Optical Brain Imaging: Computational Dewarping and Neuron Selection

LACEY KITCH\(^1\) AND NOAH YOUNG\(^2\)

\(^1\)Department of Electrical Engineering \quad \(^2\)Department of Bioengineering

Introduction: Optical Brain Imaging in Freely-Moving Mice

Here we present methods for the analysis of optical brain imaging data obtained using a miniature integrated microscope. The microscope is mounted to the head of a freely-moving mouse and images the Ca\(^{2+}\) activity of the mouse’s neurons. Ca\(^{2+}\) is a proxy for neuronal activity and is visualized with a fluorescent indicator. The eventual goal of this type of data collection is to understand the relationship of neural activity to behavior. The methods shown here will assist in the extraction of neuronal signals from imaging movies and with the visual display of the data.

Computational Aberration Removal

Here we present a method to computationally lessen optical aberrations. We first use the properties of the identified neurons to estimate the spherical imaging surface and then use map projection to flatten this sphere in a way which produces less distortion.

Candidate Neuron Region Classification

Here we present a method to classify candidate regions as either neurons or some other artifact. We begin by creating a neuron-shaped template to match against each image. Since aberrations make neurons look different in different parts of the image, we vary this template by position in the image. Matching against these average-neuron filters lets us find how “neuron-like” each image is, and we can eliminate images on this criterion. We next perform binarization and labeling on the remaining unfiltered images and subject images to a series of morphological tests to reject images with other undesirable features.

Goal 1: Aberration removal and image dewarping

Our microscope system introduces aberrations into the brain imaging movies. These aberrations are evident in the elongated cells appearing on the sides of the field of view, and are not desirable for scientific display of data. The first part of our project is to dewarp these images and create a cell map which portrays all neurons as having an even circular shape.

Goal 2: Candidate neuron region classification

A single experiment produces over 1000 candidate neuronal regions, making manual classification an arduous task. The second part of our project is to automate this classification process. We are firm in our requirement that components which represent noise, dust, or anatomical clutter (e.g. blood vessels) be removed, while on the other hand we tolerate a small percentage of filters appearing on the sides of the field of view, but give large frame distortions. Others, such as the Wiechel projection, leave cells more aberrated but have a more pleasing frame.

Conclusions

Depending on the desired visual effect, several candidate map projections could suffice. Here we show several projection options. Some, such as the Lambert projection, are successful at evening major axis length across the field of view, but give large frame distortions. Others, such as the Wiechel projection, leave cells more abberated but have a more pleasing frame.

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