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Manifold blob detection by interpretation of blob detection as non-linearity seeking

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Abstract This paper is devoted to the problem of blob detection generalization for manifold-valued images. Our solution is based on a new interpretation of blob detection, which is in agreement with intuitive understanding of the algorithm. We interpret blob response functions as a measure of local non-linearity. This interpretation with minor modifications is extended to the manifold case, what allows to define the algorithm for this case. Then we derive an expression of the manifold blob response functions through the image Hessian. This gives the manifold algorithm a form similar to the grayscale case. Finally, we provide experiments for the case of vector-valued images on 2D surfaces: the algorithm is tested for physico-chemical properties of chemical compounds.

Keywords Blob Detection · Image Processing · Manifold-valued Images · Vector-valued Images · Differential Geometry

1 Introduction

Recently there is a big demand in non-Euclidian data processing. In informational geometry, chemical compounds classification, 3d reconstruction, 3d models recognition, action recognition, medical images processing we deal with vector-valued or manifold-valued functions defined on manifolds. One approach to a manifold data processing development is a generalization of grayscale image processing methods.

Blob detection [?] is a widely used method of keypoints detection in grayscale images. It has applications in 3D face recognition, object recognition, panorama stitching, 3D scene modeling, tracking, action recognition, medical images processing, etc. The algorithm consists of 3 steps: first, a scale-space is constructed from the original image, second, a blob response is calculated from the scale-space, third, blobs centers are sought as local extremums of the blob response in spatial and scale dimensions. An intuitive (heuristic) understanding is that blob detection aims to find regions which are different from surroundings and with similar intensity inside, i.e. blobs. For a generalization of the algorithm to non-scalar-valued images the main question is how to generalize the blob response functions, because they are calculated from the image Hessian.

Our goal is to develop a generalization of blob detection for the case of an image being a map between Riemannian manifolds $I(x) : X \to Y$. So we need to pick key algorithm properties which we want to preserve in the generalization. In order to do this we propose a new interpretations of the blob response functions, which are in agreement with intuitive (heuristic) understanding and which can be extended to the manifold case. In our interpretation the blob response functions show how different is the image from being a linear function at a point. So blob detection becomes seeking locally "most non-linear" regions. The idea of this interpretation is that a linear function is the most different from being a blob, because it has no difference with surroundings. So the more different is an image from being linear at a point, the more "blobness" it has.

In the manifold case obviously there is no notion of linear functions. So instead of it we use another class of functions - affine at a point. A function is affine at a point if its coordinate expression is linear in normal coordinates. It has the same property of linear functions of "not being different from surroundings": the graph of affine at a point function has the same curvature as the ambient space $X \times Y$, i.e. its graph "consists of geodesics" at a point.

So for the manifold case we extend (define) blob re-

Table 1 Please write your table caption here

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sponse functions so that they show how different an image is from being affine at a point. These definitions are not computationally tractable, so then we derive expressions of manifold blob response functions through the image Hessian. These expressions are similar to the expressions of the grayscale case.

1.0.1 Contributions:

1. We are the first to provide a blob detection framework for the general setting of an image being a map between manifolds. This framework can be viewed as a generalization of grayscale blob detection. Our framework provides blob response functions for the previously uncovered problems: blob detection in color images on manifold domain and blob detection in manifold-valued images (both on Euclidian and manifold domains).
2. We are the first to analyze connections between the blob response functions and curvatures of image graph both for Euclidian and manifold domains.
3. The experiments on the task of chemical compounds classification show the effectiveness of our approach for the case of vector-valued images on 2d surfaces.

Fig. 1 Please write your figure caption here

2 Section title

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2.1 Subsection title

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Paragraph headings Use paragraph headings as needed.

$$a^2 + b^2 = c^2 \tag{1}$$

References

1. Author, Article title, Journal, Volume, page numbers (year)
2. Author, Book title, page numbers. Publisher, place (year)

Fig. 2 Please write your figure caption here