

# Feature Point Detection of an Image using Hessian Affine Detector

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## ABSTRACT

This paper proposes a modified method to detect the feature point of an image using Hessian Affine Feature detector. In this approach Hessian matrix is used that helps to reduce the computational effort. It can also deal with significant affine transformations including large scale changes. Moreover, to deal with the scale changes a scale selection function is used known as Difference of Gaussian (DoG). The simulations and analysis are done in MATLAB and presented here to verify the efficiency of this method.

**Keywords:** Hessian Affine Detector, Image processing, Affine transformation, Hessian Matrix.

## I. INTRODUCTION

In image processing the concept of feature detection refers to methods that intend for computing the image information and making local decisions at every image point whether there is an image feature of a given type at that point or not. Feature is an interesting point of an image and the attractive property for a feature detector is repeatability. There are different types of features and feature detectors. Some of them are edges, corners, blobs or regions and ridges. Common feature detectors are canny, sobel, Laplacian of Gaussian, and Determinant of Hessian etc. In this paper a modified method is used which is known as Difference of Gaussian method. In Laplacian of Gaussian (LOG) method the concept of scale space is used [1]. It can be used for finding the characteristic scale for a given image location. Also it can be used for finding scale invariant regions by searching 3D (both location and scale) extrema of the LOG and for edge detection. Section II involves the details about Hessian Affine detector. Section III presents the proposed technique. The last two sections show the results and discussion and detection ratio analysis.

## II. THE HESSIAN-AFFINE FEATURE DETECTOR

Hessian-Affine detector [1] is a scale and affine invariant interest point detector, proposed by Mikolajczyk and Schmid in [2, 3]. Hessian-Affine regions are invariant to affine image transformations. Localization and scale are estimated by the Hessian-Laplace detector and the affine neighbourhood is determined by the affine adaptation process [5, 6, 7, 8]. The detector is adopted to obtain the feature points and the characteristic region of an image.

## III. PROPOSED TECHNIQUE

The procedure of the Hessian-Affine detector is as follows:

- 1) Initial points are detected with Hessian detector and select the characteristic scale.
- 2) Estimate the shape with the second moment matrix.
- 3) Normalize the ellipse region to circular one.
- 4) Recover the point location and scale.
- 5) Go back to step 2 if the second moment matrix of new point is not isotropic.

In the first step, the Hessian detector is used to detect the initial points that are based on the Hessian matrix.

$$H(x, \sigma) = \begin{bmatrix} L_{xx}(x, \sigma) & L_{xy}(x, \sigma) \\ L_{xy}(x, \sigma) & L_{yy}(x, \sigma) \end{bmatrix} \quad (1)$$

Where  $\mathbf{x}$  is the coordinate of a point  $(x, y)$ ,  $\sigma$  is the differentiation scale of the Gaussian kernel, and  $L_{ij}$  is the second derivative of a point with respect to  $i$  and  $j$  variables. In scale invariant detection a function is used to determine the scale. The function is nothing but the product of kernel and image. Laplacian and Difference of Gaussian are the generally used kernels for the scale selection function [4, 5, 6].

Laplacian,

$$L = \sigma^2 (G_{xx}(x, y, \sigma) + G_{yy}(x, y, \sigma)) \quad (2)$$

In this paper Difference of Gaussians is used for the scale selection and is given as:

$$\text{DoG} = G(x, y, k\sigma) - G(x, y, \sigma) \quad (3)$$

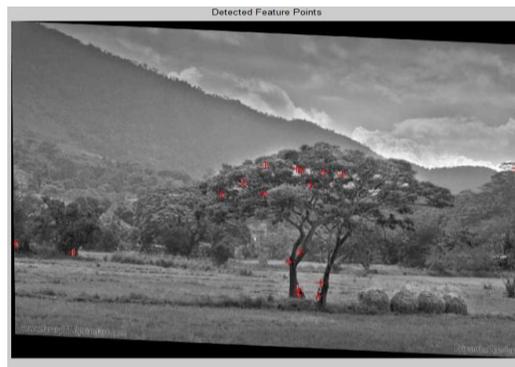
Where Gaussian is

$$G(x, y, \sigma) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (4)$$

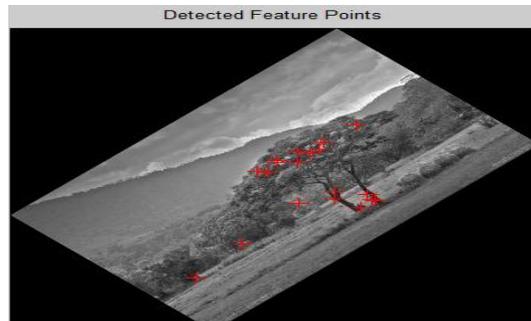
In the second step the elliptical shape is estimated with the second moment matrix of the point. In step 3, the normalization of the obtained elliptical region of the feature point is done and transformed into circular one by taking the square root of the second moment matrix of the point. In step 4, a new feature point is obtained when they applied obtained circular region to the Hessian detector with a new differential scale. Finally, the procedure would be repeated if the eigen values of the second moment matrix of the new feature point is not equal to that of the original one.

#### IV. RESULTS AND DISCUSSION

Many feature points and regions are obtained in the processed image, and the example of Two images, Zebras and Nature, are used to evaluate the performance of the proposed algorithm are shown in Fig. 1. Furthermore, the feature points of both the images which have been rotated for various degrees, scaled with different factors of scaling, and cropped. Most of the obtained feature points in the original image are the same as those in the rotated one. Therefore, the robustness of the feature detector is exploited to resist various attacks in the proposed algorithm.



**Figure 1: Linear Transformed image with Feature Points**



**Figure 2: 45° Rotated image with Feature Points**

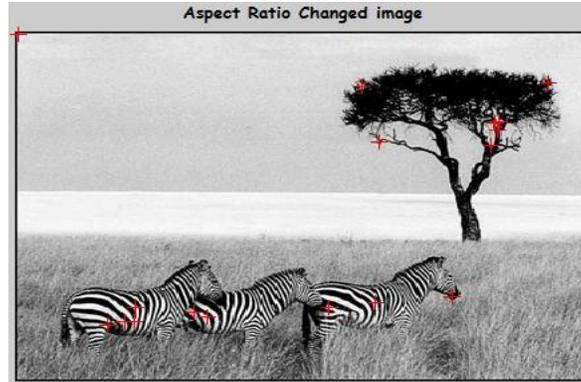


Figure 3: Aspect Ratio Changed image with Feature Points



Figure 4: Cropped image with Feature Points

## V. DETECTION RATIO ANALYSIS

Two images, Zebras and Nature, are used to evaluate the performance of the proposed algorithm. All attacks used in the experiment are generated by the benchmark program; StirMark [1, 9]. The first column indicates the attacks applied to the image. The 2th ~ 3th columns are the detection ratio for two different images.

Detection ratio refers to the ratio of the number of extracted regions from original images to the number of correctly redetected regions from attacked images. Compared with other methods, the proposed algorithm for resisting most of attacks has better results, the aspect ratio change especially.

Table 1. Detection Ratio Obtained for different attacks applied to two images.

Attack	Zebras	Nature
None	11/23	24/25
Rotation( 1°)	14/25	18/25
Rotation (5°)	17/24	18/25
Rotation (45°)	16/25	19/25
Cropping	3/12	18/24
Linear transform	21/25	20/25
Aspect Ratio change(1.0, 1.1)	17/25	24/25
Scale (50%)	7/24	15/24
Scale (110%)	14/25	22/25

Table 1 shows the detection ratio obtained for different attacks applied to two images Zebras and Nature. The same has done for ten different images and got the results. The different attacks applied to the images are rotation,

cropping, scaling, aspect ratio change and linear transform. In the case of rotation, the image is rotated to a particular angle in the counterclockwise direction around its center point. To make a clockwise rotation the angle must be given as negative. Also the interpolation method can be used for rotation. In this paper I have used bilinear interpolation method.

When transformation is applied to the image it applies two dimensional spatial transformations to it. Here an N-dimensional affine transformation is applied and creates a spatial transformation structure. Using this structure geometric transformation is applied to the image. Also nearest-neighbor interpolation method is used to resize the image and different scaling factors are given and verified that the feature points detected by Hessian Affine detector will not be affected so much due to these attacks.

## **CONCLUSION**

A robust Hessian-Affine feature point detector using Difference of Gaussian (DoG) as the scaling function is proposed and the analysis has done to verify its performance and robustness. The detector is adopted to obtain the invariant points and regions. Most of the removal and geometric attacks are resisted because of the invariant property of the feature points and characteristic regions. Also high computing complexity required for the Hessian-Affine detector is avoided due to the appropriate scale selection function even though it is an iterative method.

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