MACHINE LEARNING AND PATTERN RECOGNITION REPORT

Fingerprint Spoofing Detection

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Who?
Where?
When?

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Introduction The project task consists of a binary classification problem. The goal is to perform fingerprint spoofing detection, i.e. to identify genuine vs counterfeit fingerprint images. The dataset consists of labeled samples corresponding to the genuine (True, label 1) class and the fake (False, label 0) class. The samples are computed by a feature extractor that summarizes high-level characteristics of a fingerprint image. The data is 6-dimensional.

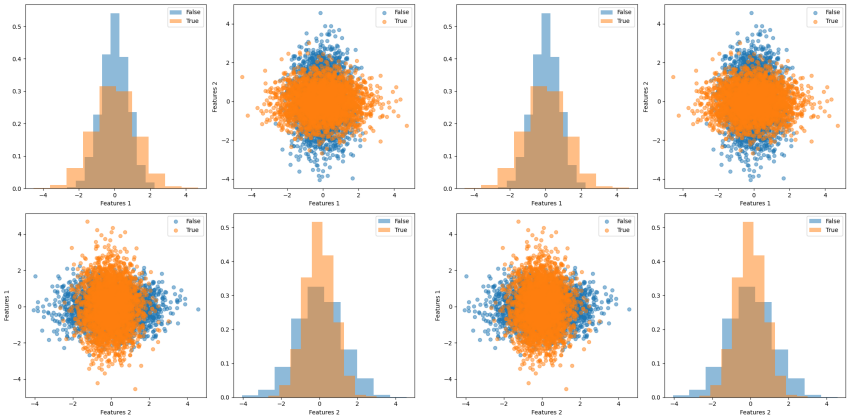
1 Dataset Analysis

In our analysis process, one first begins to represent what are the data related to the various features and how among the various features the data are distributed by making a visual representation in pairs of features.

1. Starting with the analysis of the first two features and creating a histogram and a scatter Figure 1, one can see:

   - Both features overlap
   - Follow a Gaussian distribution
   - Feature 1 has a peak at [-0.213, 0.276] and it is worth 0.541 for the false class, instead for Feature 2 the peak at [-0.402, 0.165] and it is worth 0.516 for the true class.

   Seeing Figure 1 again, it would appear that Figure 1a and Figure 1b appear to be visually the same but in b they are represented centred which as can be seen is quite similar because Feature 1 has $\mu = 0.00170711$ and $\sigma^2 = 1.00134304$, instead Feature 2 has $\mu = 0.00503903$ and $\sigma^2 = 0.9983527$



(a) Without mean (b) With mean

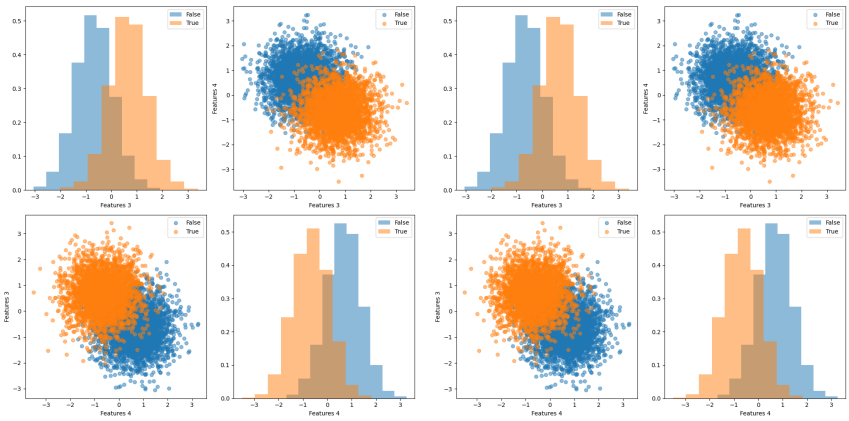
Figure 1: Feature 1 vs Feature 2 - Without centering the data relative to the average (a) and with centering the data relative to the average (b)

2. For features 3 and 4, observed in Figure 2, on the other hand, they have:

   - do not overlap like the previous two
   - Follow a Gaussian distribution but the true and false labels are centred at different points

- Feature 3 has a peak at [-1.063, -0.568] and it is worth 0.517 for the false class, instead for Feature 4 the peak at [0.290, 0.783] and it is worth 0.525 for the false class.

Seeing Figure 2a and Figure 2b, data are already similar because, the mean calculated with reference to the two classes is close to 0, in fact: Feature 3 has $\mu = -0.00560753$ and $\sigma^2 = 1.0024818$, instead Feature 4 has $\mu = 0.00109537$ and $\sigma^2 = 0.99029389$



(a) Without mean (b) With mean

Figure 2: Feature 3 vs Feature 4 - Without centering the data relative to the average (a) and with centering the data relative to the average (b)

3. For features 5 and 6, observed in Figure 3, one can see:

   - Do not totally overlap
   - For both features, the true labels don't follow a Gaussian distribution as opposed to the false ones, which could be more approximate
   - Feature 5 has a peak at [-1.211, -0.783] and it is worth 0.572 for the true class, instead for Feature 6 has a peak at [-1.273, -0.817] and it is worth 0.553 for the true class.

   Also in this other case, Figure 3a and Figure 3b are similar because again the average is close to 0. Feature 5 has $\mu = -0.00700025$ and Feature 6 has $\mu = 0.00910515$

2 Dimensionality Reduction

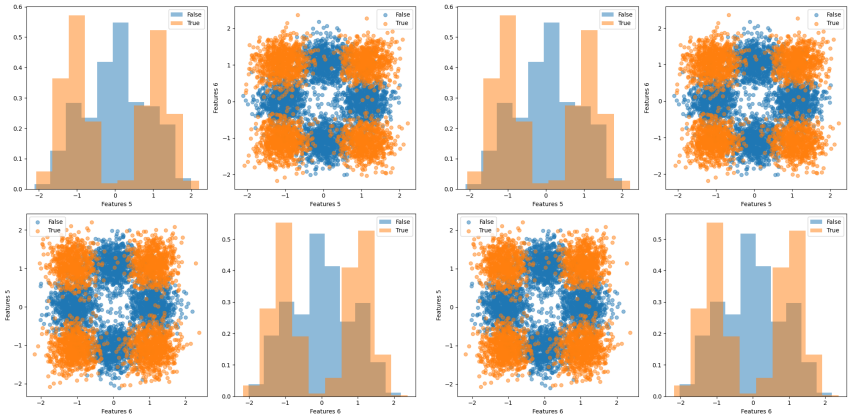
3 Classifaication Models Analysis

3.1 Gaussian Models

3.2 Logistic Regression Classifier

3.3 Support Vector Machine Classifier

3.4 Gaussian Mixture Models Classifier



(a) Without mean (b) With mean

Figure 3: Feature 5 vs Feature 6 - Without centering the data relative to the average (a) and with centering the data relative to the average (b)