# Wide Angle Lens Distortion Correction To Have Wider Undistorted Field of View

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**Abstract -** *In today's imaging system Enhancement and improvisation has been developed wisely such a way that there is lots of scope to have better applications with the improved results. There are many applications such as Automobile system, surveillance system etc where the image improvisation and enhancement has wide scope. The Normal camera can capture image but with the smaller angle of view on the other hand if we use the fisheye lens camera then the view of the image is wider and have large FoV (Field of view). It gives the wider view but at the cost of distortion. So image captured by these cameras exhibits the distortion which creates problems in many applications such as object detection, surveillance, Automobile Systems. The methodology discussed in the proposed work will help to reduce such distortion occurred due to fisheye lenses so that FoV of the camera will increase.*

***Key Words***: **Fisheye, Field of View (FoV)**

## 1.INTRODUCTION

Different types of lenses used in cameras are available in market. They can be classifying as normal lenses, wide angle lenses and ultra-wide angle lenses. The area captured in an image is depending upon the lens or rather than we can say it is depend upon the focal length of the lens. Smaller the focal length larger the area captured by a camera. Wide angle lenses have smaller focal length than the normal lenses. Hence they capture larger field of view. There are many applications where now wide angle cameras have been used. The applications like Surveillances in security monitoring, rear view imaging in automobile industry, biomedical applications like endoscopy and surgeries[1], etc. But the problem with these lenses is that the image captured by these lenses creates radial distortion also called as barrel distortion. There are two types of distortions that are occurred due to wide angle lenses. One is radial distortion where the image is distorted in the radial direction, the straight line looking like a curvilinear due to this distortion. The corner part of an image is oval shaped. The second distortion is perspective distortion. The above distortion is also called as fisheye effect as its look like fish eye captured image in underwater. Hence most probably the wide angle lenses are developed to take underwater photographs.

These lenses fulfils the angle of view criteria compensating the radial distortion which is not acceptable in few application like rear-view automobiles imaging, object detection, and the radial distortion in an image confuses the viewer about the object details in many application. Even these images with the distortion don't look good for perception. Hence there is a need to remove this distortion in an image and make image distortion free. The technique or the method to remove such distortion is called as fisheye correction.

**Fig- 1**: Normal lens Camera Image[8]

**Fig- 2:** Fisheye Lens camera Image[8]

The proposed work emphasizes the factor field of view to be maximum with the fisheye lens minimizing the radial distortion. The paper comprises of few section to elaborate the proposed work in detail. Section II comprises of Literature survey regarding the proposed topic and summaries the available product and technologies. Section III consists of geometry of a fisheye lens and the geometrical analysis of fisheye images. Section III elaborates the algorithm and the methodology used to proceed for the distortion correction. Section IV has results and discussions. And finally section V concludes the proposed work.

## 2. LITERATURE SURVEY

There is some work done on the proposed topic. 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. The white paper published by Altera Corporation M.D.N [2] proposed a novel approach to 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 crossratio 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. There are some existing applications on proposed topic like the fisheye and also defisheye features in Photoshop. Geometrical Analysis

Geometrical analysis of an image is important to understand the distortion in an image. Once the geometry behind the distortion is cleared then the way toward the correction also clears. Here in this chapter we will see the geometrical analysis of lens and its effect on an image is discussed. Which clears the visualization of an proposed work and clarifies the objective of an algorithm.

Fig- 3 shows the block diagram of fisheye image correction system. Fisheye distorted image is gone through geometrical analysis after which we have input to output pixel mapping. After mapping the distorted pixel to undistorted pixel we get the undistorted correct image. I the following subsections we have discussion on the geometrical analysis and pixel mapping

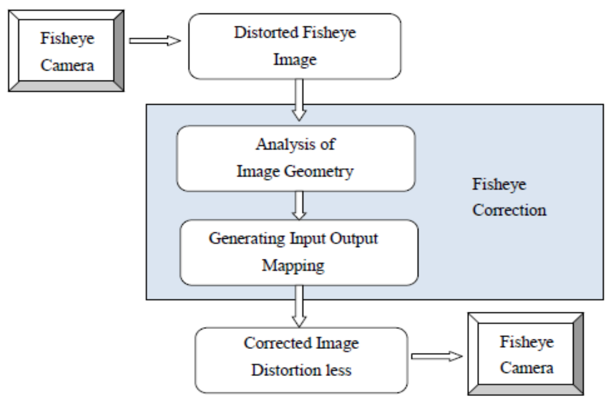


**Fig- 3:** Block diagram for the Fisheye Correction System

### 2.1 Fisheye Lens Projection Model

The fisheye lens camera model is different from the normal lens camera model. The projection of the normal camera model is equidistant but the projection of Fisheye lens camera model is like orthogonal. Hence the image captured by the fisheye lens camera has distortion in the radial direction. As we move away from the center the distortion is increases. The Figure 3 shows the fisheye camera projection model[6]. The fisheye camera image is like a projection of circular line on the straight line having same length. If we take the horizontal projection of hemisphere it looks like the circle. But information in hemisphere is more than the circle. Hence central part which has more exposure



is less distorted whereas the radial distant part has larger distortion compared to the center part. In fact from the above understanding we can say that the distortion is increases radial.

### 2.2 Algoritm 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).

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

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

### 2.3 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.

### 2.4 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).

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

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

$$SourceX = half\ width\ + Theta * newX \quad (3)$$

$$SourceY = half\ hieght\ + Theta * newY \quad (4)$$

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.

## 3.RESULTS AND DISCUSSION

The above algorithm is applied to the fisheye images which maps the input pixel to the particular output pixel location. Fig -5 and Fig -6 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 a oval line. We apply the algorithm to the input distorted image. We will get the output corrected image where distortion is reduced.

**Fig -5:** Distorted Fisheye Image

**Fig -6:** Undistorted Output Image

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