Optimizing a recurrent neural architecture for contour detection produces a tilt illusion

Drew Linsley† (drew_linsley@brown.edu)

Junkyung Kim† (junkyung_kim@brown.edu)

Thomas Serre (thomas_serre@brown.edu)
Carney Institute for Brain Science
Department of Cognitive Linguistic & Psychological Sciences
Brown University

Abstract

Context influences our perception of visual scenes. While there is a consensus in vision science that processes like contour integration depend on recurrent contextual processing, leading computer vision architectures for contour detection rely solely on feedforward operations. One explanation for this inconsistency is that existing recurrent neural network models do not capture the contextual mechanisms that biological vision relies on for contour integration. Here we rectify this issue by extending a neural field model for contextual interactions in primate visual cortex into a trainable module that can learn the patterns of feedback connections via backpropagation. We next introduce the γ-Net , which incorporates this module into a deep network for dense image prediction. We find that the γ-Net performs on par or better than the state-of-the-art model for contour detection, demonstrating the effectiveness of recurrent contextual processing. We also find that training the γ-Net for contour detection in natural images causes it to exhibit a similar "tilt illusion" in orientation estimation as humans; a non-trivial contextual bias which has mystified visual psychologists. The emergence of this visual illusion supports the theory that contextual illusions are a feature – not a bug – of robust visual strategies implemented by recurrent contextual processing.

Keywords: Perceptual grouping; recurrent feedback; segmentation; illusions.

Comment to reviewers

This work is currently under submission at NeurIPS. We originally prepared a version of this work for CCN that included figures and methods/results sections. But we received advice from the NeurIPS chair that because CCN submissions have DOIs they violate the NeurIPS dual submission policy. We didn't want to jeopardize our NeurIPS submission, so we have instead submitted this abstract. We hope that the reviewers will still consider this work for a talk despite its brevity.