Synthesis and Image Matching On Structural Patterns Using Affine Transformation

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Abstract

This paper focuses in explaining a Fourier based affine estimator which is applied to the task of Image Synthesis. An affine transformation is an important class of linear 2-D geometric transformations which maps variables into new by applying a linear combination of translation, rotation, scaling and/or shearing operations. Conventional retrieval systems are very effective when knowledge information and query information are in a uniform orientation but fails in recognition when effects such as scaling, orientation exist. But as this technique is based on texture analysis, which is termed the affine estimator, it will even match the images with non-uniform orientation.

Keywords: Affine Estimator, Image Synthesis.

1. Introduction.

Image Matching is an important problem in computer vision and pattern analysis. In this paper, recognition of objects from their boundaries that are subject to affine transformations is considered. The affine transformation includes rotation, scaling, skewing, and translation. It preserves parallel lines and equispaced points along a line. In some cases, the affine transformation can also be used to approximate the perspective transformation.

The existing techniques for Image Matching include Content Based Image Retrieval, Interactive Image Segmentation, Histogram Based Image Segmentation[1]-[4]. Unfortunately, most of these methods make restrictive assumptions on feature extraction i.e. they rely on the low level features extraction and will capture only one aspect of the multimedia data. So the results are unsatisfactory and unpredictable. Deriving a practical solution for invariance to these effects is the current problem of a conventional retrieval system.

In many imaging systems, detected images are subject to geometric distortion introduced by perspective irregularities wherein the position of the camera(s) with respect to the scene alters the apparent dimensions of the scene geometry[5]. Applying an affine transformation to a uniformly distorted image can correct for a range of perspective distortions by transforming the measurements from ideal coordinates to those actually used.

1.1 Purpose of Affine Transformation.

Affine transformations are one of the least complicated operations that can be performed in image processing. However, it is still very useful, because it is one of the basic transformations that can be used on an image.
Affine transformations do not really affect the values of the pixels. What is done during those transformations is simply a change in the pixels positions or order. But actually there will be no effect on the brightness or the contrast of the picture. It does not change the colours of the objects in the image, but rather their shapes.

This kind of transformation is used on pictures which display some distortion. If one or several objects of a picture appear badly shaped on the image, then affine transformations can be used to make them look better.

The estimation of geometric deformation can be simplified by using knowledge of the imaging process to constrain the class of transformation. The simplest example is to assume that the deformation is only translational. This is an adequate assumption only when certain imaging conditions are maintained, such as when the viewpoint is perpendicular to the object and the distance to the object is constant.

A more flexible approach is to assume that the images are related by a six parameter affine transformation, corresponding to scaling, rotation, shear, and translation. The standard affine transformation, in space is defined as:

$$T \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} A_{xx} & A_{xy} \\ A_{yx} & A_{yy} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix} \quad (1)$$

Where $A$ and $t$ represent a linear part and a translational part of the transformation respectively.

A straightforward approach to determining the optimal affine parameters involves a brute-force search of a 6D space. It requires computation of the matrix multiplication using (1) and the corresponding error, shown in (2) resulting from not only every translational change but also by all possible linear deformations where $f_i(u)$ and $f_j(u)$ are the two patches.

$$d_{ij} = |f_j(u) - T_{ij}(f_i(u))| \quad (2)$$

This suggests two possibilities to simplify the problem. The first is to reduce the volume of data because comparing the whole image pixel by pixel is time consuming; instead, extracting spatial features that represent the characteristics of an image well, and are invariant, under affine deformation, trims down the volume to a much smaller set of 2-D coordinate points. Their deformation with respect to that of the target image directly reveals the affine transform of the whole image.

The second possibility is to make the search space smaller. This is where the various properties of the Fourier domain are beneficial to simplify the problem. For instance, translational change can be sought in the frequency domain regardless of rotation, scale or shear change. Hence, reducing the search space dramatically the second method is used in this project.

![Image of Block to Block affine transformation](image)
2. Implementation Strategies.

![Block diagram for the proposed method](image)

Figure 2.: Block diagram for the proposed method i.e., synthesis and image matching on structural patterns using affine transformation

The designed system is developed for recognizing the given query image with a feature based classifier using the features extracted with invariant moments and curvature features. The designed system architecture is as presented in the figure 2.

The above architecture consists of two units viz. the training unit and the testing unit. In the training unit the images are trained in the data base i.e. the features are extracted from the image by processing it according to the blocks in the architecture. In the testing block the features of the query image is extracted in a similar way as it is done in the training block. The training and the testing blocks carry out same process except that the former has a knowledge bank and the later has the classifier and decision blocks. The details of the each block are as below:

2.1 Preprocessing Unit

This unit is used in all the image processing logics as the primary step. In this unit the image is standardized. The image which is to be processed is first converted into a standard size of 128×128. Matlab cannot process a colored image so, if the image is a colored image it is converted into a gray image.

2.2 Translation Operator.

In the translation operator unit the image is converted into frequency domain. The technique used in here is discrete wavelet transformation (DWT). In this unit the gray image from the processing unit is first filtered with high and the low pass filters and then the output of the each is fed to the individual high and the low pass filters. Thus, we get four outputs of a single gray image which is in frequency domain viz. low-low, low-high, high-low and high-high. The variables HH, HL, LH give the variations in the image in diagonal, horizontal and vertical directions respectively. The variable LL gives approximate information about the image.

2.3 Feature Extractor.

This unit gives the texture information about the image. It processes the four variables given out by the translation operator. Fast Fourier transformation is applied to these variables and the mean values of each are calculated. These mean values give the texture information.
2.4 Knowledge Bank

The features extracted from the feature extractor are stored in the database of the system. For each image only the four mean features of the image are stored rather than storing the whole image. This saves the memory and can help in retrieving the image with variations.

In the training unit a recursive process is carried out in order to extract the features of the image in one step rather than going for individual training.

The testing unit follows the same procedure as that of the training unit for the first three steps. Now let us see the operation carried out in the classifier and the decision blocks of the testing unit.

2.5 Classifier

The texture features of the sample image are compared with texture features present in the data base. This is done by finding the affine difference between each image feature. This process is carried out with every image feature in the data base.

2.6 Decision

The decision is taken based on the least difference between the sample and the image in the data base. The image which gives the least error is considered to be the exact image which should be retrieved in the output.

Here in our logic four images which match with the sample image based on the differences are displayed.

![Query Image](image1)

![Retrieved Image](image2)

Figure 3: Query Image and the retrieved image with least error.

3. Software Description.

The implementation of the code of this project is done with the help of Matlab as it is a powerful programming language as well as an interactive computational environment. The main aim of any language is development of applications. This can very easily be done in Matlab through a set of Matlab functions, code words and a proper logic. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. The tool of choice for high-productivity research, development, and analysis.

In the program first take the number of Images N as 20. Select an image i from the data base and standardize the image by resizing it to 128×128 and if it is 3D image convert it to gray and then to frequency domain and then to gray or else directly to frequency domain and then extract the texture features of the image. If i!=20 then go back to the start or else read the query image and repeat the above and find the affine difference between the texture features of the images in data base and the query image. Sort the differences and display the image which has least difference with the query image and name it as the retrieved image and display images which have first four least difference with the query image.
Figure 4.: Flow chart for synthesis and image retrieval on structural patterns using affine transformation.
4. Experimental Results.

The synthesis and image matching on structural patterns using affine transformation has greater efficiency compared to the existing approaches i.e., by merging or by histogram based approaches. For the structural patterns or images as input are taken from COIL Database (Columbia Object Image Library from Columbia University) is assumed as a standard database.

The images are tested for variation in the orientation in image at different angles and the classification of image is carried out as shown below and total four tests are performed in the project during project execution.

In the project the database is generated from COIL database. The steps performed during the program execution are as follows:

- Firstly, a database of 20 images is generated and then preprocessed.
- These preprocessed 20 images are taken and their features are extracted as b1, b2, b3 and b4 using dwt and fft techniques.
- These are considered as “Trainer Images” in training part of the project.
- Secondly, a database of 3 images is generated and then preprocessed.
- These preprocessed 3 images are taken and their features are extracted as b11, b12, b13 and b14 using dwt and fft techniques.
- These are considered as “Query Images” in testing part of the project.
- Then the difference between the spectral features of trainer and testing images are taken and this difference estimation is the affine transformation.
- The minimum difference obtained between the query image and the training images are the correct matched pair.

4.1 Advantages of the Project

The advantages of the project are as specified below:

- Locate an arbitrary number of affine invariant points in the spectrum that latch onto significant structural features.
- Match the estimated invariant points with the target spectrum by the slice wise phase correlation.
- Use affine invariant points to directly compute all linear parameters of the full affine transform by spectral alignment.
- In this method the computation time of the project decreases and hence the accuracy of the project increases.
- It is an efficient method compared to the existing methods.

4.2 Disadvantages of the Project.

The disadvantage of the project is images having greater phase difference cannot be retrieved properly and hence the efficiency of the system may reduce. To overcome this problem images have to be processed by using 3D analysis of an image.

4.3 Conclusion.

An ability to efficiently estimate geometric transformations is desired in many vision related applications. Determining the transformation parameters, which map pixels from one image to the corresponding pixels in related images, enables the comparison of images obtained from different views or time frames.

A general purpose block-to-block affine transform estimation method has been presented. It has use in many applications, including image segmentation, registration, image coding and motion analysis. Motion estimation and image registration in particular, require fast computation and high reliability.

The proposed technique has some important features, it can:

- Identify the significant directional structure from the power spectrum, which is invariant under geometric deformation by the affine theorem.
- Apply slice wise phase correlation to determine the exact corresponding invariant points;
- Perform spectral alignment to reveal the affine transformation and is particularly adept at estimating shears.

Compared to state-of-the-art phase correlation schemes, the advantages of the proposed method are the ability to accurately estimate not only the full affine transform but also reflection symmetry, although its computation time is not yet comparable to the phase correlation based scheme. However, there is room for optimization in many parts of the implementation to further reduce the computation time.
Figure 5: Images obtained while performing four tests.
5. Future Scope

When we consider an image which has a phase variation i.e. an image which having variation in all the three dimensions the above logic may not work. But the logic can be developed for processing an image in three dimensions. For processing an image in all the three dimensions, a program which processes the length, height and depth of an image is designed. The logic for image retrieving is complete when the images with phase variations are also retrieved. However the logic for such retrieving is still under research.

References

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She has 6 years of research experience and has 20 papers to her credit in journals and presented papers in conferences held at Spain, USA and India. Her areas of specialization include VLSI Design, Microprocessor based System Design, Fault Tolerance and Digital Electronics and has received awards for academic excellence. She is author of two text books: Advanced Microprocessors (New Age International Publishers) and Electronic Devices and Circuits (Falcon Publishers).

Dr. K. Anitha Sheela Specialized in Digital Signal Processing. Her research interest include Speech Processing, Image Processing, Neural Networks and DSP Processing. She has around 14 publications in National & International journals & Conferences. Total service is 11 years out of which 2 years in industry & remaining 9 years in Teaching. At present working as Associate Professor, Department of ECE, and JNTU CEH. She has conducted a number of workshops & attended various conferences National & Abroad.