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A Novel Method for Measuring, Regardless of Image Distortion and Lens Varying Specifications in Endoscopic Treatment of Vesicoureteral Reflux

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Physicians need to know the exact size of objects or measure the distance between two landmarks, not only for the diagnosis and staging the disease but also for prognostication.

When we were working on numerical simulation of vesicouretral reflux in children, we found that the diameter of ureter opening in the urinary bladder was a determinant of the pathogenesis of the disease.

Over the past decade, endoscopic correction has become increasingly popular for treatment of vesicoureteral reflux [1]. To optimize performance of this procedure, the physician should know the amount of the injected gel and the height of the projection caused by the injection [2].

Distortion is a major problem in most images taken by endoscopy camera. It is therefore, necessary to eliminate this distortion before any measurements made [3]. In most cases, lack of a reliable software installed on a suitable computer and the associated high expenses, are a huge impediment. Elimination of this distortion is a time-consuming process depending mostly on the lens. This means that one should specify the distortion before the preprocessing phase [4]. In this technical note we introduce a novel method to measure the specified height. The privilege of this method is that it does not require any digital image processing for its measurement.

In order to guesstimate the size of an object in front of the lens, we should know the exact situation of the object. This situation may be determined using the position vector of the camera and the angles it made with the coordination axes. We defined a standard Cartesian coordination system (X, Y, Z) as shown in Figure 1, to locate the situation of lens, the main object and its image.

In this system, *W* represents the object in front of the camera (Fig. 1), and *c* represents the object image on the camera. Assume that the camera has a coordination of (X_0, Y_0, Z_0) and a location vector of W_0 (Fig. 1). Assume that *r* is the location vector of the image, in respect to the camera sill. α and θ are angles between the camera axis and the X and Y axis, respectively; (X, Y, Z) is the coordinate of the plate where the image is created. Now, if we want to derive a relationship between the object location, image location and the introduced space, say when an endoscopy lens is inserted into an organ, we should consider various things to compute the size of a specified object and to do so four vec-

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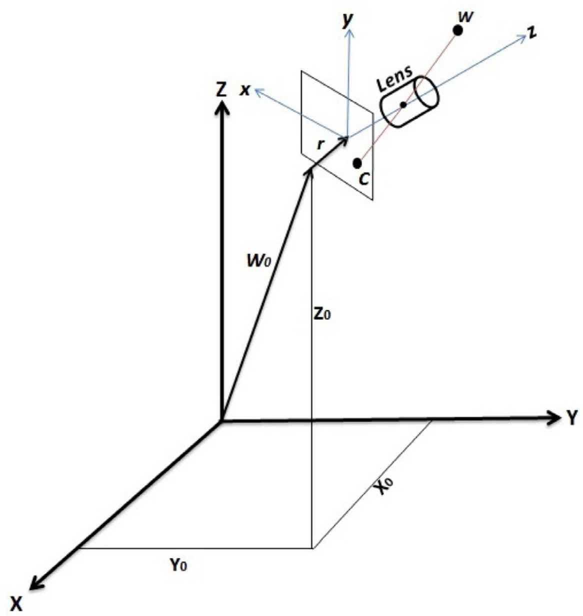

Figure 1: The standard Cartesian coordination system, for observer, lens and image location

tors should be modified: 1) the displacement vector of the camera sill center; 2) horizontal rotation around the X axis; 3) vertical rotation around the Z axis; and 4) displacement of the image plate in respect to the camera sill.

After computing the relationship between the image plate and the current standard space, we will get to the following equations:

$$x = \frac{\beta(X - X_0)\cos\theta + (Y - Y_0)\sin\theta}{-(X - X_0)\sin\theta\sin\alpha + (Y - Y_0)\cos\theta\sin\alpha - (Z - Z_0)\cos\alpha + \beta} \quad (1)$$

$$y = \frac{-\beta(X - X_0)\sin\theta\cos\alpha + (Y - Y_0)\cos\theta\cos\alpha + (Z - Z_0)\sin\alpha}{-(X - X_0)\sin\theta\sin\alpha + (Y - Y_0)\cos\theta\sin\alpha - (Z - Z_0)\cos\alpha + \beta} \quad (2)$$

when (X, Y) designates the coordinates of the image plate in the introduced space for the camera and the object in front of it. In the above two equations, is the distance between the lens and the image. Determining all the above parameters is not simple and sometimes it is even impossible. So we had better to simplify the equations as much as possible. α and θ are the camera axis angle with respect to X and Y axes, respectively. One can decrease these angles to zero by moving camera axis on Z axis. β is the lens distance from the image, which is constant for each camera. Now, to simplify the computations, we move the image plate on the (X, Y) plate to change (X_0, Y_0, Z_0) and the ***r*** vector to zero. So x and y can be computed through the following equations:

$$x = \frac{\beta X}{\beta - Z} \quad (3)$$

$$y = \frac{\beta Y}{\beta - Z} \quad (4)$$

In the above equations, Z is the distance between the object and its image. We can use the needles that have been inserted to the tissue and the lens to measure Z or to make it constant (Fig. 2).

To compute any of the x and y, we can measure one while the other is supposed to be zero (Fig 2). For example, to measure x while y is zero, considering the similarity of triangles we will have:

$$\frac{h'}{h} = \frac{\beta}{\beta - Z} \quad (5)$$

when h' is the image size on the screen which is accessible; h is the real height of the object. This measurement is not affected by distortion and lens type and thus, it is applicable for any lens type and distortion.

In this project we used cystoscopy system of Namazi Hospital which has the following specifications:

Lens: R.WOLF 0˚8616.411 CE0124 COMPACT FIBROCYSTO-URETHEROSCOPE 6/7.5 Fr.

Screen Monitor: SEC-21Q-8 DOUBLE QUAD AC 110-245V50/60 Hz 90W 21”

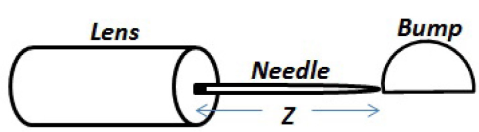

Figure 2: Using a deflux needle to make the distance between object and lens constant

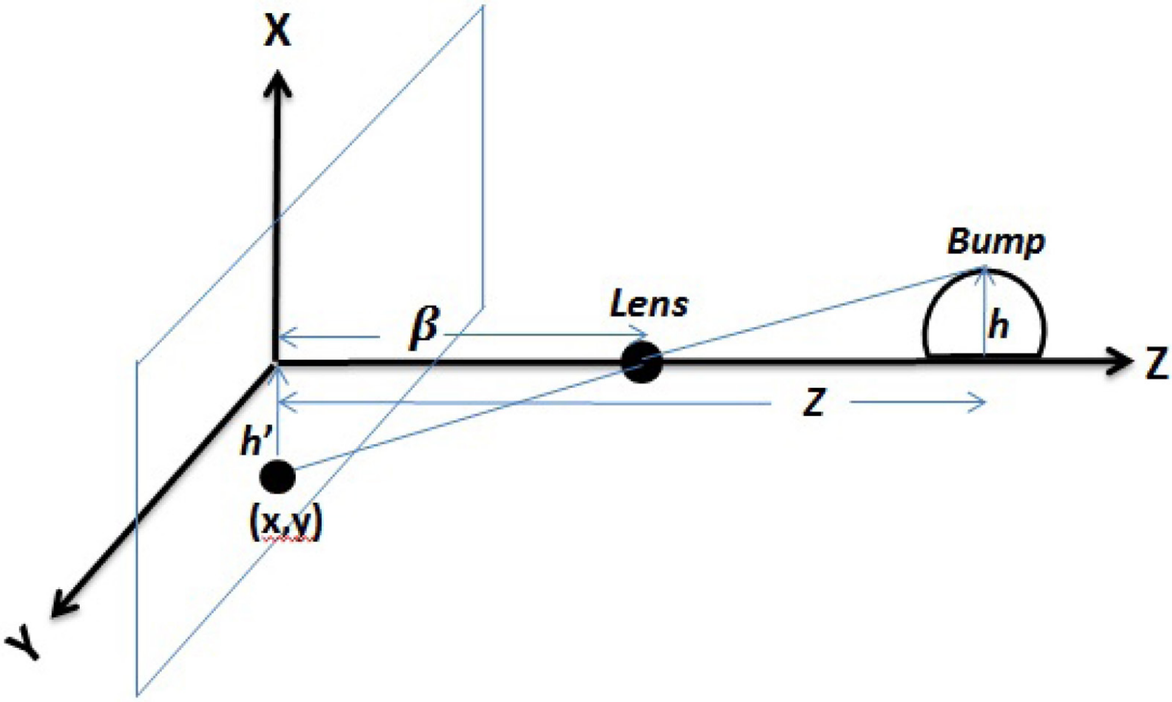

Figure 3: The lens, object and image space (the distance between lens and the image is constant for each lens)

Needle: Deflux Metal Needle 3.7 FR×23 G(tip)×350 mm ART No. 10-35811

The needle had a sign 6 mm away from its tip. By putting the needle on the object of interest (a tissue) and signing the needle in front of the lens we can make the space between the lens and the object constant. Considering the fact that the relationship between magnification, distortion, and the object distance from the lens, is not linear, the magnification rate should be computed for each distance separately. This means that by putting the object with a known height at an exact distance of six mm in front of the lens and measuring the object size on the monitor, the h'/h ratio can be computed. For the lens with the above specifications and in 6 mm distance, the ratio is found to be 10. Having computed this ratio, one can easily compute the object size by measuring the image size on the monitor.

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