Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

HMAX

Diploma thesis

The hierarchical network

Adding feedback connections

Training and analysis

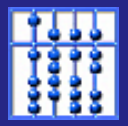
Object recognition and localisation

Diplomarbeit

Melanie Dietz

TU München

November 24, 2005



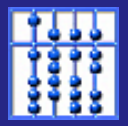
Outline

Neural Networks
Basics
Feed forward vs. backward

Vision and localisation
The human vision
Hierarchical Networks
HMAX

Diploma thesis
The hierarchical network
Adding feedback connections
Training and analysis

1. Neural Networks
   - Basics
   - Feed forward vs. backward
2. Vision and localisation
   - The human vision
   - Hierarchical Networks
   - HMAX
3. Diploma thesis
   - The hierarchical network
   - Adding feedback connections
   - Training and analysis



Basics

Object recognition and localisation

Melanie Dietz

Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

HMAX

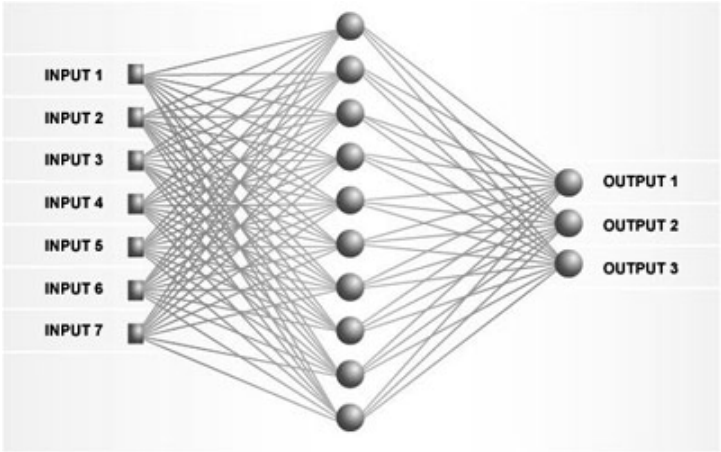
Diploma thesis

The hierarchical network

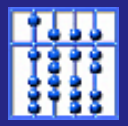
Adding feedback connections

Training and analysis

- Modelled on biological system
- It works! (look in a mirror)
- Components:
  1. nodes
  2. weighted connections



- many types (unidirectional, bidirectional, layered, hierarchical, ...)
- empirical design or training of weights

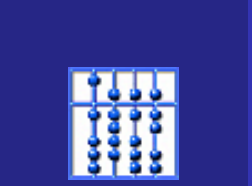


Feed forward vs. backward

Object recognition and localisation
Melanie Dietz
Outline
Neural Networks
Basics
Feed forward vs. backward
Vision and localisation
The human vision
Hierarchical Networks
HMAX
Diploma thesis
The hierarchical network
Adding feedback connections
Training and analysis

- *Feed forward*
  'A feed-forward network can be viewed as a graphical representation of parametric function which takes a set of input values and maps them to a corresponding set of output values (Bishop, 1995).'
  $\Rightarrow$: classification and prediction applications
- *Feed backward*
  - No declared output nodes
  - Instead output is fed back as input signal

  $\Rightarrow$: optimization applications



The visual cortex

Object recognition and localisation

Melanie Dietz

Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

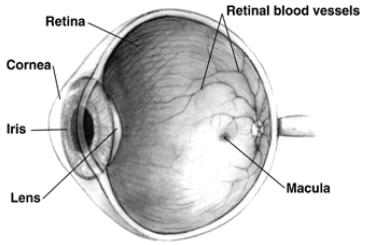
HMAX

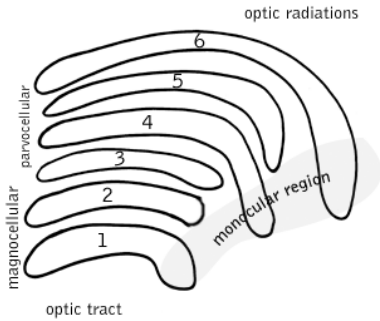
Diploma thesis

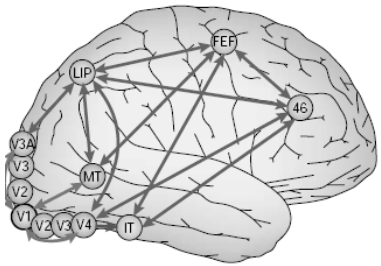
The hierarchical network

Adding feedback connections

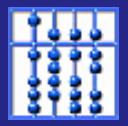
Training and analysis







- The retina
- LGN
- Visual cortical areas
- Visual pathways
- Hierarchical structure



Hierarchical Networks

Object recognition and localisation

Melanie Dietz

Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

HMAX

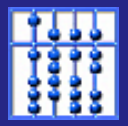
Diploma thesis

The hierarchical network

Adding feedback connections

Training and analysis

- nodes are arranged in layers
- information gain per layer increases
- number of nodes per layer decreases
- new concepts:
  - *physical position in lower layeres*
  - *receptive fields*
  - *translation invariance* (2D)

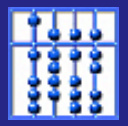


Simple and complex cells

Object recognition and localisation
Melanie Dietz
Outline
Neural Networks
Basics
Feed forward vs. backward
Vision and localisation
The human vision
Hierarchical Networks
HMAX
Diploma thesis
The hierarchical network
Adding feedback connections
Training and analysis

Hubel and Wiesel (1962)

- Simple cells
  - small receptive fields
  - strong phase dependence
- Complex cells
  - larger receptive fields
  - no phase dependence



HMAX

Object recognition and localisation

Melanie Dietz

Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

HMAX

Diploma thesis

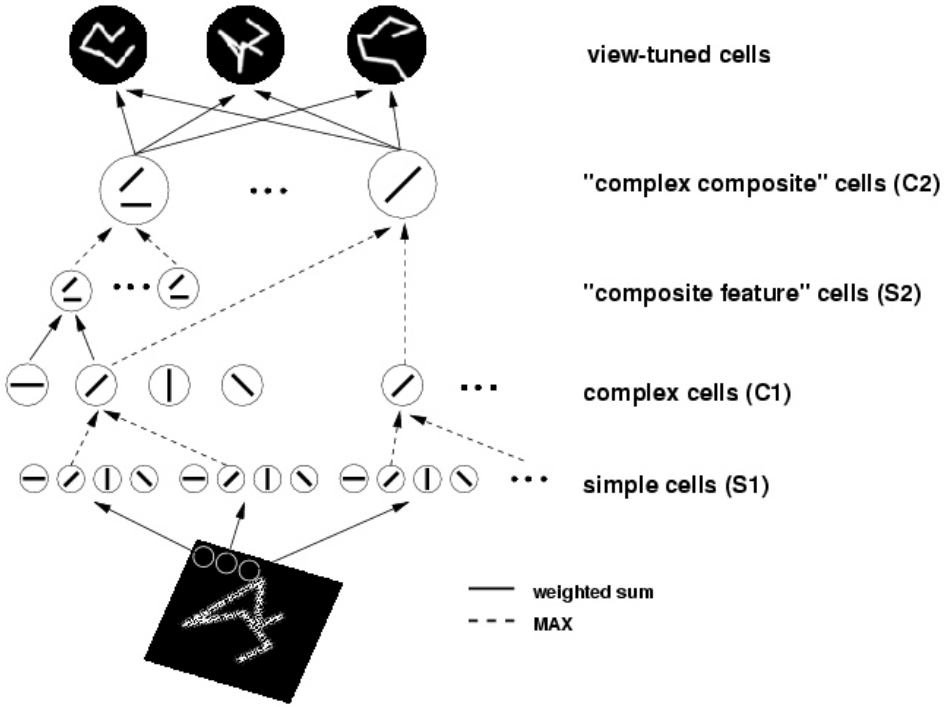
The hierarchical network

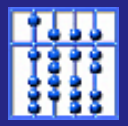
Adding feedback connections

Training and analysis

Riesenhuber and Poggio (1982)

- pooling operation $\longrightarrow$ *view invariance* (3D)
- simple and complex cells

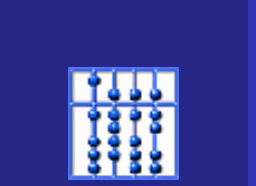




The hierarchical network

Object recognition and localisation
Melanie Dietz
Outline
Neural Networks
Basics
Feed forward vs. backward
Vision and localisation
The human vision
Hierarchical Networks
HMAX
Diploma thesis
The hierarchical network
Adding feedback connections
Training and analysis

- implementation modelled on HMAX
- First layer: noise reduction
- Second layer: S1 (orientation filter)
  C1 (orientation collection)
- Third layer: S2 (simple features)
  C2 (complex features)
- Forth layer: view-tuned cells



Orientation detection

Object recognition and localisation

Melanie Dietz

Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

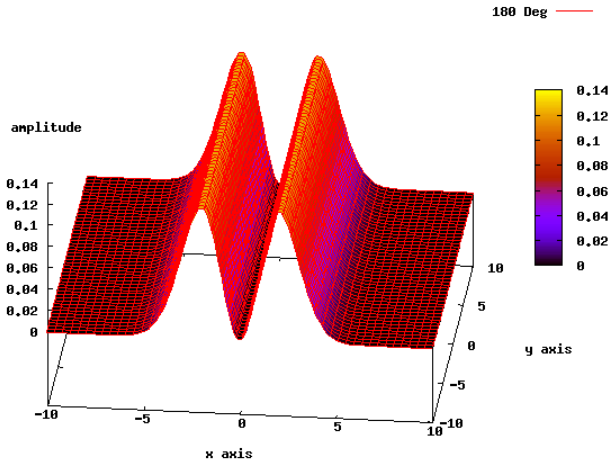
HMAX

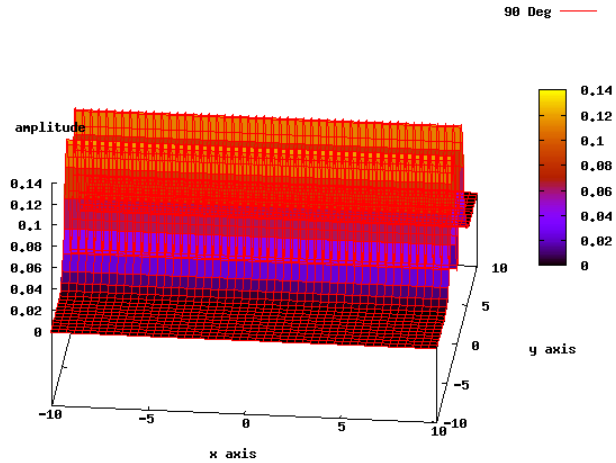
Diploma thesis

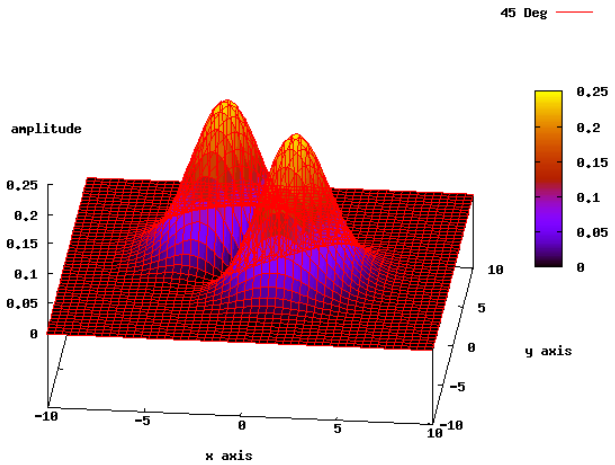
The hierarchical network

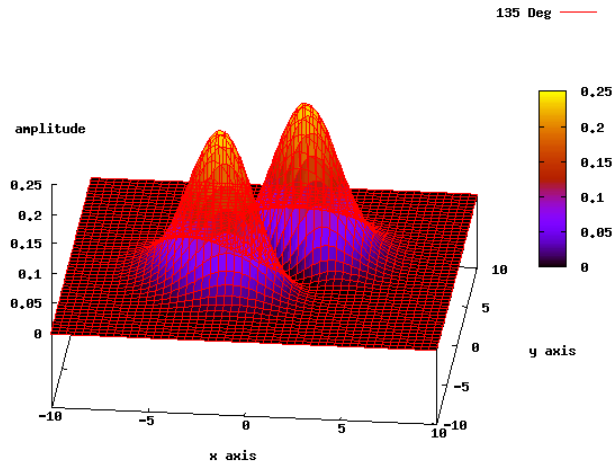
Adding feedback connections

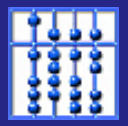
Training and analysis











Training and analysis

Object recognition and localisation

Melanie Dietz

Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

HMAX

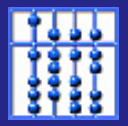
Diploma thesis

The hierarchical network

Adding feedback connections

Training and analysis

- usage of BP for VTU's
- creation of trainig data
- composition of training sets
- comparison to HMAX (Matlab version)



Adding feedback connections

Object recognition and localisation

Melanie Dietz

Outline

Neural Networks

Basics

Feed forward vs. backward

Vision and localisation

The human vision

Hierarchical Networks

HMAX

Diploma thesis

The hierarchical network

Adding feedback connections

Training and analysis

- not only ventral stream but also dorsal stream
- backward connections for asking where the object was
- usage of shape AND color for object recognition