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Image Based Distance Measurement Technique for Robot Vision using New LBPA approach

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Abstract: **One of the problems that affect the development of vision based robot is the Image accuracy taken by camera mounted on the robot. Robot Vision with Image programming and filtration technique of that image improves the accuracy and can also be used as a diagnostic tool in robot production and maintenance. This work presents techniques for measuring distance as well as height of the target/object/wall using Laser beam pixel area (LBPA) based Image programming technique. As an alternative routine a hybrid system is proposed here. The proposed measurement system is portable, accurate and low cost, able to use in outdoor region also, consisting of a single camera with laser pointer mounted on the robot. It is not a robot building hunt basically it focuses on machine vision or robot vision. Results in past literature shows that the achieved distances using White line tracing algorithm with single camera& without laser varies from 0.11m to 0.66m i.e. less than one meter. Experiments are conducted to show the effectiveness of the proposed method for the measurement of distance as well as height of target/wall/object in indoor as well as outdoor environments. The results on the basis of experiments are analysed as distance & height can be measured accurately using new LBPA approach. This proposed methodology is fast, accurate and easy to set up with this approach possible future refinements are also discussed.**

Keywords: **Image processing, Computer Vision, Camera, Green Laser pointer, camera images.**

1. INTRODUCTION

The time has gone when humans were considered the most intelligent species on the earth. Since long, humans have tried to develop systems that can work like them. These intelligent machines are termed as robots. A huge progress has been made in this area but a lot is still left to achieve. During this experiment, the importance of precision and accuracy can never be neglected. The current trend in mechanical and electronic engineering is the building of more sophisticated mechatronic systems excelling in simplicity, reliability and versatility. Moreover, the intricacy nature of their parts requires integrated control systems accompanied with advanced visual feedback [1]. Now a day's every system is automated in order to face various challenges. In the present days automated systems have unmanned operations, flexibility, reliability and accuracy. Due to this demand every field prefers automated control systems. Especially in the field of electronics automated systems are giving good performance. If we are talking about distance measurement, there are various method which are as discussed on the basis of literatures, ultrasonic-based [3-6] and laser-based [7-13] techniques are among the most commonly used methods. Unfortunately, measurement accuracy via the laser- and ultrasonic-based methods heavily depends on environment, natural light if it is outdoor, surface reflectivity of the object under measurement. These methods also have difficulties in recording images of the objects while measuring distance. Alternatively, imaged-based methods have been proposed for distance measurement by using a CCD (Charged coupled device) [14-17].These methods, however, generally require two cameras set up at different positions to capture two different pictures for further analysis. As a result, pattern recognition or image analyses of a whole image frame were required [18, 19] to extract features from the images for obtaining the distance measurement. Thus, a huge amount of storage capacity and high-speed DSP processors are required for system so established, inevitably resulting in disadvantages in terms of system complexity, processing speed and establishment cost. As a result, the performance of real-time measurements via the pattern recognition or image analysis methods [20-25] was generally not satisfactory because of the speed constraint.

Based on a triangular relationship, image-based distance measuring systems (IBDMS) [26-31] were proposed to measure distance and area using two laser projectors and a CCD camera. Unfortunately, the two laser projectors needed to be

precisely aligned with the camera, which inevitably imposed a critical constraint on the calibration of the measuring system. Furthermore, measurement accuracy of the IBDMS depended on the distance between the laser projectors. Incorporation of the measuring system into a digital camera might become cumber some if higher measuring resolution is required [31]. Because of the problems and difficulties via the above-mentioned methods, accurate and reliable measurements were not always guaranteed in real-world applications. To overcome the problems and difficulties encountered via existing image-based distance measuring methods, this paper, LBPA i.e. laser beam pixel area with image based distance & height measurement technique in robot applications presents a distance measurement method based on pixel count in images taken by 8 megapixel cameras by referencing to two laser-projected spots in the object/target/wall using green laser pointer. Commonly available camera of 8 megapixels and very commonly available green laser pointer make this experiment less costly. Here camera is fixed from where the images are to be taken, of both laser projected spots; these images are loaded into vision algorithm/ into MATLAB programme. As the objective function is chosen "Distance is a function of pixel counts" pixel counts are obtained. By establishing a relationship between pixel counts and distance two different distances are obtained; say horizontal distance and incline distances through which height of the object, wall or target can be estimated as these distances are base and hypotenuse of right angle triangle. One of the advantage with proposed measuring approach that can also be used as a diagnostic tool for height measurement

2. FRAMEWORK OF THE SYSTEM

Generally, in the last few years, the ultimate goal of robotics researchers is the construction of autonomous vehicles that can substitute humans in time demanding tasks. To this end, industries put efforts on developing machines capable of assisting people in everyday life. Among all the operations realized by human beings, the majority is directly related to object manipulation either for eating/drinking (i.e., grasping the spoon or the cup) or for handling an object[1].

The aim of this paper is to estimate distance as well as height using 2D photograph/image only. This idea comes from base paper that if robot is a basketball player so how robot can estimate distances, where to do goal how far that basket is? If this mind is given to a robot so that machine can estimate distance, In achieved literatures based on pixel area target distance estimation using single video camera applicable only for distances less than 1 meters (0.11 to 0.66m) and it was an hard ware which is based on white line algorithm. So, this work is further extended and make it efficient for measurement of distances as well as height of the object. Its distance and height measuring technique is based on laser beam and a programme of MATLAB in Image Processing.

Some limitations were observed on the basis of literature survey and modern WLTA (White line tracing algorithm : - 1) It was not able to measure distance more than 1 meter. 2) It was totally indoor. 3) It cannot be able to measure height of that object/wall. Now to overcome drawbacks of white line tracing algorithm, this paper presents hybridization of laser beam, camera and image processing based program for counting pixels. This experiment is useful in robot vision and separately it can be used as an instrument for measuring distance and height as well. In proposed work there are some Merits:-1) It can measure distance more than 1 meter. 2) This is semi hardware programming based approach, with making it efficient for outdoor also. 3) It can be able to measure height of that object/wall. This alternative framework i.e. hybrid system of laser beam ,camera and image processing based programme for counting pixels of laser projected spots is as follows:-

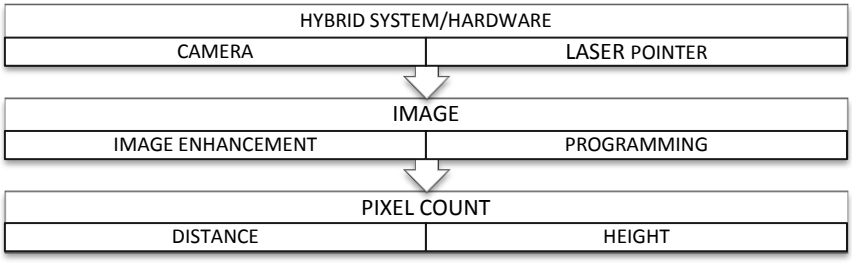

Fig.1 Arena of Hybrid System

Here distance= f(pixel count), which is nothing but research objective. This work is only concentrated in robot vision for making it efficient and more useful. The heart of this distance & height measurement technique for robot vision is MATLAB programming/coding, using image processing toolbox, which reads the image taken by camera.

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3. EXPERIMENTATION SYSTEM AND PROCESS

In research of measuring distance and height using hybrid system, both coding & experiment are trained and tested, Coding for achieving our research objective and experiment for obtaining images. The fundamental idea is that stationary camera laser pointer combination aligned to target perpendicularly starting from the base or lower end of the target, and project green laser pointer on target then image of laser projected spot were captured, from the same place move pointer's tip towards the peak or upper end of the target throw green laser light from the same position and clicked another image of laser projected spot. These two images go throw filtration process which is nothing but image enhancement and noise reduction process. As distance is a function of pixel count is considered, loading this two images into the coding program distance say $d_1$is obtained of lower end and say d_2 of upper end, after obtaining these two distances, easy to find height by applying Pythagoras theorem. Several images were clicked at different times of a day with green laser pointer & camera of 8 megapixels on various places like in terrace with 10x10 meter square area and in a small room of 6x6 meter square area. Captured several images to make an effective program. To understand the proper functioning of this robot vision system it is categorized into two prominent divisions –

A. Basic robot vision using camera and green laser pointer.

B. Image Processing on MATLAB

The essential clue is that fixed camera laser pointer combination aligned to target perpendicularly starting from the base or lower end of the target contributes laser projected spot's image after filtration which deliver distance d1, from the same place pointer's tip tilted towards the peak or upper end of the target throw green laser light from the same position and clicked another image of laser projected spot after filtration, d_2 distance obtained. As distance is a function of pixel count is considered, after obtaining these two distances this is easy to find height by applying Pythagoras theorem. The maximum distance considered for measuring height is ten meter (from the target/ pole/object).

The Flowchart for the adequate accomplishment of image based tasks is as follows:

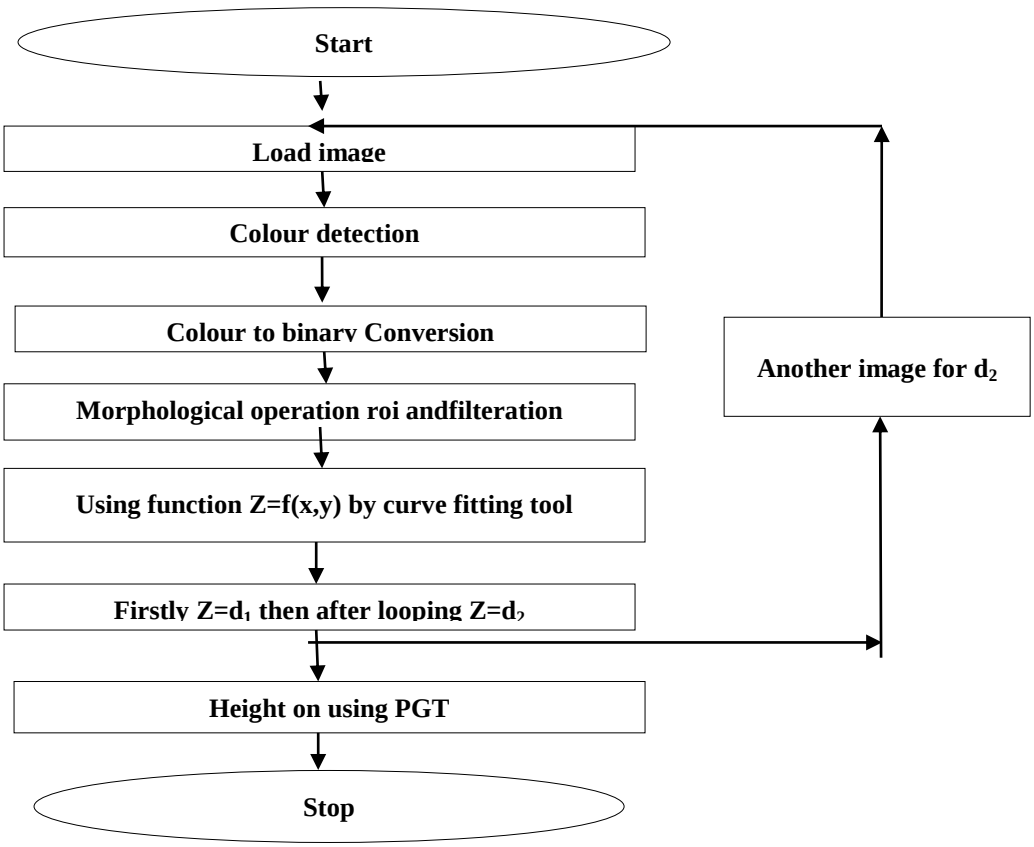


Fig.2 Flowchart for accomplishment of image based task

3.(A). Basic Image capturing method using laser pointer and camera combination in indoor and outdoor places:

Fig.3 Image capturing device with laser pointer

These images were taken in both indoor and outdoor places For indoor we captured images of 1m,1.5m,2m,2.5m,3m etc. In indoor images there is no variation of light so there is no need of capturing images in different times of a day. For outdoor we captured two meter, five meter & ten meter at the time of 8 to 10am, 10 to 12pm, 12 to 2pm, 2 to 4pm and finally at 5 to 7pm as natural light effects more in this experiment, we also use black paper so that laser is more visible in day time. Images are shown here after cropping.

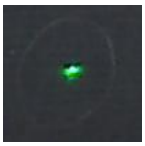
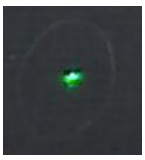
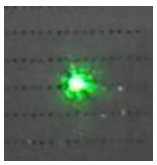
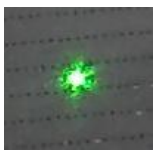
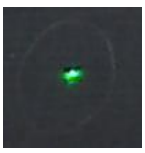
8-10am			
10-12 pm			
12-2 pm			
2-4 pm			
5-7 pm			

Fig.4 Original Images at different times of a day

3(B). For Noise reduction and improvement in image a process of color enhancement is used:

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A Flowchart to show that filtration process is as given below and after that images are shown which is going through this process.

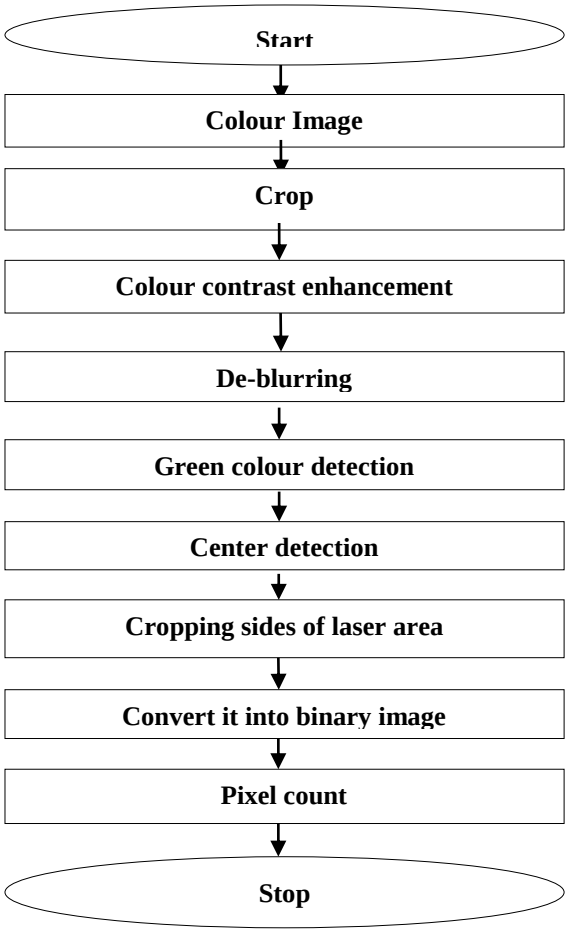

Fig.5 Filtration process through flowchart

Filtered & converted Images into binary image than enhancing this image color to count pixels.

4. RESULT ANALYSIS

1) Time Slot Analysis at 8am-10am

Fig.6 (a) Original Images (2m, 5m, 10m)

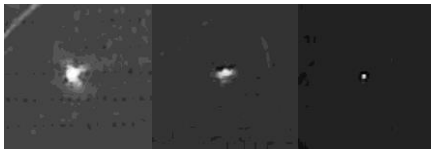

Fig. 6 (b) Binary Images of Original Image,(2m, 5m, 10m)

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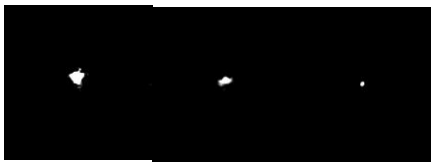

Fig. 6(c) Enhanced Binary Images (2m, 5m, 10m)

Table.1 (8-10 am Pixel counts at 2m,5m,10m distances)

Time Slot	Distance	Pixel count
8am-10am	2	379
8am-10am	5	195
8am-10am	10	97

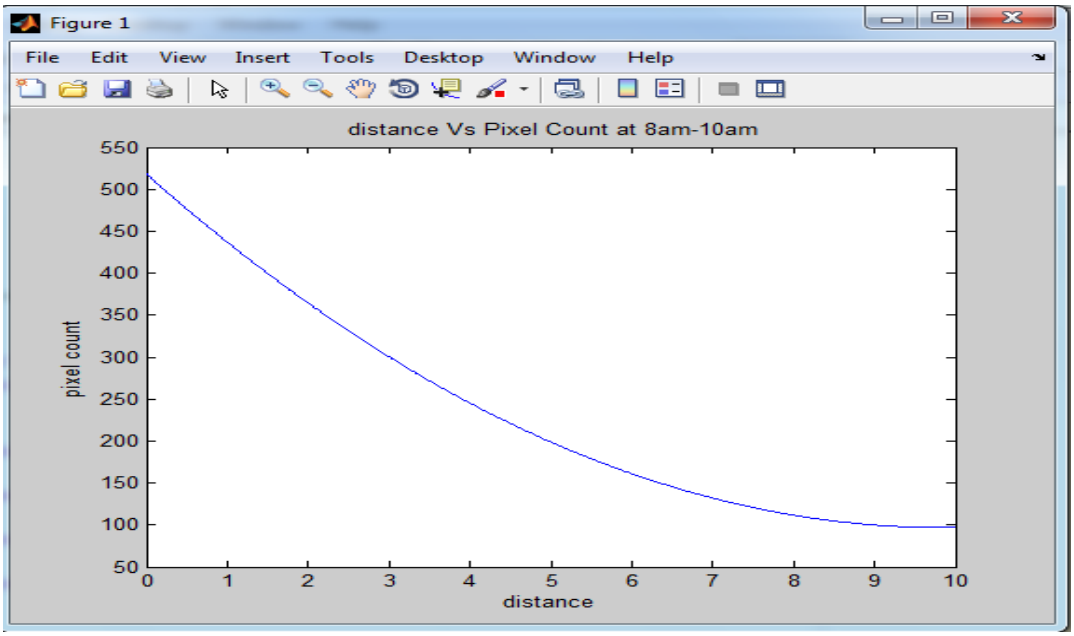

Fig. 6(d) Distance Vs pixel count at 8am to 10 am

2) Time Slot Analysis at 10am-12am

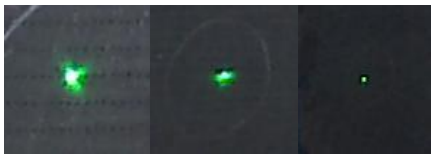

Fig. 7 (a) Original Images (2m, 5m, 10m)

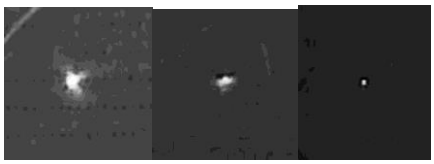

Fig. 7 (b) Binary Images of Original Image, (2m, 5m, 10m)

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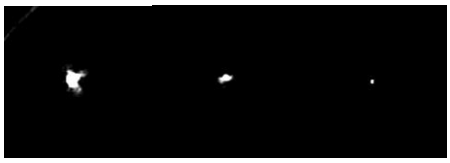

Fig. 7(c) Enhanced Binary Images (2m, 5m, 10m)

Table.2 (10-12 am Pixel counts at 2m,5m,10m distances)

Time Slot	Distance	Pixel count
10 am-12 pm	2	359
10 am- 12 pm	5	191
10 am - 12 pm	10	98

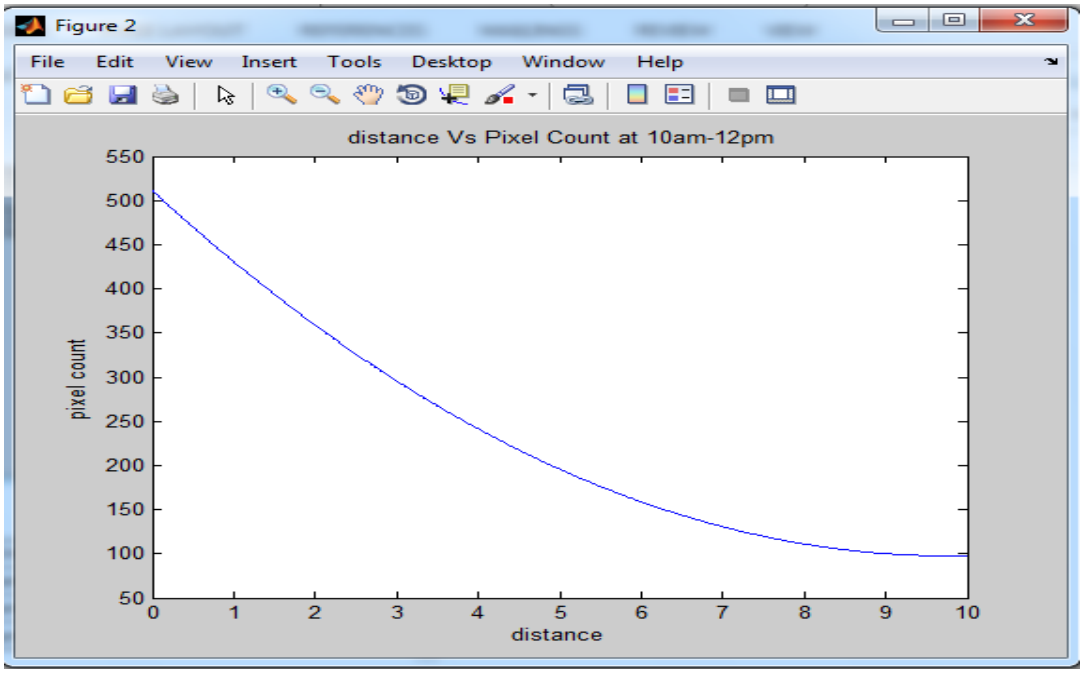

Fig. 7(d) Distance Vs pixel count at 10am to 12 pm

3) Time Slot Analysis at 12pm-2pm

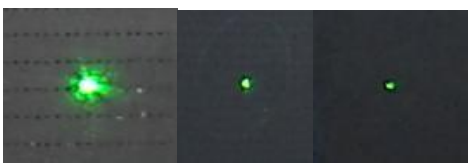

Fig. 8 (a) Original Images (2m, 5m, 10m)

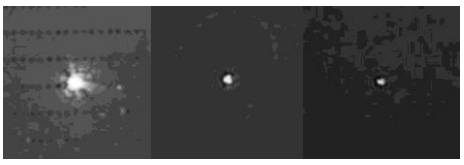

Fig. 8 (b) Binary Images of Original Image,(2m, 5m, 10m)

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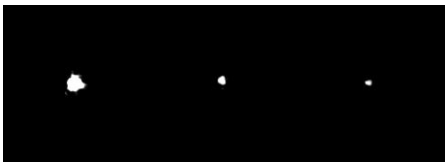

Fig: 8(c) Enhanced Binary Images (2m, 5m, and 10m)

Table.3(12pm– 2pm Pixel counts at 2m,5m,10m distances)

Time Slot	Distance	Pixel count
12 pm - 2 pm	2	341
12 pm - 2 pm	5	198
12 pm - 2 pm	10	101

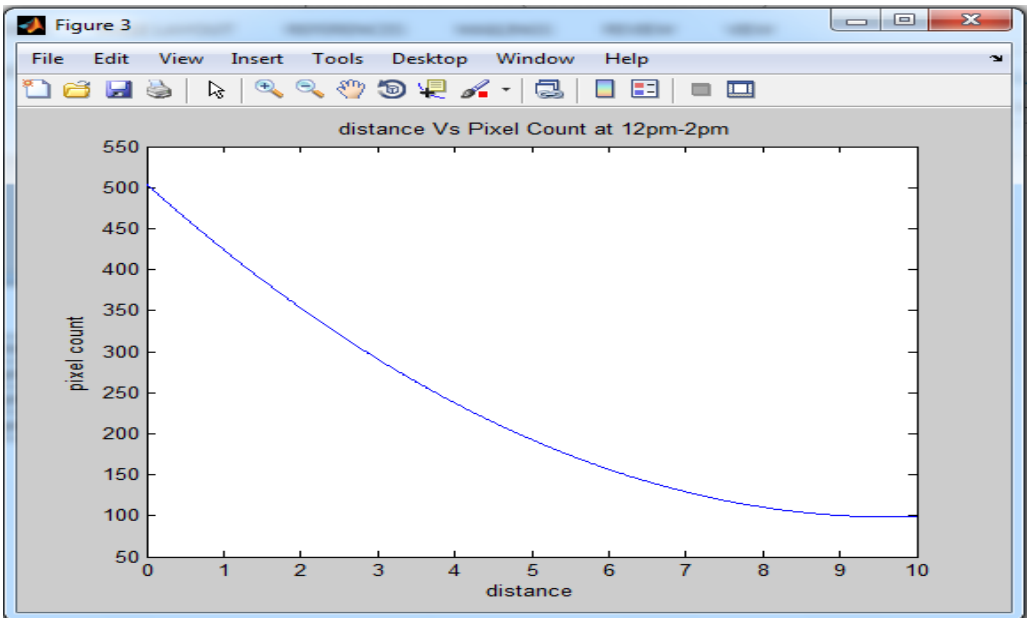

Fig: 8(d) Distance Vs pixel count at 12pm to 2 pm

4) Time Slot Analysis at 2pm-4pm

Fig. 9 (a) Original Images (2m, 5m, 10m)

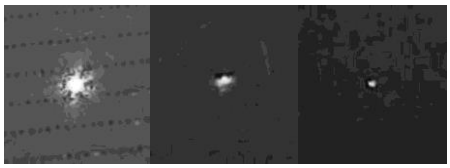

Fig. 9 (b) Binary Images of Original Image, (2m, 5m, 10m)

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Fig. 9(c) Enhanced Binary Images (2m, 5m, 10m)

Table.4 (2pm– 4pm Pixel counts at 2m,5m,10m distances)

Time Slot	Distance	Pixel count
2 pm - 4 pm	2	348
2 pm - 4 pm	5	194
2 pm - 4 pm	10	98

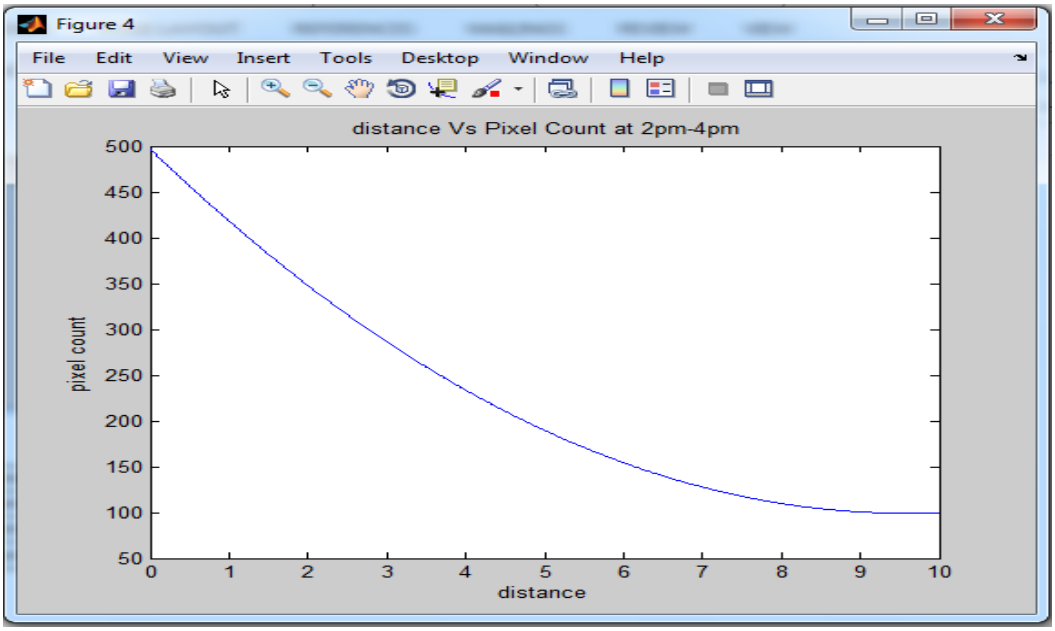

Fig. 9(d) Distance Vs pixel count at 2pm to 4 pm

5) Time Slot Analysis at 5pm-7pm

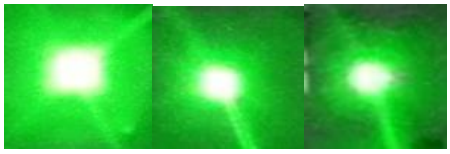

Fig. 10 (a) Original Images (2m, 5m, 10m)

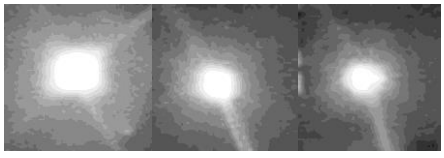

Fig. 10 (b) Binary Images (2m, 5m, 10m)

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Fig. 10(c) Enhanced Binary Images (2m, 5m, 10m)

Table.5 (12pm– 2pm Pixel counts at 2m,5m,10m distances)

Time Slot	Distance	Pixel count
5 pm-7 pm	2	391
5 pm-7 pm	5	205
5 pm-7 pm	10	120

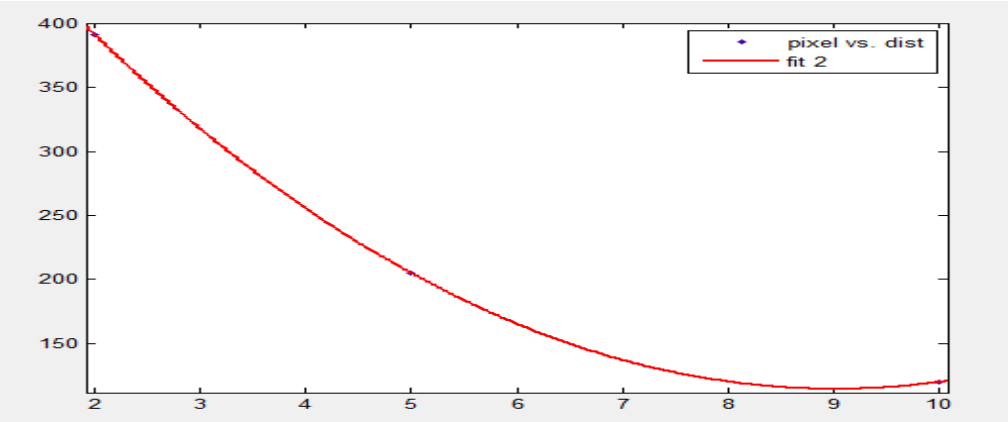

Fig. 10(d) Distance Vs pixel count at 5pm to 7 pm

5. RESULTS AFTER FILTRATION OF IMAGES USING IMAGE PROCESSING IN MATLAB

Table .6

SPECIFICATION	TIME	ACTUAL DIST.	MESURED DIST.	EFFICIENCY
GREEN LASER POINTER + 8 MEGA PIXEL CAMERA	8 -10 AM	2m (TWO METERS)	1.983	99%
	10 – 12 PM		1.995	99%
	12 – 2 PM		2.03	99%
	2 – 4 PM		1.97	98%

This table 6 shows that the alternative approach of Hybridization of camera ,laser pointer with Image processing toolbox based image programming gives us satisfactory results for two meter images filtration process plays an important role for maintaining efficiency.

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Table .7

SPECIFICATION	TIME	ACTUAL DIST.	MESURED DIST.	EFFICIENCY
GREEN LASER POINTER + 8 MEGA PIXEL CAMERA	8 -10 AM	5m (FIVE METERS)	5.025	99%
	10 – 12 PM		5.03	99%
	12 – 2 PM		5.05	99%
	2 – 4 PM		5.03	99%

This table 7 shows that the alternative approach of Hybridization of camera ,laser pointer with Image processing toolbox based image programming gives us satisfactory results for five meter filtration process plays an important role for maintaining efficiency.

Table .8

SPECIFICATION	TIME	ACTUAL DIST.	MESURED DIST.	EFFICIENCY
GREEN LASER POINTER + 8 MEGA PIXEL CAMERA	8 -10 AM	10m (TEN METERS)	9.97	98%
	10 – 12 PM		9.97	97%
	12 – 2 PM		10.05	99%
	2 – 4 PM		9.94	99%

This table 8 shows that the alternative approach of Hybridization of camera ,laser pointer with Image processing toolbox based image programming gives us satisfactory results for ten meter images, filtration process plays an important role for maintaining efficiency.

GRAPHICAL REPRESENTATION

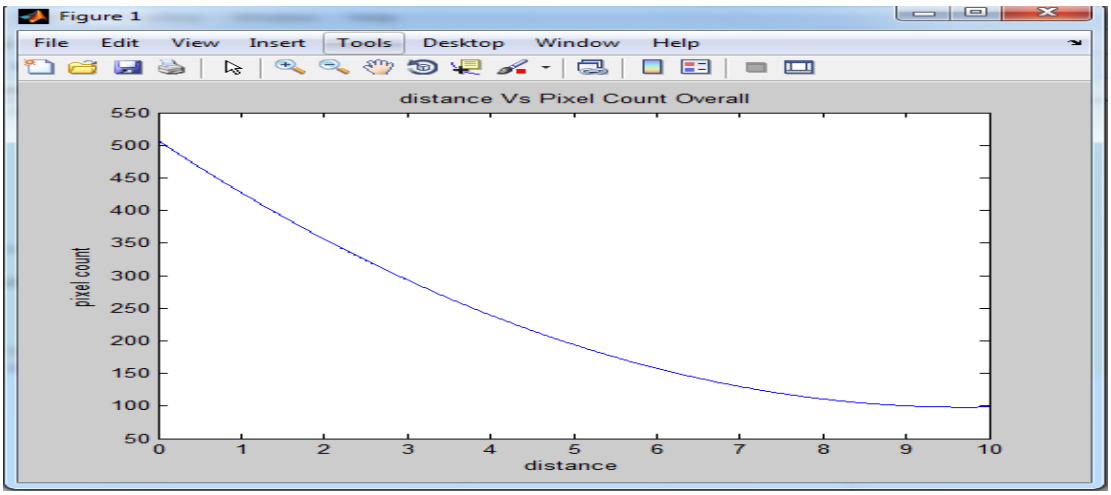

Fig. 11 Distance verses pixel count inside.

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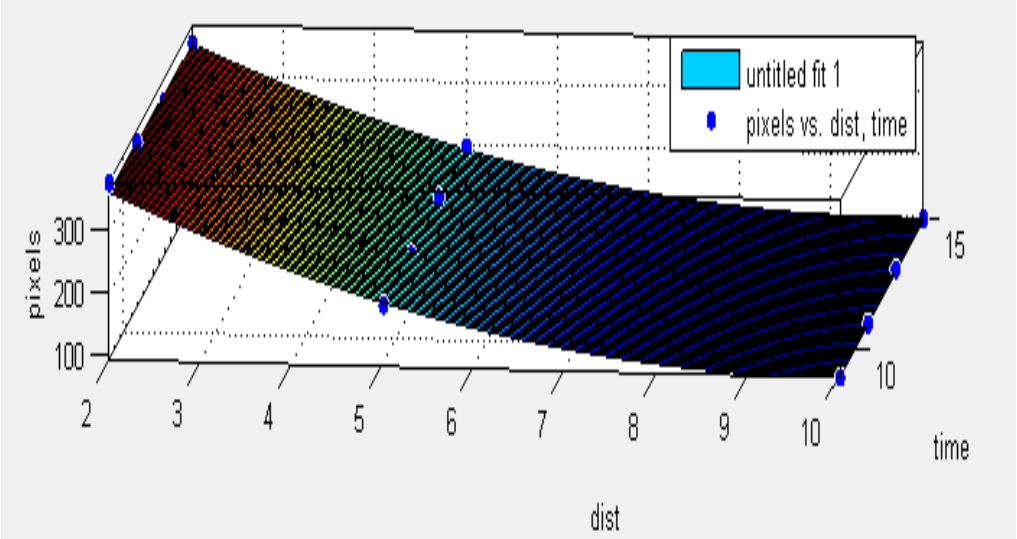

Fig. 12 Distance verses pixel count and time outside.

This three dimensional graph concludes that distance is inversely proportional to pixel area,Daylight and sunlight are not a constant source, because they change hourly with the weather, season, location, and latitude. This changing daylight cannot affect our experiment hardly because of coloured laser and laser colour based programming hence there is negligible difference in readings with varying time or best results are obtained at about 5 to 7 pm. Most appropriate results are obtained this time.

This experiment needs a high beam laser, not any specific color laser sothere should not be any difference in the overall result if other colour lasers are used. More pixels mean more area of laser pixels. However for a particular mega pixel camera the pixel versus distance plot remains almost similar to the plot shown in this paper. Weather/ Season should not affect the method as along as view is clear and there is no mist. Position of Camera is approximately 1 meter above the ground. This 3d graph shown here concludes that distance is inversely proportional to pixel area. This proposed method's program is trained and tested so that it can measure distance and height within the specified range. Program can be trained for higher distances also after maintaining this relationship. High resolution camera can only change picture quality without effecting vision algorithm and research objective.

6. CONCLUSION

This design focusing on robot vision, which has been successfully developed and practiced. The results have been satisfactory. The graphs obtained as displayed in figures are based on the practical values attained after experimentation. The algorithm can further be refined to measure distances of every type of object more than ten meters& measuring height of target/pole/wall/object greater than ten meters and this hybridization of camera , laser pointer and image programming will results in an instrument of measuring distance as well as height .

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