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# Binary Morphological Neural Network

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## Résumé

Conventional filters have had a lot of success for diverse tasks in computer vision, such as image filtering or feature extraction. Finding the right filters for a specific task is a challenge; convolutional neural networks (CNNs) can learn task-specific filters, given only inputs-outputs couples. They have achieved outstanding results. Today, they are the go-to technology for almost any computer vision task, if enough data is available.

However, they still remain some tasks for which other methods are preferable. Mathematical morphology is one of these. For many applications, it is more suitable than convolution-based methods. However, finding the right sequence of operations, and the right structuring elements, can be difficult and time-consuming depending on the problem we want to solve. Our objective is to mimic the way CNNs are built on convolutional filters, and create a morphological network that can learn the best parameters.

The idea of learning the morphological operations is not new. However the trend of replacing the "convolutional element" of CNNs by morphological operations is more recent. Some researchers investigated further the max-plus algebra, for example to perform image filtering (de-raining and de-hazing). Others replaced the non-differentiable max / min operators by differentiable approximations. All these methods were extensively studied for grey-scale morphology.

In this work, we learn binary morphological operations with binary images as inputs. This could be very useful for shape analysis, such as shape reconstruction or classification. We introduce the Binary Structuring Element (BiSE), a neuron that can learn both erosion and dilation as well as their structuring element. The BiSE neuron is built using the convolution operation: we can use the highly optimized implementations of the convolutions. We use the equivalence between a thresholded convolution and a dilation or erosion.

We train our network on generated binary images based on random ellipses and oriented rectangles. We also apply complementation half of the time to have a similar playground for dual operations. The results are promising: we manage to learn perfectly the dilation and erosion. Then, we stacked two BiSE neurons to learn opening or closing. It succeeds in some cases, while it fails in others. We investigate why this problem is a more difficult one.

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