Data Extraction from Computer Acquired Images of a Given 3D Environment for Enhanced Computer Vision and its Applications in Kinematic Design of Robos

K. Selvaraj
Department of Electrical and Electronics Engineering,
Sri Sapthagiri Institute of Technology, Ocheri, Vellore District, TN, S. India

Abstract: Problem statement: Literature review was mainly aiming at recognition of objects by the computer and to make explicit the information that is implicit in the attributes of 3D objects and their relative positioning in the 3D Environment (3DE) as seen in the 2D images. However quantitative estimate of position of objects in the 3DE in terms of their x, y and z co-ordinates was not touched upon. This issue assumes important dimension in areas like Kinematic Design of Robos (KDR), while the Robo is negotiating with z field or Depth Field (D_F). **Approach:** The existing methods such as pattern matching used by Robos for Depth Visualization (DV) using a set of external commands, were reviewed in detail. A methodology was developed in this study to enable the Robo to quantify the depth by itself, instead of looking for external commands. **Results:** The Results are presented and discussed. The major conclusions drawn based on the results were listed. **Conclusion:** The major contribution of the present study consists of computing the Depth (D^1) corresponding to the depth (d) measured from the photographic image of a 3DE. It had been concluded that, there exists an excellent agreement between the computed depth D^1 and the corresponding actual Depth (D). The percent deviation of D^1 from D (D_P) lies between ±2 over the entire region of the (D_F). Through suitable interfacing of the developed equation with the kinematic design of Robos, the Robo can generate its own commands for D_F negotiations.

Key words: Computer Vision (CV), Human Vision (HV), Depth Field (D_F), Computed Depth (D^1), actual Depth (D) measured depth (d)

INTRODUCTION

CV includes various techniques for making the computer simulate the functions of human vision, through electronically perceiving and understanding the 2D images (Sandyarani and Vaithyanathan, 2009a; Pridmore and Hales, 1995; Keium, 2000).

Giving the computer ability to see is not an easy task. The basic limitations of CV are that, the computer has to analyze the 2D images having enormous loss of information (Sonaka *et al*., 1999). Further CV basically lacks wide applicable and general modifiable knowledge of the real world (Rao, 1996). Controlling and analyzing the inputs poses yet another problem in CV. Effects such as lighting and shadows, lens focus, make it impossible to guarantee that two digitized images of the same scene will be identical (Rosenfeld, 1988).

However all above techniques enable the computer to understand the 3DE represented by the corresponding 2D images/Photographs. A quantitative estimate of the x, y and z coordinates of a point in a given 3DE remained untouched by the researchers. Some additional data must be extracted from the 2D images that were to be used for comprehending the 3D objects, helping the computer to quantitatively estimate the coordinates (Sandyarani and Vaithyanathan, 2008; 2009b). An attempt is made in the present study to address above issue.

MATERIALS AND METHODS

The D_F is assumed to be a line AB of length 1 m situated behind the pp, above GP and perpendicular to GP. Line ApBp is the Photographic images of depth field AB. Let D represent the actual depth (Length AB), Let d represent the length as measured on the Photographic image (length ApBp). An attempt is made to establish an equation between D^1 and d in the form:

$$D^1 = c_o + c_1.d + c_2.d^2 \tag{1}$$

Where:

D^1 = The computed depth for a measured d on the photograph

c_0, c_1, c_2 = Constants obtained by numerical methods for a set of known values of D (actual depth) and the corresponding measured depths (d) on the photograph, for the entire region of depth

Present study: In the actual experiment set up, a pure black string of 1000 mm length having knots an intervals of 50 mm is chosen to represent the DF. Its photograph is shown in Fig. 2. The different sets of known D and corresponding d are shown in Table 2.

In Fig. 1, Line AB represents the depth field which is perpendicular to the picture plan and parallel to the ground plan. The observer (camera lens) is in front of the picture plan. Length A_p, B_p as seen on the picture plan is the perspective projection of the depth field. This can be considered as the photographic image of the depth field seen in Fig. 2.

Fig. 1: Schematic representation of experimental setup

Fig. 2: Photographic images of D_F

It is seen from Table 2 that there is an excellent agreement between D^1 and D and the percent deviation of D^1 from D is with in ±2.0. Hence the proposed equation can be used for unknown depth computations. Through suitable interfacing the proposed equation in the kinetic design of Robo, the Robo can generated the commands for depth, by itself (Rao and Vaithyanathan, 2008a; 2008b) The Values D, d, c_0, c_1, c_2, D^1 and D_P are tabulated and are shown in Table 1 and 2.

RESULTS

- Table 2 reveals that there exist a wide variation between the measured values of depth on the photograph (d) and the actual Depth (D). The above variation is more pronounced for depths nearer to the observer

Table 1: Values of c_0, c_1, c_2

C_0	C_1	C_2
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392
20.773592	0.718659	0.000392

Table 2: Percent deviation of D^1 from D

d	D	Order	D^1	D_p
41	50	2	50.89	1.79
104	100	2	99.75	-0.24
165	150	2	150.02	0.01
226	200	2	203.21	1.60
272	250	2	245.25	-1.89
324	300	2	294.76	-1.74
374	350	2	344.38	- 1.60
424	400	2	395.43	-1.14
479	450	2	454.40	0.97
523	500	2	503.29	0.65
567	550	2	553.69	0.67
611	600	2	605.61	0.93
650	650	2	653.52	0.54
688	700	2	700.13	0.01
732	750	2	756.22	0.83
755	800	2	786.15	-1.73
798	850	2	843.21	-0.79
831	900	2	887.99	-1.33
886	950	2	964.51	1.52
908	1000	2	995.79	-0.42

- Results 1 and 2 justify the need for present research
- As seem from Table 2 the percent deviation (p) of computed depth D^1 from the actual depth D for a given d on the photograph is with ±2.0

DISCUSSION

Various methods are reported in the literature for D_F computations, like using intensity of pixels, parallel projection methods. The justification for choosing the proposed method for D_F computation is that, the photographic techniques offer better accuracy, more ease of handling of computing data:

- The proposed equation offers minimum variation (±2.0%) of D^1 from D and hence can be effectively used for depth computations
- The existing methods of depth sensing of Robos is through external commands. The current method, through suitable interfacing can help the Robo, to generate its own command for depth sensing

CONCLUSION

The major contribution of the present study lies in proposing an equation between D^1 and D. There exists a good agreement between D^1 and D. The proposed equation can be effectively used for D_F calculations

The industrial applications of the proposed equation are in the areas of Computer Integrated Manufacturing (CIM), Special Mathematical Program for Rapid Manufacturing (SMPRM), Satellite Map Rearing (SMR) and Rapid Prototyping (RPT).

REFERENCES

Keium, D.A., 2000. Designing pixel-oriented Visualization techniques: Theory and application. IEEE Trans. Visualiz. Comput. Graph., 6: 59-60.

Pridmore, T.P. and W.M.M. Hales, 1995. Understanding Images: An Approach to the university teaching of computer vision. Eng. Sci. Educ. J., 162-165.

Rao, K., 1996. A computer vision system to detect 3D rectangular solids. Proceeding of the 3rd IEEE Workshop on Application of Computer Vision, Dec. 02-04, IEEE Xplore Press, USA., pp: 27.

Rao, M.N. and V. Vaithyanathan, 2008a. Computer aided interactive learning of engineering graphics-an e-Learning module. Proceedings of the International Conference on Computing Communication and Networking, Dec. 18-20, IEEE Xplore Press, USA., pp: 132-135. DOI: 10.1109/ICCCNET.2008.4787747

Rao, M.N. and V. Vaithyanathan, 2008b. Visual computing of parameters/attributes of geometric solids using color gradation/queuing theory and its applications in engineering graphics. Proceedings of the International Conference on Computing Communication and Networking, Dec. 18-20, IEEE Xplore Press, USA., pp: 1-4. DOI: 10.1109/ICCCNET.2008.4787756

Rosenfeld, A., 1988. Computer vision: Basic principles. Proc. IEEE., 76: 564-565.

Sandyarani, N. and V. Vaithyanathan, 2008. Depth computations using data in the form of intensity of pixels for enhanced computer vision. Proceedings of the International Conference on Computing Communication and Networking, Dec. 18-20, IEEE Xplore Press, USA., pp: 1-5. DOI: 10.1109/ICCCNET.2008.4787729

Sandyarani, N. and V. Vaithyanathan, 2009a. Non-linear projection methods for mapping the coordinates of a point in a given 3D environment and its application for enhanced computer vision. Proceedings of the International Conference on Emerging Trends in Computing, Jan. 8-10, IEEE Xplore Press, USA., pp: 247-250.

Sandyarani, N. and V. Vaithyanathan, 2009b. Depth computations using data in the form of intensity of pixels for enhanced computer vision. Proceeding of the International Conference on Computing, Communication and Networking, (ICN'09), IEEE Xplore Press, St. I., pp: 1.

Sonaka, M., V. Hlavac and R. Boyle, 1999. Image Processing, Analysis and Machine Vision. 2nd Edn., Thomson Asia Pte Ltd., Singapore.