Helsinki University of Technology Control Engineering Laboratory

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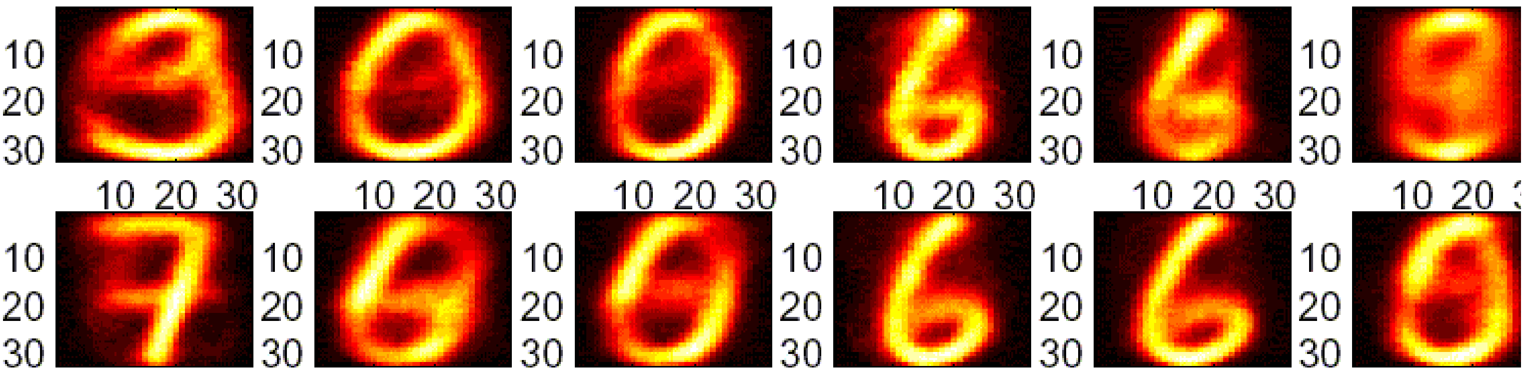
HEBBIAN NEURON GRIDS: SYSTEM THEORETIC APPROACH

Heikki Hyötyniemi



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Abstract: This report consists of three chapters that together give a view of how the very simple structures, the Hebbian/anti-Hebbian neuron grids, can implement interesting, practically and theoretically relevant functionalities.

In Chapter 1, it is shown how the very basic Hebbian/anti-Hebbian principles are only needed to implement principal subspace analysis without extra structural assumptions or nonlinearities. Stability of the neural structures is achieved by applying linear negative feedback. The proposed PCA scheme is compared against other neural principal component algorithms. The results are utilized towards a practical regression scheme, and it is shown how the same ideas can be utilized to implement a distributed sensor network.

In Chapter 2 it is shown how the Hebbian/anti-Hebbian learning principles can be extended to nonlinear neuron systems. The proposed algorithms can be interpreted as optimizing explicit optimality criteria: This interpretation offers new tools for analysis of the algorithm behavior. The optimality criterion is modified to implement sparse component analysis, and extensions towards self-organization are presented. As application examples, analysis of handwritten digits is carried out, and modeling of textual documents is illustrated.

In Chapter 3 it is shown how the proposed methodology makes it possible to integrate structural knowledge into the data-oriented framework as well, thus offering new intuitions into declarative and procedural as compared to merely associative information representations. A general cognitive model structure is suggested based on these experiences.

Keywords: Hebbian neuron, anti-Hebbian learning, principal subspace analysis, principal component regression, subspace identification, distributed sensors (Chapter 1). Optimality criteria, sparse coding, self-organization, feature extraction, pattern recognition, data mining (Chapter 2). Declarative and associative representations, cognitive models, backward chaining inference, computability theory (Chapter 3).

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