A Novel Camera Calibration method for measurement of horizontal and vertical displacement of target object using LABVIEW

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Abstract—*This paper presents a method of identifying the target distance from the source depending upon the variation in pixel area through a camera calibration technique. The variation in pixel area is used as a property for calculation of distance and displacement. Using this technique , an object's movement can be traced with the help of reference marker.*
Keywords— Camera calibration, non linear calibration, linear calibration, photometry, intrinsic parameters.

I. INTRODUCTION

Camera calibration is a necessary step in 3D computer vision in order to extractmetric information from 2D images. It has been studied extensively in computer vision and photogrammetry.[1]Various techniques about camera calibration have been developed over time.[2]

This paper is divided into three sections : Section A deals with the theory and usage of NI LABVIEW software for measurement of pixel area variation. Section B deals with the mathematical part of the calculation and calibrating the camera for horizontal distance measurement and Section C deals with vertical displacement estimation followed by result and conclusion.

II. LITETURE SUREVY

A. Modelling equation for pixel size and area for calibration

A reference object of known dimensions is kept exactly in front of the camera,and images at various distances are taken keeping camera fixed.Analysis of those images are done through Labview Vision Software.Significant lensdistortion[3] is not assumed here.

It was observed that the pixel area of object was inversely related to the distance between the object and camera (Fig 1).

$$r \alpha \frac{1}{\sqrt{Ap}} \qquad (1)$$

Relation between pixel Area and distance is found out by the given relation

$$\mathbf{r} = \frac{k}{\sqrt{Ap}} + \mathbf{c} \qquad (2)$$

Where :

r : Distance between camera and image (cm)

$\mathbf{A_p}$**:**Area occupied by the reference object in image(pixels)

k,c : Constants

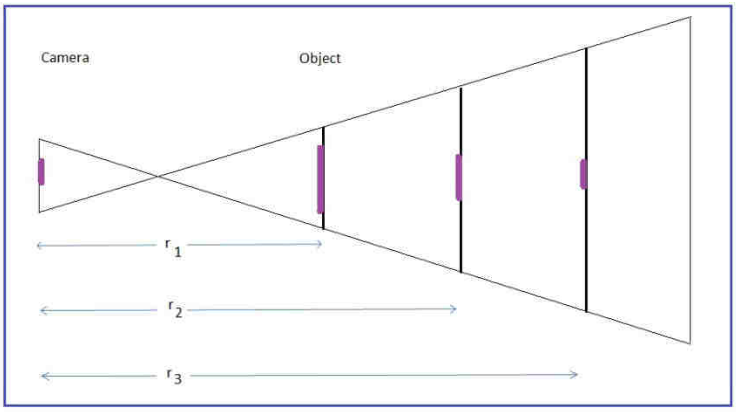
Calculation of k and c:

Two images containing the reference are taken at different distances.

kis found out by the following result:

Fig 1 : Capturing the object image at different distances.

Δr = **k**



(3)

$$\sqrt{A1} - \sqrt{A2}$$

A_1,A_2: Area of reference objects in the image(pixels) taken at distance r_1 and r_2

Δr :Difference in the distance between the two captured images.
c is found by substituting k,r,A_p in eq(2) and the corresponding distance in terms of pixels is found out through a NI LABVIEW software.

B. Measuring vertical distance from camera

Thus having calibrated the camera for values of k and c, the distance of the object can be found out through the formula using the above approximations in the following table.

OBSERVATION TABLE :

$Xavg_p$ (Pixels)	$Yavg_p$ (Pixels)	Area A_p(Pixels)	Actual Distance(cm)	Calculated Distance r (cm)
296	304	89984	34	32.03
186	189	35154	54	52.036
136	137	18632	74	71.96
107.6	107.6	11521.7	94	91.86

Fig 2 shows the various images taken from the camera by varying the distance.

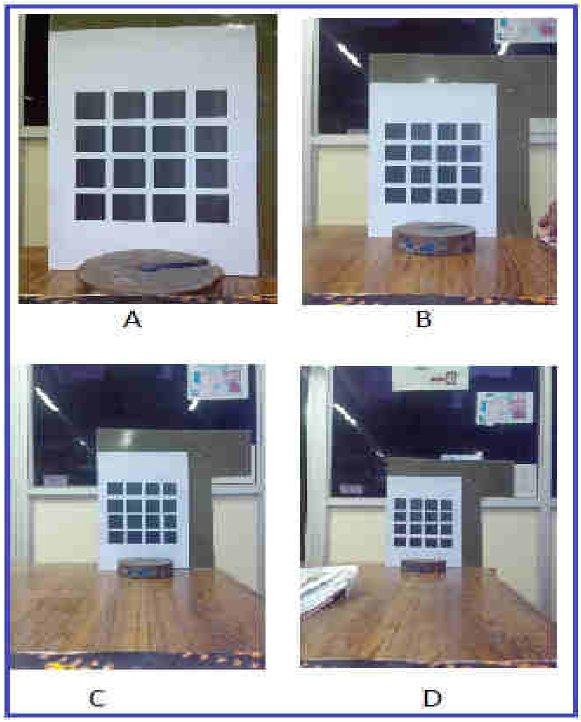


Fig 2 : Images taken from camera at various distances

C. Meausring vertical displacement of object

Keeping reference object in front at distance r ,wefind out the angle subtended by the reference object onto the camera by the following equation:

$$\alpha = \frac{d}{r} \quad (4)$$

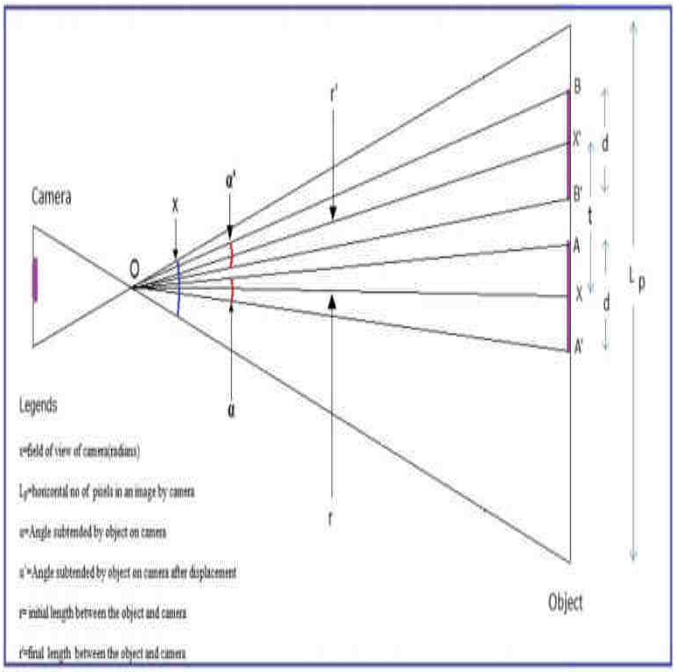
Where :

α: Angle subtended by object on camera(radians)
d: horizontal dimension of the reference object (cm)
r(α): distance between camera and the reference object (cm)

Similarly the angle subtended by the target object on camera is:

$$\alpha' = \frac{X}{P_p} \quad L_p \quad (5)$$

Where :
x=field of view of camera(radians)



L_p=horizontal no of pixels in an image by camera
α'=Angle subtended by object on camera after shifting object
P_p=Horizontal Dimensions in Pixels of an object

Fig 3 :Measuring horizontal displacement

Also, by (4)

$$\alpha' = \frac{d}{r'}, \qquad (6)$$

r' can be found out by dividing (4) and (6)

$$\frac{\alpha}{\alpha'} = \frac{r'}{r} \qquad (7)$$

Where
α: Angle subtended by object on camera(radians)
α': Angle subtended by object on camera after shifting (radians)
r=initial distance between camera and object (cm)
r'=final distance between camera and object after being shifted (cm)

It can be now observed that r and r' form perpendicular and hypotenuse of a right angle triangle. OXX'

The displacement 't' can be calculated by using Pythagoras Theorem:

$$t=\sqrt{(r)^2-(r')^2} \qquad (8)$$

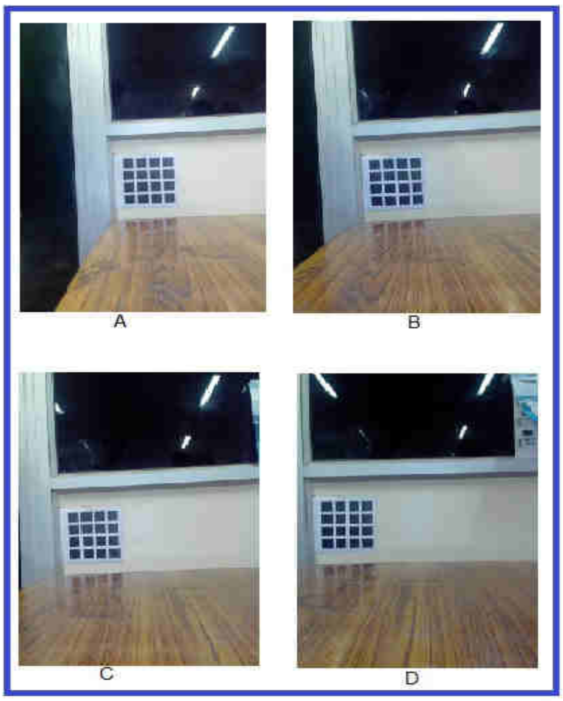


Fig 4:Images taken from camera at various distances for horizontal displacement calculation of object

Table 2

α(radians)	α'(radians)	r (cm)	r' (cm)	Distance shifted (t)	Actual distance shifted (cm)	Moving Object Pixels(P')
0.03404	0.03414	94	94.2821	7.288	8	108.11
0.03404	0.03448	94	95.224	15.218	16	109.19
0.03404	0.03506	94	96.8286	23.233	24	111.03
0.03404	0.03587	94	99.0525	31.231	32	113.58

III. RESULTS

The motion of the object was estimated and was found in

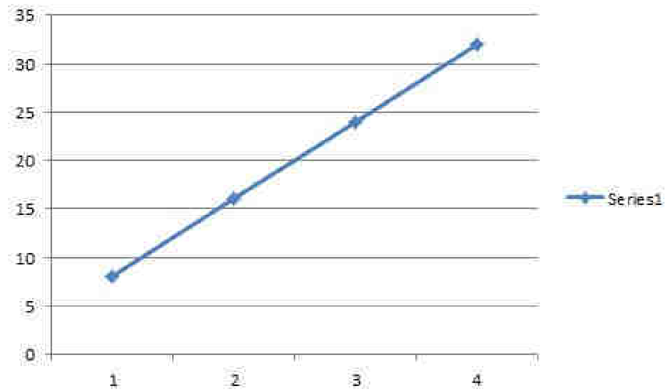


Fig 5 : Plot of actual and estimated horizontal displacement

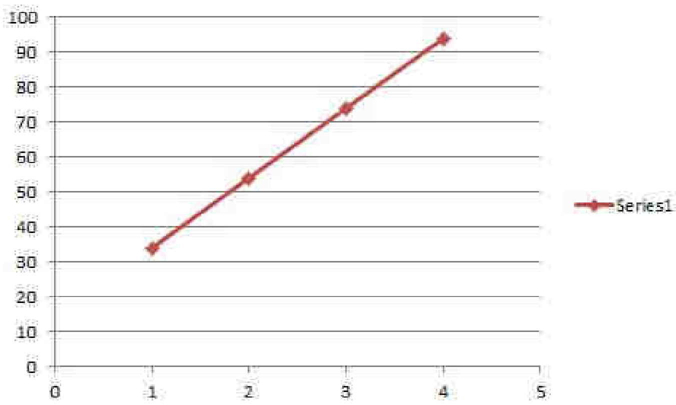


Fig 6 : Plot of actual and estimated vertical displacement agreement with the actual horizontal displacement with ….. % accuracy and vertical displacement with ….% accuracy.

We further assume that the the object and camera are exactly vertical to the ground plane in order to avoid warping effects.

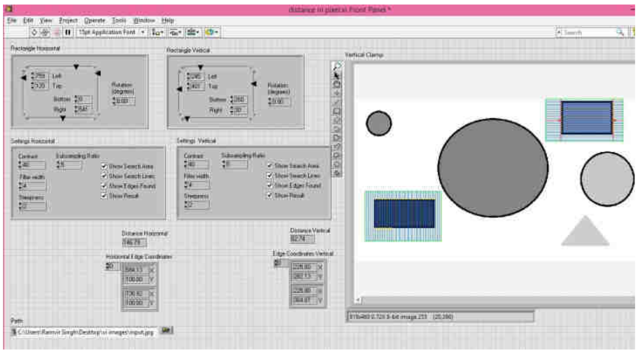


Fig 7: NI Labview software used to calculate pixels.

IV. CONCLUSION

It is possible to find the distance between the object and the camera using the set of relations.

Area of object in image decresaes as distance increases.

The mean % error for horizontal displacement was and for vertical displacement was … %.

Lens distortion can be manipulated using various techniques.[4] and various methods[5] can thus be used for improving the accuracy.

REFERENCES

[1] Z. Zhang, "Camera Calibration", Chapter 2, pages 4-43, in G. Medioni and S.B. Kang, eds., *Emerging Topics in Computer Vision*, Prentice Hall Professional Technical Reference, 2004.

[2] Clarke, T.A. & Fryer, J.F. 1998. The development of camera calibration methods and models, Photogrammetric Record, 16(91): pp 51-66.

[3] ZhengdongZhang Yasuyuki Matsushita Yi MaCamera Calibration with Lens Distortion from Low-rank Textures.

[4] DUANE C. BROWN,Decentering Distortion of Lenses

[5] Suchi Upadhyay, S.K.Singh ,Manoj Gupta ,Ashok K. Nagawat LINEAR AND NON-LINEAR CAMERACALIBRATION TECHNIQUES Volume 2, No. 5, April 2011 Journal of Global Research in Computer Science