# Mosaicing of Orthonormal Split Images: A Novel Approach Based on Junction Points


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*Abstract - Real world computer vision applications pose many threats, not being able to capture a single large sized scene with the given imaging devices such as satellite sensor, camera or scanner in a single stretch because of their inherent limitations. This results in capturing large image in terms of split images. Later, these split images are to be mosaiced to create a single large image. This paper presents a novel approach to mosaic multiple split images without human intervention, based on control points. Using geometric hashing technique, matching of control points in the Overlapped Region (OR) is accomplished. The proposed methodology is robust, have low time complexity since it deals with the control points only.*



***Keywords-*** **Control points (CPs), Geometric hashing technique, Image Mosaicing.**


## 1. Introduction

Real world computer vision applications pose many threats, not being able to capture a single large sized scene with available sources of imaging devices due to inherent limitations of imaging devices as regard to their fields of view. A post imaging operation of adhesiving these small images to create a single image corresponding to the source scene and the operation is called IMAGE MOSAICING. The general task of image mosaicing is divided into two subtasks namely, Image Registration and Image Composition. Image registration is an important task for matching two or more images. Several researchers have addressed different methods for image registration. Gonzalo et.al (2001) has proposed an algorithm for image matching using edge segments and their attributes as a feature. Based on these attributes, matching probability between pairs of features of the stereo images is computed. Bigand et.al (2001) has addressed an algorithm for image matching using fuzzy integral. Only linear features and their geometric attributes are considered in this method, which uses a direct matching of image features.

Irani et.al (1995) proposed an algorithm to mosaic video sequence images. The algorithm is effective only in very limited cases where the image motion is almost a uniform translation or the camera performs a pure pan. A corner based method to compute the homography between the two images with small overlap and arbitrary rotation around the optical axis is addressed by Zoghlami et.al. (1997). Zhigang Zhu (2003) proposed as algorithm which fuses images from video camera and provides wide field of view, preserves 3D information and represents occlusions. This representation can be used as a video interface for surveillance or preprocessing of 3D reconstruction. Doron Feldman and Assaf Zomet (2004) proposed an algorithm for mosaicing of minimum distorted images, by linear sampling function with maximal slope. The approach uses scene depth and camera parameters for mosaicing of distorted images.

Schutte & Vossepoe (1995) have described the usage of flat bed scanners to capture large utility maps. The method selects the control points in different utility maps to find the displacement required for shifting from one map to the next. These control points are found from the pair of edges common to both the maps. However, the process requires human intervention to mask out the region not common to both the split images in image mosaicing. In order to circumvent the above mentioned drawback and to mosaic different intensity images, a robust method is devise in this paper. To achieve proper mosaicing of split components, it is assumed that the two adjacent split images shall have sufficient overlap region.

The organization of the paper is as follows. Section 2 describes extraction of CPs and finding of corresponding CPs (CPs in the overlap region); section 3 gives evaluation of the proposed methodology. Section 4 gives experimental results describes and section 5 summarizes the work.

# 2. Proposed Methodology

The proposed algorithmic model for mosaicing split images has two phases. The first phase determines the corresponding CPs by finding the CPs (namely, Junctions) and the second phase is to merge the adjacent split images. Initially, the split images to be mosaiced are preprocessed by extracting the edges. Canny edge detector [9] is used to extract the edges. The Canny edge detection method differs from other methods since it uses two different thresholds to detect strong and weak edges, which will be useful for finding all dominant CPs. Extracted edges in the split images are skeletonized to a single pixel width for further processing.

## 2.1 Extraction of Control Points

The features used to find the CPs are those points where two or more edges intersect each other (Junction). These points are obtained by applying a 3x3 mask on the edge extracted images, where multiple pixels may be grouped to get a CP. Refinement of control points has been done by applying a 5x5 mask, which helps in minimization of finding the correspondence points in the split images.

## 2.2 Matching Criteria

Because of the large computational costs associated with many of the matching features and similarity measures, the main step is to reduce the search space. The proposed method reduces the search space by considering only the CPs for matching. It uses euclidean distance and geometric hashing technique for finding the best corresponding CPs points in the overlap region. The euclidean distance is utilized to create an array, which incorporates the distance of a control point with all remaining control point for each image individually. Using geometric hashing technique, each element of each row (set) of an array is compared with that of the second array i.e. sets of first split image are compared with that of second split image. The maximum element matched gives the corresponding CPs. Many a times, the control point in the first split image will match with more than one CPs in the second split image, which results in ambiguity in matching. These can be eliminated by analyzing distances between CPs and selecting the best of it.

*Algorithm1*: Extraction of corresponding CPs.
Input : Split images (Image1, Image2..)
Output : Control Points extracted images.
Method :

Step 1. Using Canny edge detector, extract edges in split images and skeletonize it.

Step 2. Find the CPs by moving the 3x3 mask on both the images. If center pixel is set and there are more than three set pixels in 3x3 mask then that center is termed as a CP.

Step 3. Calculate the distance of one CP with other CPs in Image1 and store it in array DIST1. Repeat the process for Image2 and find array DIST2.

Step 4. Compare DIST1 and DIST2 to find corresponding CPs in the overlapped region and give *votes* as per the number of distance matches in DIST1 and DIST2. Store the votes in array VOTES.

Step 5. CPs having the maximum votes are considered as corresponding CPs. Store the corresponding cartesian co-ordinates of these CPs in array COR1 and COR2. Remove ambiguity if present (i.e. one CP in COR1 corresponds to two or more CPs in COR2 and vice-versa.) by analyzing other CPs and selecting the best of it. The output images will have corresponding CPs in the overlapped region.

Step 6. End of Algorithm1.

## 2.3 Image Composition

In pervious section, the algorithm to find the corresponding CPs based on junctions is presented. This corresponding CPs gives the transformation parameters. Based on these parameters the split images are composited by taking an average of the pixels values in the overlap region if the images to be mosaic are of same intensity and translated such that the overlap region coincide with each other.

Different intensity images are mosaiced by considering the brightness difference between the corresponding CPs. The relative brightness difference between the corresponding CPs is added in Image2 which nullifies the effect of seam in mosaiced image.

*Algorithm2* : Mosaicing of Images
Input : Control Points extracted images.
Output : Mosaiced image.
Method :
Step 1. Calculate the brightness to be added in Image2 as the relative difference between corresponding CP.
Step 2. Merge Image1 and Image2 using the translation parameters that are obtained by corresponding CPs.
Step 3. End of Algorithm2.

## 3. Evaluation of Proposed Algorithms

The indicators defined to evaluate the performance of the proposed algorithm are mean and standard deviation. The values of the sample indicators are obtained by testing the algorithm on different images. The sample images are captured as two split images with overlap region. At the same time, a single image with the same imaging device is also captured and these images are used as reference images to test the efficacy of the proposed algorithmic model. The indicators evaluated during testing of the algorithm for different data sets are given in Table and 2.

| Image | Original Image | | Mosaiced Image | |
|---|---|---|---|---|
| | Standard Deviation | Mean | Standard Deviation | Mean |
| Blood Cell | 40.46 | 196.01 | 40.45 | 196.26 |
| Calcutta City | 45.96 | 51.14 | 44.43 | 50.89 |
| New York | 55.57 | 97.32 | 55.42 | 95.30 |
| Aerial Image | 34.88 | 141.75 | 35.3 | 137.59 |

**TABLE I: PERFORMANCE PARAMETER**

| Image | StandardDeviation Error (%) | Mean error (%) |
|---|---|---|
| Blood Cell | 0.024 | 0.127 |
| Calcutta City | 3.32 | 0.488 |
| New York | 0.269 | 2.07 |
| Aerial Image | 1.204 | 2.93 |

**TABLE II: ERROR COST PARAMETER**

## 4. Experimental Results

The proposed methodology is tested on different types of data sets namely satellite, aerial and medical images. This automated images mosaicing is carried out using MATLAB .

**Result 1:**

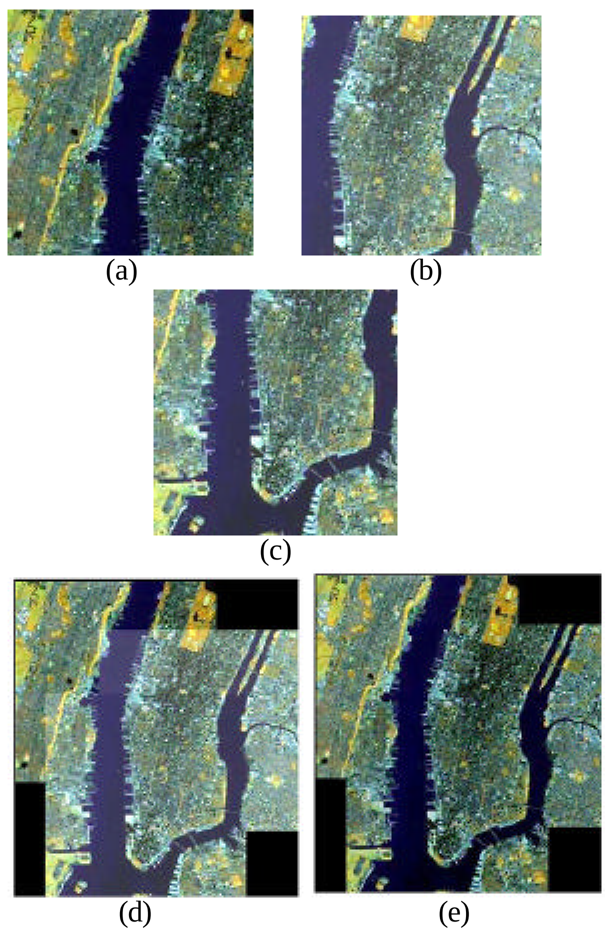


Fig 3 New York Satellite Images. (a)-(c) different intensity split images; (d) mosaic of (a)-(c) without brightness correction; (e) mosaic of (a)-(c) with brightness correction.

**Result 2:**

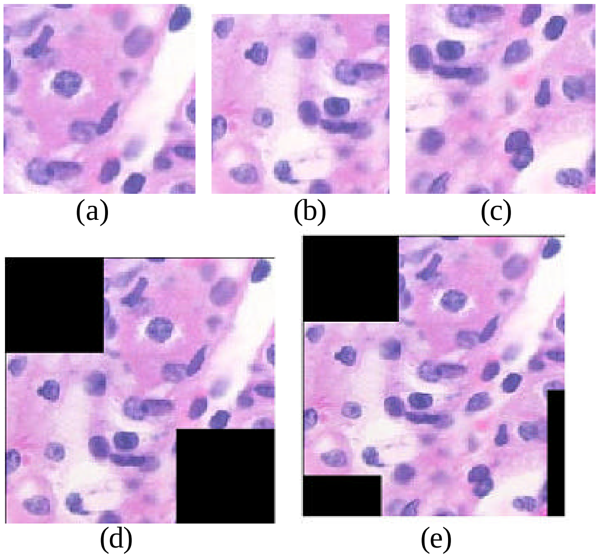


Fig 2 Blood Cell Images. (a)-(c) split images; (d) mosaic of (a)-(b); (e) mosaic of (a)-(c)

## 5. Conclusion

In this paper, a novel, simple and self-acting approach for mosaicing of multiple split images is presented. CPs selection is based on the intersection of edges and distance measured between the CPs are used for finding corresponding CPs in the overlap region. The proposed scheme assumes that the images to be mosaiced are orthonormal and distortion free. Though images with contrast can be mosaiced, a seam is obtained in the mosaiced image, which needs to be rectified. Future work encompasses rotation and scaling of the image in the fixed plane. This paper provides good results for brightness changes in the split images and needs to be worked for contrast variations.

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