

# A Conceptual Framework of Computations in Mid- Level Vision

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MODVIS / 2015-05-14

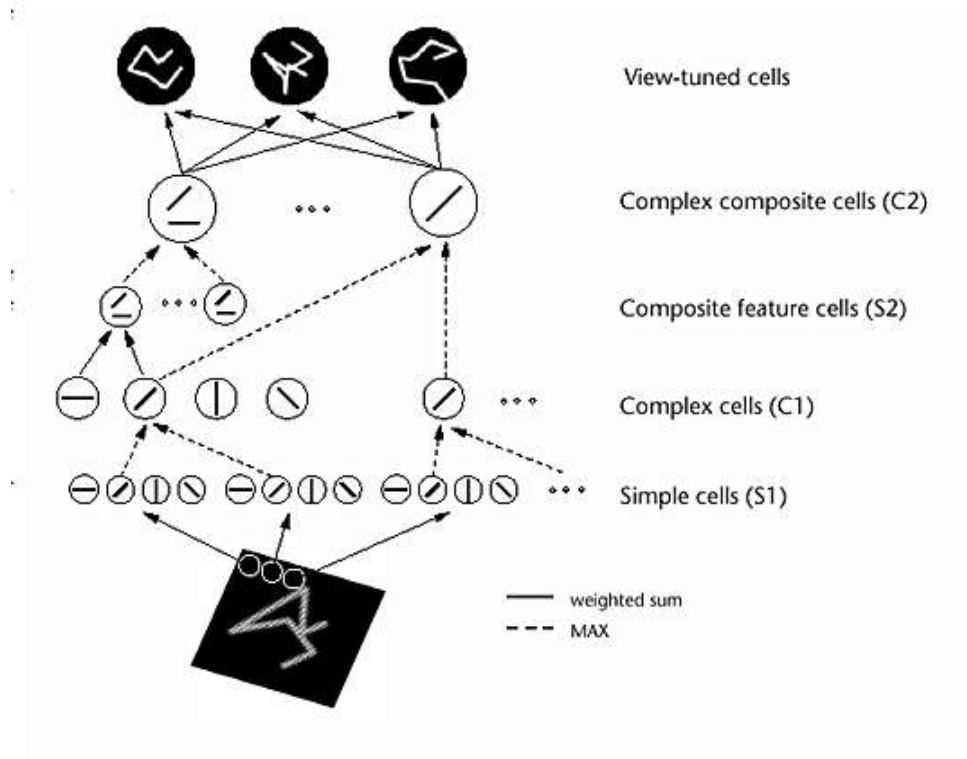


klab.lt

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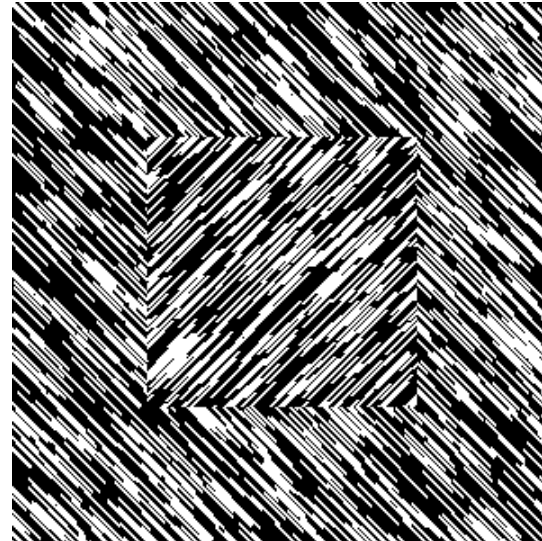
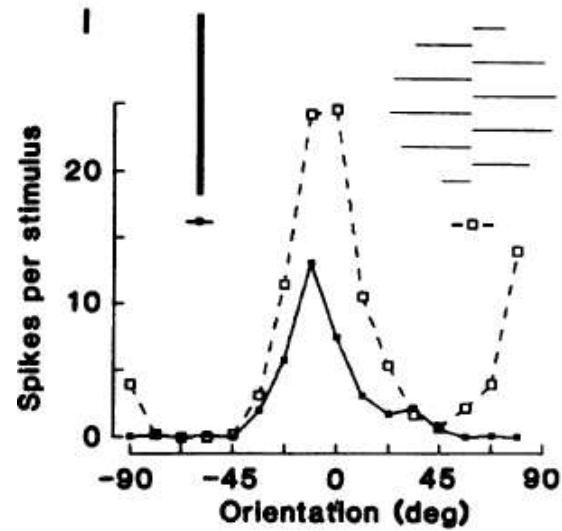
**Mid-level vision does a lot of things...**

# Selectivity & invariance



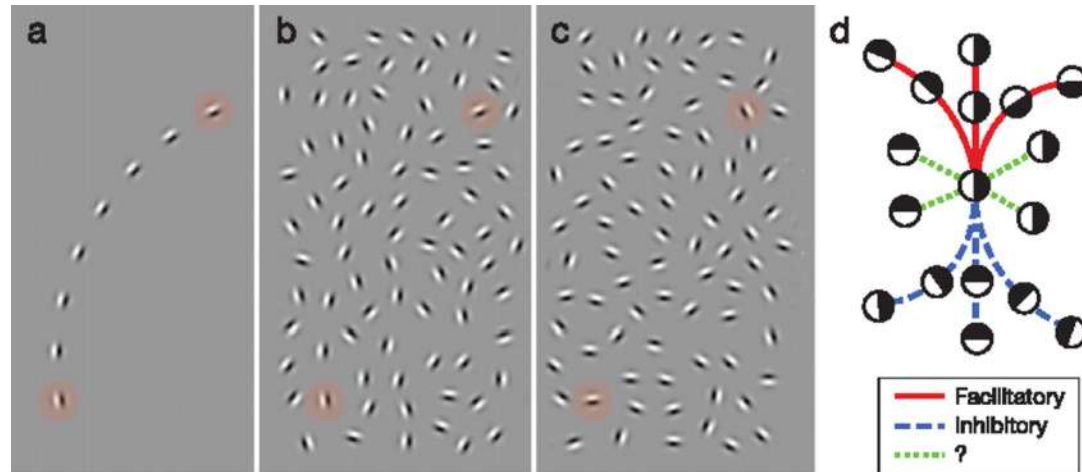
fair use - [Riesenhuber & Poggio \(Nature Neuroscience, 2007\)](#)

# Second-order edges



fair use – von der Heydt et al. (Science, 1984)

# Grouping

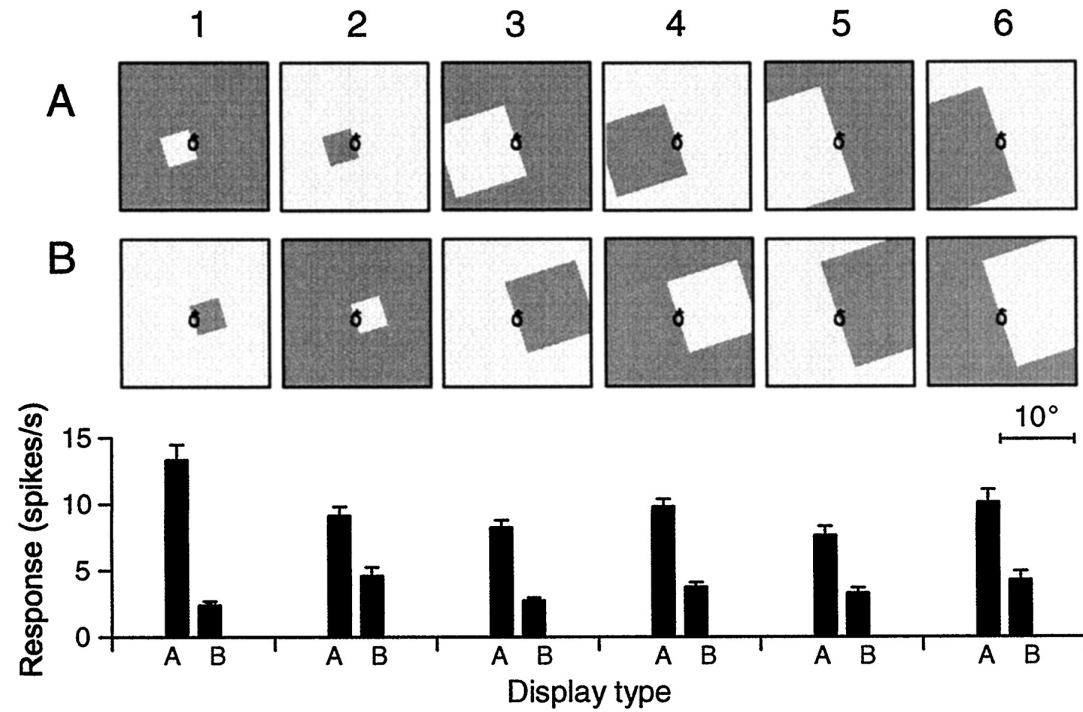


fair use – Dakin & Baruch (Journal of Vision, 2009)

e.g., association field

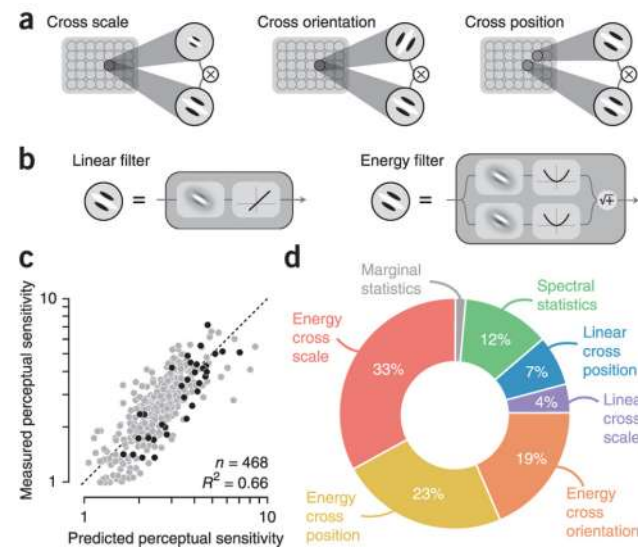
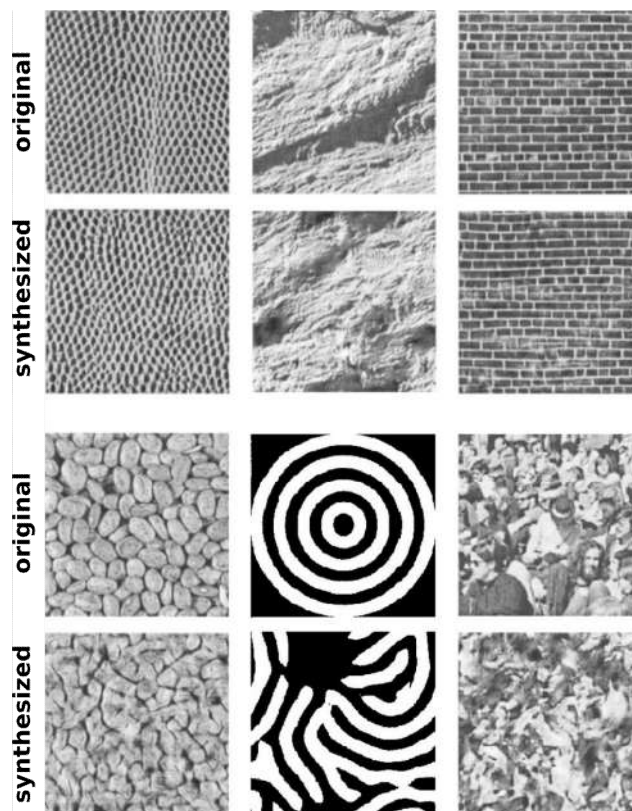
# Border-ownership

Cell 13id4 (V2)



fair use - Zhou et al. (Journal of Neuroscience, 2000)

# Summary statistics



fair use - Freeman et al. (Nature Neuroscience, 2013)

# Mid-level processes

- Feature detection
- Second-order feature detection
- Feature integration / linking (incl. border-ownership)
- Texture processing / summary statistics
- ...



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## Issues

- Many phenomena modeled but no unified framework
- Models work with simplistic stimuli – generalizability to natural scenes?
- Code not available

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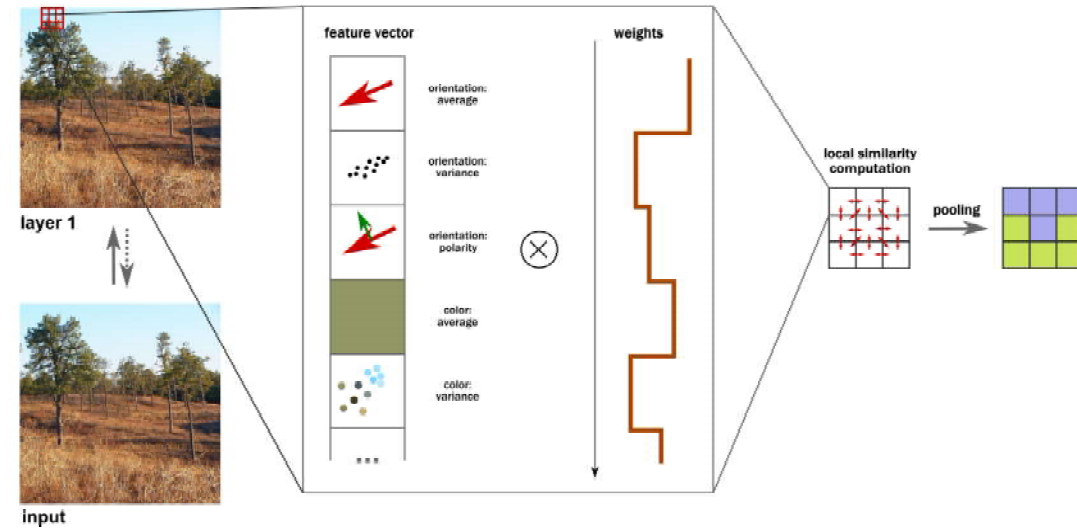
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## similarity & pooling

# **gmin**

**an open, minimalist mid-level framework**

# gmin layer 1



cc by 4.0 – Kubilius et al. (Frontiers in Computational Neuroscience, 2014)

# In practice

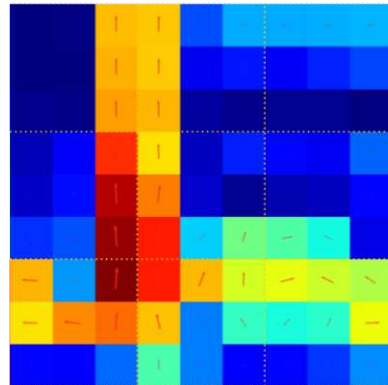
input



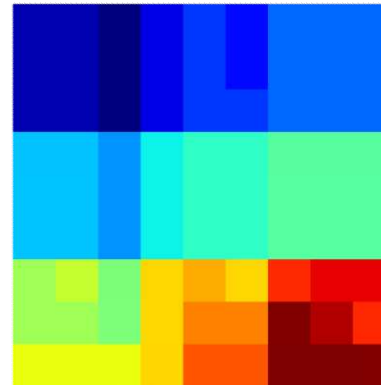
9x9 zoom area



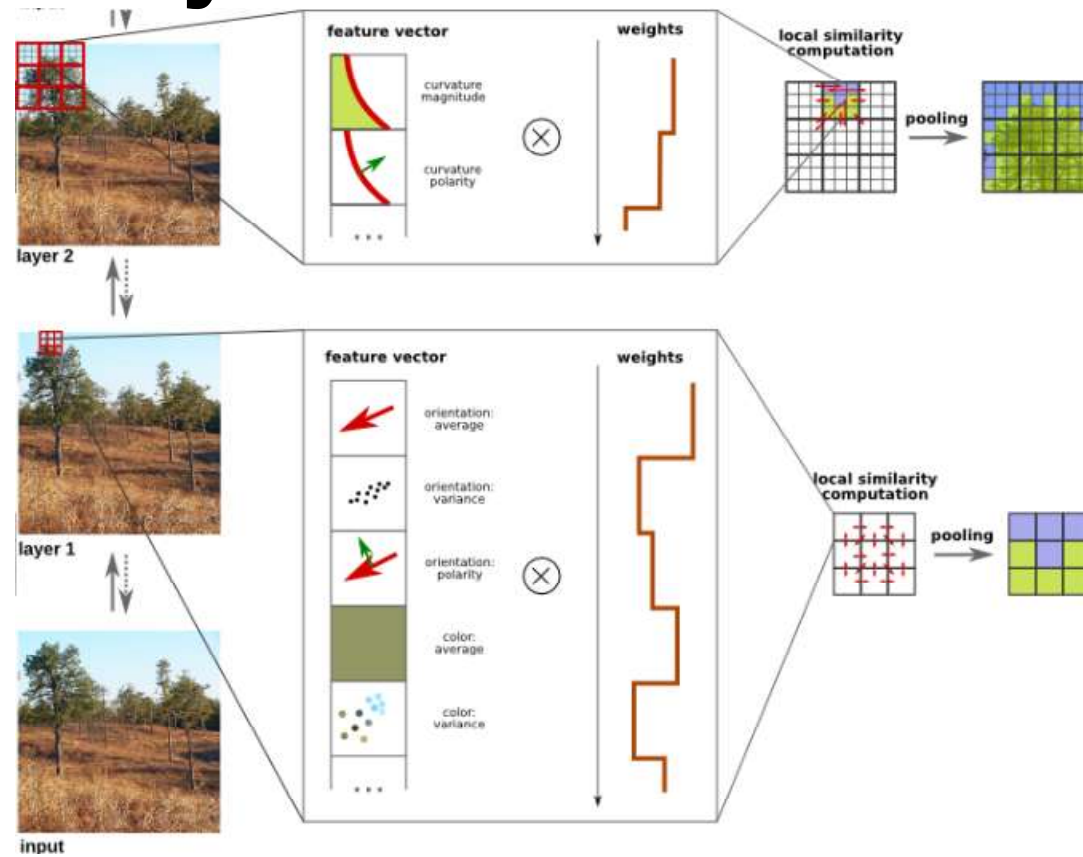
initial orientation detection



layer 1: similarity & pooling



# gmin layers 1 & 2



cc by 4.0 - Kubilius et al. (Frontiers in Computational Neuroscience, 2014)

# In practice

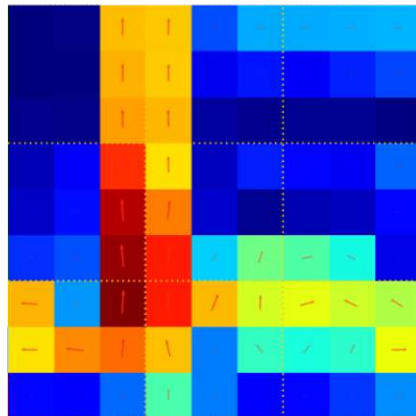
input



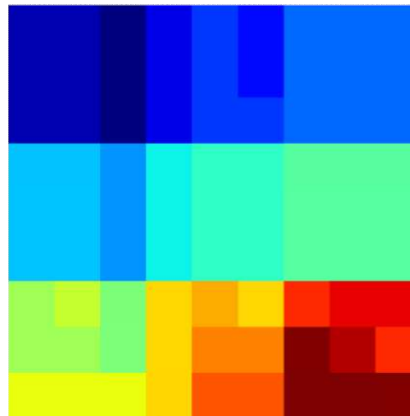
9x9 zoom area



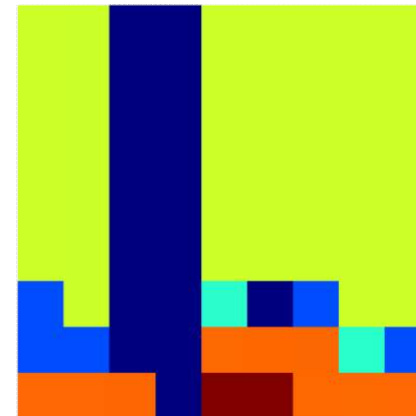
initial orientation detection



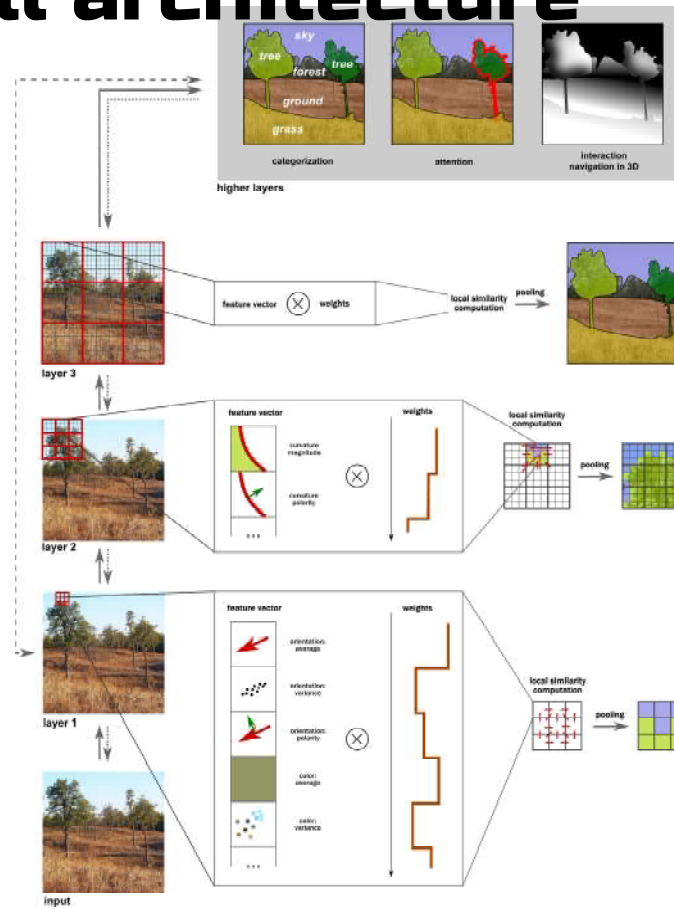
layer 1: similarity & pooling



layer 2: similarity & pooling



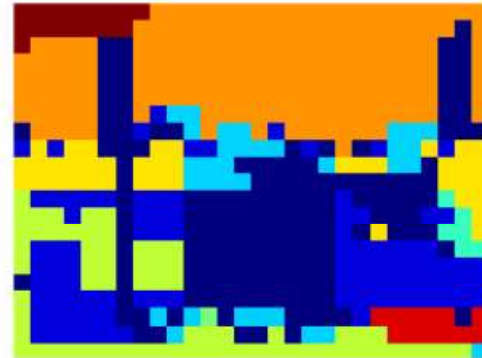
# gmin full architecture



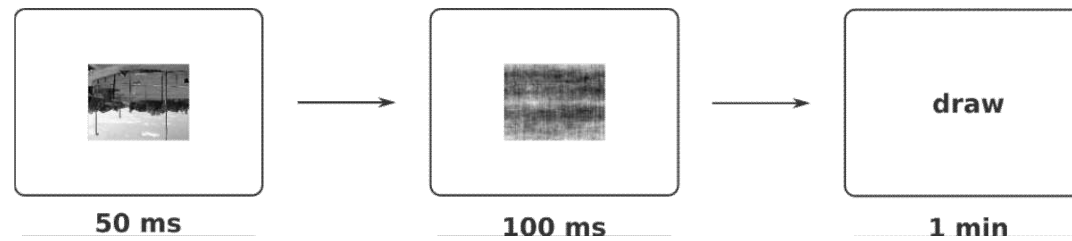
cc by 4.0 - Kubilius et al. (Frontiers in Computational Neuroscience, 2014)



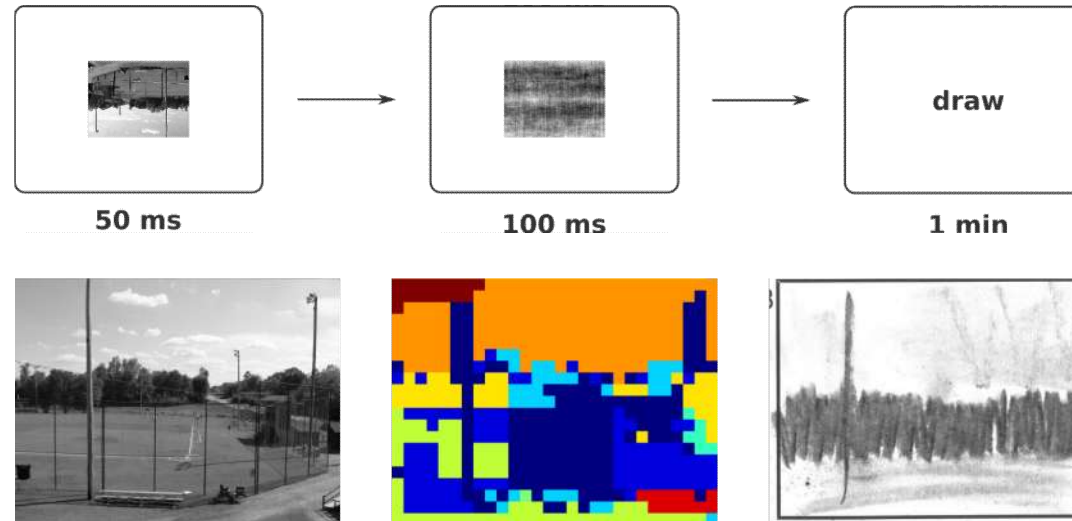
# In practice



# What does feedforward look like?



# What does feedforward look like?

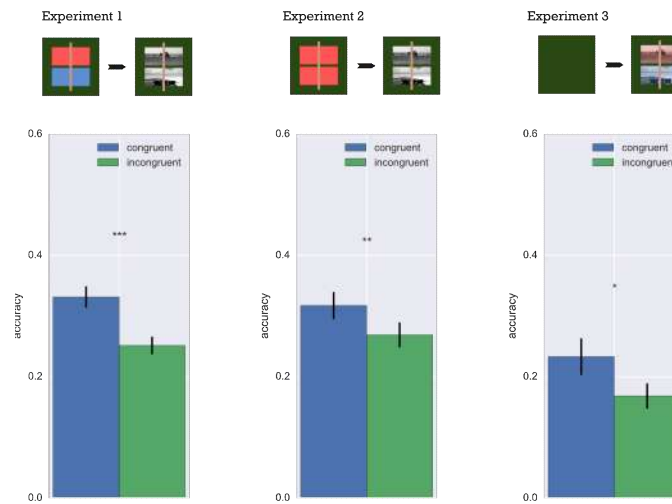


fair use - LabelMe

# Some interesting predictions

- Grouping present in feedforward signals
- Similarity and pooling as basic mechanisms

# Rapid grouping



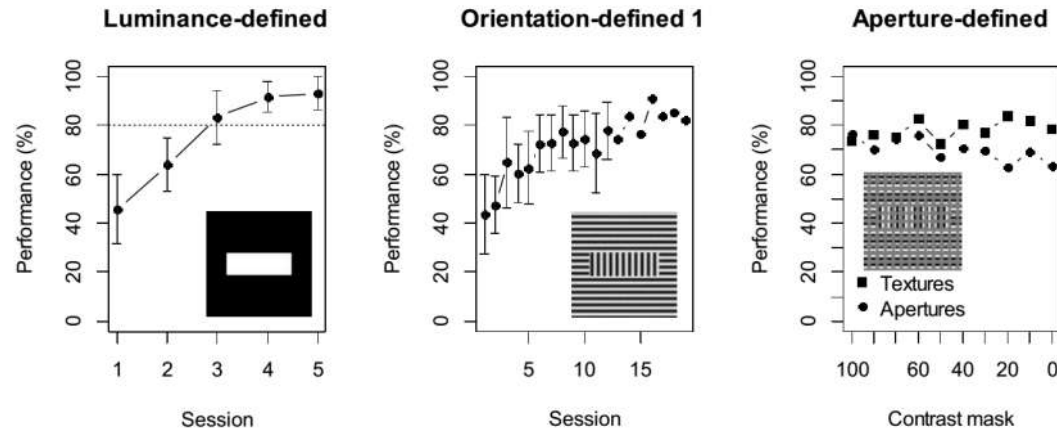
Kubilius et al. (VSS 2015)

*See my poster on Saturday*

**Does segmentation influence rapid scene categorization?**

*(2:45 pm / Scene Perception: Categorization and memory)*

# Cue-invariant processing in rats



fair use – De Keyser et al. (submitted)

# Strengths

- Synthesis of older ideas
- Compatible with many known neural and behavioral results
- Biologically plausible



- Similarity and pooling are **unsupervised** image processing rules
- Provides insights into feedforward representations
- Fast (takes seconds), can be implemented in parallel
- Free and open source ([github.com/qbilius/gmin](https://github.com/qbilius/gmin)), try it yourself now:  
[gmin.klab.it](http://gmin.klab.it)

# Limitations

- How are feature weights learned?
- Can a single set of weights work for all images?
- Picks up *similarities* but not necessarily *discriminative* features
  - Might be resolved in combination with deep networks
- No recurrent processing
  - Not the purpose of this model



Try it online: [gmin.klab.it](http://gmin.klab.it)

or

read more: [Kubilius et al. \(Frontiers in Computational Neuroscience, 2014\)](#)

# Thank you!

*slides available at [klab.it](http://klab.it)*

*code available at [github.com/qbilius/gmin](https://github.com/qbilius/gmin)*