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 $\Rightarrow$ change of one neuron results in changes of its neighbors
Algorithm

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

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

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

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

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

stimulus

neurons
Principle

stimulus

neurons
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%
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