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RENEWED APPROACH FOR IMAGE RECTIFICATION

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Abstract: This paper proposed a new method for image rectification ,it is the process by which the pairs of stereo images of same solid scene taken from different viewpoints in order to produce a pair of "matched epipolar projections" and become parallel to the x-axis of image. A stereo rectified images are helpful for matching algorithms.It restricts that each line parallel to x-axis.The stereo rectification is not unique and actually lead to undesirable distortions. To overcome the drawback of the relative distortion between left image and right image an epipolar line rectification technique is used for point detection and reduce the distortion by minimized the camera rotation angle at each step.By comparative experiments show that the algorithm has an accuracy where other methods fail, namely when the epipolar lines are far from horizontal.

Keywords: Rectification, stereovision, epipolar, distortion, camera rotation.

INTRODUCTION

Image Rectification is a transformation process used to project two-or-more images onto a common image plane. It corrects image distortion by transforming the image into a standard coordinate system. Image Rectification is used in computer stereo vision to simplify the problem of finding matching points between images. Image Rectification is also used in geographic information systems to merge images taken from multiple perspectives into a common map coordinate system. The stereo rectification of image pair is an important component in many computer vision applications. By estimating the epipolar geometry between two images and performing stereo-rectification, the search domain for registering algorithms is reduced and the comparison simplified, because horizontal lines with same y component in both images are in one to one correspondence. Stereo rectification methods simulate rotations of the cameras to generate two coplanar image planes that are in addition parallel to the baseline. This pair of homographies are not unique because a pair of stereo rectified images are under a common rotation of both cameras around the baseline. This remaining degree of freedom can introduce an undesirable distortion to the rectified images. Stereo vision uses triangulation based on Epipolar geometry to determine distance to an object. Between two cameras there is a problem of finding a corresponding point viewed by one camera in the image of the other camera known as the correspondence problem. In most camera configurations, finding correspondences requires a search in two-dimensions. However, if the two cameras are aligned to be coplanar, the search is simplified to one dimension horizontal line parallel to the baseline between the cameras. Furthermore, if the location of a point in the left image is known, it can be searched for in the right image by search left of this location along the line, and vice versa. Image rectification is an equivalent alternative to perfect camera alignment. Image rectification is usually performed regardless of camera precision due to two reasons:-

- Impractically or Impossibility of perfectly aligning cameras.
- Perfectly aligned cameras may become misaligned over time.

Stereo images can also be taken with a single camera in motion. In this case the relationship of the images can have significant forward-motion components, and a linear transformation may produce severely warped images or very large images. Non-linear transformation techniques can be used to manage this difficulty.[3]

A. Transformation and Geographical System

If the images to be rectified are taken from camera pairs without geometric distortion, this can be calculated easily be made with a linear transformation. X & Y rotation puts the images on the same plane, scaling makes the image frames be the same size and Z rotation & skew adjustments make the image pixel rows directly line up. The rigid alignment of the cameras needs to be known by calibration and the calibration coefficients are used by the transform. In performing the transform, if the cameras themselves are calibrated for internal parameters, an essential matrix provides the relationship between the cameras. The more general case is represented by the fundamental matrix. If the fundamental matrix is not known, it is necessary to find preliminary point between stereo images to facilitate its extraction. Image rectification in GIS converts images to a standard map coordinate system. This is done by matching ground control points (GCP) in the mapping system to points in the image. These GCPs calculate necessary image transforms.[1]

B. Camera Model.

Many algorithms in multi-view geometry are based on the assumption that the camera is ideal pinhole. But in practice, the camera is deviated from a pinhole model by lens distortion. In this sense, distortion is the only gap between the theory and the practice. That is the reason why we want to correct it in high-precision.[6]

In this,some basic concepts about pinhole camera model and distortion model are introduced. A typical bundle adjustment like camera calibration method is also explained in detail to show the problems we shall meet in distortion correction. Once the distortion is removed and the camera becomes pinhole, the projective geometry is a useful tool to solve different problems in multi-view geometry, like image rectification and mosacing. The model allows for the modeling of several parameters like the location and orientation of the camera, the principal point offsets in the image space and unequal scale factors in two orthogonal directions not necessarily parallel to the axis in image space.[2]

C. Parameters Used for image rectification

- Orthogonality: It means that the two vectors are orthogonal if they perpendicular. Orthogonality occurs when two things can vary independently and they are perpendicular. Two vectors are orthogonal if they form a right angle with each other.
- Aspect Ratio: It is the ratio of the width of the image to the height. If a image has *x*:*y* aspect ratio, no matter how big or small the image is, if the width is divided into *x* units of equal length and the height is measured using this same length unit, the height will be measured to be *y* units.
- Rectification Error: It is the unnecessary and unwanted value which is known as error. The ideal value for rectification error is zero.
- Distortion: It is the parameter used in the image rectification if there is any distortion in an image then we remove it using a proposed method or algorithm.[10]

EPIPOLAR GEOMETRY

In the epipolar geometry when two cameras view a 3D scene from two distinct positions,there are a no. of geometric relations between the 3D points and their projections on 2D image that read the constraint between the image points.Here we concentrate on the simplest two-view geometry because it is difficult for three or more images to share enough stable feature points in practice. The relation between corresponding points in two views is described by epipolar geometry. In algebraic viewpoint, the epipolar geometry is coded by a 3X3 matrix, called fundamental matrix, F. Fundamental matrix only depends on the relative position of two cameras and the intrinsic parameters of cameras, but not on the 3D scene.

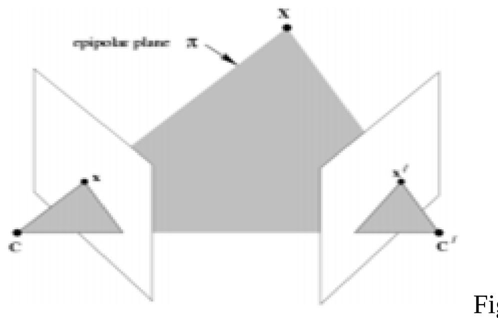

Fig II.(a) The optic center of two cameras and a 3D point form a epipolar plane which intersects two image planes at the epipolar line.

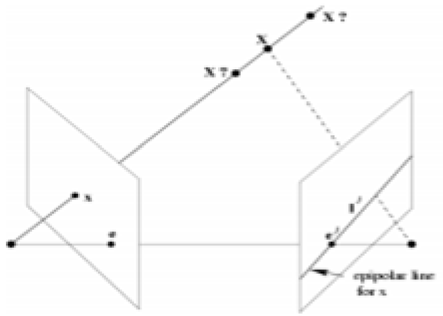

Fig II.(b) Given one point x in the left image, its correspondence in the right image must be on the corresponding epipolar line.

A. Importance of Epipolar Geometry

If one point x in the left image, its corresponding point in the right image must be on the line called epipolar line, which can be explicitly computed as F x. This provides a necessary condition to test whether two points correspond to the same 3D point or not.

By using this corresponding points in two images, the 3D scene can be reconstructed up to a 3D projective transformation, as well as the camera position and orientation

B. Steps for Rectification

First of all for rectification we compute the Fundamental matrix F.

$$[\mathbf{i}]_\times = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}_\times = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}$$

In this the fundamental matrix is propotional to$[i]_x$ and the motion between both cameras being only the translation along the x-axis.

We assumed that the cameras used are not calibrated i.e uncalibrated environment it is captured in the fundamental matrix

- The fundamental matrix encapsulates both the intrinsic and the extrinsic parameters of the camera.
- Fundamental matrix F maps image points to their corresponding epipolar lines.

- Fundamental Matrix F maps epipoles to the origin of corresponding image plane.

Here both cameras pointing the same direction with their image planes co-planar and parallel to base line but it is not sufficient to achieve rectification, the orientation of the camera can be adjusted by applying homography on the image.

So we take a simple calibration matrix K.

$$\mathbf{K} = \begin{bmatrix} f & 0 & \frac{w}{2} \\ 0 & f & \frac{h}{2} \\ 0 & 0 & 1 \end{bmatrix}$$

with w, h the width and height of the image and f the unknown focal length. The fundamental matrix F is computed from a group of non-degenerate correspondences between two images. The epipoles for the left image $e = (e_x,e_y,1)^T$ and right image $e' = (e'_x,e'_y,1)^T$ can be computed as right and left null vectors of F: $Fe = 0$ and $e'^T F = 0$.[4].

The idea is to transform both images so that the fundamental matrix gets the form $[i]_x$. In this we shall compute the homography explicitly by rotating each camera arount its optical center. Instead to compute directly homographies from constraints and remove the distortion from images [9]

C. Steps for decomposition of algorithm

1.Compute the fundamental matrix and find the epipoles of left and right image.

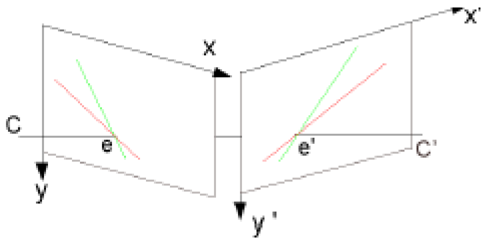

Fig II(c) In this the epipoles are compute.

2.Compute the homographies H_1 and H'_1 by rotating both cameras so that the left epipole $(e_x,e_y,1)$ is transformed to $(e_x,e_y,0)$ and right epipole $(e'_x,e'_y'1)$ transformed to $(e'_x,e'_y,0)$.

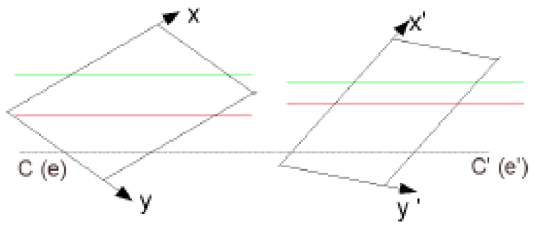

Fig II(d)

In this the image planes become parallel to CC'.

3.Rotate both cameras so that $(e_x,e_y,0)$ is transformed to (1,0,0) and $(e'_x,e'_y'1)$ to $(e'_x,e'_y,0)$. The corresponding homographies are denoted by H_2 and H'_2.

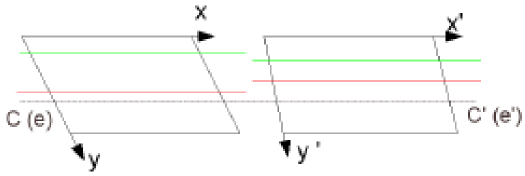

Fig II(e) In this the images rotate in their own plane to have their epipolar lines also parallel to CC'[9].

4.Rotate one camera or both cameras together to compute the residual relative rotation between both cameras around the baseline.The corresponding homographies are denoted by H_3 and H'_3.

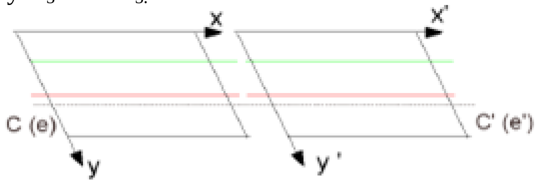

Fig II(f) A rotation of one of the image planes around CC' aligns corresponding epipolar lines in both images.

RESULTS

In this the algorithm is tested on real images. Firstly, the images are tested by Fusiello and then tested by a proposed algorithm.The fundamental matrix was computed by normalized 8-point algorithm and calibration matrix is known and the performance of algorithm is compared with Fusiello method.[9]

The performance is evaluated on two aspects: the rectification error and introduced distortion. The Distortion is measured by orthogonality and aspect ratio. But the rectification error is measured as the average and standard deviation of the y-disparity of rectified correspondences. The original epipolar geometry is the distance from points to the corresponding epipolar line as metric.

By using this proposed algorithm the distortion is reduced when apply on the images. Fusiello method is very comprtative ,in particular for rectification precision.But its result does not always have a correct geometric meaning. When we have taken a images by a camera so that the base line is parallel to x-axis.Only our algorithm rotates the images and other are failed.[5]

Fig III(a) Original Left Image

Fig III(b) Original Right image

The original images left and right image taken by a camera and then both the algorithm are apply to check the output.Firstly the proposed algorithm is apply on the image.

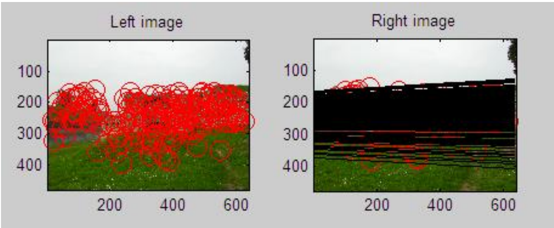

Fig III(c) Evaluate Epipolar Points

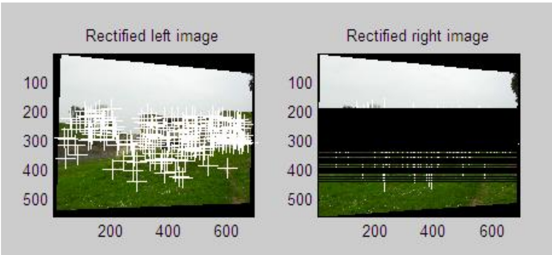

Fig III(d) Find Epipolar lines between images

When we apply our proposed algorithm on these images left and right image then we have a rectified images,firstly it finds the epipoles in left and right image and then epipolar lines are drawn on images to produce a rectified image without distortion.[7]

The Output images by our proposed algorithm

Fig III(e) Rectified Left Image

Fig III(f) Rectified Right Image

These are the rectified left and right images after apply the proposed algorithm.

After apply the fusiello method the output of images.

Fig III(g) Rectified Left image by Fusiello's Method

Fig III(h) Rectified Right image by Fusiello's Method[8]

CONCLUSION

A new image rectification algorithm is proposed. Different steps of algorithm is used for camera rotation. By reduce the rotation angle at each step the distortion is reduced. The reduction of distortion is measured by two parameters Orthogonality and Aspect ratio. The ideal value of orthogonality is 90 and aspect ratio is 1 and the ideal value for rectification error is zero.The performance comparison between the proposed and Fusiello method are calculated based on these parameters and the result gathered in a table.

Image	Method	Orthogonality H , H'	Aspect Ratio H , H'	Rectifica-tion Error
Fort Garden	Proposed	90.00 , 90.00	1.000 , 1.000	0.27015

Fort Garden	Fusiello	90.00, 90.19	1.002, 1.004	0.32058

REFERENCES

[1] R. I. Hartley. "Estimation of relative camera position for uncalibrated cameras". In Proceedings of the European Conference on Computer Vision, pages 579–587, 1992.

[2] R. Hartley. "Theory and practice of projective rectification" International Journal of Computer Vision, 35(2):1–16,November 1999.

[3] A. Fusiello, E. Trucco, and A. Verri. "A compact algorithm for rectification of stereo pairs".Machine Vision and Applications, 12(1):16–22, 2000.

[4] J. Mallon and Paul F. Whelan. "Projective rectification from the fundamental matrix".Image and Vision Computing, 23:643–650, 2005.

[5] Andrea Fusiello and Luca Irsara "Quasi–Euclidean Uncalibrated Epipolar Rectification", University of Verona, IEEE, 2008.

[6] Li He-xi,wang guo-rong,shi Yong- hua "Application of Epipolar Line Rectification to the stereovision –Based measurement of workpieces" IEEE , pp 758-762,2009.

[7] Di Wu and Naiguang Lu,Peng Sun "Truncated Epipolar line matching based on image rectification" IEEE International Conference on information and computing, pp 198-201,2010.

[8] Lin Guo-Yu and Chen-Xu "A robust epipolar rectification method of stereo pairs" IEEE international conference on measuring technology and mechatronics automation, pp 322-326, 2010.

[9] Pascal Monasse and Jean Michel Morel "Three step image rectification"BMVC, pp 1-10,2010.

[10] Zeyu Li and Harlyn Baker "Projective Epipolar Rectification For a Linear Multi-Imager Array" pp 1-8,2010.

