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A Comparison On Image Based Distance Estimation Techniques, For Robot Vision Using Single Video Capturing Device

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***Abstract*: This paper presents the comparison on Image based distance estimation methods for machine/robot vision used in Robot applications. Robot vision is the heart of Robot applications & Distance measurement is one of the advantageous tasks taken from machine/robot in several automated works. There are various methods of Target distance estimation but White Line tracing algorithm is the modern distance estimating approach introduced for "*Robotic basketball player*". Here this paper compares pros & cones of White line tracing algorithm and Laser Beam Pixel Area based new approach. This latest methodology is fast, accurate and easy to set up, with this tactic possible future refinements are also discussed.**

***Keywords*: Camera, Green laser pointer, Image programming, robot vision.**

I. INTRODUCTION

Generally in the last years, the eventual purpose of researchers is the construction of autonomous vehicles that can substitute humans in time demanding tasks. To this end, industries put efforts on developing machines proficient of assisting people in daily life. Between all the functions 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. The time has gone when humans were considering as 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 [1].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 natures of their parts require integrated control systems accompanied with advanced visual feedback. 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 bases 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 analysis of a whole image frame was required. This paper, gives comparison for best robot vision between these two methods named as White line algorithm based and LBPA i.e. laser beam pixel area, Image based Distance Measurement Technique for Robot Application. While focusing on Robot vision both the system requires single video camera.

II. DESCRIPTION OF METHODS

To understand the proper functioning of robot vision this paper compares distance measurement methods based on pixel counts.

A. White line Tracing algorithm
B. LBPA Image based technique

A. *White line tracing algorithm*

When Robot is a basketball player and if there is a target, to make goal then, how robot will use its vision, and mind, to estimate distance of that basket??Basically, the term *Distance measurement* produced from here. On measuring distance, robot vision system uses modern White Line Tracing algorithm &MATLAB programming. For White line Tracing algorithm there is a need to draw a broad white line (vertically & horizontally both) or a pole of white colour in front of black background (with single white line drawn horizontally). A normal camera is also needed for clicking real time images and MATLAB programming provides pixel counts.

On the horizontal white line, a number of discrete junctions are fixed. The user inputs the point, from which he wants the ball to be thrown, as achieved distance from using this algorithm basically performs a ball throwing mechanism as here robot is a basketball player.

The maximum distance considered for throwing the ball is 0.66 meter (from the pole) and minimum distance is 0.11 meter (from the pole). This distance range is measured on the straight white line starting from the base of the pole and aligned to it perpendicularly. There are five points fixed at a distance of 0.11m, 0.22m, 0.33m, 0.44 m and 0.66m from the pole. These points are identified as white junctions for better judgment. The robot can start from any point beyond 0.66m mark on the white line as in Fig1

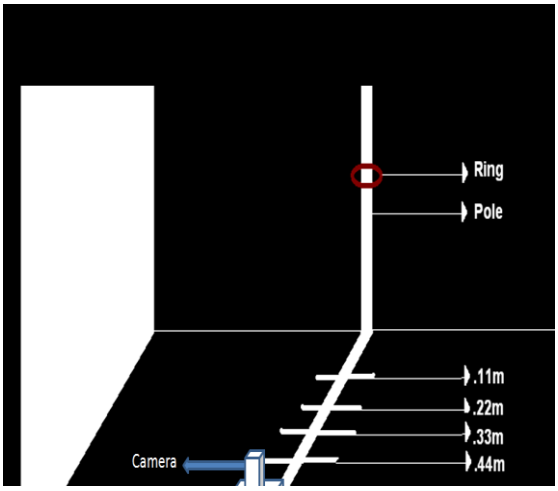

Fig. 1 Arena for practical run

The distance of these points from the pole is saved in the MATLAB as corresponding pixel area values. The robot moves along the white line and takes the snapshot from each predefined point. This Image is sent to the computer where it is processed on the basis of the pixel area of the pole. The MATLAB uses a function to calculate the area of all white pixels from the snapshot of the pole. This area decides the distance of the pole from the robot.

Image Processing on MATLAB for estimating Distance

Under this WL algorithm, the on-board camera takes the snapshot of the solid colour pole (white in this case) situated in front of a solid colour background (black in this case). This image is passed through a filtering algorithm which is developed to refine the image at the points where contrasting pixels meet. This algorithm gives a sharpened image (Fig 2) as output which contains only contrasting pixels i.e., pixels having values 0, 0, 0(black) or 255,255,255 (white). This image is passed through another function defined in MATLAB which counts the number of white pixels present in it to calculate the pixel area of the pole in the image.

Fig. 2 the refined image of the pole and background after applying algorithm

The graph for variation between area and corresponding distance from pole was found out to be as shown in Fig 3 which can be used to find out area of pole from any point between 0.11m to 0.66 m.

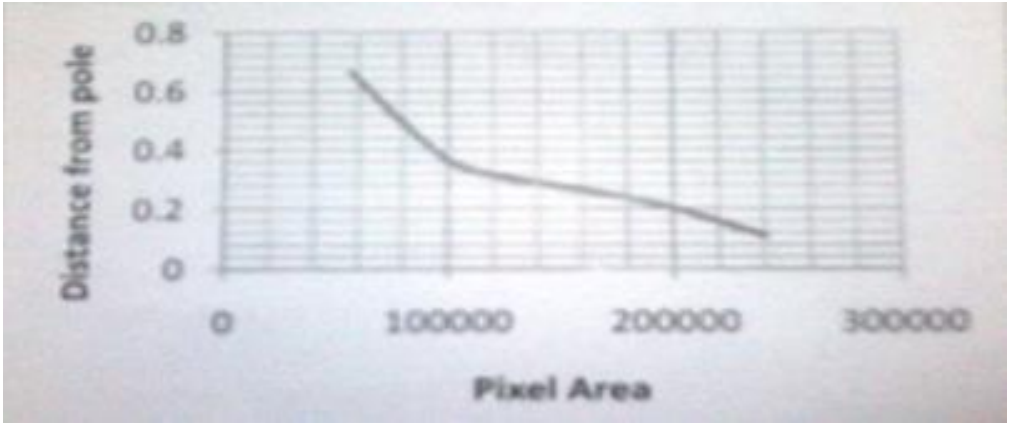

Fig. 3 Variation of pixel area of pole with distance

The area coming out as an output from this function is applied as input to another algorithm. This algorithm works on a predefined database. This database contains approximate value of pixel area of pole from each of five junctions. Each of these areas is associated with its position index from the pole, i.e. 0.11 m is 1st point, and 0.22 m is 2nd point and so on. The desired point, passed as argument to *Begin* function is saved in a variable say *desired_junction_area*. Since each area in database has its index associated with it, the area of the pole from the desired point is known. When robot calculates area from present point at run time, it compares it with *desired_junction_area*and if comparison returns true, MATLAB sends a character as a command to the microcontroller to throw the ball. So, this description shows how distance is measured for robot application using white line tracing algorithm & single video capturing device. This section focuses only on the way how white line tracing algorithm with MATLAB programming & single camera measures distance of the target/ object.

Its result basically shows in Fig 3 which is pixel area of pole verses distance graph. This is totally indoor because in this experiment there is no discussion of light variation or natural light variation with respect to distance and time.There are some limitations in earlier approach (WL Algorithm) : - 1)This method will not give satisfactory performance for distance more than 1 meter. 2) It is completely indoor.

B. *LBPA Image based technique*

This latest approach, LBPA (laser beam pixel Area) Image based Technique presents a distance & height measurement method. It is one of the simple, fast and accurate method based on pixel counts. The basic idea is the use of a hybrid system which is a combination of camera, generally available high beam laser pointer& MATLAB programming. For MATLAB programming Image processing/acquisition toolbox is used. Fig 4 shows schematic view of hybrid system to understand it properly.

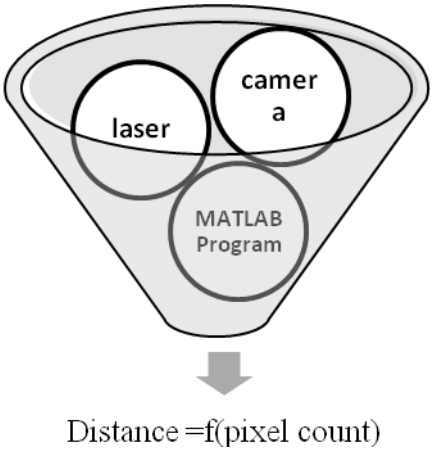

Fig. 4 Hybrid System

This method suggests a research that, camera will take snapshot of laser projected spot from random distances that image will undergo a process in which MATLAB program will detect color of laser pointer ,detecting center of that spot ,filtering this image ,cropping it and counting its pixels. Hence this technique has two main phases first capturing Images from different distances& second MATLAB programming for counting pixels.

There are three steps involved for height measurement, first, Fix camera and laser pointer arrangement in front of the target, slightly above the ground, and so that laser falls on the target perpendicularly. Nowcapture image of that laser spot, suppose that it is taken from distance d_1.In second step, tilt that laser camera combination slightly from the same place to fall laser light on the top of the target & again click its image say distance d_2.In the third stage, on assuming $d_1$as base of a right angle triangle & d_2 as the hypotenuse than it is easy to calculate perpendicular distance say d_3, using conventional Pythagoras theorem. Here perpendicular distance $d_3$is nothing but the height of the target/object.

For Snapshots, camera resolution is very important for best results, to make this experiment less costly, this will use commonly available camera between five to ten megapixels and very commonly available red or green color laser pointer. Here camera is fixed, from where images are taken of both laser projected spots (from distance d_1&d_2) ,and this images are going through a programmed made in MATLAB using image processing toolbox which will able to give pixel count of that image. *As distance is a function of pixel count*. By establishing a relationship between pixel counts and distance two different distances are obtained through which height of the object can be measured, wall or target as these distances are base and hypotenuse of right angle triangle. On further study & research, proposed technique will applicable for building height measuring instrument too.

In this method hybridization of laser beam, camera and image processing based program for counting pixels is required. 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 between up to 10 meters. 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.

So, LBPA approach is based on distance= f (pixel count), which is 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. In the experiment of measuring distance and height, both coding & experiment are done, coding for achieving research objective and experiment for obtaining images.

To understand the proper functioning of this research for robot vision system it is categorized into two prominent divisions –

A. Basic robot vision using camera and laser pointer.

B. Image Processing on MATLAB

The essential clue is that fixed camera (8 megapixels in this case), laser pointer (Green in color) combination aligned to target perpendicularly starting from the base or lower end of the target gives laser projected spot's image after filtration which will gives as distance $\boldsymbol{d_1}$, from the same place pointer's tip tilted towards the peak or upper end of the target throw laser light (Green in this case) from the same position and clicked another image of laser projected spot after filtration, will gives $\boldsymbol{d_2}$ distance. As distance is a function of pixel count is considered, after obtaining these two distances it will be easy to find height by applying *Pythagoras theorem*. The maximum distance considered for measuring height is ten meters (from the target/ pole/object). These images were taken in both indoor and outdoor places.

For indoor images were captured 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 also two meter, five meter & ten meter snapshots were captured 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 to some extent in this experiment because color detection algorithm are made as laser is of green color, Use of black paper is required so that laser is more visible in day time. Here the process starts from loading image on programmed, then that code will detect color firstly which is green in this case and converting it in to binary, then Morphological operation performed in the region of interest and normal filtration is done. Using function $Z=f(x,y)$ by curve fitting tool box of MATLAB where Z denotes distance ,x denotes pixel count & y denotes light intensity (for outdoor experiment).Estimating distance $\boldsymbol{d_1}$, similarly applying process from start till function Z & now Z is the another distance $\boldsymbol{d_2}$ .Now by using *Pythagoras theorem* thus how height is obtained. For Noise reduction and improvement in image filtration is needed. This process starts from color Image and cropping it then color contrast enhancement after that de-blurring now green color is detected than center detection, cropping sides of laser area, converting it into binary image then refined pixel count are obtained. The graph for variation between pixel count and corresponding distance was found out to be as shown in Fig 5 which can be used to find out distance as well as height of target/object/wall.

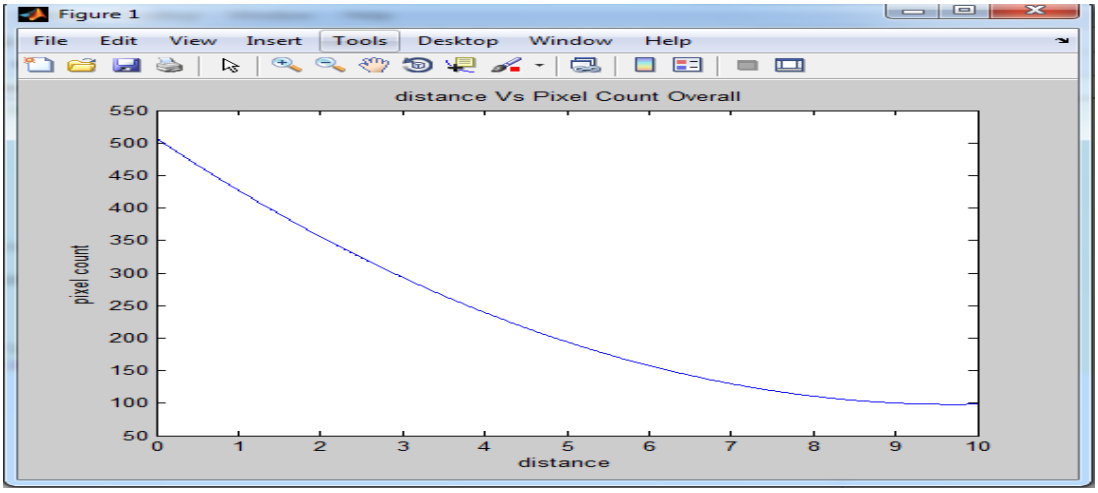

Fig. 5 Distance verses pixel count inside

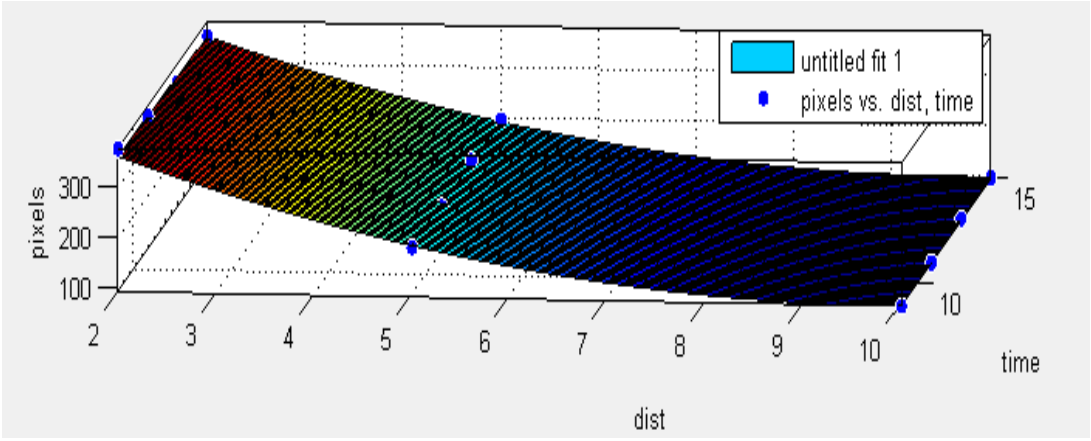

Fig. 6 Distance verses pixel count and time outside

This alternative approach of Hybridization of camera ,laser pointer with Image processing toolbox based image programming gives us satisfactory results for two, five & up to ten meter images filtration process plays an important role for maintaining efficiency. 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 this experiment hardly so colored laser is used and made laser color based programming hence there is negligible difference in readings with varying time. Most appropriate results are obtained at about five to seven pm.

This experiment needs a high beam laser, not any specific color laser so there should not be any difference in the overall result if other color lasers are used. More pixels mean more area of laser pixels. However for a particular mega pixel camera the pixel verses 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 one meter above the ground. This proposed method's program is trained and tested so that it can measure distance and height within the specified range.

III. CONCLUSION

This design is focused on robot vision, which has been successfully developed and practiced. There are some limitations in White line tracing algorithm that are : - 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. In proposed work or in LBPA image based algorithm there are some Merits:-1) It can measure distance between up to 10 meters. 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. 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/height of ten meter or more 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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