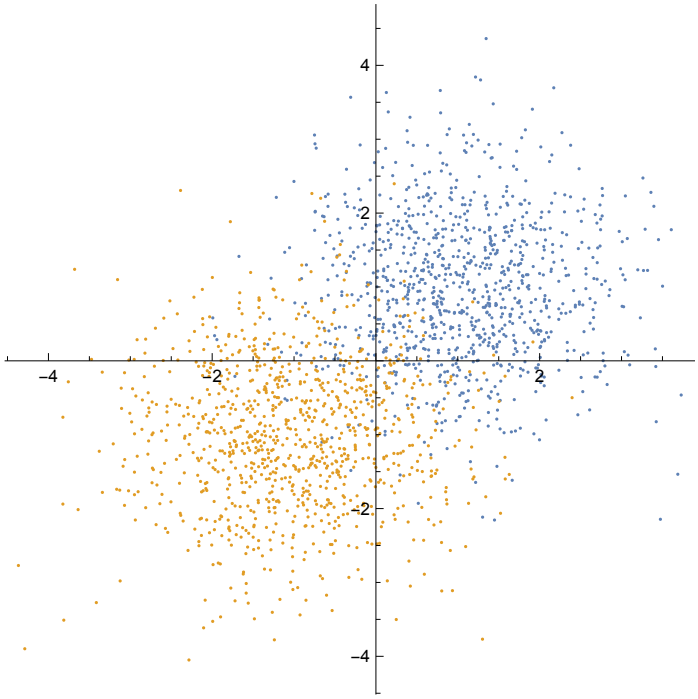
Illustration of linear discriminant analysis

Let's generate data with two features:

```
data = RandomVariate[ProductDistribution[
    NormalDistribution[1, 1], NormalDistribution[1, 1]], 1000];
data2 = RandomVariate[ProductDistribution[NormalDistribution[-1, 1],
    NormalDistribution[-1, 1]], 1000];

ListPlot[{data, data2}, AspectRatio → 1]
```



We want to classify this using linear discriminant analysis

Calculate means and covariance from these data sets:

```
μ0 = Sum[data[[i]], {i, 1, Length[data]}] / Length[data]
μ1 = Sum[data2[[i]], {i, 1, Length[data2]}] / Length[data2]
```

```
{1.03567, 0.97435}
```

```
{-1.03395, -1.03116}
```

Covariance

```
Σ0 = Sum[
    {{(data[[i, 1]] - μ0[[1]])^2, (data[[i, 1]] - μ0[[1]]) (data[[i, 2]] - μ0[[2]])},
     {(data[[i, 1]] - μ0[[1]]) (data[[i, 2]] - μ0[[2]]),
      (data[[i, 2]] - μ0[[2]])^2}}, {i, 1, Length[data]}] / Length[data]
Σ1 = Sum[{{(data2[[i, 1]] - μ1[[1]])^2,
       (data2[[i, 1]] - μ1[[1]]) (data2[[i, 2]] - μ1[[2]])},
     {(data2[[i, 1]] - μ1[[1]]) (data2[[i, 2]] - μ1[[2]]),
      (data2[[i, 2]] - μ1[[2]])^2}}, {i, 1, Length[data2]}] / Length[data2]
```

```
{{0.917495, -0.00543106}, {-0.00543106, 0.974447}}
```

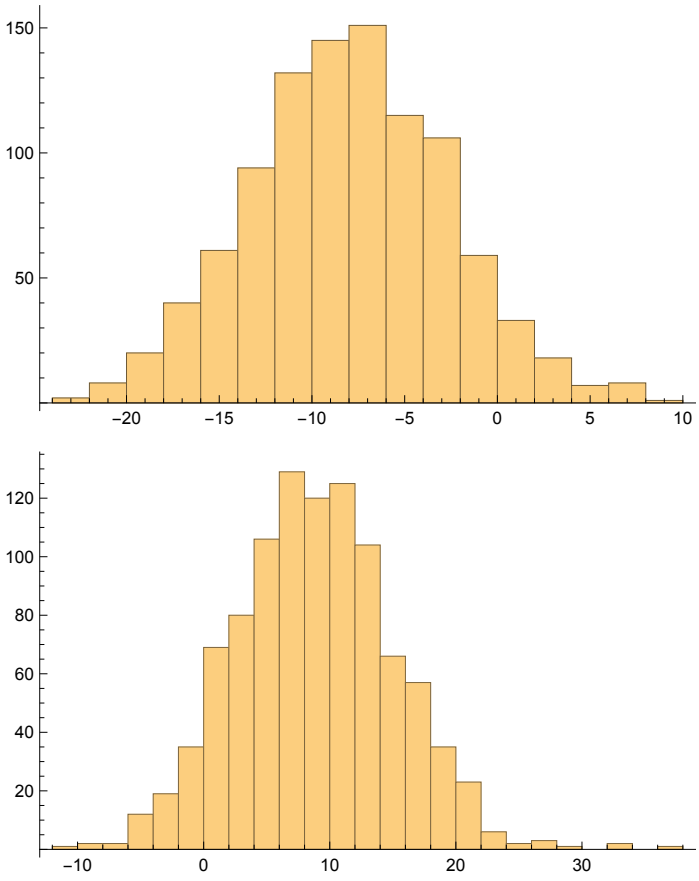
```
{{1.03835, 0.0204218}, {0.0204218, 1.00165}}
```

We can now take a look at establishing the threshold. The LHS is given by:

```
ps[x_] := (x - μ0).Inverse[Σ0].(x - μ0) +
  Log[Det[Σ0]] - ((x - μ1).Inverse[Σ1].(x - μ1) + Log[Det[Σ1]])
```

A histogram for our data set from above looks like:

```
Histogram[Table[ps[data[[i]]], {i, 1, Length[data]}]]
Histogram[Table[ps[data2[[i]]], {i, 1, Length[data]}]]
```



For instance by taking the mean of these data sets we can come up with a threshold.

```
Sum[ps[data[[i]]], {i, 1, Length[data]}] / Length[data]
Sum[ps[data2[[i]]], {i, 1, Length[data2]}] / Length[data2]
(Sum[ps[data[[i]]], {i, 1, Length[data]}] / Length[data] +
   Sum[ps[data2[[i]]], {i, 1, Length[data2]}] / Length[data2]) / 2
```

```
-7.98911
```

```
8.8558
```

```
0.433345
```