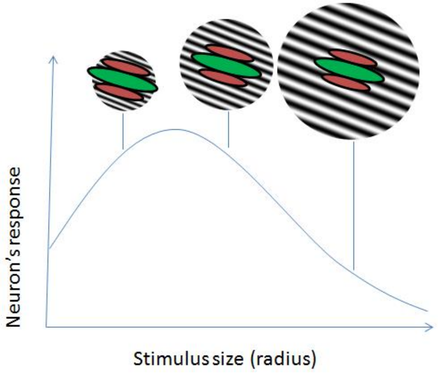
# Surround Modulation: A Bio-inspired Connectivity Structure for Convolutional Neural Networks

Hosein Hasani  Mahdieh Soleymani Baghshah  Hamid Aghajan
Sharif University of Technology

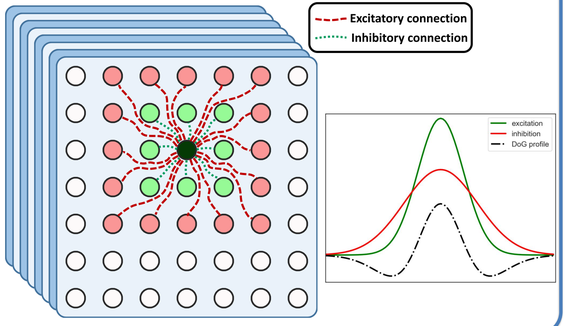
## Motivation




- The classical receptive field of a neuron is the region of sensory space where stimuli elicit neural responses.
- Convolutional kernels mimic the role of receptive field concept in CNNS.
- The classical receptive field of a V1 neuron is surrounded by the nonclassical receptive field in which the stimuli can modulate the response of that neuron.
- One neural mechanism for this modulation is lateral excitatory-inhibitory connections existing in a specific layer of the visual cortex.
- By implementing a simplified and bio-inspired version of surround modulation, we introduce the concept of the nonclassical receptive field for CNNs.

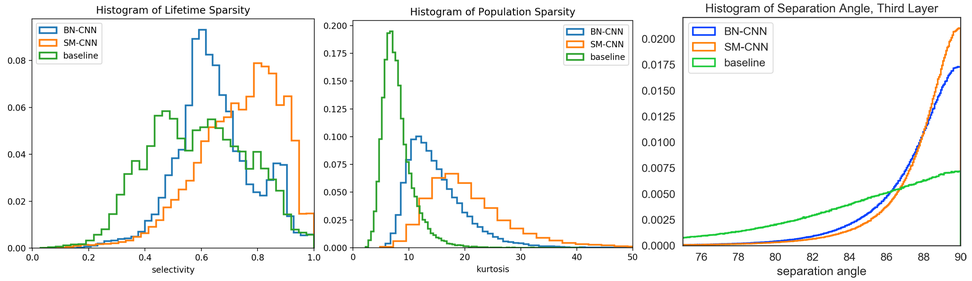
## Main Idea of This Work

- Adding lateral excitatory-inhibitory connections between each unit of a feature map and its surrounding units
- The amount of modulation depends on the distance and the level of neural activity of units.
- Near neighbors excite each other while far neighbors inhibit each other based on a DoG profile



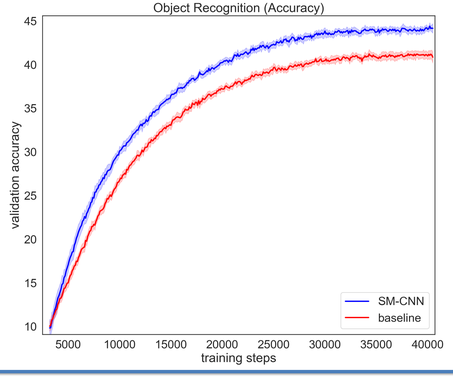

## Effects on Neural Coding

- Increasing lifetime and population sparsity of units in the CNN
- Decreasing correlation between the information carried by different units



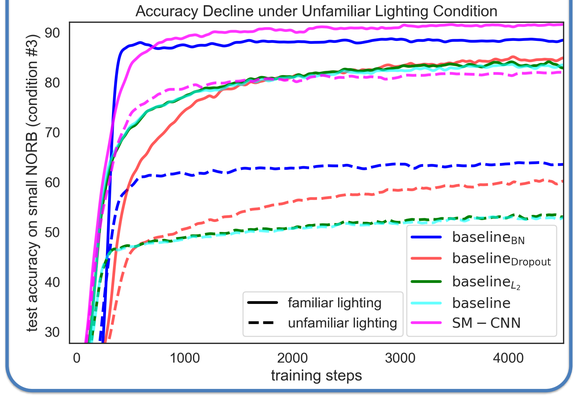

## Object Recognition Experiments

The capability of reaching higher accuracy and training speed when performing classification task on naturalistic images




## Generalization Experiments

Higher generalization when testing on unfamiliar domains like changing in the lighting situation




## Conclusions

This work introduces a new bio-inspired connectivity structure for the CNNs to better resemble the structure of the brain. As a result, the following advantages are also achieved:

- Better classification performance and higher generalization capability
- More biologically plausible behavior (generalizing from fewer samples)
- More biologically plausible neural coding (sparsity and decorrelation)

**Future directions**:

- Searching for better configurations of surround modulation
- Incorporating surround modulation in semantic segmentation task motivated by the similar roles of surround modulation in visual system