RECONSTRUCTION AND DISPLAY OF THE RETINA

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ABSTRACT

The retina is an approximately spherical structure. In order to gather information such as the density of rods and cones it is necessary to flatten the retina. It is desirable to project these measurements back onto the original spherical form of the retina, interpolate the sampled data, and display the results. This paper is a summary of techniques which we have developed to perform these tasks.

RÉSUMÉ

La rétine peut être approximée par une surface sphérique. Pour recueillir certaines informations comme la densité des cônes et des bâtonnets, il faut aplatir la rétine. Nous aimerions reprojeter ces mesures sur la surface sphérique originale, interpoler les données recueillies et afficher les résultats. Cet ouvrage est une synthèse des techniques que nous avons developpées pour effectuer ces tâches.

KEYWORDS: human retina, recontruction, spherical geometry, interpolation.

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1. Introduction

The topography of the constituent cells and efferent pathways of the retina is important for understanding how the visual world is sampled and how it is represented in the central nervous system. The retinal whole mount is the histological method of choice for revealing these topographical relationships (Stone, 1981, for review). Because the retina covers the major part of the sphere, it must be cut so that it can be flattened for viewing under a microscope. Thus, a general problem with whole mounts is that spatial relationships are lost across the cut edges. Furthermore, locations of features on the retinal sphere, which in theory could be specified with great precision, are not readily determined from their positions in the flattened tissue.

These problems may be solved by reconstructing the original spherical surface from the flattened tissue. Such a reconstruction has been accomplished manually by approximating tracings of the tissue to the surface of a sphere of appropriate diameter (*e.g.*, Østerberg, 1935).

The advent of sophisticated and affordable computer technology has made digital reconstruction techniques possible. We report methods for specifying a retinal coordinate system, reconstituting the retinal sphere from a three-piece whole mount (Curcio, *et al.*, in preparation), and displaying topographic data.

Our key reconstruction step relies on the fact that one of the three pieces of the retina has a particularly easy mapping back to the sphere, based on natural landmarks. Once this piece has been placed on the sphere, the other two are positioned relative to it, using a small set of fiducial points. In the first case, we can assume that there has been little or no distortion of the tissue. For the second placement problem, we cannot make this assumption. Instead, we assume that the tissue has been warped, and rely on an iterative relaxation procedure to place each point.

The reconstructed retina is then used as the basis for display. We construct a triangular mesh connecting