International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970)
Volume-3 Number-3 Issue-12 September-2013

Image Based Measurement of Length and Distance of an Inaccessible Object

Md. Imdadul Islam[1], Mahbubul Alam[2], Sarnali Basak[3], Md. Al-Amin Khandaker[4], S M Raihan Azim[5]

Abstract

Sometimes it is necessary to measure the length of an object or its distance from a particular location when it is difficult to access the location of the object even not at all accessible. In this paper we proposed an image based measurement technique of such an object and its distance. The technique is very simple, only a digital camera, a wooden bar and three LASERs of intense beam are necessary. Entire measurement is taken ignoring the focal length of the camera but the result provides above 95% accuracy. Such measurement technique; for example is essential for a civil engineer to take approximate measurement before work plan even for a zoologist to measure the size of a wild animal which cannot be caught.

Keywords

Distance Measurement, Pixel-based Length Measurement, LOS, Numerical Integration.

1. Introduction

If someone is asked to measure the size of an object or its distance from a particular point, the most realistic and easiest thinking is to use a measuring tape. If the length of the object or its distance is very large then civil engineering survey is the optimum solution. Although such survey provides very accurate results but sometimes it is necessary to take an approximate initial measured data for preplan (before mobilization surveying equipment). In this paper work we introduce very low cost equipment, based on image processing technique at the expense of accuracy.

Md. Imdadul Islam, Computer Science and Engineering, Jahangirnagar University, Dhaka, Bangladesh.
Mahbubul Alam, Computer Science and Engineering, Jahangirnagar University, Dhaka, Bangladesh.
Sarnali Basak, Computer Science and Engineering, Jahangirnagar University, Dhaka, Bangladesh.
Md. Al-Amin Khandaker, Computer Science and Engineering , Jahangirnagar University, Dhaka, Bangladesh.
S M Raihan Azim, Computer Science and Engineering, Jahangirnagar University, Dhaka, Bangladesh.

Very few research papers are found pertinent to this work. Only four papers are found (not very closed to our analysis) about measurement of length of a fish. The basic principle of these papers are discussed here as the previous literature. The measurement of distance of an object covering this paper is a newly proposed model.

In [1] first of all, the edge of the fish is determined which is then splitted into 100 equidistance segments. The center and principle axis of the resultant polygon is determined using moment integration. The result of the moment provides the actual orientation of the fish. The next step is to draw a set of horizontal and vertical lines with respect to the principle axis. Finally the length of the fish is measured along the central axis of the fish taking 8 points on the axis.
A cost effective and faster method of measurement of length of fish is proposed in [2]. First of all pre-processing is done on the image to detect the head and tail of fish using canny edge detection, scale-map and sub-segments using a relevance model of [3]. Length of the fish is then measured considering, bending ratio plot, corner factor, focal length (f) and mean object distance (O). Entire procedure is given in block diagram in [3] and the authors of claims 95% accuracy of their result. In [4] the author develops software named '*AnalyzingDigitalImages'* to measure the length of an object, using its image. The paper is organized like, section 2 provides the methodology of the proposed model with mathematical formulation, section 3 deals with image based results on several objects, and finally section 4 concludes the entire analysis.

2. Methodology

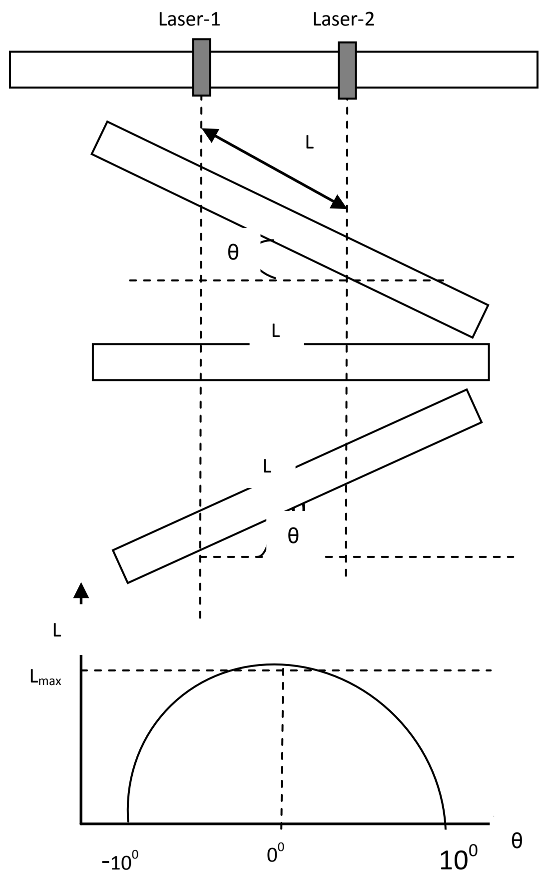
The procedure regarding to the implementation of physical equipment, extraction of the image and the corresponding measurements can be explained with following seven steps:
Step 1. Two LASERs of intense beam are placed at 1ft apart on a wooden bar. They are attached on the bar with adhesive material so precisely that the beams emitted are parallel.
Step 2. Laser beams are projected on an arbitrary object. The object (the major axis of the object) and

the beam should be (approximately) mutually perpendicular.

Step 3. Image of the object (including the beam spot) is taken by high resolution digital camera. The camera should be placed on the wooden bar at the midpoint between the LASERs.

Step 4. Image is extracted using **imtool(**'*file name of the image with extension'***)** function under MATLAB 9.x or above version.

Step 5. Using pixel based distance measurement tools, the size of the object is measured according to fig.1 and corresponding condition is: L_i is the maximum when $\theta_i \approx 0$ and this maximum length is the actual length of the object.



(b)

Fig. 1(a)&(b) Measurement of size of an object

To measure the distance between the object and the location of experiment we have to follow the following procedure:

Step 6. Three LASER beams are projected on the object two beams are perpendicular to the wooden bar where the separation between them is 1ft like step-1, and the third beam makes an angle α (we recommend to take α below 10^0) with the direction of first two parallel beams like fig.2.

Step 7. Image of the object (including the three beam spots) is taken by high resolution digital camera. The image is extracted like step-4 under MATLAB software. Here both α and L are known therefore l can be calculated from pixel based measurement tool. Now, the distance of the object, $x = \frac{l}{\tan \alpha}$.

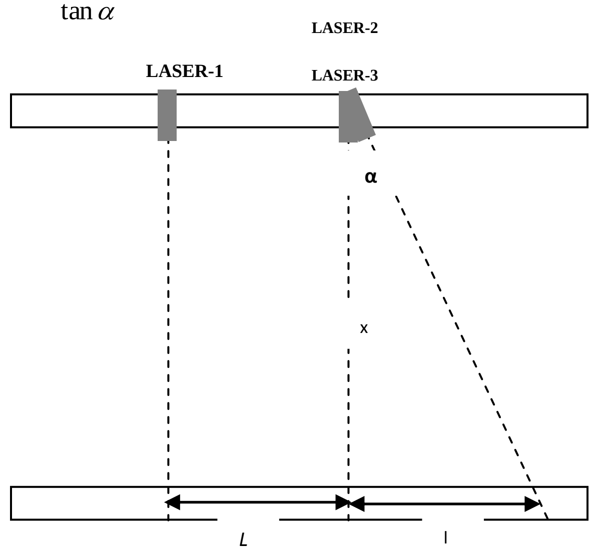


Fig.2 Distance measurement apparatus

3. Results

In this paper work we first considered a smooth object of uniform and periodic structure. The line of sight (LOS) of the camera is placed parallel to horizontal whereas the object is perpendicular to the LOS of camera. We used high resolution camera of, 5184×3456 pixels and of size 5.7MB. We first select a vertical wall like fig.3 and the snap was taken 10ft ahead of the wall. The width of bricks is measured in number of pixels. The widths are found almost same for all the bricks. The small variation occurs because of angular variation of sides of the object and irregular width of adhesive element between bricks.

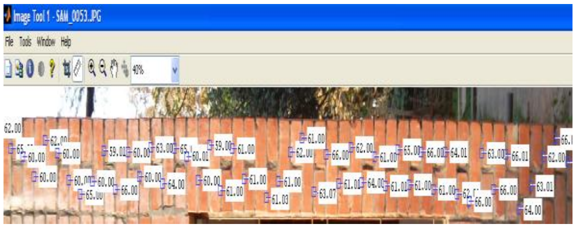


Fig.3 Non-uniform wall

The situation is complexly different if the LOS of the camera is slant w.r.t. the horizontal. Fig.4 shows more precise brick wall where the LOS of the camera is placed 15^0 with respect to the horizontal plane. The variation of width of the bricks is visualized from the figure. To observe the profile of such variation, the width of bricks is plotted against the distance in number of bricks shown in fig.1. Fitting the data with 3^{rd} order polynomial, it is found that the deviation in width with distance is almost linear.

Fig.4 (a) Uniform wall

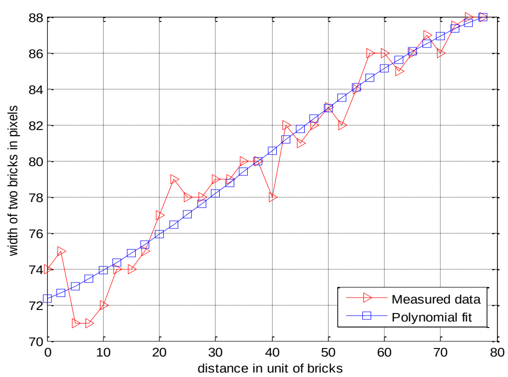


Fig.4(b) Width of bricks vs the distance of the number of bricks

The phenomena of slant LOS is also visualized from fig.5 where grill of window and door of straight curving are used. In both cases the snap is taken 10 ft away from the object at an angle of 15^0 w.r.t. horizontal.

Fig.5(a) Uniform window grill

Fig.5(b) Door with uniform curving

Let us now apply the above technique on the most uniform structure of Jahangirnagar university campus which is the Shahid Minar. For the case of horizontal LOS a snap is taken 50ft away from it and the variation width of bricks from top to bottom is found almost same like fig.6.

Fig.6 LOS is horizontal

Finally three snaps of the Shahid Minar is taken 30ft away from it at 0^0, 15^0 and 30^0 w.r.t. horizontal line. A closed view of the image of 30^0 case is shown in fig.7(a) where the variation in length of bricks are visualized. The profile of pixels/brick vs. distance along the object is plotted for three images shown in fig.7(b). All the curves are found linear. The variation of width of a brick is found very small within 50ft when the LOS of the camera is perpendicular to the object. Since the bricks are squeezed linearly, applying the regression of 3^{rd} order polynomial we got the constant rate of squeeze, S = 0.965. Therefore the distance measured by the proposed technique should be divided by the factor S.

Fig.7(a) LOS is 30^0 with respect to horizontal

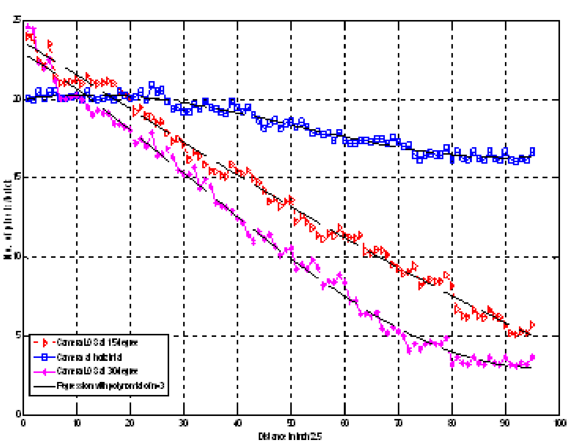


Fig.7(b) The variation of width of a brick w.r.t. for different height

Applying the LASER spot at 1ft apart on the Shahid Minar we got the distance between them equal to 70 pixels and the height of the tower above the platform is found 4508 pixels shown in fig.8. Now the height of the tower, h = 4508.92/70 = 64.413ft. Using the factor S, the true height will be, 64.413/S=66.749ft. This factor can be ignored for measurement of a small object like fig.9 and 10.

Fig.8 Measurement of height

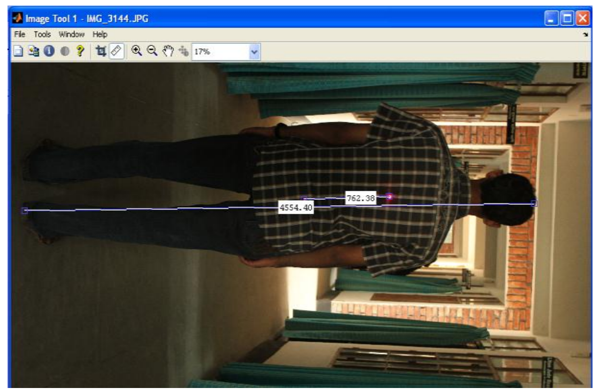


Fig.9 Height measurement of a person

Let us introduce some application example pertinent to the paper. The first example is the measurement of the height of a man like fig.9. The measured height of the man, h = (4554.4/762.38)×1 = 5.97ft; whet the actual height is 5ft and 11 inches. Therefore the accuracy is well satisfactory. Our second example is the measurement of height of a column of a building shown in fig.10.

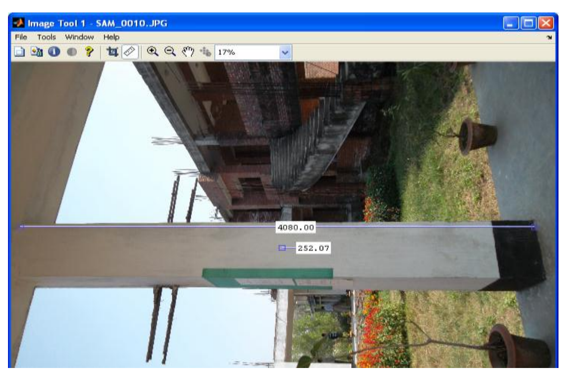


Fig.10 Height measurement of a pillar of a building

The measured height of the column= (4080/282)/1.5 = 10.79ft; where the exact height = 10.5ft. Our third example is the measurement of length of a curved body based on piece wise linear model like fig.11. Smaller the segments more accurate the result will be like the trapezoidal method of numerical integration.

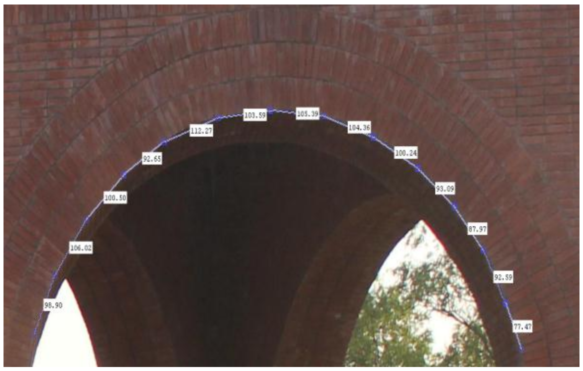


Fig.11 Piece wise linear approximation

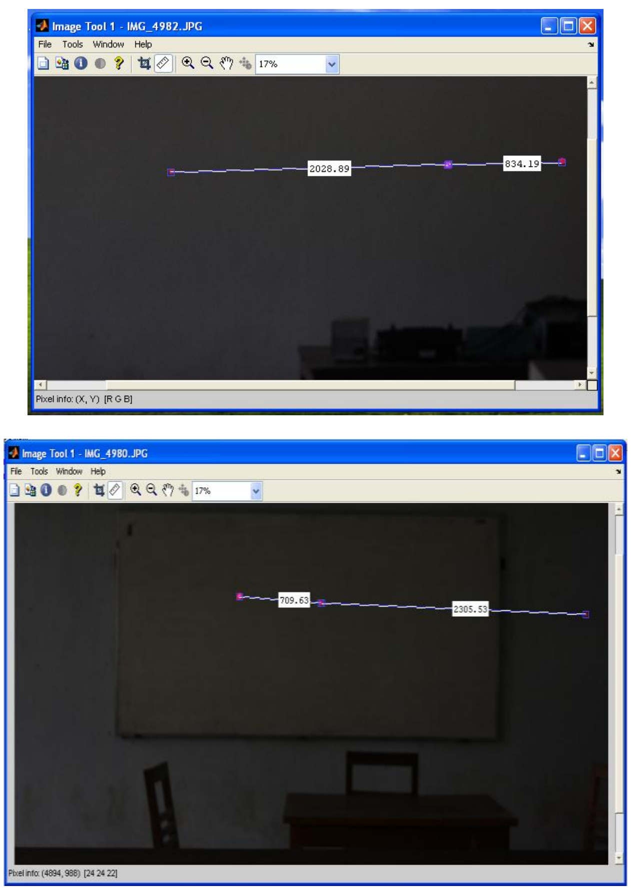


Fig.12 (a) and (b) Three point's model to measure the distance of an object

Let us now apply three points model to measure the distance of an object (wall of a room is selected to get distinct Laser spot on the image) like fig.4. In fig.12(a) the geometry of right angle triangle is found like, L = 2028.89/834.19 = 2.43216ft, l = 1f and $\alpha=10^0$. Now the distance measured by apparatus, x = L/tan(α) = 2.43216/0.173 = 13.79ft. The exact length is found 14.5ft. Now the error, ε = (14.5-13.79/14.5) = 4.89%. From fig. 12(b) we got the error ε = 4.63%.

4. Conclusions

Laser spots are found very blur on the image while taking readings on day light. Therefore very intense Laser beam is necessary to take reading on day light. Edge detection technique or contrast enhancement can also be applied (followed by some preprocess) to locate the blur Laser spot. The concept of the paper can be applied to measure the length of a straight road from the profile of variation of its width with distance. The entire work can be extended to measure the velocity of a vehicle along a straight road taking video on the front side of the moving car (with two Laser spots). Now from the variation of number of pixel between two Laser spots (from consecutive video frame) per unit time will give the indication of its velocity.

References

[1] D.J. White, C. Svellingen , N.J.C. Strachan, "Automated measurement of species and length of fish by computer vision," Elsevier Fisheries Research 80 (2006) 203–210.

[2] Mohd Rahim, Norhaida Abdullah, Ismail Amin, Mohammad Zakaria, Mustafa Man, Nur Othman, "A New Approach in Measuring Fish Length Using FiLeDI Framework," IAJIT, 2010.

[3] Kiranyaz S., Hantao Liu, Ferreira M., and Gabbouj M., "An Efficient Approach for Boundary Based Corner Detection by Maximizing Bending Ratio and Curvature," in Proceedings of 9th International Symposium on Signal Processing and its Applications, Sharjah, UAE, pp. 1-4, 2007.

[4] John Pickle, "Measuring Length and Area of Objects in Digital Images Using AnalyzingDigitalImages Software," Concord Academy, March 19, 2008, http://mvh.sr.unh.edu/software/software.htm.

Md. Imdadul Islam has completed his B.Sc. and M.Sc Engineering in Electrical and Electronic Engineering from Bangladesh University of Engineering and Technology, Dhaka, Bangladesh in 1993 and 1998 respectively and has completed his Ph.D degree from the Department of Computer Science and Engineering, Jahangirnagar University, Dhaka, Bangladesh in the field of network traffic engineering in 2010. He is now working as a Professor at the Department of Computer Science and Engineering, Jahangirnagar University, Savar, Dhaka, Bangladesh. Previously, he worked as an Assistant Engineer in Sheba Telecom (Pvt.) LTD (A joint venture company between Bangladesh and Malaysia, for Mobile cellular and WLL), from Sept.1994 to July 1996. Dr Islam has a very good field experience in installation of Radio Base Stations and Switching Centers for WLL. His research field is network traffic, wireless communications, wavelet transform, OFDMA, WCDMA, adaptive filter theory, ANFIS and array antenna systems. He has more than hundred research papers in national and international journals and conference proceedings.

Mahbubul Alam He completed his B.Sc. (Hons.) in Computer Science and Engineering from Jahangirnagar University, Savar, Dhaka, Bangladesh in 2006. He received the "Asadul Kabir Gold Medal" for securing the highest grade in the B.Sc.(Hons.) final examination 2006 at Jahangirnagar University. He is now working as a Lecturer, at the department of Computer Science and Engineering, Jahangirnagar University, Savar, Dhaka, Bangladesh from 13th July 2009. His research interests are wavelet transform, wireless communications, adaptive filter theory, artificial intelligence, image processing and machine learning.

Sarnali Basak received her B.Sc. (Hons.) and M.S. degrees in Computer Science and Engineering from Jahangirnagar University in Savar, Dhaka, Bangladesh in 2008 and 2010, respectively. She is working as an assistant professor in the Department of Computer Science and Engineering at University of Asia Pacific, Dhanmondi, Dhaka-1209. She received an NSICT fellowship from the Ministry of Science and Information & Communication Technology, Bangladesh for her MS research in 2011. Ms. Basak has also several research papers in reputed international journals. Her research fields are Image Processing, Pattern Recognition, Artificial Intelligence, Neural Networks and Biometrics.

Md. Al-Amin Khandaker completed his Bachelor in Computer Science and Engineering from Jahangirnagar University, Dhaka, Bangladesh in 2012. He is pursuing Masters in Computer Science and Engineering from the same University. He has been working as a Software Engineer at Metatude Asia Ltd, Dhaka (A Dutch offshore software company) since May, 2012. He has expertise in mobile application development. His research interest includes Wireless Communication, Software Engineering, Image Processing and Human Computer Interaction.

S M Raihan Azim has completed his B.Sc (Hons.) in Computer Science and Engineering from Jahangirnagar University, Dhaka, Bangladesh in 2012. He is now working as a software Engineer in Vizrt Bangladesh Ltd. His research interests are in Wireless Communication, Artificial Intelligence, Software Engineering and Programming Languages.