Epilogue: Face interpretation

Initially this thesis was to be a theory of face recognition and interpretation. Unsatisfied with extant theories of face perception which relied on isolated features, such as hair or eye color, or which mentioned but never really explored canfigural properties, I decided that I would try to develop a theory of face perception which focussed on the shapes of the surface of the face. I speculated that, given an appropriate representational scheme, the shape of a face might yield such secrets as the age, sex, race, emotions, and identity of the individual. A quick literature search would reveal a representation of shape that, with little remodelling, would be appropriate for faces.

I still think the shapes of faces can be made to betray interesting secrets. I don't think there is a representation of shape in the literature which is suited for the task. Using generalized cylinders to represent faces, for example, is comparable to forcing square pegs into round holes. Consequently, this thesis represents some haltering steps in the direction of a representation with pretenses of being appropriate for the shapes of faces. A rigorous test of the segmentation rules proposed here will come when they are applied to real depth maps of more complex natural surfaces, such as faces. Issues like scale, quantization, and noise will come to the fore and will have to be dealt with in a principled manner.

But suppose that an elaborated version of the schemes presented here, or some other scheme, turns out to be appropriate for representing the surfaces of faces. How can properties like age, race, sex, and mood be inferred from the shape of the face?

Once again the role of natural constraints in explanatory theories of visual inferences cannot be overemphasized. In the case of faces many of the constraints will ultimately have their source in genetics. For example, systematic differences in faces due to sex and race must at root be genetic. On the other hand, systematic differences in faces due to age likely have genetic and environmental components.

Whatever the underlying source of the constraints, I suggest that they are all expressed at one or more of three basic levels of face structure: (1) the *deep structure,* which includes the bones and cartilage of the face, (2) the *middle structure,* which includes the muscle and fat of the face, and (3) the *surface structure,* which includes the skin and facial hair.

A concrete example is helpful: the deep structure of the face differs systematically between the two sexes. According to Gray's anatomy, the female skull has thinner walls, less strongly marked muscular ridges, less prominent glabella and superciliary arches, smaller air sinuses, a sharper upper margin of the orbit, a more vertical forehead, more prominent frontal and parietal eminences, a more flattened cranial vault, a more rounded contour to the face, smoother facial bones, a smaller maxilla and mandible, and smaller

teeth. Not all of these differences in deep structure between the sexes are reflected in the surface structure of the face, but those that are can often be exploited to determine the sex of the individual, thereby cutting the the search space for recognition in half. Gray, however, makes the following disclaimer about these skull differences (p. 151), “A well marked male or female skull can be easily recognized as such, but in some cases the respective characteristics are so indistinct that the determination of the sex may be difficult or impossible”.

To a large extent the deep structure determines what is unique or characteristic of a given face. From the deep structure alone it is possible to infer the race, age, and as just mentioned above, the sex. The deep structure largely determines whether the face is square, rounded, narrow, or wide. The shape of the jaw, nose, upper cheek, and forehead all reflect the structure of the underlying bone. In addition, the deep structure remains relatively invariant for long periods of time. This facilitates recognition despite changes in hair style, skin tone, and other changes in surface structure.

Quantitative studies of the deep structure of faces performed by dentists are one potential source of useful characterizations (Endow 1975). Dentists recognize three basic types of facial profiles: orthognathic, retrognathic, and prognathic. These categories depend upon the spatial relationship between the mandible and the maxilla. A retrusive mandible and a convex profile are characteristic of the retrognath. The prognath, in contrast, has a protrusive mandible and a concave profile. The orthognathic profile strikes a happy medium between these two extremes.

The mandible is also an important indicator of age. As one grows from youth to adulthood the angle between the ramus and corpus of the mandible decreases from about 140 to 110 degrees (Gray 1977). The mandible takes a more prominent role in the overall structure of the face. As one approaches old age the angle again increases and the mandible becomes edentulous and less prominent.

The two nasal bones are an informative part of the deep structure in that their shape varies considerably from individual to individual and between races (Enlow 1975), and in that the overlying skin reflects quite faithfully the curvature of these bones. Generally the nasal bones have negative Gaussian curvature. The absolute magnitude of this curvature is much less in orientals than europeans. The curvature of the nasal bones increases from infancy to adulthood.

The point of all this is simply to show that the deep structure of a face provides a potentially powerful locus of constraints for the tasks of segmentation, identification, and interpretation. A fuller understanding of these constraints may come from an examination of the literature in the fields of dentistry, plastic surgery, art, perception, and basic anatomy.

I have tried to give some idea of the role of the deep structure in determining the shape of the visible surfaces of a face. Similar accounts can be developed for the middle and surface structures. Knowledge of the constraints embodied at each of these three levels should make possible reliable inferences about age, sex, race, identity, and even mood, from the surface shapes of a face.