

Modeling Cortical Neural Surround Effects Using Deep Neural Networks

REU 2021
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Significance

- Stimulus that surrounds center location affects neurons
- Surround effects influence perception
 - Tilt illusion
- Deficits in surround effects associated with disorders
- Can NN predict biological processing of contextual surround effects?

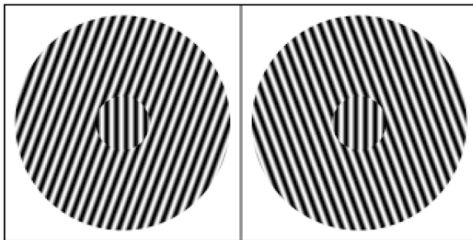
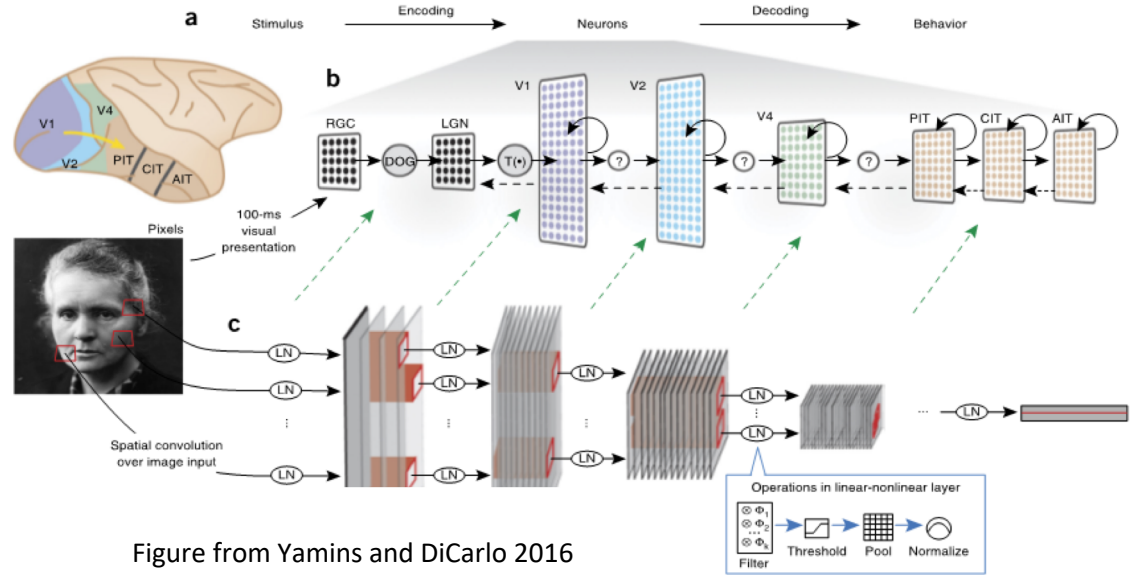


Figure from Kitaoka 2021

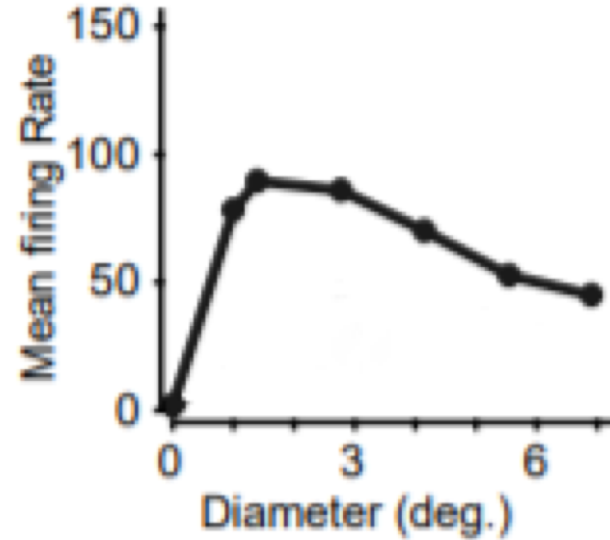
Neural Network Structure

- Only very loosely designed to mimic the brain hierarchy
- Supervised deep CNN have explained aspects of cortical processing (e.g., Kriegeskorte 2015; Yamins and DiCarlo, 2016; Güçlü and van Gerven, 2015)

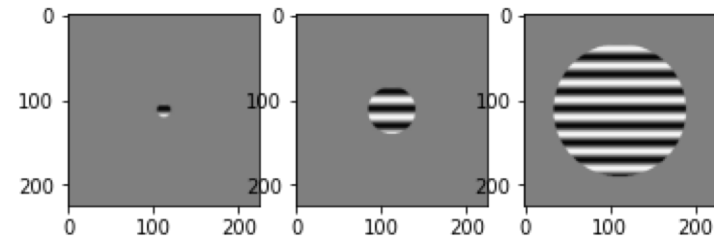


Size Variation

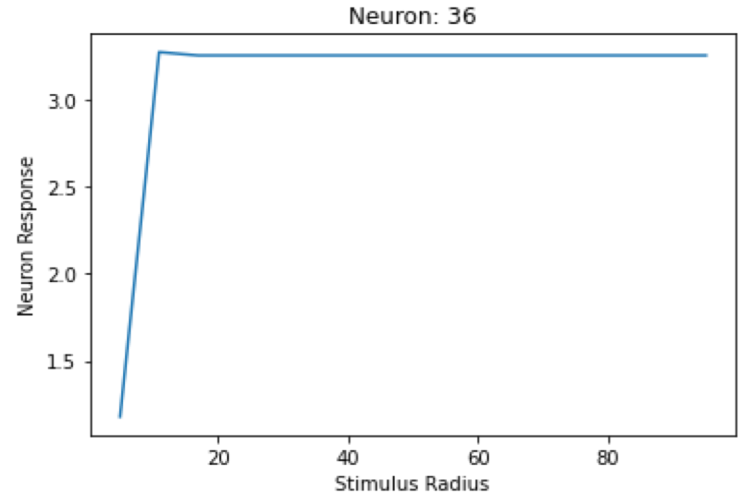
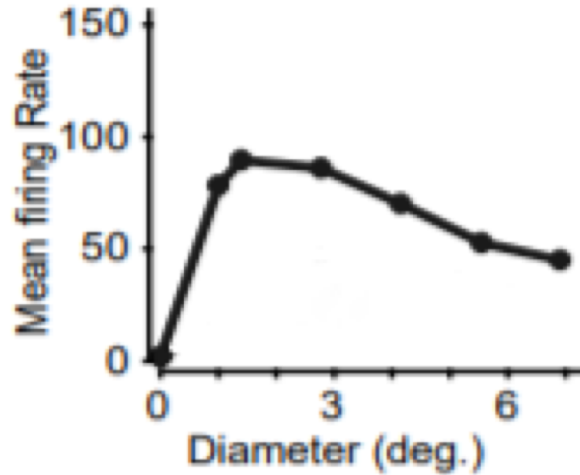
- A neuron has a receptive field size but is affected by stimulus outside of that field
- Change size of grating at preferred frequency and orientation



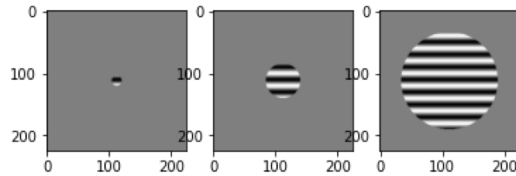
Biological data replotted from Cavanagh 2001



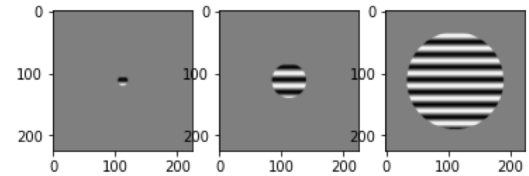
Size Variation



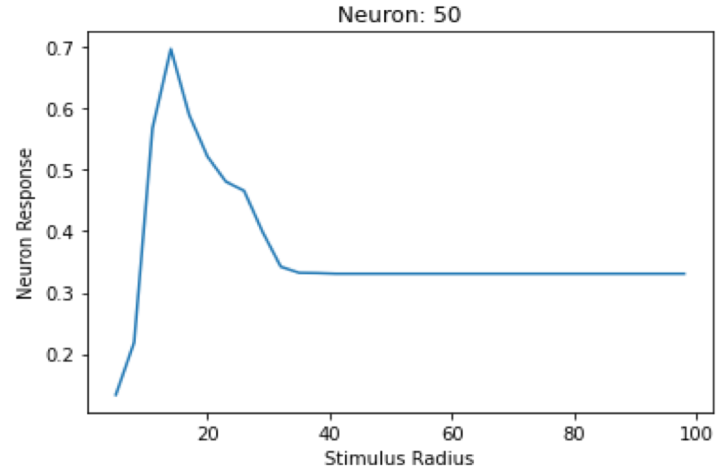
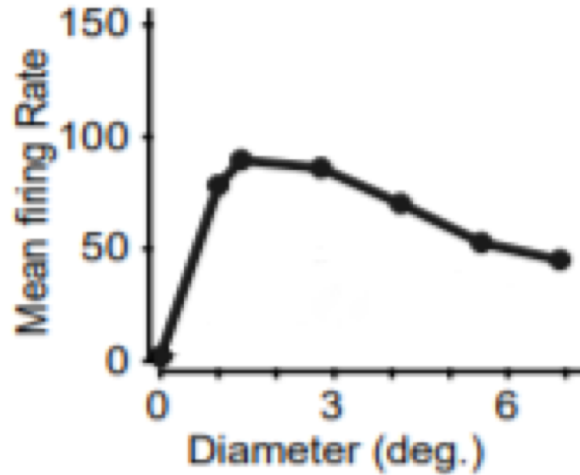
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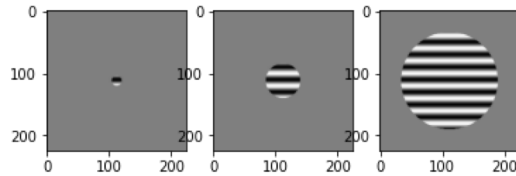
Layer 1



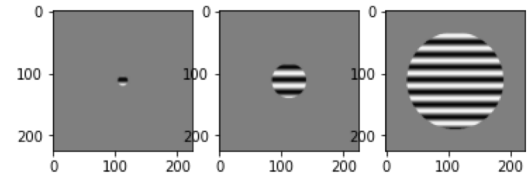
Size Variation



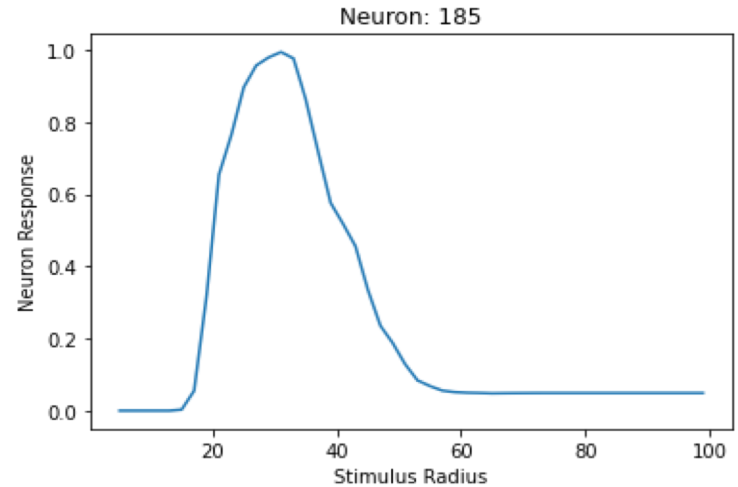
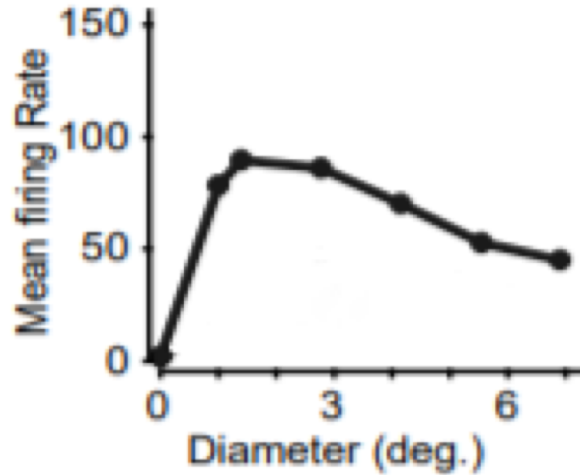
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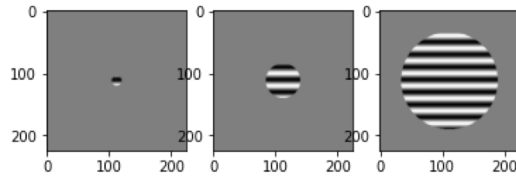
Layer 2



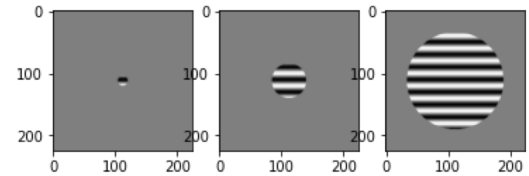
Size Variation



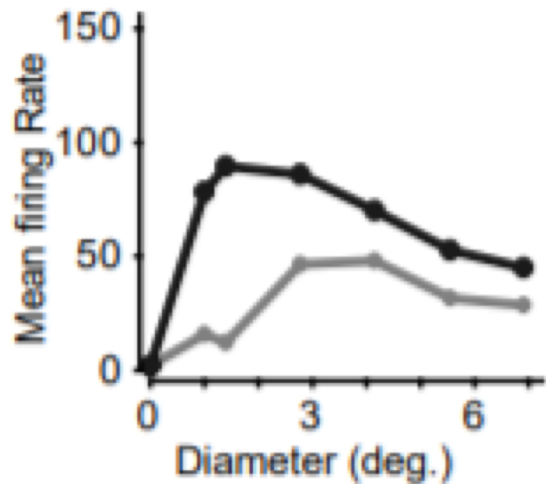
Biological data replotted from Cavanagh 2001



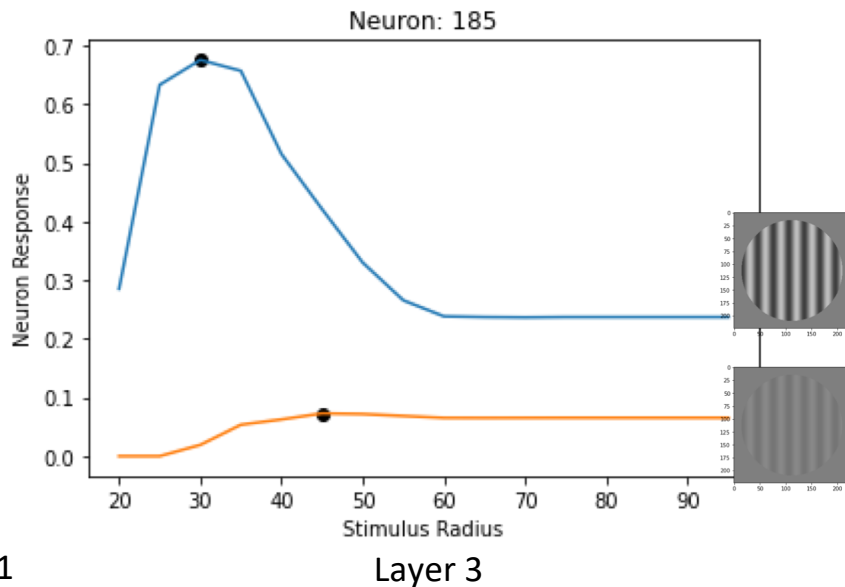
Layer 1



Contrast Manipulation Examples



Biological data replotted from Cavanagh 2001



Outcomes

- Neurons in the middle layer showed suppression for increased stimulus size
- Neurons showed shift in peak radius with lower contrast
- Multiple layers of neural network able to capture contextual nonlinearities
- Expand on surround stimuli experiments across wider range of neurons
- Help identify neural network models that are better at capturing biological neural processing