Hopfield network approach to optimization problems

1 Description

Hopfield networks [1] are one of the foundational neural network models. This recurrent NN, which is based on an energy-based model is usually applied for recovering stored patterns given its content-addressable memory capabilities. However, an interesting application of Hopfield networks is to solve optimization problems [2, 3]. In this type of application, the problem consists on selecting the parameters of the network in such a way that the points of minimal energy found by the NN would correspond to the optimal solutions of the original optimization problem.

2 Objectives

The goal of the project is to define a Hopfield network that can solve an instance of an optimization problem (e.g., an instance of the Traveling Saleman Problem (TSP).

The student should: 1) Introduce and explain the optimization problem that will be solved. 2) Explain how the Hopfield network is defined to solve the given problem. 3) Use the network to solve one or more instances of the problem. 4) Present and discuss the results. 4) Answer to the following questions about the Hopfield network in the report:

- What class of problems can be solved with the NN? (e.g., supervised vs unsupervised problems)
- What is the network architecture? (e.g., type and number of layers, parameters, connectivity, etc.).
- What is the rationale behind the conception of the NN?
- How is inference implemented? (e.g., How is the information extracted from the network?). Type of prediction or type of inference process.
- What are the learning methods used to learn the network ? Algorithms used for learning the network.

As in other projects, a report should describe the characteristics of the design, implementation, and results. A Jupyter notebook should include calls to the implemented function that illustrate the way it works.

3 Suggestions

- See [2, 3] for explanation of how can the Hopfield network be used for optimization.
- See the following example of Hopfield network formulation of an optimization problem `http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/BMVA95Tut/node11.html`.
- You may use the Hopfield network function included in the library NeuPy `http://neupy.com/2015/09/20/discrete_hopfield_network.html` or implement your own Hopfield network from scratch.
- Implementations can use any Python library.

References

[1] John J Hopfield. Neural networks and physical systems with emergent collective computational abilities. *Proceedings of the National Academy of Sciences*, 79(8):2554–2558, 1982.

[2] Gonzalo Joya, MA Atencia, and Francisco Sandoval. Hopfield neural networks for optimization: study of the different dynamics. *Neurocomputing*, 43(1-4):219–237, 2002.

[3] Kate A Smith. Neural networks for combinatorial optimization: a review of more than a decade of research. *INFORMS Journal on Computing*, 11(1):15–34, 1999.