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Reflectance Based Edge Classification

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Abstract

Discriminating edge types, based on their local surface reflectance properties, is useful for a number of applications such as object recognition, stereo vision and structure from motion, where similar edge types (e.g. material transitions) from two distinct images are used for image matching while discounting other "accidental" edge types (e.g. shadows and highlight transitions).

Because intensity-based edge detectors cannot distinguish between various transition types (that is whether the transition is due to material changes, shadows, abrupt surface orientation changes or highlights), in this paper, we aim at using color information to classify the physical nature of the edge.

Therefore, the effect of varying imaging circumstances is analyzed. From this analysis we present the color models $c_1c_2c_3$ and $l_1l_2l_3$. It is shown that $l_1l_2l_3$ varies with a change in material only, $c_1c_2c_3$ with a change in material and highlights, and RGB vary with a change in material, highlights and geometry of an object. From these color models we derive gradient information which is used to classify edges in a color image to be one of the following types: (1) a shadow or geometry edge, (2) a highlight edge, (3) a material edge.

Experiments conducted with the edge classification technique on different color images show that the proposed method successfully discriminates the three different edge types.

keywords: image matching, color gradients, surface reflectance, color edge detection, color edge classification, photometric color invariants.

1 Introduction

Discriminating edge types, based on their local surface reflectance properties, is useful for a number of applications such as object recognition, stereo vision and structure from motion, where similar edge types (e.g. material transitions) from two distinct images are used for image matching while discounting other "accidental" edge types (e.g. shadows and highlight transitions).

The color (or rather, the apparent color) of an object varies with changes in illuminant color, illumination geometry (i.e. angle of incidence), viewing geometry (angle of reflectance), and miscellaneous sensor parameters. Consequently, the apparent color of an object can be different due to the varying imaging conditions.

Because intensity-based edge detectors cannot distinguish between different transition types, we use color information to classify the physical nature of a color edge. To this end, the effect of the varying imaging circumstances is analyzed. From this analysis, we derive color invariant gradient information which is used to classify edges in a color image to be one of the following types: (1) a shadow or geometry edge, (2) a highlight edge, (3) a material edge.

Different color edge detection schemes have been proposed. One of the first methods based on physics considerations is Klinker *et al.* [6] and Bajscy *et al.* [1]. Both methods retrieve "dog-leg" planar clusters in RGB-space yielding segmentation independent of the object's geometry, illumination conditions and highlights. Healey[5] proposes a method to segment images on the basis of normalized color. Recently, various color features have been studied using a multi-resolution segmentation method [7]. Although the above segmentation techniques are based on physics considerations to obtain segmentation results independent of the varying imaging conditions, they do not classify different color transitions in different transition types such as material changes, shadows, abrupt surface orientation changes or highlights. Therefore, in this paper, we propose a taxonomy for color invariance. The taxonomy is based upon the sensitivity of the different color models with respect to the following imaging conditions: object geometry, shadows, highlights, and material. From the taxonomy the edge classifier is derived.

The paper is organized as follows. In Section 2, color and reflection is discussed. In Section 3, different color models are presented. Then, in Section 4, we discuss the sensitivity of the different color models with respect to the imaging conditions. In Section 5, computational methods are proposed to compute color