Proximity Relations in a Polar Frequency Face representation

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Abstract. We assessed the representation space created by a Fourier-Bessel transformation (FBT) of face images that varied in view angle, translation, rotation, and scale. Multidimensional scaling analysis, detection and recognition tests were explored to assess the conservation of real-world proximity relations. View angle variation was well represented by FBT raw coefficients, but not their moduli. Translation, rotation, and scale variations were represented in a way that partially conserved the proximity relations. These properties corroborate our representation approach.

1. Introduction

Image analysis in polar coordinates gained importance after indications of polar analysis capabilities of the human visual system [1]. However, the analysis of the polar frequency content of images was never applied in the vision or face recognition fields.

2. Methods

All tests were performed using face images from 200 subjects that varied by view angle, translation, rotation, and scaling. Images were represented in the polar frequency domain by applying a 2D Fourier-Bessel transform (FBT). The FBT representation was evaluated by graphical visualization of the distance between the different images with the multidimensional scaling (MDS) technique, as well as by recognition and detection tests.

3. Results

Figure 1 shows an MDS analysis example of the FBT raw coefficients representation of different view angle images from 3 subjects. It can be noted that the images of each subject are clustered together and that the clusters of different subjects are not mixed up. This result indicates that similarity aspects that existed in the original images were preserved. View angle representation was less well represented by the FBT modulus.

Rotated images from different subjects formed circular clusters in the FBT raw coefficients space, but the clusters were very close to each other. This is not desirable, since images that are "far" from each other (like –40 and 40° images) are located closer than images that are more "similar" (like –40 and -10° images). Moreover, images from different subjects are located very close to each other, thus affecting face recognition. With modulus features, images from the same subjects were localized at the same coordinates, while keeping high distance between images of different subjects.

Scale variation was translated to variation in image representation in the FBT raw and modulus space in such a way that images of the same subjects were ordered according to the degree of scale variation, indicating conservation of the original image proximities relations.

For all variation types, the recognition and detection tests confirmed the observations made based on the MDS analysis.

Figure 1 MDS analysis of raw FBT coefficients of different view angle images from 3 subjects. The spatial distribution represents the distance between the FBT representations of each face image.

4. Conclusions

We showed that the properties of polar frequency representation space can be explored for view angle detection, and suggest that other variables, like translation, rotation, and scale, can also be detected. The FBT is useful for face recognition, being rotation invariant.

5. References

[1] J.L. Gallant, J. Braun, and D.C. VanEssen, "Selectivity for polar, hyperbolic, and Cartesian gratings in macaque visual cortex", *Science* 259 (1993), 100-103.