Interfacing Image Processing and Computer Graphics Systems Using an Artificial Visual System

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ABSTRACT

An Artificial Visual System (AVS) has been developed to simplify three-dimensional microscope images for presentation and manipulation in an interactive computer graphics system. The AVS consists of several sets of spatial filters that decompose an image along three different measurement continua. A recombination algorithm processes the filter outputs to detect objects, to eliminate noise, and to map the detected objects into points in a multidimensional feature space. Recent discoveries regarding the geometry of the points in the feature space are described. One recent result simplifies the AVS by decreasing the number of filters required to obtain the same measurements. Not only are accurate measurements possible, but certain image distortions can be modelled and counteracted in the feature space.

Key words: computer vision, pattern recognition, interactive computer graphics

Introduction

Difficulties in the analysis of natural images arise from random noise, aliasing from the digitization grid, systematic distortions such as optical blur, and from an excess of information -- accurate but irrelevant data, relevant but ambiguous data, or simply too much relevant data -- that we call "information overload". Many techniques exist for correcting noise and distortion [1], but the information overload problem requires an understanding of the aspects of the image that are important for the particular application and techniques for specifying and extracting the relevant aspects of the image. Once the information is extracted, then interactive computer graphics can be applied to present the extracted information and to provide powerful interactive facilities to support image interpretation activity [2].

We have developed an interface between image processing and computer graphics systems that both provides a mechanism for specifying the salient aspects of the image and extracts that information in a form that can be used to build an interactive graphics model of an image. The interface takes the form of an artificial visual system (AVS).

The development of the AVS as a means for addressing the information overload problem has been motivated by a biomedical research problem involving interpretation of three-dimensional fluorescence images. In this paper we will present an overview of the biomedical research problem and then show how the AVS for this problem was designed. Additional applications of AVS techniques will be discussed.

Background

Our goal is to elucidate the contractile mechanism of smooth muscle cells [3,4]. One of the proteins believed to play a role in that mechanism is a-actinin, which occurs in two types of discrete bodies of concentration: irregular plaques on the cell membrane, and oblong bodies distributed throughout the cytoplasm and oriented within 30 degrees of the long axis of the cell. Organizational patterns such as strands of these bodies branching and twisting through three dimensions may be discerned if the locations of the bodies and the orientations of the oblong bodies are known. Different kinds of organizational patterns could support different hypotheses of cell structure and function.

A three-dimensional image of the protein distribution in a single, isolated cell is obtained by acquiring a series of 2-D optical sections of the cell using Fluorescence Digital Imaging Microscopy [3,5]. Several types of noise are minimized using averaging and normalizing operations during image aquisition [3].

There remains a serious optical distortion in the direction of focus arising from fluorescence sources from out-of-focus planes above and below the focal plane. This distortion has been empirically modelled by imaging a