MACHINE LEARNING

BITS F464

ASSIGNMENT 1

Done By:

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Assignment 1A: **Fischer's Linear Discriminant**

Model Description

Fisher Linear Discriminant technique is used to project the Higher Dimensional data to a line which preserves direction useful for data classification.
The three main steps involved are:

1. The first step is to calculate the separability between different classes (between-class variances)
2. The second step is to calculate the distance between the mean and the samples of each class.
3. The third step is to construct the lower dimensional space which minimizes the variance and maximizes the Mean distance between the classes.

Model implementation

- Aim is to maximise $\frac{(M_1 - M_2)^2}{s1^2 + s2^2}$ where M1 and M2 are the data mean in 3D space and $s1^2$ and $s2^2$ are corresponding variances

- Solving the optimisation problem by Legrange multiplier, to find the weights
  - $\omega \propto S_W^{-1}(M_1 - M_2)$

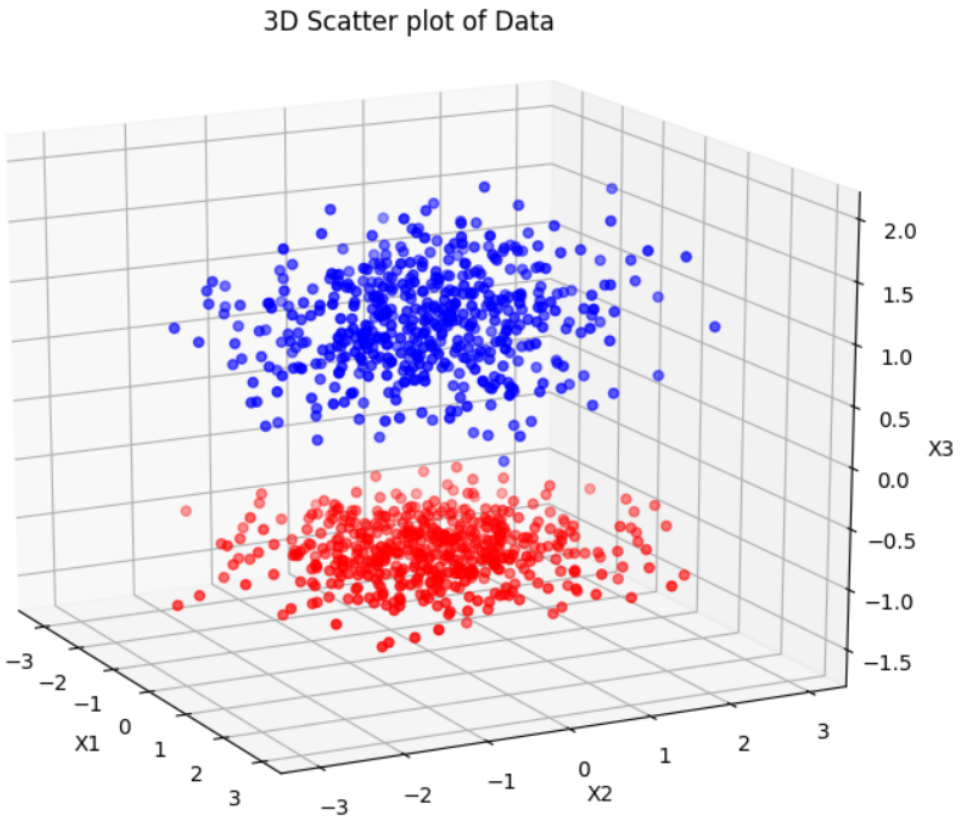
- Project the 3 dimensional points to a single dimension and then visualise their Normal Distribution
  - $N_1(x) = \frac{1}{\sqrt{2\pi\sigma_1^2}} exp\{\frac{-(x-\mu_1)^2}{2\sigma_1^2}\} \; \forall \, x \in C_1$
  - $N_2(x) = \frac{1}{\sqrt{2\pi\sigma_2^2}} exp\{\frac{-(x-\mu_2)^2}{2\sigma_2^2}\} \; \forall \, x \in C_2$

- Finding the intersection of these distributions
  - Solving the Quadratic Equation

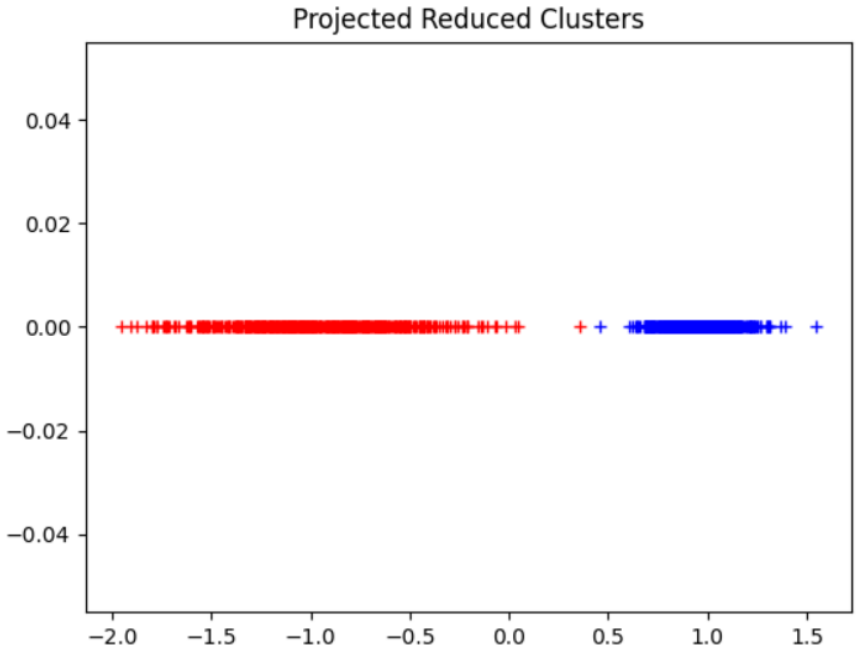
$$(\frac{1}{\sigma_2^2} - \frac{1}{\sigma_1^2})x^2 + 2(\frac{-\mu_2}{\sigma_2^2} + \frac{-\mu_1}{\sigma_1^2})x + (\frac{\mu_2^2}{\sigma_2^2} - \frac{\mu_1^2}{\sigma_1^2} + log_e(\frac{\sigma_2^2}{\sigma_1^2}) = 0$$

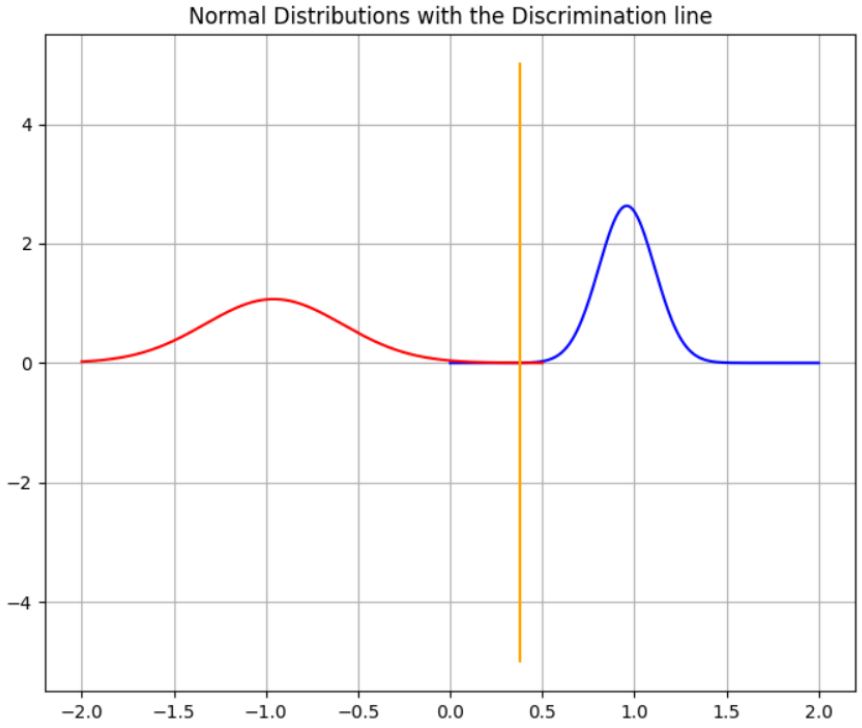
- And hence plotting the Discriminating Hyperplane by projecting this threshold value back High Dimensional Space.
- Estimating the accuracy of Classification

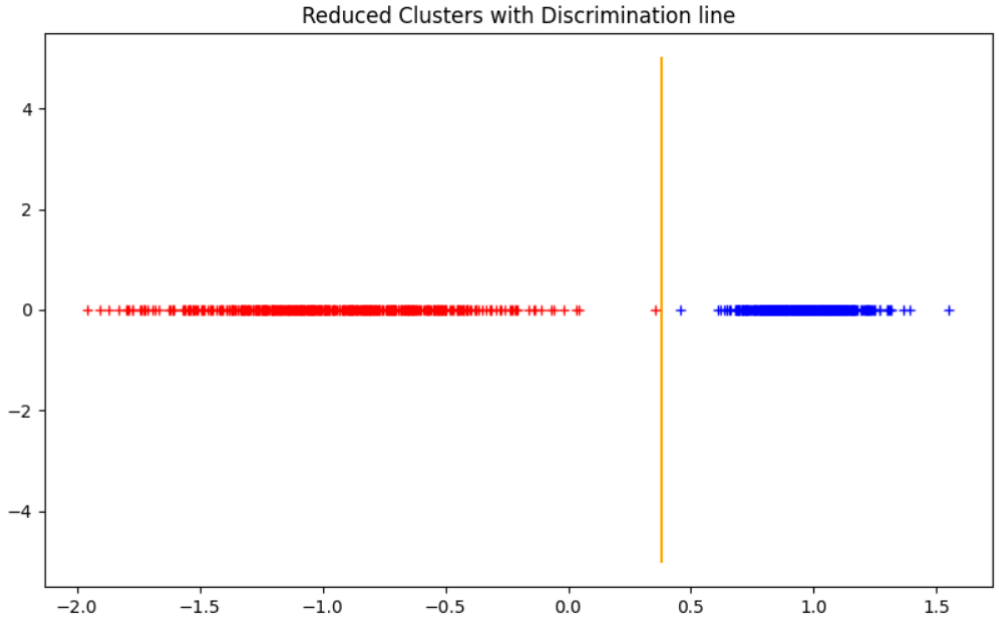
3D Plot of Data



Plot of Reduced Clusters



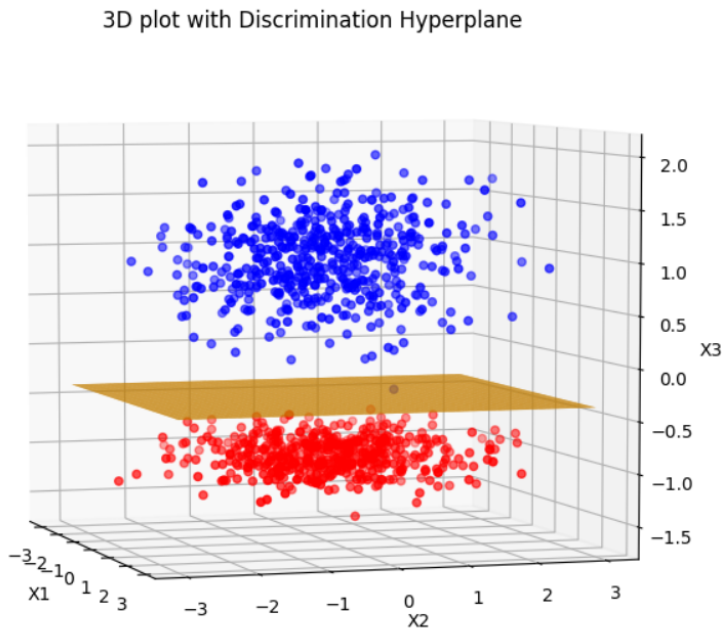


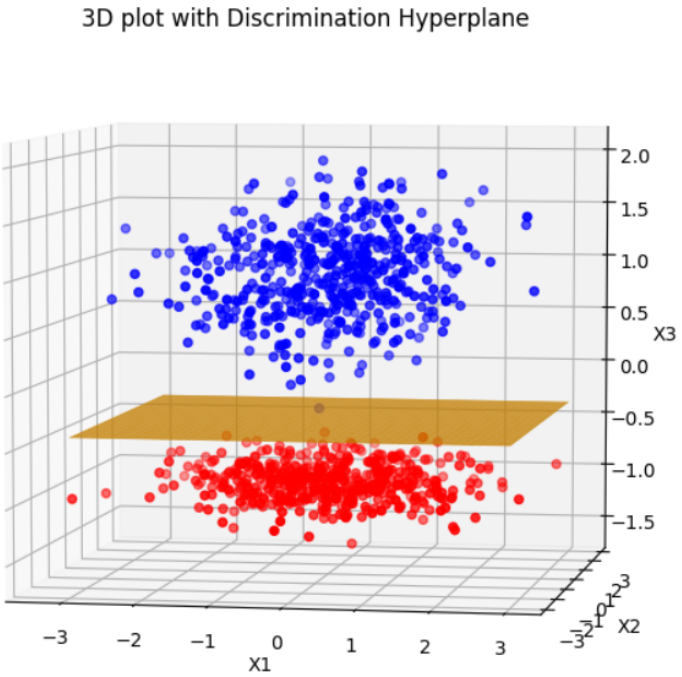


- Unit Vector = $-4.06021104e-04\,x_1 + 1.41373466e-04e-04\,x_2 - 9.99999908\,x_3$
- Threshold value = 0.3784587887994166

- Accuracy = 100 %, since there are no Misclassified points.

Plot of Discriminating Hyperplane





Major Limitations

- LDA technique is very useful for discriminating between different linearly separable classes. However, if the classes are non-linearly separable, LDA cannot find a lower dimensional space.
- For very high dimensional Classification tasks, with low number of training points, the model fails to give a good accuracy.