

PhD thesis on morphological neural networks

1 Background

Morphological neural networks [3] mainly differ from classical neural networks by changing the linear scalar product for its max-plus counterpart ($\max_i\{w_i+x_i\}$ instead of $\sum_i w_i x_i$). In the current resurgence of interest in neural networks, the morphological approach has been little revisited [4, 2] despite very promising results. Recent studies [6, 5] at the Center for Mathematical Morphology (CMM, Mines ParisTech) brought significant improvements in the understanding of the interactions between deep learning and mathematical morphology, and laid the basis for further developments in this area.

2 Research tracks for the thesis

Three tracks of research shall be explored during this PhD.

1. Reduction (pruning) of deep neural networks based on max-plus layers. Latest work [6] showed new and robust results in network reduction by max-plus layers, when the latter was the last layer of a network, placed after a fully connected layer. Many generalizations need to be studied and tested, such as deeper and convolutional architectures.

2. Learning morphological representations of datasets. This point deals with the representation of a large dataset (e.g. images) as a sparse combination by supremum (hence non-linear) of dictionary elements. This kind of representations is particularly suited to data produced by the non-destructive contributions of several sources (e.g. hyperspectral images), and is also more compatible with morphological operators than linear decompositions. Building on preliminary work [1, 5], the PhD candidate shall focus on new auto-encoder architectures based on max-plus layers.

3. Learning morphological operators. Mathematical morphology is very powerful for image analysis. However, like in many image processing methods, designing an algorithm for a precise application requires to tune several parameters. The present research track aims at determining whether a deep morphological neural network can learn a complex pipeline of morphological operators achieving tasks such as image segmentation, object detection and counting in images.

3 Required skills

The successful candidate should have a strong mathematical background, experience with deep learning tools such as Tensorflow, Keras, PyTorch, etc, and motivation for research work in mathematics and image processing.

4 Contact and supervision

The Center for Mathematical Morphology is located in Fontainebleau, France (40 minutes from Paris by train), near the castle and the forest. Flexibility in the workplace is also possible.

Please send your application (CV and short motivation letter) to the team who will supervise the thesis: Jesús Angulo (jesus.angulo@mines-paristech.fr), Santiago Velasco-Forero (santiago.velasco@mines-paristech.fr) and Samy Blusseau (samy.blusseau@mines-paristech.fr).

References

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