Artificial and robotic vision

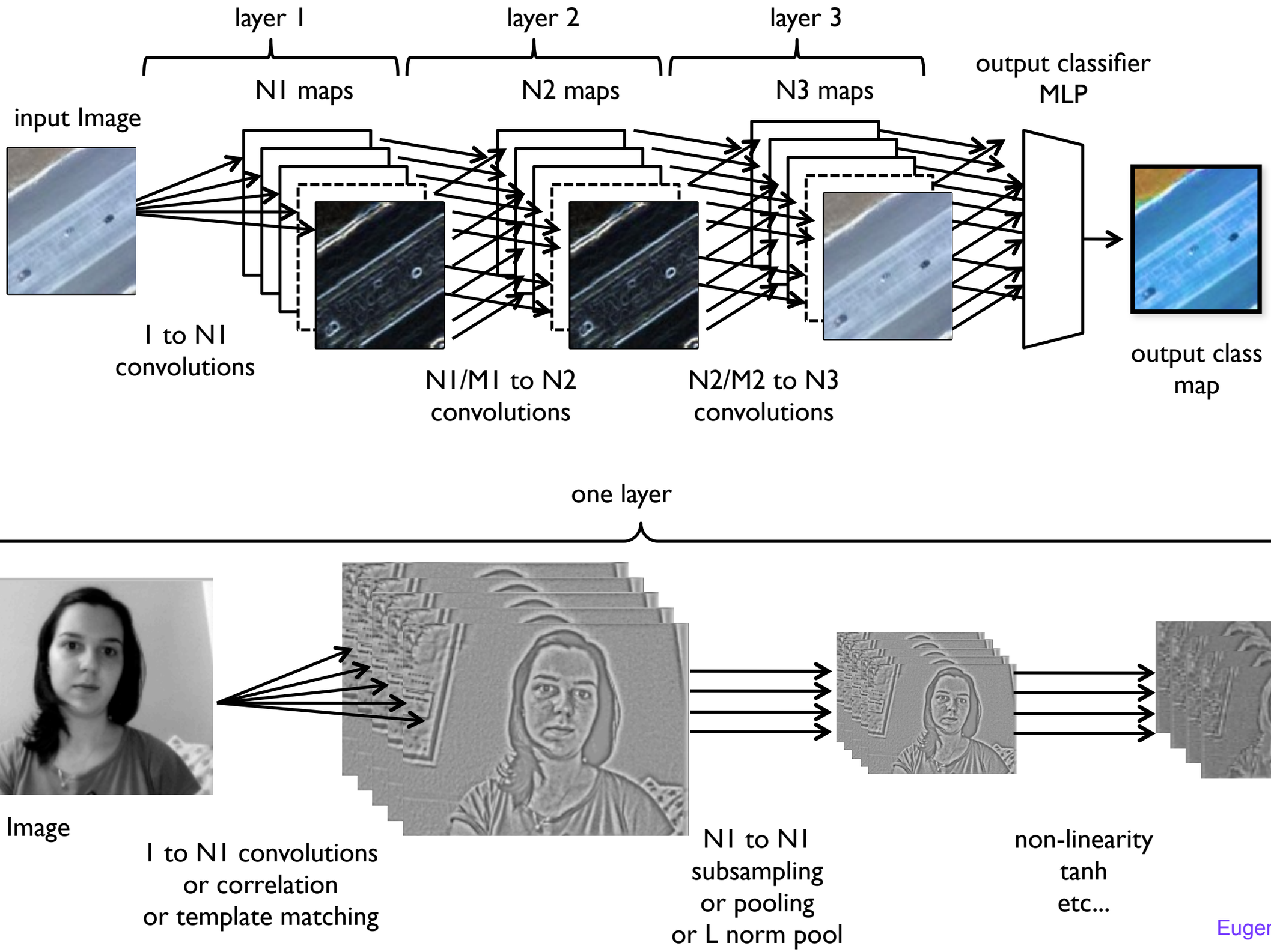
Spring 2013

Lecture 7: Clustering Learning

e-Lab

Eugenio Culurciello

deep networks



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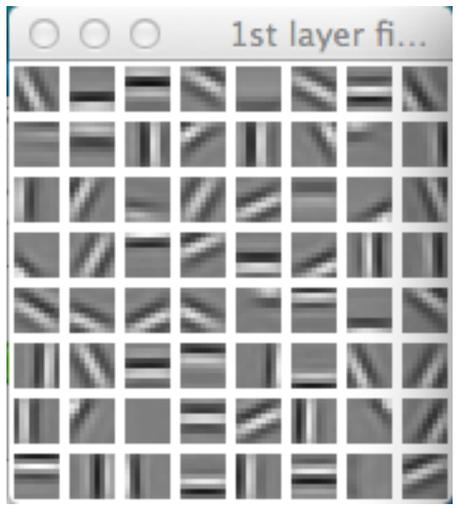
deep networks

one layer

input Image

1 to N1 convolutions
or correlation
or template matching



N1 to N1
subsampling
or pooling
or L norm pool

non-linearity
tanh
etc...

How do we compute these filters?

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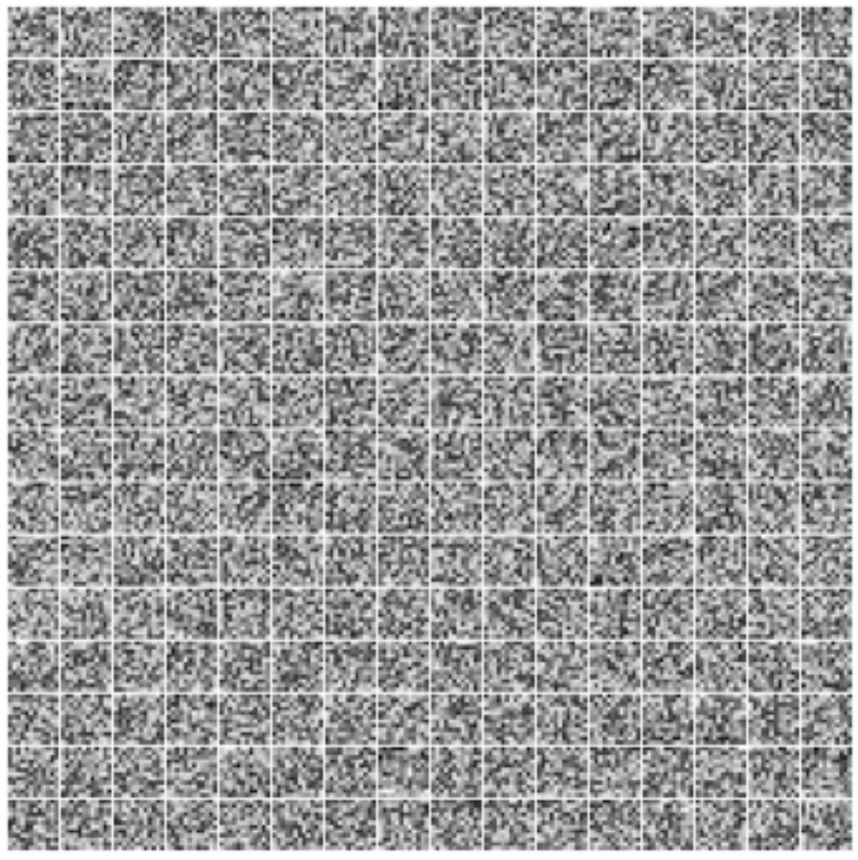
unsupervised training: clustering

main idea: learn to CLUSTER the input

```
1- initialize k clusters: random input data
2- repeat for N input examples
  pick an input example
  average the example with closest cluster
3- return averaged clusters
```



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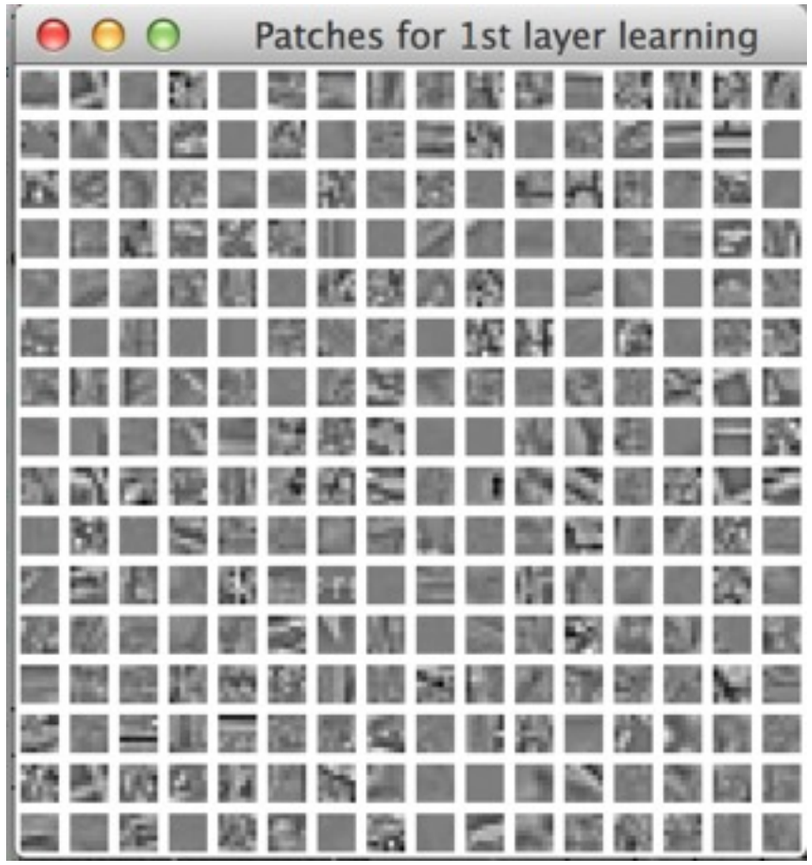
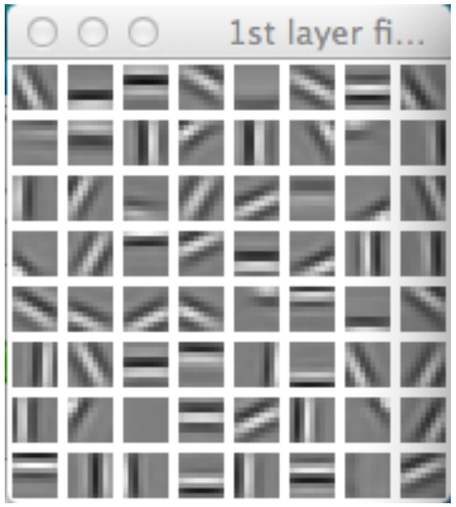
clustering learning

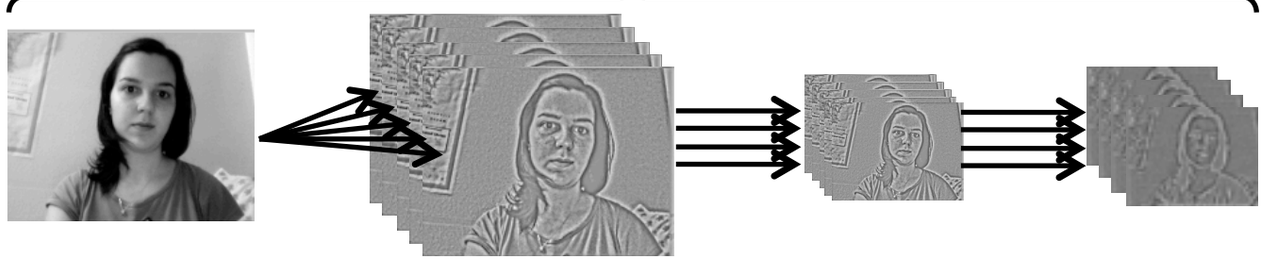


random patches of images



clustered means

use filters as parameters for this layer



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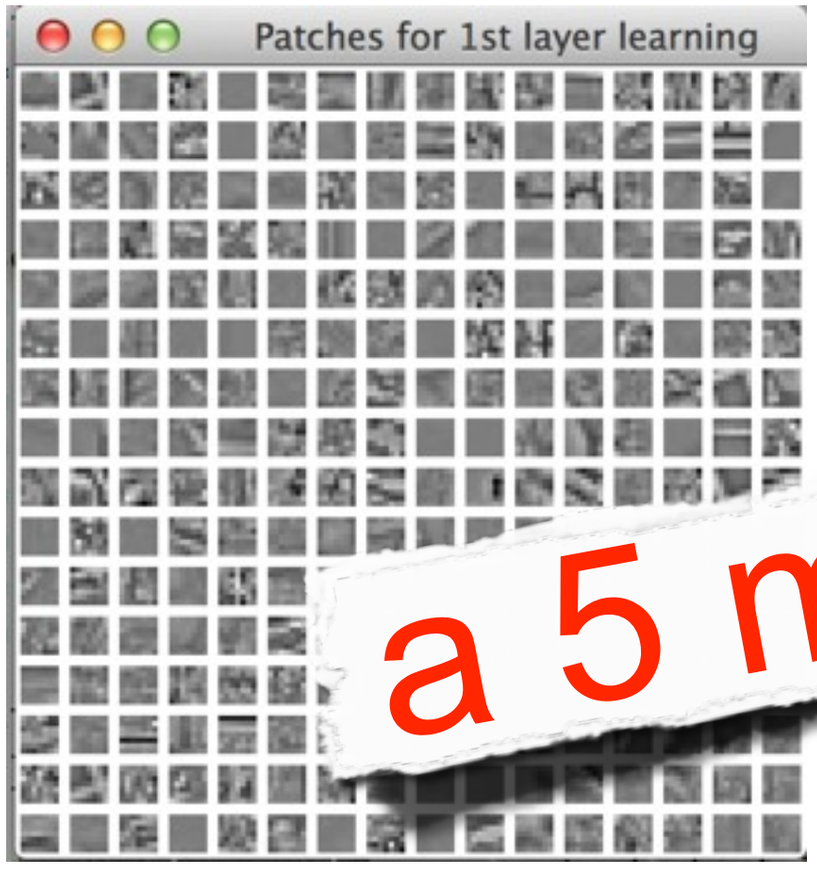
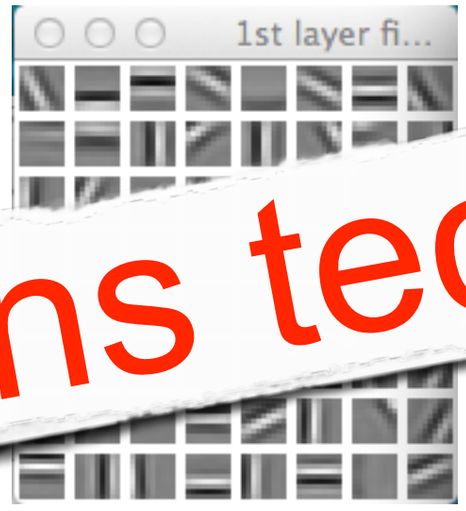
clustering learning



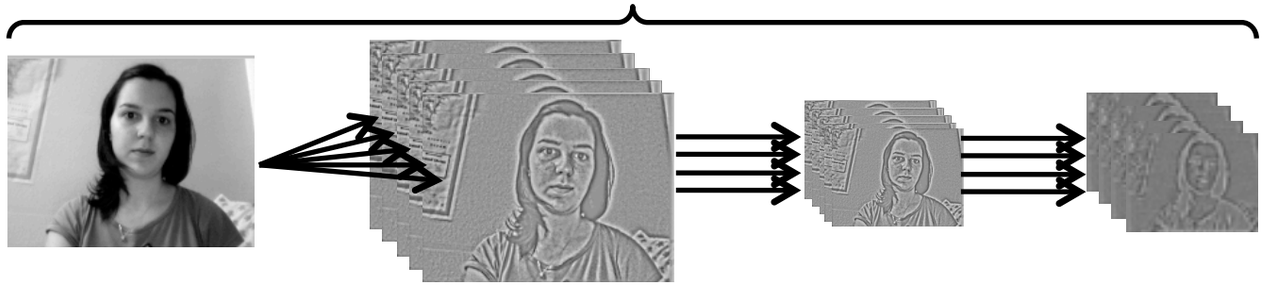
random patches of images



clustered means

a 5 mins technique!

use filters as parameters for this layer



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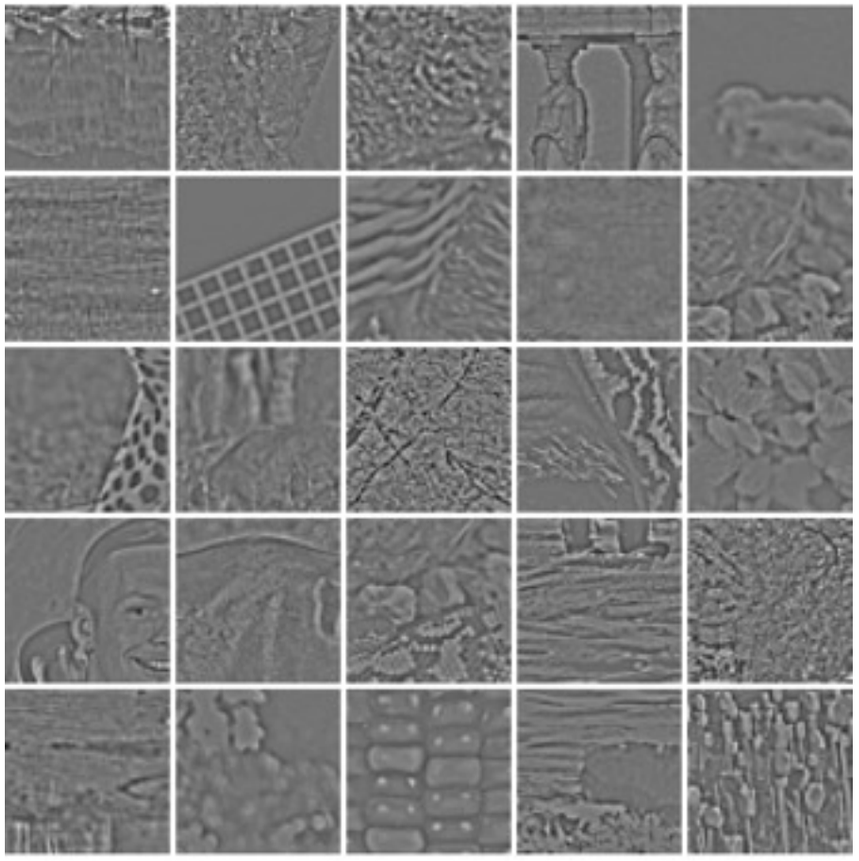
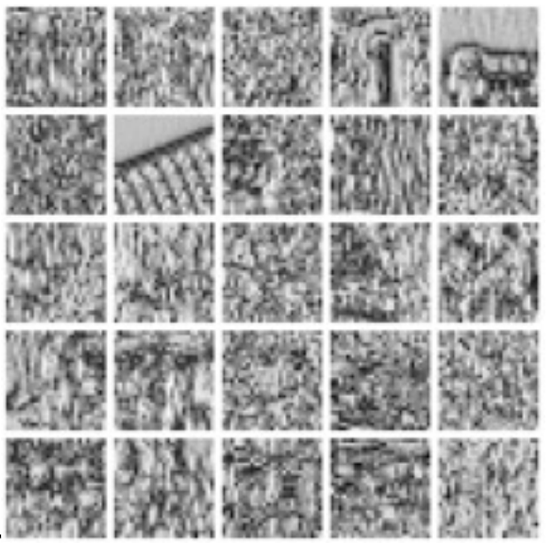
clustering learning

inputs

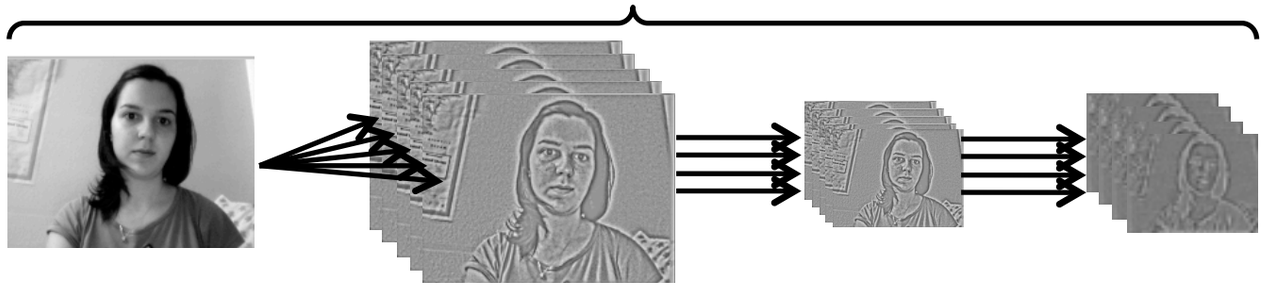


outputs



Network Layer

1. template-match (SAD)
2. normalize
3. nonlinearity
4. L2 pooling



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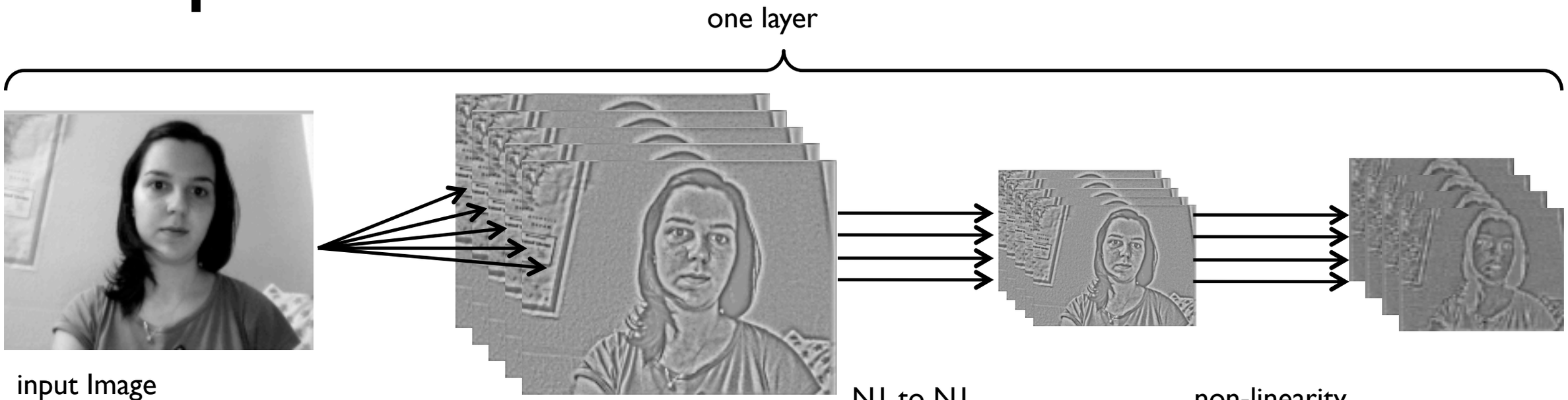
deep networks



Multiple layers of deep network:

Repeat for each layer:

1- sample output of previous layer (new input)

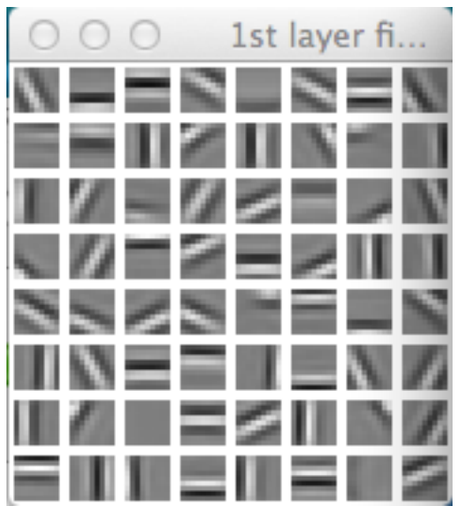
2- cluster these inputs = filters

3- use filters to generate outputs

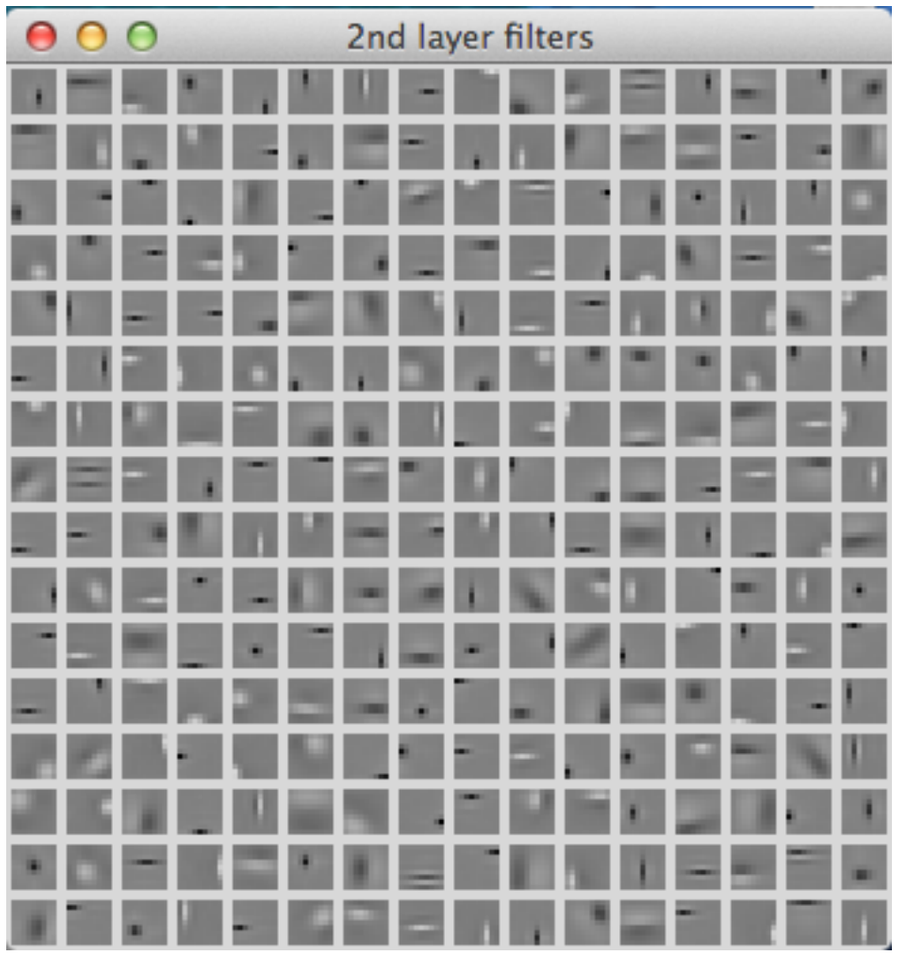
clustering learning

repeat: N layers

random patches of images



clustered means
1st layer



clustered means
2nd layer

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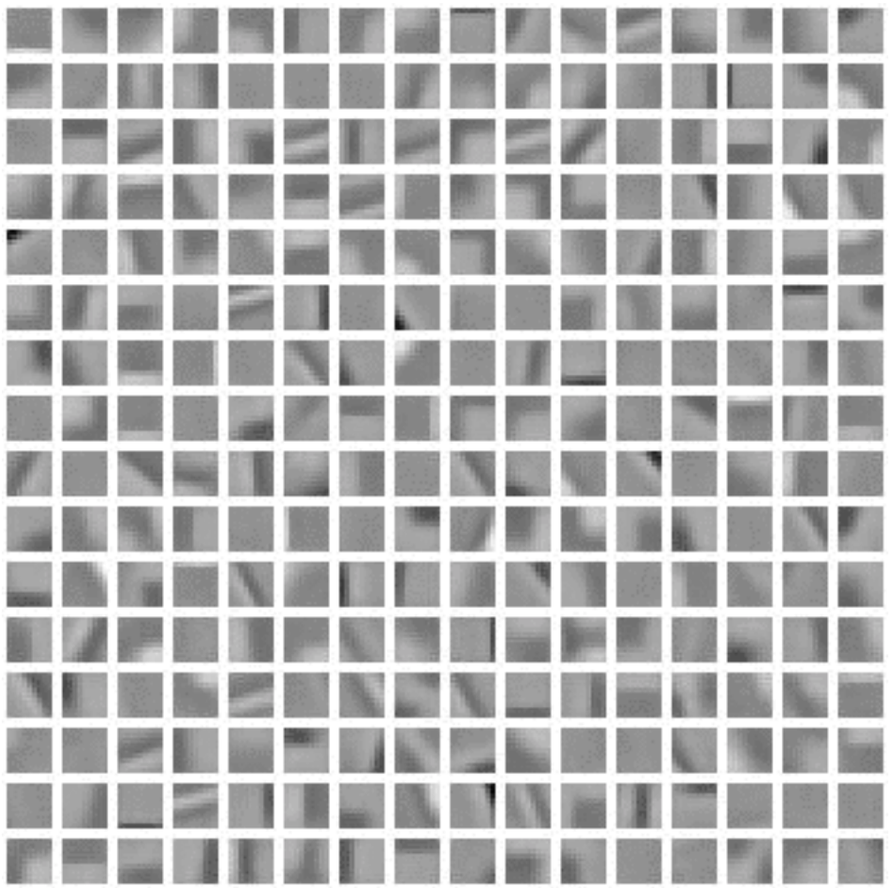
clustering learning: motion filters

same patch location for multiple frames

run k-means on group of patches



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Hebbian Learning

Clustering Learning

fire together

wire together

respond

together

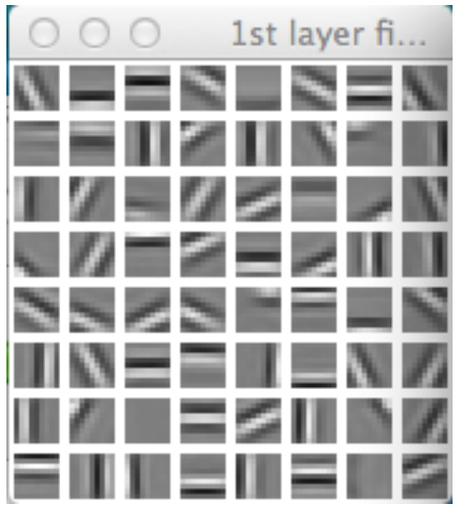
cluster together

compatible with STDP learning

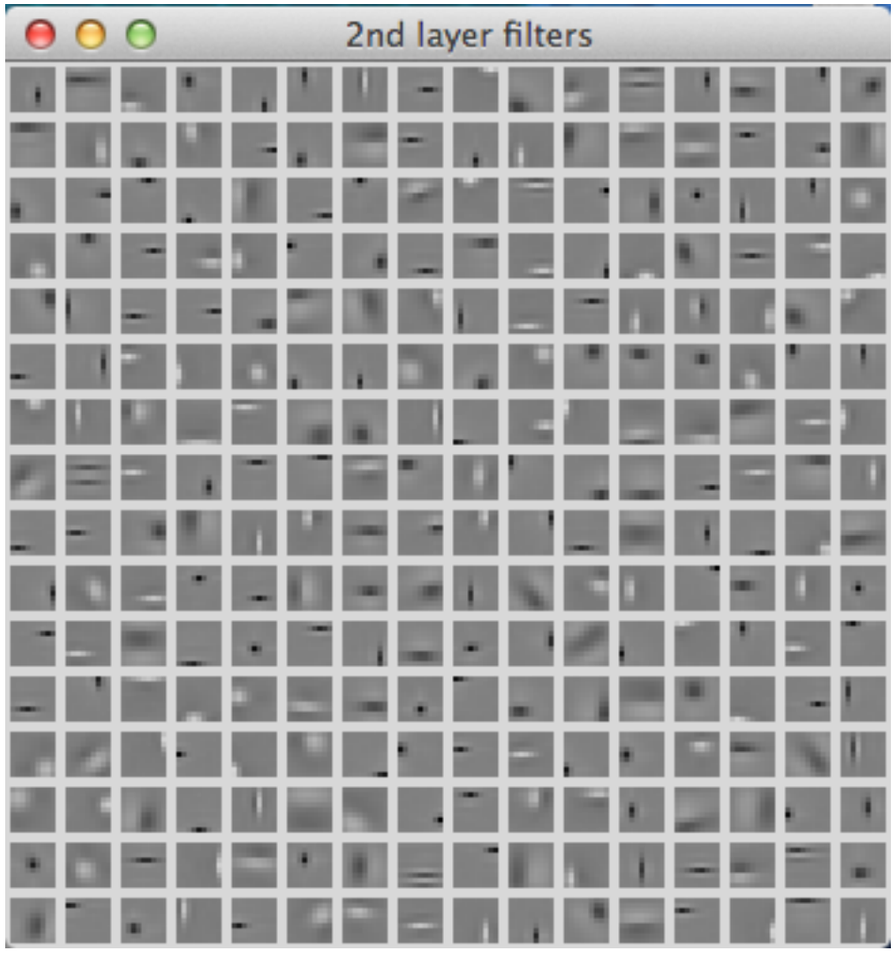
a theory of the mind

clustering

random patches of images



clustered means
1st layer



clustered means
2nd layer

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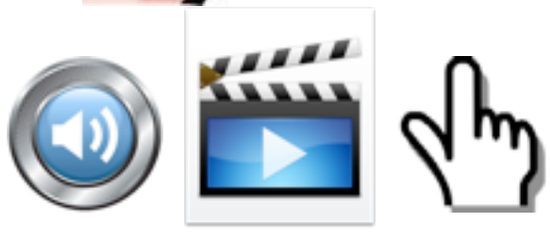
a theory of the mind

features
of deep networks



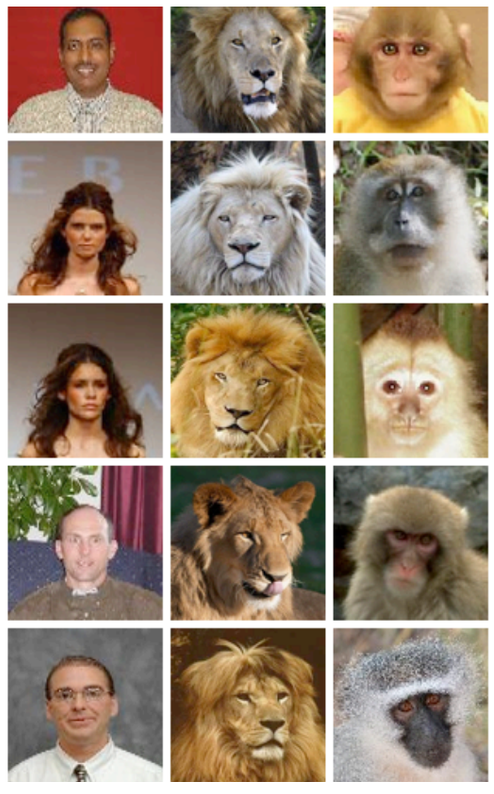
sensory inputs

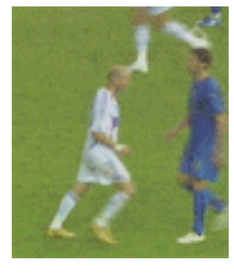
clustering of similar features

a theory of the mind

sensory inputs

features
of deep networks





clustering of similar features