A Biologically Inspired Model of Chromatic Assimilation & Contrast in the Primary Visual Cortex

Sean Thomas Connolly

Abstract

We present a computational model of the primary visual cortex (V1) inspired by current neurobiological understanding. This understanding treats color and shape information as intrinsically connected and, as a consequence, predicts perceptual phenomena such as color induction and assimilation to arise very early in visual processing. Our model confirms such predictions on a number of psychophysical experiments, offering credence to the biological theories.

Index Terms

Primary Visual Cortex, V1, Receptive Field, Single Opponent, Double Opponent, Color Assimilation, Color Induction

I. Introduction

COLOR induction and contrast are two related, opposing, perceptual phenomena. The former is a change in color perceived ”toward” a nearby color, while the latter is a change of one color ”away” from the nearby color. Neurophysiological research suggests that these phenomena may arise as early in primate vision processing as the primary visual cortex (V1). It is proposed that the boundaries between two colored regions drive these effects. Specifically, research in the field describes neurons which fire selectively to boundaries between specific colors, so called double opponent cells, and identifies them as being critically related to the color perceived.

Within, we propose a computational model inspired by the current understanding of this biology. We present two implementations, one more biologically accurate, and another more computationally elegant. We explore the behavior of these models with respect to what they can teach about the biological theories, as well as their application to the field of computer vision.

II. State of the art

A. *Notes:*

Purpose:

- BIBLIOGRAPHICAL REVIEW ABOUT THE TOPIC OF THE PROBLEM

Overview:

1) Historical view → separation of color & shape
2) Current view → integration of color & shape
   - Color opponency
   - Receptive fields
   - Spatial opponency
   - DO & SO roles
   - Interactions (hypercolumns, CO blobs, etc.)
3) Z. Li's edge detection work
4) Xavi's PLoS One 2013 paper
   - Avoid detail, save that for *Method*..?
5) Xavi's JoV 2010 paper; differences
   - Weighing Function/Extended CSF vs. Implicit CSF
   - Mathematical vs Dynamical
   - .. err, worth mentioning?
6) **Any other models?**

Author: Sean Thomas Connolly, connolly.st@gmail.com
Advisor: Xavier Otazu, Computer Vision Center, Computer Science Department, Universitat Autnoma de Barcelona, Barcelona, Spain
Submitted: September 2014

III. Method

A. Image Data Transformation

TODO introduce the 2 data transformations and their respective meanings

1) Opponent Receptive Fields:

- describe motivation

2) Discrete Wavelet Transform:

- describe motivation

B. Neuro-Dynamical Model

- describe what exactly 'neuro-dynamical' means
- describe how the Z. Li model is used here
- describe how this is agnostic to the initial transformation (data is normalized)

C. NOTES:

We can consider breaking the project down to three distinct problems:

1) What's the data representation input to V1?
    - RGB $\rightarrow$ receptive fields $\rightarrow$ LDRGBY
    - RGB $\rightarrow$ L*a*b* $\rightarrow$ DWT
2) What's the data representation internal to V1?
    - Neuronal excitation and inhibition
3) How does V1 process the data?
    - Based on Z. Li's dynamic model of neuronal interactions

IV. Experiments

All the details about the experiments design and process

V. Results

Explanation about the performance evaluation procedure and results analysis.

VI. Conclusions

Summary about the degree of achievement according to the given problem and the adopted hypothesis; and outline about open research lines...

Appendix A
Appendix title

Appendix one text goes here.

Acknowledgment

The authors would like to thank...

References

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.