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A Survey on Panorama Image Stitching

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ABSTRACT:
Panorama image stitching is process of combining two or more images of the same scene into one high resolution image called as panoramic image. In today's world an image stitching is considered as an dynamic research area in computer visualization and graphics. Image stitching literature shows that image stitching is still a challenging problem for single and panoramic images. In recent years many algorithms deal with panoramic image stitching problem. Panorama Image stitching process can be divided into four main components – image registration, Image warping, color correction, image labeling and image blending. This paper present a survey about the process of panorama image stitching. The main components of panorama image stitching will be described in this paper. A framework of a complete panorama image stitching system based on these approaches will be introduced. Finally, we are going to discuss the current challenges of panorama image stitching technique.

Keywords:
panorama image Stitching, feature detection, matching feature, image warping, color correction, image labelling, image blending

INTRODUCTION:

Many applications in computer visualization and computational photography that could only work on Personal Computer before, can now be implemented and run on mobile devices. Modern mobile phones have become computational devices equipped with high-resolution cameras, high-quality color displays, and powerful graphics processors, which can makes it possible to develop applications for mobile computational photography and augmented reality [1], [2]. User can take an image sequence for a wide range of scenes with camera phone immediately, and share them right away with friends. Image stitching very practical and has a widely range of applications. In early of photography had just developed, people used the images stitching technology in topographic mapping. Using the image which shooting from the high place such as slope and plane to stitch together by hand in order to obtain a broader view topographic map[3]. With the rapid development of multimedia technology is increasing every day. More and more people came into contact with a large number of images and video information. In the same time, the single text way of exchange information on the net changed into graphics, images, animation, video and other multimedia step by step. Therefore, people's request of image have become increasing. Composition of the panoramic image, synthesis of the earth's satellite photos, image mosaic and computer vision, etc, all of these fields need to use stitching technology. Image stitching is very important step in creating high quality panorama images. Simply copying and pasting of overlapping areas of source images may produce visible seams between source images, due to differences in camera responses and spatial alignment errors. Panorama image stitching can find optimal visible seams in the overlapping areas of the source images, cut the images along the seams, and blend them together seamlessly. Image stitching methods mainly include regional- based and feature- based. Region based methods adopt relevant technology to match the similar position of a frame image. This method is easy to implement but its computation costs increases. Especially when the presence of rotating, zooming and translation transformation relation, blocking and degradation distortion images, the performance of algorithm would drop dramatically. Feature-based method extracts common invariance features, such as contours, moments, and then accurate match. The general procedure for panoramic image generation [4-7] uses feature matching, which has the advantage of fast computational speed. Image processing experts considered the use of image stitching in real time application is considered as a challenging field. Image stitching technology has been widely used in remote sensing image processing, medical image analysis, virtual reality technology super reconstruction and other fields. In medical images, the wide-angle and high-resolution of microscopic image always can't have them all, however, Image stitching technology can solve this problem [8]. Stitching high-resolution images together can get the global structure of biological samples, which can help doctors a comprehensive, intuitive observation of lesion and its surrounding area. There are already lots of panorama image stitching software's in the market, such as Photo stitcher, Quick time, REALVIZ.

PANORAMA IMAGE STITCHING TECHNIQUE:

There are two main techniques considered for image stitching techniques in which first one is regional and second one is feature based techniques. Approaches that use pixel-to-pixel matching are often called direct methods as opposed to the feature-based methods described in this section.

A. DIRECT TECHNIQUE:

Direct technique uses pixel to pixel matching, that is this technique depends on comparing all the pixel intensities of the images with each other. To use a direct method a suitable error metric must first be chosen to compare the images. Once this has been established a suitable search technique must be devised. The simplest technique is to exhaustively try all possible alignments, that to do a full search. In practice this may be too slow so hierarchical coarse-to-fine techniques based on image pyramids have been developed. Alternatively, Fourier transforms can be used to speed up computation. To get sub-pixel precision in the alignment, incremental methods based on a Taylor series expansion of the image function are often used. These can also be applied to parametric motion models [5].Direct techniques minimize the sum of absolute differences between overlapping pixels or use any other available cost functions. Direct technique methods are computationally complex because they compare each pixel window to others. These methods are not invariant to image scale and rotation. There are many techniques for solving image mosaicing problems using direct methods such as Fourier analysis techniques [9] and also simon baker have proposed a unifying framework to fine optimization of cost or objective functions [10]. The main advantage of direct methods is that they make optimal use of the information available in image alignment. They measure the contribution of every pixel in the image. However, the biggest disadvantage of direct techniques is that they have a limited range of convergence [5].

B. FEATURE BASED TECHNIQUES:

The simplest way to find all corresponding feature points is compare all features in one image against all features in the other using one of the local descriptors. For panorama image stitching based on feature based techniques, feature extraction, image registration, and image blending are different steps required for doing panorama image stitching. Feature based methods start by establishing correspondences between points, lines, boundaries, corners, or other geometric entities. Characteristics of strong detectors include invariance to image noise, scale invariance, translation invariance, and rotation transformations. There are many feature based detector techniques, such as Harris [11], SIFT [5], SURF [13], FAST [14], PCA-SIFT [15] and ORB [16] techniques. The well-known SIFT (Scale-Invariant Feature Transform) [5] technique is very robust, but the problem with this method is computation time is not feasible for real-time applications. Harris corner detector [18] is used to detect the features points. It uses a normalized cross-correlation of intensity values to match them. Whereas, SURF (Speeded Up Robust Features) [13] improves the computation time of SIFT by using an integral image for fast local gradient computations on an image. Recently, binary feature descriptors have received more attention. These descriptors are described with a binary string such as ORB (Oriented FAST and Rotated BRIEF) [16] technique which is used to keep track of the popularity with SIFT and SURF. It's tremendously fast operation, while sacrificing very little on performance accuracy. ORB is scale and rotation invariant, robust because it deals with noise and affine transformations. The ORB algorithm is a combination of the FAST (Features from Accelerated Segment Test) key point detection, and the BRIEF (Binary Robust Independent Elementary Features) key point descriptor algorithm modified to handle oriented key points. Feature based algorithms have the advantage of being more robust against scene movement. These method are potentially faster and they have the ability to recognize panoramas by automatically determining the adjacency (overlap) relationships among an unordered set of images. These features make them suited for fully automated stitching of panoramas taken by casual users [17].

PANORAMA IMAGE STITCHING MODEL BASED ON FEATURE BASED TECHNIQUE:

Feature detection and matching are powerful techniques used in many computer graphic applications such as image registration, tracking, and object detection. In this application, feature based techniques are used to automatically stitch together a set of images. The procedure for panorama image stitching is an extension to the feature based image registration. Instead of registering a single pair of images, multiple image pairs are successively registered relative to each other to form a panoramaIn this section, a complete panorama image stitching model based on feature based techniques will be discussed. As shown in Fig. 1, panorama image stitching is divided into two parts: Image Registration (IR) and Image Composition (IC) algorithm. This panorama image stitching model consist seven stages: input images, features detection, matching feature, image warping, color correction, image labeling, and image blending. In the following subsections, these stages of feature based panorama image stitching will be described in detail.

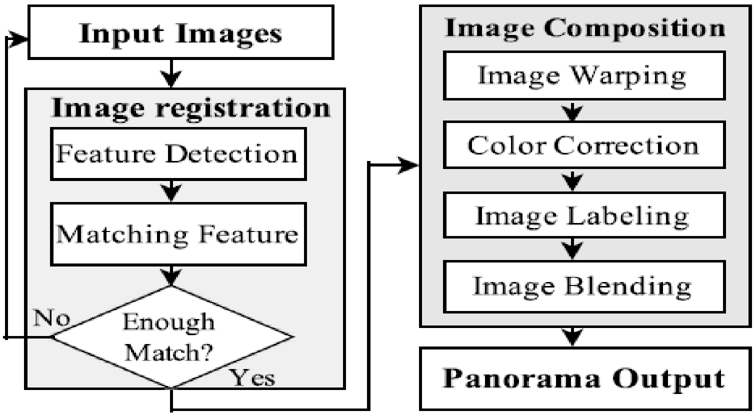

Fig. 1 The block diagram of general panorama image stitching model based on feature based approaches

A. **INPUT IMAGES:**

Input images in panorama image stitching can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. Input image is nothing but an image acquisition. Performing image acquisition in panorama image stitching is always the first step in the workflow sequence because, without an image, no processing is possible. The image that is acquired is completely unprocessed and is the result of whatever hardware was used to generate it, which can be very important in some fields to have a consistent baseline from which to work.Depending on the field of work, a major factor involved in image acquisition in image processing sometimes is the initial setup and long-term maintenance of the hardware used to capture the images. The actual hardware device can be used here is camera. Typically, images can be acquired for panorama imaging by three different methods. These methods are translating a camera parallel to the scene, rotating If the camera device is not properly configured and aligned, then visual artifacts can be produced that can complicate the image processing [18]. Improperly setup hardware also may provide images that are of such low quality that they cannot be salvaged even with extensive processing. All of these elements are vital to certain areas, such as comparative panorama image stitching, which looks for specific differences between image sets. One of the forms of image acquisition in image processing is known as real-time image acquisition. This usually involves retrieving images from a source that is automatically capturing images. Real-time image acquisition creates a stream of files that can be automatically processed, queued for later work, or stitched into a single media format.

B. FEATURE DETECTION:

The second step panorama in image stitching process is the features detection which is considered as the main image stitching stage. Features can be defined as the elements in the two or more input images to be matched. It relies on the idea that instead of looking at the image as a whole, it could be advantageous to select some special points in the image and perform a local analysis on these ones. According to the different search methods, each image can be analyzed on the basis of a set of feature points that contains from ten to hundreds of feature points anywhere in the two images. Three methods are often used for feature detection and matching: SURF [13], SIFT[5], Harris[20].The Harris feature detector is the effective and widely used method to detect feature points and to detect the corners from the input images. Harris But considering the speed the Harris Corner is the fastest than the SIFT. Harris corners are not scale invariant. SIFT is currently the gold standard for scale or rotation invariant features detection, but it takes more computational cost in real time and large scale applications. Several researchers have then developed a more efficient detector and descriptor algorithm called SURF, which has similar performance of SIFT. To find the corners in the input image Harris method take look at the average intensity which is directional. The intensity change in the small specific area called window around an interested point. Feature detection forms an important part of many computer vision algorithms. Online image processing algorithms need real-time performance. Real-time processing requires the feature detection, description, and matching to be as fast as possible. On the other hand, local feature descriptors describe a pixel (or a position) in an image through its local content. They are supposed to be robust to small deformations or localization errors, and give us the possibility to find the corresponding pixel locations in images which capture the same amount of information about the spatial intensity patterns under different conditions [21].

C. FEATURE MATCHING:

Once we have extracted features and their descriptors from two or more images, the next step is to establish some preliminary feature matches between these images. The approach we take depends partially on the application. Feature matching algorithm divides the problem into two separate components. The first one is to select a matching strategy, which determines which correspondences are passed on to the next stage for further processing. The second is to devise efficient data structures and algorithms to perform on the images. At present the more consistent search strategy is full traversal search, but the calculation is too large. The more efficient search strategy is the Best-bin-first (BBF), which is based on the k-d tree algorithm. This method identify the nearest neighbours with high probability using only a limited amount of computation. The BBF search method uses a modified search ordering for the K-d tree algorithm so that bins in feature space are searched in the order of their closest distance from the query location [22]. BBF search order requires the use of a heap based priority queue for efficient determination of the search order. The candidate matching for each key point is found by identifying its nearest neighbour in the database of key point from sample images. The nearest neighbours are defined as the key points with minimum Euclidean distance from the given descriptor vector. Probability that match is correct can be determined by the ratio of distance from the closest neighbour to the distance of the second closest. Using these method can quickly and efficiently find matching speed in overlapping regions, depends on the ratio of the two categories.

D. IMAGE WARPING:

Image warping is the process of digitally manipulating an image such that any shapes portrayed in the image have been significantly distorted. Warping may be used for correcting image distortion as well as for creative purposes (e.g., morphing). The same techniques are equally applicable to video. The warp is done by applying a 3x3 matrix called a homographic to the image. To find this homographic you need to have 2 sets of corresponding points in your original image and your resulting image. Using this homographic, you're able to do image rectification and change the perspective on an image. Homographies can also be used to create a panorama. First picked corresponding points between two images and used them to find a homographic warping one image into the other. This results in two images that are from the same perspective that can be pieced together into one image. When to cameras are observing the region and if they have overlapping viewing region then they observe the same points from different viewing angles. While matching the feature points in the images we have to consider the points that fall on to the epipolar lines. To find the exact transformation matrix between the mage planes we need good matching points. But this is not the case after applying the corner detector we get large number of corners from them we have to select the points which give better matrix. To get the better estimate of the matrix we use RANSAC based algorithm. The RANSAC algorithm estimates the good points from the available set of data which containing a number of outliers. The RANSAC method randomly selects some points and calculates the matrix and this is repeated over the set of available points. To find Homography matrix we need at least 8 number of point pairs. The RANSAC method produces the better estimate of the matrix if the data set is larger. The objective is picking eight random matches several times from the data points so that eventually we select the eight good matching points to produce the good estimate of the matrix.

E. COLOR CORRECTION:

The digital camera records large shifts in image colors under different illuminations. When, a human observer viewing each scene will be able to discount the colors of the illumination and perceive the colors in each scene as the same. This property of compensating for illumination is called as color constancy. Color constancy is a hidden color correction that all humans have. So when we are going to produced panorama image stitching we try to overcome the problem of color distortion by capturing images under different lighting or different camera properties by linear color correction. Panorama images are constructed from multiple image sequences which are captured continuously by rotating a camera so it covers the whole scene. During image capturing, varying illumination levels in different parts of the same scene lead the automatic gain control to produce different exposure levels, and automatic white balance methods lead to different color tones. If no further color processing is done, visible contrast or color discontinuities are likely to appear in the final panorama. When we want to create panorama image there are multiple source images have very different colors and luminance. So for this we have to apply the method for panoramic image construction on mobile phones. There are various approaches now a day that minimizes both the color differences of neighbouring images and the overall color correction over the whole image sequence. There are several combinations of gamma correction and linear adjustment over different color representations, and from that we have to select the method with best results: use Y CbCr and apply gamma correction for the luminance component and linear correction for the chrominance components [23].

F. IMAGE LABELIN:

Labeling of a binary image is the operation of assigning a unique value to pixels belonging to the same connected region. A connected component in a binary image is a set of pixels that form a connected group. Connected component labeling is the process of identifying the connected components in an image and assigning each one a unique label. Image labeling approach combining a set of aligned source images into a composite image by finding optimal seams in overlapping areas between adjacent source images and can be applied to produce high-resolution and high-quality panoramic images on mobile devices using less computation and memory than other often used methods.Image labeling is a operation in which, an error surface is constructed with squared differences between overlapping images. A low cost path is found through the error surface by dynamic programming [24-25] and used as an optimal seam to create labeling. The overlapping images are merged together along the optimal seam. Compared to the commonly used graph cut method [26], the labeling process is much faster and memory consumption is much lower. The use of color correction for the source images can improve qualities of image labeling.

G. IMAGE BLENDING:

When different images are stitched together, for various reasons (changed lighting conditions, vignette effects) the adjacent pixel intensities differ enough to produce artifacts. To remove these artifacts, we use image blending algorithms. Image blending is applied across the stitch so that the stitching would be seamless. After the source pixels have been mapped onto the final composite surface, then next step is to blend them in order to create an final attractive looking panorama. If all of the source images are in perfect registration and identically exposed, then this is an easy problem that is any pixel combination will do. There are various different image blending methods used in image stitching, such as alpha blending[27-28], gradient domain[29-30] and Image Pyramid blending [31]. The first simplest approach, in which the pixel values in the image blended regions are, weighted average from the two overlapping images. But the problem is sometimes this simple approach doesn't work well (for example in the presence of exposure differences). But if all the images were taken at the same time and using high quality tripods, therefore, this simple algorithm produces excellent results. An approach to multi-band image blending is to perform the operations in the gradient domain. Instead of working with the initial image color values, the image gradients from each source image are copied and then in a second pass, an image that best matches these gradients is reconstructed. Copying gradients of domain directly from the source images after seam placement is just one approach to gradient domain blending. one more important approach of image blending is Pyramid blending in which the image pyramid is actually a representation of the image by a set of the different frequency-band images that is hierarchical representation of an image at different resolution. Pyramid of image provides many useful properties for many applications, such as noise reduction, image analysis, image enhancement, etc.

LITERATURE REVIEW OF PANORAMA IMAGE STITCHING:

In the last few years, there are many researchers implemented and proposed various panorama image stitching systems. For example, Levin and Weiss [32] introduced several formal cost functions for the evaluation of the quality of image stitching. This approach is established in various applications, including generation of panoramic images, object blending, and removal of compression artifacts. The aim of a panorama image stitching algorithm is to produce a visually plausible mosaic with two desirable properties. First one is the image stitching should be as similar as possible to the input source images, both geometrically and photo metrically. Then second one is the seam between the stitched images should be undetectable. While these requirements are widely acceptable for visual examination of a stitching result, their definition as quality criteria was either limited in previous approaches. Researchers presented several cost functions for these requirements, and define the panorama image stitching as their optimum. The image stitching quality in the seam region is measured in the gradient domain. The mosaic image should contain a minimal amount of visible seam artifacts.Scale Invariant Feature Transform (SIFT) algorithm [35] is a robust algorithm produced by Lowe in 1999, it is able to extract invariant features from the images at different scales. SIFT has been applied in many fields since it was put forward. These features focusing on speed by using some algorithm like image registration, object recognition, camera calibration and image retrieval. SIFT features are invariant to image scale, rotation, addition of noise, change in viewpoint and illumination. Limitation of SIFT is that it extract 128-dimentional feature vector for each interest point which causes huge computation of feature matching. To overcome this problem Bay proposed SURF (Speeded-Up Robust Features)[36] in 2006. SURF algorithm is achieved by relying on integral images for image convolutions can be computed and compared much faster. SURF algorithm not only guarantees the similar robustness with SIFT algorithm but also it increases the computational efficiency a lot. After finding features and matching feature, they used RANSAC to select a set of inliers that are compatible with a Homography between the images. Then, they applied a probabilistic model to verify the match; then they used bundle adjustment to solve for all of the camera parameters jointly and finally they have applied the multi-band blending strategy. The idea behind using multi-band blending is to blend low frequencies over a large spatial range and high frequencies over a short range. This task can be performed over multiple frequency bands using a Laplacian Pyramid. There are two main approaches to stitch multiple images for panorama: optimal seam finding and transition smoothing. Optimal seam finding algorithms [24-25],[33] search for a seam in the overlapping area so that the differences between two adjacent images on the visible seam are minimized. The optimal seam can be found by graph-cut [26], dynamic programming [24-25] or other algorithms uses for finding optimal seam. Then each input image is copied to the corresponding side of the seam. The advantage of optimal seam finding algorithm is its low computational and memory cost. But the main problem of optimal seam finding is that sometimes the seams are also visible and artifacts may arise in the final panorama. Transition smoothing algorithm can reduce the seam artifacts by smoothing the transition between images. One of the simplest algorithm is using alpha blending [28] to combine adjacent images through weighted combination. Pyramid blending [31] on the other hand blends the frequency bands of the images and different frequency bands are combined with different blending masks. Gradient domain techniques [30] are also widely used in which they operate directly on the gradient field of an image and the blending is typically carried out by solving a Poisson equation with boundary conditions. While these approaches can reduce artifacts effectively, they require large computational costs and memory consumption. In addition, these approaches focus on smoothing the transition in the surrounding area of the overlapping area. If the illumination and color differences among images are very big, while seams can be smoothed to almost invisible, the color tones change from one image area to another image area shown on the final panorama which makes the image look unnatural. Thus color correction is often used before the stitching process to balance colors and luminance in the whole image sequence. A main approach is to transform the color of all the images in the image sequence to match the basis image. Transform matrix across images can be represented as a linear model [23] or a diagonal model [37], in which the mapping parameters are computed from the averages of each channel over the overlapping areas or from the mapping of histograms [23][34]. These approaches are not sensitive to the quality of geometric alignment, but the correctness of color correction needs to be improved. In recent years, Xiong et al. [33] proposed a much accurate color correction algorithm that minimizes a error function, to get the correction coefficients simultaneously for the whole image sequence, followed by a color blending step to further smooth the transition. To establish the global error function, it is necessary to extract all the mean values of overlapping areas between every pair of adjacent images.

CHALLENGES OF PANORAMA IMAGE STITCHING:

There are various challenges in panorama image stitching such as noisy image data or data with uncertainties which means an image is often corrupted by noise in its acquisition and transmission, the cost of extracting features is minimized by taking a cascade filtering approach. Another challenge is that there is a very larger image collection need for efficient indexing that is large amount of images may lead to high processing time, since each image needs some processing. The main challenge on panorama image stitching is the using of handled camera which may lead to presence of a shift in apparent object position while observed from different angles of view, small scene motions such as waving tree branches, and large-scale scene motions such as people moving in and out of pictures. Another frequent problem in creating photo stitching is the elimination of visible seams, for which a variety of techniques have been developed over the years.

CONCLUSION:

Panorama Image stitching is an active research area in the fields of computer vision and computer graphics. It has a huge amount of different algorithms for features detection and description. The choice of the feature detection algorithm depends on the problem. In this paper, we have presented a comprehensive study on features-based panorama image stitching such as SIFT algorithm which is rotation, scale invariant as well as more effective in presence of noise. It has highly idiosyncratic features. Nevertheless, it needs high computational time; the SURF algorithm proves superior in terms of execution time and illumination invariance property; the Harris feature detector algorithm is the effective and widely used method to detect feature points and to detect the corners from the input images. In future we want to compare between the algorithms we have studied and other feature based panorama image stitching algorithms, also Stitching videos together to create dynamic panoramas, and stitching videos and images in the presence of large amounts of parallax.

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