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Survey on the Techniques Used in Removing Camera Shake

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Abstract: **Many algorithms were formulated in the field of image processing especially to remove blurriness in the image. The reasons for obtaining blur images are: out-of-focus, light diffraction, light integration in the photo sensor and relative motion between the camera and the location. The camera shake usually caused by hand-held tremors which produces a blurry image. The goal of image restoration was to reconstruct the original scene from a degraded observation. The proposed survey paper gives a detailed description on the techniques followed by many authors to remove camera shake. Both, the algorithms and its drawbacks are given in this paper.**

Keywords: **Blur kernel, Deblurring, Deconvolution, Denoising, Point spread function and SIFT.**

1. INTRODUCTION

Camera shake usually occurs due to physiological tremors. Physiological tremor was a very small involuntary movement that was present in every healthy individual. In picture shooting conditions, hand tremors originate from the random firing of muscular cells in antagonistic muscles of the arm limbs. These independent events results in a time varying random force signal applied to the various axes of the complex shoulder-arm-hand mechanical system. This results in the blurs which spoils the photos taken in low-light conditions. Even for a professional photographer, it is a frustrating experience to take pictures under bad lighting conditions with hand-held cameras. Usually there exist two conditions in taking the photograph. One is taking photos in long exposure time and other in short exposure time. But taking the photographs in long exposure time results in motion blur and on the other side short exposure time results in noisy but sharp image. Image fusion is the process of combining multiple images to get a desired image. The multiple images are related by a homography and the following are the assumptions that should be satisfied for the homography assumptions:

1) Camera motion was an arbitrary rotation around its optic centre.
2) The same plane was shared by the photographed objects.
3) The camera was far away from the scene.

The image homography is same as that of the image registration. Regarding the camera, the hand tremor vibrations result in translational and rotational motion as shown in the figure 1.

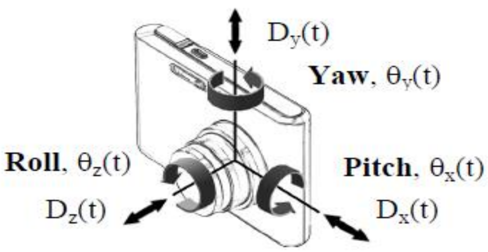

Figure1 Six degrees of freedom for camera

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The positional noise produced was integrated during exposure time by the camera image sensor and was responsible for the motion blur noise. The camera lens systems have six degrees of freedom which have different impacts on the resulting blur. By analysing the impact of the various translations and rotations of a typical lens system at the pixel level, it can be shown that:

$$\begin{bmatrix}\Delta_x \\ \Delta_y\end{bmatrix} = F\begin{bmatrix}\tan(\theta_x) \\ \tan(\theta_y)\end{bmatrix} + \frac{F}{D_{scene}}\begin{bmatrix}D_x \\ D_y\end{bmatrix} + f(x,y,D_z,\theta_z) \qquad (1)$$

In (1), Δ□x and Δ□y the resulting displacement in the focal plane, the focal length was defined by F and the distance between the camera pupil and the scene was defined by Dscene. Given variations z, Dz, the rotation and the homothetic transformation function f also depends on the considered location (x,y) on the focal plane can be bounded by:

$$f(x,y,D_z,\theta_z) < 2\, d_{x,y} \tan(\theta_z) + \frac{d_{x,y}\, D_z}{D_{scene} + D_z} \qquad (2)$$

In (2), dx,y the distance of the considered pixel to the focal axis. In typical conditions, Dscene >> F >> dx,y. The distance to the scene dominates all other distances and (1) can be reduced to:

$$\begin{bmatrix}\Delta_x \\ \Delta_y\end{bmatrix} \approx F\begin{bmatrix}\tan(\theta_x) \\ \tan(\theta_y)\end{bmatrix} \qquad (3)$$

The formula (3) illustrates why, as it is widely observed, among the six degrees of freedom of a camera depicted by Figure.1 only the pitch and yaw rotations dominate the motion blur noise in standard shooting condition.

The process of aligning two or more images of the same scene is called as image registration. This involves one as reference image (or fixed image) and applying geometric transformations to the other images to that they align with the reference. Image registration is the preliminary step which allows comparing common feature in different images. The three image registration solutions are:

1) Automatic image registration based on intensity maps certain pixels in each image based on relative intensity patterns. It is best suited for workflow that involves a large collection of images or when the workflow is automated.

2) Control point registration manually selects the common features in each image to map to the same pixel location.

3) The automated feature based workflow automatically aligns images by selecting matching features between two images.

2. LITERATURE SURVEY

A. REMOVING CAMERA SHAKE FROM A SINGLE PHOTOGRAPH:

A uniform blur in the image and the negligible in-plane rotation in camera was assumed in this method. The user specifies a region in the image without any saturation effects for estimating the blur from the camera shake. In the paper [1], two approaches are followed. The first approach was the estimation of blur kernel from the image which was taken as an input. In the estimation process, to avoid the local minima, the whole process was done in a coarse-to-fine fashion. The second approach objective was to find the latent image. The estimated blur kernel in the previous approach was used here and a standard deconvolution was applied. In the implementation part, two methods were explained, one was estimating the blur kernel and another was reconstruction of images.

Drawback:

The drawback in this method was that the usage of complex optimization framework and both the blurring kernel and the sharp image has to be estimated in this method.

B. TWO BLURRED IMAGES ARE BETTER THAN ONE:

Alex Rav-Acha and Shmuel Peleg defines motion blur as a smearing of an image due to long aperture time. In the paper [2], they show that the two motion blurred images that are blurred in a different directions can be restored easily. In this approach, the blur functions are recovered instead of the inverse motion of blur function. Then the image restoring was carried out. The advantages of this approach are:

1) The blur functions are recovered instead of inverse motion blur function which has smaller supports. This enables the restoration of wider blurs.

2) To get better restoration of image, both the images are used to reconstruct the original image.

3) Since, the recovery of blur functions and image restoration were done separately, it was easier to incorporate regularization. This algorithm uses regularization to reduce the noise.

Point Spread Function (PSF):

For restoring the image PSF was used. Both the strength and weakness of this algorithm was that each images in the burst are blurred in the different directions. The directions also need not be known for finding the PSF.

Drawback:

The drawback of this algorithm was that it was computationally intensive to produce a good result.

C. A NOTE ON MULTI-IMAGE DENOISING:

The algorithm used in the paper [4] was a complex image processing chain. This involves:

- Registration of accurate key points
- Equalization of video
- Estimation of noise
- Denoising.

Though it was complex, it estimates the noise model from the burst of images. The preliminary works that were carried out was image matching, image/video denoising algorithm and noise estimation. SIFT (Scale Invariant Feature Transform) is used to find the key points in the images. The steps followed in this paper are:

- Finding the accurate keypoints by SIFT
- Registering multi-images
- Equalizing the video
- Estimating noise in the image
- Denoising multi-images.

Drawback:

The drawback was that it fails to denoise the region of the fixed pedestal.

D. NON-UNIFORM DEBLURRING FOR SHAKEN IMAGES:

In the paper [3], the authors O. Whyte, J. Sivic, A. Zisserman, and J. Ponce mentions that the blurriness in the image was caused due to 3D rotation of the camera which results in the blur kernel that may significantly non-uniform across the image. Here two algorithms were employed where first algorithm uses single blurry image and the second algorithm makes use of sharp image with noise of the same scene. By using the properties of camera two deblurring problems are applied with the existing camera shake removal algorithms.

Drawback:

The main drawback was that it was not applicable for non-static scenes or nearly scenes with large camera translations which becomes insignificant for the parallex effects.

E. MULTI-IMAGE BLIND DEBLURRING USING A COUPLED ADAPTIVE SPARSE PRIOR:

The paper [5], provides a technique in which multiple blurry and / or noise observations are used to estimate the single latent sharp image. Bayesian-inspired penalty function was used to combine all the observations which help to couple the unknown image. Here, two theorems are taken into an account where the first theorem states that the penalty function h(x,p) was a concave non-decreasing function of |x| and the second theorem states about the relative sparsity functions. This paper gives an unified approach for recovering a latent and high quality image from a set of blurred images. The modifications in the blurry image were not required.

Drawback:

The drawback was that the algorithm does not support for video deblurring and non-uniform deblurring.

F. DENOISING VS DEBLURRING HDR IMAGING TECHNIQUES:

This is a theoretical paper [6] on the exploitation of new cameras with high resolution quantization. Here comparisons are made with two HDR imaging alternatives where the first was deblurring a single blurry clean image and second was denoising a sequence of sharp noisy image. The authors, Li Zhang, Alok Deshpande and Xin Chen conclude that denoising with multi-images gives a more reliable solution. This paper compares the resultant image of both deblurring and denoising process. The clean image was considered as J and J was estimated by deblurring and denoising. The conclusion from the paper was that denoising was more reliable than deblurring for exploiting new camera to obtain HDR photography from a moving camera.

Drawback:

The drawback of this paper was that the authors haven't explored any other aspects of photography from fast cameras.

G. AUTOMATIC HOMOGRAPHIC REGISTRATION OF A PAIR OF IMAGES:

The algorithm which was explained in the paper [7] was the RANSAC algorithm ((RANdom SAmple Consensus). By using the outliers in the data the parameters are estimated in the model. For estimating the parameters the random samples are iteratively extracted from the data. The preliminary step in this algorithm was finding the homography between the pair of images. After finding the homography, the panaroma was built by stitching the base image and the image to be registered. The point correspondences between the images are computed by SIFT algorithm. For evaluating point correspondences between the images, the ORSA (Optimized RANSAC) algorithm was used. At the last, the duplicates are removed and the output was obtained.

Drawback:

The failure of this algorithm occurs if there are few matched in the algorithm. If there are only 4 correspondences, then there are no NFA associated, a homography could be estimated, but the quality of the result fails.

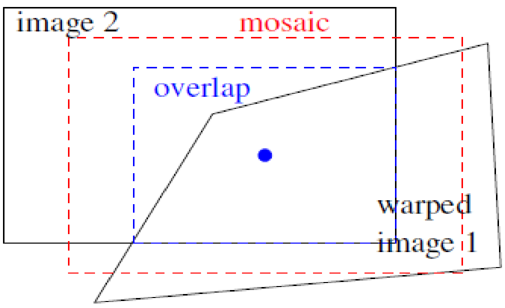

Figure 2 Automatic homography image registration

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In the figure 2 the warped first image was intersected with the second image and the center of the bounding rectangle of the overlap was fixed as mosaic's center.

H. A CONCEPT ON POINT MAPPING:

The point mapping is used to determine the parameters for aligning an image on another image by transformation. In point mapping the points is selected in a pair of images that identify the same features or landmark in the image. The point mapping process can be used as a script by automating all the steps in the figure 3 by creating a script. The 'wait' option was used to find the control points in the images. If it was not then the efficient control points cannot be obtained and also it does not return any return values. The transformation image was obtained with the help of the control points in the images. The transformed image that was obtained can be used to register the image over the other image.

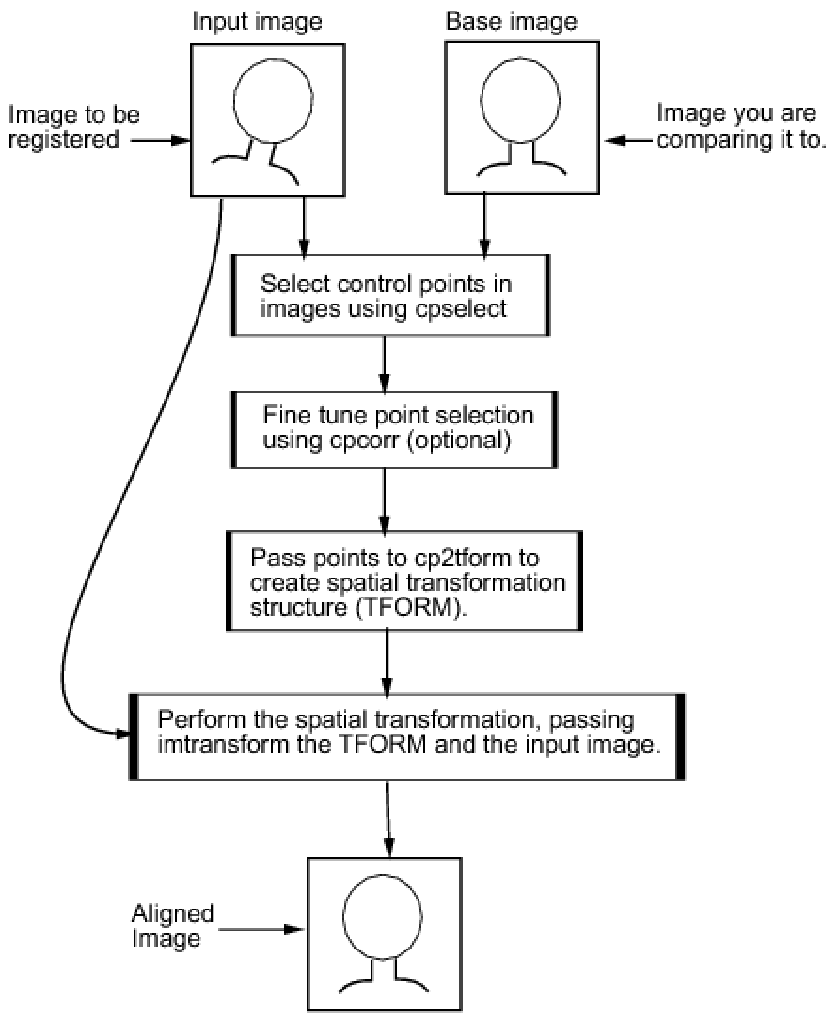

Figure 3 Steps involved in point mapping

The steps involved in point mapping include:

1) Reading the base image and image that is to be registered.
2) Choosing the control points in the images.
3) Saving the control point pairs.
4) Specifying the type of transformation and infer its parameters
5) Transforming the unregistered image.

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3. CONCLUSION

In most of the algorithms the image registration was carried out as the preliminary step and later the processing was done. To estimate the burst registration the algorithm may consider the key points mapping as one of the steps. This helps in mapping the images with same features. The camera shake was removed by using both single and pair of images. The algorithms for the removal of blurriness using burst of images was less compared to that of other. This paper provides knowledge on various techniques/algorithms involved in removal of blurriness in the image. The drawbacks and the steps involved in the algorithm are explained in this paper. The study is further increased in the fourier domain field for finding the average weight for the images to remove the blurriness. For starting the work with burst of images, burst registration is followed were burst of images are registered and the fourier weight is calculated. The resultant image produced with help of fourier domain contains a less percentage of noise which can be recovered by Gaussian denoising. The main idea was that, each image in the burst is blurred differently. When working with the fourier domain, it does not produce blur estimation or any inverse problem. The concept of removing the camera shake can be implemented in the camera phone and the registration can be done as the automatic homographic registration. The best capture can be obtained by determining the total exposure time and also total exposure time will be given which would be convenient to take short exposure pictures.

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