Automatic Image Mosaicing using Harris Corner Detector

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Abstract**—**Mosaicing is a computer-vision-based approach to produce high field of view with best image quality. It is the process of generating a single, large, joined image by combining the visual options from multiple images .Image mosaics are set of overlapping images together with coordinate transformations regarding the different image coordinate systems. By applying the appropriate transformations via a warping operation and merging the overlapping regions of warped images, it is possible to build a single image covering the entire visible area of the scene. The proposed algorithm for Image Mosaicing using Harris Corner Detector and template matching for automatic control points' selection has been discussed. The implementation section of the algorithm is discussed along with test results. The merits and demerits of the algorithms have been analyzed. We have used our own image datasets for experimenting.

Keywords**—** *Image Mosaicing, Harris corner detector, control points, Transformation, warping, bilinear interpolation.*

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I. INTRODUCTION

It is not possible to visualize the panoramic image with the help of an eye than a pair of eyes. Keeping this in mind, one can understands that two eyes capture the two split images of a large object which are later mosaiced into a single complete large image. Similarly, even in the real world the concept of mosaicing is essential because it may not be possible to capture a large document with a given camera in a single exposure. Image mosaics are set of overlapping images together with coordinate transformations regarding different image coordinate systems.

Image registration plays crucial role in image stitching process. Using an appropriate transformations method and merging the overlapping regions of warped images, it is possible to produce a large single image covering the entire visible area of the scene. This merged single image is the motivation for the term "mosaic". Image mosaicing can be done in a variety of ways. There are many algorithms to do image mosaicing. The algorithm does require effective corner matching. Usually, the algorithms differ in the Image registration process. The proposed algorithm using "Harris Corner Detector and Template Matching Algorithm" is discussed. This is very simple using which the image registration parameters are automatically extracted [2]. Once the transformation matrix is constructed, the bilinear interpolation technique is used.

The basic goal of the program is to stitch a series of flat images together to produce a continuous panoramic image (a mosaic) [2]. The difficulty here is that in order for the images to fit together some of the images must be transformed to adjust for the difference of perspective in the images

II. REGISTRATION PROCESS

IMAGE registration is a main problem seen in many image processing applications where it is necessary to perform joint analysis of two or more images of the same scene acquired by different sensors, or images taken by the same sensor but at different times[3]. Given two images, I1 and I2 to match the reference image, the goal of image registration is to align the sensed image into the coordinate system of the reference image and to make corresponding coordinate points in the two images fit the same geographical location.[3] These unregistered images may have relative translation, rotation, and scale between them.

Image Registration method can be done manually and also automatically.In, this paper we have used approach for Automatic Image registration. The overall registration process carried out in the following steps:[4]

1) The first step consists of detecting automatically a set of control points from the reference image using Harris Corner Detector.[4]
2) In the second step, the corresponding control points are computed in the sensed image by means of template matching technique using normalize cross correlation based on similarity measure. Then the control point displacement is computed.[4]
3) Last, the parameters of the best transformation which models the deformation between the images are estimated using the two sets of corresponding control points. [4]
4) Then finally, according to this transformation, warping one of the images with respect to the other one using the bilinear interpolation function and the estimated parameters.[4]

2.1 Control Points Selection

In order to reduce the computation time to an acceptable level, a frequently used approach is to consider only a limited set of interest points, where the image information is supposed to be the most important [4]. Therefore one easy way to speed up the algorithm and to reduce the computation time is to process some few pixels belonging to regions that contain significant gray-level variations (referred to as the control points), instead of processing all image edges.[4]

2.1.1 Edge Detection: The first step in the selection of the CPs Consists of finding image edges. The location of edges can easily be computed by detecting local maxima of the gray-level gradient magnitude.[4] Since edges are scale dependent image features, they can only be detected properly using derivatives calculated at the proper scale. The commonly used edge detection filter for this purpose is Gaussian derivative. It should be noted that it is necessary to indicate which edges are important for extracting strong CPs.[4] This is done by thresholding the gradient magnitude image, resulting in a binary image consisting of connected regions that are of interest. The value of the threshold is assigned as the average gradient magnitude [4].

2.1.2 Control Points Detection: To select CPs in the reference image, the second step consists of detecting interest points that have stronger strength than most of other pixels in this image. The strength is basically measured by the change in pixel values along two-dimensional directions [4] are evaluated and compared different interest point detectors and concluded that the best results are provided by the Harris detector [4].

2.1.2.1 Harris Corner Detector

In this paper, an improved version of the Harris corner detector [4] is used to detect points of interest in the reference image. This detector uses only first-order derivatives and is well known as one of the most stable and robust corner detectors in image processing.[4] The basic idea is to use the autocorrelation function in order to determine locations where the signal changes in two directions. A matrix related to the autocorrelation function that takes into account the first derivatives of the signal on a window is computed.[4] The eigenvectors of this matrix are the principal curvatures of the autocorrelation function. Two significant values indicate the presence of an interest point.[4]

The Harris detector is defined as the positive local extreme of the following operator [4]:

$$S=\text{Determinant}(C)-\text{trace}^2(C) \qquad (1)$$

$$C = \begin{pmatrix} (\delta I/\delta X)^2 & (\delta I/\delta X)(\delta I/\delta Y) \\ (\delta I/\delta X)(\delta I/\delta Y) & (\delta I/\delta Y)^2 \end{pmatrix} \qquad (2)$$

Where S is a strength or corner response and α scalar is equal to 0.04 as suggested in [4] and the matrix C, which is related to the autocorrelation function, where I is the gray-level intensity image. To implement this detector, the standard default parameter values recommended by the authors, are used in this work[4]. The Harris detector [5] computes the derivatives of the matrix C by convolution with the mask [-2 -1 0 1 2]. A Gaussian with standard deviation is used to weight the derivatives. In an improved version of Harris [4], the 1derivatives of the matrix are computed more precisely by replacing the mask with derivatives of a Gaussian (σ =1). A corner is detected when the two eigenvalues of C are large since this indicates grayscale variations in both the directions[5]. To avoid the extraction of the eigenvalues of the matrix, the strength of interest points is measured by the operator S of (1). Nonmaximum suppression using a 3x3 mask is then applied to strength and a control points[5]. The threshold is set to 1% of the maximum observed interest point strength [4]. To spread out the detected CPs (corners), a user-defined distance is incorporated. Finally, the algorithm will automatically produce the extracted CPs that satisfy the above criteria and maximize the strength function[5].

In this implementation, the CPs are detected in the reference image by applying the improved version of the Harris corner detector at regions where the gradient magnitude is high. This has the following two advantages[4].

Control Points Detection Algorithm: The following is a summary of the different steps to be followed in the selection of CPs.[4]

1. Compute the gradient of the reference image. It is based on an edge detection filtering with the application of Gaussian derivative [4].
2. Compute the average gradient magnitude to extract potential regions by means of thresholding the gradient magnitude image at average gradient magnitude level. If gradient magnitude is greater or equal to average gradient magnitude only then it is considered as an edge.[4]
3. For each pixel in the reference image compute the strength according to equation (1).
4. Apply nonmaximum suppression to the strength by using a 3x3 mask.
5. Extract strong corners by means of thresholding the strength at some desired level.
6. Retain the first corners of large strength as control points if their distance is higher than the minimum allowed distance.

2.1.2 Control Point Selection in sensed image using Template Matching Algorithm: The displacements of CPs are determined by carrying out the following steps.

1. For every control point, choose a moving circular template window w1 of size (3x3) of radius centered at this point in the reference image.
2. Compare template window w1 with the searching window w2 of processed (sensed) image using Normalized cross correlation.
3. Find maximum similarity from the output and store the points for establishing the correspondence.
4. The control point in the sensed image that might correspond to the candidate point in the reference image is determined by the shift position giving the minimum distance.

2.2 TRANSFORMATION AND WARPING

After establishing control points correspondence, the parameters of the best transformation which models the

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deformation between the images are estimated using the two sets of corresponding control points to construct a transformation matrix.

III. IMAGE STITCHIN

By applying the appropriate transformations via a warping operation and merging the overlapping regions of warped images, it is possible to construct a single image covering the entire visible area of the scene. This merged single image is the motivation for the term "mosaic". The final correction is performed according to this transformation by warping one of the images with respect to the other one using the bilinear interpolation function and the estimated parameters.

3.1 Bilinear Interpolation Technique

Interpolation is defined as estimation of a missing value by taking an average of known values at neighboring points. The more adjacent pixels included while interpolating which is more accurate in estimation[1]. But this comes at the expense of computational time. In bilinear interpolation, the intensity at a point is determined from the weighted sum of intensities at four pixels closest to it. Therefore, given location (X,Y) and assuming u is the integer part of X and v is the integer part of Y , the intensity at (X,Y) is estimated from the intensities at (u, v), (u +1,v), (u, v +1), (u +1,v +1)[1]. Bilinear interpolation includes best of both worlds; it is accurate as well as fast. Hence, Bilinear Interpolation is used here. For bilinear interpolation, weighted average of two translated pixel values for each output pixel value is used [1].

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

The parameters of the Harris detector are set to the standard default values recommended by the authors [4]. The standard deviation of the Gaussian is set to 1 for all examples. During these experiments, the minimum allowed distance between two CPs are set to 10. The maximum translational shift used in template matching is set to 100[4]. In order to reduce the computation time to a minimum, template should be as small as possible. We have extract two input frames from the video as input image as shown in (Figure 1,Figure 2).Then after applying Harris corner Detector CPs as corners are automatically detected as shown in figure 7.Then using nonmaximum suppression and thresholding strength reduced corners are detected as shown in Figure 3. Using Template matching technique corresponding CPs are selected in the sensed image as shown in figure 4.Estimating transformation parameters from CPs transformation matrix is constructed and using it we can warped the sensed image as shown in figure 6 and applying bilinear interpolation we can merged warped image with the reference image and get merged image as shown in Figure 5.

Figure 1 Reference Image

Figure 2: Sensed image

Figure 3: Reduced detected corner points

Figure 4: Matching points in sensed Image

Figure 5: Mosaic Image

Figure 6: Warped Image

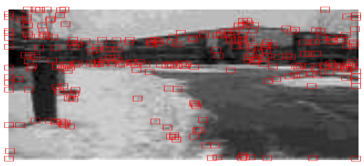

Figure 7: Detected Total Corner Points

V. CONCLUSIONS

The limitation of Harris corner such as, in the harris corner detector algorithm sometimes there will be chances of getting misalignment due to not proper matching of control point selection. In the technique which we have applied is good to reduce the detected corners to strong corners but still we cannot reduce it to 4 best matches for getting proper homography matrix. So, sometimes we can get misalignment. The above limitations of the algorithm we can solve it using RANSAC algorithm which is used to get four best matches to construct perfect homography matrix.

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