A Self-Organized Neuronal Comparator

Guillermo A. Ludueña (luduena@itp.uni-frankfurt.de)
Institute for Theoretical Physics, Max-von-Laue-str. 1,
60438 Frankfurt am Main, Hessen, Germany

Claudius Gros (gros07@itp.uni-frankfurt.de)
Institute for Theoretical Physics, Max-von-Laue-str. 1,
60438 Frankfurt am Main, Hessen, Germany

Keywords: Unsupervised Learning; Neural networks; Self-organization in complex systems; Artificial intelligence

Abstract

In order to develop a complex targeted behavior, an autonomous agent must be able to relate and compare the information received from the environment and internally generated (Billing, 2010). For example it is often necessary to decide whether the visual image currently being perceived is a similar image encoded in some form in memory.

Neural learning architectures hence need a unit, a comparator, able to compare several inputs encoding either internal or external information, like predictions and sensory readings. Without the possibility of comparing the values of prediction to actual sensory inputs reward evaluation and supervised learning would not be possible.

Comparators are usually not implemented explicitly, necessary comparisons are commonly performed by directly comparing one-to-one the respective activities, see for instance (Bovet & Pfeiffer, 2005a, 2005b). This implies that the characteristics of the two input streams (like size and encoding) must be provided at the time of designing the system.

It is however plausible that biological comparators emerge from self-organizing, genetically encoded principles, which allow the system to adapt to the changes in the input and in the organism.

We propose an unsupervised neural circuitry, where the function of input comparison emerge via self-organization only from the interaction of the system with the respective inputs, without external influence or supervision.

The proposed neural comparator neural circuit adapts according to the correlations in the information streams received as inputs. The system consists of a multilayer feed-forward neural network which follows a local output minimization (anti-Hebbian) rule for adaptation of the synaptic weights.

The local output minimization allows the circuit to autonomously acquire the capability of comparing the neural activities received from different neural populations, which may differ in the size of the population and in the neural encoding used.

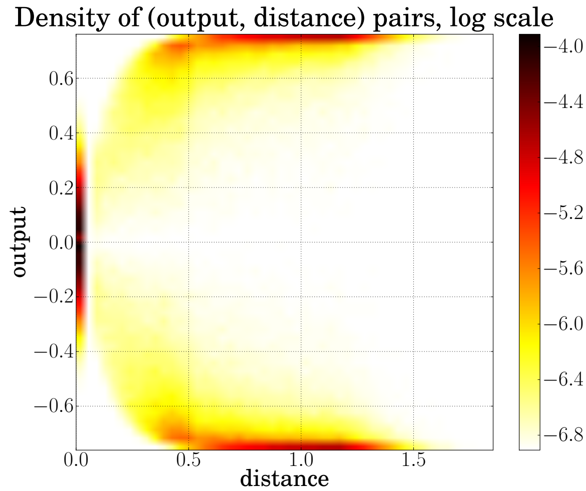

Figure 1: Density of output-distance pairs from the last 10% of 700000 iterations of the comparator, comparing inputs of dimension $N = 5$ under the same encoding. 20% of the Input were randomly-chosen equal vectors. The network self-organizes to assign large output when the vectors are separated by a large euclidean distance and small output when the distance is zero. Thus the output behaves as a sigmoid of the distance between input vectors, despite the network having no information about the input being two vectors or about how to calculate an euclidean distance.

References

Billing, E. A. (2010). Cognitive perspectives on robot behavior. In *Proceedings of the 2nd international conference on agents and artificial intelligence: Special session on computing languages with multi-agent systems and bio-inspired devices* (p. 373-382).

Bovet, S., & Pfeiffer, R. (2005a). Emergence of coherent behaviors from homogenous sensorimotor coupling. In *Proceedings of the 12th international conference on advanced robotics (icar).*

Bovet, S., & Pfeiffer, R. (2005b). Emergence of delayed reward learning from sensorimotor coordination. In *Proceedings of the ieee/rsj international conference on intelligent robots and systems (iros).*