A Chamfer Matching Algorithm for Human Profile Recognition *

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The Chamfer matching technique searches for the best match between two binary images. Geometric transformations are used to distort one image (referred as the *candidate image*) to another (the *reference image*) in order to minimize a given distance measure between them. These binary images are often derived from the image edges. Here, we make use of the shape of the profile only. Profile authentication can be seen as an easy way to recognize human faces. Although we cannot expect as much identification potential from the profile shape as from other techniques (e.g. fingerprint, speech or facial analyses), profile recognition can be useful in the framework of a multi-modal person identification as described in [1].

The Chamfer Matching Algorithm

The first step of the algorithm is to generate a *distance map* from the reference profile. This map associates with each pixel of the reference picture, its distance from the closest profile pixel. As the true Euclidian distance is costly to compute, we make use of a *sequential Chamfer distance approximation* [2]. By superposing the candidate image on this distance map and by summing up all distances found along the candidate profile, we get an estimate of the global distance that stands between them.

Actually, we cannot directly compare the reference and the candidate profiles together. The candidate profile has first to be compensated from the possible geometric transformations that can affect a face from one shot to the other, i.e. translations along x and y axes, scaling factor and rotation in the x/y plane. Given a set of values for these parameters, we then build a *compensated profile* from the candidate profile. This compensated profile is superposed on the reference distance map and a new global distance is computed. The best match between the candidate and the reference profiles is obtained by finding the set of parameters that minimizes this global distance. In other words, it reverts to minimize a compensation function which in our case depends on the translation, scale and rotation variables. This can can be done through any classic multidimensional minimization. Here we make use of a *Downhill simplex algorithm* [3].

The global matching process is illustrated in figure 1. First, the candidate profile is projected onto the reference distance map and a global distance is computed. By minimizing this distance, the optimum compensation parameters are found. Then, the residual distance between the best compensated and the reference profiles is used to decide whether the two profiles belong to the same person or not.

Attention must be paid to the equations describing the geometric transformations between one profile and the other. In particular, we have to avoid as much as possible the influence of one parameter to the other(s). For example, by compensating the profile for rotation, we might have chosen a rotation center – usually the (0;0) coordinate – that is far from profile center of mass. On a theoretical viewpoint, it does not matter since every rigid transformation can be described by a rotation followed by a translation whatever the center that has been set for the rotation. In practice, chosing a rotation center that is far from the center of mass of the object to be rotated, induces an additional (and ofter large) translation of the object that has to be compensated for. In such a case, the minimization algorithm encounters some problems when being close to the minimum but still searching for the best rotation parameter (same problem for the scale factor). Changing the rotation value will shift the profile and introduce an additional translation : then the translation vector previously found to be correct is not valid anymore. We can solve this

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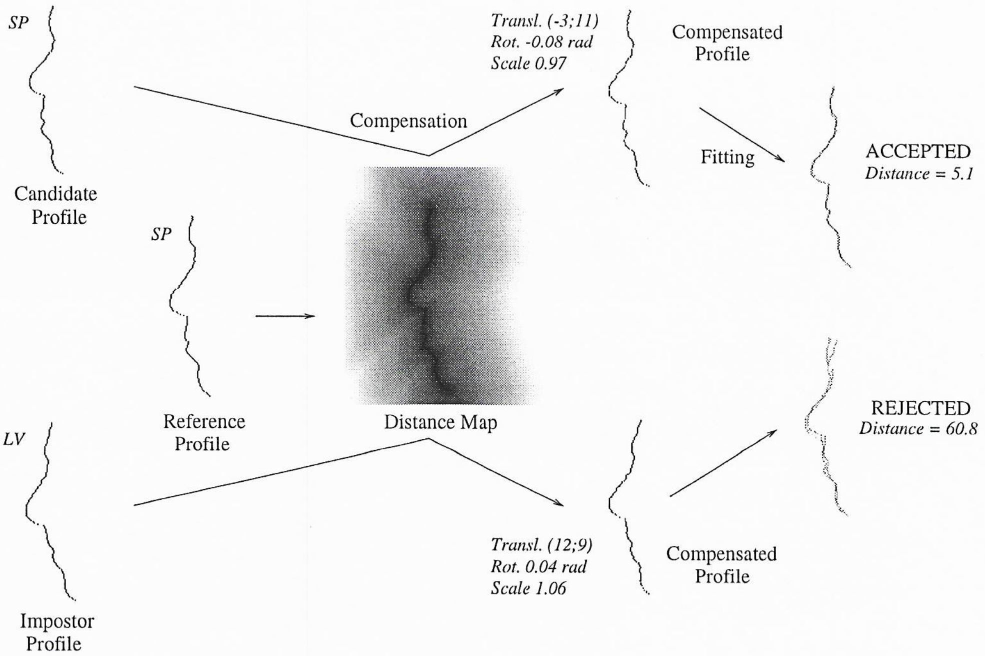

Figure 1: *The Chamfer Matching Process*

problem by properly centering the rotation and the scaling around the center of mass of the profile.

Profile Authentication Results

Four different shots taken from the M2VTS Multimodal Face database (37 faces / 5 shots) are used to perform our tests [4]. Profiles from shots 1/2/3 are used as a reference while shot 4 provides the candidate profiles. Authentication results are computed by matching each candidate profile with all the references of the same subject. The lowest score (i.e. the lowest Chamfer distance) is kept as the final score. If the final score is below a given threshold, the matching is accepted, rejected otherwise. Once the false rejection rate is computed, the candidate profiles are then matched with the references of other subjects in order to compute the false acceptance rate. As final results, we get an *equal error rate* (i.e. when the threshold is such as the false acceptance rate is equal to the false rejection rate) of 5.5% when we are able to deal with full profiles, 10.5% when only partial profiles can be used (e.g. due to the presence of facial or long hair). For a given false acceptance rate of 1%, recognition rates are 83% for full profiles and 64% for partial profiles.

References

[1] M. Acheroy, C. Beumier, J. Bigün, G. Chollet, B. Duc, S. Fischer, D. Genoud, P. Lockwood, G. Maitre, S. Pigeon, I. Pitas, K. Sobottka and L. Vandendorpe. "Multi-Modal Person Verification Tools using Speech and Images". In *Proceedings of the European Conference on Multimedia Applications, Services and Techniques (ECMAST '96)*, pp. 747-761, Louvain-La-Neuve, May 28-30 1996.

[2] Gunilla Borgefors, "Hierarchical Chamfer Matching : A Parametric Edge Matching Algorithm", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, pp. 849-865, Vol. 10, No. 6, November 1988.

[3] W. H. Press, S. A. Teukolsky and W. T. Vertterling, *Numerical Recipes in C : The Art of Scientific Computing*, Cambridge University Press, 1988.

[4] The M2VTS Database (Release 1.00) : see <http://www.tele.ucl.ac.be/M2VTS/>