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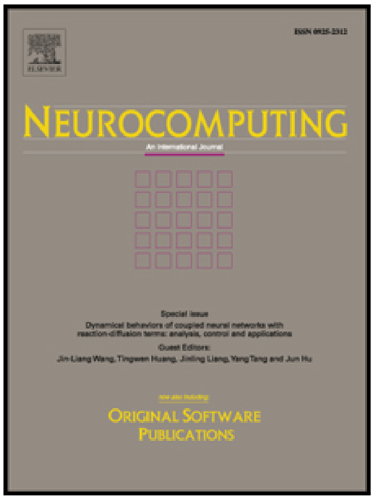

Expression-Invariant Face Recognition using a Biological Disparity Energy Model

Jaime A. Martins, R.L. Lam, J.M.F. Rodrigues, J.M.H. du Buf

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Expression-Invariant Face Recognition using a Biological Disparity Energy Model

Jaime A. Martins[a], R. L. Lam[a], J. M. F. Rodrigues[a], J. M. H. du Buf[a]

[a]*Vision Laboratory, FCT & ISE, LARSyS, University of the Algarve, Portugal*

Abstract

Biologically–compatible methods are not commonly used for face recognition. Complex computational approaches are preferred and dominate the state of the art. However, we know that the human brain is very efficient at processing faces, without explicitly depending on advanced mathematics. In this paper we focus on evaluating the performance of an expression-invariant face recognition system, which is based on the most widely-accepted biological model of stereo vision: the Disparity Energy Model (DEM), which has been shown to deliver precise but inaccurate results. We show that the DEM can provide 3D disparity maps which are suitable for both identity recognition and verification, even coping with a wide range of facial expressions. We test disparity information, both alone and in combination with luminance data, achieving state-of-the-art results. We also compare DEM results with those obtained by precise and accurate laser range maps, concluding that the differences in performance are very small.

Keywords: Stereo vision, visual cortex, disparity-energy model, population coding, face recognition, verification, neural network, LDA, PCA.

1. Introduction

Human faces are among our most important visual stimuli, as they are paramount to socialization. Extensive neuropsychological research has shown that we can obtain a host of information from faces: gender, age, race, emotional state, intention, direction of gaze and even physical health [4]. Neural systems involved in face recognition become active very early in life. In infancy, faces provide non-verbal information which is essential for communication and survival [20]. During the first six months, infants quickly develop the capacity for detecting and recognizing faces. Newborns already show a visual preference for faces and the capacity of prototyping them very rapidly [11, 52]. At about four months, infants are able to discriminate upright faces from upside-down ones, and at six months they show different brain potentials in case of familiar *vs.* unfamiliar faces [9, 15]. Hence, faces provide the most important biometric cues [21].

In computer vision, face processing consists of two tasks: (1) detecting faces in all types of scenes, and (2) recognizing the persons associated with the detected faces. Significant problems are involved in both tasks, ranging from partial occlusions [37, 39] to dealing with different facial expressions, even extreme ones. These are huge hurdles for face recognition technology [17, 27]. Therefore, a robust face recognition system should employ techniques which give reliable results, regardless of any differences in acquired images. Most state-of-the-art face recognition methods rely heavily on image processing techniques which are normally not related to models of cortical processing [54, 32, 33, 56, 55]. However, Siagian and Itti [43] proposed a biologically inspired face *detection* model based on saliency, gist and gaze data, to sequentially detect image regions containing faces. For general surveys on face recognition approaches we refer to Abate et al. [1] and Li and Jain [26].

One of the more difficult problems of face recognition is to deal with facial expressions, where 3D structural information can help immensely. In addition, 3D face recognition is attracting more research effort as 3D data is less affected by pose, illumination, scaling and even person aging [42]. Disparity information from stereo is mainly used for face *detection*, since it has several advantages for that. In case of *recognition*, several studies

Email addresses: jamartins@ualg.pt (Jaime A. Martins), rlam@ualg.pt (R. L. Lam), jrodrig@ualg.pt (J. M. F. Rodrigues), dubuf@ualg.pt (J. M. H. du Buf)