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Image detection method based on building structure

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Abstract: With the rapid development of digital image technology, image processing technology has been widely used in various industries. In view of the wide use of lines in modern buildings, this paper proposes an image detection method based on building structure. The characteristics of building images are analyzed. The commonly used color space models are introduced. Finally, the canny operator is selected to extract building image edge features, using Hough transform to detect straight lines in these extracted edges. The experimental results show that the proposed method can extract the feature information of the building structure.

1. Introduction
With the rapid development of Internet technology and the popularity of digital electronic devices such as digital cameras, camcorders, printers, and scanners, people can access these image media more conveniently, quickly, and economically[1-2]. As a result of the creation of human labor, from ancient times to now, architecture has emerged various architectural styles, such as different styles, different materials, different uses et al. In this paper, we will use image detection methods to study how to extract building image features and analyze features to effectively identify building structures. In this paper, the feature extraction method and data analysis of architectural images are helpful to the design of architectural renderings and the three-dimensional model of buildings, so that the buildings can truly serve humans and provide reference value for subsequent research.

2. Feature analysis of building images
In many building structures, in order to analyze the structure of the building, computer processing technology must be used to obtain the structural information of the building image, which is called image feature extraction of the building structure[3]. Therefore, in order to acquire the features in the building structure, it is necessary to understand the specific content, main features of the image features and the basic knowledge of the means of extraction.

2.1 Image feature classification
An image feature is the most basic attribute or feature that expresses an image[4]. Among them, some features are natural features that the human eye can recognize, such as brightness information in the image area, contours of the edges of the image, texture, and color. However, some images are characterized by features that need to be identified by transformation or measurement[5]. Image
features can be divided into point features, line features, and regional features according to the representation of the image. According to the size of the region extracted by the feature, it can be divided into global features and local features. The specific classification is shown in Figure 1.

![Image feature classification](image)

**Figure 1. Image feature classification**

2.2 Characteristics of image features

The color feature describes the surface properties of the scene corresponding to the image or image area and is a pixel-based feature[6]. Texture feature is a global feature, but since it is only a feature of the surface of an object, it does not fully reflect the properties of the object. There are two types of representation methods for shape features, one is contour feature and the other is region feature. The contour feature of the image is mainly for the outside world of the object, while the regional feature of the image is related to the entire shape region. The spatial relationship feature can enhance the ability to distinguish image description methods, but is more sensitive to image geometric transformation.

2.3 Image color feature acquisition and expression

Color is a visual property of the surface of an object. Each object has its own unique color characteristics. The same type of object has similar color characteristics, so we can distinguish objects based on color features[7]. In buildings, different from other images, buildings have no gradual color, often only a single color or several colors, and in landscape or other images, generally have light blue to dark blue, light green to dark green color gradient. If you can separate the building separately from the image and count its color histogram, you will have a better distinction.

2.3.1 Color model. (1) RGB color space model

RGB color space is based on rectangular coordinate system, and a certain color is represented by a point in the three-dimensional space, as shown in Figure 2. Where, each point contains three components, which respectively represent the brightness values of red, green and blue, and the brightness value is limited to [0,255].

![Figure 2. RGB color space model](image)

(2) HSV color space model

HSV color space directly corresponds to the three elements of human visual features, each component of HSV color space is visually independent. The space distance is consistent with human visual characteristics. The transformation from RGB to HSV is simple and fast. In addition, the quantization results of HSV color space can generate a color space with smaller dimensions consistent with visual features, which is helpful for the application of color feature query[8]. Therefore, HSV color space was selected for color image retrieval research, and the image matching measurement was determined according to the three histogram components of hue, saturation and brightness, as shown
2.3.2 Transformation of RGB color space to HSV color space. RGB is based on the principle of the addition of three primary colors to represent colors. The significance of HSV model lies in that, on the one hand, it removes the relation between brightness component (V) and color information in the image; on the other hand, the saturation component is closely related to the way people obtain color. These features make the HSV model an ideal tool for studying image processing algorithms, which are based on the color perception features of the human visual system. However, the image stored in most computers at present is in RGB format. Therefore, the color space must be converted from RGB to HSV. The conversion formula is as follows:

\[
\begin{align*}
P_1 &= \max(r, g, b), \quad P_2 = \min(r, g, b) \\
r' &= \frac{P_1 - r}{P_1 - P_2}, \quad g' = \frac{P_1 - g}{P_1 - P_2}, \quad b' = \frac{P_1 - b}{P_1 - P_2} \\
\phi &= \begin{cases} 
5 + b (r = P_1 \& g = P_2) \\
1 - g (r = P_1 \& g \neq P_2) \\
1 + r (r = P_1 \& b = P_2) \\
3 - b (g = P_1 \& b \neq P_2) \\
3 + g (b = P_1 \& r = P_2) \\
5 - r \ (\text{others})
\end{cases} \\
V &= \frac{P_1 - P_2}{P_1} \\
L &= \frac{P_1}{255}
\end{align*}
\]

3. Feature extraction of building image

3.1 Linear analysis of building images
In modern architecture, there are often many artificial things. The obvious difference between these buildings and natural environment is that they have abundant straight lines, especially vertical and horizontal ones\cite{9}. For building and landscape images, the biggest difference is that the former has a large number of horizontal and vertical straight lines. If the horizontal and vertical lines in the image are found, the number and direction of them can be counted to detect whether the image contains buildings.

However, some non-buildings also have distinct linear features. Such as the coastline, books, furniture, etc. as shown in figure 4.

![Figure 4. Shows non-building images with distinct lines](image)

3.2 Linear features of buildings
The lines on the building's surface are relatively concentrated, in many images with buildings, sometimes there are other backgrounds besides the building itself, and these backgrounds also have some lines, however, the lines on the surface of the building are not as concentrated as in the background\cite{10}, so, only areas with relatively concentrated lines are likely to be building areas. In many buildings, its contour line is longer. If length is not taken into account, both building and non-building images will have straight lines. Therefore, too short lines should not be considered as straight lines of buildings.

3.3 Acquisition of linear features of building image
(1) Hough transform
Hough transformation is a shape matching technology proposed by Paul Hough in 1962. The basic
idea of Hough transformation is to transform the image space to the parameter space, and describe the curve (boundary) in the image with some parameter form satisfied by most boundary points[11], as shown in figure 5. In Hough transformation, the following formula is used to represent the polar coordinate form of the linear equation:

\[ \rho = x \cos \alpha + y \sin \alpha, \quad 0 \leq \alpha \leq \pi \]

\( \rho \): The distance from the origin of this line. \( \alpha \): The Angle between the normal line and the X-axis.

Figure 5. Hough transformation diagram

(2) Radon transform

Radon transform is mainly used for projection of image matrix in the direction specified by computer. Let the projection of binary function \( f(x, y) \) be a line integral in a certain direction, and the projection can be carried out by any angle \( \alpha \). In general, the Radon transformation of \( f(x, y) \) is \( f(x, y) \) line integral which is parallel to \( y' \) axis, namely:

\[
R_x(x') = \int_{-\infty}^{\infty} f(x' \cos \alpha - y' \sin \alpha, x' \sin \alpha + y' \cos \alpha) \, dy'
\]

Where, \( x', y' \) represent the new coordinate axis obtained after the original coordinate axis rotates counterclockwise at angle \( \alpha \). Radon transform and the Hough transform in computer vision is similar, so it can be used to detect straight lines.

The specific operation is as follows: a linear equation of plane \( xoy \) is given as:

\[ y = ux + v \]

Where, \( u \) and \( v \) are respectively the slope and intercept of the line. Therefore, such a number pair \( (u, v) \) and a line can form a relationship. A line can be represented by a normal equation, that is:

\[ x \cos \alpha + y \sin \alpha = \rho \]

Step 1: In order to better extract the straight lines in the building, suppose the contour map of the building is "I". The pixels in "I" are flipped, that is: \( A_{ij} = 1 - A(i, j), \quad i = 1, 2, \ldots, n; \quad j = 1, 2, \ldots, m \). Step 2: Radon transform the flipped I, namely: \( R = radon(I) \). Step 3: Keep the largest elements in R, and set the remaining elements in R to 0. Step 4: Radon invert R to get the image \( I = Radon^{-1}(R) \). Step 5: Carry out two valued processing of I and get two value image \( P \). After the above processing, the binary image \( P \) will retain the main straight line.

4. Edge detection of architectural images

4.1 Common Edge Detection Operators

One way to determine the boundary of an object in an image is firstly to detect the state of each pixel and its immediate domain, so as to determine if the pixel is indeed at the boundary of an object, and pixels with this characteristic are labeled as edge points[12]. Commonly used edge detection operators are Canny operator, Sobel operator, Prewitt operator, Roberts operator and so on.

4.2 Building image edge detection and comparison of common operators

The Canny double threshold edge detection operator is used here to extract the edges of the architectural image. The Canny operator is based on the first derivative to determine the edge point. It is one of the best operators for detecting the step edge in the first-order differential. It has stronger denoising ability than the Roberts operator, Sobel operator and Prewitt operator minimum value algorithm.
4.3 Experimental results and analysis

(1) Experimental conditions

Experimental platform: Lenovo PC, main frequency is 2.60GHz, 8G memory. Operating system: Windows 7 Ultimate SP1. Programming software: Matlab 2016a. Experimental object: Building image.

(2) Analysis of experiments and results

This experiment uses the image of the building as shown, and the Canny double threshold edge detection algorithm is used to extract the edge map of the building. The experimental results and comparison with other operators are shown in Fig. 6.

![Original image, Grayscale, Gaussian filter, Roberts, Prewitt, Sobel, Canny]

Figure 6. Comparison of edge detection results of architectural images

The experimental results show that compared with other operators, the Canny operator has better effects, and the detection effect is clearer, brighter and more obvious. At the same time, the operator can set the threshold of the gradient. Although its operation speed is relatively slow, it is more suitable for the extraction of the edge of the building. By setting different thresholds, the structure of the building can be better tested to determine the configuration of the building.

5. Conclusion

In this paper, the image detection method of building structure is deeply researched and analyzed. The characteristics of the line in the building image and the method of acquiring the line feature are studied. The extracted line feature is used to segment the image to obtain the possible building area. The experiments in this paper are all implemented on Matlab software. Through experimental results, it is found that the Canny operator is used to detect images, which can better identify building images.

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