Research on High Precision Algorithm of Scale-Spatial in Computer Vision

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Abstract. The intra class differences of object categories will bring great challenges to the image matching algorithm in machine vision. In order to guarantee the accuracy and quality of image matching algorithm, it is necessary to accurately define and understand the scene and semantics of the image, so as to find out the typical similar features of the image. On account of this, this paper first analyses the role and traits of scale-spatial theory, then studies the high-precision algorithm of scale-spatial in computer vision, and finally gives the extremum detection of scale-spatial, the determination of extremum position and the generation of feature point descriptor.

Keywords: High Precision Algorithm, Scale-spatial, Computer Vision

1. Introduction

With the iterative progress and maturity of computer tech, it has been widely and deeply studied and popularized in many fields, especially in the utilization of machine vision, which greatly promotes the amelioration of high-precision algorithm ability of computer vision scale-spatial. With the continuous amelioration of computer data processing ability, the utilization field of computer algorithm is constantly expanding; especially the utilization and development direction of computer vision has been greatly enriched [1]. At present, the utilization of computer vision tech in face recognition and object detection has greatly ameliorated the ability of computer processing image matching and visual utilization.

In the motion analysis of computer vision, it should to use the algorithm to match the acquired image or video, so as to judge the specific motion changes of the object in the image or video. In addition, in order to guarantee the robustness of computer vision algorithm, it needs to track the object dynamically, so as to achieve multi view and multi scene matching [2]. In this process, it should to make full use of the scale-spatial info, so as to construct the depth info of the object image.
In addition, the intra class differences of object categories will bring great challenges to the image matching algorithm in machine vision. In order to guarantee the accuracy and quality of the image matching algorithm, it is necessary to accurately define and understand the scene and semantics of the image, so as to find out the typical similar features of the image [3]. The utilization of scale-spatial in computer vision is gradually deepened with the maturity of several methods as shown in Figure 1 below. Its core idea is to establish scale coefficients of image processing model, and obtain different scale info in visual processing on account of the variability of scale coefficients. Using scale-spatial coefficients to mine the typical features of visual image can transform the single scale visual info into a dynamic multi-scale analysis framework, so as to realize the in-depth mining of image feature info.

![Figure 1. The development of scale-spatial in computer vision](image)

Scale-spatial mainly includes linear scale, nonlinear scale, shape scale and mathematical morphology scale [4]. These different forms form the main body of computer vision scale-spatial method. In computer vision, the scale change between matching images will have a great impact on the image matching algorithm. The traditional matching algorithm usually carries out image feature matching on a fixed scale, so it can only deal with the image features with small size change. With the increase of scale difference between matched images, the challenge to image matching of computer vision is also increasing. The utilization of scale-spatial feature matching algorithm can effectively reduce the adverse impact of image scale difference, and has great expansion in the scope of utilization and utilization level. Therefore, it is of great practical value to study the high-precision algorithm of computer vision mesoscale-spatial.

2. Scale-spatial theory

2.1. The development of scale-spatial theory

Scale-spatial is gradually applied and popularized in the field of computer vision with the maturity of methods represented by nonlinear diffusion equation and mathematical morphology, and has entered a rapid development stage. As a partial differential mathematical method, scale-spatial method plays an important role in computer vision image processing [5]. Scale-spatial inputs scale coefficients into the visual image model and ignore the visual processing info of the image, which includes ever-changing scales, so as to realize the effective mining of the elementary features of the image. Scale-spatial realizes the dynamic analysis of changing scale, which can effectively imitate the multi-scale features of image data.
2.2. The function of computer VR tech in basketball teaching

Scale-spatial can effectively observe and control the traits of multi-scale image through the representation of image data, and organically integrate the structural traits of image signal to realize the characterization of continuous scale coefficients [6]. Through the scale transformation of the original image, the multi-scale image space is expressed serially, and the contour features of the image scale-spatial are extracted organically. In addition, with the help of the main contour feature vector, the image features represented by fringe and resolution can be effectively extracted. As a region based representation, scale-spatial computing efficiency and high-resolution representation often need to reduce the size of the image to achieve.

2.3. Typical scale of spatial feature representation

Scale-spatial can achieve simple formal expression on account of the structural traits of scale, and accurately connect the features of continuous scale. As an important concept in the theory of scale-spatial, the core of scale-spatial is defined as:

\[ f_{out} = K \times f_{in} \] (1)

In which, \( f_{in} \) is the signal, \( K \) is the transform kernel, and \( f_{out} \) is the signal after convolution. When the signal extremum is less than the original image extremum, \( K \) can become the scale-spatial kernel, and the convolution process is scale transform.

In the Gaussian scale-spatial, the new character points will change with the spatial. As the only transform kernel of scale transformation, the Gaussian kernel can be used to represent the operator to transform the scale-spatial [7]. For the vision system with large scale change, the image collected will be affected by the change of many elements, and the large-scale image can only get the rough image. In addition, due to the influence of the scale range, the feature corner of the image will lead to large uncertainty of the scale info. Generally, the smaller scale can achieve the accurate positioning of the feature corner.

The advantages and disadvantages of corner detection algorithm can be determined by changing the coefficients, threshold or increasing the repetition rate \( \eta \) between the detected corner and the initial detected corner.

\[ \eta = \frac{|C_i \cap C_j|}{\min(|C_i|,|C_j|)} \times 100\% \] (2)

In the process of calculating the same corner detected in different scales, the larger the repetition rate is, the higher the stability of the algorithm is [8]. The quantitative evaluation and calculation of the extraction effect of feature points at different scales are shown in equation 3:

\[ \eta = \frac{C(I_1, I_2)}{\text{mean}(m_1, m_2)} \times 100\% \] (3)
In which, \( C(l_1, l_2) \) is the quantity of repeated character points in the two images, and \( \text{mean}(m_1, m_2) \) is the mean value of the quantity of character points extracted in the two images. The larger the value is, the better the effect of the character point algorithm is, that is, the better the stability of the character points extracted by the algorithm is.

3. High precision algorithm of mesoscale-spatial in computer vision

3.1. Local character algorithm in scale-spatial

The algorithm is mainly used to extract the local scale invariants of the noise, and also to keep the scale invariants [9]. As a local character algorithm in scale-spatial, SIFT algorithm has several typical characters as shown in Table 1, which is helpful to find extremum in scale-spatial.

Table 1. Characters of local character algorithm in scale-spatial.

| Characters       | Contents                                           |
|------------------|----------------------------------------------------|
| Uniqueness       | Fast and accurate matching in massive character database |
| Multiplicity     | Could generate a large quantity of eigenvectors    |
| High speed       | The optimized matching algorithm can fulfil real-time needs |
| Scalability      | It is convenient to combine with other forms of eigenvectors |

In which, \( C(l_1, l_2) \) is the quantity of repeated character points in the two images, and \( \text{mean}(m_1, m_2) \) is the mean value of the quantity of character points extracted in the two images. The larger the value is, the better the effect of the character point algorithm is, that is, the better the stability of the character points extracted by the algorithm is.

3.2. Generation of scale-spatial

In order to imitate the multi-scale characters of image data, GDK is used to realize scale transformation. For the scale-spatial of 2D image, there are:

\[
L(x, y, \sigma) = G(x, y, \sigma) \times I(x, y)
\]  

(4)

In which, \( G(x, y, \sigma) \) is a spatial variable Gaussian function, and \((x, y)\) is the spatial coordinate and \(\sigma\) is the spatial coordinate. The size of \(\sigma\) determines the silky of the image. The large-spatial conforms to the general characters of the image, and the small spatial conforms to the detail characters of the image. A large \(\sigma\) value means that the spatial resolution is low; otherwise, it means that the spatial resolution is high.

\[
G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2 + y^2)}{2\sigma^2}} / 2\sigma^2
\]  

(5)
In addition, in order to effectively detect the stable critical-points in the spatial-spatial, the Gaussian difference spatial-spatial is applied, and the GDK of different spatial is used to convolute the image.

\[
D(x,y,\sigma) = (G(x,y,k\sigma) - G(x,y,\sigma)) \times I(x,y) = L(x,y,k\sigma) - L(x,y,\sigma)
\]

3.3. Extremum detection in spatial-spatial

The extremum detection of spatial-spatial is to introduce the spatial coefficients into the visual info processing model, obtain the visual processing info of different spatial by ever-changing the spatial coefficients, and then synthesize the info to deeply mine the elementary characters of the image[10]. In addition, in order to find the extreme point of spatial-spatial, it should to compare the theiving with all the adjacent points around it to see whether it is larger or smaller than the adjacent points of its image domain and spatial domain, as shown in Figure 2.

![Figure 2. Local extremum detection in spatial-spatial.](image)

In which, the middle detection point is compared with its adjacent points of the same spatial and the conforming points of the upper and lower adjacent spatial to guarantee that extremum are detected in both spatial-spatial and 2D image space. If a point is the extremely large or small in all fields of the spatial-spatial and the up layers and sublayers, it is considered as a character point of the image at that spatial.

3.4. Determination of extreme point position and generation of character point descriptor

In order to enhance the stability of image matching and ameliorate the ability of anti-noise in computer vision, it is necessary to fit the 3D quadratic function to accurately determine the location and spatial of critical-points, and dislodge the low contrast critical-points and transitional fringe response points. Secondly, for the detected character points, it should to dislodge the low contrast character points and transitional fringe response points. In addition, in the aspect of direction assignment of critical-points, it is necessary to specify direction coefficients for each critical-point by using the gradient direction scatter traits of adjacent pixels of critical-points, so that the operator has rotation invariance [10].

Finally, at the level of character point descriptor generation, spatial-spatial is constructed to detect extremum and obtain spatial invariance. Then the character points are filtered and accurately located, and the direction values are assigned to the character points, and finally the character descriptor is generated.
4. Conclusion

In summary, the core idea of spatial-spatial utilization in computer vision is to establish spatial coefficients of image processing model, and get different spatial info in visual processing on account of the variability of spatial coefficients. Using spatial-spatial coefficients to mine the typical characters of visual image can realize the in-depth mining of image character info. Through the study of spatial-spatial theory, this paper analyzes the development, function and typical traits of spatial-spatial theory. On account of the analysis of the high-precision algorithm of spatial-spatial in computer vision, the generation of spatial-spatial, the extremum detection of spatial-spatial, the determination of extreme point position and the generation strategy of character point descriptor are studied.

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