A Review Paper on Various Approaches for Image Mosaicing

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Abstract

Image mosaicing is one of the most important subject of research in computer vision. Image mosaicing requires the integration of direct methods and feature based methods. Direct methods are found to be useful for mosaicing large overlapping regions, small translations and rotations while feature based methods are useful for small overlapping regions. Feature based image mosaicing is combination of corner detection, corner matching, motion parameters estimation and image stitching. In this paper we present a review on different approaches for image mosaicing and the literature over the past in the field of image mosaicing methods. We take an overview on the various methods for image mosaicing.

Keywords: *Direct method, feature based method, homography, image registration, image wrapping,image compositing, pixel blending.*

I. INTRODUCTION

An Image mosaic is a synthetic composition generated from a sequence of images and it can be obtained by understanding geometric relationships between images. The geometric relations are coordinate transformations that relate 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 construct a single image indistinguishable from a single large image of the same object, covering the entire visible area of the scene. This merged single image is the motivation for the term mosaic. Various steps in mosaicing are feature extraction and registration, stitching and blending. Image registration refers to the geometric alignment of a set of images. The set may consist of two or more digital images taken of a single scene at different times, from different sensors, or from different viewpoints. The goal of registration is to establish geometric correspondence between the images so that they may be transformed, compared, and analyzed in a common reference frame. This is of practical importance in many fields, including remote sensing, medical imaging, and computer vision [1].Registration methods can be loosely divided into the following classes: algorithms that use image pixel values directly, e.g., correlation methods [2]; algorithms that use the frequency domain, e.g., fast Fourier transform based (FFT-based) methods [3]; algorithms that use low-level features such as edges and corners, e.g., feature based methods [1]; and algorithms that use high-level features such as identified (parts of) objects, or relations between features, e.g., graph-theoretic methods [1].The registration method presented uses the Fourier domain approach to match images that are translated and rotated with respect to one another. The algorithm uses the property of phase correlation which gives the translation parameters between two images if there is no other transformation between the images other than translation, by showing a distinct peak at the point of the displacement [4]. The next step, following registration, is image stitching. Image integration or image stitching is a process of overlaying images together on a bigger canvas. The images are placed appropriately on the bigger canvas using registration transformations to get the final mosaic.

II. LITERATURE REVIEW

Registration and mosaicing of images have been in practice since long before the age of digital computers. Shortly after the photographic process was developed in 1839, the use of photographs was demonstrated on topographical mapping [5]. Images acquired from hill-tops or balloons were manually pieced together. After the development of airplane technology (1903) aerophotography became an exciting new field. The limited flying heights of the early airplanes and the need for large photo-maps, forced imaging experts to construct mosaic images from overlapping photographs. This was initially done by manually mosaicing [6] images which were acquired by calibrated equipment. The need for mosaicing continued to increase later in history as satellites started sending pictures back to earth. Improvements in computer technology became a natural motivation to develop computational techniques and to solve related problems. The construction of mosaic images and the use of such images on several computer vision/graphics applications have been active areas of research in recent years. There have been a variety of new additions to the classic applications mentioned above that primarily aim to enhance image resolution and field of view. Image-based rendering [7] has become a major focus of attention combining two complementary fields: computer vision and computer graphics [8]. In computer graphics applications images of the real world have been traditionally used as environment maps. These images are used as static background of synthetic scenes and mapped as shadows onto synthetic objects for a realistic look with computations which are much more efficient than ray tracing. In early applications such environment maps were single images captured by fish-eye lenses or a sequence of images captured by wide-angle rectilinear lenses used as faces of a cube. Mosaicing images on smooth surfaces (e.g. cylindrical or spherical allows an unlimited resolution also avoiding discontinuities that can result from images that are acquired separately. Such immersive environments (with or without synthetic objects) provide the users an improved sense of presence in a virtual scene. A combination of such scenes used as nodes allows the users to navigate through a remote environment. Computer vision methods can be used to generate intermediate views between the nodes. As a reverse problem the 3D structure of scenes can be reconstructed from multiple nodes. Among other major applications of image mosaicing in computer vision are image stabilization , resolution enhancement , video processing (e.g. video compression,video indexing).

III. IMAGE MOSAICING METHODS

Image mosaicing methods can be classified broadly into direct method and feature based method. Direct Method uses information from all pixels. It iteratively updates an estimate of homography so that a particular cost function is minimized. Sometimes Phase-Correlation is used to estimate the a few parameters of the homography. In Feature Based Method a few corresponding points are selected on the two images and homography is estimated using these reliable points only. Feature Based Methods are in general more accurate. It can handle large disparities. Direct methods, may not converge to the optimal solution is the presence of local minima. For reliable performance direct methods rely on feature based initialization. Feature based methods [9] mosaic the images by first automatically detecting and matching the features in the source images, and then warping these images together. Normally it consists of three steps: feature detection and matching, local and global registration, and image composition.

Feature detection and matching aims to detect features and then match them. Local and global registration starts from these feature matches, locally registers the neighboring images and then globally adjusts accumulated registration error so that multiple images can be finely registered. Image composition blends all images together into a final mosaic. Direct methods [10] attempt to iteratively estimate the camera parameters by minimizing an error function based on the intensity differences in the area of overlap. But this type of methods needs initialization, either by correlation or by manually setting some corresponding points. It is hard for the user to manually set the corresponding points correctly especially when the photographed scene does not have planar faces while Feature Based Methods mosaic the images by detecting the features in the images automatically, matching these features, and then creating the final mosaic image by warping other images related to one base image. Direct methods are useful for mosaicing large overlapping regions, small translations and rotations. Feature based methods can usually handle small overlapping regions and in general tend to be more accurate but computationally intensive.

IV. IMAGE MOSAICING PROCESS

The image mosaicing procedure generally includes three steps. First, we register input images by estimating the homography, which relates pixels in one frame to their corresponding pixels in another frame. Second, we warp input frames according to the estimated homographies so that their overlapping regions align. Finally, we paste the warped images and blend them on a common mosaicing surface to build the panorama result.

4.1. Image Registration: given a set of N images $\{I_1, I_2, \dots I_N\}$ with a partial overlap between at least two images, compute an image-to- image transformation that will map each image I_2 ..., I_N into coordinate system of I_1.

4.2. Image Warping: warp each image I_2 ..., I_N using the computed transformation.
4.3. Image Interpolation: resample the warped image.
4.4. Image Compositing: blend images together to create a single image on the reference coordinate system.

4.5 Image Registration

Image registration is the task of matching two or more images. It has been a central issue for a variety of problems in image processing [11] such as object recognition, monitoring satellite images, matching stereo images for reconstructing depth, matching biomedical images for diagnosis, etc. Registration is also the central task of image mosaicing procedures. Carefully calibrated and prerecorded camera parameters may be used to eliminate the need for an automatic registration. User interaction also is a reliable source for manually registering images (e.g. by choosing corresponding points and employing necessary transformations on screen with visual feedback). Automated methods for image registration used in image mosaicing literature can be categorized as follows:

Feature based [12] methods rely on accurate detection of image features. Correspondences between features lead to computation of the camera motion which can be tested for alignment. In the absence of distinctive features, this kind of approach is likely to fail.

Exhaustively searching for a best match for all possible motion parameters can be computationally extremely expensive. Using hierarchical processing (i.e. coarse-to-fine [13]) results in significant speed-ups. We also use this approach also taking advantage of parallel processing for additional performance improvement.

Frequency domain approaches for finding displacement and rotation/scale are computationally efficient but can be sensitive to noise. These methods also require the overlap extent to occupy a significant portion of the images (e.g. at least 50%).

Iteratively adjusting camera-motion parameters leads to local minimums unless a reliable initial estimate is provided. Initial estimates can be obtained using a coarse global search or an efficiently implemented frequency domain approach.

4.6 Warping in the Discrete Domain

Forward and reverse mapping

In the forward mapping the source image is scanned pixel by pixel, and copies them to the appropriate location in the destination image.The reverse mapping goes through the destination image, pixel by pixel, and samples the corresponding pixel from the source image. The main advantage of the reverse mapping is that every pixel in the destination image will have assigned an intensity value. In the forward mapping case, some of the pixels in the destination images may not be coloured, and would have to be interpolated[15].

Expansion and contraction problems

When working with digital images, we deal with a discrete space and quantized intensities. Warping an image in the discrete space has as a consequence dilations and contractions of the rectangular pixels, originating, in general, quadrilaterals. This expansion/contractions demands the use of convenient methods for estimating pixel intensities on the image result. Two different problems may arise. In the case of expansion some pixels have no intensity assigned. In the case of contraction, several original pixel may converge to a single one. In both cases we need to estimate the new pixel intensities. These two problems are two typical instances of image resampling. In the first case, expansion, we have to use interpolation techniques to estimate the intermediate pixel intensities. The contraction may originate aliasing problems. To limit its effect we can use anti-aliasing filters[16].

4.7 Image Compositing

Images aligned after undergoing geometric corrections most likely require further processing to eliminate remaining distortions and discontinuities. Alignment of images may be imperfect due to registration errors resulting from incompatible model assumptions, dynamic scenes, etc. Furthermore, in most cases images that need to be mosaiced are not exposed evenly due to changing lighting conditions, automatic controls of cameras, printing/scanning devices, etc. These unwanted effects can be alleviated during the compositing process. The main problem in image compositing is the problem of determining how the pixels in an overlapping area should be represented. Finding the best separation border between overlapping images has the potential to eliminate remaining geometric distortions. Such a border is likely to traverse around moving objects avoiding double exposure . The uneven exposure problem can be solved by histogram equalization, by iteratively distributing the edge effect on the border to a large area , or by a smooth blending function [14].

A particular case of image combination is the function *dissolve* characterised by

I = **Dissolve a** $(I_1 I_2) = (1 - a) I_1 + a I_2$.

where *a* is in the interval [0, 1]. We may notice that for *a = 0*, we have

I = **Dissolve 0** $(I_1 I_2) = I_1$

and for *a =1*

I = **Dissolve 1** $(I_1 I_2) = I_2$

For other values of *a*, the image result is the weighted average of the two images, as illustrated in Figure below. The value of *a* is constant, being independent of the position of the pixel to be combined.

a) b) c) d) e)

Image dissolving: a) Image(I_1); b) Dissolve 0.25($I_1 I_2$); c) Dissolve0.25($I_1 I_2$); d) Dissolve0.75($I_1 I_2$); e) Image (I_2).

4.8 Pixel Blending

Once the correspondences between input images have been correctly aligned, inputs are warped onto the common mosaicing image surface according to the estimated homographies and then merged to build the output panorama. However, due to exposure differences, misregistrations or even movement of objects in the scene, merging warped inputs is not simply an averaging process between overlapping pixels.A better approach is to take a weighted averaging that assigns pixels closer to the center of the image higher weights before blending them. Such a technique of blending pixels by a weighted averaging is called feathering [14], and is helpful in overcoming the exposure differences between inputs. When integrated with the high dynamic range(HDR) radiance map and the exposure invariant feature-based image alignment method, it can even construct panoramas over tremendous exposure differences. Feathering can be performed within pixel color spaces, or in the gradient domain.

V. CONCLUSION

Image mosaicing is useful for a variety of tasks in vision and computer graphics .Due to the wide range of applications, image mosaicing is one of the important research area in the field of image processing. Here we have presented some of the very fundamental and basic techniques used in image mosaicing. This paper presents a complete process for image mosaicing.

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