KAUNAS UNIVERSITY OF TECHNOLOGY
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INVESTIGATION OF PANORAMIC CAMERA VIEW ALGORITHMS

Master's Degree Final Project

Supervisor
Assoc. prof. dr. ARMANTAS OSTREIKA

KAUNAS, 2017

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DEPARTMENT OF MULTIMEDIA ENGINEERING (P000M106)

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"INVESTIGATION OF PANORAMIC CAMERA VIEW ALGORITHMS"

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SUMMARY

The purpose of this project is to investigate algorithms that stitch two or more corresponding images of the same scene to form a Panorama. Several algorithms are studied based on the image stitching parameters. A brief review of the existing algorithms are made in the analysis section. Implementation is made by considering two algorithm SIFT, RANSAC and Correlation Technique.

SIFT algorithm is used for experimentation of the panoramic image formation, alpha blending is done to remove seam between images and weighed average method to stitch images together. RANSAC method is used for outlier elimination after feature extraction and feature matching. Correlation Technique uses the weighed scale average for stitching for images, it has no feature extraction, and no outlier elimination is not performed.

These methods are compared with an image of good resolution which is stitched using the same, run-time of both the methods are compared. Image quality parameters such as mean square error, peak signal-to-noise ratio, normalized cross correlation, average difference, structural content, maximum difference and normalized absolute error values are used for comparison.

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LIST OF ABBREVIATIONS

SL.NO	ABBREVIATED WORD	ABBREVIATION
1.	Scale Invariant Feature Transform	SIFT
2.	Field Of View	FOV
3.	Speeded Up Robust Features	SURF
4.	Laplacian of Gaussian	LOG
5.	Difference of Gaussian	DOG
6	Photodynamic diagnosis	PDD
7	Random sample consensus	RANSAC
8	Principal Component Analysis	PCA
9	Fast Fourier Transform	FFT
10	Fourier Transform	FT
11	Speeded up robust features	SURF
12	K-nearest neighbor	K-NN
13	Signal to Noise Ratio	SNR
14	Peak Signal to Noise Ratio	PSNR
15	Mean-Squared Error	MSR

INTRODUCTION

Image stitching has been an ongoing topic for researchers in the areas of graphics. Image stitching is nothing but merging or combining two or many images which are in or of the same scene in order to produce a really good high-quality image which is called as a panoramic image or mosaic [11]. Image Mosaicking is a combination of images that are of same scene or are correlated to obtain an image that is of the greater field of view (FOV). Image stitching is more likely used in application for video stitching, for digital maps and for satellite photos. Since basic cameras generate very low FOV and can never produce images with have high FOV. But image mosaicking generates good set of high FOV. Images are stitched together for generation of a better FOV.

The process of stitching an image undergoes several stages, direct and feature based techniques are the main methods used in the stitching of images. And to generate panorama these five basic steps are certain to be followed; Feature extraction, Feature Matching, Outlier Elimination, Stitching, and Blending. In this paper, feature descriptors algorithms are studied and used to form the panoramic image, Correlation Technique is also taken into account. Furthermore, evaluation is decided upon the output of stitched panoramic image quality and the run time to generate the output image.

Numerous mosaicking algorithms have been proposed. These proposed algorithms are tested and compared based on the image quality parameters and the run-time. Image quality of the output can certainly be decided upon human perception but in order to compare the initial quality and the final output experimental results are considered.

AIM AND TASKS

The main aim is to compare few of popular algorithms for image stitching, to determine which algorithm works out best in the creation of panoramic Images in terms of output quality. The objectives are formulated in the following manner.

- Review the algorithms based on the creation of panoramic images;
- to make implementation of the chosen algorithms;
- to elaborate the implementation for the algorithms;
- to compare distinct algorithms for panorama creation based on the output quality parameters and run time.

1 ANALYSIS OF EXISTING SOLUTIONS

Image mosaicking is the phenomenon of producing the high resolution disjoint mosaicked image so as to achieve a large field of view. It is done by stitching multiple overlapping visual images with overlapping fields. The mosaicked or panorama image can be generated using the computer software. Many of the algorithms for mosaicking of images require a nearly rigorous overlap between images. Also if the exposure id identical in all the images, it will help to produce seamless results [13] [11].

1.1 Image Stitching Using MATLAB

Tejasha Patil, Shweta Mishra, Poorva Chaudhari, Shalaka Khandale [1]

In this paper the main goal is to stitch smaller images together in order to form a larger and well-formed image, script for this is written in MATLAB. Different methods of stitching stages are analyzed in the iteration of the stitching process.

In this paper, for stitching of the images 3 important image stitching process is considered:

a. Image Acquisition
b. Image Registration
c. Image Merging

Further on for detection and matching Scale Invariant Feature Transform (SIFT) algorithm is used. They have proposed a novel image matching algorithm. The algorithm can altogether expand the number of matching pairs and matching accuracy.

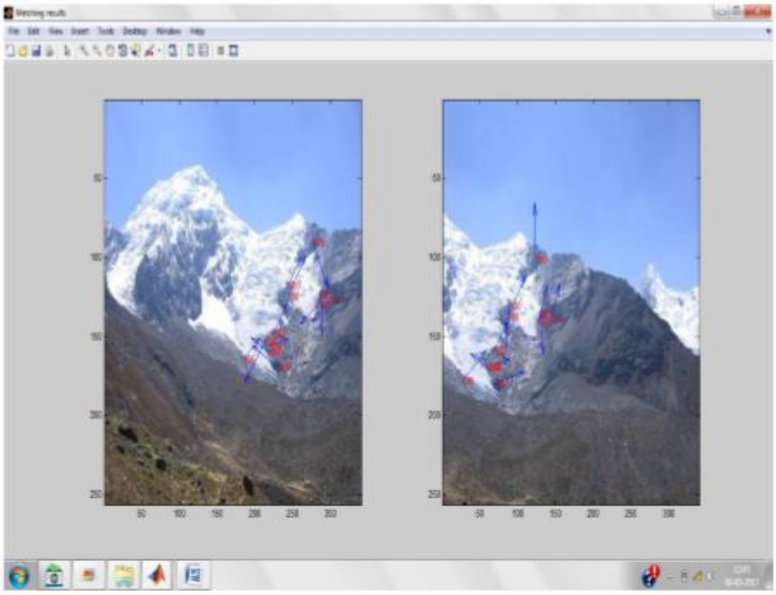

Figure 1 Keypoint detection [1]

And RANSAC algorithm for a large proposition of outliners in the input image [1].

Extensive experimental results show that this method improves the traditional detectors, even in large variations, and the new indicators are distinctive. Their algorithm increases the possible number of matching accuracy and matching pairs. But fails to provide consistency in the image [1].

1.2 Creating Panoramic Images for Bladder Fluorescence Endoscopy

This paper was developed to create an image mosaicking algorithm for endoscopic bladder fluorescence video sequences. Based on SIFT features Alexander Behrens [3] estimate a 2-D homograph for each image pair, stitching process is applied and perform a mutual linear interpolation [3]. Image preprocessing, feature detection, feature matching, homography estimation and stitching and blending the image are the steps that is followed.

a. **Feature Detection:** The author has chosen a feature-based method since the PDD bladder images generally show a high-contrast structure. SIFT features are located by detecting the local extrema of the difference-of-Gaussian (DOG) function, which approximates the scale-normalized Laplacian of Gaussian (LOG) [3]. The relationship between DOG and LOG can be under- stood from the heat diffusion equation:

$$\frac{\partial G}{\partial \sigma}=\sigma \nabla^2 \mathrm{G}, \tag{1}$$

$$\sigma \nabla^2 \mathrm{G}=\frac{\partial G}{\partial \sigma} \approx \frac{G(x,y,k\sigma)-G(x,y,\sigma)}{k\sigma-\sigma} \tag{2}$$

$$\Leftrightarrow \underbrace{G(x,y,k\sigma)-G(x,y,\sigma)}_{DoG} \approx (k-1)\sigma^2 \underbrace{\nabla^2 \mathrm{G}}_{LoG}. \tag{3}$$

Eq. (3) shows that the DOG function with a constant scale difference (k-1) approximates the σ^2 scale-normalized LOG multiplied by a constant factor (k -1), which does not influence the extrema detection [3].

A result of feature detection is shown in Fig 2

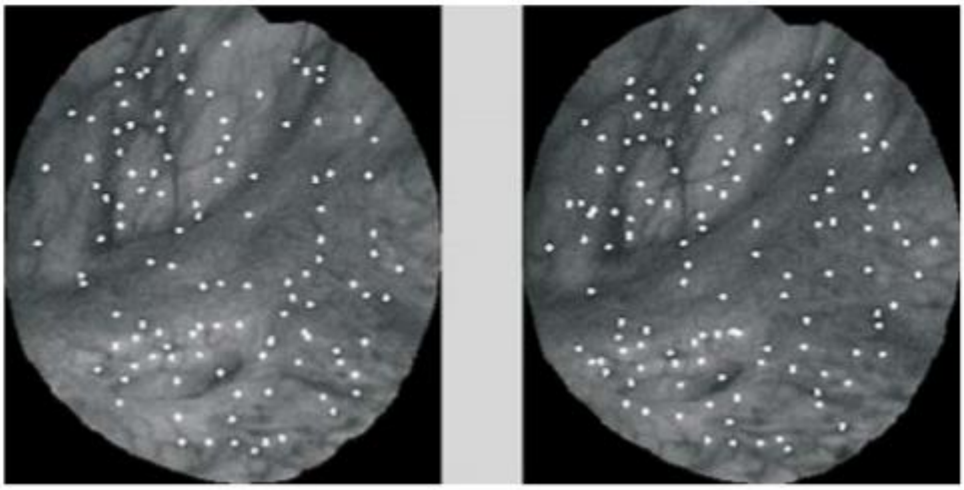

Figure 2 SIFT features located in image one (left) and image two (right) [3]

b. **Homograph estimation:** In this step, the authors have determined an image-to-image transform, so-called 2-D homographs, based on the final point correspondences. In homogeneous coordinates, the homograph matrix M can be written as

$$M=\begin{bmatrix} a & b & c \\ d & e & f \\ 0 & 0 & 1 \end{bmatrix}=\begin{bmatrix} A & \vec{t} \\ 0^{-T} & 1 \end{bmatrix} \quad (4)$$

with,

$$A=\begin{pmatrix} 1 & a \\ 0 & 1 \end{pmatrix}\begin{pmatrix} s_x & 0 \\ 0 & s_y \end{pmatrix}\begin{pmatrix} \cos(a) & -\sin(a) \\ \sin(a) & \cos(a) \end{pmatrix}. \quad (5)$$

RANSAC algorithm is used for outliers in the resultant match.

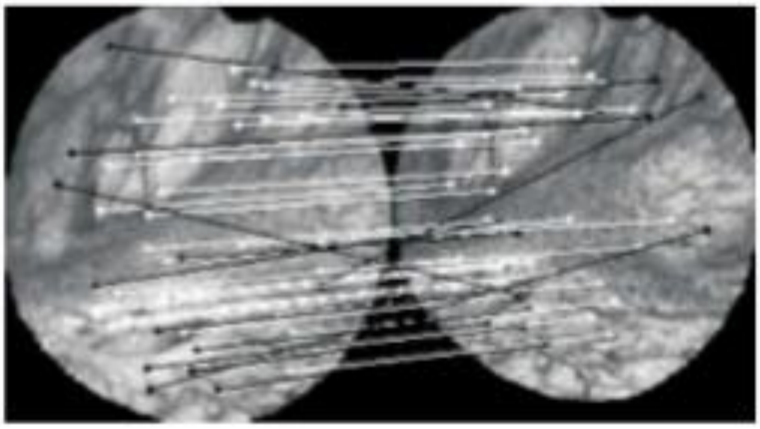

Figure 3 Rejected outlier points (labeled black) performed by the RANSAC algorithm [3]

Due to quite less amount of image contrast structure, not enough matching points are found and therefore leads to failure in the matching points. Therefore an image mosaic algorithm was developed for bladder video sequences in fluorescence endoscopy [3].

1.3 Fast Image Mosaicking For Panoramic Face Recognition

In this research paper, Yang, Fan, et al [4] proposes few development results of a system that performs mosaicking of panoramic faces. 5 different cameras were used to take 5 different images in different angles to study the feasibility of panoramic face construction. Liner transformation was chosen to form panoramic image for these 5 views. Study on panoramic face recognition was undertaken in order to approve the system of panoramic face mosaicking, it was done based on the PCA method [4].

PCA for face recognition is applied which proceeds by first performing a PCA on a well-defined set of images of known human faces [4].

$$A = P\Delta G^T \quad (6)$$

Given the singular vectors P, every face in the database is represented as a weight vector in the principal component space [4].

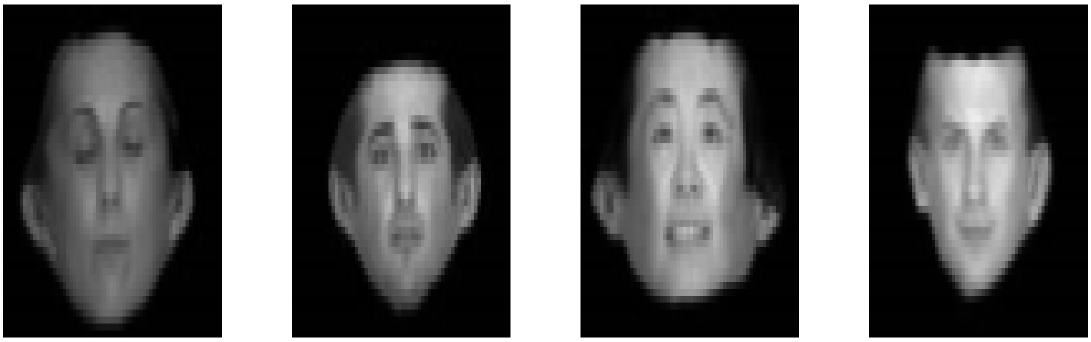

Figure 4 Panoramic faces of four unknown person [4]

Experimental results show the feasibility and viability of the system. Hence a fast and simple method for panoramic face mosaicking was proposed. Two panoramic face representations: spatial and frequently, were tested and the result was that the frequent representation gives the best performance with a correct recognition rate of 97.46% versus 93.21% for spatial representation [4]. Negative samples were used for panoramic face recognition and the result was 92.38%. An advantage of the fast mosaicking system is that it gives relevant 3D facial surface information for recognition application.

1.4 Image Mosaicking and Producing a Panoramic Visibility

The main aim of this research paper is to take multiple input images with each image having overlapped image of the other. Since normal digital cameras cannot take a picture with a wider view, the idea in this paper is to develop a methodology that can enable these images to form a single panoramic image. Sharma, Manmohan [5] have proposed an algorithm that is used and applied to some of the advanced function available in MATLAB to make this work much more efficient.

In order to form the panoramic image 4 sub-parts of image mosaicking is focused in here:

- Image registration;
- Image stitching;
- finding line of cut in new image;
- Image blending.

In the verge of getting a better panoramic view of the stitched image the following steps are performed.

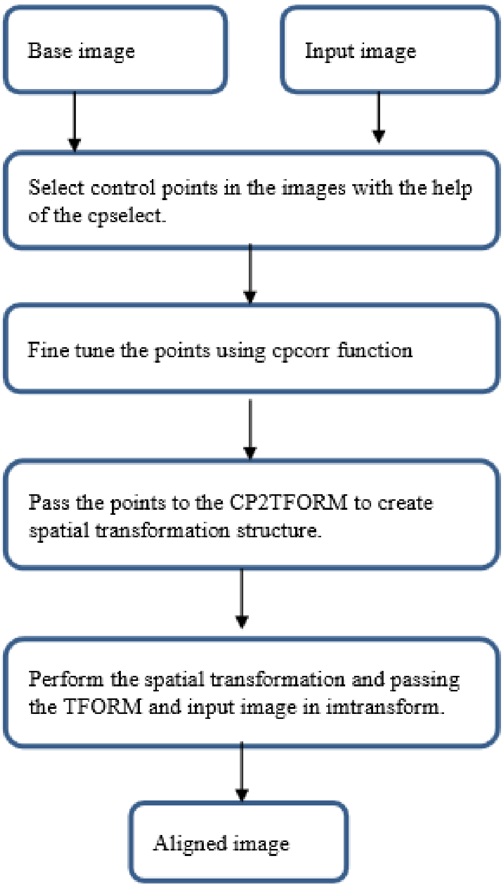

Figure 5 Steps of image registration [5]

Points in an Image were taken and transformation matrix was calculated which later helped in Image registration. 30-70% of overlapping in the images are taken.

Figure 6 input images [5]

After the image registration, stitching and blending mosaic image were done.
On performing image mosaic on the three images output mosaic image was formed.

Figure 7 Final output of the 3 images [5]

The final output looks just fine and the efficiency and correctness are largely dependent upon the user while selecting the control points. Some of the sub-parts like image blending, image registration or interpolation can be more optimized and can be made efficient [5]. The disadvantage of this method is that there is no automatic image mosaicking which could give control points. Therefore all these aspects of image mosaicking can be extended.

1.5 Generation of Panoramic View with Depth Cue Using Image Convergence Technique

Authors Audu, Abdulkadir Iyyaka [6] proposes a method for generation of a panoramic view of a scene significant difference when compared with the conventional panorama. This technique is based on the continuous division method. Algorithm which is implemented by this technique is characterized by reliable results and fast implementation run time.
Feature descriptors are extracted using SIFT algorithm. Candidate correspondence points as shown in Fig. 8, two images are computed based on these descriptors.

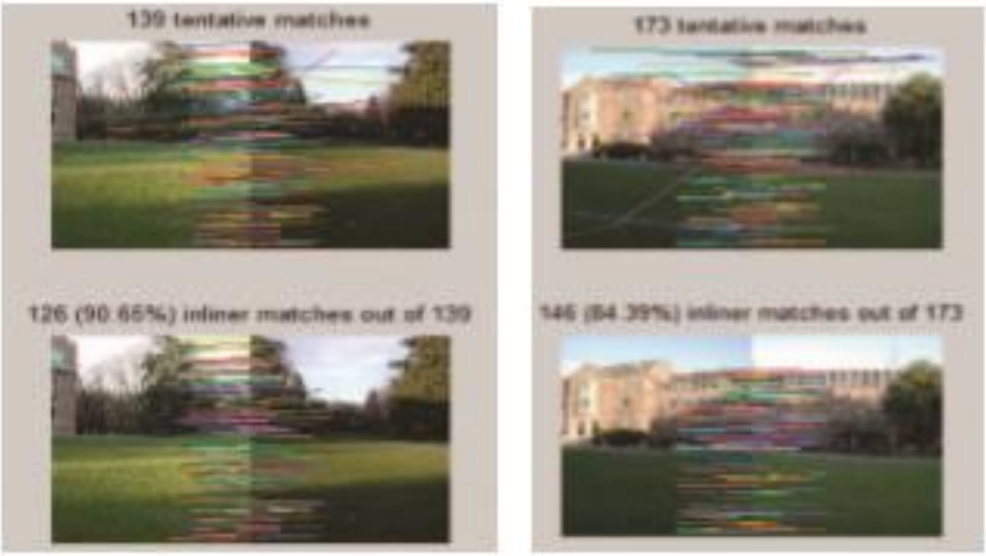

Figure 8 Candidate corresponding points and
inliers for some image samples [6]

To complete homographs the output of RANSAC is used. This paper mainly focused on the depth cue based on the continuous division method of converting one number system to another.

Figure 9 Panoramic view with depth cue [6]

Realization of perspective projection in panoramic views has been impressively demonstrated using both theoretical analysis and implementation results. Unlike the conventional panoramic view, an object in the distance appears to be smaller compared to the nearby [6].

1.6 Automatic Image Mosaicking: An Approach Based On FFT

Patidar, Ms Durga [7], in this paper have formulated image mosaicking based on Fourier domain that is used for finding translational and rotational parameters and use them for image mosaicking. In view of this, it has been calculated the translational parameters and proposed an algorithm for finding the angle of rotation using Fourier Shift approach. Finally, it shows merging of two images. In the paper have worked with Mosaicking two images. It can extend it to multiple images by sending two images at a time to the algorithms proposed and merge them accordingly [7].

Figure 10 Input images [7]

Figure 11 Mosaicked image [7]

A key feature of Fourier-based registration methods is the speed offered by the use of FFT routines. This paper presents a successful method for binarized images that are automatically mosaicked, these images are taken by a lost cost camera and phase correlation method is applied to it. The proposed algorithm gives a prominent angle of rotation efficiently [7].

1.7 Recognizing Panoramas

Brown, Matthew, and David G. Lowe [9] the problem that is being addressed in this paper is the fully automatic construction of panoramas. Technically, this problem demands recognition to know which parts of the panorama are to merge. In this paper, object recognition techniques based on invariant local feature is used to select similar or matching images, and a probabilistic model for verification. The camera takes an input image on an entire flash card and it recognizes images that form part of a panorama, and stitches them with no user input. Now assuming that the camera rotates about its optical center, the group of transformations the images may undergo is a special group of homographs [9].

This gives pairwise homographs

$$\overrightarrow{u_i} = H_{ij}\overrightarrow{u_j} \quad (6)$$

$$H_{ij} = K_i R_i R_j^T K_j^{-1} \quad (7)$$

where;

$$K_i = \begin{bmatrix} f_i & 0 & 0 \\ 0 & f_i & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad (8)$$

Exponential representation for rotation;

$$R_i = e^{[\theta_i]x},\ [\theta_i]x = \begin{bmatrix} 0 & -\theta_{i3} & \theta_{i2} \\ \theta_{i3} & 0 & -\theta_{i1} \\ -\theta_{i2} & \theta_{i1} & 0 \end{bmatrix} \quad (9)$$

Once features have been extracted from all n linear time images, they are matched.

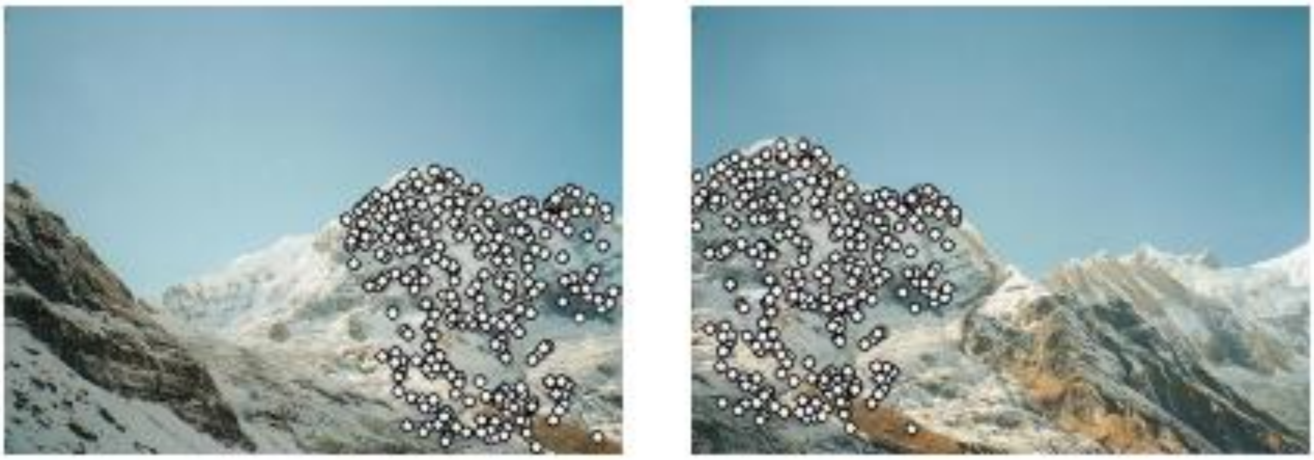

Figure 12 SIFT matches [9]

SIFT features are extracted from all of the images. RANSAC is performed to compute the homography, image match based on the number of inliers is verified with the help of another model.

Figure 13 Images aligned according to a homograph [9]

In the Fig.12 the input images are 517 × 374 pixels, and feature matches are around 247. SIFT features are matched fasters and the panorama image is seamless [9].

1.8 SURF Applied In Panorama Image Stitching

Juan, Luo, and Gwun Oubong [10] this paper proposes SURF (Speeded up Robust Features) an image blending. Comparison is between SIFT (Scale Invariant Feature Transform) and modified SURF. According to the experiments, can manage to get a perfect panorama with stitching seam being invisible, it is faster and more reliable.

Figure 14 Panorama stitched 16 images based on SIFT [10]

Fig. 14 shows good SIFT demo, it is known for its robust performance and perfect result. The Fig. 15 shows a well stitched panorama which is experimented.

Figure 15 Panorama stitched 16 images based on modified SURF [10]

Modified SURF allows high resolution panorama to be created. K-NN and RANSAC improve the repeatability of matching [10].

1.9 Image Stitching Approach

Image stitching is stitching or merging of two or more images to form a mosaic with good quality. Images stitching techniques are classified into two methods: Direct and Feature based techniques. [2].

In direct-technique, the comparison is based on every pixel's intensity of an image with that of the other, whereas Feature-based techniques extract distinct features from the processed images and correlate them [2]. Direct-based is considered to be more advantageous as it I faster, robust and can automatically determine relationship overlapping relationships among an unordered set of images. In the direct technique, pixel to pixel variation is reduced to do image stitching. While feature-based technique works by pulling out a feature set and then does the matching with each other. [2]

1.9.1 Feature Detection and Matching

In image stitching Feature Detection is one of the basic steps. Feature correspondence between the images have to be present to blend the images properly. Feature detection and correlation is described briefly:

Feature

Feature is a part of image which can be considered as an identity point for further evaluation. To achieve correlation between images, a better set of feature points are to be considered. To be precise, the points that have smooth variation in pixel points should be considered. The points which have large pixel value variation is taken as candidate points.

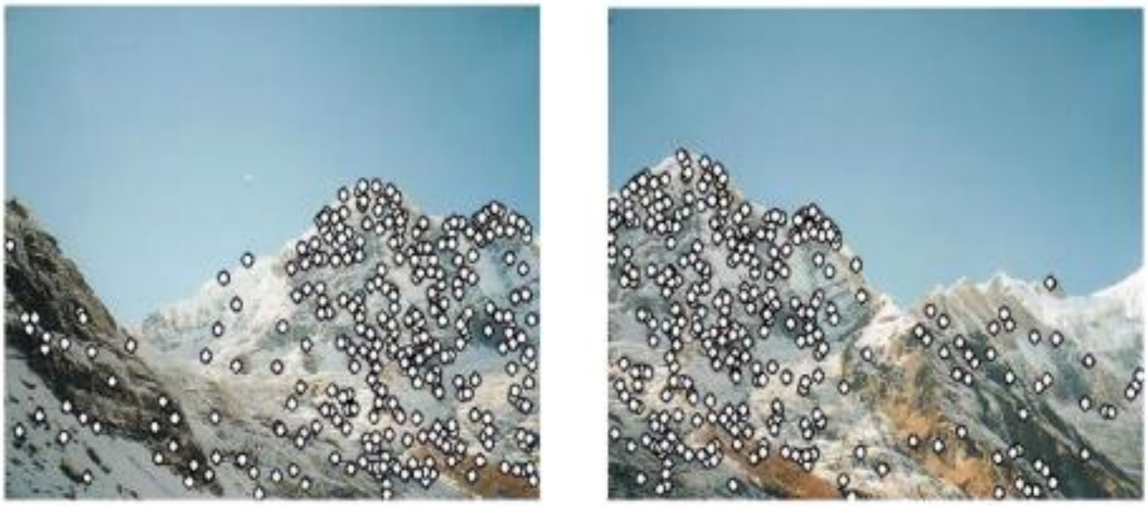

Figure 16 Detecting the points [9] [11]

As seen in Figure 16 edges or corners are generally considered good candidate points.
The following are the types of features present:

a) **Points**

Points are not considered as features since an image has quite a good number of points in them and because of which the processing time would be longer and would also require high memory.

b) **Edges**

Edges are boundary points of an image, it can be a network or a structure between pixel values which are different to the neighboring pixel values.
Edges are one-dimensional feature points that has good features for low level processing.

c) **Corners**

Corners are usually two-dimensional feature points and they produce greater values, corners keep changing in the pixel values. Sometimes the dark patches in a white background are considered as corner points even when they technically are not corner points, but they are not considered as interest points. Therefore corners provide features that a like points. LOG and DOG are included in corner detection algorithm.

d) **Blobs**

Blobs give the description of feature points that is complementary and the structures are region-type [9]. Center point works as a preferred point and all the other points are compared with the center point. Blob detectors may also be considered as interest point operators. Blob detectors works with a patch of image rather than a localized point. Scale is always considered while processing the image as the smooth patch is converted to point of intersect.

1.9.2 SIFT Algorithm

Scale invariant feature transform (SIFT) is used to detect and describe local features in an image. Image features in SIFT provide object features which are not affected by any parameters during other method, for example while scaling or rotation [19].

SIFT algorithm undergoes 4 approaches:

a) Scale-Space Detection:

This stage identifies scales that are detectible from different views of same object. This is achieved by "scale space" function which is defined by the following based on Gaussian function:

$$L(x, y,\sigma) = G(x, y,\sigma) * I(x, y) \tag{10}$$

Where G(x, y,σ) is variable set and I(x, y) is input image.

Difference of Gaussian technique is used to detect stable keypoint location.

b) Keypoint Localisation

In this stage points that have low contrast or poor edges are eliminated, calculation is done using Laplacian value. The location of extremum, z, is given by:

$$z= -\frac{\partial^2 D^{-1}}{\partial x^2} \frac{\partial D}{\partial x} \tag{11}$$

If function value at z is seen below threshold value then this point is excluded, this helps in removing extrema with very low contrast [19] [20].

c) Orientation Assignment

This step assigns steady orientation to keypoints based on local image properties [19]. The following approaches are taken in account to find an orientation:

- Computation of gradient magnitude, *m*

$$m (x, y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2} \tag{12}$$

- Location of highest peak in the histogram.

d) Keypoint Descriptor

The local gradient data is also used to form keypoint descriptors. The descriptor vector has (4x4) x 8= 128 entries [19] [20].

1.9.3 RANSAC Algorithm

RANSAC (Random Sample Consensus) estimates image transformation parameters by the minimal set of random data. The outliers and inliers are calculated for the set of observed data set [21]. RANSAC goal can be achieved by iterative selection of a random subset data points from the original data, supposed to be inliers [21].

RANSAC is suitable for applications where understanding is based on data that is given by feature detectors, as it is capable of giving out data with total errors.

1.9.4 Direct (Pixel-Based) techniques

In this technique, each pixel is compared with the other, it uses information achieved from the image alignment. Direct methods are all known as Pixel-to-pixel matching, data from all the pixels are collected the role of each element is measured.

Remapping of pixel coordinates from one image into another is carried out when there are two consecutive photos with a slight shift while capturing the second one. This transformations is grouped in a Homography matrix. The main disadvantage of this technique is that it has limited range of convergence [21].

1.9.5 Harris-Corner Detection

Harris-Corner Detection method as the name suggest is used to detect corners and feature points from images, this method is rotation-invariant i.e., even if the image is rotated we can find the same corners. Therefore it helps in finding the difference in finding the intensity of displacement. Comparison of different patches on two images is one of the main criterion. A point is easily recognized by shifting the window in any direction and see a large change in intensity [22].

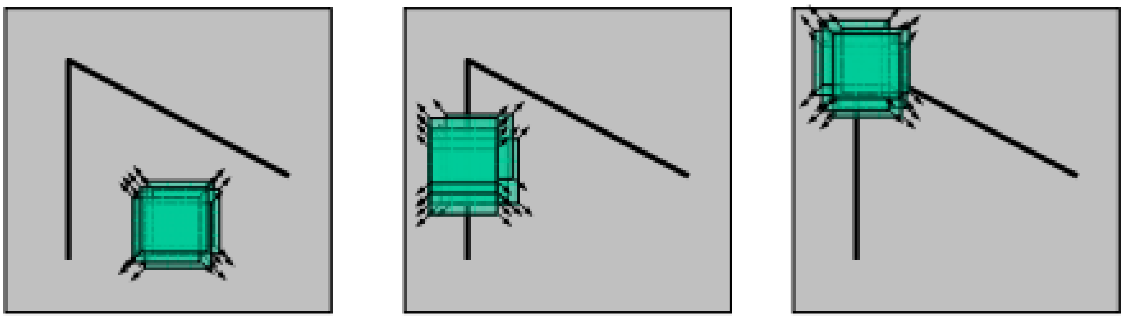

Figure 17 Harris Detector [22]

The Fig. 17 shows the flat, edge with no change in change in direction when shifted, whereas corner shows significant change.

Change of intensity for the shift is given by the following equation:

$$E(u, v) = \sum_{x,y} w(x, y)[I(x + u, y + v) - I(x, y)]^2 \quad (13)$$

Average intensity change is calculated using the above equation, where window function, shifted intensity and intensity are given.

2 METHODOLOGY OF PROPOSED SOLUTION AND PLANNING

After a detailed study on number of image mosaic algorithm and methods for the panoramic image formation and considering all the advantages and disadvantages, it is noticed that each algorithm is considers a few variation in account while generating the output.

Patil, Tejasha [1] in the paper a novel method for image matching is proposed, where the SIFT algorithm is used for feature matching approach and RANSAC as an elimination technique for outlier elimination in the input image or data. But they fail to estimate the quality of the image after it is stitched.

2.1 Experimental Planning

This paper's main objective is to formulate or experiment algorithms such as SIFT and RANSAC is considered for the panorama formation and Correlation Technique is also considered, further the two resultant images are used to check and compare the quality of image mosaic and the time taken, by executing and testing the robust mosaic algorithms for panorama which is based on SIFT and RANSAC, and panorama based on Correlation Technique.

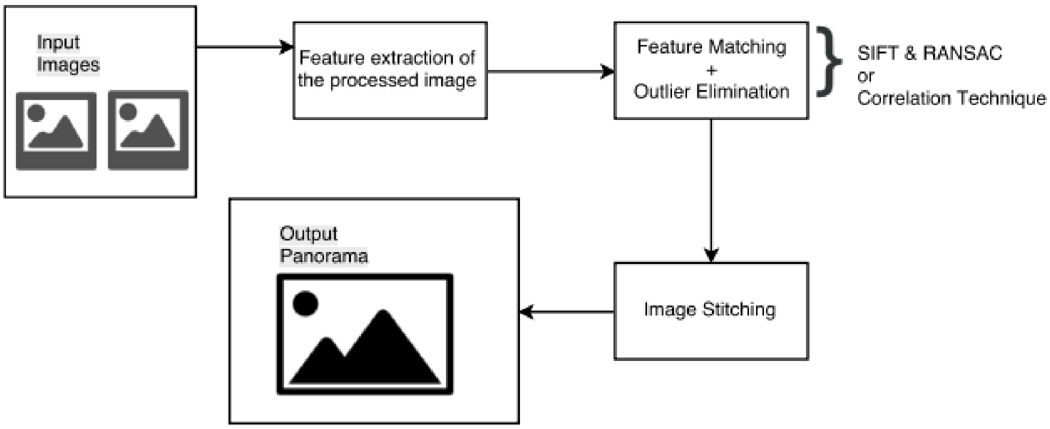

Figure 18 Process flow diagram

2.1.1 Input image

This is basically image acquisition, this image acquisition is always the very first step in panorama image stitching work flow sequence. These image acquired can be from any sources or of any hardware and is unprocessed. Here in this paper images are considered to be taken from a basic handheld camera.

2.1.2 Feature Extraction

Feature Extraction establish the correspondences between points, lines, edges, corners, or other geometric entities. Feature based method extract multiple features from every input image which will correspond with other images, and feature descriptors are used to extract the feature points of the input image which will match with the other.

2.1.3 Feature Matching

Feature Matching is the next step which is performed to match the input images based on the features that are extracted, feature matching does the calculation part wherein different images are calculated to provide a better matching for the image pairs. In this paper SIFT based matching technique is done between the images to find the match.

2.1.4 Outlier Elimination

After estimating the features from the image outlier elimination is carried out where outliers are original pixel from the image. Here outliers are eliminated uses the RANSAC outlier elimination technique, iterations are done in order to estimate parameters of the data that contains outliers. The RANSAC algorithm inputs a set of data values, a parameterized model that explains or fits to the observations, and a few confidence parameters.

RANSAC succeeds by iteratively choosing a random set of the initial data. These data are known as inliers and this hypothesis is then tested

2.1.4 Stitching

This process is carried out once the pixels have been mapped into composite surface for mapping. In this process step blending of the image is carried out to get the final output panorama image. One of the image is taken as a reference and the rest are wrapped to the reference coordinate system The paper focuses on gradating in and out amalgamation is done, where the pixel values of the blended region is combine with the distance between overlapping areas in the image that is blended.

2.2 Software used

- MATLAB R2013 and has been executed in system with configuration i5 processor, 4 GB RAM, 2 GB cache memory and 2.8GHz processor.

Image quality parameters are compared.

For run time experiment is carried out through multiple system and the process run time is calculated

3 IMPLEMENTATION AND EXPERIMENTAL ANALYSIS

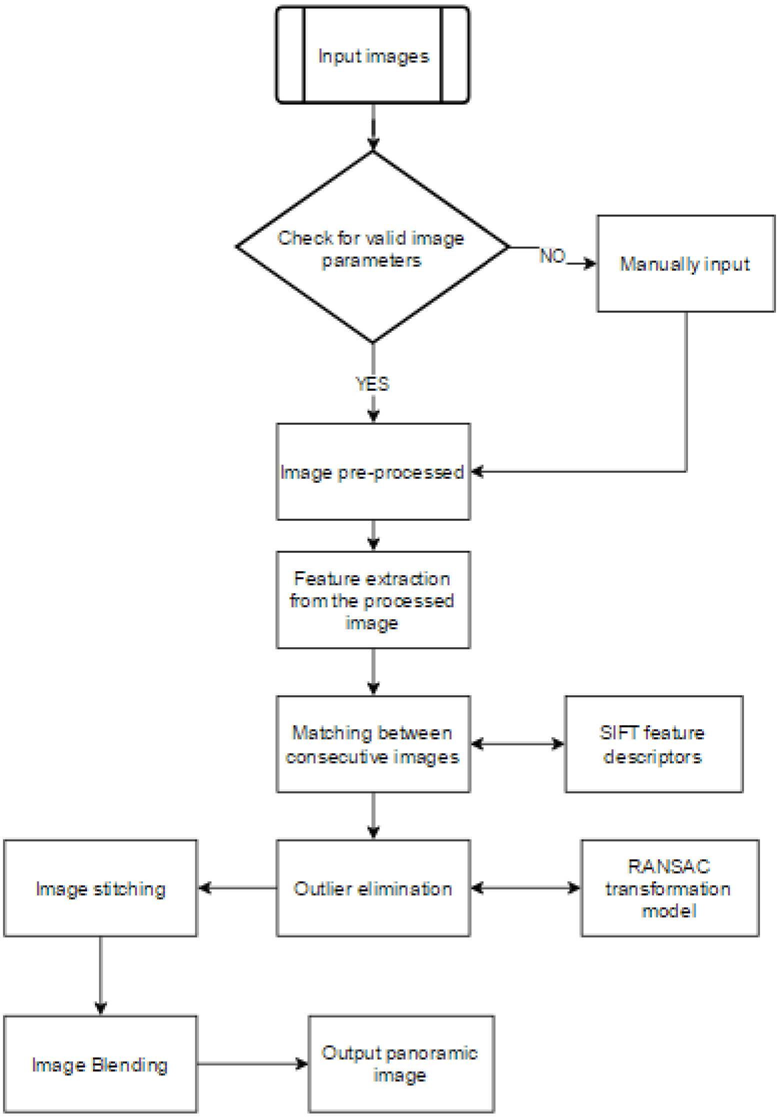

Figure 19 Main steps to render a panoramic image

The input image is taken from a handheld camera, two set of images are considered. The pixel size of the images are reduced to 500x500. Next step is to load input images into the program.

Feature extraction is performed, where intimal set of data or values are calculated. SIFT technique is used for feature matching and the outlier elimination is carried out using RANSAC. Whereas for Correlation Technique the images are stitched based on the weighed scale average and there is no feature extraction. Furthermore images are merged, stitched and blending to form fine panoramic output.

The algorithms for mosaicking of panoramic images are implemented in MATLAB R2013 and has been executed in system with configuration i5 processor, 4 GB RAM, 2 GB cache memory and 2.8GHz processor.

Figure 20 Input image 1

Figure 21 Input image 2

Input images are taken from a handheld camera, these images were reduced to 500 pixels for faster run time process

3.1 Panorama based on Correlation

There is no feature extraction in Panorama based on Correlation. It is based on the relation between the images. Images are stitched based on the weighted average. Masking of images in performed in the method. A patch of the second image is taken as a mask and is correlated with the same size of an image pixel of the very first image, the mask, therefore, shifts and correlates.

The point where the correlation is maximum is taken as an optimum point. This point is used for stitching the second image over the first. The time taken for the creation of the panorama when experimented is found to be 4sec. But the quality of the output produced is less. Comparison of more than two images is difficult in the correlation. It is variant to rotation, scaling and other transformation. But correlation can be used for smaller set of images that are preprocessed as the run-time for such image is very less.

```
F = im2double(I1);
S = im2double(I2);
```

These function are used to convert the intensity image I to double precision, rescaling the data if necessary.

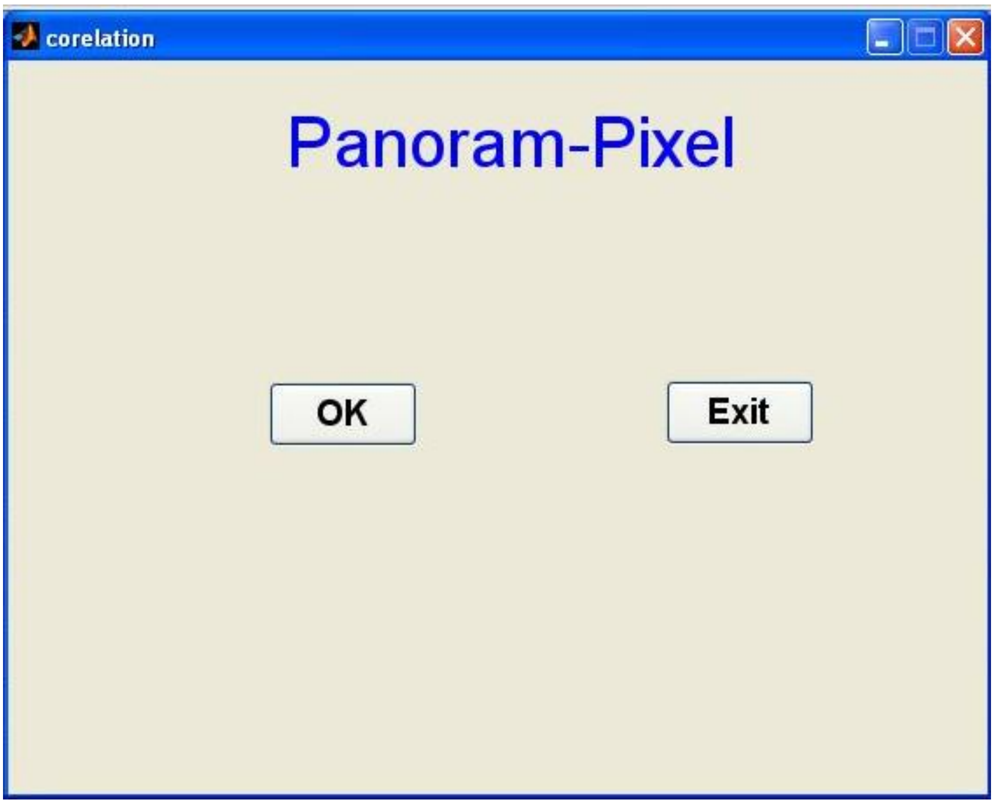

Figure 22 Alert box

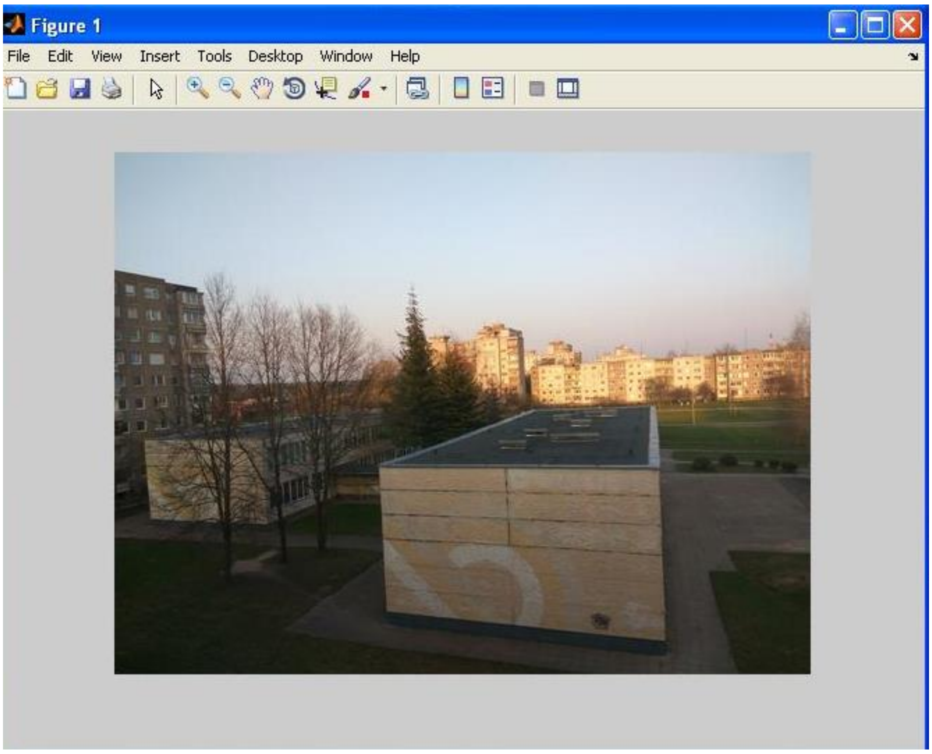

Figure 23 Input image 1

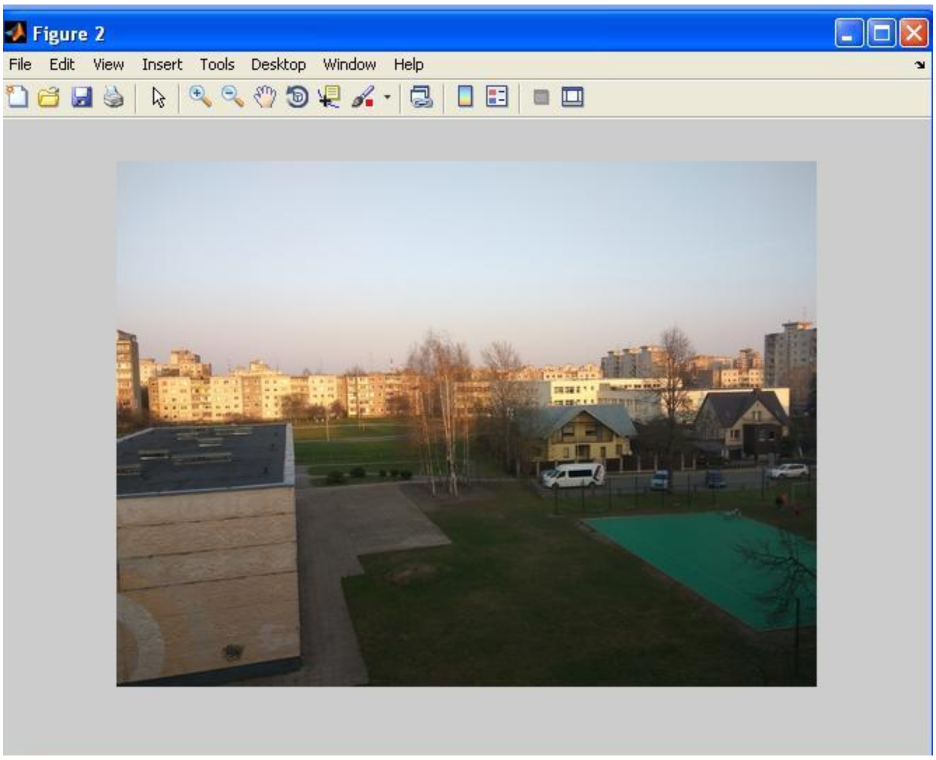

Figure 24 Input fig 2

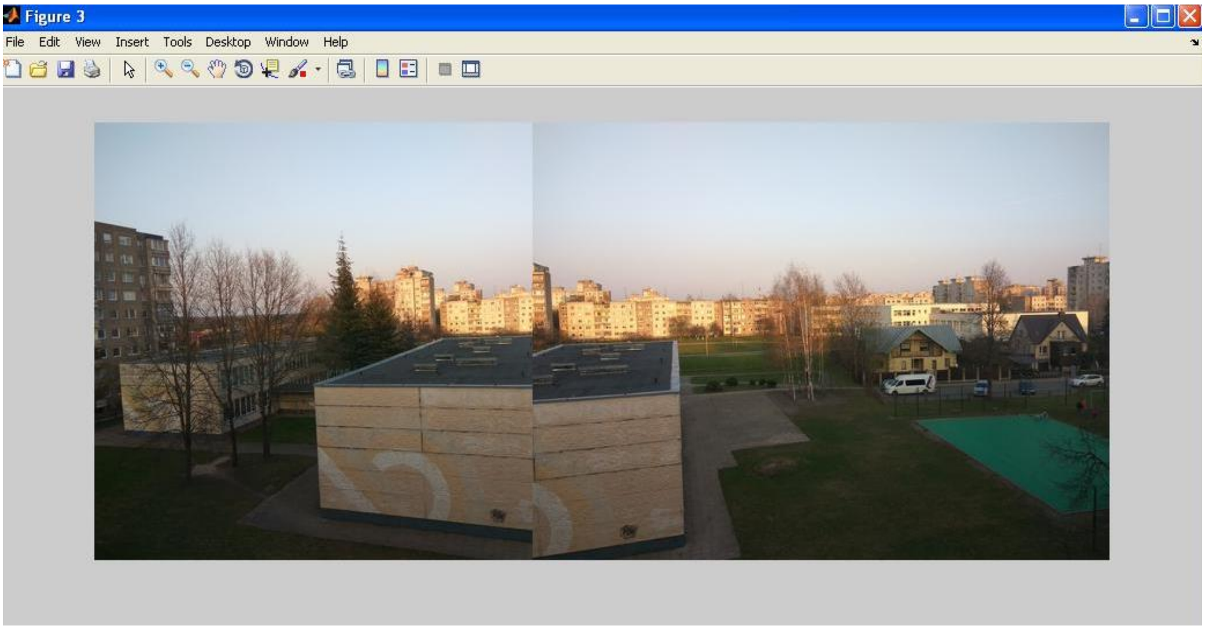

Figure 25 Output of correlated image

From the Fig. 25 clearly seen that correlation technique just stitches two images but fails to form a panorama image for the considered images.

3.2 Panorama based on SIFT and RANSAC

After estimating the features, feature matching is carried out on the basis of the SIFT matching technique. Feature detection method is used for outlier elimination, therefore RANSAC is used.

function g= getFilter(sigma) (14)

Filter function finds keypoints and descriptors for an image in the SIFT algorithm. Detected keypoints are parsed to build panorama function for matching.

Later the keypoints are matched and compared.

3.2.1 Scale-space computation

It is the first stage of feature extraction which searches over all scales and image locations, the difference-of-Gaussian function is used for implementation where potential interest points are found. The very initial image is constantly convolved with Gaussian to produce scale space images. And Gaussian is subtracted to get DOG. Gaussian and DOG pyramid localization is evaluated.

3.2.2Keypoint localization

At each key location, a model is built to determine location and scale of the key point, based on the measure of stability keypoint is selected. Scale maxima and minima in found in the location. And hessian matrix is built, later it is checked for the threshold.

3.2.3 Orientation assignment: Based on local image gradient directions, orientations are assigned to the keypoints. And maximum histogram is found for all the key point peaks.

3.2.4 RANSAC feature detection: During this stage the function receives two key point sets and a matching matrix which is computed using the RANSAC algorithm. Transformation parameters and source coordinates of the image is calculated. Best transformation vector is updated.

3.2.5 Merging: Two images and transformation vectors are merged, the below function is used.

function im = merge(p,a,b) (15)

Image boundaries and corners are calculated, source location of all the target points are calculated and images values are computed. Gaussian and laplacian pyramids for the images are masked. Furthermore transformed images are borders are found and the images are stitched.

3.3 Experimental Results

3.3.1 Loading input images

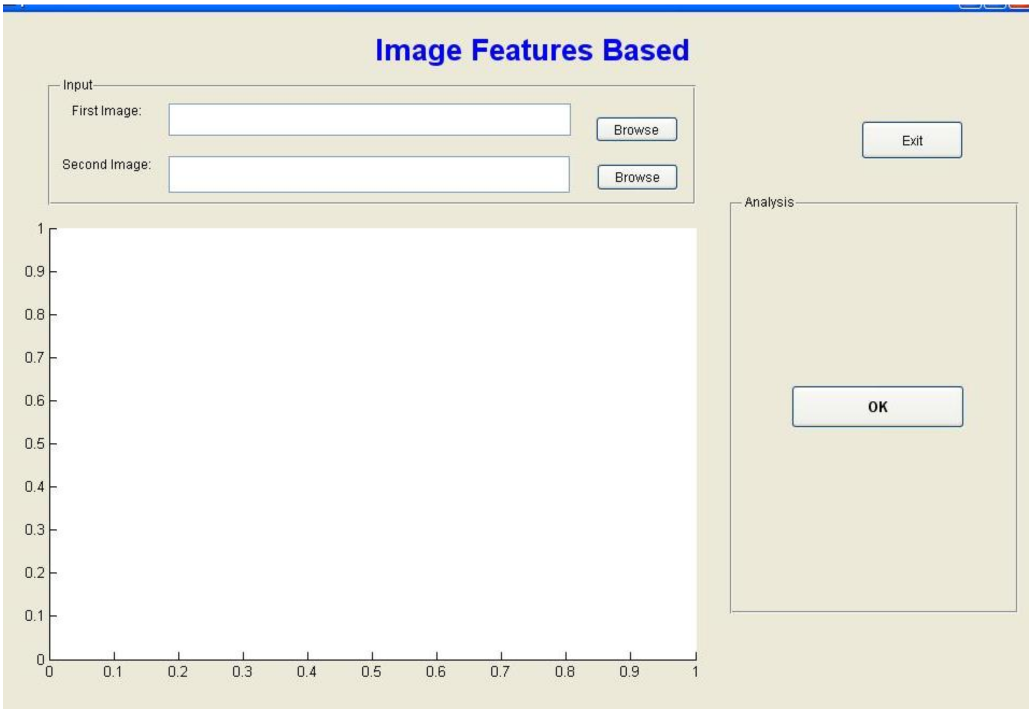

Figure 26 Alert box to load the images

.

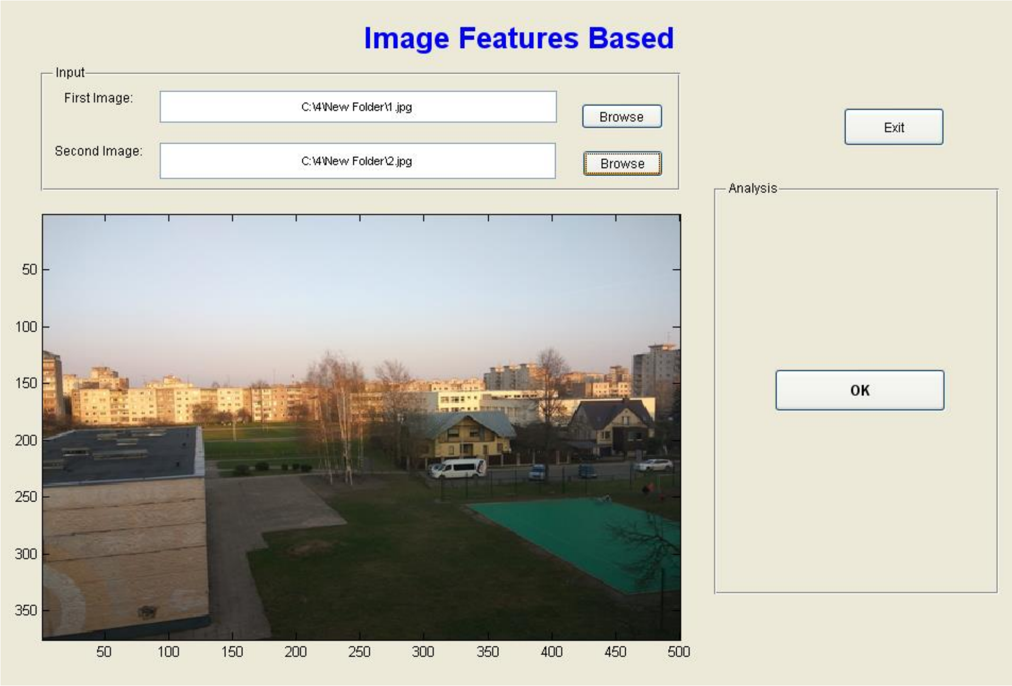

Figure 27 Input images loaded

The first step in the creation of a panoramic image is to select the positions of images. The output image taken here is reduced to 500x500 of pixel size considering the system configuration. By using GUI browse button images are loaded here.

3.3.2 Feature detection

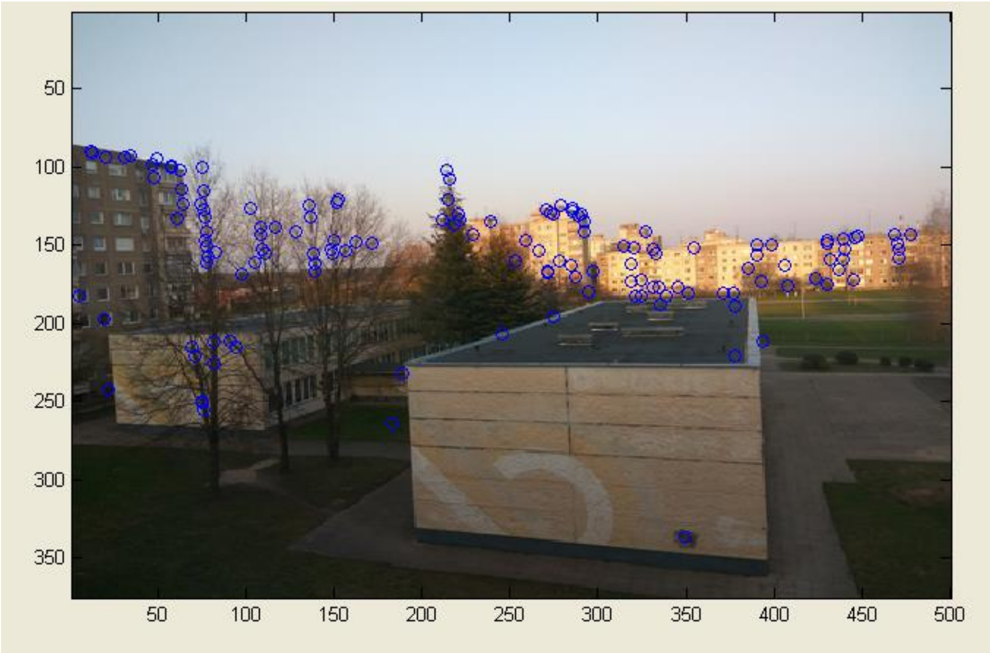

Figure 28 Feature detection image 1

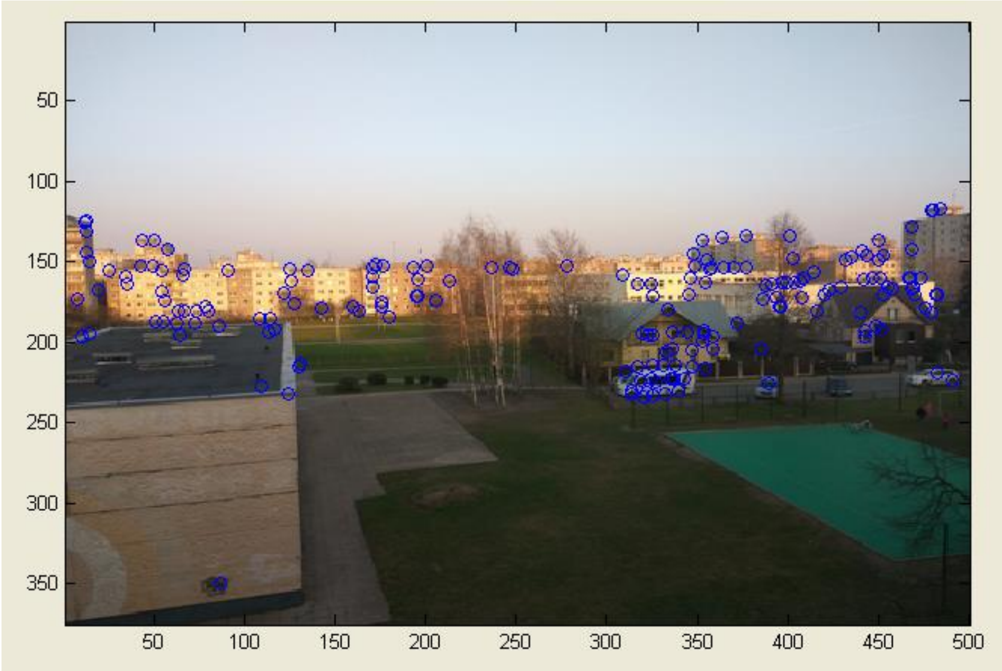

Figure 29 Feature detection image 2

First stage where extraction which searches over all scales and image locations. It is implemented by using a difference-of-Gaussian function which helps in finding interest points that are invariant to scale. Candidate points are found for further processing, candidate points chosen are high are easily detectable

3.3.3 Feature Extraction & Features Matching

Orientations are assigned to each key point in the image based on local image gradient directions.

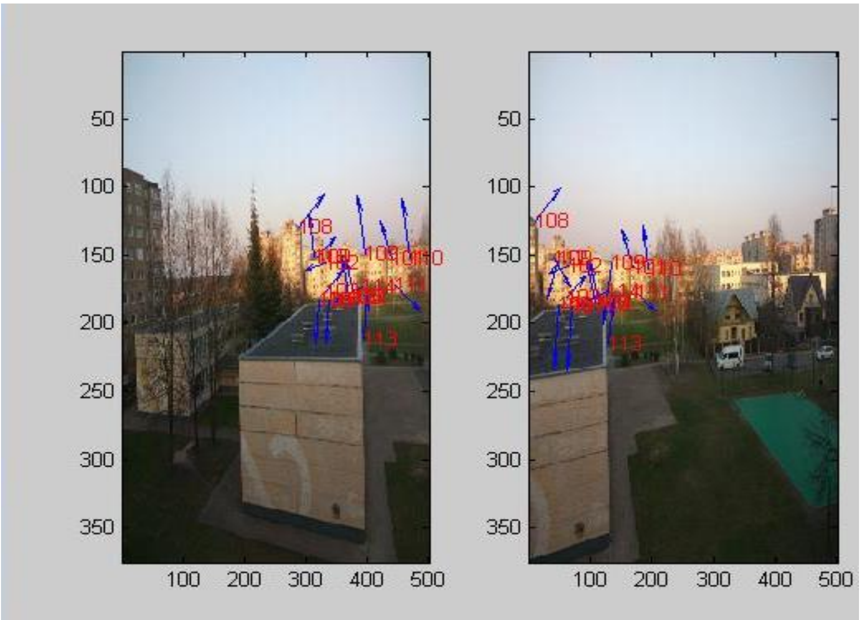

Figure 30 Feature Matching

Fig. 30 depicts the features matched between input image one and two, after match key point detection, these points are transformed into a representation that allows for significant levels of local shape distortion. The weighted average method is used to stitch the images together.

3.3.4 Final Output

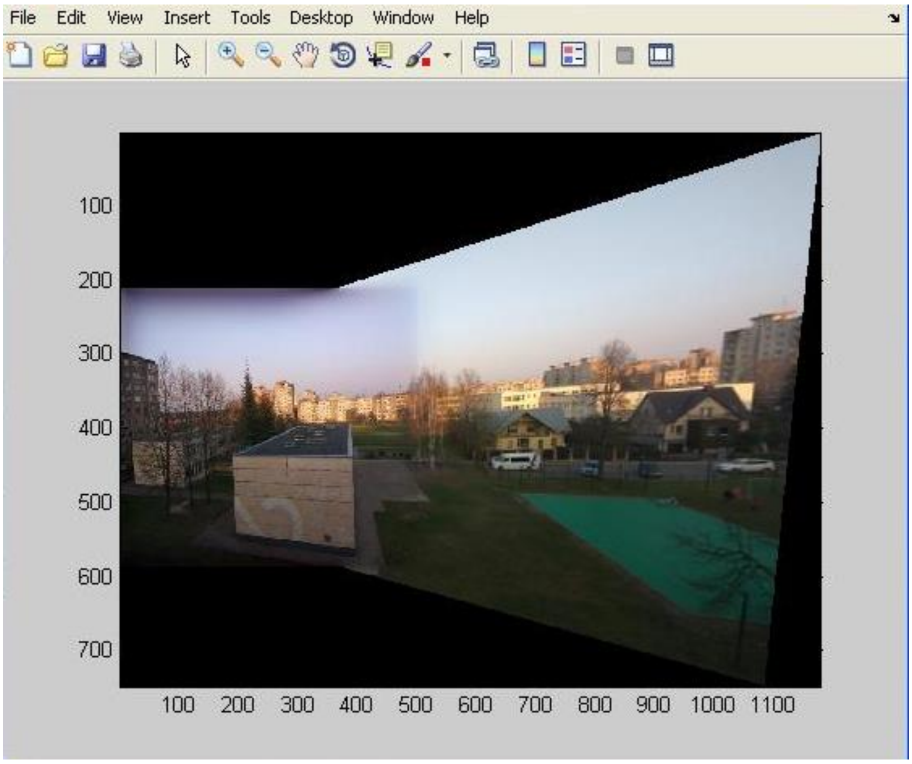

Figure 31 Panoramic view of the two stitched image

After feature extraction and feature matching the outlier elimination is done using RANSAC method. The run time is considered to be minimum 40seconds.

4. COMPARISION OF EXPERIMENTAL RESULTS

The two resultant output images are compared with respect to run time and the image quality or accuracy. The below table shows the comparison data.

Various Image Stitching Methods	Feature Extraction	Feature Matching	Outlier Elimination	Stitching	Run-time
Panorama based on SIFT	SIFT	SIFT	RANSAC	Weighted average	Minimum 40sec
Panorama based on Correlation	Correlation	Correlation	No Outlier Elimination	Weighted average	4-5sec

4.1 Comparison with respect to run-time

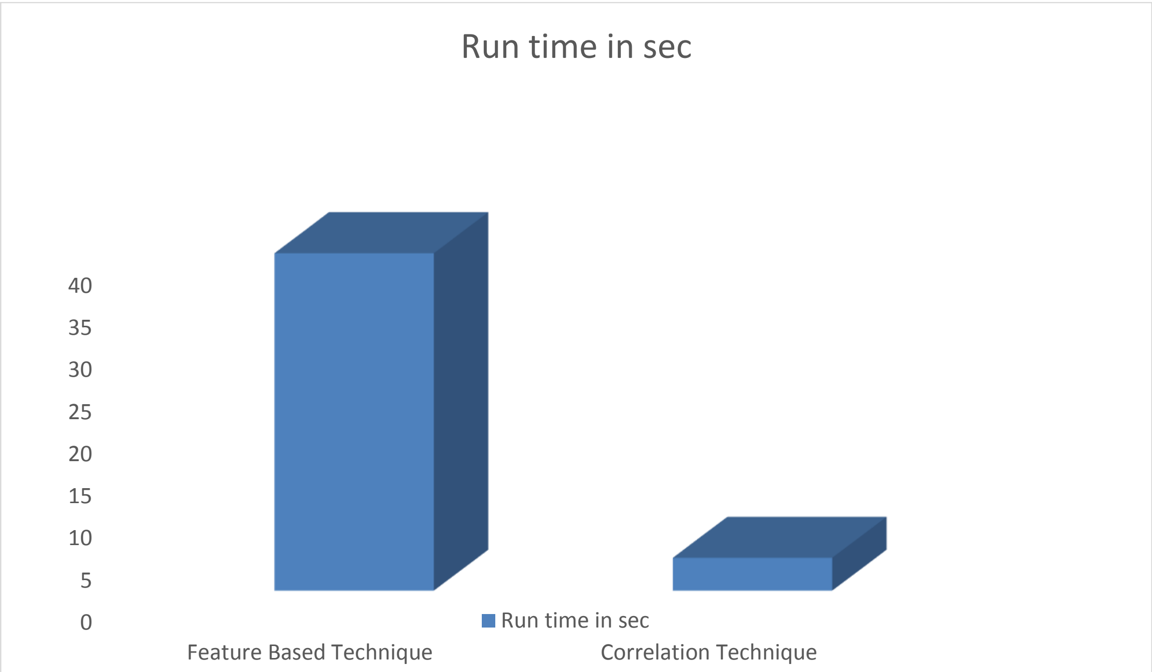

Figure 32 Comparison with respect to time taken

The minimum time taken for output image formation is

1) SIFT Algorithm = 40sec
2) Correlation Algorithm= 3.9sec

Experiment was conducted using multiple system, where the runtime for the similar set of images were different.

Table 1 Run-time

System	**Configuration**	**Run-time for Correlation**	**Run-time for SIFT**
1	Windows 8, 2.3GHz, core-i5	4.4sec	2min 58sec
2	Windows 10, 2.1GHz,core-i5	3.9sec	40sec
3	Windows 10, 2.8GHz, core-i7	3.8sec	1min 12sec
4	Windows 10, 2GHz,core-i3	3.9sec	53sec

The above considered experimental output images was considered for run-time comparison. Whereas with resprct to the output image quality parameters several high resolution images were considered for the comparison result

4.2 Comparison with respect to image quality parameters

Quality of an image cannot just be determined by human perception. Therefor the resultant images are compared through image quality parameters. An image of a higher resolution is cut and stitched using the algorithms mentioned in Section (3), i.e. SIFT, RANSAC and Correlation Technique and is compared with the initial input image

4.2.1 Comparison 1

The input image considered for comparison is of 4226x2569 10.85MP, SIFT method is used.

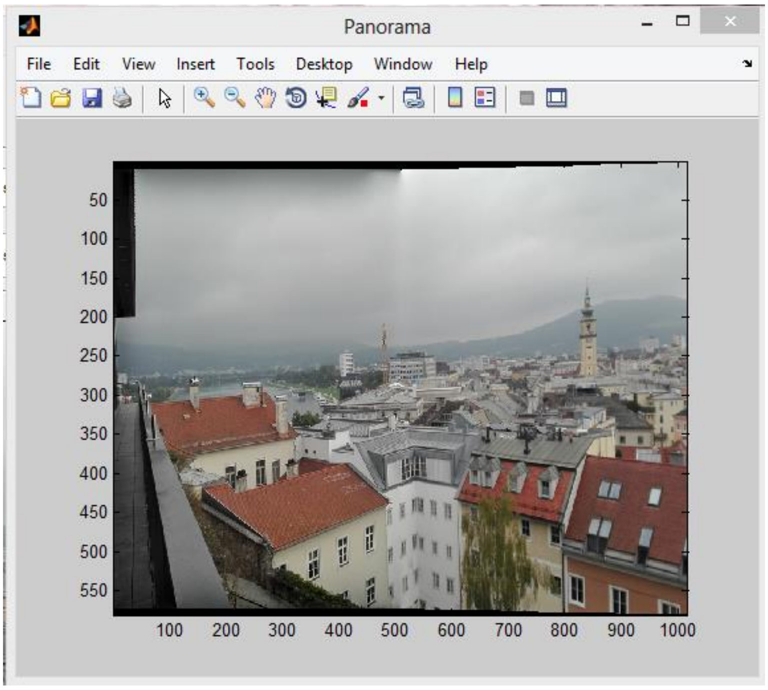

Figure 33 Output image

Table 2 Image Quality Parameters Comparison 1

Mean Square Error	2.3858e+003
Peak Signal to Noise Ratio	20.3544
Normalized Cross-Correlation	0.9776
Average Difference	0.7066
Structural Content	0.9919
Maximum Difference	239
Normalized Absolute Error	0.1072

In this section the initial image is compared with the final output, and the following are the image quality parameters.

Figure 34 Input image

Figure 35 Output stitched image

- Mean Square Error measures average of squares of error, MSE is always non-negative value and values closer to zero are considered as better values. MSE prediction is given as [23];

$$\text{MSE}=\frac{1}{n}\sum_{i=1}^{n}\left(\breve{Y}_i - Y_i\right)^2 \quad (16)$$

- Peak signal-to-noise ratio is used to measure the quality of lossy compression in images, PSNR in dB is given as [24];

$$\text{PSNR}= 20.\ \log_{10}(MAX_I) - 10.\log \quad (17)$$

- Normalized cross correlation measures similarity of two series as a function of displacement.
- Normalized absolute error calculates distorted image with reference to the original image.
- Average Difference of both the image is calculated.

4.2.2 Comparison 2

Comparison in this column is based on the output that is generated using Correlation technique.

Figure 36 Output image

The image is finely stitched but there is loss of pixels.

Table 3 Image Quality Parameters Comparison 2

Mean Square Error	3.7038e+003
Peak Signal to Noise Ratio	12.4444
Normalized Cross-Correlation	1.0281
Average Difference	-16.8769
Structural Content	0.8784
Maximum Difference	231
Normalized Absolute Error	0.1425

The image stitched by correlation's image quality is a bit lesser when compared to the one stitched by the SIFT and RANSAC.

When compared with respect to the experimented output the image quality of Panorama by SIFT RANSAC is much better than that of the Correlation Technique. Where PSNR measure value was 6db, therefore the quality is in consideration of Correlation Technique.

4.2.2 Comparison Analysis

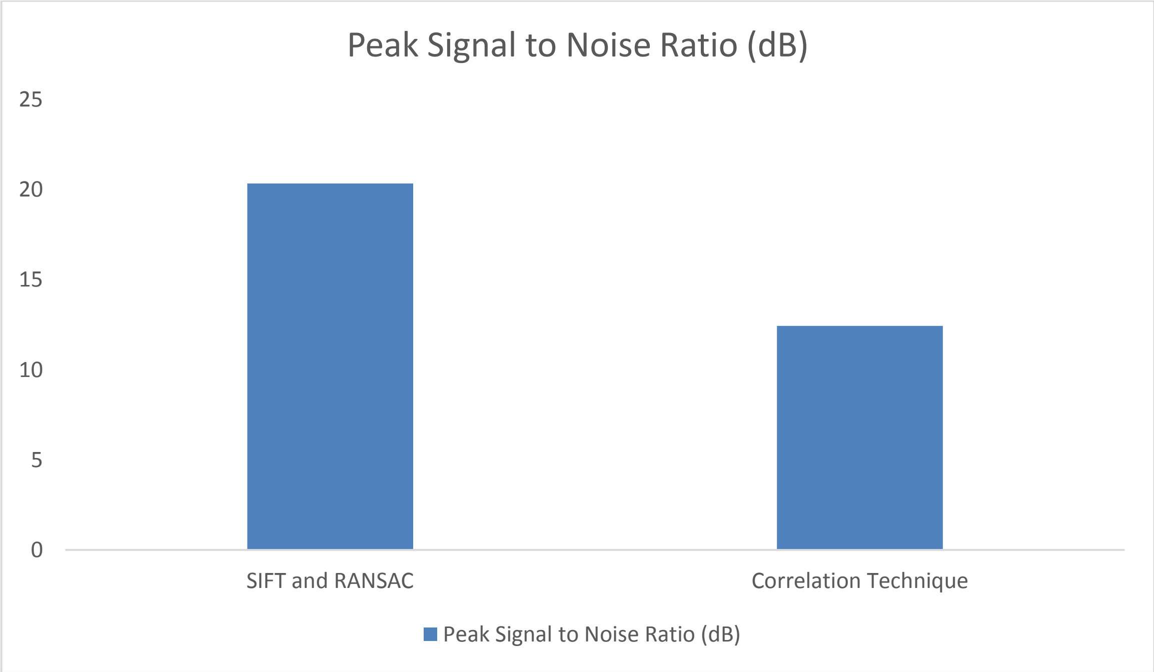

Figure 37 Average Peak Signal to Noise Ratio of images

When PSNR is considered SIFT and RANSAC method shows a better result when compared to that of the Correlation Technique, as observed in Fig. 37 and as mentioned in Table 2 the average PSNR obtained is 20.35 dB for SIFT and RANSAC.

6 CONCLUSION

The two distinct algorithms namely the Correlation and SIFT techniques were compared for Panorama Creation of images.

1. The process run time for Panorama image creation is 40Sec minimum using SIFT Algorithm and 3.9Sec minimum using Correlation Algorithm.

2. Feature descriptors consumes more time but then produce the output panorama and the image quality parameters are good. Correlation method takes very less time but the quality of the output parameters is not good.

3. PSNR value for the panorama image for SIFT is 20.35 and Correlation Technique is 12.44.

4. Thus it can be concluded that the quality of the image could be slightly higher using SIFT as compared to correlation technique even though it takes minimal time.

REFERENCE

1. Patil, Tejasha, et al. "Image stitching using MATLAB." *International Journal of Engineering Trends and Technology* 4.3 (2013): 302-306.
2. Pravenaa, S., and R. Menaka. "A Methodical Review on Image Stitching and Video Stitching Techniques." *International Journal of Applied Engineering Research* 11.5 (2016): 3442-3448.
3. Behrens, Alexander. "Creating panoramic images for bladder fluorescence endoscopy." *Acta Polytechnica* 48.3 (2008).
4. Yang, Fan, et al. "Fast image mosaicing for panoramic face recognition." *Journal of multimedia* 1.2 (2006): 14-20.
5. Sharma, Manmohan. "Image mosaicing and producing a panoramic visibility." *International Journal on Recent and Innovation Trends in Computing and Communication*.
6. Audu, Abdulkadir Iyyaka, and Abdul Hamid Sadka. "Generation of panoramic view with depth cue using image convergence technique." *AFRICON, 2013*. IEEE, 2013.
7. Patidar, Ms Durga, and Akshay Jain. "Automatic image mosaicking: an approach based on FFT." *International Journal of Scientific Engineering and Technology* 1.1 (2011): 01-04.
8. Zhang, Zhenhai, and Kejie Li. "Study on algorithm for panoramic image basing on high sensitivity and high resolution panoramic surveillance camera." *Advanced Video and Signal Based Surveillance (AVSS), 2013 10th IEEE International Conference on*. IEEE, 2013.
9. Brown, Matthew, and David G. Lowe. "Recognizing panoramas." *ICCV*. Vol. 3. 2003.
10. Juan, Luo, and Gwun Oubong. "SURF applied in panorama image stitching." *Image Processing Theory Tools and Applications (IPTA), 2010 2nd International Conference on*. IEEE, 2010.
11. *Image stitching*, Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Image_stitching
12. Benosman, R., E. Deforas, and J. Devars. "A new catadioptric sensor for the panoramic vision of mobile robots." *Omnidirectional Vision, 2000. Proceedings. IEEE Workshop on*. IEEE, 2000.
13. Shishir Maheshwari. "Image Blending Using Graphic Cut Method for Image Mosaicking", *Department of Electronics & Communication Engineering National Institute of Technology, India*. May 2014.
14. Arya Mary K J1 and Dr. Priya S. "Panoramic Image Stitching Based on Feature Extraction and Correlation." *International Journal of Modern Trends in Engineering and Research.* @IJMTER-2017.
15. Adel, Ebtsam, Mohammed Elmogy, and Hazem Elbakry. "Image stitching based on feature extraction techniques: a survey." *International Journal of Computer Applications (0975-8887) Volume* (2014).

16. Liu, Shuai, Lingli Zhao, and Junsheng Li. "Panorama Measurement Based on Spherical Projective Geometry." *International Journal of Database Theory and Application* 9.2 (2016): 81-92.
17. Image in features methodology accessed from: https://www.cs.toronto.edu/~kyros/courses/2503/Handouts/features.pdf
18. Local Feature Matching [Zhile Ren]. 2013 [accessed 2017-05-07] Accessed on: http://cs.brown.edu
19. SIFT image features [accessed on 2017-05-10] Accessed from:http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/AV0405/MURRAY/SIFT.html
20. Scale Invariant Feature Transform [David Lowe] and Short Explanation of the Approach [Michela Lecca] [accessed 2017-05-07] Accessed on: https://copilosk.fbk.eu
21. MATTHEW BROWN AND DAVID G. LOWE *Automatic Panoramic Image Stitching using Invariant Features*, Department of Computer Science, University of British Columbia,Vancouver, Canada. 2001.
22. Lecture on Feature Detection [accessed on 2017-05-10] Accessed from: http://alumni.media.mit.edu/~maov/classes/comp_photo_vision08f/lect/18_feature_detectors.pdf
23. Signal to noise ratio (imaging)- Wikipedia [accessed on 20-05-2017] accessed from: https://en.wikipedia.org/wiki/Signal-tonoise_ratio_(imaging)].
24. Peck noise-to-signal ratio- Wikipedia[accessed on 20-05-2017]] accessed from: https://en.wikipedia.org/wiki/Peak_signal-to-noise_ratio
25. Difference of Gaussian (DOG) [accessed on 05-05-2017] accessed from: http://fourier.eng.hmc.edu/e161/lectures/gradient/node9.html
26. Computer Vision CSCI-GA.2272-001 Assignment 1. October 18 2016 [accessed on 05-05-2017] Accessed from: http://cs.nyu.edu/~fergus/teaching/vision/assign1.pdf