CASA0018 – DEEP LEARNING FOR SENSOR NETWORK

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Colours Detection tool using Arduino Nano Sensor

Project Objective

- Recognizing a colour seems very easy for humans but as a machine it can be very difficult.
- Humans use simultaneously their eyes and brain to convert light into colours, when our eyes have difficulties to do it it can lead to colour blindness or event blindness.
- This project aims to detect the colour with data collected with the Colour Sensor of the Arduino Nano 33 BLE and return the label of this colour

Steps of the project
Data collection

- An object appears coloured because of its interaction with the light and its ability to revert the light received.

- An element seems to be red because it reflects the red light and absorb all the other rays of light

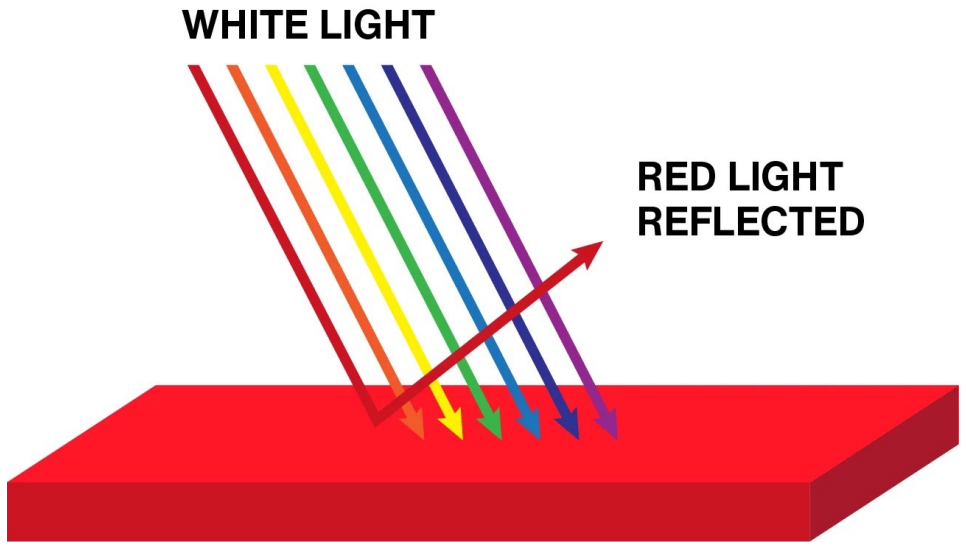

Figure 1: Red Light reflection (Pantone n.d.)

Steps of the project
Data collection

- A colour can be expressed by a combination of Hue, Saturation and Value (HSV) or with a combination of Red, Green and Blue (RGB)

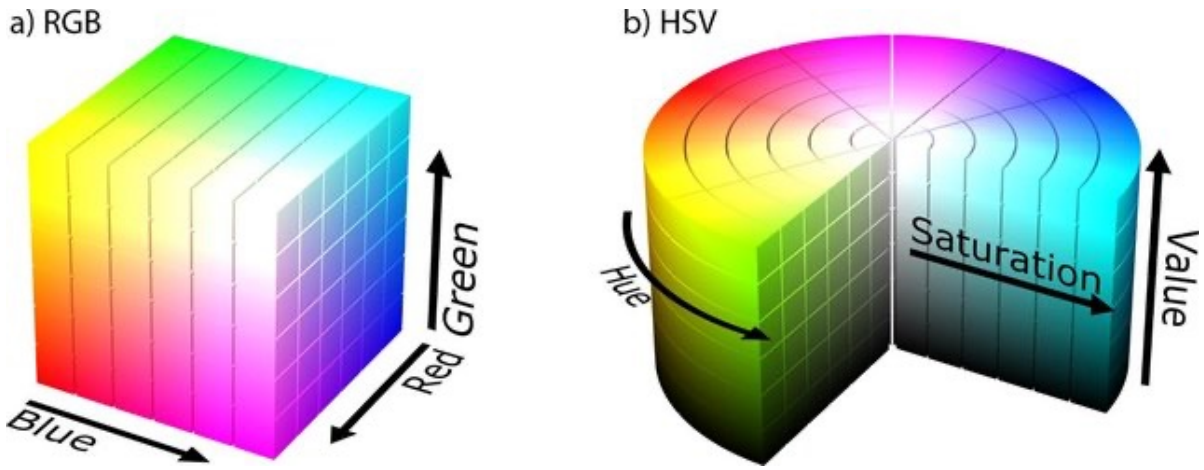

Figure 2: RGB and HSV Colour space (Popov 2018)

- In this project the data uses the RGB format
- Such as the colour Orange has the RGB value of:

  (250, 104, 0)

Figure 3: Colours values in RGB (CREEPYED 2012)

Steps of the project
Data collection

The data used to train the model of colour recognition has been manually labelled by Ajinkya Chavan (Chavan 2020) by generating random RGB values and assigning them the correct colour label

The dataset contains more than 5000 observation with 3 features (Red, Green, Blue) and the label for each

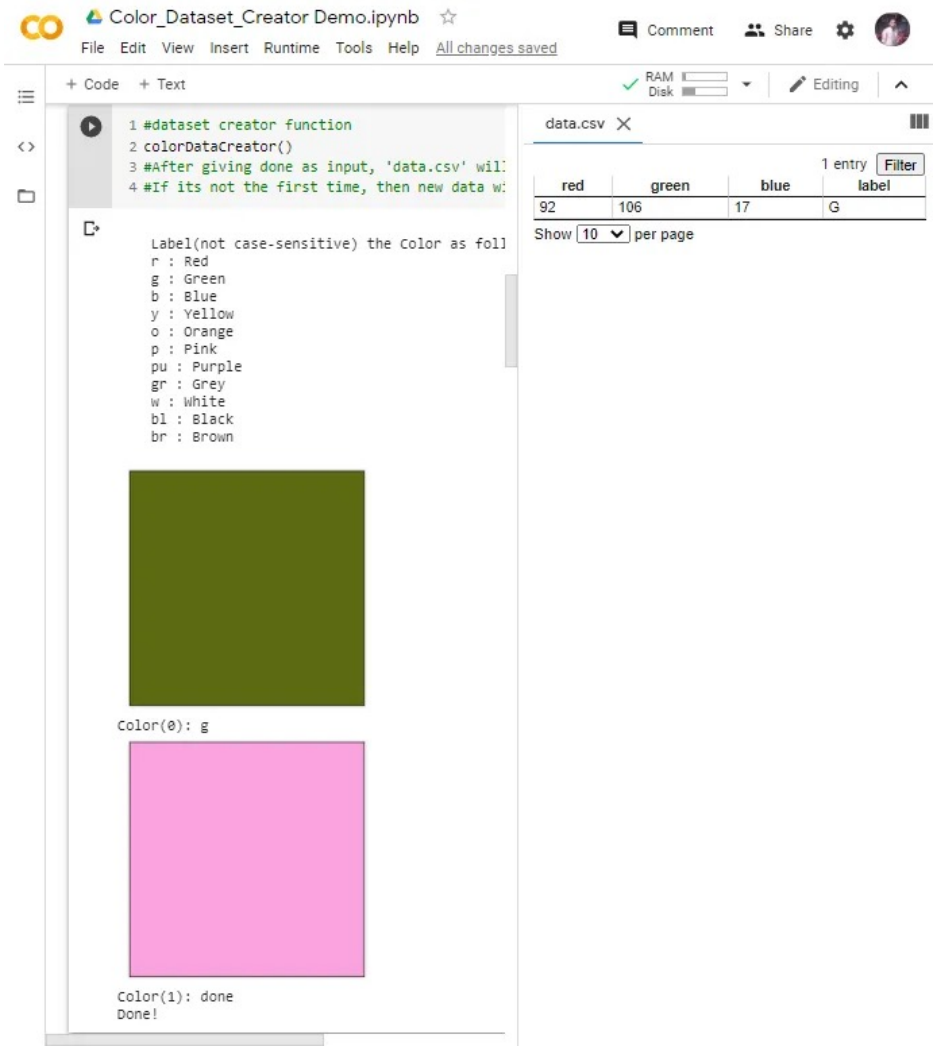

Figure 4: Colours labelling (Chavan 2020)

Architecture of the best model and results

Data preprocessing:

Data encoding:

Creating binary variables for each class of the target column, it leads to create 11 new columns

Normalizing the features:

$$feature\ norm_i = \frac{feature_i}{255}$$

As the range of the color value is between 0 and 255

Dividing the dataset into train and test set with the folowing proportion 85% and 15% respectively

```
color_set.head()
```

	red	green	blue	label
0	20	139	240	Blue
1	174	83	72	Brown
2	144	249	131	Green
3	168	25	156	Pink
4	30	182	136	Green

Architecture of the best model and results

Modelling:

Several studies on the topic of color recognition suggest the use of neural network models to identify pattern and classify RGB data (Chavan 2020 or Griffin 2005)

Training of multiple ANN:

From a simple model with 1 hidden layer to a neural network with 3 hidden layers with different method of defining the parameters and hyperparameter, the best model with the best accuracy on the test set is a model with:

- 2 hidden layers (30 and 16 nodes)
- ReLU as the activation function
- Adam as the optimizer

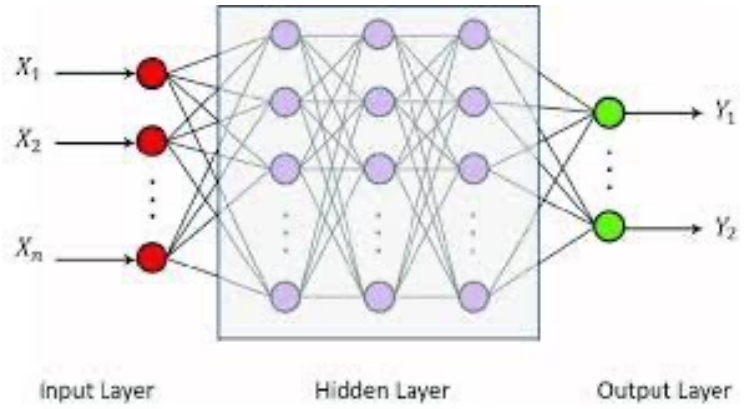

Figure 5: Neural Network Diagram (Shahriar 2020)

Architecture of the best model and results

Results:

Accuracy measures:

The accuracy is ranging from 56% to 85% on the test set

Confusion Matrix and Report:

With the confusion matrix we get a better understanding of the performance of the model for each class.

Most of the classes are well predicted unless the grey and the black colour which can be explained because of the RGB values of this colours, close to 0

	precision	recall	f1-score	support
Black	0.38	1.00	0.55	3
Blue	0.90	0.92	0.91	221
Brown	0.80	0.94	0.87	69
Green	0.89	0.91	0.90	281
Grey	0.76	0.42	0.54	38
Orange	0.88	0.72	0.79	39
Pink	0.83	0.83	0.83	121
Purple	0.86	0.79	0.82	128
Red	0.76	0.83	0.80	47
White	1.00	1.00	1.00	4
Yellow	0.73	0.78	0.76	60
accuracy			0.85	1011
macro avg	0.80	0.83	0.80	1011
weighted avg	0.86	0.85	0.85	1011

Export to Arduino

- After training the model with python in a Google Colab notebook
- The model is converted to a TensorFlow Lite model using the TensorFlow Lite converter function
- Before being export to a C file so it can be loaded into the Arduino Nano 33 BLE

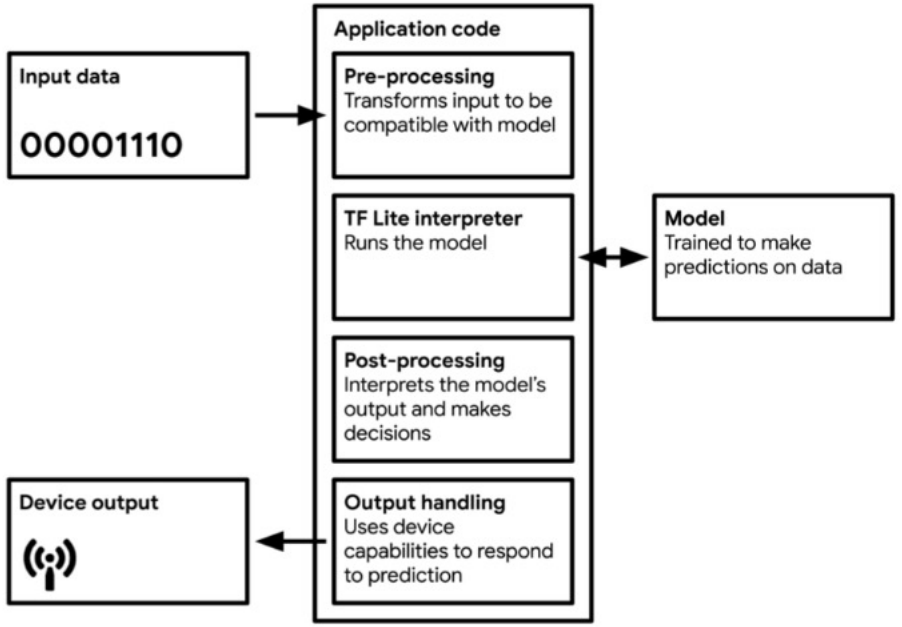

Figure 6: A basic TinyML application architecture

Use of Arduino

Arduino Nano 33 BLE has a sensor APDS9960 to read colours as RGB values. This will be used as input of the model and the output will be the label of the colour predicted by the neural network.

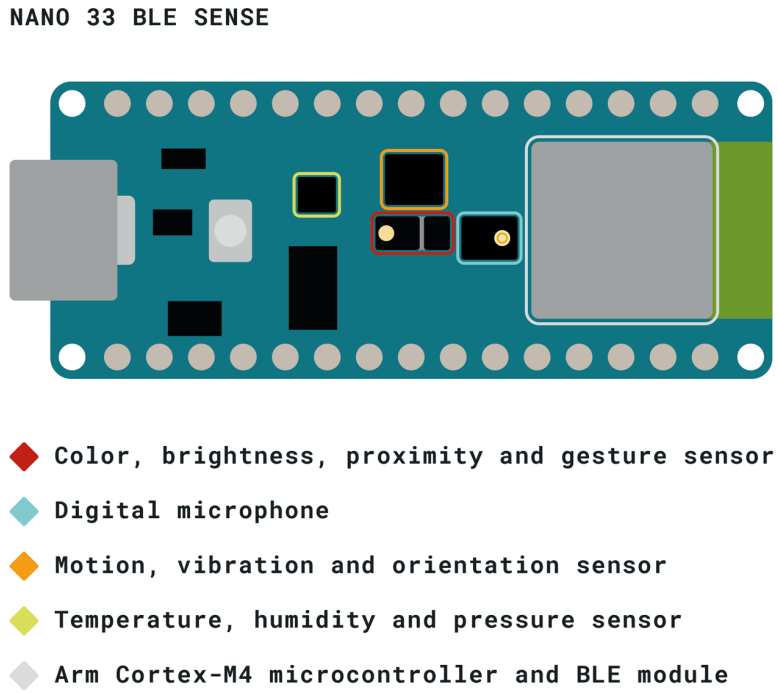

Figure 7: Arduino Nano 33 BLE Sense board description


Output
Serial Monitor
New Line
31250 baud
15:19:23.498 -> Red light = 94
15:19:23.498 -> Green light = 113
15:19:23.498 -> Blue light = 103
15:19:23.498 ->
15:19:23.498 -> BLACK 0%
15:19:23.498 -> BLUE 0%
15:19:23.498 -> BROWN 0%
15:19:23.498 -> GREEN 0%
15:19:23.498 -> ORANGE 0%
15:19:23.498 -> PINK 0%
15:19:23.498 -> PURPLE 0%
15:19:23.498 -> RED 0%
Ln 128, Col 4
Arduino Nano 33 BLE on /dev/cu.usbmodem14201
SAMSUNG
GIS: A Computing Perspective

Improvments

- As of now, the model as been trained and manually tested on several input collected from the Arduino sensor APDS9960. The results of this tests are promising.
- The light of the room has an important impact on the predictions as the sensor is less able to collect information in darker environment, so more data need to me collected in different condition to improve the performance
- Unfortunately the sketch is not returning the output of the model but only the initial values. So further developments are needed on this side of the project
- As well, the idea behind this project was to develop a tool to help the blinds to have a better idea of the colour of the objects around them such as the colour of their clothes

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