**A geometric approach to blob detection on color images**

**Abstract**: Blob detection is a classical low-level computer vision method. Informally speaking, it aims to find circle-like regions of different sizes in grayscale image with similar intensity inside. It is the base of widely used SIFT and SURF key-point detection methods. Recently generalizations for grayscale images on surfaces were proposed. But the generalization for color images is not so straightforward. A naïve approach of per-channel blob detection has serious drawbacks. Existing more sophisticated generalization for color images can be described as converting image to grayscale in some way and the apply base method.

In this paper we propose a generalization of blob detection for color images. It is based on reformulation of original method through the curvatures of image plot. Tests on chemical classification dataset show the superiority of the proposed approach. The theoretical results include a formulation of curvature-based blob detection functions through hessian invariants, volumes of plot and base manifold, proofs of preservation of the original method properties and connection with previously proposed generalizations. Also calculations through curvature techniques are proposed.

**Introduction**

Blob detection [, , , , ,] is a classical low-level computer vision method. Informally speaking it aims to find circle-like regions of different sizes in grayscale image with similar intensity inside. It is the base of widely used SIFT [] and SURF [] key-point detection methods. Recently generalizations for grayscale images on surfaces were proposed MeshSIFT[], MeshSURF[], MeshDOG []. We will list here the formal definition of the general method for the surfaces:

Suppose we have . Blob detection method is as following:

* 1. Calculate the scale-space: the scaled solution of heat equation on surface

, where is a Laplace-Beltrami operator on surface.

* 1. Rescale
  2. Calculate detection functions or where is a Hessian of as a function of with fixed .
  3. Find blobs centers as . Find blobs radius as ;

Let’s consider the case of vector-valued image . The generalization step 1 (scale-space construction) to the color images is straightforward because of the linearity of the heat equation. Then look at the step 3. For the vector-valued function its Hessian , so we can’t use и as detector functions.

How can this problem be solved? Firstly, there are naïve approaches:

1. Apply blob detection separately to each channel of image, and the combine obtained blobs to one set. This approach has drawbacks, listed in []. Mainly it can’t find blobs which *have some intermediate color between channels*.

2. Form a vector form the components of channel-wise traces and determinants: and find it extremums as vector function extremums: iff .

The main drawback of this approach is that since final blob set is an intersection of per-channel blob sets, it will contain too few elements.

More sophisticated approaches were proposed[, , , ,]. Most of them [, , ,] can be described as finding some locally or globally optimal color to project scale-space on it and then applying the original method. The drawback of them is that due to such process not the original function is analyzed, *because projection is not a bijection function.*

We propose another approach for blob detection generalization for color images. It is based on reformulation of original method through the curvatures of image plot. The key observations are the following:

1. If tangent plane of grayscale image plot is “close” to the tangent plane of base surface then mean and Gaussian curvatures of image plot are close to the trace and determinant of image Hessian.
2. The cases of color and grayscale images differ in terms of image plot only by its co-dimension in immerision of it to .
3. The mean and Gaussian curvatures have generalizations for the case of arbitrary co-dimensions - mean curvature vector and scalar curvature.

The connection between blob detector functions and curvatures arose in several papers [], but there were errors in proposed analysis. So, our paper is the first to accurately analyze this question.

These observations are the base of our proposed approach.

Contributions

Tests on chemical classification dataset show the superiority of the proposed approach. The theoretical results include a formulation of curvature-based blob detection functions through hessian invariants, volumes of plot and base manifold, proofs of preservation of the original method properties and connection with previously proposed generalizations. Also calculations through curvature techniques are proposed.