Kohonen Feature Nets for Typification

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- Kohonen Feature Nets
- application of Kohonen Feature Nets to typification problem
- summary and outlook

Typification

- typification applies to generalization of groups of objects

- typification is the process of reducing the information content of a spatial phenomenon while **preserving the overall spatial structure** (no arbitrary reduction of number of objects!)

- typical approach:
  - determination of reduction rate
  - recognition of structure – i.e. groups, neighborhood structure
  - simplification of individual elements in group

Kohonen Feature Nets for Typification

- neural network learning technique, unsupervised learning method
- given:
  - feature space ***E*** of dimension **m** with training vectors (stimuli) **x**
  - map space ***A*** of dimension **d** with connected neurons (dimension **d** is typically 1 or 2)
- every neuron in the map space is described by the tuple **U=(w,p),** i.e. a weight **w** in ***E*** and a position **p** in ***A***
- weights of neurons correspond to positions in feature space, that are iteratively adjusted to the training vectors
- all neurons are connected →change of one neuron results in changes of its neighbors

Algorithm

- stimulus: selection of one training vector (attractor) v
- response: determination of neuron $\boldsymbol{U_c}$, whose weight w_c is most similar to the stimulus (similarity is determined by spatial proximity – Euclidian distance)

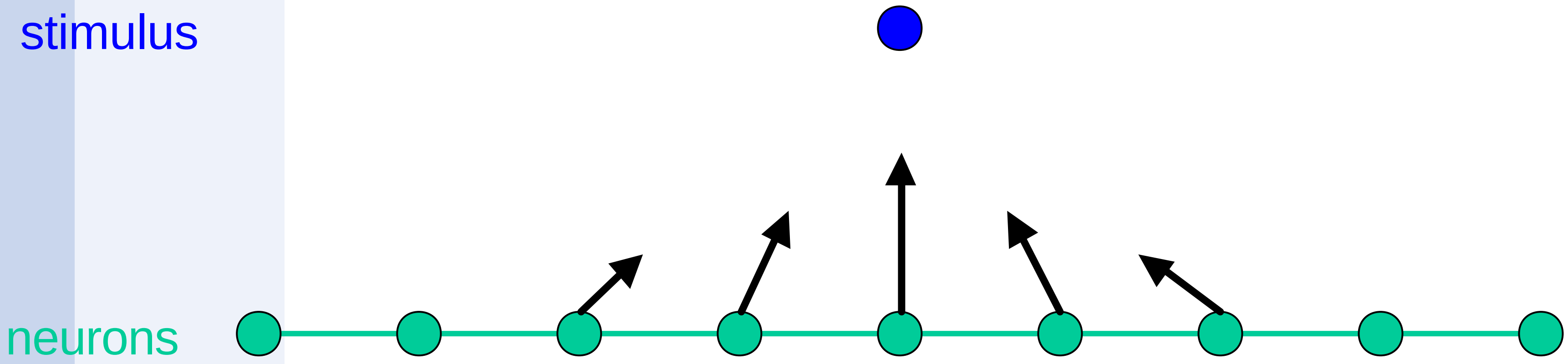
$$|v - w_c| \leq |v - w_r| \quad \forall r \in A$$

- adaptation of weights of neuron and its neighbors in order to make the weights more similar to the stimulus

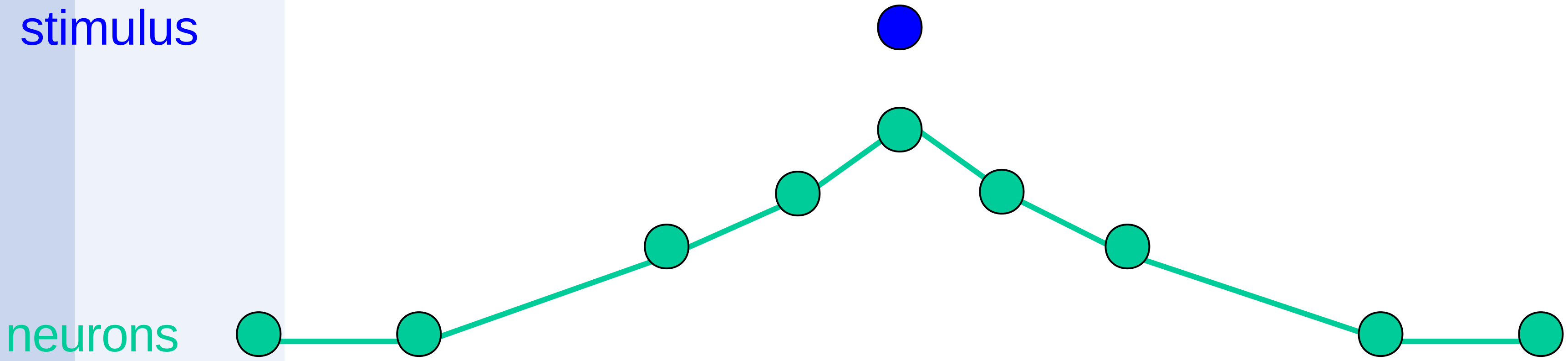
$$w_r^{new} = w_r^{old} + h\ h(v - w_r^{old})$$

- depending on learning rate h**(t)** and neighborhood ***h***
  - first iterations: large neighborhood – coarse structure of net, optimal distribution of the neurons
  - later iterations: small neighborhood – local adaptation, convergence

Principle



Principle

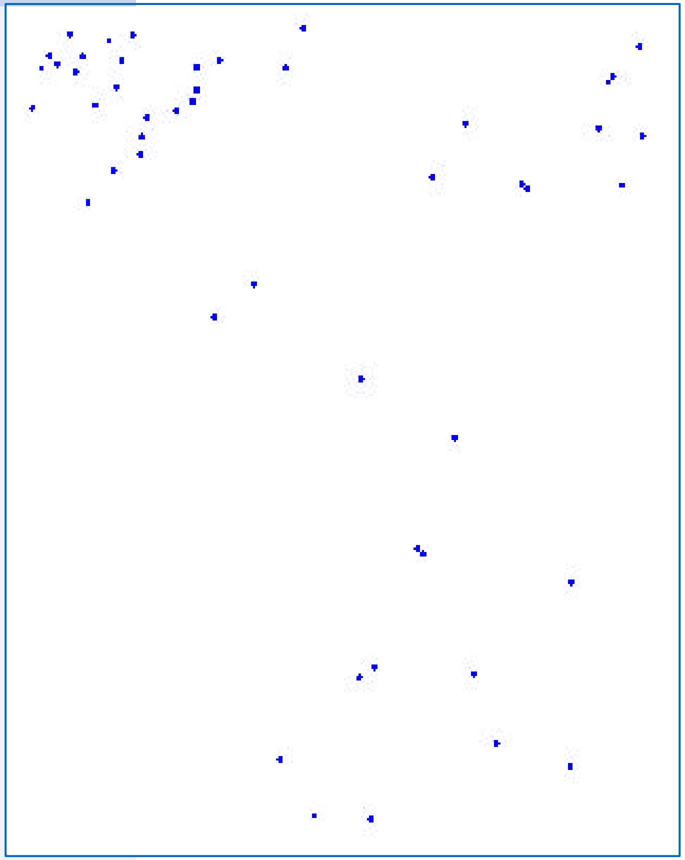


Application to typification – assumptions

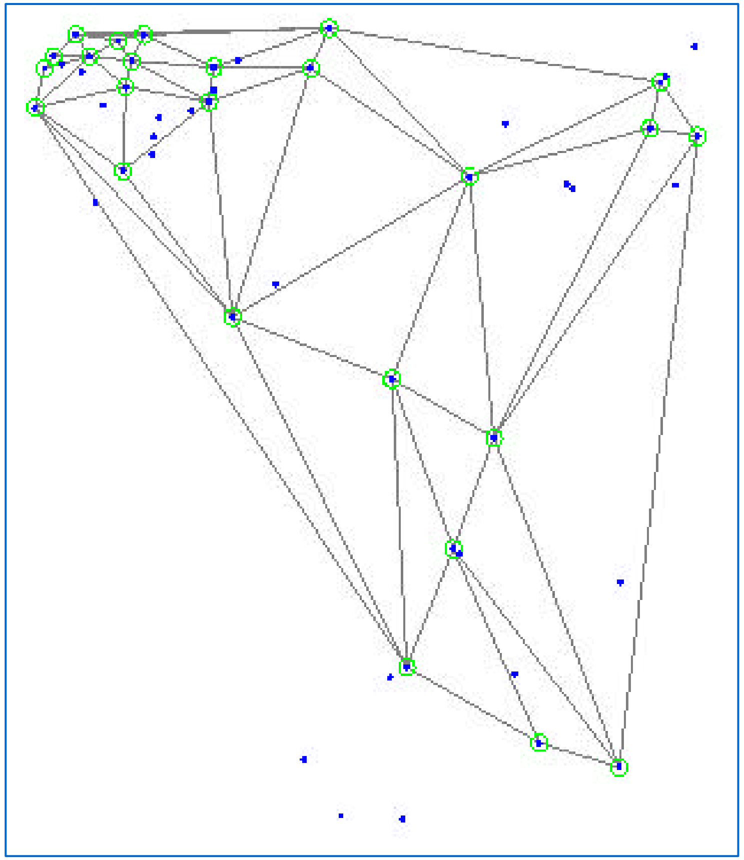
- assumptions
  - objects are given as point objects
  - all objects are of equal importance
- process steps
  - determination of reduction rate
  - random selection of points
  - determination of neighborhood based on Delaunay-Triangulation

- advantage: no detection of spatial distribution necessary, as it is implicit in the algorithm

Process

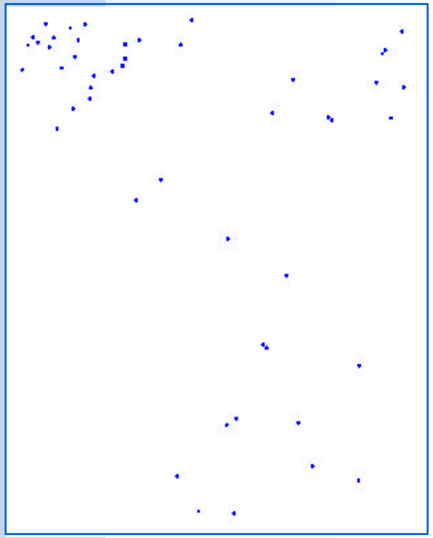


original situation:
stimuli

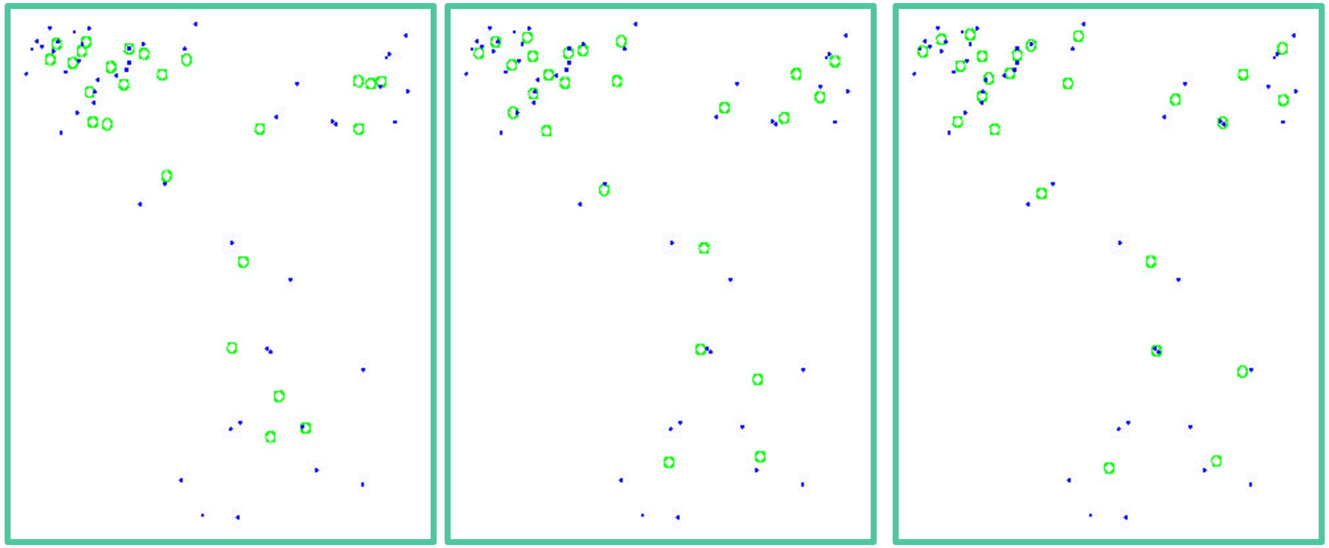


selected neurons,
triangulation

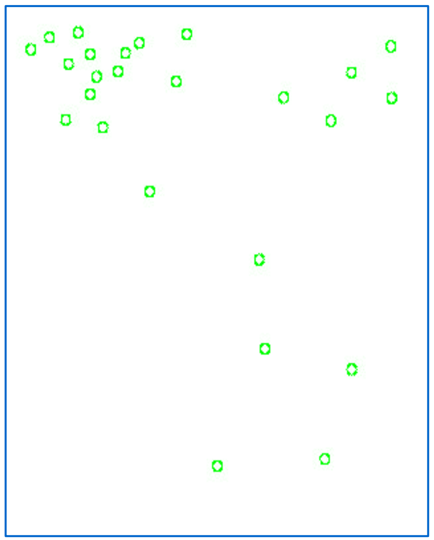
Typification – Reduction to 50%

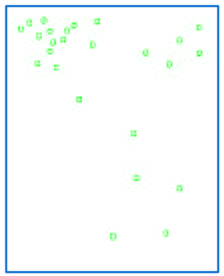


start situation



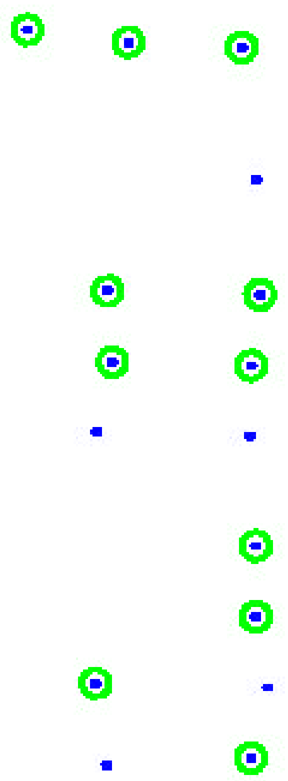
intermediate steps



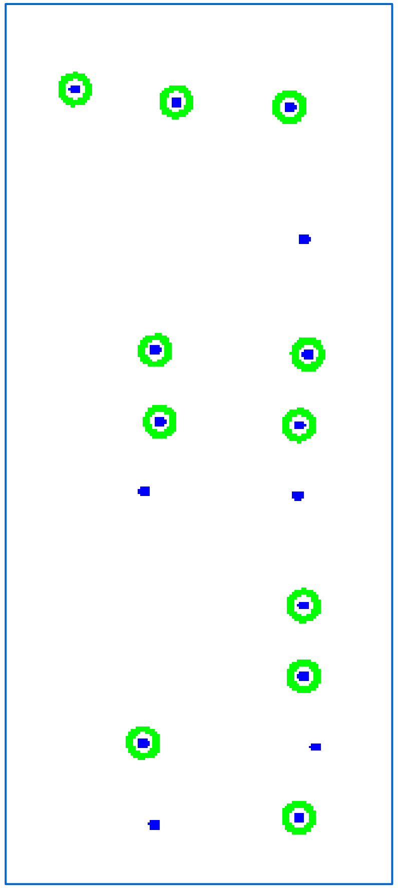


final situation

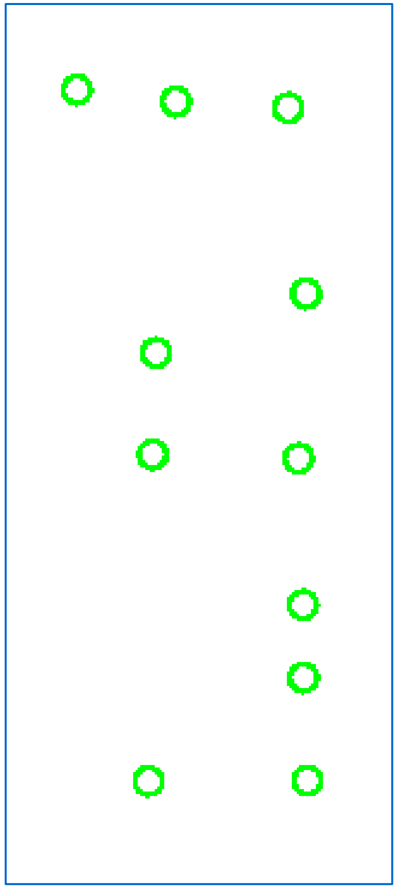
Example – linear structure



animation

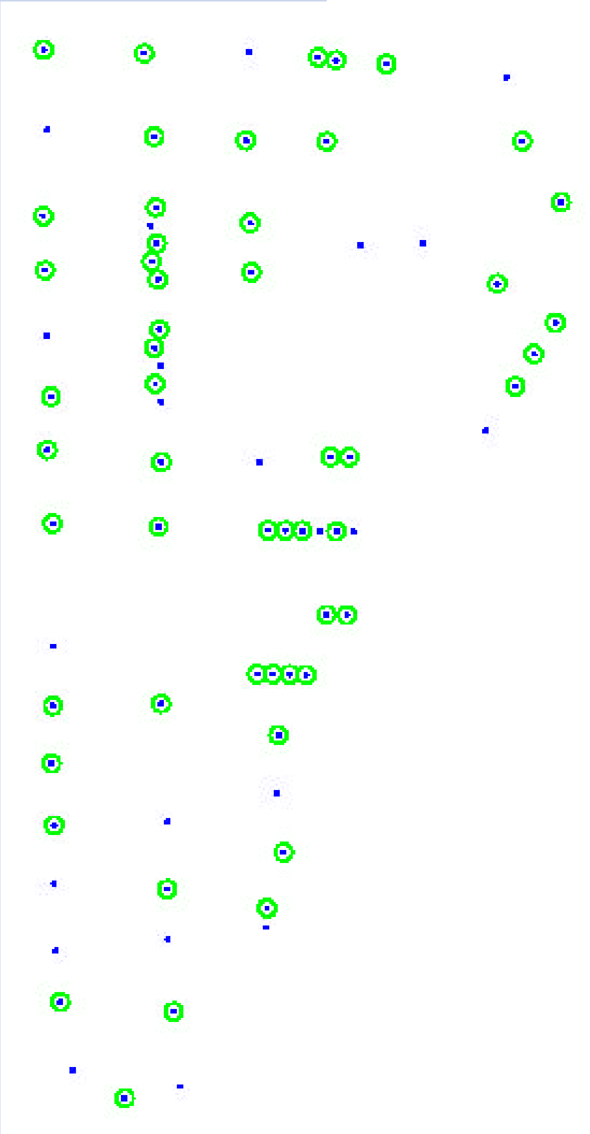


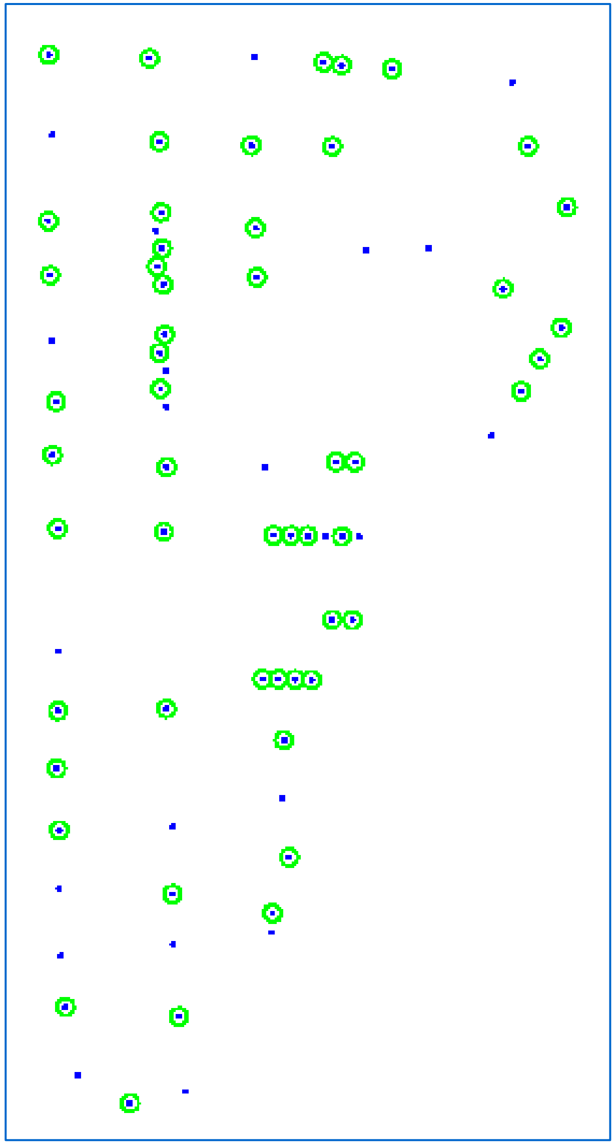
start situation

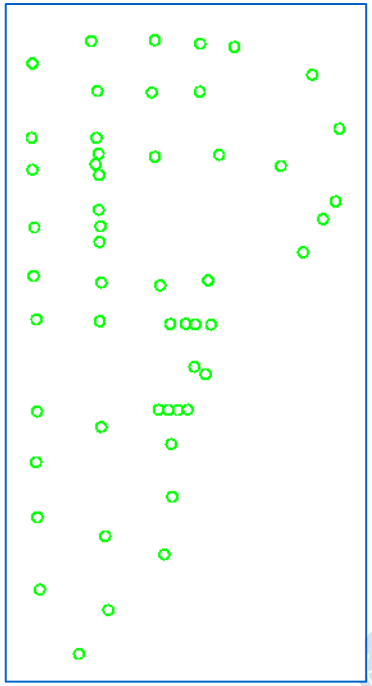


final situation

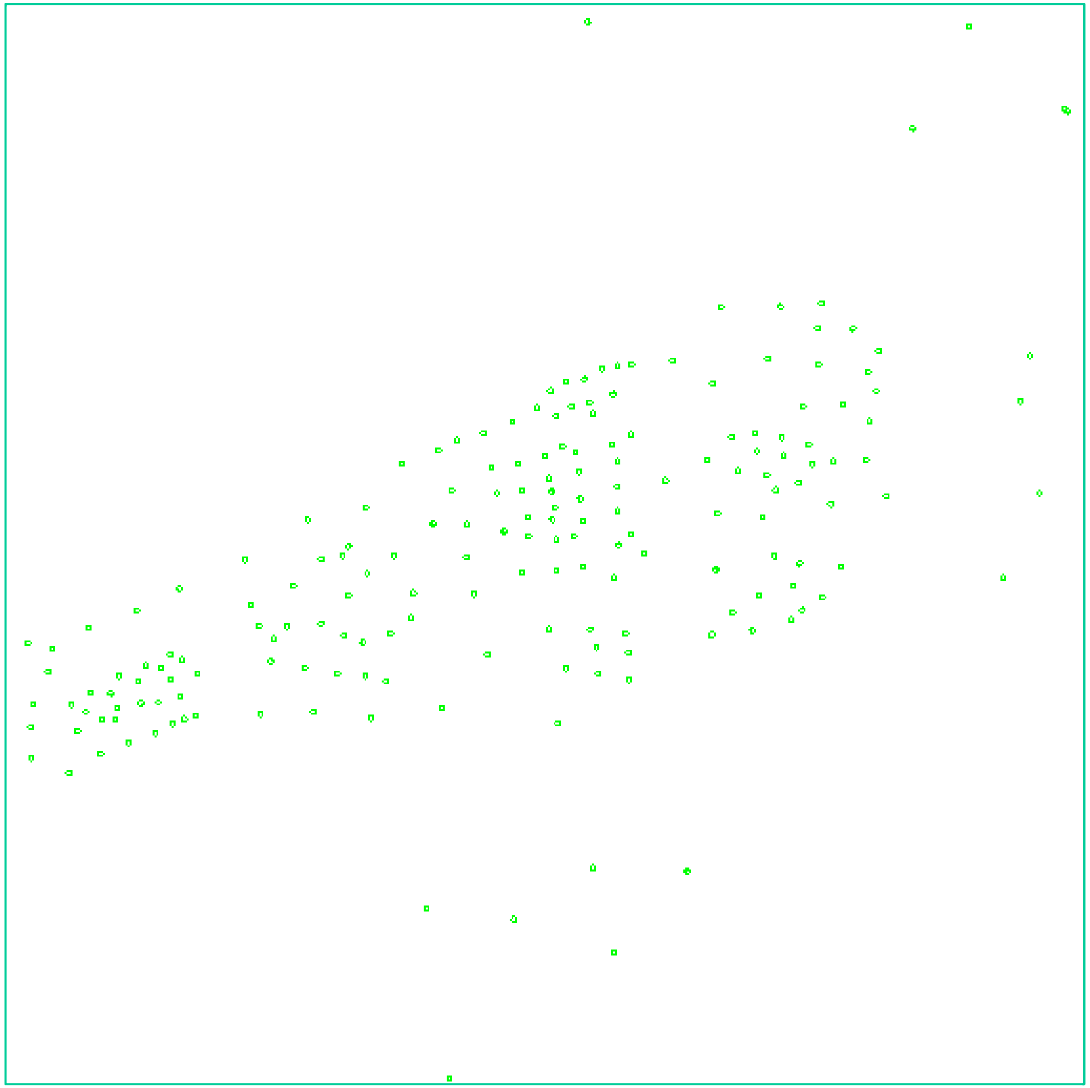
Example – regular structure







Example – large built-up area



Reduction:

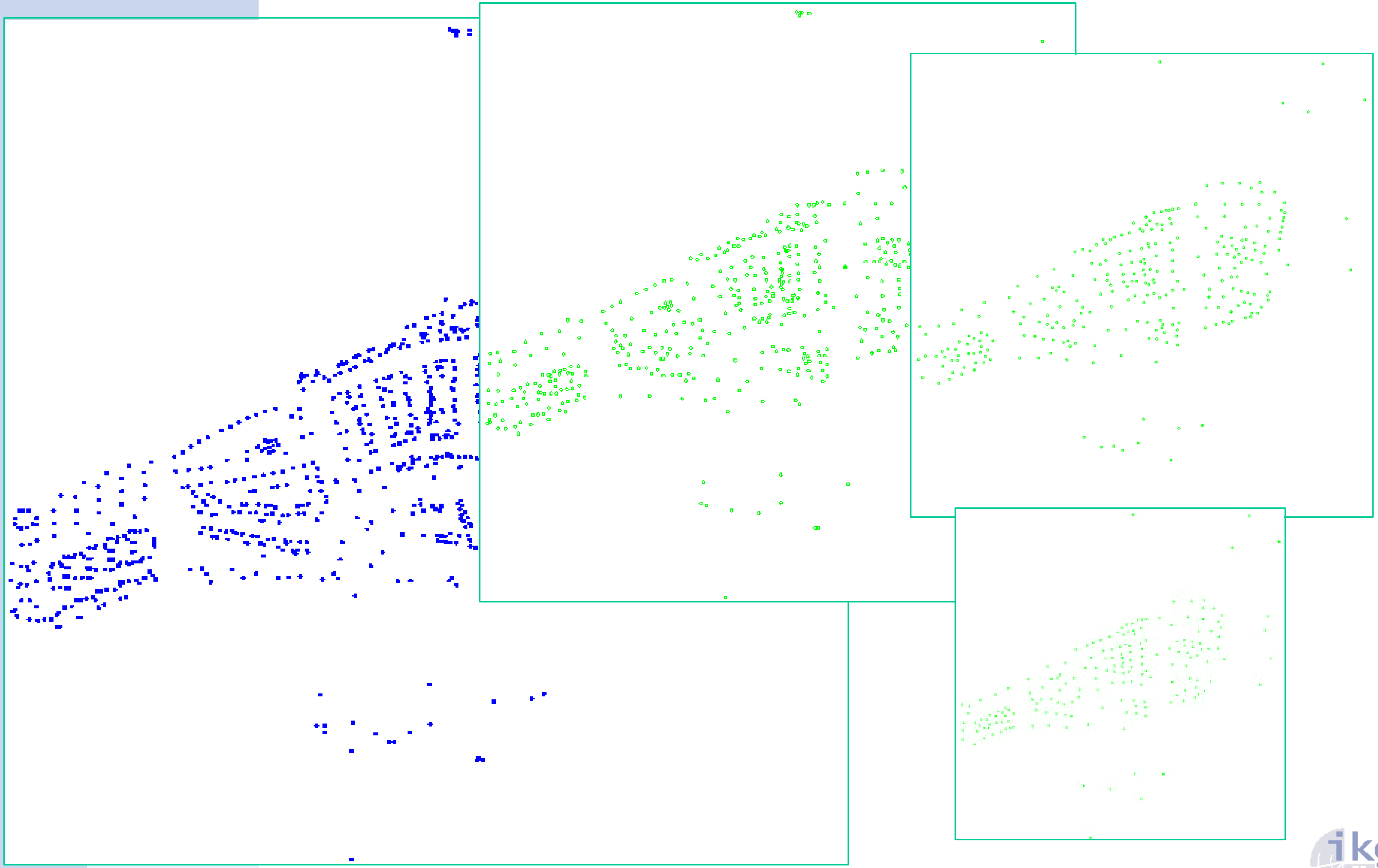
50%

30%

20%

/moni/peking

Situation in appropriate scales



Extensions

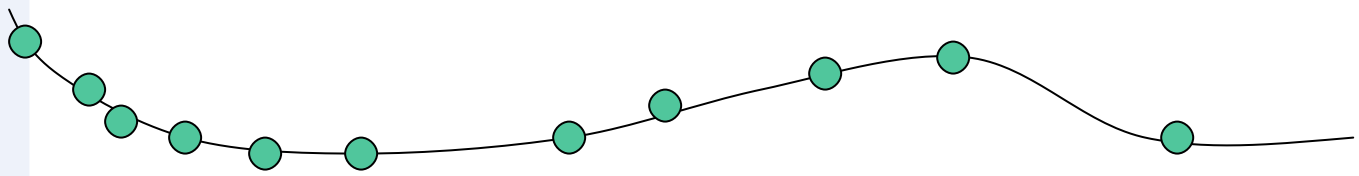
- 1D – distribution of point objects
- 2D – distribution of point objects
- 3D – distribution of point objects

Extensions – 3D

- 3D-Typification – data reduction
  - Aim: reduction of number of points on 2.5D surface, e.g. data acquired by automatic processes (e.g. image matching, laser scanning)
- Idea:
  - Eliminate points in homogeneous regions
  - Retain points at discontinuities
- Use Kohonen feature maps:
  - Derive representation in terms of gradient image
  - Give higher weight to gradient points, i.e. these points „fire“ more often
  - Effect: points „move“ into the direction of gradients

Extensions – 1D

- 1D – distribution of point objects
  - Line simplification → reduction in number of points
    - All points are equal
    - Use curvature as weight
  - Mathieu's idea: points represent features, e.g. bends of a street; → reduction in the number of bends



Extensions (ff)

- Introduction of known spatial relations
  - Preserve both connection and spatial arrangement (e.g. collinearity) using „stiff“ links
- Include objects of different importance
  - Prioritize selection of important objects
  - Important objects „fire“ more often
- Introduce minimal distances (legibility)
  - Closest neuron and its neighbors are shifted towards firing object – but not closer than min_dist
- Introduce non-valid neighborhoods
  - To prevent objects moving across limiting objects (e.g. built-up area boundary, road, …)
  - Check if shortest distance crosses limiting object

Extensions

- Assign value to new representative, e.g.
  - building properties: size, type, orientation, …
  - Height value

- Different possibilities: value of
  - Original object closest to neuron
  - Average (max, min, …) of n closest
  - Average (max, min, …) of points within Voronoi region

Summary and Outlook

- Kohonen Feature nets arrange objects according to given underlying spatial situation
- fast operation
- only a few iterations are needed, as good approximate values are given
- robust with respect to parameters
- Introduce importance of individual objects
- extension to 3D possible

- advantage:
  - no structure recognition necessary
  - one-step procedure