Dendritic-like Reliable Computation in Artificial Neurons

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Extended Abstract

Dendritic computation is a term that has been in neurophysiological research for a long time [1]. It is still controversial and far for been clarified within the concepts of both computation and neurophysiology [2], [3]. In any case, it has not been integrated neither in a formal computational scheme or structure, nor into formulations of artificial neural nets.

Our objective here is to formulate a type of distributed computation that resembles dendritic trees, in such a way that it shows the advantages of neural network distributed computation, mostly the reliability that is shown under the existence of holes (scotomas) in the computing net, without 'blind spots'.

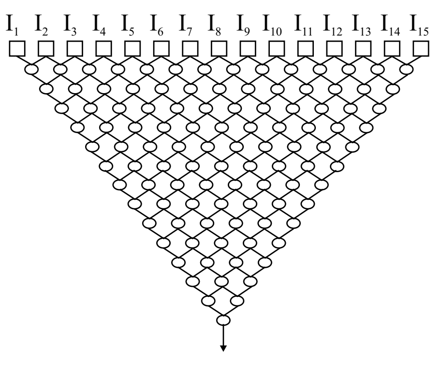
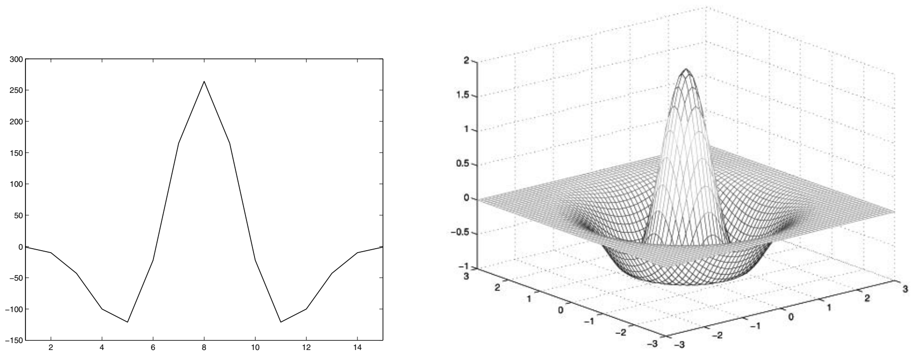


Fig. 1. Distributed layered structure with computation units of two inputs each.

The formulations are the type of distributed discrete structure that generates the weighting profiles of receptive fields close to those of retinal ganglion cells, first described in [4] (see also [5]), that were named 'Newton Filters', a generalization of which to the continuum generates profiles that correspond to

Hermite functions. Figure 1 shows the structure of the discrete filters; each node performs weighted addition or substraction of the signal arriving to it. If the weights are +1 or -1, the Newton Filters are generated. Figure 2(a) illustrates the structure of 15 inputs where all the layers are +1 except two layers which have wights (+1,-1). Figure 2(b) illustrates the corresponding Hermite profile of order two, obtained from the generalization of Figure 2(a) to the continuum.



(a) (b)

Fig. 2. (a) Resulting kernel for the structure of figure 1 with two inhibitory layers. (b) Order 2 Hermite radial function, generalization of figure 2(a) to the continuum.

It can be shown that any arbitrary discrete profile can be obtained by layers having weights $(1, e_i)$ (the same for all the nodes of each layer). The values e_i are the roots of a polynomial in which the arbitrary given desired discrete profile values are the coefficients .

A computer tool has been developed that provides for the analysis and synthesis of one dimensional (or two dimensional radially symmetric) arbitrary discrete receptive field profiles. In the analysis, the tool provides for the overall weighting profile starting with the list of weights per layer. In the synthesis, the inverse (from profile to weights) is performed.

The tool has been extended to include 'holes' or lesions (scotomas) in arbitrary parts of the net. As it would be expected from the topology of the net, the lesions affect the computational profile differently as they are produced closer to the final node (or cell body) or in the (few) inhibitory layers. The topology of the net could be changed to other than triangular form, as it happens in real neurons. Figures 3(a) and 3(b) illustrate the effect of lesions in a dendritic-like structure of 80 input lines, with four inhibitory layers. They show the changes in the weighting function (kernel) after the lesions indicated in the left part of the figures. The black lines in the triangular structure show the position of inhibitory layers. The heavy line in graphics corresponds to the weighting function after lesion.

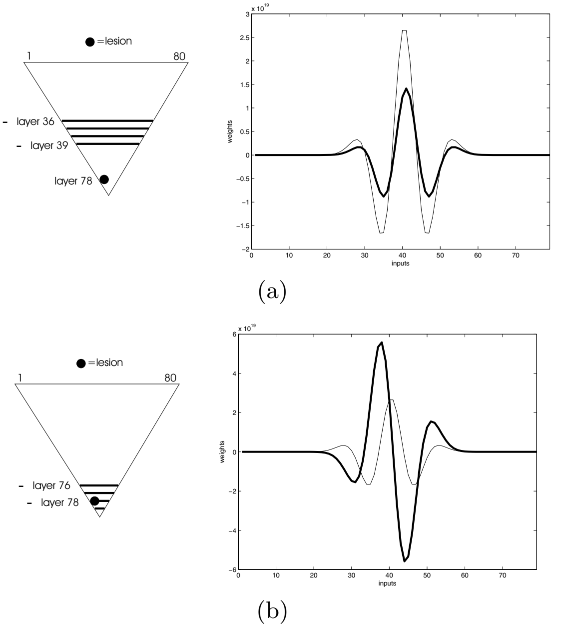


Fig. 3. Effects of lesions in a dendritic-like structure of 80 input lines. Lesion in layer 78 with four subtractive layers at (a) the middle of the structure and (b) the end of the structure.

References

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