Chapter 4
Face and Object Recognition Using Biological Features and Few Views

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ABSTRACT

In recent years, a large number of impressive face and object recognition algorithms have surfaced, both computational and biologically inspired. Only a few of these can detect face and object views. Empirical studies concerning face and object recognition suggest that faces and objects may be stored in our memory by a few canonical representations. In cortical area VI exist double-opponent colour blobs, also simple, complex, and end-stopped cells that provide input for a multiscale line and edge representation, keypoints for dynamic feature routing, and saliency maps for Focus-of-Attention. All these combined allow us to segregate faces. Events of different facial views are stored in memory and combined in order to identify the view and recognise a face, including its expression. The authors show that with five 2D views and their cortical representations it is possible to determine the left-right and frontal-lateral-profile views, achieving view-invariant recognition. They also show that the same principle with eight views can be applied to 3D object recognition when they are mainly rotated about the vertical axis. Although object recognition is here explored as a special case of face recognition, it should be stressed that faces and general objects are processed in different ways in the cortex.

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INTRODUCTION

One of the most important topics of image analysis is face detection and recognition. There are several reasons for this, such as the wide range of commercial vigilance and law-enforcement applications. Face recognition is also one of the most prominent capabilities of our visual system. A person’s gender, ethnicity, age and emotions contribute to the recognition process. For instance, in court, a lot of credibility is attributed to identifications by eyewitnesses, although studies have shown that people are not always reliable when comparing faces with recollections (Smeets et al., 2010).

State-of-the-art recognition systems have reached a certain level of maturity, but their accuracy is still limited when imposed conditions are not perfect. View-invariant object recognition is still problematic (Pinto et al., 2010). For faces, all possible combinations of changes in illumination, pose and age, with artefacts like beards, moustaches and glasses, including different facial expressions and partial occlusions, may cause problems. The robustness of commercial systems is still far away from that of the human visual system, especially when dealing with different views. For this reason, despite the fact that the human visual system may not be 100% accurate, the development of models of visual perception and their application to real-world problems is important and, eventually, may lead to a significant breakthrough.

In this chapter we present a cortical model to recognise 3D faces from their 2D projections (Rodrigues et al., 2012a), by exploiting the aspect ratios but without using stereo disparity. We consider all common degrees of rotation like pan (from frontal to lateral and profile views) and tilt (the face looking up or down). We study the number of 2D feature templates required to represent all views. In the recognition process we first detect the view and then match the input face with view-based templates stored in memory. We also test the same model to elongated 3D objects, i.e., 4-legged animals, because their shape and view can also be inferred from the aspect ratio if they are rotated about the vertical axis (pan).

The rest of this chapter is organised as follows: we first present the state-of-the-art in 3D face and object recognition. Then we discuss the cortical background of the model, before explaining the frameworks for 3D faces and 3D objects. Recognition results are presented and discussed in the next section, and we end this chapter with conclusions.

RECENT 3D FACE AND OBJECT RECOGNITION METHODS

Because of the limitations of 2D approaches and with the advent of 3D scanners, face-recognition research has expanded from 2D to 3D with a concurrent improvement in performance. There are many face-recognition methods in 2D and 3D, including facial expression recognition; for detailed surveys see Bowyer et al. (2006), Abate et al. (2007), Li & Jain (2011) and Sandbach et al. (2012). Rashad et al. (2009) presented a face-recognition system that overcomes the problem of changes in facial expressions in 3D range images by using a local variation detection and restoration method based on 2D principal component analysis. Ramirez-Valdez & Hasimoto-Beltran (2009) also considered facial expression in recognition. A 3D range image is modelled by the finite-element method with three simplified layers representing the skin, fatty tissue and the cranium. Muscular structures are superimposed in the 3D model for the synthesis of expressions. Their approach consists of three main steps: a denoising algorithm, which removes long peaks in the 3D face samples; automatic detection of control points, to detect particular landmarks such as eyes and mouth corners, nose tip, etc.; and registration of the 3D face model to each face with neutral expression in the training database. Berretti et al. (2010) took into account 3D geometrical information and encoded the relevant information