John Joseph Hopfield

Neural Networks

Biography

- John Joseph Hopfield

Princeton Homepage

- Hopfield

Hopfield Neural Networks

- Hopfield network

Five reprints

- Five Reprints

1982

Proc. Natl. Acad. Sci. USA
Vol. 79, pp. 2554–2558, April 1982
Biophysics

Neural networks and physical systems with emergent collective computational abilities

(associative memory/parallel processing/categorization/content-addressable memory/fail-soft devices)

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Contributed by John J. Hopfield, January 15, 1982

1985

Biol. Cybern. 52, 141–152 (1985)

Biological Cybernetics

"Neural" Computation of Decisions in Optimization Problems

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Abstract. Highly-interconnected networks of nonlinear analog neurons are shown to be extremely effective in computing. The networks can rapidly provide a collectively-computed solution (a digital output) to a problem on the basis of analog input information. The problems to be solved must be formulated in terms of desired optima, often subject to constraints. The general principles involved in constructing networks to solve specific problems are discussed. Results of computer simulations of a network designed to solve a difficult but well-defined optimization problem – the Traveling-Salesman Problem – are presented and used to illustrate the computational power of the networks. Good solutions to this problem are collectively computed within an elapsed time of only a few neural time constants. The effectiveness of the computation involves both the nonlinear analog response of the neurons and the large connectivity among them. Dedicated networks of biological or microelectronic neurons could provide the computational capabilities described for a wide class of problems having combinatorial complexity. The power and speed naturally displayed by such collective networks may contribute to the effectiveness of biological information processing.

Nature 1995

ARTICLES

Pattern recognition computation using action potential timing for stimulus representation

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A computational model is described in which the sizes of variables are represented by the explicit times at which action potentials occur, rather than by the more usual 'firing rate' of neurons. The comparison of patterns over sets of analogue variables is done by a network using different delays for different information paths. This mode of computation explains how one scheme of neuroarchitecture can be used for very different sensory modalities and seemingly different computations. The oscillations and anatomy of the mammalian olfactory systems have a simple interpretation in terms of this representation, and relate to processing in the auditory system. Single-electrode recording would not detect such neural computing. Recognition 'units' in this style respond more like radial basis function units than elementary sigmoid units.

2008 Neural Computation

ARTICLE Communicated by Terrence J. Sejnowski

Searching for Memories, Sudoku, Implicit Check Bits, and the Iterative Use of Not-Always-Correct Rapid Neural Computation

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The algorithms that simple feedback neural circuits representing a brain area can rapidly carry out are often adequate to solve easy problems but for more difficult problems can return incorrect answers. A new excitatory-inhibitory circuit model of associative memory displays the common human problem of failing to rapidly find a memory when only a small clue is present. The memory model and a related computational network for solving Sudoku puzzles produce answers that contain implicit check bits in the representation of information across neurons, allowing a rapid evaluation of whether the putative answer is correct or incorrect through a computation related to visual pop-out. This fact may account for our strong psychological feeling of right or wrong when we retrieve a nominal memory from a minimal clue. This information allows more difficult computations or memory retrievals to be done in a serial fashion by using the fast but limited capabilities of a computational module multiple times. The mathematics of the excitatory-inhibitory circuits for associative memory and for Sudoku, both of which are understood in terms of energy or Lyapunov functions, is described in detail.

Pictures

- Google Hopfield Pictures

n to base m

- 555_{10} to base 2
- 31_{10} to base 2
- 1024_{10} to base 2
- 555_{10} to base 16
- 31_{10} to base 16
- 1024_{10} to base 16
- 555_{10} to base 8
- 31_{10} to base 8
- 1024_{10} to base 8
- 555_{16} to base 8
- $31fa_{16}$ to base 8
- 1024_{16} to base 8

219 to binary

- 219

  = 11011011_2

921 to hexadecimal

- 399_{16}

31 to base 8

- 37_8

31 to hexadecimal

- $1f_{16}$

31 to base 2

- 11111_2

(fff base 16) / (101 base 2)

- 819

fff base 16 to decimal

- 4095