

## IMAGE MOSAIC USING PHASE CORRELATION AND HARRIS OPERATOR

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**ABSTRACT:** Image mosaic is a technique used to stitch number of images taken sequentially when image capturing devices is not capable to accommodate within a single frame. In this project we intend to investigate one of the method for image mosaicing based on corner detection technique. The method which is used here makes use of Harris corner detection along with phase correlation algorithm, which is one of the well known techniques for corner detection and Normalized Cross-Correlation (NCC). The experimental results show that, this kind of approach reduces the mosaic time compared to SIFT (Shift-Invariant feature transform) algorithm and also gives better efficiency. Also we would like to increase accuracy and reduce the time to mosaic the images by using Harris corner detection method along with phase correlation algorithm.

### 1. INTRODUCTION

In day to day life and work sometimes there is a need for wide angle and high resolution panoramic images, which the ordinary camera equipment cannot reach. However, it is not feasible as far as the issues like whole scene, professional photographic equipment, high price of maintenance convenient for operation, lack of technical personnel and unsuitability of general uses are concerned, and hence the use of image mosaicing techniques has been put forward. Currently the image mosaicing technique has become the popular computer graphics research. Also image mosaic has been efficiently and precisely applied to areas such as industry, military, and health care. Technique of image mosaic for restoring images with larger visual angle and more reality plays an essential role in detecting more information from the image. In fact, to the limit of objective conditions, i.e. equipments or weather, images are usually unable to reflect the full scene, which makes it more difficult for the further processing of those images. The general task of image mosaic is to build the images in way of their aligning series which overlaps in space. Compared with single images, scene images built in this way are usually of higher resolution and larger vision.

Image mosaic is a technique used to composite two or more overlapped images into a seamless wide-angle image through a series of processing and it is widely used in remote sensing areas, military applications, etc. When taking these photos, it's difficult to make a precise registration due to the differences in rotation, exposure and location.

In this work we have used a technique which combines both namely the feature-based method and frequency-domain method for image Mosaicing. The feature-based method used is the Harris corner detection and the frequency-domain method used is the Fourier transform-based cross-correlation or phase correlation method.

### 2. LITERATURE SURVEY

The original image alignment algorithm was the Lucas-Kanade algorithm. The goal of Lucas-Kanade is to align a template image to an input image, where is a column vector containing the pixel coordinates. If the Lucas-Kanade algorithm is being used to compute optical flow or to track an image patch from time to time, the template is an extracted sub-region (a window, maybe) of the image [1].

Algorithms for aligning images and stitching them into seamless photo-mosaics are among the oldest and most widely used in computer vision. Frame-rate image alignment is used in every camcorder that has an "Image Stabilization" feature. Image stitching algorithms create the high-resolution photo-mosaics used to produce today's digital maps and satellite photos. They also come bundled with most digital cameras currently being sold, and can be used to create beautiful ultra wide-angle panoramas.

An early example of a widely used image registration algorithm is the patch-based translational alignment (optical flow) technique developed by Lucas and Kanade [1]. Variants of this algorithm are used in almost all motion-compensated video compression schemes such as MPEG [3]. Similar parametric motion estimation algorithms have found a wide variety of applications, including video summarization [4][5], video stabilization [8], and video compression [9][10]. More sophisticated image registration algorithms have also been developed for medical imaging and remote sensing. In the photogrammetry community, more manually intensive methods based on surveyed ground control points or manually registered tie points have long been used to register aerial photos into large-scale photo-mosaics [11]. One of the key advances in this community was the development of bundle adjustment algorithms that could simultaneously solve for the locations of all of the camera positions, thus yielding globally consistent solutions [12]. One of the recurring problems in creating photo-mosaics is the elimination of visible seams, for which a variety of techniques have been developed over the years [13]-[17].

In film photography, special cameras were developed at the turn of the century to take ultra wide-angle panoramas, often by exposing the film through a vertical slit as the camera rotated on its axis [18]. In the mid-1990s, image alignment techniques were started being applied to the construction of wide-angle seamless panoramas from regular hand-held cameras [19]-[22]. More recent work in this area has addressed the need to compute globally consistent alignments [23]-[25], movement [26][27], and dealing with varying exposures [28]. (A collection of some of these papers can be found in [29].) These techniques have spawned a large number of commercial stitching products [30][31], for which reviews and comparison can be found on the Web.

While most of the above techniques work by directly minimizing pixel-to-pixel dissimilarities, a different class of algorithms works by extracting a sparse set of features and then matching these to each other [32]-[37]. Feature-based approaches have the advantage of being more robust against scene movement and are potentially

faster, if implemented the right way. Their biggest advantage, however, is the ability to "recognize panoramas," i.e., to automatically discover the adjacency (overlap) relationships among an unordered set of images, which makes them ideally suited for fully automated stitching of panoramas taken by casual users [33].

By the year 2011, at University of Victoria, Canada in Department of Electrical and Computer Engineering, Ioana S. Sevcenco, Peter J. Hampton and Pan

Agathoklis proposed a method of seamless stitching of images based on a haar wavelet 2d integration [38].

Recently, Chengcheng Liu and Yong Shi proposed SIFT algorithm for image registration. SIFT algorithm is obtained by judging the feature points of local

extreme, combined with neighbourhood information to describe the feature points to form a feature vector, in order to build the matching relationship between the feature points.

According to the comparison and analysis above, aiming at the mosaic between images that have larger scale difference, we try to synthesize the advantages both in frequency dispose and registration with features, a new robust method combined the phase-correlation and Harris corner is proposed. We can get the factor of translation and zoom by cross-power spectrum in order to optimize the detection of Harris. The feature detection then can be restricted in the overlapped area to avoid the waste of resource in irrelevant area when we do the search work. More importantly, this method can eliminate the non-adaptive weakness because of scale change. It is superior to SIFT and original Harris algorithm in terms of the calculation speed and applicability.

### 3. PROPOSED WORK

The proposed work includes the following. By keeping following things in mind as an objective, we are expecting best results from this approach of mosaicing.

- To propose a better mosaicing method, which can stitch scattered images together of the same scene (or target), so as to restore an image (or target) without losing a prior information in it.
- To increase an accuracy and reduce the time to mosaic the images which will shows better efficiency as compared to other mosaicing techniques.

**Photomosaic** - Given an image  $I_2$  in the plane  $R_2$ , a dataset of small rectangular images and a regular rectangular grid of  $N$  cells, find  $N$  tile images in the dataset and place them in the grid such that each cell is covered by a tile that "reminds" the image portion covered by the tile.

**Puzzle Image Mosaic** - Given an image  $I_2$  in the plane  $R_2$ , a dataset of small irregular images and an irregular grid of  $N$  cells, find  $N$  tile images in the dataset and place them in the grid such that the tiles are disjoint and each cell is covered by a tile that "reminds" the image portion covered by the tile.

Different solutions have been proposed to solve the above problems. In this paper we review all presented methods grouping them in an unified framework based on the obtained results. For this reason we singled out four different kind of mosaics: crystallization mosaics, ancient mosaics, photo mosaics and puzzle image mosaics.

#### Crystallization Mosaics

Many sophisticated mosaic approaches try to adopt smart strategies using computational geometry (Voronoi diagrams) together with image processing. These techniques lead to mosaics that simulate the typical effect of some glass windows in the churches.

#### Ancient Mosaics

Ancient mosaics are artworks constituted by cementing together small colored tiles. A smart and judicious use of orientation, shape and size may allow to convey much more information than the uniform or random distribution of  $N$  graphic primitives (like pixels, dots, etc.). For example, ancient mosaicists avoided lining up their tiles in

rectangular grids, because such grids emphasize only horizontal and vertical lines. Such artifacts may distract the observer from seeing the overall picture described. To overcome such potential drawback, old masters placed tiles emphasizing the strong edges of the main subject to be represented.

#### Artificial mosaics

Another approach for the creation of ancient mosaics is presented in [DG05] and in [BDFG06]; this approach is based on directional guidelines, distance transform, mathematical tools and century proved ideas from mosaicists and leads to impressive results. The examples presented in Figures 2c and 2d show respectively the rendering of an opus musivum mosaic and of an opus vermiculatum mosaic.

#### Puzzle Image Mosaics

Puzzle Image Mosaic is inspired by Giuseppe Arcimboldo [Str99], a Renaissance Italian painter inventor of a form of painting called the composite head where faces are painted not in flesh, but with rendered clumps of vegetables and other materials slightly deformed to better match the human features.

#### 4. EVALUATION APPROACH

In addition to constructing a complete image stitching assessment indicators system, this paper present a blind evaluation approach in according to the indicators system. The so-called blind assessment means evaluators do not know the specific content of the stitching algorithm. All assessment experiment in this paper only need the input image and the mosaic image after stitching algorithm without knowing the types of stitching algorithm or the information of the location of image feature points. This method not only ensures a quick and easy evaluation experiments, but also increase the possibility of automation in the practical application.

In order to improve the method of harris corner, we present an auto-adjusted algorithm of image size based on phase-correlation. First, we detect the zoom relationship and translation co-efficiency between the images and modulate the unregistered image's scale to the same level as the original image. We obtain the Region of Interest (ROI) according to the translation parameter and then pre-treat the images and mark the interest points in the area by using improved Harris corner operator. Secondly, we adopt Normalized Cross-Correlation (NCC) to wipe out the mismatched points preliminary after edging process, and get the final precise transformation matrix. At last, we are using a method of weighted average to obtain a smooth mosaic image. The experimental results have shown that the setting of ROI and handling of the edge could cut the time down to about only half of the time consuming compared to SIFT. Besides, the scale difference between the images could enlarge from 1.8 to 4.7 and can eventually obtain a clear and stable mosaic result. The translation, scale and rotation in the available set of images are handled in the following way. Initially Phase correlation algorithm is used to calculate the cross-power spectrum for registration of images and is used to get the translation factor. For images that have relative relationships in location and scale, we can also get the zoom factor and rotation angle through a series of coordination transform.

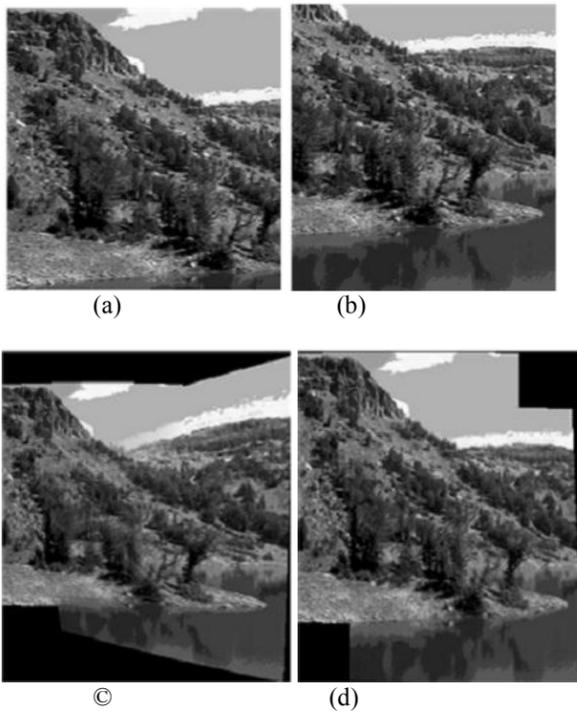


Figure 1.1: An overview of Image Mosaicing (a) First input image (b) Second input image (c) & (d) Mosaiced images by different mosaic techniques.

Figure (a) and Figure (b) are the input images, while Figure (c) and Figure (d) are mosaiced images. The image mosaic techniques are widely used in remote sensing, medical imaging, and military purposes and so on. Now a days, many smart phones are equipped with the mosaicing application which helps user in many different ways. The image mosaicing technique can be broadly classified into feature-based and frequency-based techniques. Feature-based method uses the most similarity principle among images to get the parameters with the help of calculation cost function. Method based on the frequency domain transforms the image from spatial domain to frequency domain, and get the relationships of translation, rotation and zoom factor through Fourier transformation. In frequency domain there are methods like phase-correlation, Walsh transform, etc.

#### 5. EVALUATION INDICATORS SYSTEM

First, we analyze the factors which reflect the performance of image stitching algorithm. Obviously the most direct factor is the quality of the mosaic image. Due to the two major steps of the image mosaicing: image registration and image fusion, evaluation indices must be able to quantitatively reflect the three key elements in the evaluation of image mosaic algorithm: accuracy of image registration, fusion effect of the image overlap part, visual effect of the overall image. In order to show the performance of the algorithm as

Comprehensively as possible, we use several indices instead of single one. Though practicality of the algorithm is also an important factor, it relies on the actual engineering application, so indices system in this article only focuses on the quality of the mosaic image.

#### 6.Feature extraction method

The original Harris corner detection method has some disadvantage that, even though it is robust to the illumination changes and rotations, it is very sensitive to the variation of image size. In addition, by doing a direct corner checking to images whose textures are dense or who have abundant details, we surely would get duplicate features in a local area. Inevitably, we must do extra work to extract and registration the points, including the useless ones. So additional preprocessing the image before extraction can offer a possibility to get more stable features. The improvement is done in the following way:

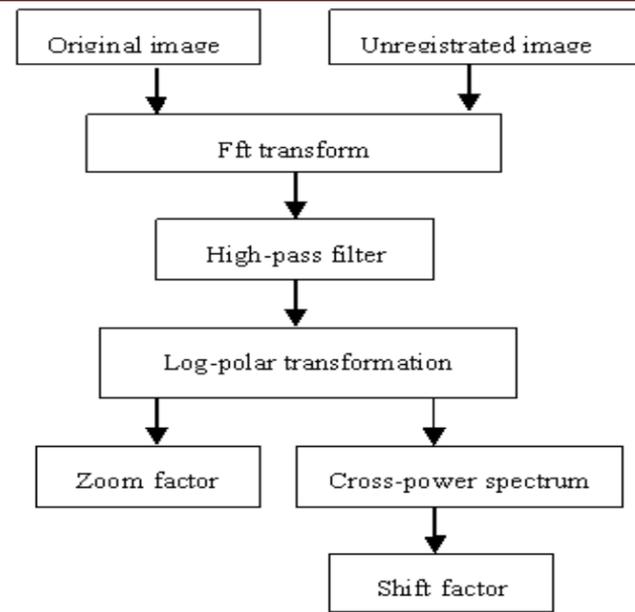


Figure .1: Flowchart to compute the factors.

Step 1: Get the shift and zoom factors with the help of phase correlation calculation.

Step 2: Modulate the unregistered image according to the zoom factor obtained from step 1 to get a couple of images with the same size.

Step 3: Ascertain the ROI (Region Of Interest) between the images.

Step 4: Preprocess image before other works. The edge detection can reduce the search area and can greatly cut the matching-time down.

#### 6.1 Image Scale Adjustment

##### 6.1.1 Phase correlation algorithm

Phase correlation algorithm uses the cross-power spectrum to registration images and is used to get the translation factor initially. Imagine there are two images I1 and I2, and the translation between them is as following:

$$I2(x, y) = I1(x - x_0; y - y_0) \quad (1)$$

The Fourier transformation:

$$F2(u; v) = F1(u; v) \cdot e^{-j(u x_0 - v y_0)} \quad (2)$$

F1 and F2 are the Fourier transformation of I1 and I2. The cross-power spectrum is:

$$\frac{F_1^*(u, v) F_2(u, v)}{|F_1^*(u, v) F_2(u, v)|} = e^{-j(u x_0 + v y_0)} \quad (3)$$

We can get an impulse function  $\delta(x - x_0, y - y_0)$  about the value of translation invariant  $x_0$  and  $y_0$  by using Fourier inverse transform to equation (3).

$F_1^*(u, v)$  is the conjugate function of  $F1(u, v)$ . We can get an impulse function  $(x - x_0, y - y_0)$  about the value of translation invariant  $x_0$  and  $y_0$  by using Fourier inverse transforming is an experiment to get the range shift of lena by using phase correlation algorithm. The preset value between image A and B is (20,50). There is an obvious impulse at the range shift coordination compared to the at site on the inverse conversion curve. So we can get the shift value via the location of the maximum value.

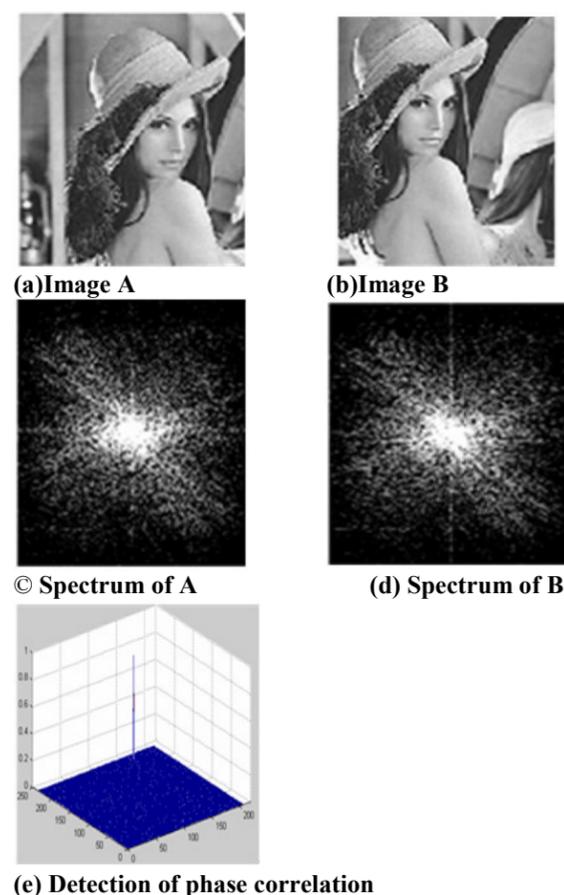


Fig. : Use phase-correlation to estimate the offset parameters

### 6.1.2 Extraction of Harris corner

In this paper, we get the corner response function by the ratio from the determinant and trace of matrix  $M$ , which can avoid the randomness when choosing the scale factor compared to the method based on the difference value of the above ones. Besides, just as the experiments show, we could get much more stable features along with a speed-up procedure.

$$R = \frac{Det(M)}{trace(M)} = \frac{\langle I_x^2 \rangle \cdot \langle I_y^2 \rangle - \langle I_x I_y \rangle^2}{\langle I_x^2 \rangle + \langle I_y^2 \rangle}$$

The non-maximum restrain of  $R$  can be obtained with the help of a maximum filter in a window that covers the area with a radius of 3, and the point whose  $R$  is less than the preset threshold would be removed.

### 7. Modified method of feature detection

Although brief and fast, the original Harris corner detection method has some shortcomings: even though it is robust to the illumination changes and rotations, it is very sensitive to the variation of image size. In addition, when doing a direct corner checking to images whose textures are dense or who have abundant details, we surely would get duplicate features in a local area. Inevitably, we must do extra work to extract and registration the points, including the useless ones. What's more, we cannot ensure the quality of the estimated results. Besides, knowing that the corners are in accordance with the curvature of the edges, we have reasons to assume that all the valid candidate features are included in the edges we get. So additional preprocessing the image before extraction can over a possibility to get more stable features.

### 8. Experiments and Discussions

All the experiments we do were on the 32-bit computer with XP system, MATLAB 7.0 platform and the pictures involved were taken from lena photos, landscape and buildings. The goal of experimentation is to evaluate our approach and compare the mosaic results during the feature extraction and matching by different methods.

#### 8.1 Results of the relatively scale by phase-correlation

The problem we focus on is to solve the scale non-invariant about Harris corner. Still with lena image as an example, the experiment was performed using the preset scales reported in Table 1, with a range variation from 1 to 4.5.

Table 1: Comparison of scales obtained by the phase correlation

Default scale	1	1.5	2	2.5	3	3.5	4	4.5
Calculate result	1	1.4845	1.9509	2.4472	2.8122	3.3128	3.7509	4.2383

Fig. 3 directly shows the measurement error of the two pairs of data as a form of line graph. Combined with Tab. 1 we can see that they are rather approximate to each other and the extent of the error is limited within 0.07 when the default scale is 1 to 4.7, even with a growth trend along with the increase of the preset value.

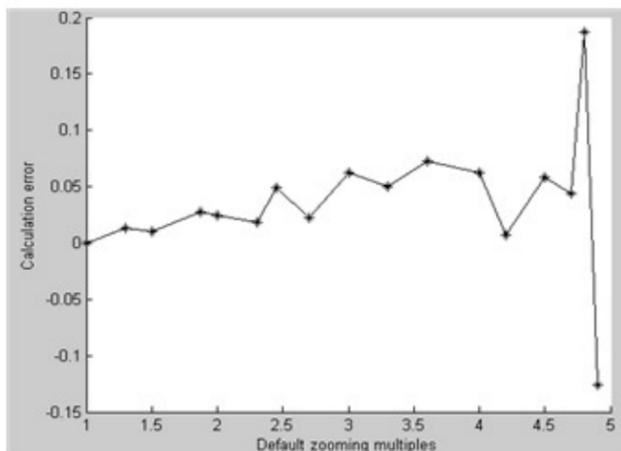


Fig. 3: Error of calculating the scales

#### 8.2 Comparison of matching results

The zoom factor between the images. Number of candidate points and matching pairs is shown in Tab. 2, including both before and after the phase correlation process. As it shows, even though there are more corner points after direct detection, we get only 5 pairs of matches after the registration, which are unstable result either and it's impossible to obtain a satisfying and seamless result. However by using the method we proposed, we guaranteed the precise matching by selecting after the scale transformation that the number of reliable feature that matches is 56.

Table 2: Comparison of the interest points detection

Number of point	Interest points	Matching points
Original image	121	----
Direct detection	612	5
Detection after translation	96	56

Fig. 4 shows the comparison of images that we got during the procedure performed on lena photos that have 3.2 times of scaling: find the ROI first through phase compute, then mark the features just in this area as Fig. 4 (a) and Fig. 4 (b) show. Fig. 4 (c) is the mosaic result using the original Harris matching, which is seriously distorted for not able to conquer the obvious difference of scale. And we can obtain a distinct and accurate result by employing our method just as Fig. 4 (d) shows. Fig. 4:



Fig. 4: Comparison between real examples (scale=3.2)

We have done the registration among about 30 pieces of photos aiming at characters, landscapes and structures, et al in our reality work. Fig. 5 are another two results about different scaling value. In Fig. 5 we can get the satisfactory mosaic image using both two methods, where the images with 1.6 times scale difference, however it's obvious that the result of our method is much better than direct matching. Let's then see the result Fig. 5 (d) shows, with no doubt that it's successful. In conclusion after numerous tests we come to a conclusion that matching based on Harris corner only works when the zoom factor between the images below 1.8 and that's the extremity and istortion has already emerged then. Through the calculation of phase correlation and adjustment to the scale relationship of the images, in contrast, we can solve the problems even the scaling is 4.7, and within this figure of course. Not only this leads to a much bigger scope of application for Harris, but also it is a promising mosaic result doing the matching work on the same order of scale.

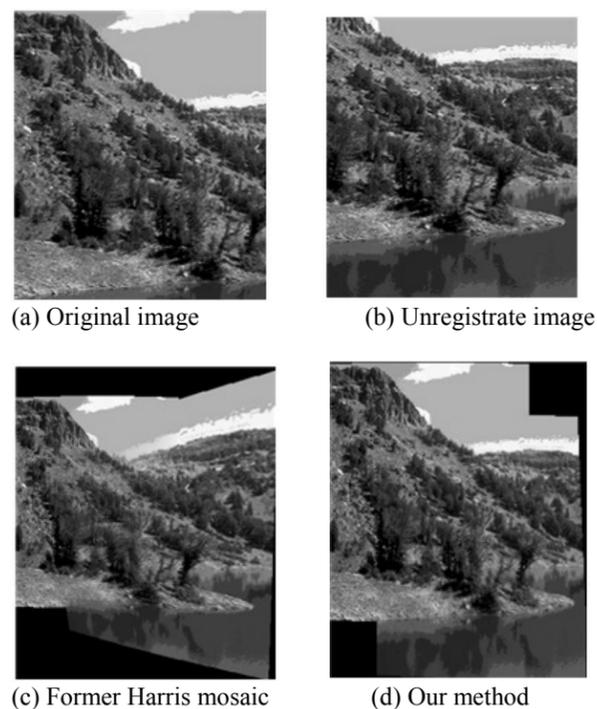


Fig. 5: Mosaicing results of landscapes (scale=1.6)

#### 8.3 Analysis of effectiveness

We have mentioned that the most valuable advantage of Harris operator compared with SIFT is its short running time. We hope this superiority could maintain even after the scale transformation, so we recorded the elapsed time of our method and confirmed the proposal afterwards.

Still with the above three groups of images as an example, from Tab. 3, we see the contrast of time-consuming between SIFT arithmetic and method used in this paper. Direct at images with diverse scaling, as expected, we only used nearly half of the time that SIFT costs to get the equal satisfying results. The explanation is as following: Although we added the amount of work for phase section, we delimit the ROI. And along with the preprocessing it decreased the workload dramatically. As a result the time-consuming was decreasing instead of increasing. This superiority can be performed better when we conduct the mosaic work aiming at big scenes and panoramic images.

Table 3: Comparison of the interest points detection

Mosaic method	SIFT time/s	Our method time/s
lena	4.859	2.641
Landscape	4.173	1.942

#### CONCLUSION

It can be possible to design an application for Smartphone OS such as Android mobile by which we can communicate with others using SIP-based VoIP. The purpose of this application is to implement a telephony program that uses WIFI in Peer-to-Peer or WLAN (Wireless Local Area Network) as a means of communication between mobile phones at no cost. The system will allow users to search for other individuals within WIFI range and to establish free peer-to-peer connections for voice communication and also for file transfer and chatting.

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