

# Super Resolution

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## 1. Kohonen's self organizing feature maps

One important organizing principle of sensory pathways in the brain is that the placement of neurons is orderly and often reflects some physical characteristic of the external stimulus being sensed [1]. For example, at each level of the auditory pathway, nerve cells and fibers are arranged anatomically in relation to the frequency which elicits the greatest response in each neuron. This tonotopic organization in the auditory cortex [1]. Although much of the lowlevel organization is genetically pre-determined, it is likely that some of the organization at higher levels is created during learning by algorithms which promote self-organization. Kohonen [2] presents one such algorithm which produces what he calls self-organizing feature maps similar to those that occur in the brain.

Kohonen's algorithm creates a vector quantizer by adjusting weights from common input nodes to M output nodes arranged in a two dimensional grid as shown in Figure. 1.

Output nodes are extensively interconnected with many local connections. Continuous-valued input vectors are presented sequentially in time without specifying the desired output. After enough input vectors have been presented, weights will specify cluster or vector centers that sample the input space such that the point density function of the vector centers tends to approximate the probability density function of the input vectors [2]. In addition, the weights will be organized such that topologically close nodes are sensitive to inputs that are physically similar. Output nodes will thus be ordered in a natural manner. This may be important in complex systems with many layers of processing because it can reduce lengths of inter-layer connections.

The algorithm that forms feature maps requires a neighborhood to be defined around each nodes as shown in Figure. 2.

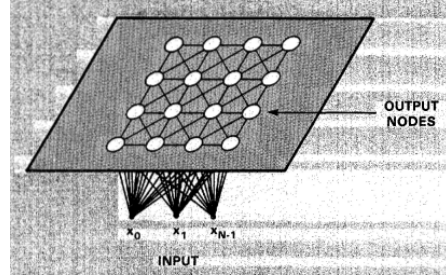


Figure 1: Two-dimensional array of output nodes used to form feature maps.

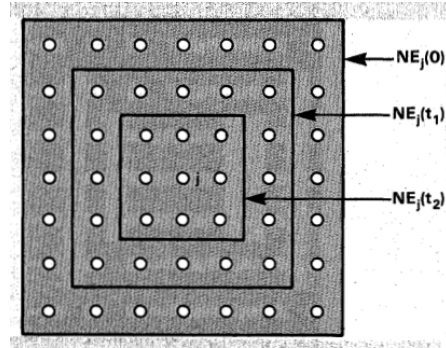


Figure 2: Topological neighborhoods at different times as feature maps are formed.

## References

- [1] E. R. Kandel, J. H. Schwartz, T. M. Jessell, S. A. Siegelbaum, A. J. Hudspeth, et al. *Principles of neural science*. McGraw-Hill New York, 2000. 1
- [2] T. Kohonen. *Self-Organization and Associative Memory*. Springer-Verlag, 1984. 1