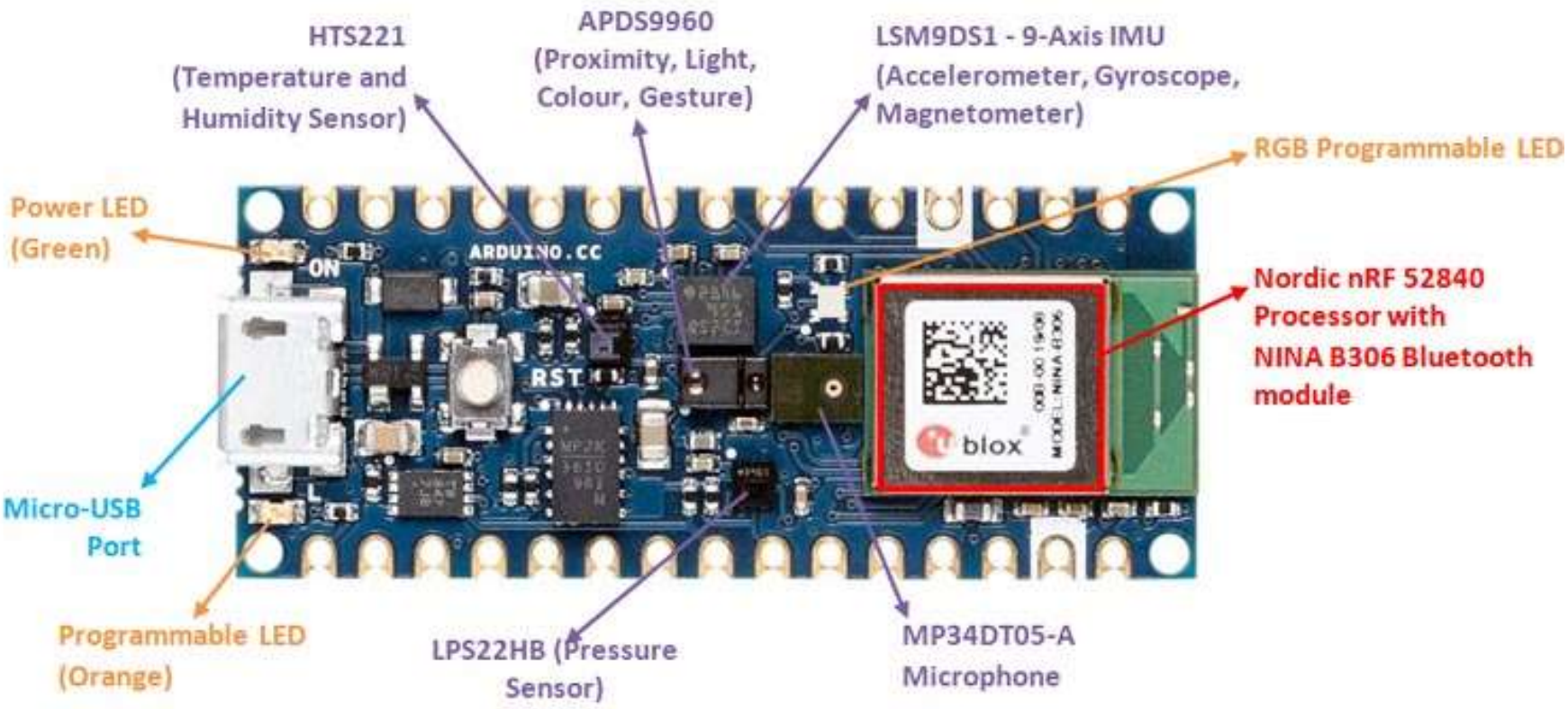
NANO 33 BLE SENSE



- Color, brightness, proximity and gesture sensor
- Digital microphone
- Motion, vibration and orientation sensor
- Temperature, humidity and pressure sensor
- Arm Cortex-M4 microcontroller and BLE module

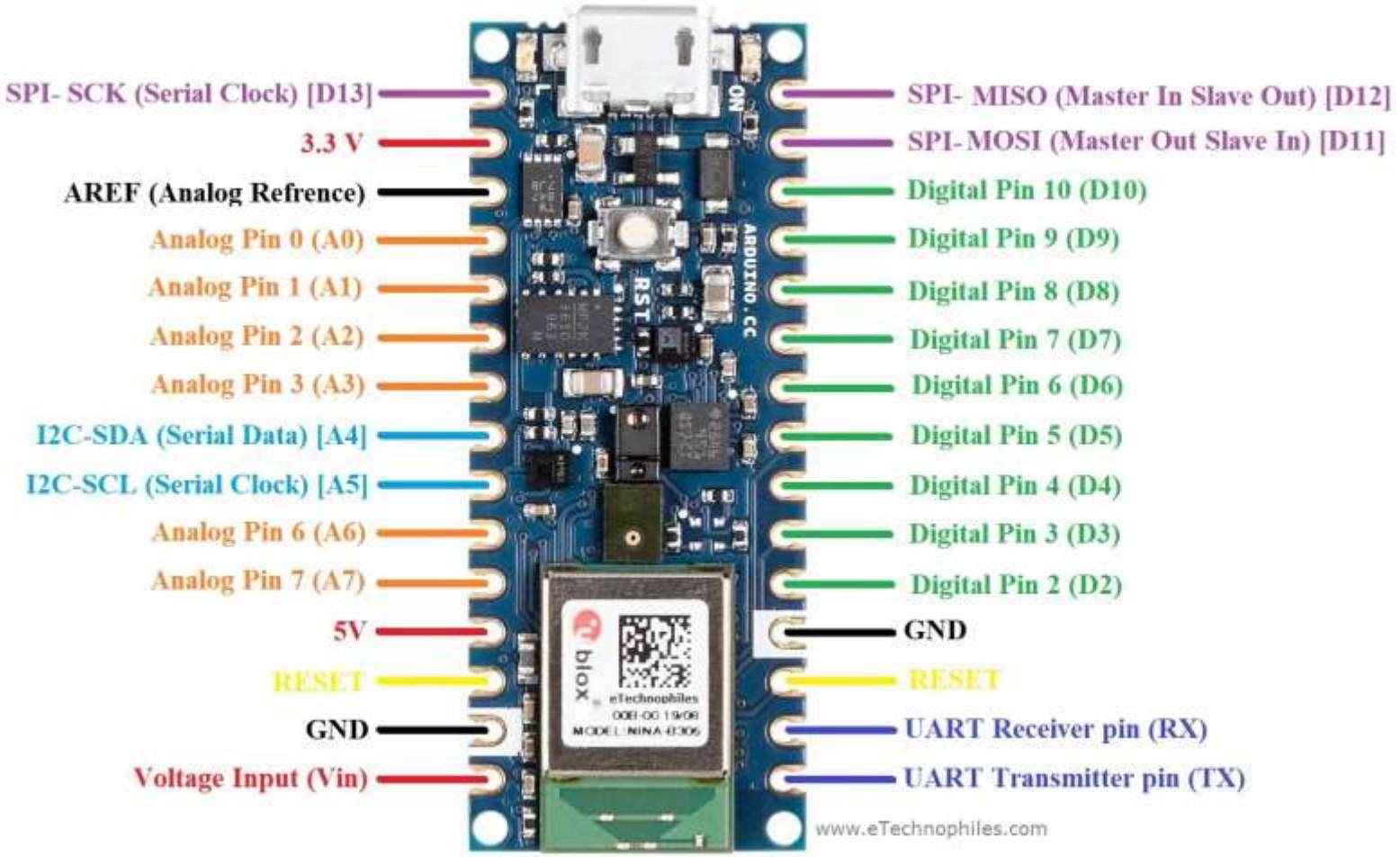
https://t1.daumcdn.net/cfile/tistory/99D8E84E5F93D2B109

nano33BLE sensor



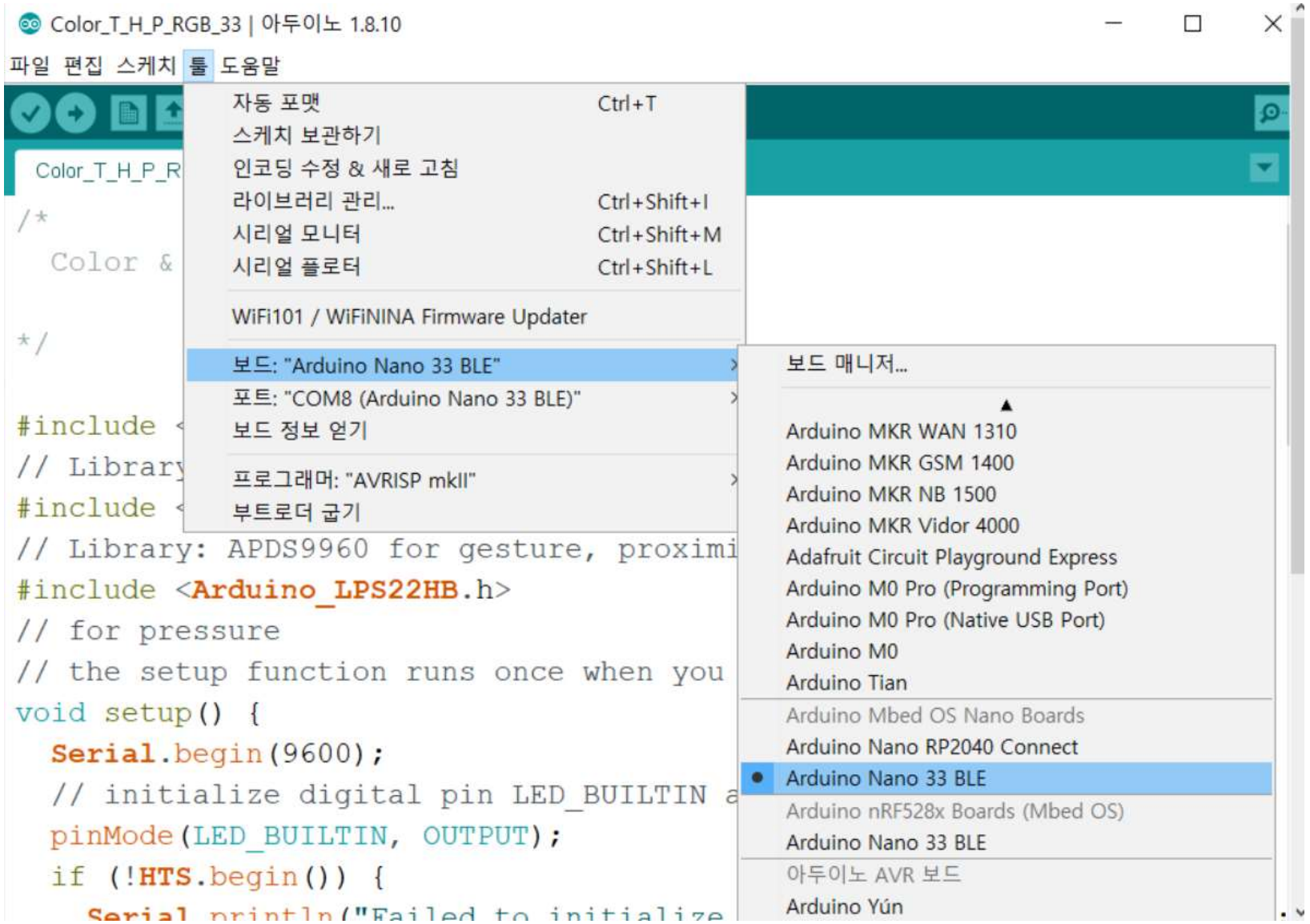
이미지 출처: https://circuitdigest.com/microcontroller-projects/arduino-nano-33-ble-sense-board-review-and-getting-started-guide

nano33BLE sensor - pins

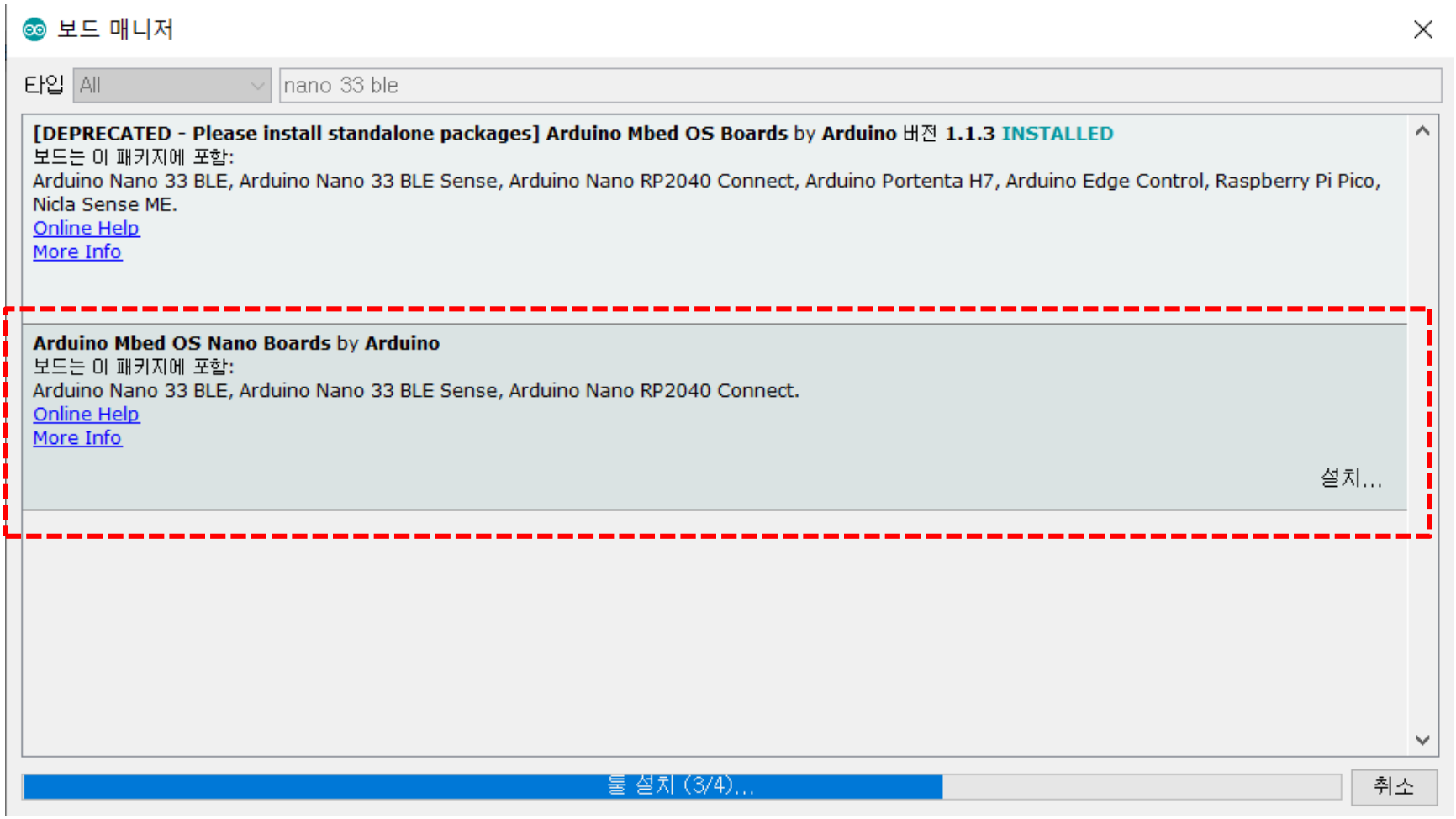


이미지 출처: https://www.etechnophiles.com/arduino-nano-33-ble-sense-pinout-introduction-specifications/

Layout [H S C]


Color_T_H_P_RGB_33 | 아두이노 1.8.10
파일 편집 스케치 툴 도움말
자동 포맷 Ctrl+T
스케치 보관하기
인코딩 수정 & 새로 고침
라이브러리 관리... Ctrl+Shift+I
시리얼 모니터 Ctrl+Shift+M
시리얼 플로터 Ctrl+Shift+L
WiFi101 / WiFiNINA Firmware Updater
보드: "Arduino Nano 33 BLE"
포트: "COM8 (Arduino Nano 33 BLE)"
보드 정보 얻기
프로그래머: "AVRISP mkII"
부트로더 굽기
보드 매니저...
Arduino MKR WAN 1310
Arduino MKR GSM 1400
Arduino MKR NB 1500
Arduino MKR Vidor 4000
Adafruit Circuit Playground Express
Arduino M0 Pro (Programming Port)
Arduino M0 Pro (Native USB Port)
Arduino M0
Arduino Tian
Arduino Mbed OS Nano Boards
Arduino Nano RP2040 Connect
Arduino Nano 33 BLE
Arduino nRF528x Boards (Mbed OS)
Arduino Nano 33 BLE
아두이노 AVR 보드
Arduino Yún
Color_T_H_P_R
/*
Color &
*/
#include
// Library
#include
// Library: APDS9960 for gesture, proximi
#include <Arduino_LPS22HB.h>
// for pressure
// the setup function runs once when you
void setup() {
Serial.begin(9600);
// initialize digital pin LED_BUILTIN a
pinMode(LED_BUILTIN, OUTPUT);
if (!HTS.begin()) {

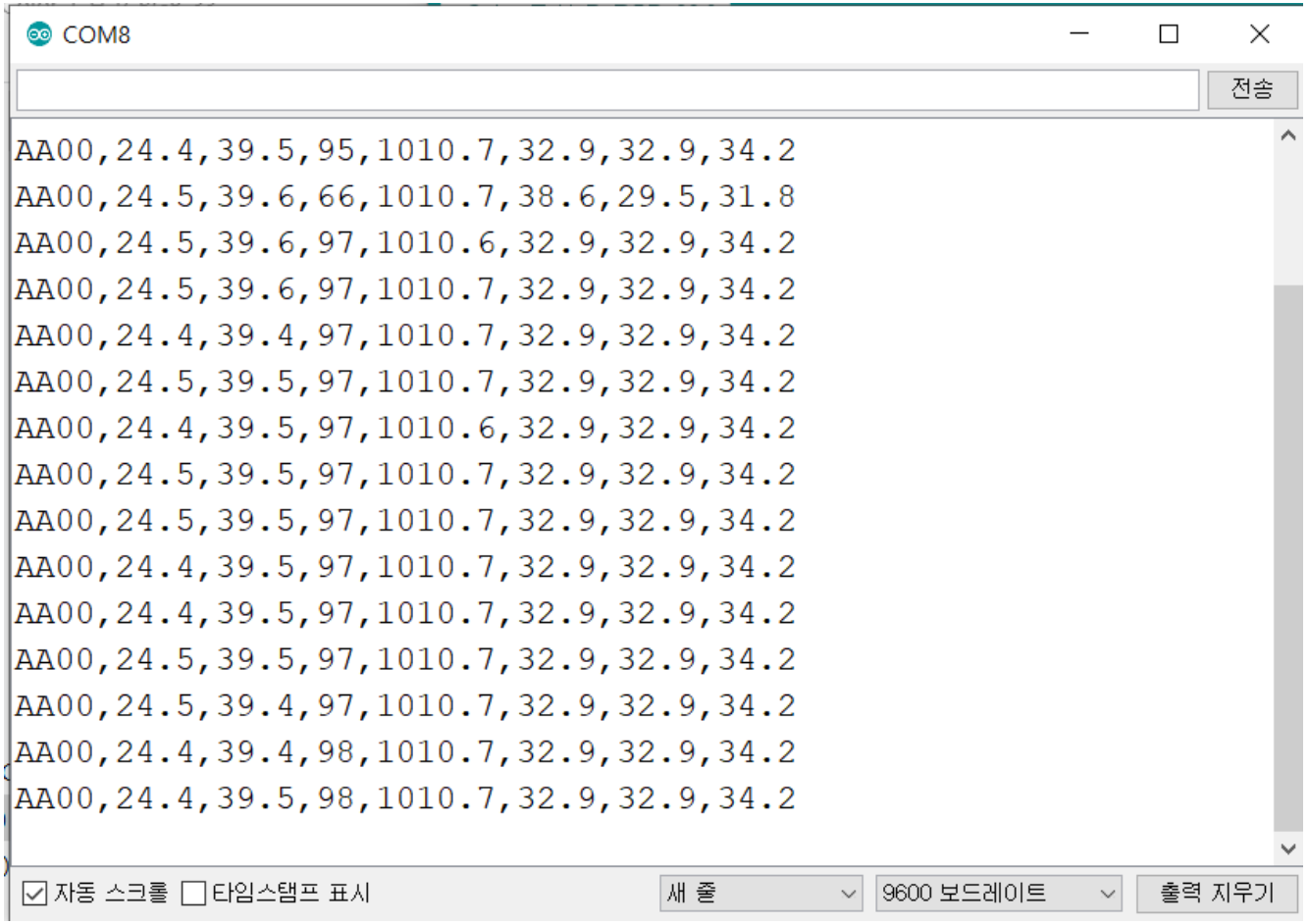
nano33 board



Sensor libraries

```
#include <Arduino_HTS221.h>   // library for temperature & humidity
// Library: HTS221
#include <Arduino_APDS9960.h>
// Library: APDS9960 for gesture, proximity, color & luminosity
#include <Arduino_LPS22HB.h>
// for pressure
```

Arduino: serial monitor



npm install

```
D:\aann\aann-rpt12\nano33>npm install
npm WARN deprecated debug@4.1.1: Debug versions >=3.2.0 <3.2.7 || >=4 <4.3.1 have a low-severity ReDos regression w
hen used in a Node.js environment. It is recommended you upgrade to 3.2.7 or 4.3.1. (https://github.com/visionmedia
/debug/issues/797)
npm WARN deprecated debug@4.1.1: Debug versions >=3.2.0 <3.2.7 || >=4 <4.3.1 have a low-severity ReDos regression w
hen used in a Node.js environment. It is recommended you upgrade to 3.2.7 or 4.3.1. (https://github.com/visionmedia
/debug/issues/797)
npm WARN deprecated debug@4.1.1: Debug versions >=3.2.0 <3.2.7 || >=4 <4.3.1 have a low-severity ReDos regression w
hen used in a Node.js environment. It is recommended you upgrade to 3.2.7 or 4.3.1. (https://github.com/visionmedia
/debug/issues/797)

added 255 packages, and audited 256 packages in 14s

29 packages are looking for funding
  run `npm fund` for details

found 0 vulnerabilities

D:\aann\aann-rpt12\nano33>
```

Project: nano33BLE sensor

db33rgb.js

```
24  // Schema
25  var iotSchema = new Schema({
26      date : String,
27      temperature : String,
28      humidity : String,
29      luminosity : String,
30      pressure : String,
31      r_ratio : String,
32      g_ratio : String,
33      b_ratio : String
34  });
```

Project: nano33BLE sensor

db33rgb.js

```
86  // process data using parser
87  parser.on('data', (data) => { // call back when data is received
88      readData = data.toString(); // append data to buffer
89      firstcommaidx = readData.indexOf(',');
90      secondcommaidx = readData.indexOf(',',firstcommaidx+1);
91      thirdcommaidx = readData.indexOf(',',secondcommaidx+1);
92      fourthcommaidx = readData.indexOf(',',thirdcommaidx+1);
93      fifthcommaidx = readData.indexOf(',',fourthcommaidx+1);
94      sixthcommaidx = readData.indexOf(',',fifthcommaidx+1);
95
96      // parsing data into signals
97      if (readData.lastIndexOf(',') > firstcommaidx && firstcommaidx > 0) {
98          temp = readData.substring(firstcommaidx + 1, secondcommaidx);
99          humi = readData.substring(secondcommaidx + 1, thirdcommaidx);
100         lux = readData.substring(thirdcommaidx + 1, fourthcommaidx);
101         pres = readData.substring(fourthcommaidx + 1, fifthcommaidx);
102         rr = readData.substring(fifthcommaidx + 1, sixthcommaidx);
103         gg = readData.substring(sixthcommaidx + 1, readData.indexOf(',',sixthcommaidx+1));
104         bb = readData.substring(readData.lastIndexOf(',')+1);
```

Project: nano33BE sensor

db33rgb.js

```
108  dStr = getDateString();
109  mdata[0]=dStr;     // Date
110  mdata[1]=temp;     // temperature data
111  mdata[2]=humi;     // humidity data
112  mdata[3]=lux;      //  luminosity data
113  mdata[4]=pres;     // pressure data
114  mdata[5]=rr;        // r_ratio
115  mdata[6]=gg;        // g_ratio
116  mdata[7]=bb;        // b_ratio
117  //console.log(mdata);
118  var iotData = new Sensor({date:dStr, temperature:temp, humidity:humi, luminosity:lux, pressure:pres,
119      r_ratio:rr, g_ratio:gg, b_ratio:bb});
120  // save iot data to MongoDB
121  iotData.save(function(err,data) {
122      if(err) return handleEvent(err);
123      data.info();  // Display the information of iot data  on console.
124  })
```

Layout [H S C]

```
D:\aann\aann-rpt12\nano33>node -v
v16.17.0

D:\aann\aann-rpt12\nano33>node db33rgb
mongo db connection OK.
iotInfo: Current date: 2022-11-14 20:18:48.836, Temp: 25.1, Humi: 55.9, Lux: 112, Pres: 1007.6, R: 27.7, G: 46.1, B: 26.2
iotInfo: Current date: 2022-11-14 20:18:53.882, Temp: 25.2, Humi: 55.9, Lux: 113, Pres: 1007.6, R: 27.5, G: 45.8, B: 26.8
iotInfo: Current date: 2022-11-14 20:18:58.926, Temp: 25.2, Humi: 56.0, Lux: 115, Pres: 1007.6, R: 27.6, G: 45.5, B: 26.9
iotInfo: Current date: 2022-11-14 20:19:03.969, Temp: 25.2, Humi: 56.0, Lux: 114, Pres: 1007.6, R: 27.3, G: 46.2, B: 26.6
iotInfo: Current date: 2022-11-14 20:19:09.013, Temp: 25.2, Humi: 56.0, Lux: 113, Pres: 1007.6, R: 27.5, G: 45.8, B: 26.8
iotInfo: Current date: 2022-11-14 20:19:14.059, Temp: 25.1, Humi: 56.0, Lux: 114, Pres: 1007.6, R: 27.3, G: 46.2, B: 26.6
iotInfo: Current date: 2022-11-14 20:19:19.103, Temp: 25.2, Humi: 56.1, Lux: 113, Pres: 1007.6, R: 27.5, G: 45.8, B: 26.8
iotInfo: Current date: 2022-11-14 20:19:24.145, Temp: 25.3, Humi: 56.4, Lux: 113, Pres: 1007.6, R: 27.5, G: 45.8, B: 26.8
iotInfo: Current date: 2022-11-14 20:19:29.192, Temp: 25.3, Humi: 56.4, Lux: 115, Pres: 1007.6, R: 27.8, G: 45.1, B: 27.1
iotInfo: Current date: 2022-11-14 20:19:34.238, Temp: 25.3, Humi: 56.3, Lux: 11, Pres: 1007.6, R: 36.4, G: 36.4, B: 27.3
iotInfo: Current date: 2022-11-14 20:19:39.281, Temp: 25.3, Humi: 56.2, Lux: 112, Pres: 1007.5, R: 27.3, G: 46.0, B: 26.6
iotInfo: Current date: 2022-11-14 20:19:44.326, Temp: 25.3, Humi: 56.1, Lux: 111, Pres: 1007.6, R: 27.3, G: 46.0, B: 26.6
iotInfo: Current date: 2022-11-14 20:19:49.370, Temp: 25.3, Humi: 56.4, Lux: 113, Pres: 1007.6, R: 27.5, G: 45.8, B: 26.8
iotInfo: Current date: 2022-11-14 20:19:54.413, Temp: 25.3, Humi: 56.2, Lux: 93, Pres: 1007.5, R: 27.1, G: 46.6, B: 26.3
iotInfo: Current date: 2022-11-14 20:19:59.459, Temp: 25.5, Humi: 59.6, Lux: 110, Pres: 1007.6, R: 27.5, G: 45.7, B: 26.8
iotInfo: Current date: 2022-11-14 20:20:04.506, Temp: 25.3, Humi: 60.6, Lux: 96, Pres: 1007.5, R: 27.3, G: 46.3, B: 26.4
iotInfo: Current date: 2022-11-14 20:20:09.548, Temp: 25.5, Humi: 63.0, Lux: 110, Pres: 1007.6, R: 27.0, G: 46.0, B: 27.0
iotInfo: Current date: 2022-11-14 20:20:14.593, Temp: 25.4, Humi: 63.1, Lux: 113, Pres: 1007.5, R: 27.0, G: 46.1, B: 27.0
iotInfo: Current date: 2022-11-14 20:20:19.638, Temp: 25.4, Humi: 62.1, Lux: 113, Pres: 1007.5, R: 27.1, G: 45.7, B: 27.1
iotInfo: Current date: 2022-11-14 20:20:24.683, Temp: 25.4, Humi: 61.5, Lux: 111, Pres: 1007.6, R: 27.3, G: 46.0, B: 26.6
```

Project: nano33BLE sensor

express33rgb.js

```
23  // Schema
24  var iotSchema = new Schema({
25      date : String,
26      temperature : String,
27      humidity : String,
28      luminosity : String,
29      pressure : String,
30      r_ratio : String,
31      g_ratio : String,
32      b_ratio : String
33  });
34  var Sensor = mongoose.model("Sensor", iotSchema);  // sensor data model
35
```

Network socket/DB server : port=3000

Express server : port=3030

node db33rgb

node express33rgb

```
D:\aann\aann-rpt12\nano33>node db33rgb
mongo db connection OK.
iotInfo: Current date: 2022-11-14 20:52:35.126, Temp: 25.9, Humi: 54.5, Lux: 109, Pres: 1007.6,
 R: 27.2, G: 46.3, B: 26.5
iotInfo: Current date: 2022-11-14 20:52:40.170, Temp: 26.0, Humi: 54.5, Lux: 111, Pres: 1007.6,
 R: 27.3, G: 46.0, B: 26.6
iotInfo: Current date: 2022-11-14 20:52:45.214, Temp: 26.0, Humi: 54.5, Lux: 109, Pres: 1007.6,
 R: 27.2, G: 46.3, B: 26.5
iotInfo: Current date: 2022-11-14 20:52:50.259, Temp: 26.0, Humi: 54.5, Lux: 109, Pres: 1007.5,
 R: 27.0, G: 46.0, B: 27.0
iotInfo: Current date: 2022-11-14 20:52:55.302, Temp: 26.0, Humi: 54.6, Lux: 110, Pres: 1007.6,
 R: 27.2, G: 46.3, B: 26.5
iotInfo: Current date: 2022-11-14 20:53:00.349, Temp: 26.0, Humi: 54.6, Lux: 108, Pres: 1007.6,
 R: 27.4, G: 45.9, B: 26.7
iotInfo: Current date: 2022-11-14 20:53:05.390, Temp: 26.0, Humi: 54.5, Lux: 111, Pres: 1007.6,
 R: 27.3, G: 46.0, B: 26.6
iotInfo: Current date: 2022-11-14 20:53:10.434, Temp: 26.0, Humi: 54.5, Lux: 110, Pres: 1007.6,
 R: 27.0, G: 46.0, B: 27.0
iotInfo: Current date: 2022-11-14 20:53:15.479, Temp: 26.0, Humi: 54.5, Lux: 108, Pres: 1007.5,
 R: 27.2, G: 46.3, B: 26.5
```

```
D:\aann\aann-rpt12\nano33>node express33rgb
Express_IOT is running at port:3030, CORS power
ed!
mongo db connection OK.
```

node

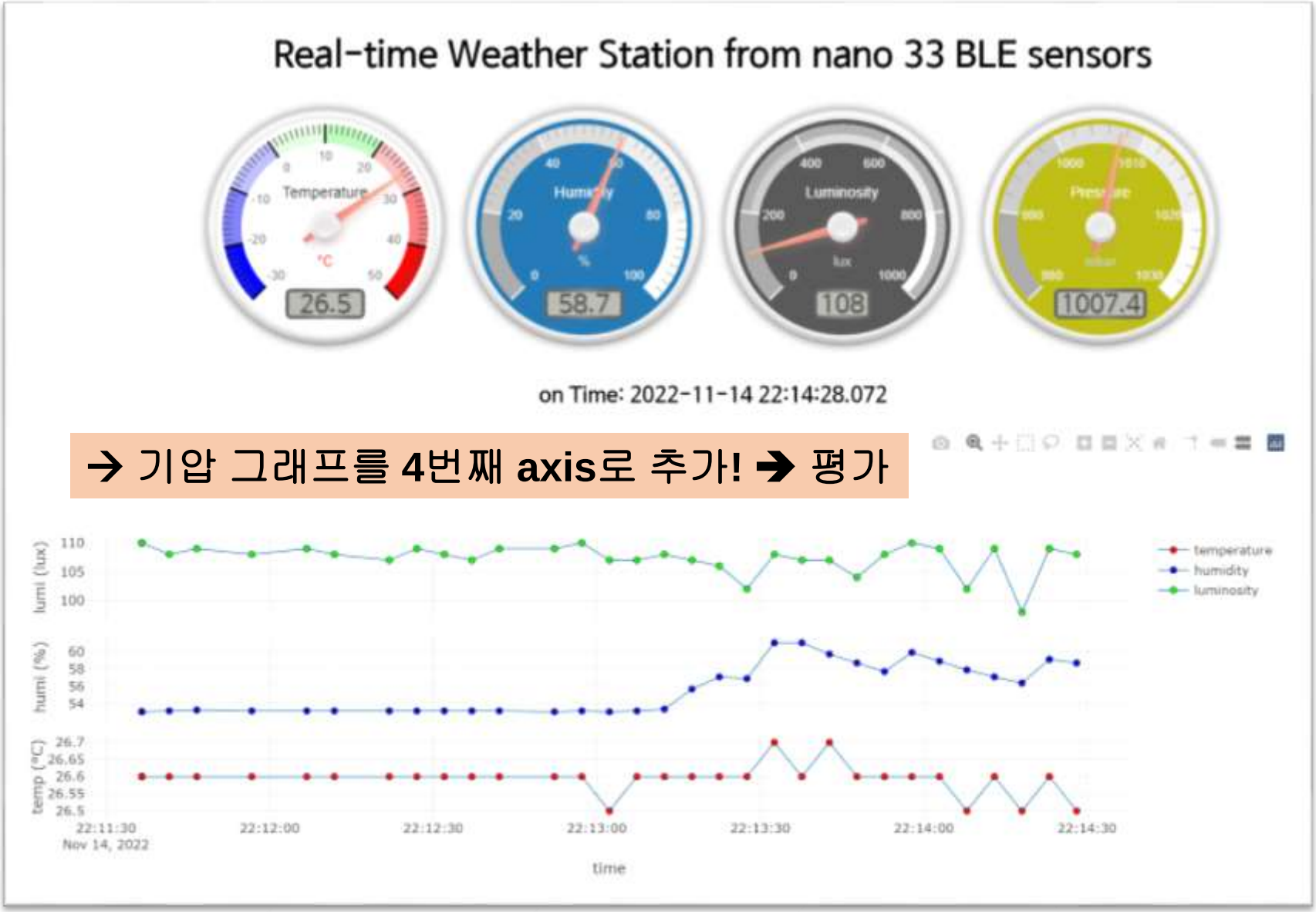
node

mongo shell

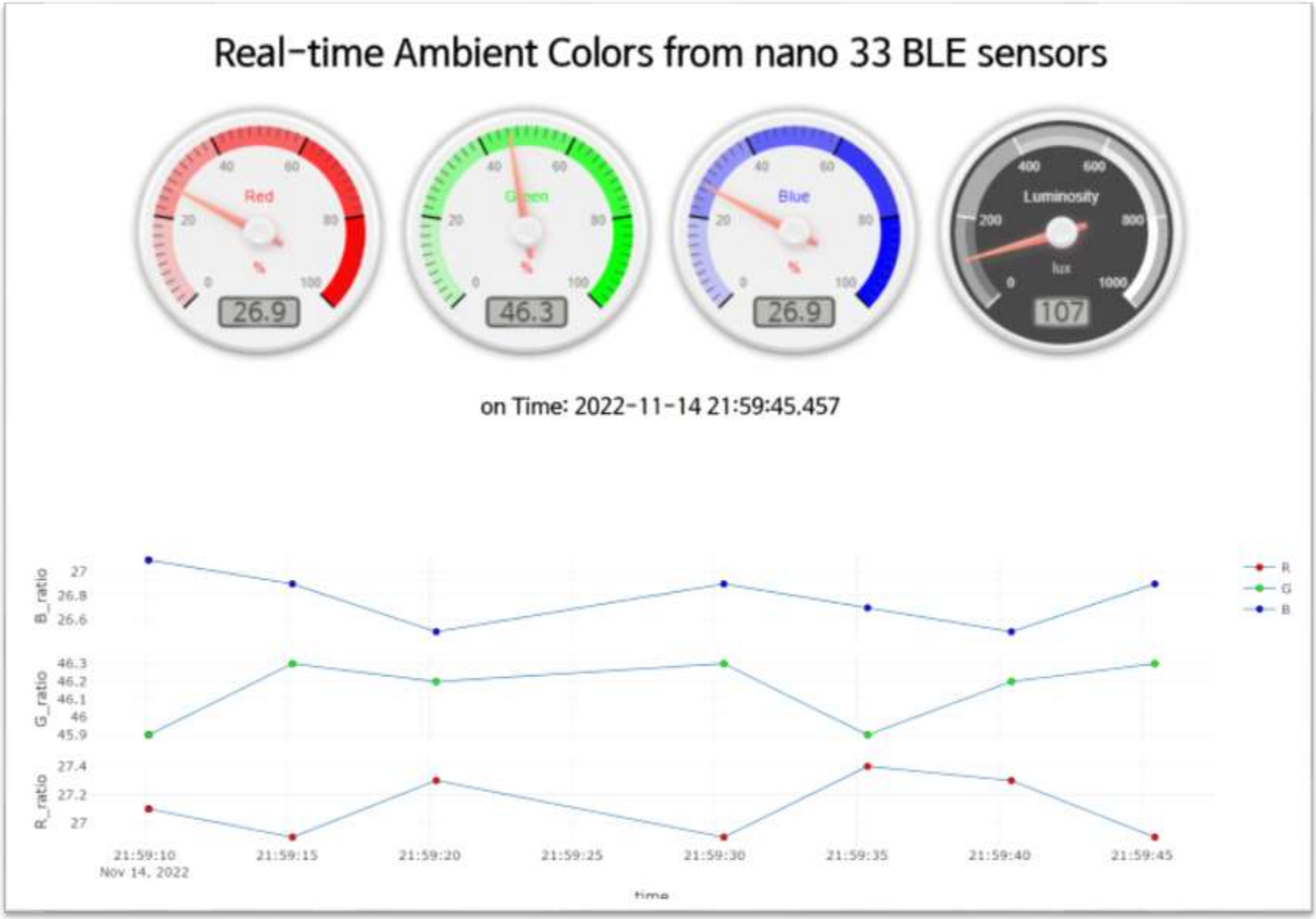
```
> show dbs
admin           0.000GB
config          0.000GB
iot             0.000GB
iot00           0.000GB
iot10           0.000GB
iot33           0.000GB
iot33rgb211119  0.000GB
local           0.000GB
test2           0.000GB
> use iot33
switched to db iot33
> show collections
sensors
> db.sensors.count()
57
> db.sensors.find()
{ "_id" : ObjectId("63722bb7535a16bfb82a8bc1"), "date" : "2022-11-14 20:51:19.470", "temperature" :
 "26.0", "humidity" : "54.6", "luminosity" : "109", "pressure" : "1007.7", "r_ratio" : "27.0", "g_r
atio" : "46.0", "b_ratio" : "27.0", "__v" : 0 }
{ "_id" : ObjectId("63722bbc535a16bfb82a8bc3"), "date" : "2022-11-14 20:51:24.514", "temperature" :
 "26.0", "humidity" : "54.7", "luminosity" : "107", "pressure" : "1007.6", "r_ratio" : "27.4", "g_r
atio" : "45.9", "b_ratio" : "26.7", "__v" : 0 }
{ "_id" : ObjectId("63722bc1535a16bfb82a8bc5"), "date" : "2022-11-14 20:51:29.558", "temperature" :
 "26.0", "humidity" : "54.7", "luminosity" : "107", "pressure" : "1007.6", "r_ratio" : "26.9", "g_r
atio" : "46.3", "b_ratio" : "26.9", "__v" : 0 }
{ "_id" : ObjectId("63722bc6535a16bfb82a8bc7"), "date" : "2022-11-14 20:51:34.602", "temperature" :
 "26.0", "humidity" : "54.6", "luminosity" : "107", "pressure" : "1007.7", "r_ratio" : "26.9", "g_r
atio" : "46.3", "b_ratio" : "26.9", "__v" : 0 }
```

http://localhost:3030/client_signal.html

http://localhost:3030/client_33.html



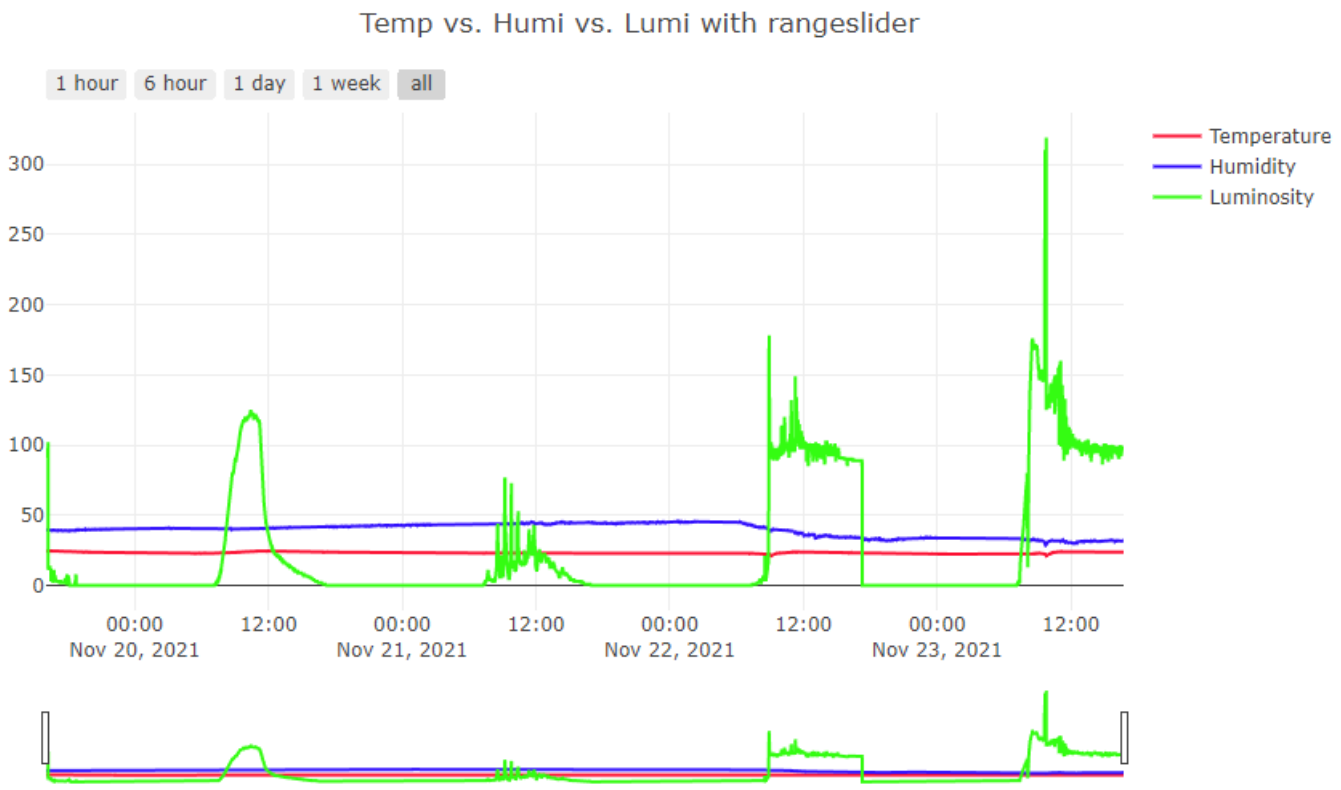
http://localhost:3030/client_33rgb.html



http://localhost:3030/client_33iot.html

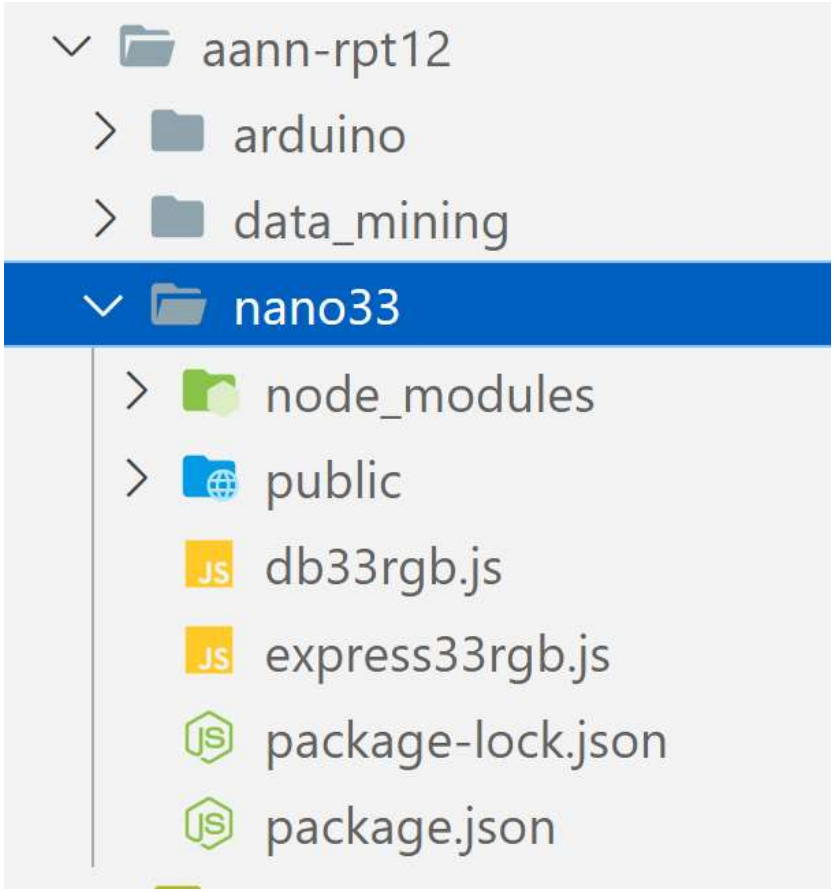
MongoDB database visualization by AA00

Time series : Multiple data from nano 33 ble sensor



Project: nano33BLE sensor

작업 폴더 구조 [2022-nano33-project]

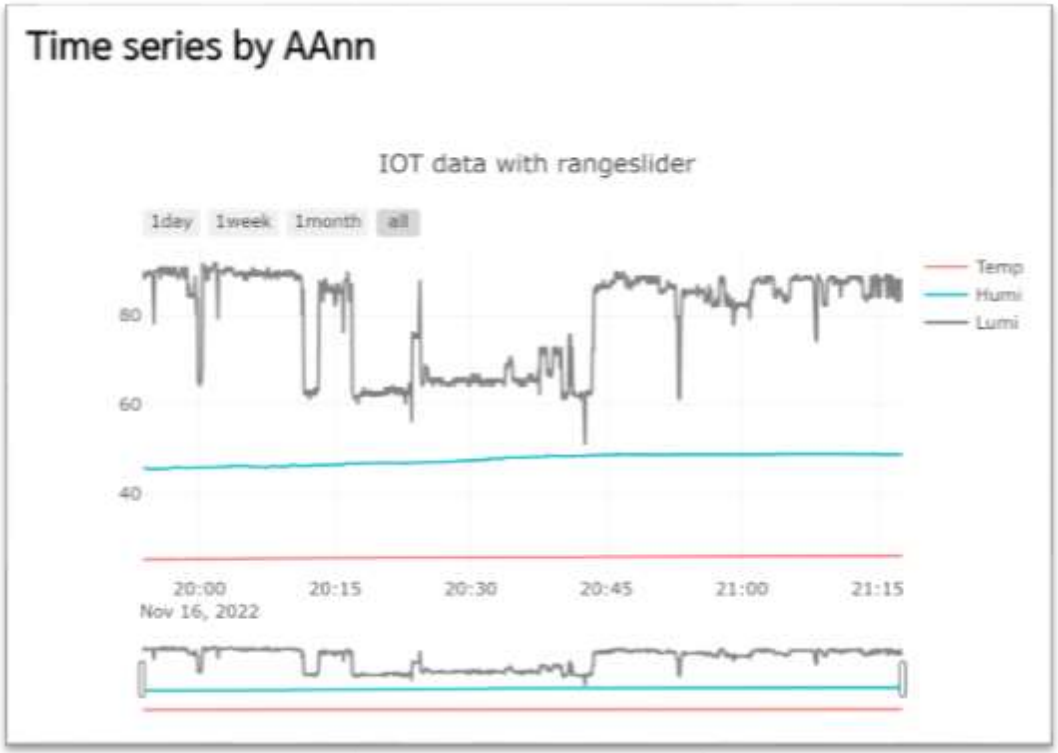


A5.9.8 MongoDB management

[DIY]
1. iot33 db의 최근 데이터 2000개를 csv 파일 (aann_iot33_1000.csv)로 저장하시오.
2. 저장된 aann_iot33_1000.csv 파일을 public/data 폴더에 복사.
3. csv 파일을 이용하는 Rangeslider가 포함된 웹 클라이언트 client_33csv.html 파일을 완성하시오.
4. localhost:3030/client_33csv.html 로 실행하고 확인.

[hint] iot33 db의 최근 데이터 500개를 csv 파일 (iot_500.csv)로 저장할 때,

- mongoexport /db:iot33 /collection:sensors /sort:"{_id: -1}" /limit:500 /fields:date,temperature,humidity,luminosity /type:csv /out:iot_500.csv



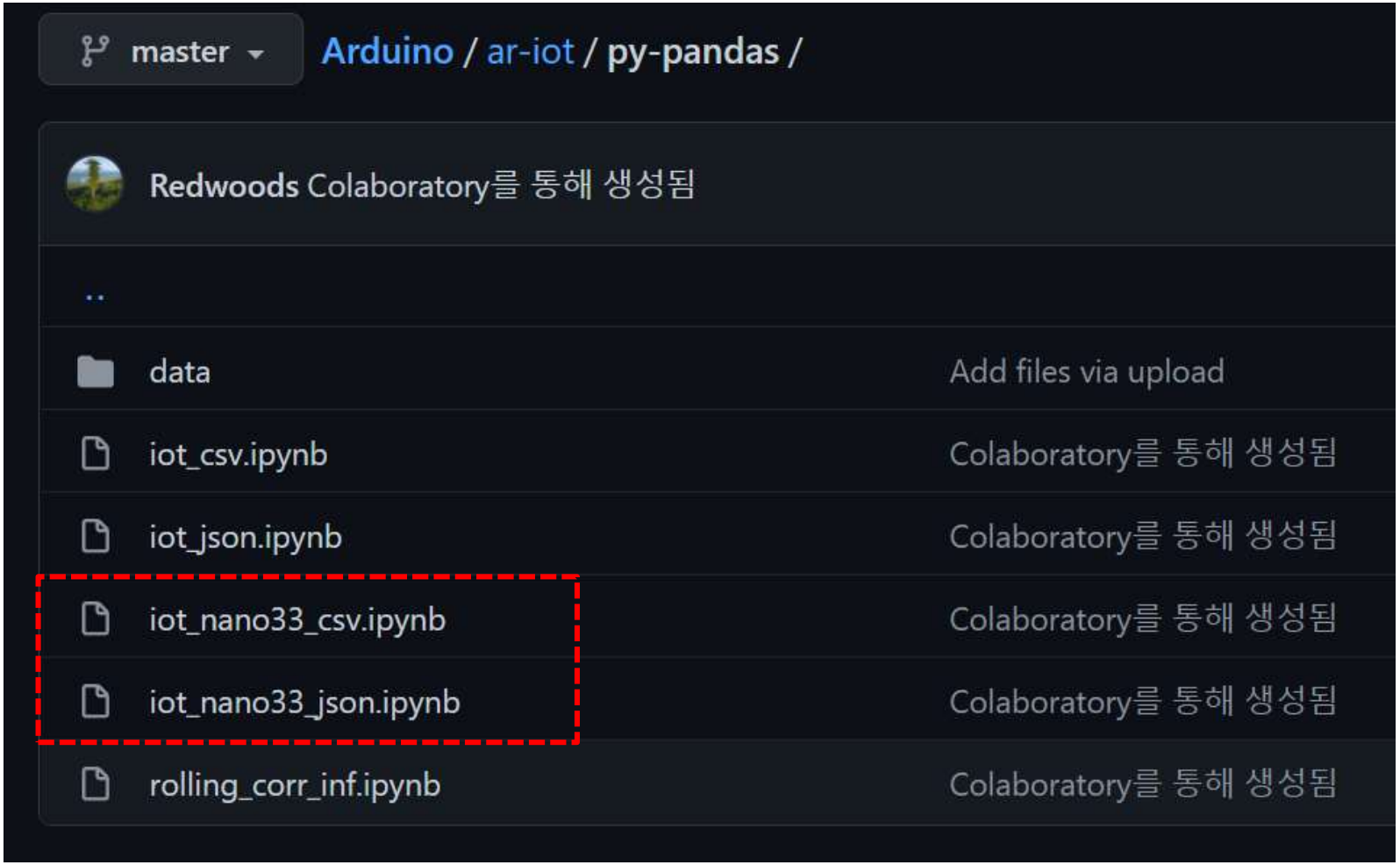
client_33csv.html

코드를 완성하시오.

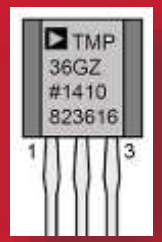
public 폴더에 저장

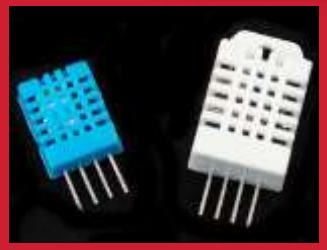
Project: nano33BLE sensor

[2022-project] IoT data mining in Colab



[Practice]





- [wk12]
  - IoT Project: nano33ble
  - Multi-sensor circuits)
  - Complete your project
  - Upload folder: aann-rpt12
  - Use repo “aann” in github

wk12 : Practice : aann-rpt12

- [Target of this week]
  - Complete your works
  - Save your outcomes and upload outputs in github

제출폴더명 : **aann-rpt12**

- 제출할 파일들

① **iot_nano33_csv.ipynb** in data_mining folder

② **iot_nano33_json.ipynb** in data_mining folder

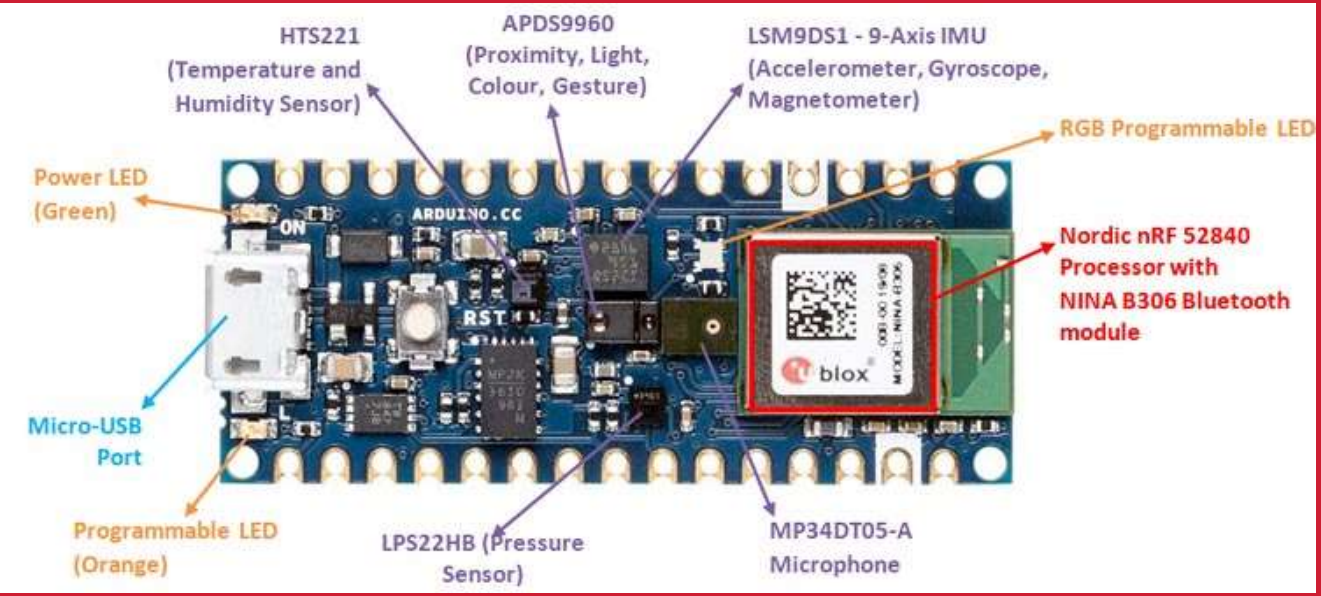
③ **All *.js** in nano33 folder

④ **public/All *.html**

⑤ **aann_Iot33_1000.csv** in public/data folder

2021/22 AA team project

nano33BLE sensor



APDS9960

- gestures
- proximity
- color, light intensity

begin()

end()

gestureAvailable()

readGesture()

colorAvailable()

readColor()

proximityAvailable()

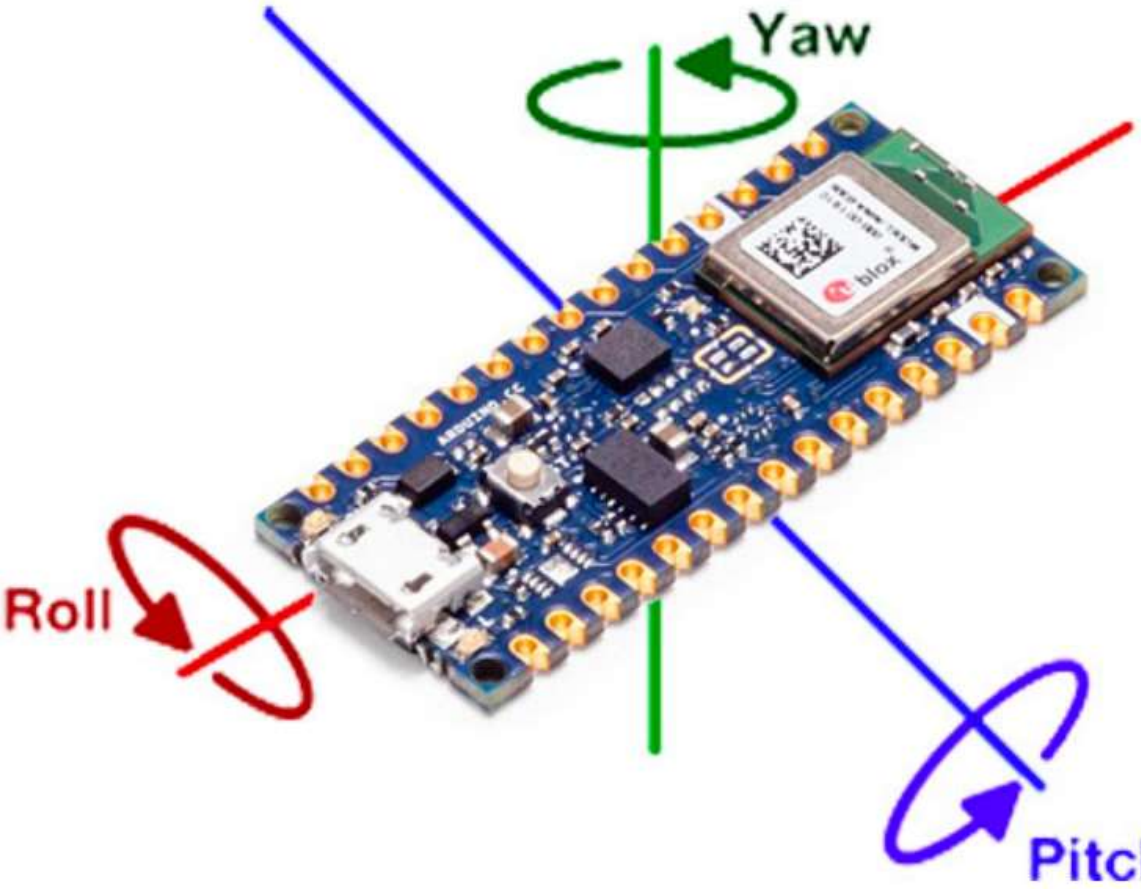
readProximity()

setGestureSensitivity()

setInterruptPin()

setLEDBoost()

LSM9DS1, 9축 IMU센서: acc, gyro, mag



자이로 스코프 측정, 이미지 출처 https://www.mauroalfieri.it/elettronica/arduino-nano-33-ble-giroscopio-lsm9ds1.html

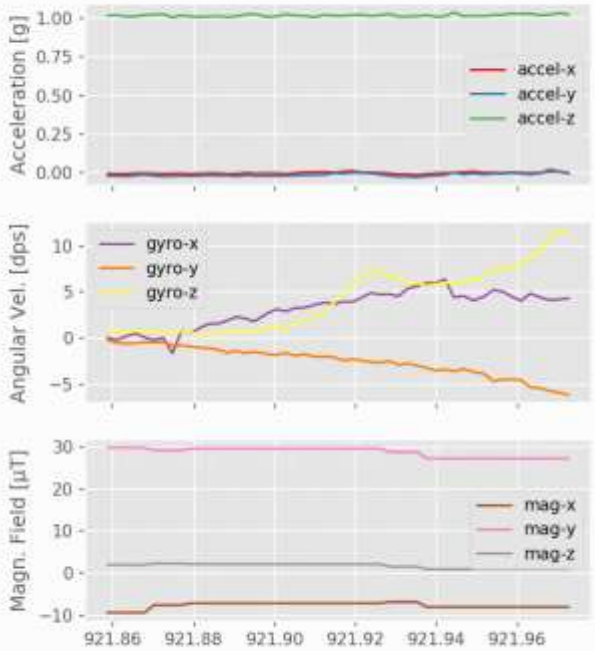
https://fishpoint.tistory.com/4438

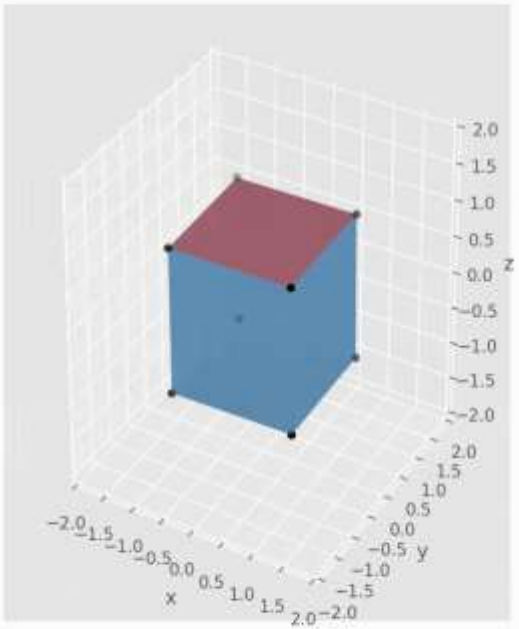
LSM9DS1, 9축 IMU센서: acc, gyro, mag

* 9축 IMU 센서 신호 마이닝

1. **MongoDB**
2. **Express server**
   - 실시간 모니터링
   - **DB** 모니터링
3. **data mining using Colab**
4. **Deep learning ?**

모션 인식(9-축 IMU)

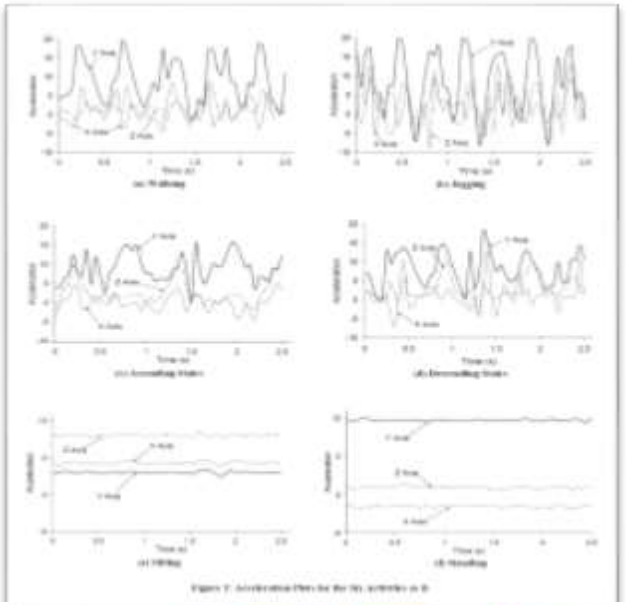


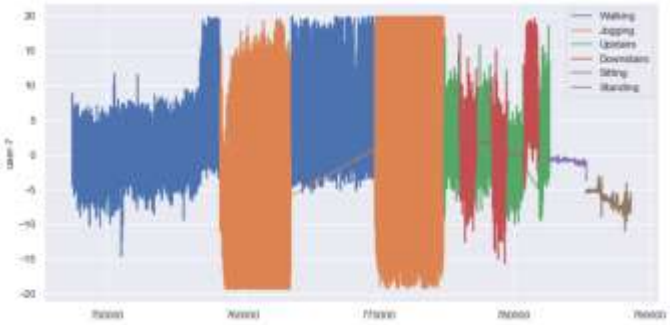


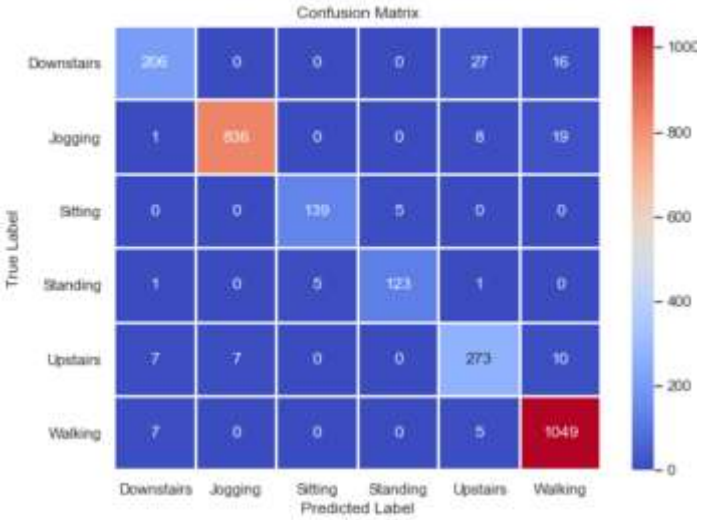
https://images.squarespace-cdn.com/content/v1/59b037304c0dbfb092fbe894/1573836927118-IS5CS61OW9XH9HSRCMA1/ke17ZwdGBTodd8pDm48kGbFogdxZzB1B7PQq3zm9xl7gQa3H78H3Y0txjaiv_0fDoOvxcdMmMKkDsyUqMSsMWxHk725yiiHCCLfrh8O1z5QPOohDIaIeljMHgDF5CVlOqpeNLcJ80NK65_fV7S1UQupMlr7Z9cq9PZkRYtzEu3SbZmkCxOjksrEup4_K2kPH3bqxw7fF48mhrq5Ulr0Hg/mpu9250_cube_rotation_compressed.gif

일상활동 인식(3축 가속도)

['Downstairs',
'Jogging',
'Sitting',
'Standing',
'Upstairs',
'Walking']

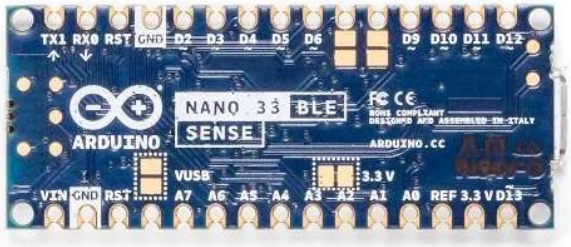






--- ACC_XYZ, 4s: classification report for test data ---

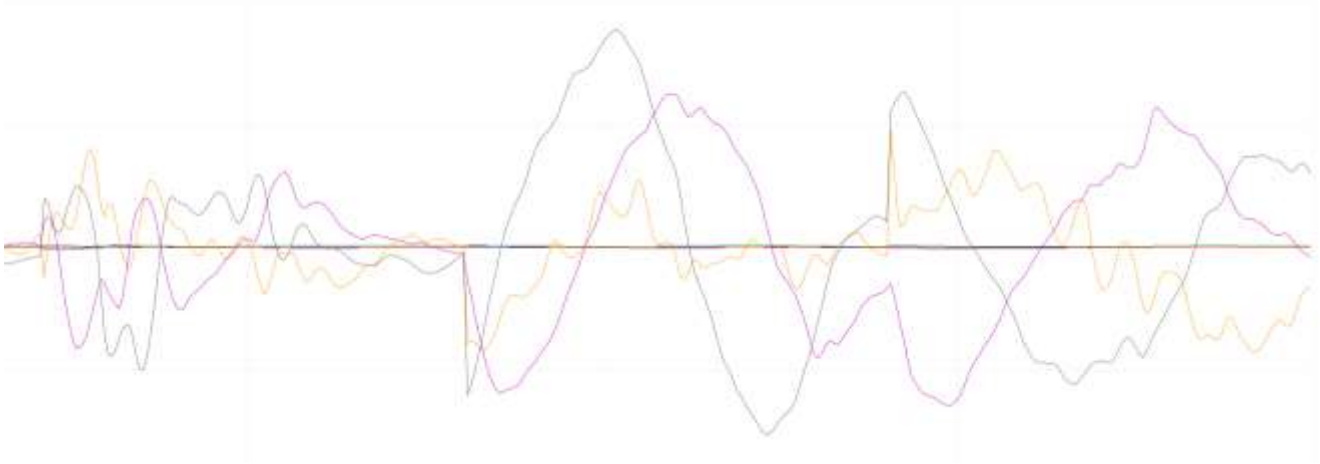
	precision	recall	f1-score	support
0	0.93	0.83	0.87	249
1	0.99	0.97	0.98	864
2	0.97	0.97	0.97	144
3	0.96	0.95	0.95	130
4	0.87	0.92	0.89	297
5	0.96	0.99	0.97	1061
accuracy			0.96	2745
macro avg	0.95	0.94	0.94	2745
weighted avg	0.96	0.96	0.96	2745



Arduino nano33 BLE

Classification of gestures using ACC in Tensorflow 2.x & TinyML/TF-Lite

Data 모으기



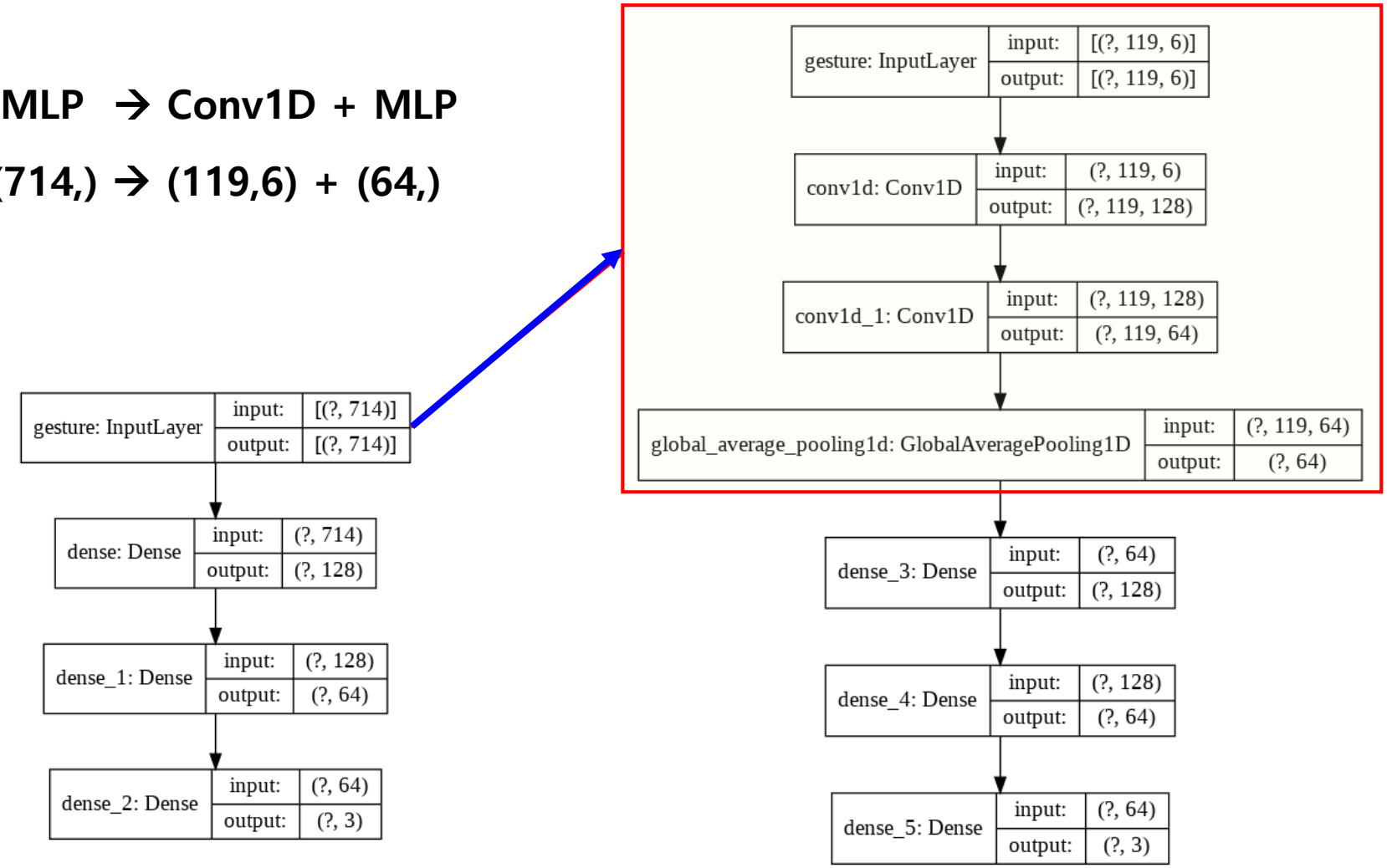
PUNCH CCW CW

119 X 6 (ax,ay,az, gx,gy,gz)

DL architecture

MLP → Conv1D + MLP

(714,) → (119,6) + (64,)



DL-model

```
from tensorflow.keras import layers
```

```
# TF2 functional API
# CONV1D & MLP
inputs = keras.Input(shape=(119,6), name='gesture')
x = layers.Conv1D(128, 3, padding='causal',activation='relu')(inputs)  # 32,
x = layers.Conv1D(64, 3, padding='causal', activation='relu')(x)      # 16
x = layers.GlobalAveragePooling1D()(x)  # New features (714 => 16 or 64)
x = layers.Dense(128, activation='relu')(x)
x = layers.Dense(64, activation='relu')(x)
outputs = layers.Dense(NUM_GESTURES, activation='softmax')(x)

model_conv = keras.Model(inputs=inputs, outputs=outputs, name='gesture_model2')

model_conv.compile(optimizer='rmsprop', loss='mse', metrics=['accuracy'])
```

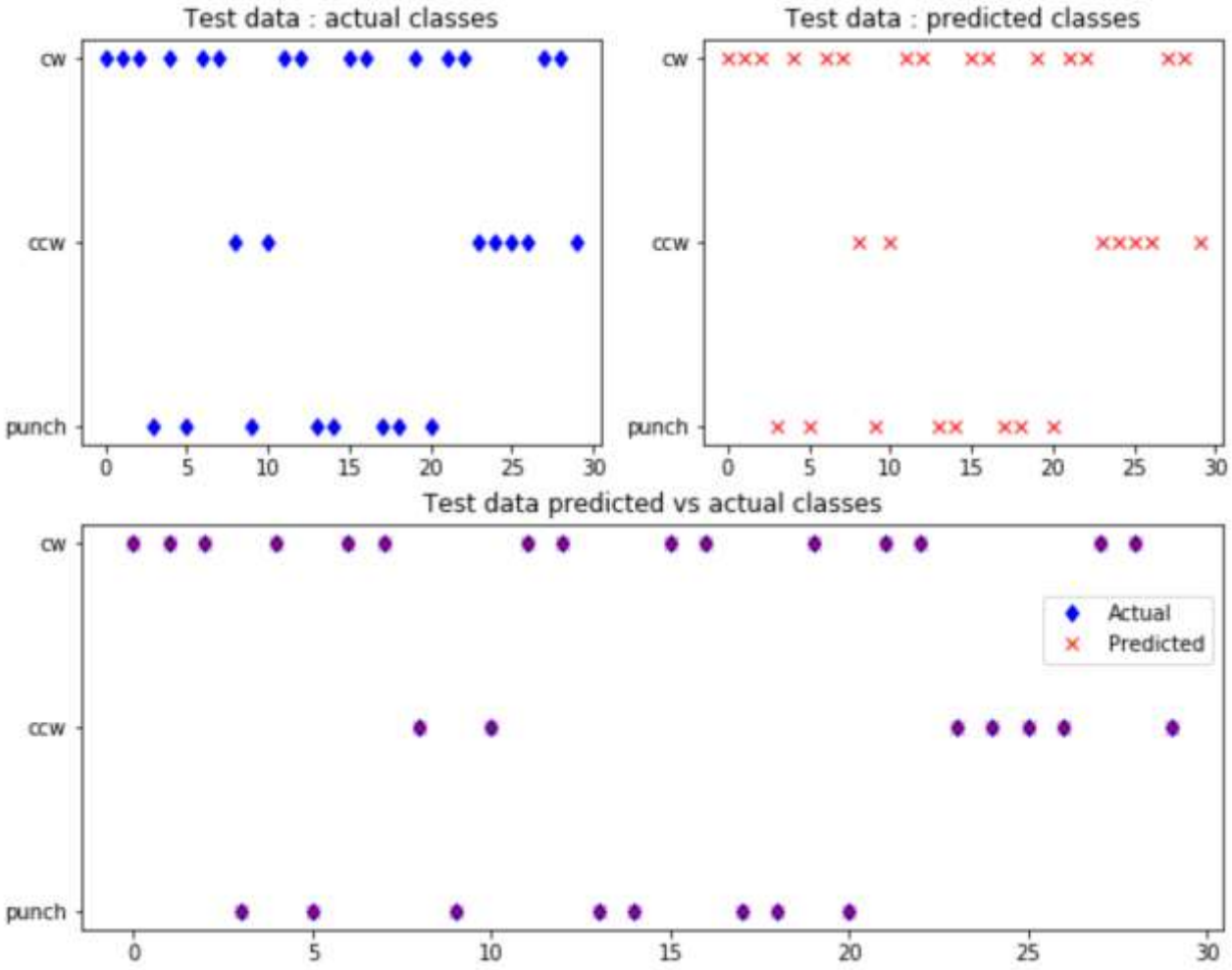
```
# train the model
history = model_conv.fit(inputs_train2, outputs_train, epochs=500, batch_size=16
                         validation_data=(inputs_validate2, outputs_validate))
```

```
model_conv.summary()
```

```
Model: "gesture_model2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
gesture (InputLayer)         [(None, 119, 6)]          0
_________________________________________________________________
conv1d (Conv1D)              (None, 119, 128)          2432
_________________________________________________________________
conv1d_1 (Conv1D)            (None, 119, 64)           24640
_________________________________________________________________
global_average_pooling1d (Gl (None, 64)                0
_________________________________________________________________
dense_3 (Dense)              (None, 128)               8320
_________________________________________________________________
dense_4 (Dense)              (None, 64)                8256
_________________________________________________________________
dense_5 (Dense)              (None, 3)                 195
=================================================================
Total params: 43,843
Trainable params: 43,843
Non-trainable params: 0
```

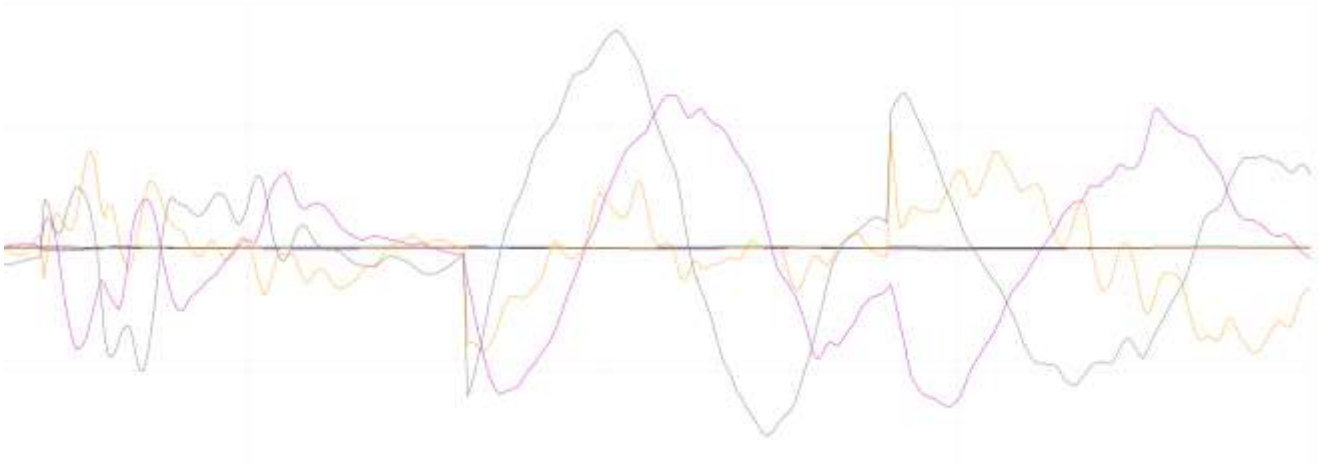
DL-model testing

actual =
[[0. 0. 1.]
[0. 0. 1.]
[0. 0. 1.]
[1. 0. 0.]
[0. 0. 1.]
[1. 0. 0.]
[0. 0. 1.]
[0. 0. 1.]
[0. 1. 0.]
[1. 0. 0.]
[0. 1. 0.]
[0. 0. 1.]
[0. 0. 1.]
[1. 0. 0.]



predictions =
[[0. 0.001 0.999]
[0.001 0.001 0.998]
[0.005 0.001 0.994]
[0.999 0. 0.001]
[0. 0.001 0.999]
[1. 0. 0.]
[0. 0.001 0.999]
[0.002 0.001 0.997]
[0. 1. 0.]
[1. 0. 0.]
[0. 1. 0.]
[0. 0.001 0.999]
[0.001 0. 0.999]
[0.997 0. 0.003]

Real-time testing



PUNCH CCW CW

COM8

```
13:24:06.140 -> punch: 0.996470
13:24:06.140 -> ccw: 0.000000
13:24:06.140 -> cw: 0.003530
13:24:06.140 ->
13:24:10.197 -> punch: 0.000095
13:24:10.197 -> ccw: 0.000000
13:24:10.197 -> cw: 0.999905
13:24:10.197 ->
13:24:13.193 -> punch: 0.000000
13:24:13.193 -> ccw: 1.000000
13:24:13.193 -> cw: 0.000000
```

Lecture materials

References & good sites

- ✓ http://www.arduino.cc Arduino Homepage
- ✓ http://www.nodejs.org/ko Node.js
- ✓ https://plot.ly/ plotly
- ✓ https://www.mongodb.com/ MongoDB
- ✓ http://www.w3schools.com By w3schools
- ✓ http://www.github.com GitHub

Target of this class