ICNMS 2015

Binary recurrent neural networks with random coding

Claude Berrou*, Xiaoran Jiang*, Vincent Gripon*, Olivier Dufor*,
Fabrice Wendling** and Mahmoud Hassan**

*Télécom Bretagne and CNRS Lab-STICC, Brest
**Université de Rennes 1 and INSERM LTSI, Rennes

ABSTRACT

Binary recurrent neural networks have proved to be very storage-efficient with an ultimate theoretical limit of ln(2) ≈ 0.69 bit/synapse for independent and identically distributed (i.i.d.) messages. Both hetero and auto-associative structures have been proposed with various practical retrieving principles achieving near-capacity performance. These good properties are explained by the strongly redundant nature of the graphical patterns (cliques) embodying information, resulting in good error correction ability.

However, the performance of binary recurrent networks deteriorates drastically when messages to be stored are not i.i.d, which is the most common situation in real applications (for instance, same root words in a dictionary, objects with shared features, faces, etc.). Inspired by the Shannon's model of communication which clearly sets apart the two operations of source coding (compression) and channel coding (error protection), we propose a novel vision of learning and storing mental information in connexionist machines, as illustrated in Fig. 1. Firstly, extraction of features from external objects is performed according to some learning algorithm (which is not the topic of this paper). Each feature is materialized by a node in the feature network. An object is thus associated with a unique set of k features, but a feature may contribute to the specification of several objects. Secondly, each set of features is projected into a second network as a clique of order c. To do so, each feature of the set is connected to each vertex of the clique by a bidirectional edge with unitary weight. kc connections are therefore used for each object.

Because each clique vertex is chosen at random in the second network, and even if two objects share several features, the two corresponding cliques have low overlapping probability and become two clearly separate concepts. These concepts, encoded as codewords with large minimum Hamming distance, may be retrieved in presence of errors, erasures and also strong correlation in the feature network. Two kinds of applications have to be considered: conceptualization and associative memory. The scheme of Fig. 1 is sufficient to carry out efficient conceptualization whereas associative memory requires additional inhibitory connections back from the concept network towards the feature network.

The performance analysis of this two-layer network, as well as some simulation results, are given in the paper. Some other advantages resulting from the physical separation of feature sets and conceptual codewords are also commented on.

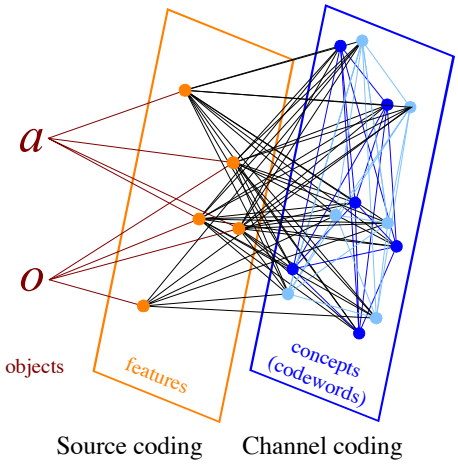

Figure 1. External objects undergo the successive operations of feature extraction (source coding) and clique projection (channel coding). Even if two objects (here: *a* and *o*) share several features, the two corresponding cliques have low overlapping probability and become two clearly distinctive concepts.