# ML Assignment 1: Fischer's LDA


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## 1 Introduction

In this assignment, we implement Fischer's Linear Discriminant, it is used for supervised learning in solving classification problems. Given the data points in $\boldsymbol{M}$ dimensional space, we project all those points to $\boldsymbol{D}$ dimensions and then try to find out a discriminant function to classify our points using a threshold found by calculating the intersection point between the normal distribution followed by the projected points. In this assignment we where given data points in ***3-D*** and we projected it to ***1-D*** and found out the threshold.

## 2 Implementation

After solving the optimisation problem:

$$max \frac{(W^T M_1 - W^T M_2)^2}{s_1^2 + s_2^2}$$

We get

$$W \propto S_W^{-1}(M_1 - M_2) \quad , where$$

$$S_W = \sum_{k=1}^{2} S_k \quad , and$$

$$S_k = \sum_{n \in c_k} (x_n - M_k)(x_n - M_k)^T$$

The threshold can be found by solving the quadratic equation $Ax^2 + Bx + C = 0$, where

$$A = -\frac{1}{\sigma_1^2} + \frac{1}{\sigma_2^2}$$

$$B = 2(\frac{\mu_1}{\sigma_1^2} - \frac{\mu_2}{\sigma_2^2})$$

$$C = \frac{\mu_2^2}{\sigma_2^2} - \frac{\mu_1^2}{\sigma_1^2} + log\left(\frac{\sigma_2^2}{\sigma_1^2}\right)$$

The algorithm can be roughly outlined as:

1. Find the individual means for different classes
2. Find $S_W$
3. Calculate unit vector $W$
4. Project all the points on to the unit vector by taking the dot product $W^T X$
5. Find the Normal distribution fitting the projected points
6. Find the ***threshold*** using the intersection point of the normal distribution.

## 3 Results

Figure 1 shows the original data plot in 3 dimensions along with the decision boundary (in green). All points above the green plane are classified as belonging to *class 1*, while those below the plane are classified as belonging to *class 0*. Figure 2 shows the data points projected to 1-dimension along with normal distributions fit on them and the threshold point. The threshold point in **1-D** is 8.122.
The discriminating plane in original dimensions(**3-D**) is: $0.148x_1 + 0.413x_2 - 22.636x_3 = 8.122$

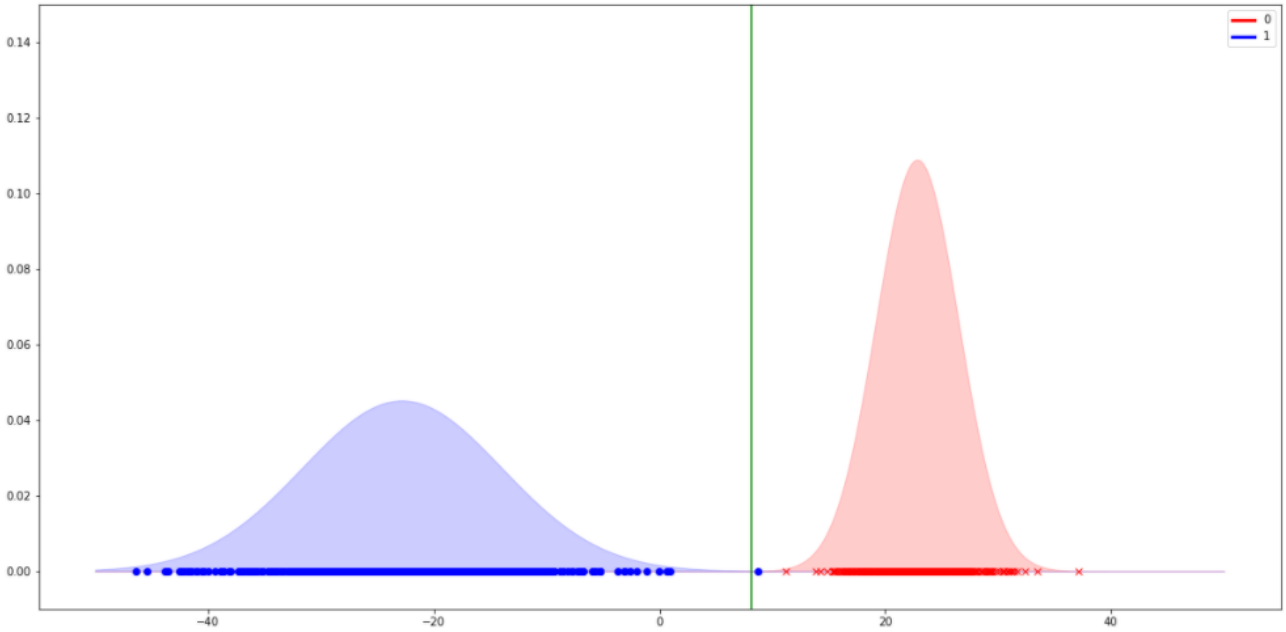


Figure 1: Normal distribution fit to each projected cluster. The green line shows the threshold point