Improvising Field of View of Camera using Fisheye Image Correction

Eknath M. Salvi
Department of Electronics & Telecommunication Engineering
Pune University, Sinhgad College of Engineering Vadgaon, Pune, India

Prof. S. O. Rajankar
Department of Electronics & Telecommunication Engineering
Pune University, Sinhgad College of Engineering Vadgaon, Pune, India

Abstract

Fisheye cameras have very good properties like wide angle view capture , cost effectiveness etc. hence they are used in variety of applications including automobile rear view imaging system , surveillance and robotics. But the produced images have some distortion and lead to have hemispherical scenes projected on flat surface and looking curvilinear. These distortions result into viewer's confusion. Hence the distortion should be corrected to rectilinear corrected version. The proposed work aims to devise a method for fisheye correction along with the enhancement of the distorted images and hence to improve the Field of View (FoV) of the camera. Referring fisheye type images like Hemispherical and Full Circular images the method will be designed considering the aspects of imaging, projection model, distortion model, bilinear interpolation adjusting etc. The resulting image is expected to have a high resolution and homogeneous illumination distribution.
Keywords: Field of View (FoV)

I. INTRODUCTION

Cameras are designed to capture the images. Now a day's cameras support the feature of panoramic view but we need to capture multiple images with overlap area in adjacent images. This report proposed a single click solution for capturing the large field of view in an image. Wide angle camera like fisheye cameras is finding an increasing number of applications like automobile rear-view imaging systems, surveillance etc. due to their ultra-wide-angle properties and cost-effectiveness.

Fisheye lenses provide very large wide-angle views (theoretically the entire frontal hemispheric view of 180°) the images produced suffer from severe distortion as a result of the hemispherical scene being projected onto a flat surface. For a viewer the wide angle camera images, such distortion can be both unusual and confusing. Therefore, it is desirable that the images captured by wide angle cameras be corrected to approximately rectilinear versions before being presented to viewers in applications such as automobile rear-view cameras.

To understand the fisheye image term Figure 1 shows the image captured from normal camera and Figure 2 shows fisheye lens camera.

Fig. 1: Normal lens Camera Image [8]

Fig. 2: Fisheye Lens camera Image [8]

As FoV of normal camera is smaller so the Normal cameras unable to capture the wide scenery even though we have panorama feature the image is obtains by the panoramic camera is obtained by clicking multiple times and overlapping that multiple images in a single image provide a larger view. But what if we have functionality which gives the wide angle view in just one click without merging multiple images. Also we have surveillance cameras which are used for monitoring, these cameras also having small field of view. So to increase the field of view to have better surveillance we may use the fisheye cameras.

There are many applications on wide angle camera images because of its wider view. Real-time rear obstacle detection system using fisheye stereo cameras is one of the main applications. As technologies related to safe driving can potentially decrease the number of traffic accidents, as most traffic accidents are due to driver error. To avoid these traffic accidents, many automobile companies have researched advanced driver assistance systems (ADAS) such as forward collision avoidance systems, lane departure warning systems, and parking assistance systems. These systems help automate driving and facilitate safe driving by using input from various sensors such as fisheye cameras Many researchers have therefore investigated vision systems (i.e. cameras) because cameras are low-cost, portable, and the driver can effectively understand the surrounding environment by viewing camera images. Fisheye camera, which has wide FOV are used for such applications

Another application we can have is use of wide angle lenses in video surveillance. Various types of video can be captured with fisheye lenses; their wide field of view is particularly suited to surveillance video. However, fisheye lenses introduce distortion, and these changes as objects in the scene move, making fisheye video difficult to interpret. Current still fisheye image correction methods are either limited to small angles of view, or are strongly content dependent, and therefore unsuitable for processing video streams. So an efficient and robust scheme is still needed for fisheye correction, which minimizes time-varying distortion and preserves salient content in a coherent manner.

A. *Field of View (FoV) of Camera:*

In photography, angle of view describes the angular extent of a given scene that is imaged by a camera. It is used interchangeably with the more general term field of view. It is important to distinguish the angle of view from the angle of coverage, which describes the angle range that a lens can image. Typically the image circle produced by a lens is large enough to cover the film or sensor completely, possibly including some vignetting toward the edge. If the angle of coverage of the lens does not fill the sensor, the image circle will be visible, typically with strong vignetting toward the edge, and the effective angle of view will be limited to the angle of coverage.

The angle of view is the visible extent of the scene captured by the image sensor, stated as an angle. Wide angle of views capture greater areas, small angles smaller areas. Changing the focal length changes the angle of view. The shorter the focal length (e.g. 18 mm), the wider the angle of view and the greater the area captured. The longer the focal length (e.g. 55 mm), the smaller the angle and the larger the subject appears to be.

II. RELATED WORK

There are many algorithms and methods put forward in various papers for fisheye image distortion correction. The majorly identified distortions are radial and perspective distortions, hence to optimize the solution and image distortion correction the algorithms are developed based on geometric projection of an image. There is some work done on the proposed topic. The white paper published by Altera Corporation M.D.N [2] Altera and MDN have developed a novel architecture for fisheye correction in wide-angle cameras which is flexible, scalable and makes efficient use of the FPGA's resources. They have perform fisheye correction on a FPGA when basic camera parameters of camera are known The camera geometry is used to have relationship between distorted and undistorted pixels. Where as in one of the paper [3] the hyperbolic geometry is used for mapping matrix in fisheye distortion correction. Saijiang Ai et al. [4]in his proposed paper correcting method which is based on the Property of invariance projective and also based on planer template. The radial distortion is corrected by using the principal operated on collinear points. This principal is called cross ratio invariability which operates template image with planer grid and the objective function is used to obtained distortion parameters. The principal of cross ratio invariability is explained which is then used for the geometric distortion correction method. Bi Kun et al. [5] In his paper proposed the method was introduced from the adjusting bilinear interpolation, imaging aspects, projection and distortion model, etc.

We have some software's which have defisheye feature which when applied to an fisheye image the distortion is corrected. But they are costly and not a real time also some issues are there which leads to loss some image dataThe photo demon tool is also one of such application where simple algorithm is used for fisheye image correction.

A. Algorithm Based on Geometry:

The algorithm is developed on the basis of geometry. First we will define the output image as a blank image with the size depends upon the input image. The width and the height of the image are derived for input image. Now we have coordinates of output pixel with us and we have to find the value of the pixel at each coordinate location in the output image. For the value of pixels in the output image we have to follow some geometrical calculations. First we find the centre of the image. After getting the centre we find the radius in the diagonal direction. This radius gives us the maximum distance along which we have to map the input pixel. The distortion occurred in a fisheye image is due to the construction of fisheye lens which is spherical in shape which having projection on the flat surface like a rectangular surface. And because of spherical projection on rectangular surface we have the radial distortion. Hence the lens parameter call the focal length eventually became a important factor to be consider while undistort the image. So in this algorithm we are using the parameter Focal length while calculating the corrected point location in an output pixel.

The proportion of the correction can be given by following equation (1).

$$\text{correction proportion} = \frac{\text{Radial corrected Distance}}{\text{Focal length of the lens}} \quad (1)$$

The focal length is to be finding by using the calibration technique.

B. Focal Length by Camera Calibration:

The Focal length is an important parameter of a lens to be considered while doing the geometrical analysis of any lens. Hence the camera calibration is one of the best techniques to find the camera parameters [10]. Camera calibration is done by using the camera calibration tool in matlab which is a freeware tool available online [9].we feed the input images to the tool which gives the output as the parameter matrix and the focal length. Hence we get our required parameter focal length for our further calculations.

C. Input-output Pixel Mapping:

As discussed earlier finding the correct position of an input pixel is our aim. In the other hand for a given output pixel position we have to find a corresponding input pixel. To find out the value of the pixel at particular location of an output image from an input image is nothing but the input to output pixel mapping. After mapping the pixel now the undistorted pixels are in the correct position in an image. So it gives us an undistorted image. The distortion is in radial direction hence at the particular angle the proportion of the distortion will be the same. So angle theta is calculated by using the equation (2).

$$\theta = \frac{\text{atan(Correction Proportion)}}{\text{Correction Proportion}} \quad (2)$$

After Calculating theta we now calculate the corrected value of x location and y location using the following equations (3) and (4).

$$\text{SourceX} = \text{half width} + \text{Theta} * \text{newX} \quad (3)$$
$$\text{SourceY} = \text{half hieght} + \text{Theta} * \text{newY} \quad (4)$$

Getting the value of sourceX and sourceY we get the pixel value of old location that has to place in our new output location. This method of finding the output pixel value from the input pixel is nothing but the input-output pixel mapping.

III. RESULTS AND DISCUSSION

The above algorithm is applied to the fisheye images which maps the input pixel to the particular output pixel location. Fig.3 and Fig.4 are the input image and output image respectively. If we see the input image we have distortion in radial direction. The straight lines look like an oval line. We apply the algorithm to the input distorted image. We will get the output corrected image where distortion is reduced.

Fig. 3: Distorted Fisheye Image

Fig. 4: Undistorted Output Image

REFERENCES

[1] T. Y. Lee, T. S. Chang, C. H. Wei, S. H. Lai, K. C. Liu, and H. S. Wu, “Automatic distortion correction of endoscopic images captured with wide-angle zoom lens,” IEEE Trans. Biomed. Eng., vol. 60, no. 9, pp. 2603–2613, 2013.
[2] A. and M. D. N. (MDN), “A Flexible Architecture for Fisheye Correction in Automotive Rear-View Cameras,” Altera corporation, White paper, vol. 1, pp. 1–8, 2008.
[3] S. Bangadkar, P. Dhane, S. Nair, and K. Kutty, “Mapping matrix for perspective correction from fish eye distorted images,” in 2011 International Conference on Recent Trends in Information Technology (ICRTIT), 2011, pp. 1288–1292.
[4] S. Ai, X. Wang, M. Ma, and K. Wang, “A method for correcting non-linear geometric distortion in ultra-wide-angle imaging system,” Opt. - Int. J. Light Electron Opt., vol. 124, no. 24, pp. 7014–7021, Dec. 2013.
[5] B. Kun, H. Feifei, and W. Cheng, “An Image Correction Method of Fisheye Lens Based on Bilinear Interpolation,” in 2011 Fourth International Conference on Intelligent Computation Technology and Automation, 2011, pp. 428–431.
[6] H. Zhu, X. Wang, and C. Yi, “An elliptical function model for fisheye camera correction,” 2011 9th World Congr. Intell. Control Autom., no. 60875023, pp. 248–253, 2011.
[7] D. Claus and A. W. Fitzgibbon, “A Rational Function Lens Distortion Model for General Cameras,” in 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR’05), 2005, vol. 1, pp. 213–219.
[8] Olloclip iPhone Camera Lens System for iPhone 5 _ ThinkGeek – Macabolic http://www.macabolic.com/stores/thinkgeek/products/olloclip-iphone-camera-lens-system- for-iphone-5
[9] Camera Calibration Toolbox for Matlab http://in.mathworks.com/videos/camera-calibration-with-matlab-81233.html
[10] Steffen Urban , Jens Leitloff, Stefan Hinz, “Improved wide-angle, fisheye and omnidirectional camera calibration,” ISPRS Journal of Photogrammetry and Remote Sensing 108, June 2015, pp. 72–79