. . . , L. The classifier is trained using feature matrices for the reference image, where these reference feature matrices can be represented by $X_k=(x_i^k)$, where k=1, . . . N; i=1, . . . L, and $x_i^k=[x_1^k, x_2^k, \ldots x_p^k]^T$ is a p-dimensional feature vector of the kth sample in the ith sub-region. Once trained on the reference notes, the classifiers for the various segments can be used to validate other banknotes. In particular, the classifiers D_i can be used to determine whether or not each segment of the note is within the defined classification boundary and so acceptable or outside the defined boundary and so rejected.

[0068] When a test sample t is presented, its feature matrix $T=t_i$, where i=1, . . . , L, is extracted. Then, using the ith one-class classifier D_i trained by $\{x_i^1, x_i^2, \ldots x_i^N\}i$, t_i can be tested using the same rule to give the decision $y_i(t)$ whether it is rejected or accepted. As a specific example $y_i(t)$ may be defined as 0 if t_i is rejected by D_i and 1 if t_i is accepted by D_i. There are various ways in which the final decision Y(t) for the test sample t can be calculated. As one example, the product Y(t) of individual decisions $y_i(t)$ can be determined. The test note t is rejected as a forgery if Y(t)=0, or accepted as a genuine note if Y(t)=1. This product combination decision rule described above can be seen to be equivalent to a unanimous vote. This means that a note is only accepted if all selected classifiers indicate that it is genuine, otherwise it would be rejected. Unanimous voting is an extreme situation of commonly used majority voting when requiring all the voters to agree with consensus. Unanimous voting is preferred technique here, because of the higher cost assigned to incorrectly accepting forgeries. Nevertheless, in some circumstances majority voting may be useful.

[0069] To illustrate the differences between unanimous and majority voting techniques, consider the following definitions for the final decision $Y_{MV}(t)$ made by employing a majority vote and the final decision $Y_{UV}(t)$ by a unanimous vote for a note under test t:

$$Y_{MV}(t) = INT\left[\frac{\sum_{i=1}^{L} y_i(t)}{INT(L/2)+1}\right]$$

$$Y_{UV}(t)=\Pi_{i=1}^{L} y_i$$

[0070] Here, INT(·) means rounding down the element to its nearest integer, and both $Y_{MV}(t)$ and $Y_{UV}(t)$ can only have the value of either 1 or 0. The expression for $Y_{UV}(t)$ can be re-written as:

$$Y_{UV}(t) = INT\left[\frac{\sum_{i=1}^{L} y_i(t)}{L}\right]$$

[0071] Given N_f counterfeit samples $\{t_f^{k1}\}$, where k_1=1, . . . N_f, and N_G genuine samples to test $\{t_g^{k2}\}$, where k_2=1, . . . , N_g, the False Negative (FN: false acceptance rate of forgeries) and False Positive (FP: false rejection rate of genuine notes) can be calculated by

$$FN = \frac{\sum_{k_1=1}^{N_f} Y(t_f^{k_1})}{N_f}$$

$$FP = \frac{N_g - \sum_{k_2=1}^{N_g} Y(t_g^{k_2})}{N_g}$$

[0072] where Y( ) can be either $Y_{UV}(t)$ or $Y_{MV}(t)$. As can be shown from the above equations, the unanimous vote approach achieves lower FN than the majority vote. However, at the same time the unanimous vote also produces higher FP than majority voting. This is because majority voting looks at the average information rather than the individual characteristics. Therefore, for testing genuine notes, as their features are relatively uniform within the reference samples in all sub-regions, majority voting can potentially achieve better results. In contrast, for identifying counterfeits, a unanimous vote may be more appropriate. This is because very high quality counterfeits have similar feature distributions as genuine notes in a number of sub-regions and differences exist in a few specific sub-regions where the genuine features might be too complex to be completely duplicated by the counterfeiting process. By taking account of the average information, majority voting may give the final decision according to most of the sub-regions that might give an incorrect judgment for counterfeits. Hence, for identifying counterfeits unanimous voting may be preferred.

[0073] Whilst the unanimous vote based technique does not have the problem of giving wrong decisions towards counterfeits, it does however suffer from falsely rejecting, for example, poor quality genuine notes due to the worn nature of the note in some sub-regions. Hence, as with all statistical tests, there is a trade-off between FN and FP. In this particular application, FN is more important than FP. The proposed log-likelihood ratio tests described previously allow the expected FP level of individual classifiers to be specified by setting the significance levels of each test. Therefore, the extreme unanimous vote is preferred to balance the overall FN and FP performance. As an example, by segmenting a whole note into 3 by 3 equal sized regions and combining all 9 classifiers, in testing 1000 genuine notes and 1000 forgeries, majority voting achieved FN=23.9% and FP=0.50%; while unanimous voting achieved values of FN=2.30% and FP=8.20%.

[0074] When applying the unanimous vote combination rule, selecting appropriate classifiers to be combined is important. Not all the classifiers built on sub-regions have to be combined and indeed doing so may reduce the robustness of the whole classification system as mentioned above. This is because some of the segments of the note may be more difficult to copy than others and so may be more likely to provide evidence of a counterfeit. Hence, to make the classification process more accurate, there is provided an optimization technique for identifying the ideal number of