A warping based approach to correct distortions in endoscopic images

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***Abstract*—This work proposes a technique to correct distortions in endoscopic medical images using concepts of morphing and warping. A triangular mesh is used to apply transformations in each region of the image separately. A chess pattern is used to verify the distortion of the endoscopic system. The same pattern is used to generate the mesh and the equations for the transformations of the warping and morphing step. After the computation of each triangle affine transformations the same equations are used to correct the real endoscopic images.**

***Keywords*-Endoscopic Image; Automatic Warping; Visual Computer;**

I. Introduction

The Endoscopy is a method of investigating diseases of the esophagus, stomach and intestines through oral or nasal introduction of a flexible tube (endoscope). This turns possible visualize the mucosa (internal lining) of the digestive tract, collect material and even perform minor surgery [1]. Endoscopic images can present some distortion due to the lens used [2]. This distortion affects the diagnosis. However many works considers the acquisition correction [2], [3] and [4], no works use warping technique. This work proposes a technique to correct this distortion based in automatics warping technique.

II. Automatic Warping Techniques

The warping based in mesh is characterized to transform a triangle in another triangle in a target position different in the image, using an affine transformation to it [5]. In this work the warping techniques is used automatically to correct the distortion endoscopic image.

To developer this method was create an image in chess pattern limited for a circle to be acquired by endoscope system (Figure 1) to see the difference between then (Figure 2).

The method can't just take the pixels of an image to another by simply copying as this would cause a discontinuity in the image, resulting in problems like having pixels in the target image without a value of color and pixels with multiple values of colors.

In the case of an expansion has the problem of providing values for pixels that were not corresponded in the mesh of destiny. And in the case of contraction, there is the problem of multiple pixels being aggregated in the same region, so we must use some method to choose the final value of the color pixel.

In this work these problems were solved by applying a magnification in the acquired image, resampling four times the image size, before applying the changes and the color values of each pixel is defined as an arithmetic mean between the possible values.

The pattern used is adequate to a triangular mesh, because of the squares that form the image and is adequate to capture by endoscope system because is limited by a circle. The implementation uses the designed pattern and the pattern acquired by the endoscope system to create two meshes that can be seen in the Figure 3. The triangular meshes created are adequate to generate the equations for apply the affine transformations to each triangle in the mesh.

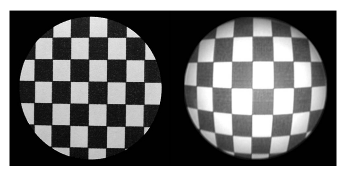

Figure 1. Chess pattern created (left) and the pattern acquired by endoscope system (right)

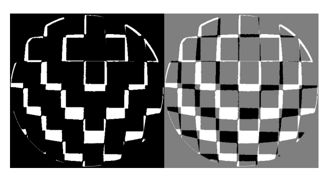

Figure 2. Binarized distorted image minus binarized pattern chess (left), and the same after rescale them to [0, 255] (right).

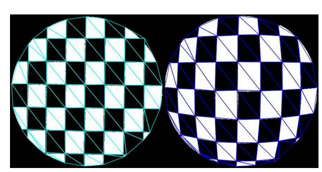

Figure 3. Mesh in the chess pattern image (left) and the mesh in the pattern image acquered by endoscope system (right)

Having mapped the two meshes, the next step is to define linear equations that transform the coordinates of the vertices of a triangle on the distorted image corresponding to the vertices of the triangle in the pattern image, calculating for all triangle of the mesh. This affine transformation of the coordinates of a triangle in another can be understood as a multiplication of matrix of the type:

$$\begin{bmatrix} w_x \\ w_y \end{bmatrix} = \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix} \cdot \begin{bmatrix} v_x \\ v_y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

Where w_i represents the pixels of the pattern image, v_i represent the distorted chess, m_{ij} is responsible for transformation of position of pixels in the original image and t_i represents the translation of the pixels, where m_{ij} and t_i are unique and different for each of the triangles of the mesh. Developing the matrix operations for each triangle, has the following equations:

$$\begin{aligned} w_{1x} &= m_{11}.v_{1x} + m_{12}.v_{1y} + t_x \\ w_{1y} &= m_{21}.v_{1x} + m_{22}.v_{1y} + t_y \\ w_{2x} &= m_{11}.v_{2x} + m_{12}.v_{2y} + t_x \\ w_{2x} &= m_{21}.v_{2x} + m_{22}.v_{2y} + t_y \\ w_{3x} &= m_{11}.v_{3x} + m_{12}.v_{3y} + t_x \\ w_{3x} &= m_{21}.v_{3x} + m_{22}.v_{3y} + t_y \end{aligned}$$

The system get the values of the vertices of triangles from the mesh that was designed, therefore, the values of w_1, w_2, w_3, v_1, v_2 and v_3 are known both in coordinates *x* and in *y*, remaining only the variables: m_{11}, m_{12}, m_{21}, m_{22}, t_x and t_y to find the value.

In this work the values for the m_{ij} and t_i were found solving a linear system with the six equations generated previously, using the method of Gauss. With this matrix responsible for transforming the vertices of the triangle, apply it in all the pixels inside the triangle. The system makes this for each triangle with its corresponding matrix. After the system diminish some of the edge pixels to maintain the circularity, since the region of interest is located in the center of the image.

III. Results

After determination of all m_{ij} and t_i for each triangle and the use this for correct the pixels gray level inside the mesh, we achieve the results on Figure 4 (letf). The efficiency of the method can be seen when a processed image is subtracted of the pattern (Figure 4 right). In the circular limit, the approximation caused for the use of lines not curves are more evident. This justify the amount of error on this position. Figure 5 shows real image of an endoscopy before and after processed by this technique. More results can be seen and the executable software can be try in [6].

IV. Conclusion and Future Works

The great advantage of this technique is that can to create several triangular regions in an image and warp each region of a different way and it provide a much freedom to handle the image.

As can be seen the technique developed applied in the chess pattern acquired by endoscope result in a image fairly close the original pattern with respect to topology. To improve the results using this method of warping can refine the mesh further, building smaller triangles and based on other standards than chess.

As future work we can handle the extra lighting in the image caused by light source coupled to camera and try to optimize the algorithm to be applied directly in videos and in real time during an examination.

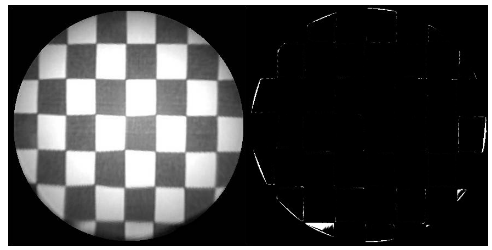

Figure 4. Result of application of the distorted image of chess (left) and the binary subtraction: distorted image processed minus chess pattern (right) using linear equations

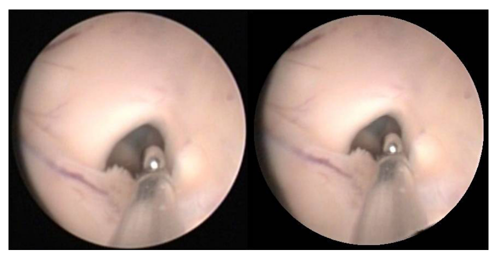

Figure 5. Real image of an examination of endoscopy before (left) and after (right) processed using linear equations

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