Erratum

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Due to a technical error, on page 33 the cross-reference numbers to the Reference Section were not completed before printing. To correct this error, we reprint overleaf the complete page with the reference numbers inserted.

Minkowski Operations and Vector Spaces

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Abstract. Mathematical morphology started as a set of tools for analysing images by the use of transformations based on set-theoretical operations which are the Minkowski sum and subtraction. It was first developed for the analysis of binary images. Its extension to grey-level images was a later development with the extension of the Minkowski operations to real-valued functions in terms of sup-convolution and inf-convolution. The purpose of this paper is to define a type of convolution between set-valued maps, to study its properties, and to establish some associated differential relations. This set-convolution map allows us to extend the Minkowski sum and subtraction to multivalued functions and to functions with vectorial values.

Mathematics Subject Classifications (1991): 47H04, 68U10.

Key words: mathematical morphology, Minkowski sum, Minkowski subtraction, set-convolution, internal set-convolution, Steiner selection.

1. Introduction

Mathematical morphology [6, 15] was initially an approach based on set-theoretical concepts. It uses the idea of Boolean operators to compare a reference set called *the structuring element* $B \subset X$ to a set K by means of ‘morphological operators’ based on the Minkowski sum and subtraction of sets.

We recall that a binary image is a numerical function $f: X \mapsto \{0, 1\}$ which is identified by the set $K = \{x \in X \mid f(x) = 1\}$.

At this point, mathematical morphology can be seen as a set of tools for analysing binary images by using set-theoretical transformations.

Recently, Serra [16, 17] and Matheron [7, 8, 9] have generalized morphological operations to complete lattice, that is, sets in which the supremum and infimum operations are well-defined.

The first extension to grey-level images was proposed in [12, 4, 15]. It was digital and based on the idea that a set transformation acting on a threshold of the initial function, could generate the threshold at the same level as the transform function.

Sternberg’s [18] extension to grey-level images used extended functions $f: X \mapsto \mathbb{R}$. Considering a grey-level image as the epigraph or hypograph of an extended function representing it, and applying the set-theoretical operation to these epigraphs or hypographs, he could adapt the morphological viewpoint to