國立中正大學
National Chung Cheng University

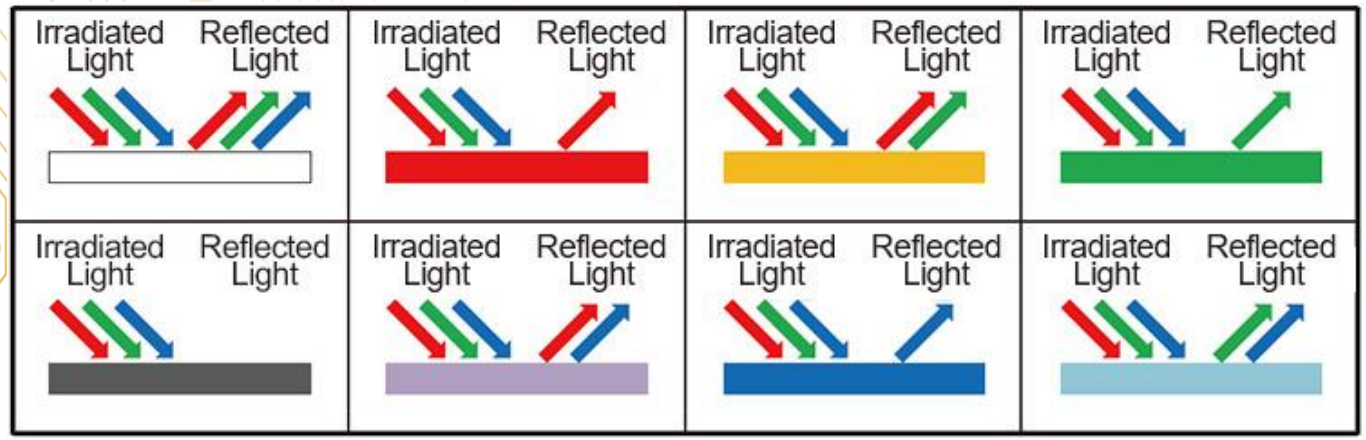
微處理機系統與介面技術

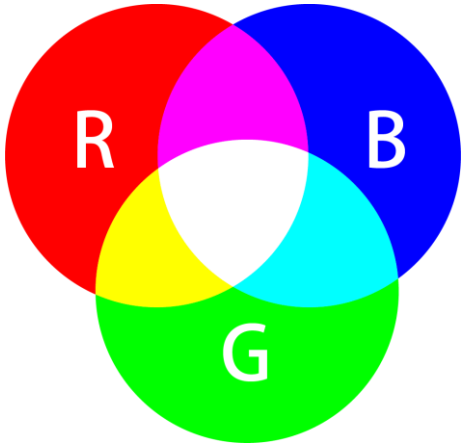
LAB 8 – Machine Learning

www.neatlab.tw
neat Laboratory
CCU@Taiwan 中正大學

Color Sensor

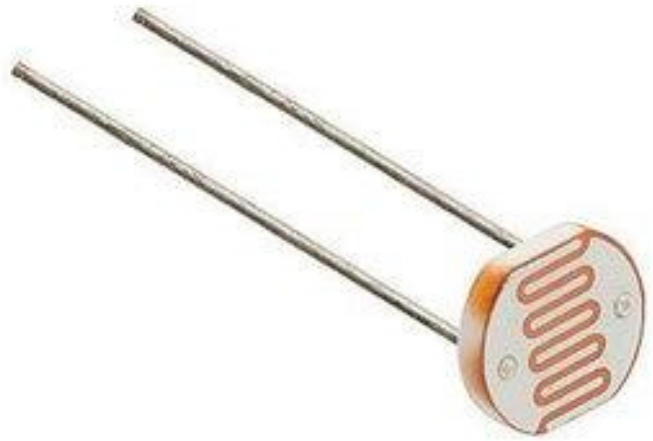
- When an object is illuminated with white light, it reflects the wavelengths of light that correspond to its inherent color.
- Reflected light can be used to determine an object's color.

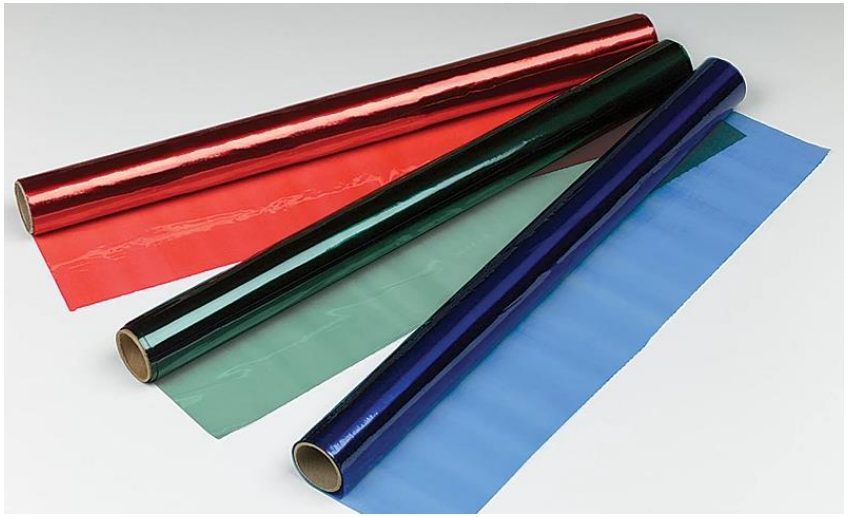




How to detect reflected light?

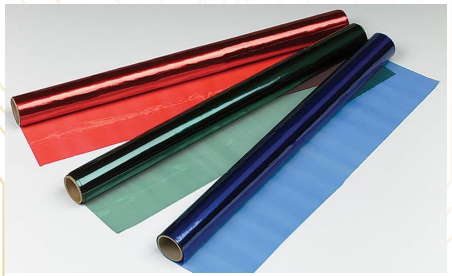
- A photoresistor's resistance varies with light intensity
- Cellophane can assist in filtering light
- Combining these helps detect the intensity of specific colored light

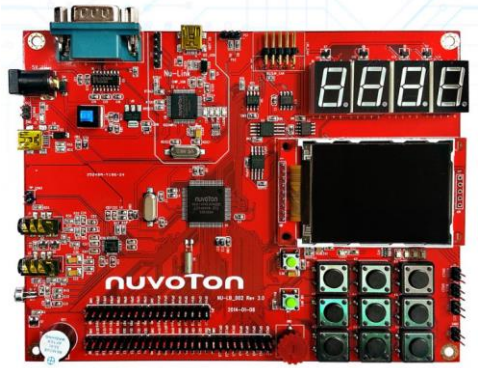


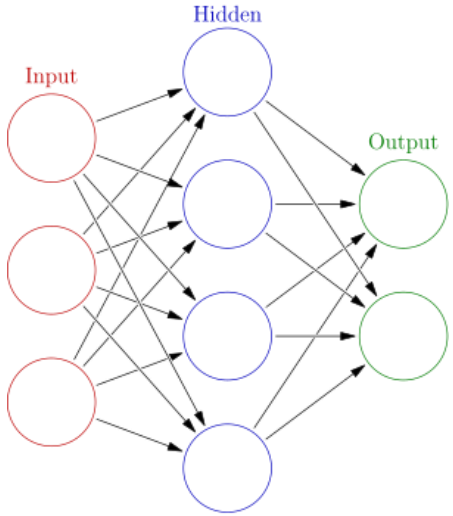


How to detect reflected light?

- All light can be composed of the RGB primary colors.
- The intensity of the three primary colors can be used with machine learning to predict the perceived color





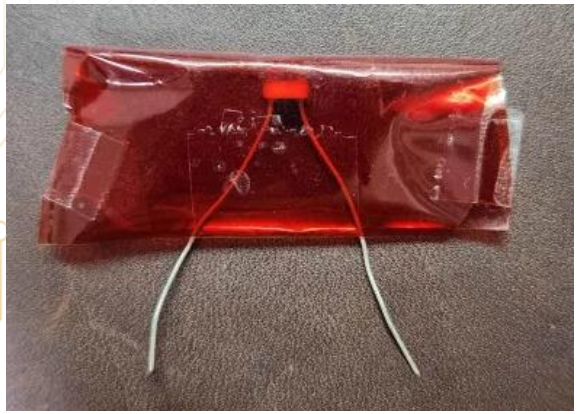


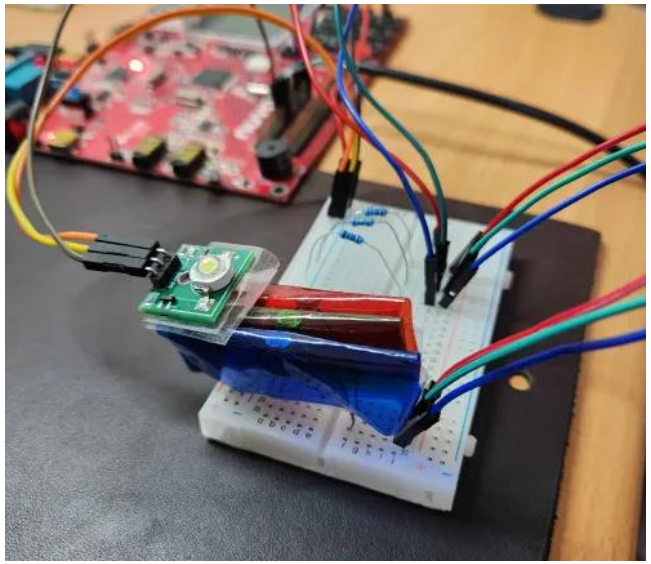
Light Source – LED Module

- Connect VCC and GND
- Use GPIO to control the switch (1 = on, 0 = off)
- LED is very bright. Please avoid staring at it for long periods

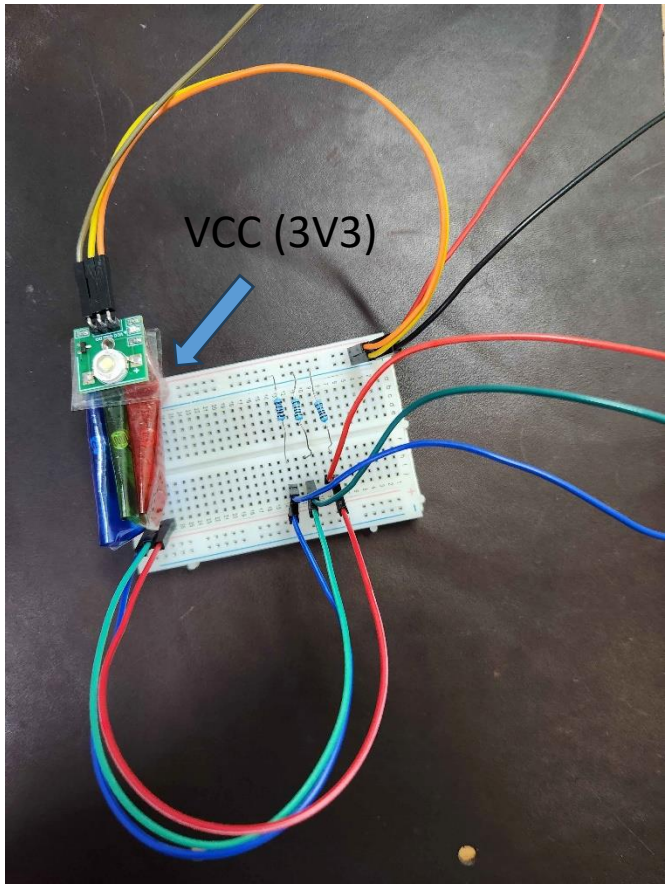
Experimental Setup

- Cover the photoresistor with cellophane
- Align three photoresistors side by side
- Attach the LED module above the three photoresistors
- Connect the remaining circuitry (VCC, GND, ADC, Control Pin)

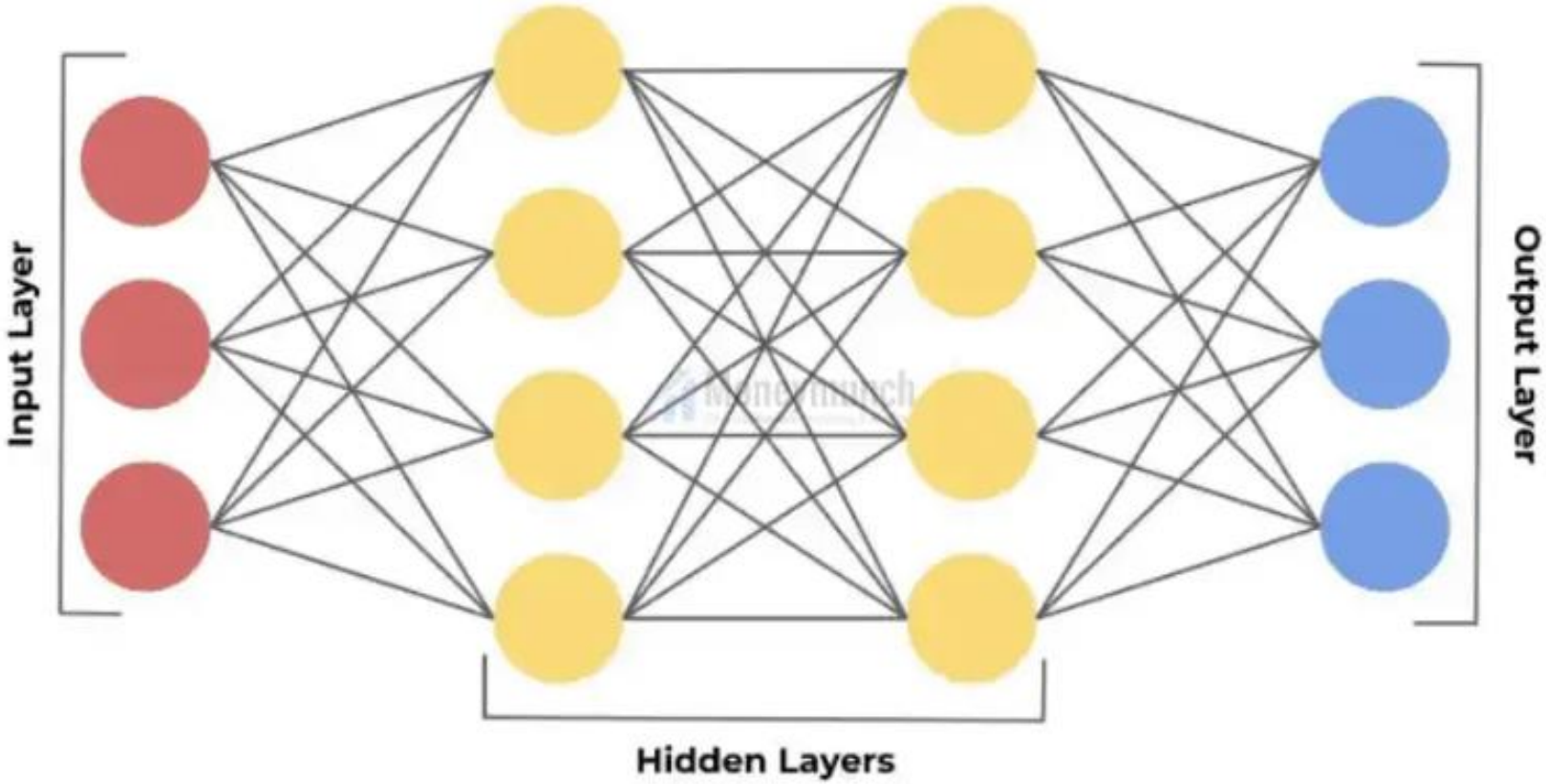




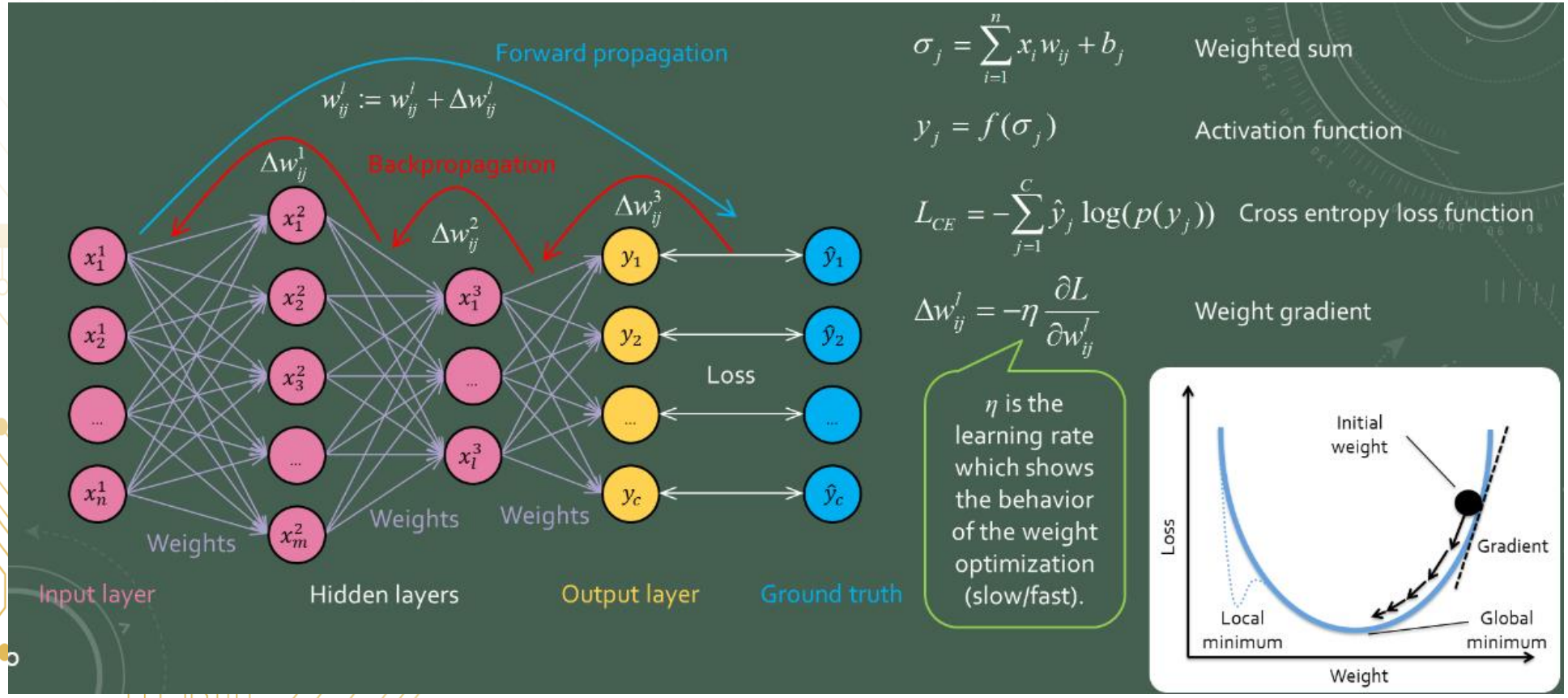
Experimental Setup



Machine Learning



Machine Learning - ANN



$$\sigma_j = \sum_{i=1}^{n} x_i w_{ij} + b_j$$ Weighted sum

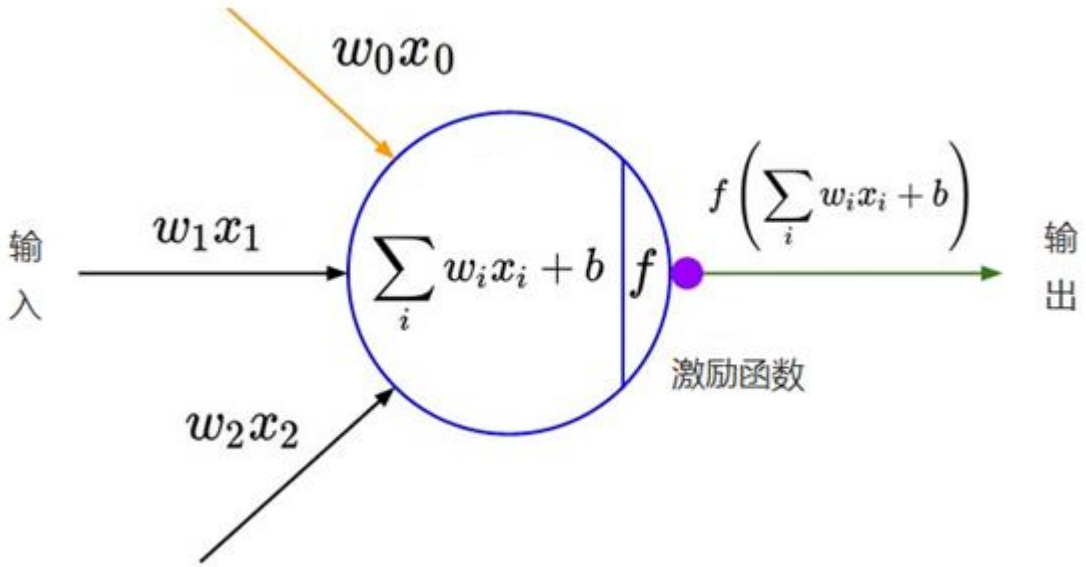
$$y_j = f(\sigma_j)$$ Activation function

$$L_{CE} = -\sum_{j=1}^{C} \hat{y}_j \log(p(y_j))$$ Cross entropy loss function

$$\Delta w_{ij}^l = -\eta \frac{\partial L}{\partial w_{ij}^l}$$ Weight gradient

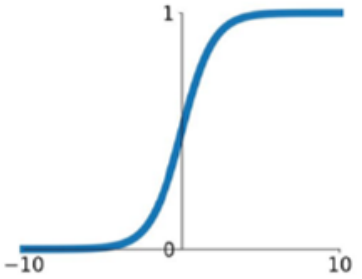
η is the learning rate which shows the behavior of the weight optimization (slow/fast).

Activation Function



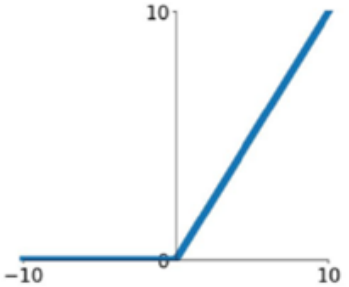
Sigmoid

$$\sigma(x) = \frac{1}{1+e^{-x}}$$



ReLU

$$\max(0, x)$$



Softmax

$$S(z) = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_i}}$$

Loss Function

- Mean Square Error (MSE) →basic loss function $$MSE = \frac{1}{n}\sum_{i=1}^{n}\left(y_i - \hat{y}_i\right)^2$$
- Mean Absolute Error (MAE) $$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|y_i - \hat{y}_i\right|$$
- Cross Entropy → advanced! $$H = \sum_{c=1}^{C}\sum_{i=1}^{n} -y_{c,i}\log_2(p_{c,i})$$

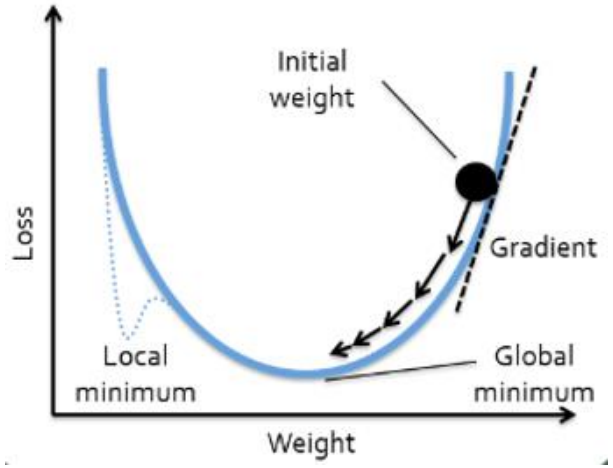
Optimization function

- Gradient Decent (GD) →conceptual
- Stochastic Gradient Decent (SGD)→basic
- Adam → adaptive learning rate

- What's learning rate?

$$\Delta w_{ij}^{l} = -\eta \frac{\partial L}{\partial w_{ij}^{l}}$$

η is the learning rate which shows the behavior of the weight optimization (slow/fast).



Data Set / preprocess

- Data set (You need to collect the data yourself)
  1. Training data
  2. Testing data

- How to distribute train/test data?

- Normalization / Standardization?

$$x_{norm}^{(i)} = \frac{x^{(i)} - \mathbf{x}_{min}}{\mathbf{x}_{max} - \mathbf{x}_{min}}$$

$$x_{std}^{(i)} = \frac{x^{(i)} - \mu_x}{\sigma_x}$$

Tips

- 參考網站：https://www.the-diy-life.com/running-an-artificial-neural-network-on-an-arduino-uno/

- 程式碼可以分成 收集資料、訓練+預測 兩份程式碼
- 收集資料可以使用 ADC_SingleCycleScanMode
- 每種output的訓練資料約15~30筆即可
- Input 要先做 Normalization 或 Standardization
- 實驗室的 ambient light 請從 data.txt 取一部分加進訓練資料

Basic

- Use machine learning to predict 4 outputs:
  - red, blue, green and ambient light

Bonus

- Use machine learning to predict 7 outputs:
  - red, blue, green, magenta, orange, yellow and ambient light

- Demo Video

Demo

- Place: 創新大樓515 找助教 潘冠豪
- Demo Time: (二)(四)下午兩點~四點半
- Report deadline: 01/10 (五)
- Report title format: LABx_ID_Name.pdf

- Demo必須在Report deadline前完成
- Demo前須先上傳程式碼(上傳main所在的.c檔即可)

Graded

- Basic : 70%
- Bonus : 15%
- Report & Code : 15%