FIELDS OF APPLICATION, TASKS AND CLASSIFICATION OF VISUAL INFORMATION PROCESSING SYSTEMS. LINEAR SEPARATION AND IMAGING IN A PERCEPTRON.LINEAR SEPARATION AND IMAGING IN A PERCEPTRON.

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Abstract *: Solving the traveling salesman problem by Hopfield network and Boltzmann machine. The parameters of the energy function of neural networks that provide the solution to the traveling salesman problem are estimated.*
Keywords: *Hopfield network, Boltzmann machine, Consensus function.*

Consider the urban traveling salesman problem. The distances between each pair of cities are known; a traveler who leaves one city must visit other cities, enter each one once, and return to his original city. It is required to determine the order of traversing the cities with the minimum total distance traveled.

Let the Hopfield network consist of neurons, and the state of the neurons is described by double indices, where the index is related to the name of the city - the position of the city on the route of the traveler. Let's write the computational energy function for a network designed to solve the traveling salesman problem. Then the state with the least energy must be on the shortest route. The energy function must meet the following requirements:

1) must maintain a stable state in matrix form (1)

here the lines correspond to the cities, the columns correspond to their direction numbers; one in each row and one in each column, the rest are zero; 2) the energy function of all solutions in the form (1) must support those corresponding to short directions. These requirements are satisfied by the energy function in the following form: (2) the first three terms support the first requirement, while the fourth term supports the second. If each row has more than one unit, the first term is zero. The latter is zero if each column contains at most one unit. The third is zero if there is only one in the matrix. The fourth term supports short routes. Then the indices are obtained modulo, because this city is adjacent to c on the route, i.e. ... The fourth period is equal to the length of the route by number. The canonical expression for the computational energy function is as follows and from and we obtain the weights of the Hopfield network:

Modeling the performance of the Hopfield network showed that the best-quality solution is provided by a network with sigmoidal properties of neurons, and a network with gradual transitions of neurons is suitable for routes that are slightly better than random routes came to the last state. Many studies show that the quality of solving the problem of minimization of the energy function (2) depends on the choice of the derivative of the activation function of sigmoid unipolar neurons close to zero. For a small value of the derivative, the energy minima are located in the center of the hypercube of the solution (incorrect solution); for a large value of the derivative, the Hopfield network falls on top of the hypercube corresponding to the local minimum level of the energy function. In addition, the choice of coefficients significantly affects the quality of the solution. The search for optimal selection methods for these coefficients is currently the subject of intensive research.

The mathematical basis for solving combinatorial optimization problems in the Boltzmann machine is an algorithm that simulates solidification of liquids or solutions (annealing simulation algorithm). It is based on ideas from two different directions: statistical physics and combinatorial optimization. A Boltzmann machine (MB) is able to implement this algorithm both in parallel and asynchronously. MB is given by four - the number of neurons, - a set of connections between neurons, while all automatic connections belong to this set, i.e. ... Each neuron can have a state of 0 or 1. The state of the MB is determined by the state of the neurons - the initial state. Each link has a weight - a real number, a set of links -. If the connection state is called active. Link weight is interpreted as a quantitative measure of the relevance of an active link. Activity is highly desirable and activity is highly undesirable. As in Hopfield's model, connections in MB are symmetric, i.e. ...

The concept of consensus is introduced for the MB situation

Each link in this number is counted once. Consensus is interpreted as a quantitative measure of the appropriateness of all communications in an active state. A set of neighbors is defined for the state. A neighboring state is obtained when the state of the neuron changes,

The difference between the consensuses of neighboring states is equal to and

where is the neuron's set of connections. It can be seen that all can be calculated in parallel.

Maximize Consensus

The transition of the MB with maximum consensus from one state to another occurs by performing a step-by-step procedure. At each step, a test consisting of two parts is performed:

1. a neighboring state is created for this case,

2. the condition is evaluated whether it is acceptable or not, if so, the test result - otherwise.

Condition is accepted with probability (4)

where is the control parameter ("temperature").

The consensus maximization process starts with a high parameter value and a randomly selected initial state. During the process, the parameter decreases from 0 to 0, as it approaches zero, the neurons change their states less and less, and finally, the MB stabilizes in its final state. In practice, the MB stabilizes at a position corresponding to a local maximum consensus that is close to (or equal to) the global level. The MB approximation is controlled by the following parameters:

1. The initial value of the parameter for each neuron
2. Downgrading rule where a positive number is less than but close to one.
3. Number of tests performed without changes (- function).
4. The number of consecutive trials (- function) that do not result in a change in the state of the machines, as criteria for completing the process.

synchronous and asynchronous operation of the oltzman machine

To perform a synchronous process, the entire set of neurons is divided into connected subgroups, so that the neurons that fall into one subgroup are not connected to each other. Then, in each synchronization cycle, randomly selected internal elements can simultaneously change their state according to a certain probability.

In an asynchronous parallel process, all neurons can change their states only based on the probability value. In practice, asynchronous parallelism can be implemented as follows. A subset containing neurons is randomly selected. From this subset, the state for each neuron is set accordingly. The resulting state is the result of a single asynchronous step.

Solving the traveler's problem using a Boltzmann machine

A general approach to programming combinatorial optimization problems is as follows:

each solution is represented by the set, - the number of neurons in the network, - the state of the neuron. The structure of connections and weights is chosen as follows:

... All local maxima of the consensus function correspond to optimal solutions of the problem;

... The better the solution, the greater the agreement on the appropriate state of the Botsman machine.

Let's paraphrase the traveling salesman problem for MB.

... The MB state corresponds to the local maximum of the consensus function, if this state corresponds to the optimal direction.

... The shorter the route, the higher the consensus of the corresponding MB state.

Each neuron corresponds to an element of the matrix, the position of neurons is determined by (- the number of cities). Consensus function

A set of links in a network is defined as the union of three distinct subsets:

- many links with information about distances between cities,

- many inhibitory (forbidding) relationships,
- many transfer links,

Here. The total number of connections is equal.

Braking links ultimately ensure that no row or column contains more than one unit. Offset links ensure that each column and each row have at least one unit. Thus, bindings and constraints in the problem are guaranteed to be fulfilled, and their weights contribute equally to the consensus in all acceptable directions.

The connection is activated only when the route has a direct route from city to city. The link weight is equal to the distance between cities and has a negative sign. Therefore, the negative contribution of a link to consensus for a given route is proportional to the length of the path; therefore, maximizing the consensus function corresponds to minimizing the route length.

The requirements for convergence and if only the weights of connections are chosen as follows are proved.

LIST OF REFERENCES:

1. Акбаров Д. Е. и др. Исследования Вопросов Необходимых Условий Крипто Стойкости Алгоритмов Блочного Шифрования С Симметричным Ключом //CENTRAL ASIAN JOURNAL OF MATHEMATICAL THEORY AND COMPUTER SCIENCES. – 2021. – Т. 2. – №. 11. – С. 71-79.

2. Акбаров Д. Е., Умаров Ш. А. Анализ приложения логических операций к криптографическим преобразованиям средств обеспечения информационной безопасности //Universum: технические науки. – 2020. – №. 2-1 (71). – С. 14-19.

3. Тожибоев И. Т. Краевые задачи в специальной области для уравнения смешанного типа //Вестник Томского государственного университета. Математика и механика. – 2018. – №. 56. – С. 17-28.

4. Mirzapolatovich E. O., Eralievich T. A., Mavlonzhonovich M. M. Analysis of Static Characteristics Optoelectronic Level Converters Liquids and Gases Based on Hollow Light Guides //EUROPEAN JOURNAL OF INNOVATION IN NONFORMAL EDUCATION. – 2022. – T. 2. – №. 6. – С. 29-31.