Self Organizing Maps (SOM)

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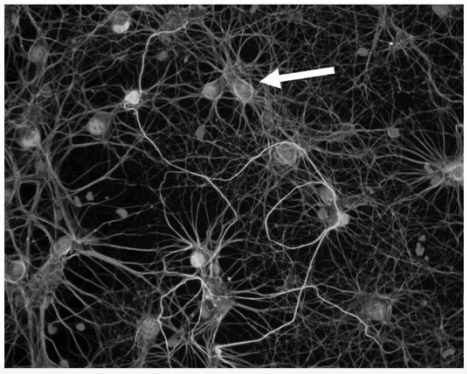
Introduction of SOM

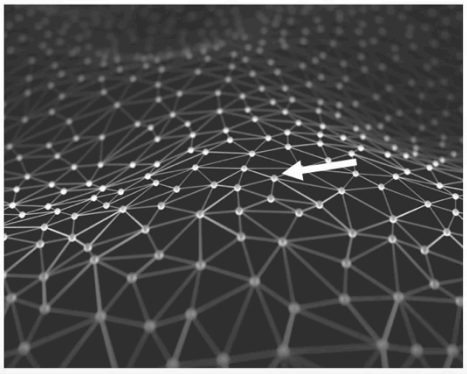
- Introduced by Prof. Teuvo Kohonen in 1982
- Also known as ***Kohonen feature map***
- Unsupervised neural network
- Clustering tool of high-dimensional and complex data

Biological Inspirations

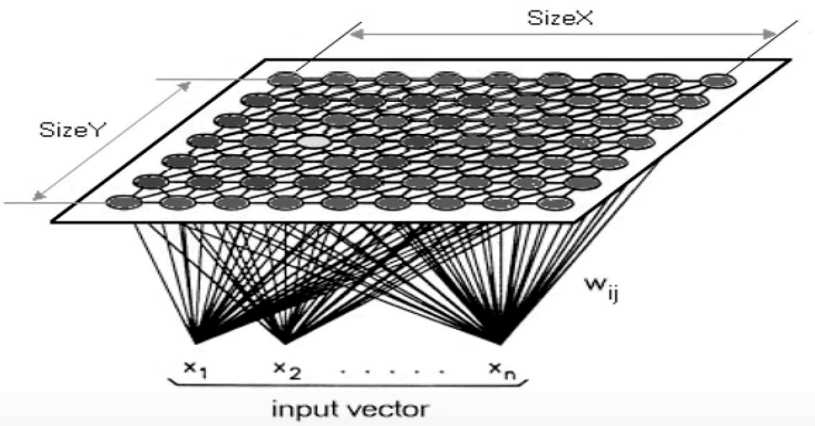
Biological Nervous System



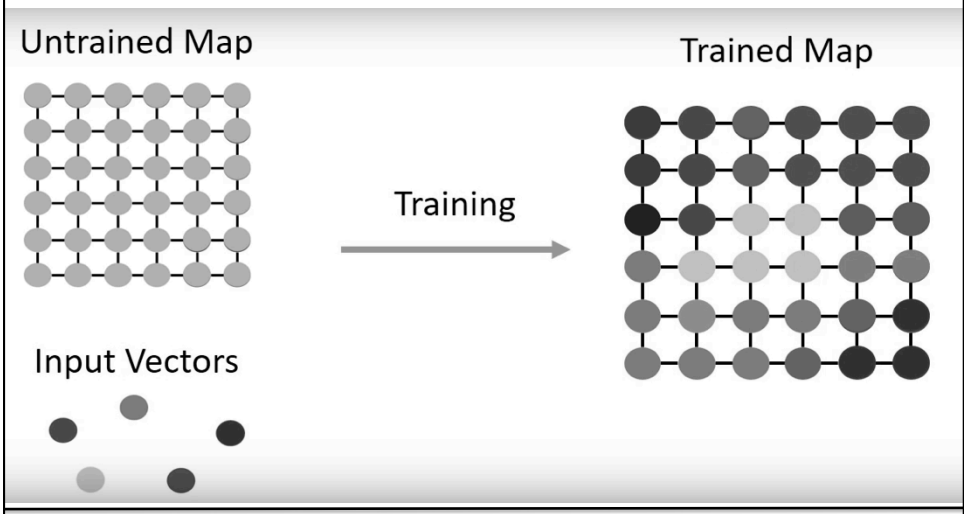
Artificial Neural Network



Unsupervised Learning: Kohonen Self-Organizing Map



Self-Organizing Maps (Kohonen Maps)



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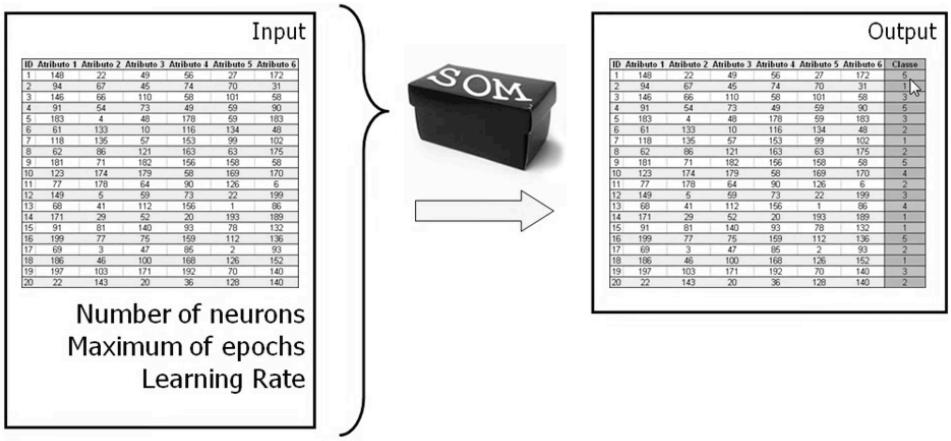
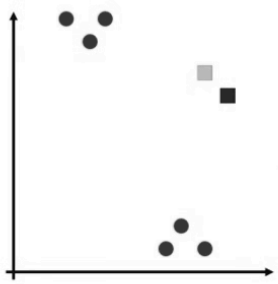


ID	Atributo 1	Atributo 2	Atributo 3	Atributo 4	Atributo 5	Atributo 6
1	148	22	49	56	27	172
2	94	67	45	74	70	31
3	146	66	110	58	101	58
4	91	54	73	49	59	90
5	183	4	48	178	59	183
6	61	133	10	116	134	48
7	118	135	57	153	99	102
8	62	86	121	163	63	175
9	181	71	182	156	158	58
10	123	174	179	58	169	170
11	77	178	64	90	126	6
12	149	5	59	73	22	199
13	68	41	112	156	1	86
14	171	29	52	20	193	189
15	91	81	140	93	78	132
16	199	77	75	159	112	136
17	69	3	47	85	2	93
18	186	46	100	168	126	152
19	197	103	171	192	70	140
20	22	143	20	36	128	140

ID	Atributo 1	Atributo 2	Atributo 3	Atributo 4	Atributo 5	Atributo 6	Classe
1	148	22	49	56	27	172	5
2	94	67	45	74	70	31	1
3	146	66	110	58	101	58	3
4	91	54	73	49	59	90	5
5	183	4	48	178	59	183	3
6	61	133	10	116	134	48	2
7	118	135	57	153	99	102	1
8	62	86	121	163	63	175	2
9	181	71	182	156	158	58	5
10	123	174	179	58	169	170	4
11	77	178	64	90	126	6	2
12	149	5	59	73	22	199	3
13	68	41	112	156	1	86	4
14	171	29	52	20	193	189	1
15	91	81	140	93	78	132	1
16	199	77	75	159	112	136	5
17	69	3	47	85	2	93	2
18	186	46	100	168	126	152	1
19	197	103	171	192	70	140	3
20	22	143	20	36	128	140	2

Self-Organizing Maps (Kohonen Maps)



Operations

Select random input

Compute winner neuron

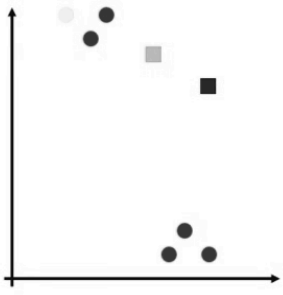
Update neurons

Repeat for all input data

Classify input data

□ 2 Neurons
○ 6 Inputs

Self-Organizing Maps (Kohonen Maps)



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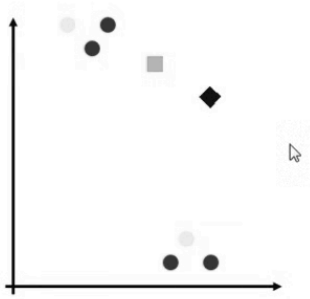

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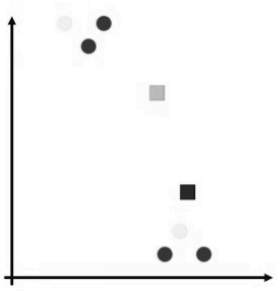

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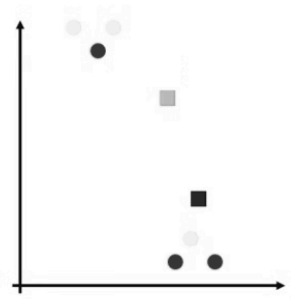

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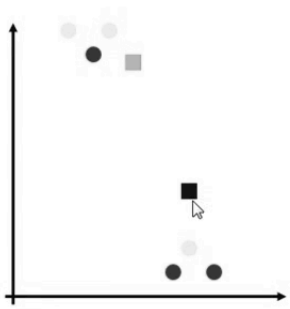
Self-Organizing Maps (Kohonen Maps)



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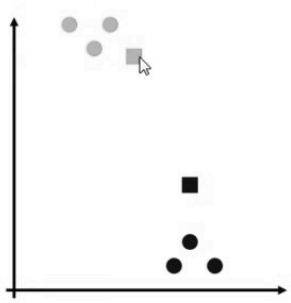
Self-Organizing Maps (Kohonen Maps)



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Self-Organizing Maps (Kohonen Maps)

In the BPN, we used **supervised** learning.

This is not biologically plausible: In a biological system, there is no external "teacher" who manipulates the network's weights from outside the network.

Biologically more adequate: **unsupervised** learning.

We will study Self-Organizing Maps (SOMs) as examples for unsupervised learning (Kohonen, 1980).

Self-Organizing Maps (Kohonen Maps)

- In the human cortex, multi-dimensional sensory input spaces (e.g., visual input, tactile input) are represented by two-dimensional maps.
- The projection from sensory inputs onto such maps is topology conserving.
- This means that neighboring areas in these maps represent neighboring areas in the sensory input space.
- For example, neighboring areas in the sensory cortex are responsible for the arm and hand regions.

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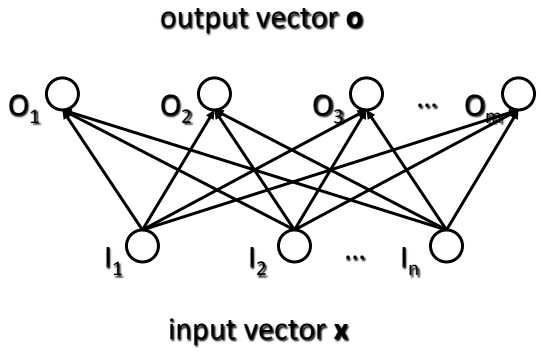
Introduction of SOM contd…

- Maintains the topology of the dataset
- Training occurs via competition between the neurons
- Impossible to assign network nodes to specific input classes in advance
- Can be used for detecting similarity and degrees of similarity
- It is assumed that input pattern fall into sufficiently large distinct groupings
- Random weight vector initialization

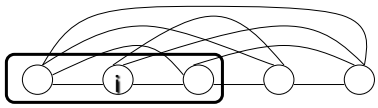
Self-Organizing Maps (Kohonen Maps)

•BPN structure:

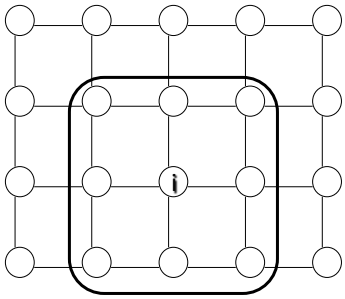


Self-Organizing Maps (Kohonen Maps)

Common output-layer structures:



One-dimensional
(completely interconnected
for determining "winner" unit)



Two-dimensional
(connections omitted, only neighborhood
relations shown [green])

Neighborhood of neuron i

Unsupervised Learning in SOMs

For n-dimensional input space and m output neurons:

(1) Choose random weight vector w_i for neuron i, i = 1, ..., m

(2) Choose random input x

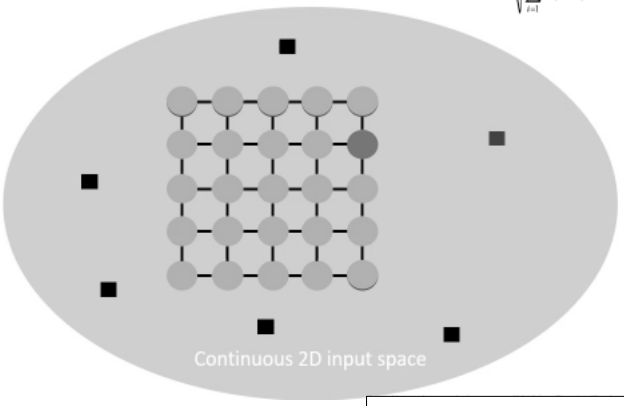
(3) Determine winner neuron k:
$||w_k - x|| = \min_i ||w_i - x||$ (Euclidean distance)

(4) Update all weight vectors of all neurons i in the neighborhood of neuron k: $w_i := w_i + \eta \cdot \varphi(i, k) \cdot (x - w_i)$
(w_i is shifted towards x)

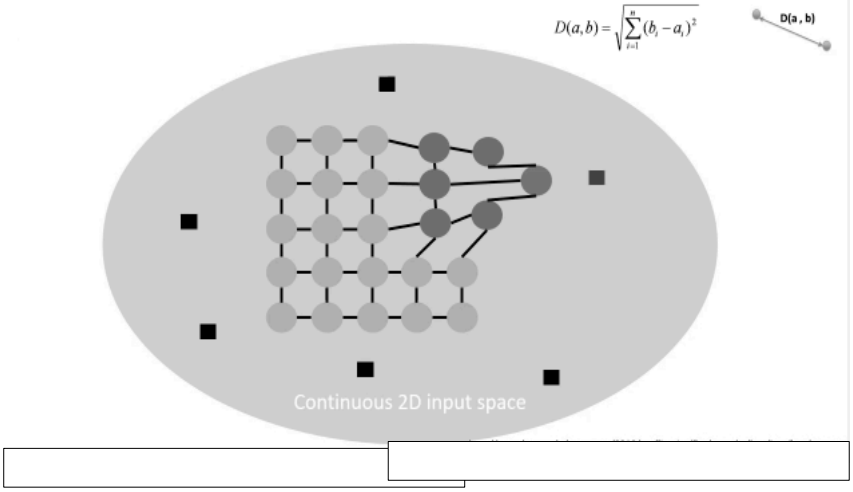
(5) If convergence criterion met, STOP.
Otherwise, narrow neighborhood function φ and learning parameter η and go to (2).

Self-Organizing Maps (Kohonen Maps)

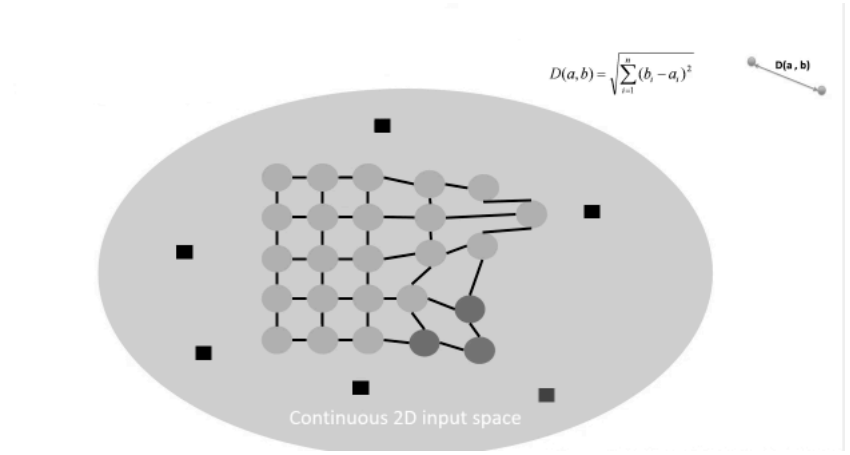
$$D(a,b) = \sqrt{\sum_{i=1}^{n} (b_i - a_i)^2}$$



Self-Organizing Maps (Kohonen Maps)



Self-Organizing Maps (Kohonen Maps)



Get Best Matching Unit

- Any method for vector distance i. e.
  - –Nearest neighbor
  - –Farthest neighbor
  - –Distance between means
  - –Distance between medians
- Most common method is Euclidean distance.

$$\sqrt{\sum_{i=0}^{n} x_i^2}$$

- More than one contestant, choose randomly

Tugas LVQ dan SOM

- Download data Ecoli : http://archive.ics.uci.edu/ml/datasets/Ecoli
- Buat program LVQ (classification) dan SOM (clustering) → Tidak boleh menggunakan library (R atau Python atau C++)
- Bandingkan kinerja LVQ dan SOM
- Dikumpulkan tanggal: 18 April 2017