Classification of Image Edges

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Abstract

Edges are relevant information for image representation. In this paper, we propose an algorithm for the classification of *step, concave slope, convex slope, roof, valley* and *staircase* edges. The importance of the classification is that it simplifies several problems in artificial vision and image processing, by associating specific processing rules to each type of edge. Our classification is based on the behavioral study of these edges with respect to differentiation operators and scale. The first directional derivative, the gradient and the Laplacian are used as operators. We test our algorithm on synthetic and real grey-level images. In most cases, the classification obtained corresponds to the intensity profile of the image.

1 Introduction

Edges are the most common features in an image; they are local variations in the image function. We limit ourselves here to the study of *step, concave slope, convex slope, roof, valley* and *staircase* edge types. These models cover the majority of edge types which can be generated by physical contours of a scene. The majority of existing edge detectors are intended for only one edge type. This is a significant limitation, because the consideration of several edge types will simplify a number of problems in artificial vision and image processing. Thus it is necessary to identify the edge types present in an image, whether by using several detectors or only one. In this paper, we are interested in using only one detector, so edge classification is required. The classification of edges consists in associating, with characteristic points of the image, the type of intensity variation which takes place at each point. In the literature, there is little work on classification. We present an algorithm based on the simultaneous use of inflection points of the first directional derivative or characteristic points of the gradient image, and those of the Laplacian image. The classification rules are derived from edge behavior with respect to differentiation operators and scale.

In Section 2, we summarize existing research on the detection and classification of edges. In Section 3, we present the edge models mentioned above. Then, we study their behavior when differentiation operators are applied. In Section 4, we study this behavior in the scale space. In Section 5, we present the classification algorithm. To illustrate the classification rules, we consider the case of *step*. In Section 6, we test our detector on synthetic and real images. Finally, a short discussion is presented in Section 7.

2 Related Work

Parallel to the continual development of edge detection algorithms, methods are necessary for their evaluation [9], and an overview of research in edge detection is needed [25]. In this section we cite those existing edge detectors which are most commonly used and are regarded as optimal. Detectors of *step* edges are the ones usually mentioned in the literature. In general, these edges correspond to discontinuities in the image function, and these discontinuities are generated by the borders of objects in the scene. The majority of *step* detectors involves two operations: filtering and differentiation. Lowpass filters are the most often used [2, 5, 18], while the most common operators are the gradient [2, 5], the Laplacian [13, 10], and the second directional derivative [8]. *Step* edges are localized as maxima of the gradient modulus taken in the direction of the gradient, or as zero-crossings of the Laplacian or the second derivative along the gradient direction.

Contrary to *step* detectors, those for other type of edges are rather rare, because their usefulness was understood later. Consideration of these types is unavoidable for several reasons: for instance, some approaches to the acquisition of 3D information require the determination of all types of edges (e.g., *"shape from contour"* [13, 16]). Furthermore, the images of fingerprints, roads or characters contain thin lines difficult to locate by a *step* detector. We present some of these detectors below. Haralick [7] detects lines at