

New Improved Circular -Radial Method for Correction of Misrepresentation in Endoscope Medical Images



R.Sathiya, R.KalaiMagal

Abstract: Endoscope Medical Images are distress from a spatial misrepresentation due to the wide-angle nature of the endoscope's neutral lens. This change in the size of objects with position prevents numerical measurement of the area of the objects, which is important in endoscopy for accurately measuring sore and wound sizes over time. A method for correcting the misrepresentation characteristic of endoscope images is presented. Circular -Radial correction formula was developed for the endoscope lens and validated by comparing quantitative test areas before and after the misrepresentation correction. The misrepresentation correction has been incorporated into a computer program that could readily be applied to electronic images obtained at endoscopy using a desktop computer. The research presented here is a key step towards the quantitative determination of the area of regions of interest in endoscopy. In this paper, a model for correction of misrepresentation in endoscope image is proposed. The definition of optical misrepresentation is described briefly and the theory of correction of misrepresentation using Circular Radial consisting of solid circles is presented. Three steps are used for correction, including pre-processing of grid image, correction of spatial misrepresentation and reconstruction of gray level. Finally, the corrected results are given to demonstrate the performance and validity of correction algorithm with standard calibration grid.

- Circular -Radial correction formula was developed for the endoscope lens and validated by comparing quantitative test areas before and after the misrepresentation correction.
- The research presented here is a key step towards the quantitative determination of the area of regions of interest in endoscopy.
- Finally, the corrected results are given to demonstrate the performance and validity of correction algorithm with standard calibration grid.

Key Words: Endoscopy, IGS, Circular Radial Correction, Distortion.

Table 1.1: Specification Table

| | |
|---------------------------------------|---|
| Subject Area | Computer Science |
| More specific subject area | Image Processing |
| Method name | Circular Radial Basis Function in Endoscopy |
| Name and reference of original method | 1) An Exact Formula for Calculating Inverse Radial Lens Distortions Pierre Drap ^{†*} and Julien Lefèvre [†] 2) Smith, W., Vakil, N., & Maislin, S. (1992). Correction of distortion in endoscope images. IEEE Transactions on Medical Imaging, 1992;11(1),117-122. |
| Resource availability | Open Source Software |

I. INTRODUCTION

Medical electronic endoscopes are widely applied to the image-guided surgery (IGS) [1-3]. Medical endoscopes mainly combine a spherical lens with a miniature charge-coupled device (CCD). There are two types of endoscopes used in clinical operation: the forward viewing endoscopes and the implied viewing endoscopes [4]. In minimally invasive surgical procedures, the endoscopic captures the images of the interesting surgical region of inner body from tiny incisions (typically 5-10 mm) or natural orifices of body.

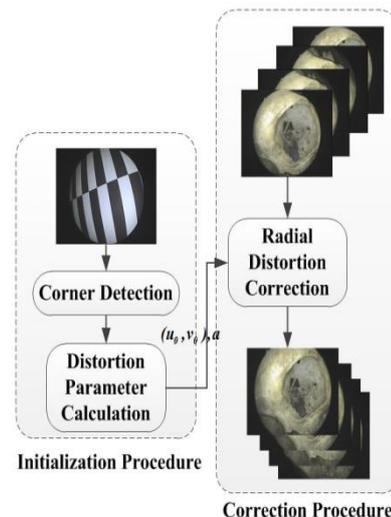


Fig1: Procedure for Radial distortion Correction

However, radial distortion is a fundamental limitation of endoscopes because of the small size of wide-eye lenses.

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*Correspondence Author(s)

Mrs.R.Sathiya, Research Scholar in Computer Science, Research & Development Centre, Bharathiyar University, Coimbatore

Dr.R.KalaiMagal, Associate Professor in Computer Science, Government Arts College for Men (Autonomous), Nandhanam, Chennai.

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The radial distortion causes a geometric nonlinear a change in form of the image, with the points being moved radially toward the center [5]. The distorted images do not meet the usual observation manner of the physicians. Therefore, the problem of radial distortion correction has become to be solved in the clinical application of the medical electronic endoscopes [6,7]. So far, the method can estimate the position of the distortion center according to the relative movement of camera and optics. In general position to estimate the real parameters and distortion coefficient and derives a formula to describe the relationship between the distortion parameter, focal length, and image edge. And the formula can estimate the focal length for a zoom able lens from endoscopic images on-line and reach real-time lens distortion correction.

1.1.1 ABOUT ENDOSCOPY MEDICAL IMAGE

An **endoscopy** (*looking inside*) is used in medicine to look inside the body.^[1] The endoscopy procedure uses an endoscope to examine the interior of a hollow organ or cavity of the body. Unlike many other medical imaging techniques, endoscopes are inserted directly into the organ.

There are many types of endoscopes. Depending on the site in the body and type of process an endoscopy may be performed either by a doctor or a surgeon. A patient may be fully aware of or anaesthetized during the procedure. Most often the term *endoscopy* is used to refer to an examination of the upper part of the gastrointestinal tract, known as an esophago-gastro duod-enoscopy.^[2]

Endoscopy may be used to examine symptoms in the digestive system including nausea, vomiting, abdominal pain, difficulty swallowing, and gastrointestinal bleeding.^[4] It is also used in diagnosis, most commonly by performing a biopsy to check for conditions such as anemia, bleeding, swelling, and cancers of the digestive system.^[4] The procedure may also be used for treatment such as cauterization of a bleeding vessel, widening a narrow esophagus, clipping off a polyp or removing a foreign object.^[4]

II. DIFFERENT CORRECTION METHODS FOR DISTORTION IN MEDICAL IMAGES FROM ENDOSCOPY

Barrel-type distortions are typical to endoscopic images. The reason for this is the optics used in endoscope devices. In endoscopy it is usually valuable to have a wide field-of-view (FOV) in order to be able to review as much as possible without the necessity of continuously adjusting the direction of the tip of the endoscope. But the enlarged visible area comes at the price of obvious distortions, especially at very wide FOV values as commonly used in endoscopes (typical values range from 100° to 170°).

In addition, the level of distortion is also dependent on the distance of the endoscope to the tissue in focus. Since endoscopes usually have a very short focal depth (a few millimeters only), barrel-type distortions get even more amplified. While moving the endoscope farther away from the tissue of interest would theoretically help to reduce the barrel-type distortions, the resulting images most likely will be out of focus since endoscopes usually also having a very narrow depth of field (i.e. the range before and after the focal plane inside which objects appear sharp). Hence, depending on the FOV and the focal depth, barrel type distortions may vary significantly in strength between the

CoD (which corresponds to the optical axis) and the outer regions of an image (i.e. the image magnification decreases with the distance to the CoD). Fig. 2 shows how the distance to the CoD affects the distortion in FOV. While the object area imaged by the angular segment pointing toward the CoD is biased, we notice that the angular slice farther away from the CoD covers a much wider object area. In other words, the object magnification is much higher in the vicinity of the CoD as compared to outer image areas. An example for barrel-type distortions is shown in

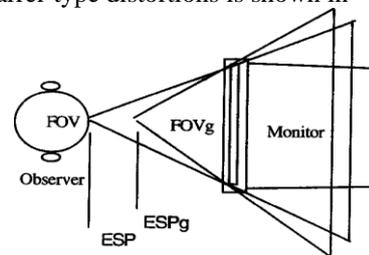


Fig. 2 – Illustration of the differently large object areas are imaged within two angular slices of equal angular width

1.2.1 Correction of barrel-type distortions:

The correction of barrel-type distortions consists of two integral parts, which impression the arrival of the distortion-corrected images: the distortion correction method and the insertion of missing information, once the distortion has been estimated correctly. 4.1. Distortion correction Barrel-type distortions are radial distortions. That is, by ignore possible small non-radial defects in the optical system, the lenses in question show rotational regularity. As a repercussion distortion correction usually consists of two steps: first, based on one or more distorted images, the camera parameters (intrinsic and extrinsic, including the CoD) and the parameters for the assumed radial distortion model are estimated. Then, according to the parameters found, the distortion is corrected by applying a pincushion distortion, which is the inverse to the barrel-type distortion and therefore exhibits rotational symmetry too.

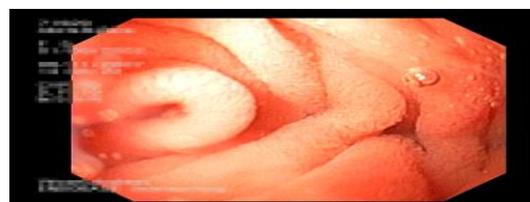
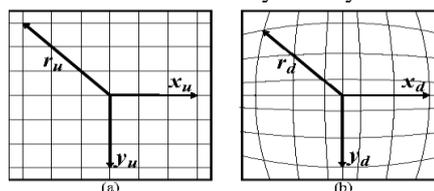


Fig. 3(a) – An example for barrel-type distortions captured with an endoscope
3(b) & (c) – Result of the different distortion correction methods.

1.3 Circular Radial Basis Function

Image registration based on landmarks and circular radial basis functions (e.g. thin plates lines) results in global changes and deformation spreads over the entire resample image. Circular Radial Basis Function (CRBF) is a real-valued function whose value depends only on the distance from two points in multi-dimensional space. One of these points is called the center, which could be the origin or alternatively some other point in this space. RBF interpolation is one of the primary methods to analyze multi-dimensional scattered data. Its abilities to generalize arbitrary space dimensions and to provide spectral accuracy have made it particular popular in different types of applications. Some of the applications include function approximation, numerical solutions of partial differential equations, computer vision and neural networks, etc.

1.4 Identifying Distortion and Remove it using Radial Basis Function

Images formed with endoscopes suffer from a spatial distortion due to the wide-angle nature of the endoscope's objective lens. This change in the size of objects with position precludes quantitative measurement of the area of the objects, which is important in endoscopy for accurately measuring ulcer and lesion sizes over time. A method for correcting the distortion characteristic of endoscope images is presented. A correction model assuming circularly symmetric distortion is introduced with the following model parameters: the centre of distortion and the coefficients of polynomials representing the distortion correction in the radial direction. If the imaging system is distortion-free, straight lines in the object space should be imaged as straight lines.

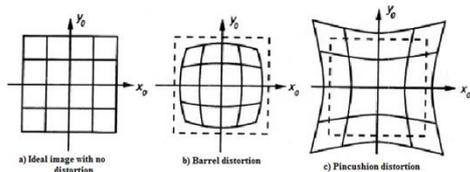


Fig4: Radial Distortion

1.5 Performance Evaluation and Comparison between Circular Radial Basis Function with other Methods.

| Author | Year | Methodology | Findings | Parameter |
|---|------|---|-----------------------|---|
| --Warren E. Smith et al., ¹⁵ | 1992 | Distortion Correction Algorithm | Distortion correction | Distortion Areas Mean – 0.1898cm ² Standard Deviation – 0.0068 cm ² No Distortion Areas Straight Line of Constant Area = 0.1963 cm ² . |
| K. Vijayan Asari et al., ¹⁶ | 1999 | Least Squares Estimation-Based Approach | Distortion correction | Avg. Mean Error Before Distortion Correction – 1.35 Avg. Mean Error after Distortion Correction – |

| | | | | |
|--|------|--|---|---|
| | | | | 0.28 |
| James P. Helferty et al., ¹⁸ | 2001 | Distortion-Correction Technique (DCT) based on least square approach | Distortion Correction | Average Error – 0.0729 Standard Deviation Error – 0.003 Maximum Error – 0.261 |
| Isabel N. Figueiredo et. al., ¹²¹ | 2017 | The Image Registration Approach | bleeding identification in small bowel images | Qualitatively measured |

III. RESULT AND DISCUSSION

Based on this criterion, a distorted image of a level pattern consisting of a grid of several straight lines is recorded, and the model parameters are then estimated as a basis for straightening distorted lines. This method has the advantage of not needing a careful placement of the standard pattern for calibration. Correction results are presented for the grid pattern chart to verify a sufficient degree of correction. A polynomial correction formula was developed for the endoscope lens and validated by comparing quantitative test areas before and after the distortion correction. The distortion correction has been incorporated into a computer program that could quickly be applied to electronic images obtained at endoscopy using a desk-top computer.

The work presented in [5] examined the impression of distortions and interpolation artifacts caused by distortion correction methods on the precision of a classification of celiac disease images. The clear outcome was that there is certainly an antagonism impact of barrel-type distortions on the classification accuracy. Moreover, this negative effect gets more outward the farther away from the Center of Distortion (CoD) features are taking out. But it has also been shown that this also accounts to distortion corrected images due to interpolation artifacts. The bottom-line result of all four studies was that the interpolation artifacts caused by the distortion correction are very likely one reason why the classification results have not been improved.

IV. CONCLUSION.

This paper take the role of several approaches used for analyzing the medical images to extract the important features that are useful to classify the images as well as guide toward diagnostic resolutions. This paper also discussed the issues related with pre-processing, quality extraction and classification of images. To further a more thorough investigation of the effect of distortion correction on the accuracy of an robot diagnosis of celiac disease, the present work compares four different distortion correction methods. In addition, this work is the first study which also contrast circular radius function using various different interpolation methods used for distortion correction.



To be able to make solid statements about the usability of the different distortion correction methods in the context of endoscopic image classification, they use various different feature extraction methods, which are evaluated on distortion corrected images.

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