



**ETH** Eidgenössische Technische Hochschule Zürich

# Learning complex cells from natural movies

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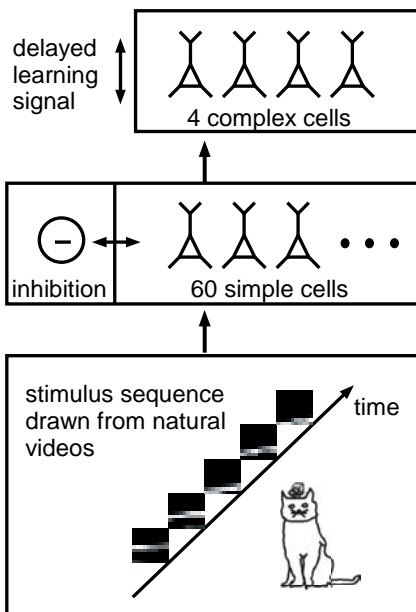
## Abstract

Hubel & Wiesel (1962) first distinguished neurons in primary visual cortex into simple and complex cells. Their feedforward model explains complex cells' invariance properties but leaves the question on how the necessary synaptic connectivity arises unanswered. We propose a network architecture capable of learning simple and complex cells by just exploiting the generic property of natural scenes being continuous over time.

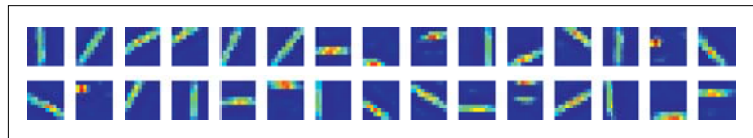
Videos obtained by a camera mounted to a cat's head provide a continuous stream of natural stimuli approximating the input to the visual system. When trained with this input the proposed network exhibits simple and complex type receptive fields, comparable to those observed in physiology. After removing temporal continuity from the sequences however, complex cells no longer emerge or refine.

Our results predict that impairing temporal continuity of the visual environment during an animal's development, e.g. by strobe rearing the animal, should affect the properties of its complex cells.

## Network layout

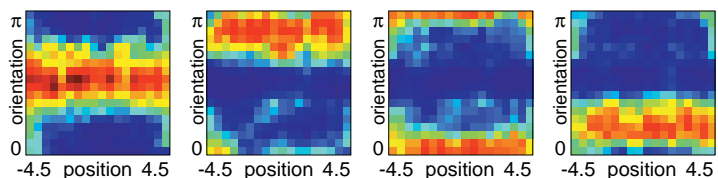


## Simple cells



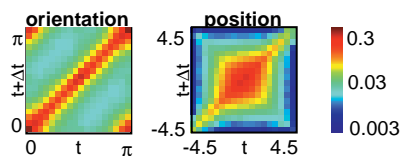
Examples for receptive fields of 2nd layer neurons. They code for bars of certain position and orientation resembling cortical simple cells.

## Complex cells



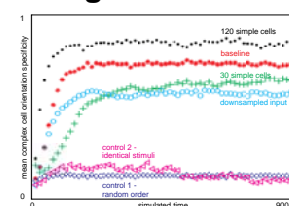
Colorcoded 3rd layer neuron's responses to a gaussian bar of given orientation and position. Each neuron is specific to orientation and invariant to position resembling cortical complex cells.

## Stimulus Statistics

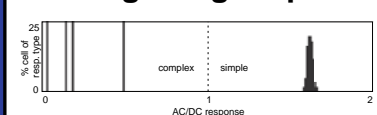


In natural scenes position changes faster than orientation.

## Convergence & controls



## AC/DC grating response



Classification into simple and complex cells matches the AC/DC criterion proposed by De Valois et al 1982.