

PATTERN RECOGNITION

The present invention relates to verification apparatus for the recognition of a person, where a recognition decision is required based on results from two
5 or more different sources. One application of the invention (merely by way of example) is the verification of the identity of a person by a system controlling access to a service or premises, and more than one test is applied for this purpose. Typical tests might be, for example,
10 face recognition, fingerprint recognition, or voice recognition (speaker verification): these techniques are often called biometric tests.

In such a test, the normal procedure is that a user inputs an identity number or other indication of his
15 claimed identity. Data derived from the relevant characteristic of the use is compared with stored data (a template) derived from a training session with that user at the time of entry of his details on the system. The result (or "score") of the comparison is then compared with a
20 threshold to give a pass/fail for the test.

In general, because of factors such as physical or temporal misalignment, or the influence of ambient factors such as noise or light, the data derived from the characteristic of the user almost never matches the stored
25 template perfectly, and each time the user's identity is tested the degree of match is likely to be slightly different. The threshold is therefore selected to pass the genuine user with a reasonable degree of certainty and reject others with a reasonable degree of certainty.

30 Where (for example) two tests are used, the question arises as to how to combine the results. An obvious option is to deem the identity verified if both tests are passed. The results of this may be unacceptable, however.

Consider the following example.

Suppose that reliability of the first test is such that it accepts 1 imposter in 1000 while rejecting 1 genuine candidate in 1000. Suppose also that the second accepts 1 imposter in 100 and rejects 1 genuine candidate in 100.

If these two results are combined as they stand the imposter acceptance rate will be 1 in 1000 x 100 - i.e. 1 in 100,000. But the genuine candidate rejection rate goes up to: -

$$1 - \frac{999}{1000} \times \frac{99}{100} = 0.011 \text{ i.e. 11 in 1000}$$

which is far worse than the first test taken above. If a threshold for the second test is reset so that its imposter acceptance rate is 1 in 1000, its genuine candidate rejection rate might typically go up to 1 in 10 giving a combined imposter acceptance rate of 1 in 10,000 while 2 in 1000 of the genuine candidates are rejected. This is only a modest improvement on the first test taken alone. Also if both thresholds are altered so that 1 in 1000 of the genuine candidates are rejected as before, the combined imposter acceptance rate would typically go up to 4 in 10,000 which is little improvement on the one test on its own.

According to the present invention there is provided a verification apparatus comprising:

(i) means for input of information as to an alleged identity of a person;

(ii) at least two recognition means to compare attributes of a person with stored templates relating to the person having the alleged identity to produce scores indicative of their similarity or otherwise; and

1 (iii) means for forming a weighted sum of the scores.

Other aspects of the invention are as defined in the accompanying claims.

5 One embodiment of the invention will now be described with reference to the accompanying drawing, which is a block diagram of one form of verification apparatus according to the invention.

10 An input device 1 such as a keyboard or card reader receives an input indicating the claimed identity of a user and produces an output in the form of a template store address.

15 Sensing devices, viz a microphone 2, a fingerprint reader 3 and a camera 4 (to form an image of the user's face) feed respective recognition units - a voice recogniser 5, a fingerprint recogniser 6 and image recogniser 7. Each of these latter devices is supplied with templates in the form of stored data from a template store 8 representing characteristics of the voice, fingerprints and face of the user identified by the
20 template store address from the input device 1 (though, in practice, the template might well be stored in the individual recogniser units 5, 6, 7).

25 Each recogniser 5, 6, 7 is of conventional construction, except that it does not perform a thresholding operation to produce a pass/fail output, but provides an output in the form of a score S_1 , S_2 , S_3 representing the square of the Euclidean distance in the pattern space between the unknown pattern and the
30 template. These scores are weighted by respective weighting factors in units 9, 10, 11, and the products summed in an adder 12. The sum is compared by a comparator 13 with a threshold value to produce a pass/fail output 14.

1 Each weighting unit (9, 10, 11) multiplies the score
 S_i ($i = 1, 2, 3$) by a weighting factor. The weighting
 factor for each score S_i employs a weighting factor
 derived in dependence upon the respective template
5 concerned. The weighting factor is preferably related to
 the variability of the scores produced under ideal
 circumstances (ie. with a user known to be genuine), such
 that a template producing very variable scores is scaled
 down by a relatively small weighting factor. The variance
10 (in the normal statistical sense) is preferably the
 measure of the variability. Preferably the weighting
 factor is of the form:

$$W_i = \frac{\bar{S}_i}{V_i}$$

 where $\bar{S}_i$ and V_i are respectively the mean and the
 variance of score S_i . $\bar{S}_i$ and V_i will have been
15 determined for each template during a training session in
 which the data from the genuine user for that template are
 repeatedly derived and compared with that template. The
 value of W_i could then be stored with the template S_i
 for each user, or a mean value of W_i could be derived
20 over a number of users.

 In general a number of pattern recognition results
 S_i can be combined according to the expression

$$S = \sum_i S_i \frac{\bar{S}_i}{V_i}$$

1 The training sequence may be carried out using an apparatus such as shown in the drawing, with a suitably programmed computer to calculate the $\bar{S}_i$, V_i , values.

5 For a two-recogniser system of this type, with the reliabilities quoted in the introduction (and assuming that the two patterns have 10 dimensional multivariate Gaussian distributions) the combined impostor acceptance rate now obtained may be shown to be only 0.0000094 with a genuine candidate reject rate of 0.001.



CLAIMS

1. A verification apparatus comprising:
 - (i) means for input of information as to an alleged
5 identity of a person;
 - (ii) at least two recognition means to compare
attributes of a person with stored templates relating to
the person having the alleged identity to produce scores
indicative of their similarity or otherwise; and
10 (iii) means for forming a weighted sum of the scores.
2. An apparatus according to claim 1 in which each of
scores is an increasing monotonic function of a distance in
the relevant pattern space between the input information
and the template.
- 15 3. An apparatus according to claim 2 in which each score
represents the square of the Euclidean distance in the
relevant pattern space.
4. An apparatus according to claim 1 or claim 2 in which,
in forming the weighted sum, each score is multiplied by a
20 weighting factor which is inversely related to the
variability of scores obtained during a training sequence.
5. An apparatus according to claim 4, in which the
weighting factor is equal to the ratio of the mean to the
variance of scores obtained during a training sequence.
- 25 6. An apparatus according to any preceding claim in which
one of the attributes is the person's voice.
7. An apparatus according to any preceding claim in which
one of the attributes is the person's face.
8. An apparatus according to any preceding claim in which
30 one of the attributes is the person's fingerprint.



- 7 -

9. Apparatus substantially as herein described with reference to the accompanying drawings.
