Determine the Best Mathematical Model for the Camera Viewing Angle as a Function of Object Distance

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Abstract

In present paper a mathematical model to determine the view angle of a camera as a function of object distance for each zoom number where the fitting curves for the practical data of the view angle($\theta_{height}, \theta_{width}$) in the image plane which constant in the all object distances (D) for each camera zoom number. Then find the mathematical modeling equation that relates view angle, real distance (D) and camera zoom number (Z) to estimate height and width for the view angle. A graph between view angle and distance (D) to the theoretical and practical results has been tabulated and there was a very good similarity between them and close to the real measurements.

Key words:
View angle, focal length, resolution, mathematical model

1.1 Introduction

Cameras are light-tight boxes that admit controlled light only through a lens, creating a series of individual frames as film is moved into place behind the lens. The film is held steady during exposure, and then advanced. Conceptually, motion picture cameras haven't changed for more than a century [1].

In this research, have been estimate the best mathematical model for the camera viewing angle based on the relation between the object distance (D), and the zoom number (Z).

Many Researchers have studied the possibility of determining view angle camera and used the techniques of variety physical foundations. Here are some of these studies addressed this issue:

Wei Huang Judith S. Olson" Camera angle affects dominance in video-mediated communication”2002, Physical proximity and appearance guide people to interact with each other in different ways [2].

Tom ´as Gonzalez Sanchez, “Artificial Vision in the Nao Humanoid Robot”, 2009, study some fundamental issues for the artificial vision in the Nao humanoid robots. In particular, color representation models, real-time segmentation techniques, of object detection. Also, Nao’s camera model, mathematical robot kinematic and stereo-vision techniques are studied and developed. Then study the integration between kinematic model and robot perception model to perform Robocop soccer games and Robocop technical challenges [3].

Yinqiang Zheng, Shigeki Sugimoto, Imari Sato, Masatoshi Okutomi, “A General and Simple Method for Camera Pose and Focal Length Determination”, 2014,they have to revisit the pose determination problem of a partially calibrated camera with unknown focal length [4].

2.1 Visual Resolution

Lenses are identified by their focal length in millimeters and maximum aperture in f-stops. The focal length is defined as the distance from the optical center of the lens to the film plane. The f-stop is calculated from the dimensions of the lens. Focal length and angle of view. The focal length of a lens determines the angle of view, or perspective, seen through the lens. Normal lenses provide respective that approximates human vision. Lenses that are shorter than normal provide a wider angle of view—they are wide-angle lenses. Lenses that are longer than normal provide a narrower point of view and magnify the subject—they are telephoto lenses. Wide-angle lenses make background objects appear further away; telephoto lenses compress distance and make the background appear closer. Thus, move the camera toward a subject results in a look that is very deferent from a scene captured by zooming the lens from a stationary camera position. The apparent separation from the background, making objects relatively smaller, makes camera movement less notice able. Thus, using wider lenses for hand-held scenes is preferable [5, 6].

The ideal optimum viewing distance is affected by the horizontal angle viewed by the camera capturing the image. One concept of an ideal optimal viewing distance places the viewer at a point where the horizontal angle subtended by the screen is the same as the horizontal angle captured by the camera. If this is the case, the angular relationships perceived by the viewer of objects viewed on the screen would be identical to the angular relationships viewed by the camera [7].

4.1 The Practical part

A digital cannon camera (power shot A800 and IXUS digital compact camera, 2011), that shown in fig. (1), with technical specifications tabulated in table 1, has been used in this study [8].

fig.(1): Cannon camera (power shot A800 and IXUS digital compact camera) [9]

Table 1: Technical specification of cannon camera [9]

Optical zoom	3.3x optical zoom, 6.6–21.6mm (35mm equivalent: 37–122 mm), f/3.0-5.8
Resolution	10.0Mp
Sensor type , size	CCD , 1/2.3in
Max image size	3648 x 2736
Focusing system , points, ,distance	TTL, AiAF (Face Detection / 5-point), 1-point AF (fixed centre), 1cm (W) from front of lens in macro
ISO sensitivity	ISO100 – 1600
Monitor	2.5in TFT, approx. 115,000 dots

First the object (picture) shown in fig. (2) is placed in front of the camera (i.e. the geometry of the scene sets object plane parallel to the image plane), for each camera zoom number (7, 8, 10, 12, 15 and 22) images have been captured for this object (with 10 Megapixels size) at different distances started from 1 m (a common distance to all zoom because at high zoom the object appears totally in captured image plane at the distance equal to or greater than 1 m) the distance range (D= 1 m to10 m) with changing step of 1m. Then measuring object's length in pixels (picture's height) for each image using a Matlab program that has been built for this purpose and this is performed to determine the length between two ends of the object (picture) manually using computer mouse.

L_r = 13.5

fig.(2): The image of object (picture)

Scaling factor (scf) can be computed for each image according to the following relationship:

$$scale\ factor = \frac{L_P}{L_r} \ldots\ldots\ldots.(1)$$

Where $L_{P:}$ object's length in pixel; L_r: object distance in centimeter.

Then can be used resulted scf from equation (1) to compute the horizontal and vertical viewing angle see fig.(3) for each captured image (i.e. images that captured at different zoom number) use follows:

$$H = scf * I_h \ldots\ldots.(2)$$

$$W = scf * I_w \ldots\ldots(3)$$

Where *H* and *W* were represent the height and width of the image plane in meter.

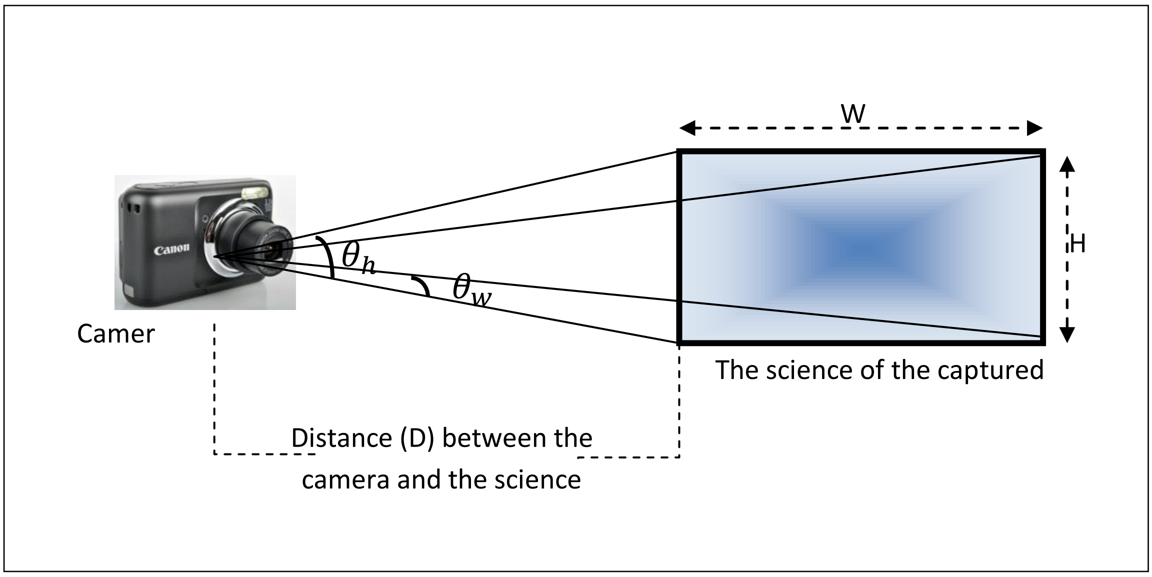

fig. (3): vertical and horizontal camera view angles (θ_H and θ_W

So can be calculating the viewing angle for the two dimensions (θ_H *and* θ_W) by using the following equations:

$$\theta_H = 2 * tan^{-1}\left(\frac{H}{D}\right) \dots\dots\dots\dots (4)$$

$$\theta_W = 2 * tan^{-1}\left(\frac{W}{D}\right) \dots\dots\dots (5)$$

Where D represent the distance between the camera and the object.

5.1 The Results

A chart between distance (D (m)) and height view angle camera (θ_H) has been plotted for each zoom number (Z) as shown in fig. (3).

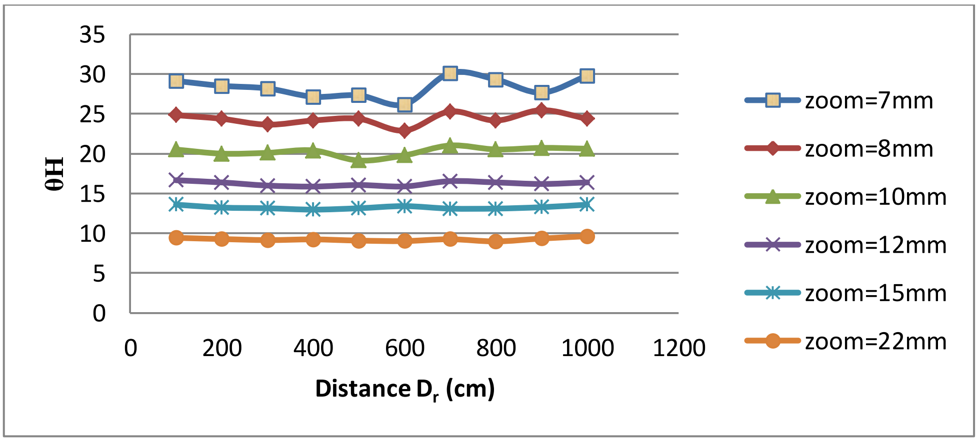

fig. (4): The relation between distance (D) and the height view angle (θ_H)

From this chart can be show that the relationship between the distance (D =100 to 1000(cm) and height view angle (θ_H)for each zoom number (Z (mm)), has been observed that the height view angles almost constant for all distances at each zoom in to linear relationship between the height view angle and distance at every Zoom.

A chart between distance (D (cm)) and width view angle camera (θ_w) has been plotted for each zoom number (Z) as shown in fig.

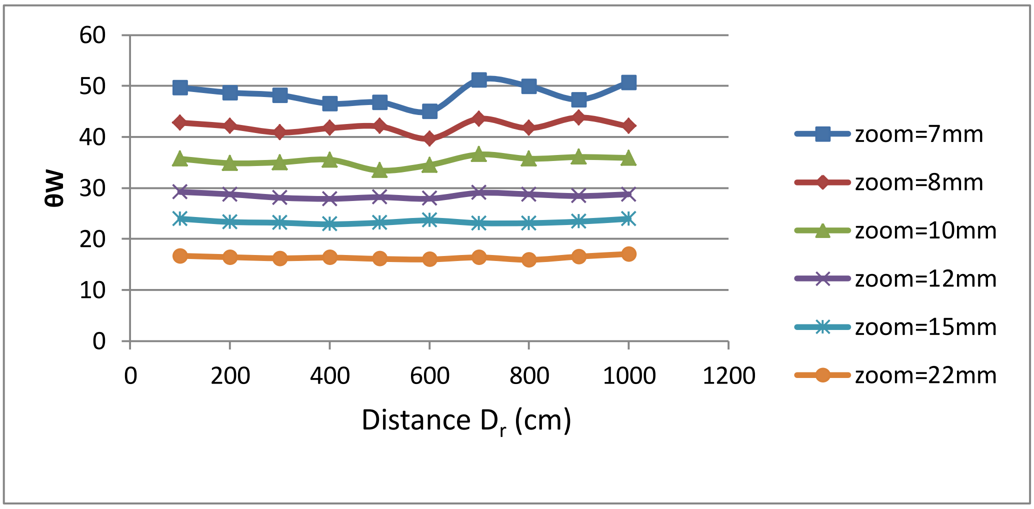

fig.(5): The relation between distance (cm) and width view angle (θ_w)

This chart shows the relationship between the distance (D =100 to 1000(cm)) and width view angle (θ_w)for each zoom number (Z), has been observed that width view angles almost constant for all distances at each zoom number in to linear relationship between the height view angle and distance at all zoom number (Z).

- A chart between distance (D (cm)) and the ratio between height view angle (θ_h) and width view angle (θ_w) has been plotted for all zoom number (Z) as shown in fig.(6).

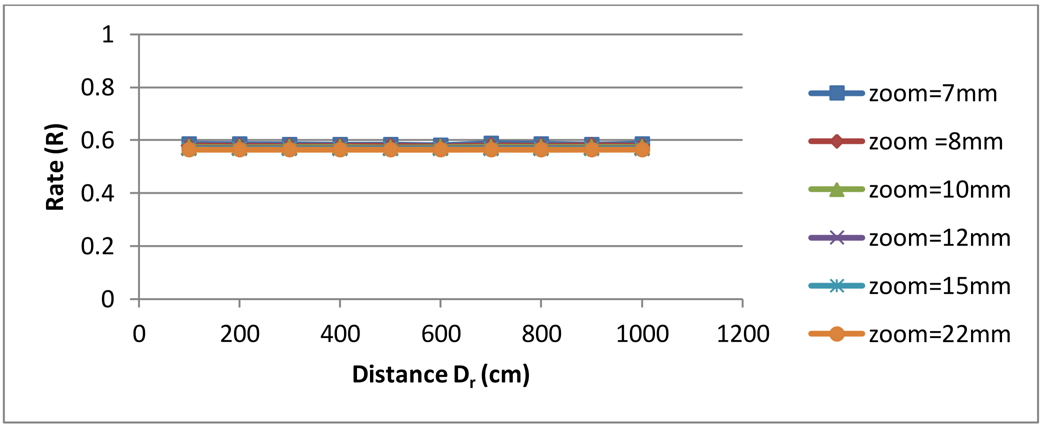

fig.(6): The relation between distance (D) and rate (R)

This chart shows the relationship between the distance and the ratio between height and width view angles of to the number of distances (R); it was observed that this ratio nearly constant for all the different distance also at different zooms.

6.1 Conclusions

Estimate mathematical model to calculate the viewing angles $(\theta_h, \theta_w)$of the camera.

$$\theta_H = K_H * D......(6)$$

$$\theta_W = K_W * D......(7)$$

Where K_H and K_W are constant

A mathematical model that is based on object's dimensions (D) to estimate (horizontal and vertical view angles) has been determined and the introduced model given by Eq. (6), (7). This model can be used to determine any one of the two parameters (view angle and distance) for any zoom number when one of them is known.

7.1 References

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تحديد افضل موديل رياضي لزاوية رؤيه الكاميرا كدالة لابعاد الجسم

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الملخص

في هذا البحث تم تحديد افضل موديل رياضي لزاوية رؤية الكاميرا كدالة لابعاد الجسم لكل درجة تكبير للكاميرا،حيث لوحظ ان مستويات الدقة العملية لزوايا الرؤيا العمودية والافقية للصورة المستوية ثابته عند كل المسافات و لكل درجة تكبيرفي الكاميرا، ثم تم ايجاد معادلة الموديل الرياضي لزوايا الرؤيا وعلاقتها بابعاد الجسم ودرجة تكبير الكاميرا لتخمين زوايا الرؤيا العمودية والافقية، من الرسوم البيانية وجد توافق كبير بين النتائج العملية والنظرية وبشكل جيد جدا حيث كانت النتائج متقاربة جدا .