APHW1
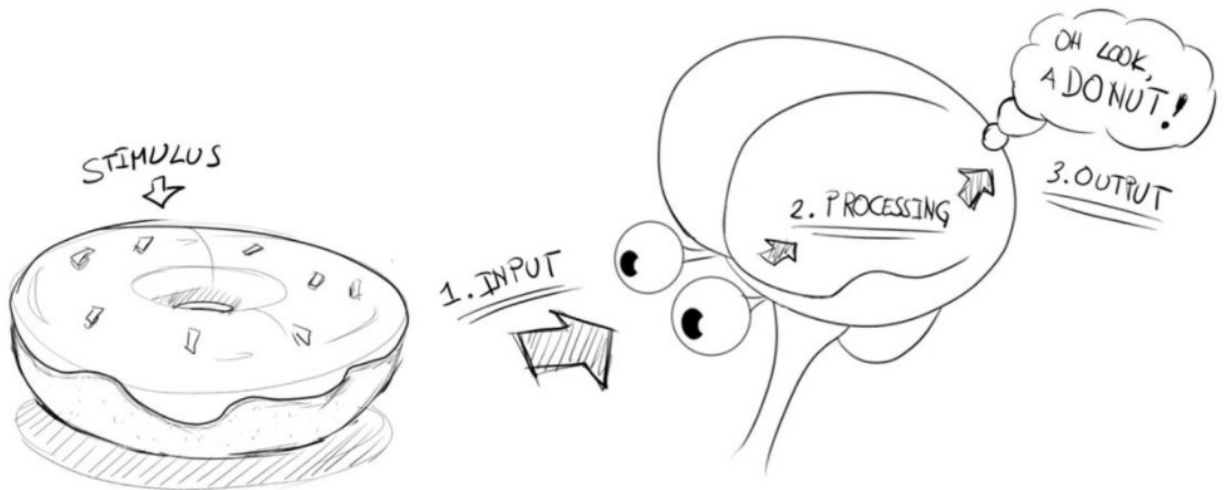
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At this homework we want to code and train with vector and smart pointer.

PERCEPTRON

The brain is complex, but can generally be divided into a small number of parts and basic operations.

The nerve is the basic unit for calculations in the brain, each nerve receives and integrates chemical signals from other nerves.

PARTS:

DENDRITES

NEURON ①

AXON

SYNAPSES

NEURON ②   NEURON ③

FLOW:
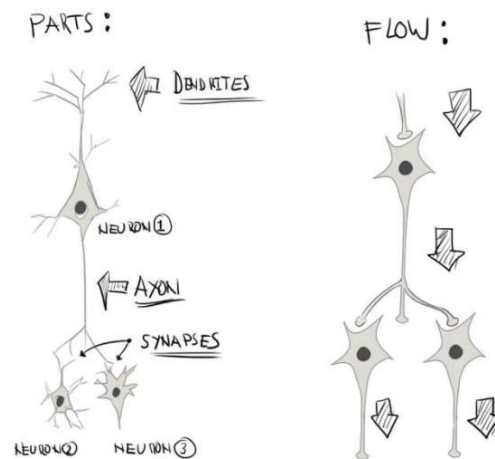
In the field of artificial neural networks, perceptron is a type of artificial neuron, capable of converting a sample to zero or one output.

Inputs

$x_0 {=} 1$

x_1

x_2

x_3

$\vdots$

x_n

w_0

w_1

w_2

w_3

w_n

$\Sigma | \varphi$ Perceptron
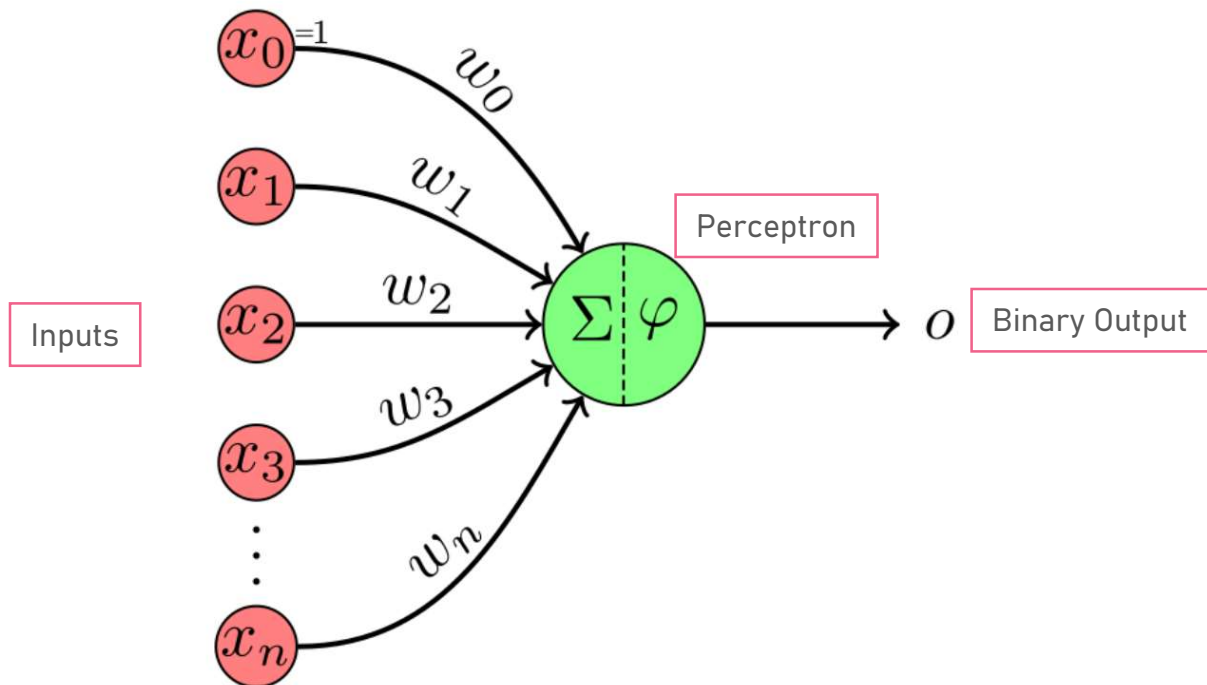
O Binary Output

Figure 1

How it works:

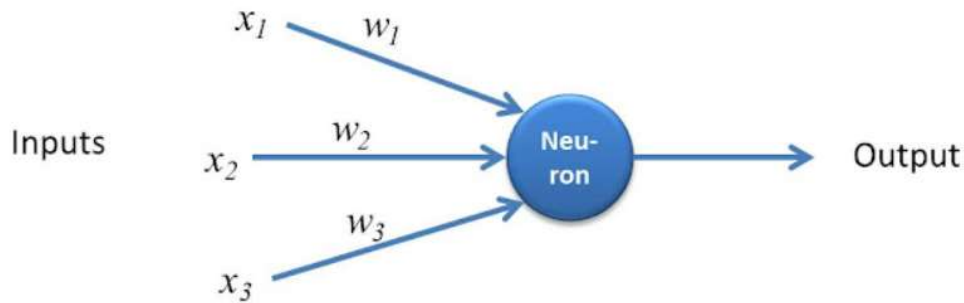Figure 2

How the perceptron works is illustrated in Figure 1. In the example, the perceptron has three inputs x_1, x_2, x_3 and one output. The importance of this inputs is determined by the corresponding weights W_1, W_2, W_3 assigned to this inputs. The output could be 0 or 1 depending on the weighted sum of the inputs. Output is 0 if the sum is below certain threshold or 1 if the output is above certain threshold. This threshold could be a real number and a parameter of the neuron. Since the output of the perceptron could be either 0 or 1, this perceptron is an example of binary classifier.

$$output = \begin{cases} 0 \; if \; \sum_i X_i W_i < threshold \\ 1 \; if \; \sum_i X_i W_i \geq threshold \end{cases}$$

Equation 1

Ok Let's go to code and make a perceptron to classification.

Question: What if when all inputs are zero?
No matter what the weights are, the output is zero. Thus, in perceptron algorithm we add bias to handle this situation. As you can see at Figure 1 $x_0 = 1$ and w_0 is bias.

PERCEPTRON WITH C++

In this exciting homework we want to classify binary data with one perceptron. At first we need to write function to import data from csv(comma-separated values) file and return data as vector of shared pointer of vector. Vectors are sequence containers representing arrays that can change in size and shared_ptr is smart pointer. In the phrase "int * p" p is

raw pointer and you see this pointer before but in this homework, we want to work with smart pointers.

```
1.  std::vector<std::shared_ptr<std::vector<double>>> read_csv(std::string filename)
```

After import data from csv file, Let's move on the next function "predict" which obtain output by weight and input.

$$sum = w_0 + x_1 w_1 + x_2 w_2 + x_3 w_3 + \cdots + x_n w_n$$

Equation 2

```
1.  int predict(std::vector<double> X,std::vector<double> weights)
```

This function calculate sum according to Equation 2 and obtain output of perceptron with Equation 1.

Question: where do weights of perceptron obtained?
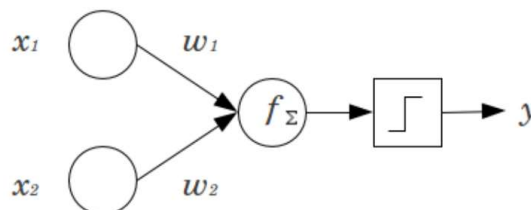
Let's understand this with a simple classification example

Figure 3

Input:

$$x_1 = Height\ of\ person$$

$$x_2 = Weight\ of\ person$$

Output:
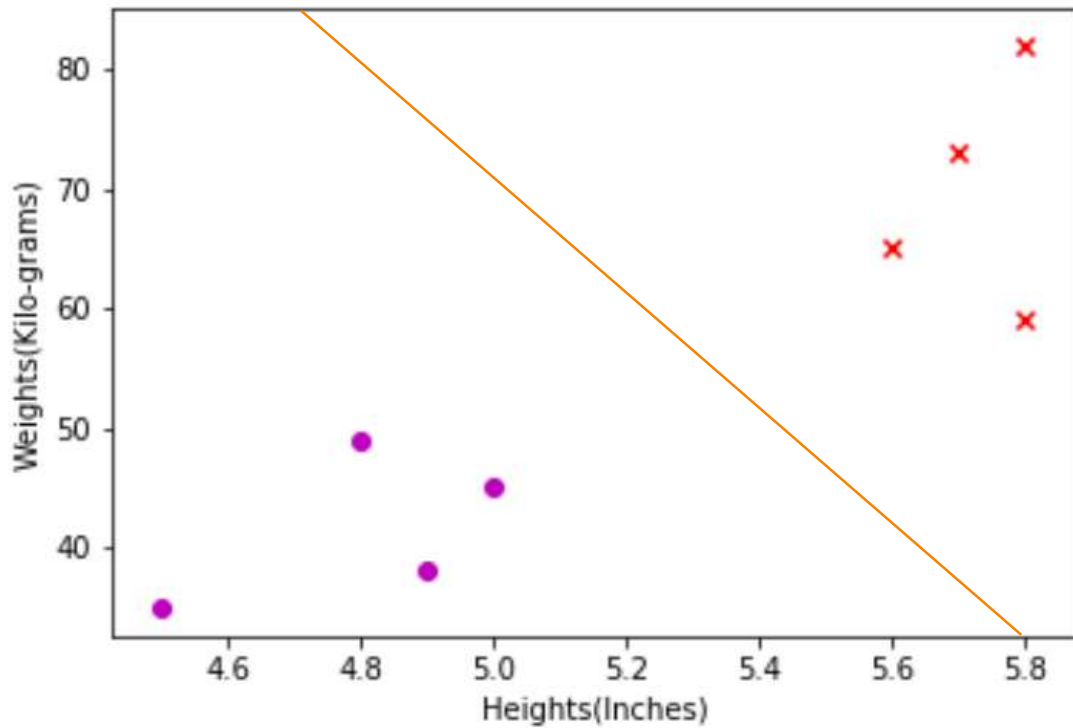
$$y = Gender\ (male\ or\ female)$$

Figure 4

Our motive is to fit a decision boundary (a line) that separates all the male samples from the female samples. We have two inputs; therefore, we need two weights and one bias.

$$sum = w_0 + w_1 x_1 + w_2 x_2$$

Equation 3

Perceptron use an iterative algorithm to train weights and find optimum ones. This algorithm updates each weight with below equation.

$$w_k[i+1] = w_k[i] + learning\_rate * (real\_value - predicted\_value) * x_k$$

Equation 4

For updating w_0 (bias) suppose $x_0 = 1$. Ok for training weights we use function below:

```
1.  std::vector<double> train_weight(std::vector<std::shared_ptr<std::vector<double>>> train,double
    learning_rate,double number_epoch)
```

train is dataset that use for training weights and we suppose that initial value for all weights is zero. Learning rate is constant value 0.1. and "number_epoch" is number of repeating perceptron algorithm. For example, we have weights and heights of 100 women and we use "train_weights" function to use 75 data and update weights. After this operation as many as the number of epochs, repeat this function again. Finally, we have training weights so we can test these with 25 test dataset and score accuracy of this algorithm. Declare function perceptron which get train dataset, test dataset, learning rate and number of epochs to do all the operation describe above.

```
1.  void Perceptron
    (std::vector<std::shared_ptr<std::vector<double>>> train ,
    std::vector<std::shared_ptr<std::vector<double>>> test,   double learning_rate ,
    int number_epochs)
```

output:

`Accuracy: 0.881559`

You must not alter the main.cpp file at all. Just write all your codes in the aphw1.cpp and aphw1.h. Good luck!