A Growing Neural Gas Network Learns Topologies

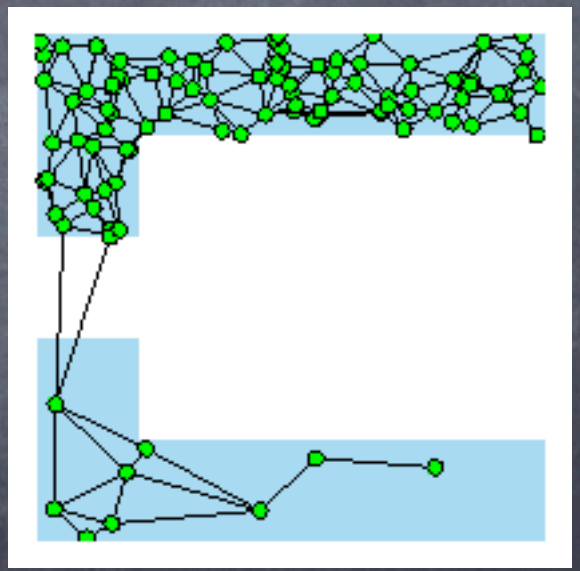
Presentation by Jonathan Beall
on the paper by Bernd Fritzke

Growing Neural Gas

- Adjust units and connections to approximate input data topology.
- Unsupervised learning
  - Dimensionality reduction
  - Topology learning

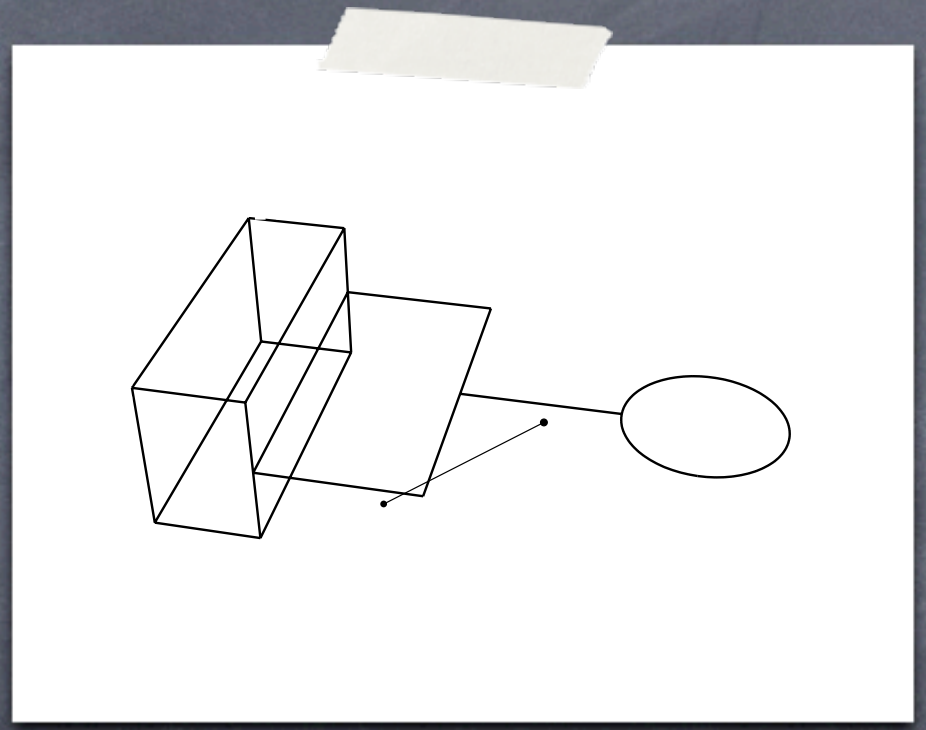
Competitive Hebbian Learning (CHL)

- For each input signal, connect the closest two centers.
- Can add in aging to eliminate now-irrelevant connections
- Creates a subgraph of the Delaunay triangulation

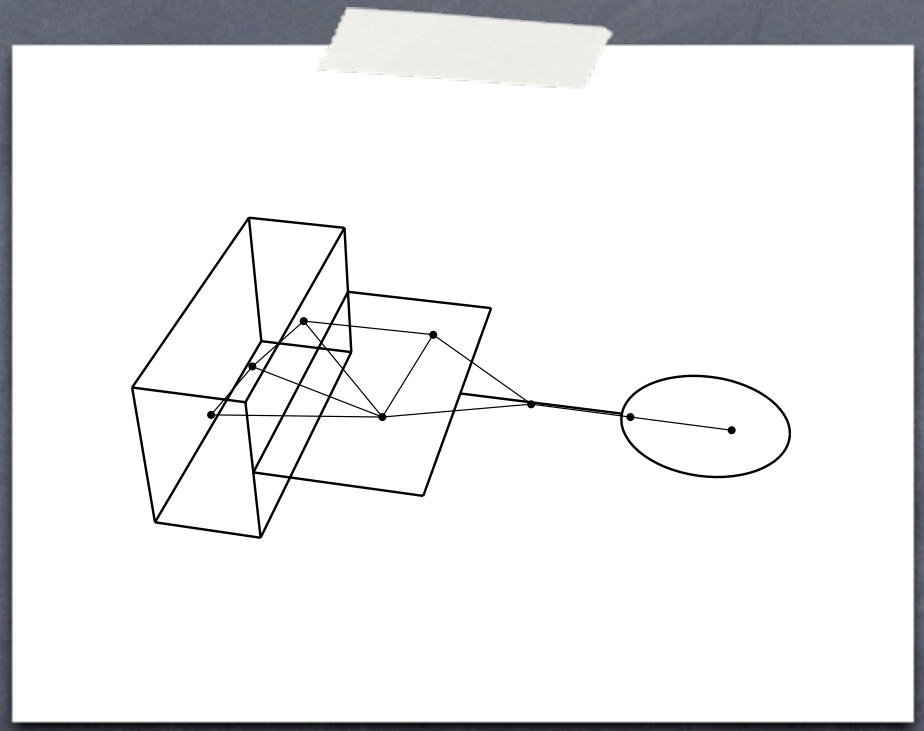


CHL and Neural Gas

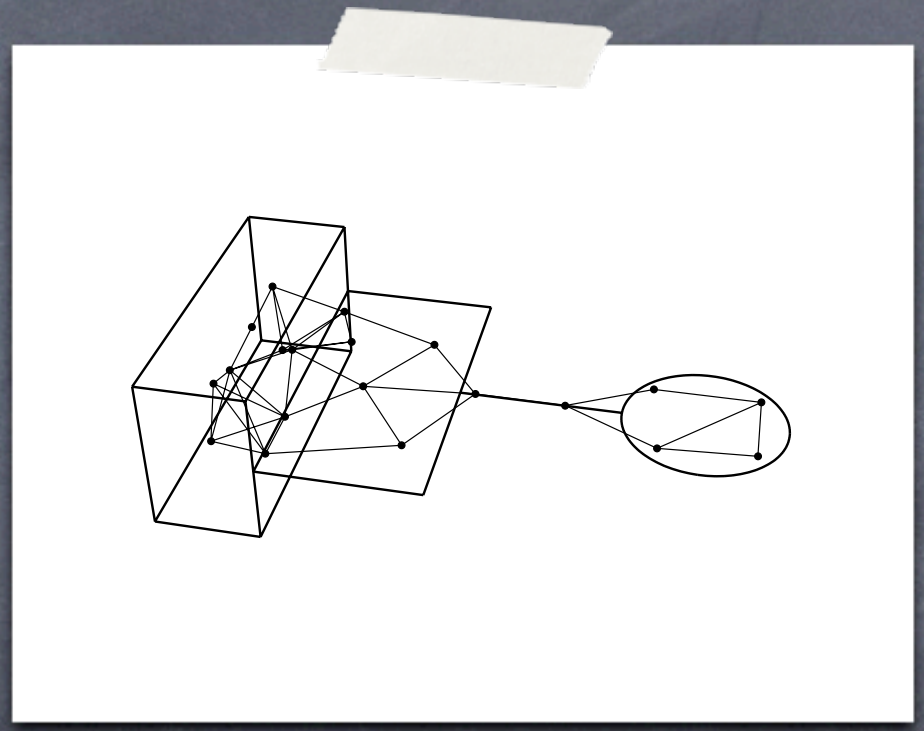
- Place all centers
- For each input
  - Perform CHL
  - Move the k closest centers toward the input
- k decays over time—annealing.



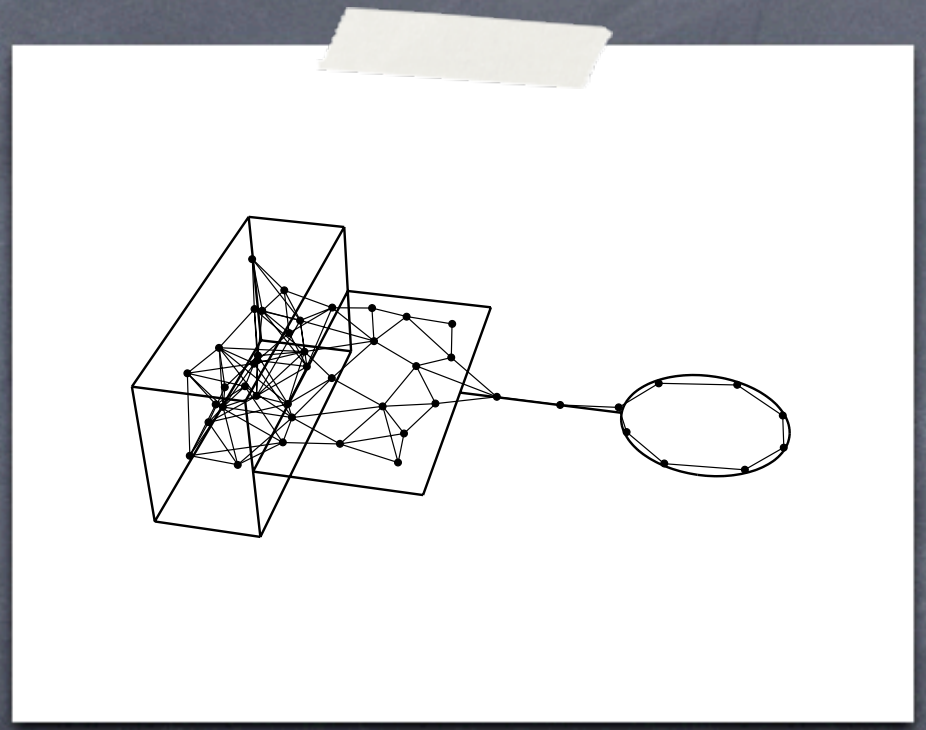
GNG in Action



GNG in Action



GNG in Action



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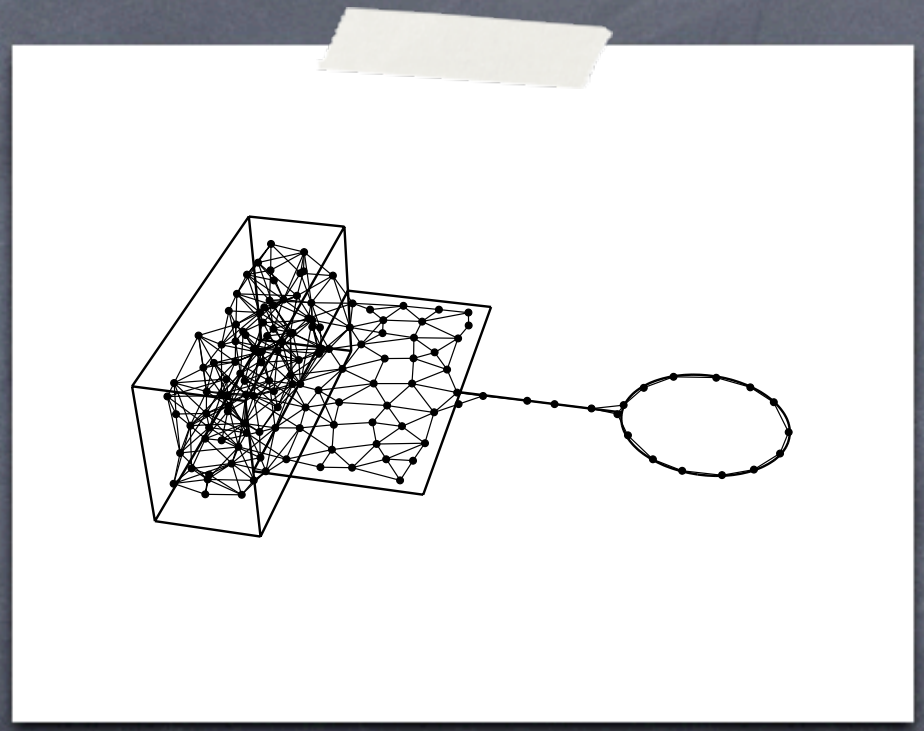

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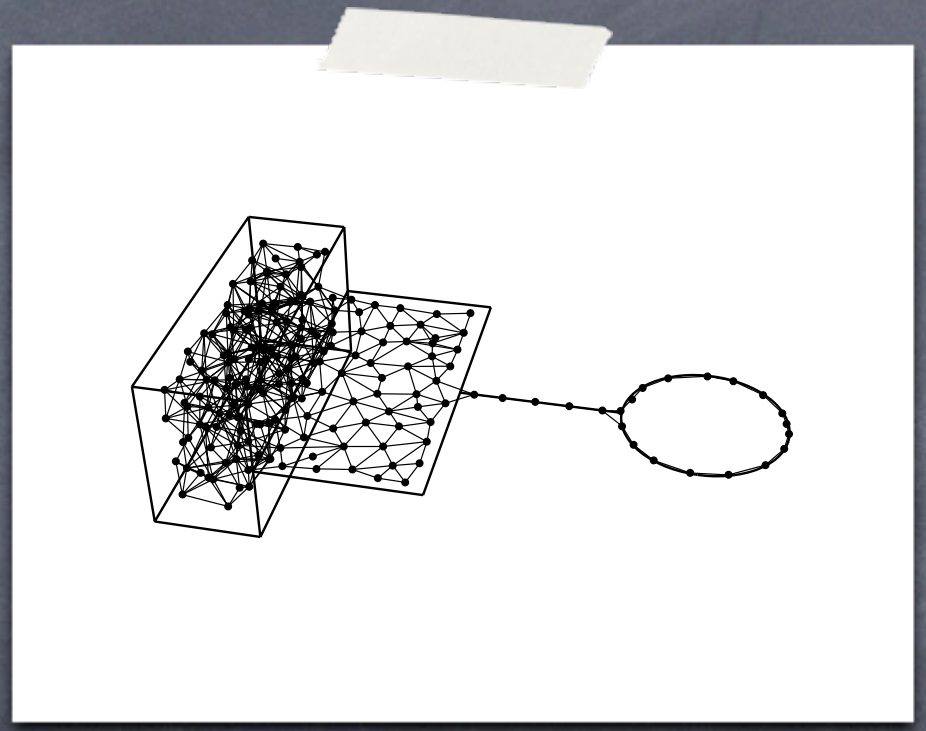


GNG in Action

Growing Neural Gas Algorithm

- Start with 2 random units
- Generate a random signal ξ and find two nearest units, s_1 and s_2.
- Increment the age of all edges coming from s_1.
- Add the squared distance $||s_1-\xi||^2$ to s1's error counter.

- Move s_1 and it's direct neighbors s_n towards ξ by fractions ϵ_b and ϵ_n, respectively, of the total distance.

- If s_1 and s_2 are connected, set the age of the edge connecting them to 0, otherwise create an edge between them.

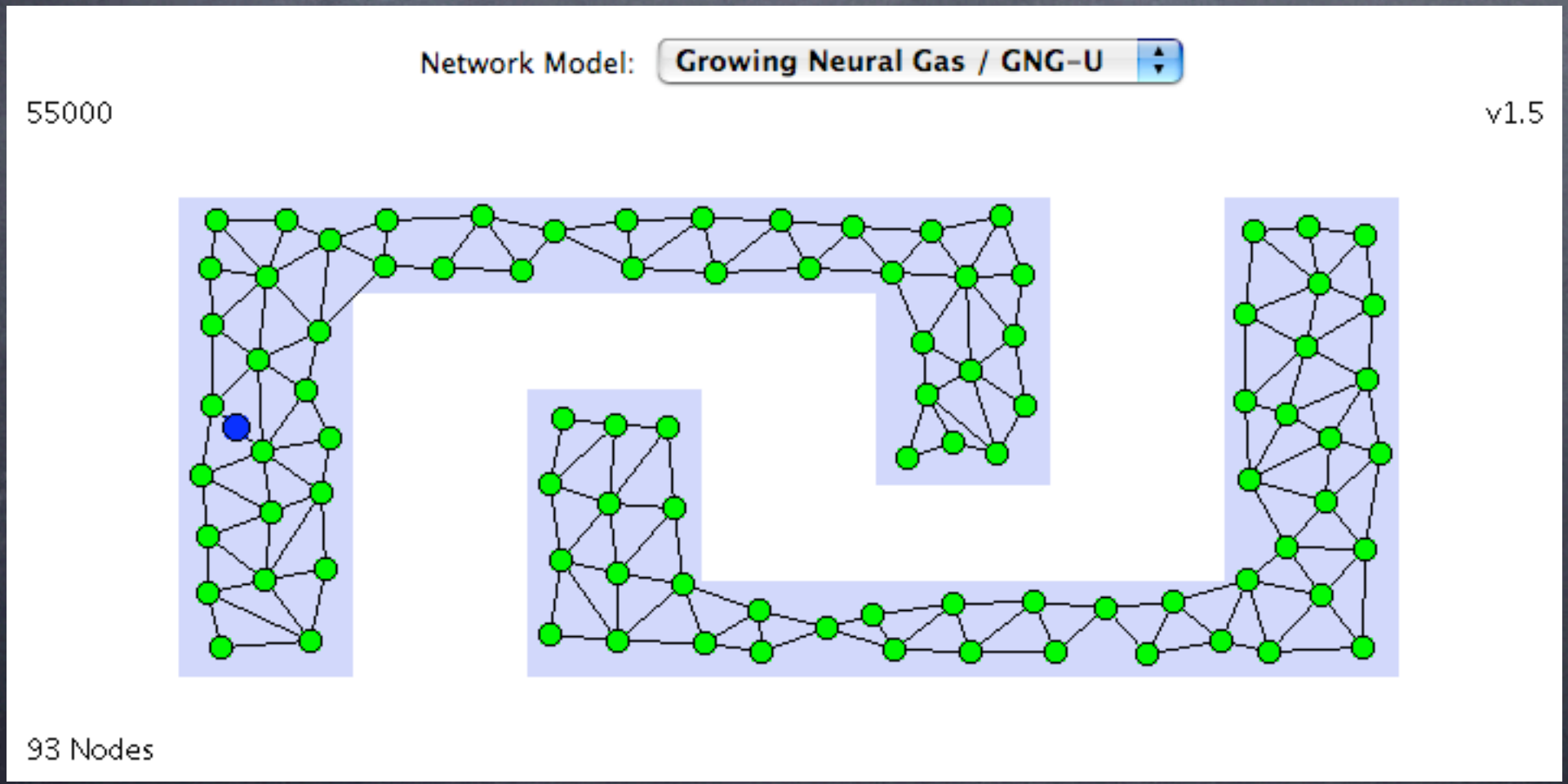
- Remove any edges with ages larger than a_{max}. If this leaves any units with no edges, delete them.

- Every λ input signals, insert a new unit:
  - Find the unit q with the maximum error.
  - Find q's neighbor f with the largest error.
  - Insert a new unit r between q and f
  - Decrease the errors of q and f by multiplying them by a constant α, and then set the error of r to q's new error.

- Decrease all error variables by multiplying them by a constant d.
- If the network is not yet complete (size, performance...), begin again by generating a new signal, ξ.

GNG Applet

http://www.neuroinformatik.ruhr-uni-bochum.de/ini/VDM/research/gsn/JavaPaper/

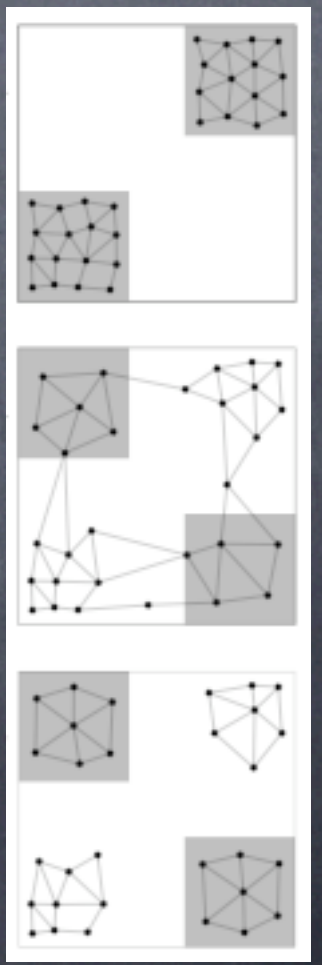


Benefits of GNG

- Variable dimensionality
- Constant parameters
- No set termination time
- Soft competition helps skip over local minima
- Insertion based on batch accumulated errors helps to avoid overfitting
- Efficient—time increases linearly with the number of links

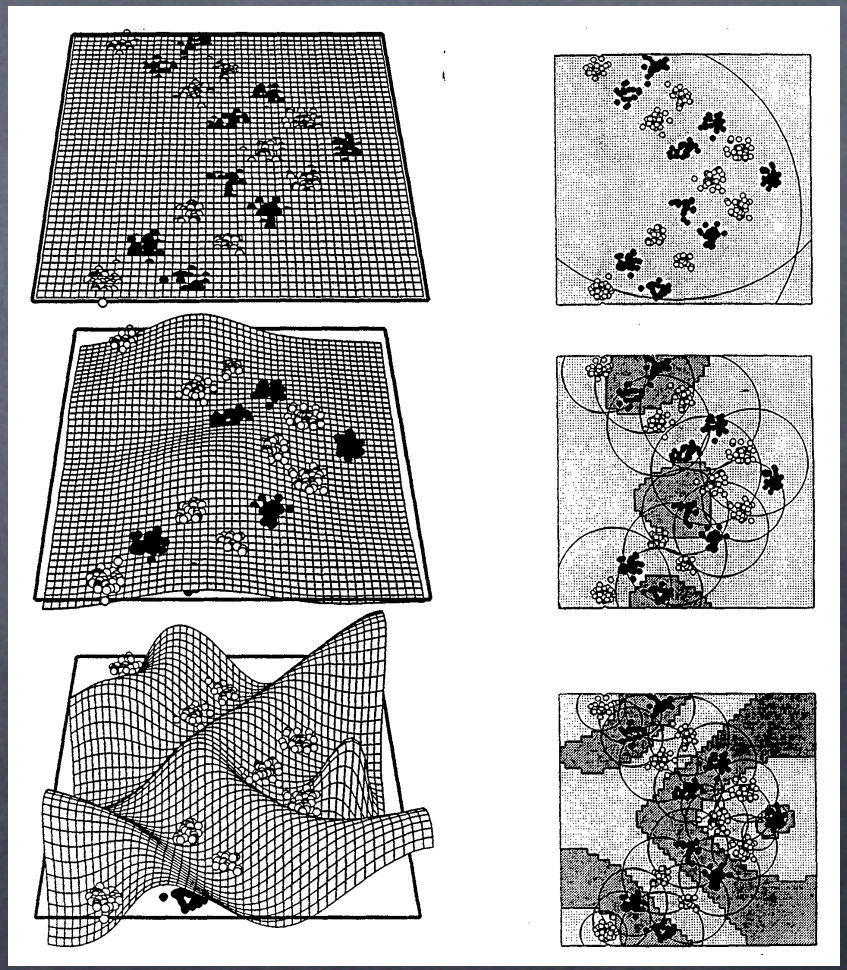
Drawbacks of GNG

- No cooling schedule, so no long term stability
- 7 parameters must be set
- CHL is not batch-driven, is sensitive to noise
- Can leave stranded units when exposed to rapidly changing data (GNG-U)
- Cannot visualize higher dimension GNGs easily.



Applications of GNG

- Incremental radial basis function networks
- 2-stage hybrid classifier (Baraldi and Blonda)
- Stability assessment of electric power systems (Rehtans and Leder)



Sources

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