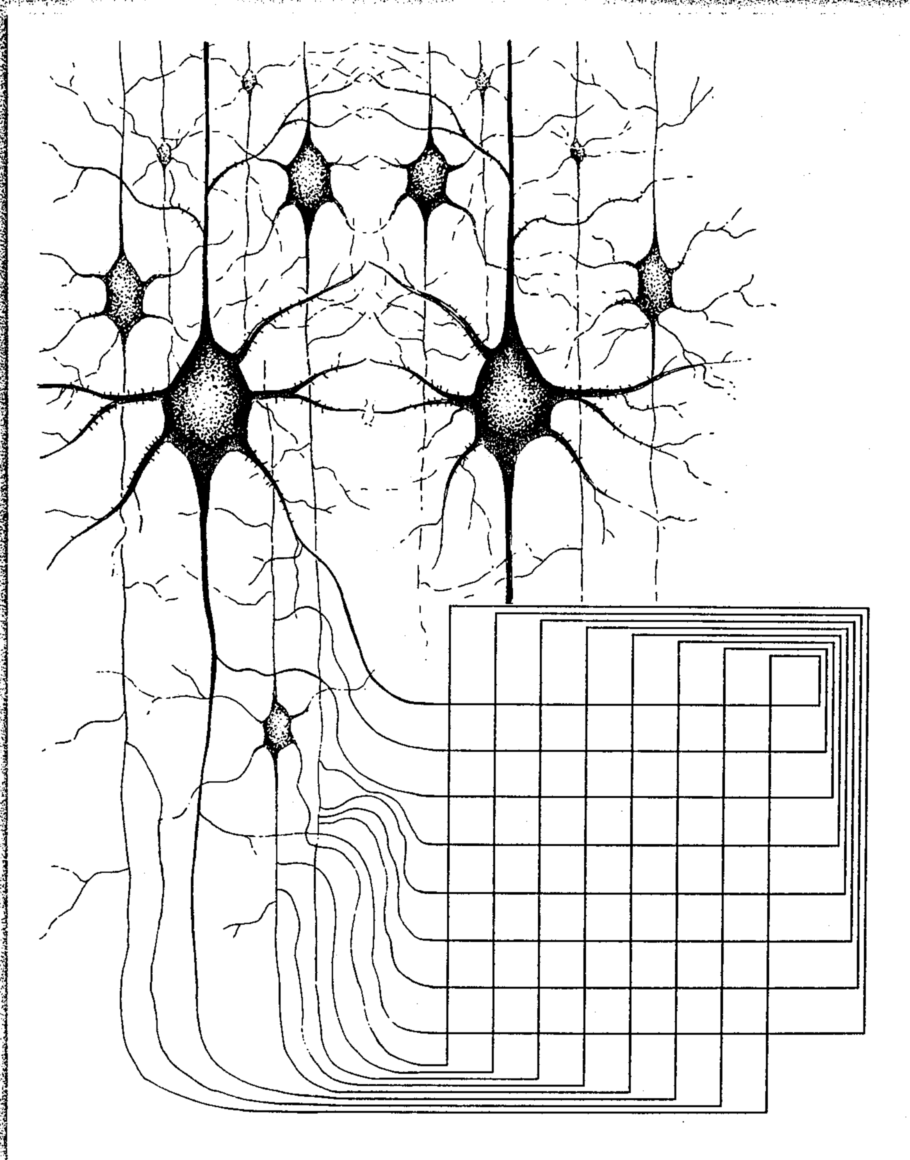
ABSTRACTS OF THE FIRST ANNUAL INNS MEETING, BOSTON, 1988

Volume 1, Supplement 1, 1988

NEURAL NETWORKS

The Official Journal of the International Neural Network Society



Pergamon Press
PERGAMON PRESS 1948–1988
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PATTERN RECOGNITION AND FAULT TOLERANCE IN NON-LINEAR NEURAL NETWORKS. R.Brause, FB Informatik VSFT, J.-W. Goethe University, Postfach 111932, D-6000 Frankfurt 11, WEST-GERMANY

In the research of Neural Networks it is widely agreed that non-linearities (e.g.thresholds) in the response of an activated neural element can suppress noise and crosstalk of other neuronal elements.
The paper investigates in detail these fault-tolerance properties for a network layer.
The input lines $\mathbf{x} = (x_1,...,x_n)^T$ of the investigated network are coupled to the output lines $\mathbf{y} = (y_1,...,y_m)^T$ by a connectivity matrix **M**

$$\mathbf{y} = \mathbf{M}\,\mathbf{x}$$

This kind of device can be used as an associative memory [KOH] if the coefficients of **M** are learned by Hebb's law. By introducing a threshold to the linear output, the device output function becomes non-linear

$$\mathbf{y} = \mathbf{f}\,(\mathbf{Mx}) \quad .$$

It is shown that the resulting device has pattern recognition and categorization properties due to vector quantization. In the case of orthogonal, stored output patterns $\mathbf{y}^1...\mathbf{y}^p$ (*orthogonal projection*) the storage of the input- output associations $(\mathbf{x}^k,\mathbf{y}^k)$ causes the pattern space $\{\mathbf{x}\}$ of non-negative **x** to devide into non-overlapping subsets (*classes*). Each class k is represented by its class-prototype $\mathbf{x}^k$; the input **x** of the subset k evokes the same output response $\mathbf{y}^k$ as the class-prototype itself. It is shown that the similarity measure (cross-correllation or distance) used in the vector quantization invokes as class boundary a hyperplane between the class-prototypes. The classification of every input pattern to the most resembling stored input pattern can be interpreted as fault-tolerance mechanism for the input data.

Three different threshold functions **f** are analytically investigated and their optimal thresholds t_i are calculated, viz.:

$y_i = (z_i-t_i)\ T(z_i-t_i)$	the biologically motivated neuronal suprathreshold linear function
$y_i = y_i^k\ T(z_i-t_i)$	the real-valued threshold function
$y_i = T(z_i-t_i)$	the binary threshold function for binary x_i and y_i, suitable for binary computer signals

with $\mathbf{z} := \mathbf{M}\,\mathbf{x}$, $T(x_i) = 0$ for $x_i \leq 0$, $T(x_i) = 1$ for $x_i > 0$.
It is shown that the inherent fault tolerance degree heavily depend on the coding (cross-correllation and distance) of the stored input patterns.

Furthermore, the hardware and the connection faults of the device are modelled as stuck_at_zero and stuck_at_one faults and the maximal occurence probabilities of both kinds of faults are calculated for a correct operation of the device. It is shown that the hardware model is very insensitive for faults of open connections (depending on the coding of the stored patterns) but very sensitive for faulty, active connections which is an important fact in VLSI-implementations.

[KOH] T. Kohonen, Correlation Matrix Memories, IEEE Transactions on Computers C21, 1972