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Image registration and retrieval of images using Harris Corner Detection and histogram of oriented gradients

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Abstract: This paper proposes the development of a system for automatic registration and retrieval of similar images from a database that are visually similar to a given query image. Firstly, an algorithm is proposed for recovering translation parameter from two images that differ by Rotation, Scaling, Transformation and Rotation Scale Translation (RST). The images having rotational, scaling, translation differences are registered using correlation with Nelder-mead method for function minimization. After the image has been registered, the Interest points based Histogram of Oriented Gradients (HOG) feature descriptor is used to retrieve the relevant images from the database. The dimensionality of the HOG feature vector is reduced by Principle Component analysis (PCA). To improve the retrieval accuracy of the system the Color Moments along with HOG feature descriptor are used in this system. The Interest points are detected using the Harris-corner detector in order to extract the image features. The KD-tree is used for matching and indexing the features of the query image with the database images.

Keywords : Harris Corner Detection, Histogram of Oriented Gradients (HOG), interest points, KD tree, Principle Component Analysis (PCA), Rotation Scale Transformation (RST).

Introduction

At present, a lot of research work has been carried out on image registration, a variety of image registration methods were put forward, which were usually divided into two categories: region-based methods and feature-based methods. Former method merges the feature detection step with the matching part. These methods deal with the images without attempting to detect salient objects. Windows of predefined size or even entire images are used for the correspondence estimation during the second registration step. The second approach is based on the extraction of salient structures–features in the images. Significant regions (forests, lakes, fields), lines (region boundaries, coastlines, roads, rivers) or points (region corners, line intersections, points on curves with high curvature) are understood as features here. They should be distinct, spread all over the image and efficiently detectable in both images. They are expected to be stable in time to stay at fixed positions during the whole experiment.
Content-based image retrieval is emerging as an important research area with application to digital libraries and multimedia databases. It retrieves the similar images from a large collection according to the similarity between features extracted from the query image and candidate images based on the low-level features such as color, texture and shape. The features are automatically extracted from the images themselves. It is an alternative to the conventional text-based image retrieval systems. In general, image features can be either local or global. The global features describe the visual content of the entire image. The retrieval systems based on global features cannot represent all the characteristics of the image. Therefore, the global features are not suitable for tasks like partial image matching or searching for images that contain the same object or same scene with different viewpoints. In order to avoid using global features, the interest points detectors were introduced to represent the local features of images in image retrieval systems. The interest points are the salient image patches that contain rich local information about an image. In this paper, we proposed a unique system by combining these two techniques for automatic registration and retrieval of similar images from a database that are visually similar to a given query image.

Image Registration

Image registration is the process of transforming different sets of data into one coordinate system. Data may be multiple photographs, data from different sensors, from different times, or from different viewpoints. It is used in computer vision, medical imaging, military automatic target recognition, and compiling and analyzing images and data from satellites. Registration is necessary in order to be able to compare or integrate the data obtained from these different measurements. Image registration has applications in remote sensing (cartography updating), and computer vision. Due to the vast applications of it to which image registration can be applied, it is almost impossible to develop a general method that is optimized for all uses. Medical image registration (for data of the same patient taken at different points in time such as change detection or tumor monitoring) often additionally involves elastic (also known as non rigid) registration to cope with deformation of the subject (due to breathing, anatomical changes, and so forth). Non rigid registration of medical images can also be used to register a patient's data to an anatomical atlas, such as the Talairach atlas for neuro-imaging. It is also used in astrophotography to align images taken of space. Using control points (automatically or manually entered), the computer performs transformations on one image to make major features align with a second image. Image registration is essential part of panoramic image creation. There are many different techniques that can be implemented in real time and run on embedded devices like cameras and camera-phones.

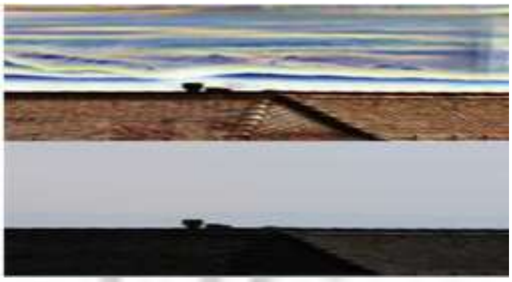

Fig. 1: In this picture, the distant Alps are made visible using image registration technique

In this paper algorithm for recovering translation parameter from two images that differ by RST (Rotation-Scale-Translation). An RST transformation may be expressed as a combination of single translation, single rotation and single scale factor, all operating in the plane of the image. This in fact is a transformation expressed as a pixel mapping function that maps a reference image into a pattern image. RST is also known as geometric spatial Transformation.

Rotation Scale Transformation (RST)

A. Rotation

For rotation by an angle θ clockwise about the origin, the functional form is x' = x cosθ + y sinθ and y' = -x sinθ + y cosθ. Written in matrix form, this becomes:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

Similarly, for a rotation counter clockwise about the origin, the functional form is x' = x cosθ - y sinθ and y' = x sinθ + y cosθ. Written in matrix form, this becomes:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

B. Scaling

For scaling (that is, enlarging or shrinking), we have $x' = s_x . x$ and $y' = s_y . y$. The matrix transform is:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

C. Translation

A translation is defined by a vector T = (dx, dy) and the matrix transform is:

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} w \\ z \end{bmatrix} + \begin{bmatrix} dx \\ dy \end{bmatrix}$$

Interest Point Detection

Different Interest points detector have been proposed and used based on the field of applications. The fast, robust and rotation invariant, Harris detector is widely used in many computer vision applications which uses the autocorrelation function to determine locations where the change of signal in one or two directions.

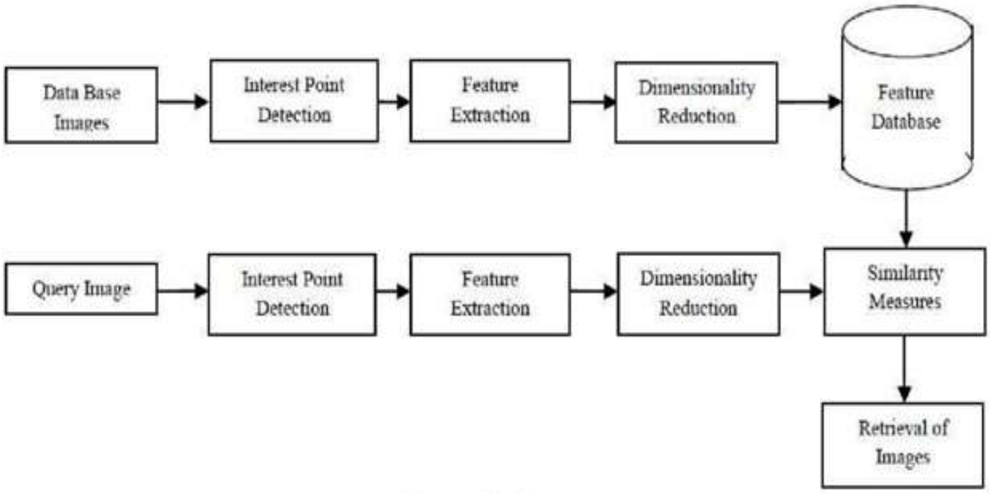

Figure 2: proposed system for retrieval of images

A matrix related to the auto-correlation function is computed :

$$C(x,\sigma_I,\sigma_D) = \sigma_D^2\, G(x,\sigma_I) * \begin{pmatrix} L_x^2(x,\sigma_D) & L_x L_y(x,\sigma_D) \\ L_x L_y(x,\sigma_D) & L_y^2(x,\sigma_D) \end{pmatrix}$$

where, *σD* is the derivation scale, *σI* is the integration scale, *G* is the Gaussian and *L* is the image smoothed by a Gaussian kernel. Edges and interest points can be computed based on:

$$\det(C) - \alpha .\, \mathrm{trace}^2(C) < T_E \text{ and}$$
$$\det(C) - \alpha .\, \mathrm{trace}^2(C) > T_E$$

Edges are computed based on second equation, where *α* is the coefficient of the Harris function and *TE* is the threshold of the Harris function (*TE* < 0).

Figure 3: Harris Corner of a stair case

Histogram of Oriented Gradients

Histogram of Oriented Gradients (HOG) are feature descriptors used in computer vision and image processing for the purpose of object detection. The technique counts occurrences of gradient orientation in localized portions of an image. This method is similar to that of edge orientation histograms, scale-invariant feature transform descriptors, and shape contexts, but differs in that it is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy.

KD tree

K-d tree (short for k-dimensional tree) is a space-partitioning data structure for organizing points in a k- dimensional space. The k-d tree is a binary tree in which every node is a k-dimensional point. Every non-leaf node can be thought of as implicitly generating a splitting hyperplane that divides the space into two parts, known as half-spaces. Points to the left of this hyperplane represent the left subtree of that node and points right of the hyper plane are represented by the right subtree. The hyperplane direction is chosen in the following way: every node in the tree is associated with one of the k- dimensions, with the hyperplane perpendicular to that dimension's axis. So, for example, if for a particular split the "x" axis is chosen, all points in the subtree with a smaller "x" value than the node will appear in the left subtree and all points with larger "x" value will be in the right subtree. In such a case, the hyperplane would be set by the x-value of the point, and its normal would be the unit x-axis.

Proposed work

In this paper we have proposed a efficient method of image registration. After authentication of image their interset points are detected using harris corner detector. We then start to obtain oriented gradient using histogram by which color features are extracted. Voting algorithm is used to count the number of matches of feature vector of query image with the database.KD tree matching algorithm is further needed to rank and retrive corresponding image.

Result/Conclusion


Fig.4. registered image


fig. 5 interest point detection


Fig.6 original image

Hence , it can be concluded that after registration of image, it can be retrived from histogram of oriented gradient with the help of intreset point using harris corner detector. All simulations were generated on Matlab 7.0

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