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A Review on Image Based Target Distance & Height Estimation Technique Using Laser Pointer and Single Video Camera for Robot Vision

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***Abstract*: One of the problems that affect in development of vision based machine is 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 proposed methodology presents techniques for measuring distance as well as height of the target/object/wall using Laser beam pixel area (LBPA) based Image programming technique used by an hybrid system which is a combination of camera and laser pointer. 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. It is not a robot building hunt basically it focuses on machine vision or robot vision. Results in past literature are shown and discussed in this paper. This approach is possible & future refinements of this also discussed.**

Keywords: **Image processing, Computer vision, Camera, Green laser pointer.**

1. INTRODUCTION

Generally in the last few 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 capable of assisting people in daily 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 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 & here this paper focuses on robot vision. The aim of this paper is to improve robot vision to estimate distance as well as height using 2D photograph/image only. This idea comes from a literature which is also discussed here on this review paper, that if robot is a basketball player so how he can be able to estimate distances, where to do goal? How far that basket is? If this mind is given to a robot so that he can estimate distances those techniques of measuring distance using images are discussed here in detail. A huge progress has been made in this area but a lot is still left to achieve. 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 methods which are as discussed on the basis of literatures.

1.1 New Approach of Ultrasonic Distance Measurement Technique in Robot Applications:

In 2000, G. Hueberl , T. Ostermann , T. Bauernfeind, R. Raschhofer, and R. Hagelauer, et al [7] deals with the development of prototype of an airborne ultrasonic distance measurement system applied to an autonomous mobile robot.

The essential point of this scheme is the use of a wideband continuous random signal where the recognition of the echo delays (time of flight) is done by cross correlation technique. Furthermore a Doppler frequency shift caused by robot or obstacle movement is estimated and included in the algorithm. The distance measurement entity uses a wide band continuous signal in the transmission frequency range of ultrasonic transducers The signal is transmitted by an ultrasonic transducer, reflected by an obstacle and received by another transducer where the signal is detected. This paper deals with the use of an ultrasonic measurement entity based on a continuous signal technique implemented in an autonomous robot vehicle. Major functional components of the distance measurement and control system are analog devices, microcontroller, analog to digital, digital to analog converter, Operational amplifier, Schmitt trigger, Transmitter, Receiver ,Sensor for measurement of wheel velocity making its circuitry more complex with totally hardware based approach. For obstacles two cylinders were used so that robot finds its way between two cylinders by estimating the distance to the cylinders. Ultrasonic based techniques are among the most commonly used methods. The measuring principle of this method is the estimation of the time-of-flight (TOF) of an ultrasonic burst (high-frequency sinusoidal pulse train) generated by a proper transducer; i.e. the time elapsing between the firing up of the transducer and the detection of the echo originated by any discontinuity or reflector in the propagation medium. The desired information, *x*, concerning distance (the object of unknown distance acts like a reflector), or level (the surface of the fluid of unknown level gives rise to a discontinuity), or integrity (any crack in the structure under test disturbs medium continuity) is then gained through a very common and straightforward expression:

$$X=\frac{c.t}{2} \qquad (1)$$

Where *c* is the propagation velocity of the ultrasonic burst, and *t* is the TOF estimate. Two sequential steps generally characterize TOF-based measurements.

Major sources of in accuracy can be found in additive noise affecting the acquired ultrasonic signal, shape distortion of the received echo, and dependence on temperature of the propagation velocity. No. of functional components of the distance measurement and control system are analog devices, microcontroller, analog to digital, digital to analog converter, Operational amplifier, Schmitt trigger, Transmitter, Receiver ,Sensor for measurement of wheel velocity making its circuitry more complex with totally hardware based approach. This proposed technique is very simple to understand and apply (from experiment point of view) .It is basically a semi hardware approach, with camera, laser pointer & Image processing based program. 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. It is not a robot building hunt basically it focuses on machine vision or robot vision, for distance and height measurement.

1.2 Vision Based Navigation for an Unmanned Aerial Vehicle:

In 2001, Bruno Sinopoli ,MarioMicheli, GianlucaDonato and T. John Koo et. al [7] proposed a system for autonomous navigation of unmanned aerial vehicles (UAVs) based on computer vision. This paper from T**he Robotics and Intelligent Machines lab at UC Berkeley**, talks about an autonomous navigation system for unmanned aerial vehicles (UAVs). Their UAV is equipped with on-board cameras and is provided with noisy estimates of its own state, coming from GPS/INS. The mission of the UAV is low altitude navigation from an initial position to a final position in a partially known 3D environment, while avoiding obstacles and minimizing path length. This paper uses a hierarchical approach to path planning. The paper distinguishes between a global offline computation, based on a coarse known model of the environment and a local online computation, based on the information coming from the vision system. The UAV builds and updates a virtual 3D model of the surrounding environment by processing image sequences and fusing them with sensor data. Based on such a model the UAV will plan a path from its current position to the terminal point. It will then follow such path, getting more data from the on-board cameras, and refining map and local path in real time. The key thing to note here is that the UAV makes use of an *a priori*, inaccurate, graph model of the terrain to plan an initial, coarse path. Then it uses wavelets to filter the map to the desired level of abstraction. A few waypoints are selected based on the desired objective. At this level of abstraction it performs a global offline computation on the entire graph. Computation of optimal path over the complete terrain model is very intensive. At this stage, the planning is performed deterministically. They use standard optimization algorithms for shortest path computation, such as *Djikstra* or A.

Once the 'strategic' coarse-grained path is computed, the UAV then computes the fine-grained 'tactical' path between the way-points computed earlier. For this it uses vision based algorithms operating upon their vision sensor data, all along the way to avoid obstacles and reach the destination. Thus, this way they are able to achieve autonomous navigation of their UAV. But disadvantage of this approach has its cost in terms of flexibility because now each intended terrain has to be

'processed' by the strategic planner and therefore adding a new terrain might involve more work. That being said, today there are services (like Google Earth, for example) which can furnish satellite images based on Latitude and Longitude and it remains to be seen if such services can be leveraged for this type of navigation. This proposed technique is very simple to understand and apply (from experiment point of view) .It is basically a semi hardware approach, with camera ,laser pointer & Image processing based program. 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. It is not a robot building hunt basically it focuses on machine vision or robot vision, for distance and height measurement.

1.3 Using Laser and Vision to Locate a Robot in an Industrial Environment: A Practical Experience:

In 2005, Guillem Alenya, Josep Escoda, Antonio B. Martinezand CarmeTorras, et.al [6] introduced a research project trying to combine the precision of laser-based local positioning with vision-based robot motion estimation. A practical experience of mobile robot localization is presented. A heavy industrial robot was placed in a real production plant, and some experiments including data collection were performed. In this paper, we describe a practical experience conducted in the warehouse of a beer production factory in Barcelona. A fully flexible navigation of autonomous vehicles in industrial environments is still unsolved. It is hard to conciliate strict precision requirements with quick adaptively to new settings without undergoing costly rearrangements.

As far as noncontact distance measurement is concerned, ultrasonic-based and laser-based techniques are among the most commonly-used methods. Unfortunately, measurement accuracy via the laser- and ultrasonic-based methods heavily depends on the surface reflectivity of the object under measurement. If the surface reflectivity is poor, the measuring system generally performs poorly or not at all. These methods also have difficulties in recording images of the objects while measuring distance.

1.4 Angle Invariance for Distance Measurements Using a Single Camera:

In 2006 J. C. Aparicio Femandes , J. A. B. Campos Neves et. al.[5] introduced a distance measure system using angle invariance method for mobile robots, such as those used in middle size robotic football league, move on a plane surface carrying a single fixed camera & images obtained with this type of system using the usual linear(or quasi-linear) system. Walls and the goal-keeper robot are the obstacles in this example and the free space in front allows the possible movements to be planned. A target can also be defined for instance, it could be defined as the right edge of the goal area, marked T on the image. How far is it and at what direction? This is the question this approach gives an answer for, using a Single conventional camera and knowledge about the geometric characteristics of the environment. For instance, in the case of the target T is on the floor. This is used to simplify the calculation process, as described in the following sections. Other cases,if the red ball in its centre is at known height - half diameter of the ball. For these cases, the general 3D location problem becomes a 2D situation that can be solved using just one image. The common central projection used in linear image produces a 2D image, from which only two coordinates can be extracted. For the central projection system, any point in a straight line to the lens optical centre of the lens has the same image pixel representation. The distance from the object to the optical centre is the unknown coordinate to be obtained by processing other information. In the case of mobile robots, the movement is usually on a plane surface, meaning that height and camera orientation remain constant. If the object is also at a fixed height, its possible positions define a horizontal plane, and its particular location can be obtained by intersecting this plane with the straight line defined by the corresponding image point on the sensor and the lens optical centre. This work presents both a calculation method and also a calibration procedure for this setup. This paper concerns the use of linear optical systems, where angles to the optical axis are maintained for both image and object sides. For optical systems with radial distortions, such as barrel and pincushion types, a one-dimensional function relating object and image side angles can be used to compensate the non-linearity and allow this approach to be used. Also in vision systems, where mirrors are combined with normal lens to allow 360 viewing, similar image-object angular relationships can be used to compute target positions. But the Problems in this technique are Correspondence, calibration & synchronization. As compare with it, laser beam pixel area based proposed method is easy to calculate distance as well as height of the target/object/wall for robot/machine vision up to ten meters, easy to set up ,less complex approach with portability of hardware.

1.5 Vision Based Distance Measurement System Using Single Laser Pointer Design for Underwater Vehicle:

In 2009 Muljowidodo A, Mochammad A Rasyid, Sapto Adi N & Agus Budiyono et al.[4] introduced a Vision based navigation has been investigated and an approach by using single laser pointer .UUV is usually equipped with camera as the eye of operator and camera supported by computer vision can also give some important information .The design of

the system and algorithm to be used for calculating horizontal and vertical distance between an object and camera. Beside the camera, a laser pointer is used for the set up and computer is used for image processing and data calculation. There are two major works in designing this distance measurement system. First is obtaining a real time image processing algorithm need for laser spot /mark detection .Second is finding a scaling factor or formula that convert the object position (pixels) on the image into real world position (meters).This technique deals with underwater unmanned vehicle used for distance measurement using red laser pointer by making spot and Image processing algorithm. There are many well-known algorithm such as MSER , SIFT etc to be used for object detection and recognition but it takes few hundreds milliseconds up to few seconds for complex image per frame. Thus it is difficult to be used as part of a real time control system. As image of laser spot is taken by camera which is kept inside water from experiment point of view it is difficult to achieve. Firstly we have to arrange shielding to protect camera and laser pointer than between camera and target there is a region of water so there is some refraction index which must affect the image information. The proposed idea is somewhat uses the same thing like laser pointer and camera of eight mega pixel but medium is air in both indoor and outdoor region and experimentation is possible. There is no complexity in experiment.

1.6 Distance measurement based on pixel variation of CCD images:

In 2009 by Chen-Chien Hsu, Ming-Chih Lu, Wei-Yen Wang, Yin-Yu Lu et.al. [3] introduced a distance measurement method based on pixel number variation in images of digital cameras by referencing to two arbitrarily designated points in the image frames .It is apparent that the actual distance between the reference points will not change no matter how the digital camera moves backwards or forwards along the photographing direction. However, objects in the image frame captured by the camera do vary in size if the camera moves backwards or forwards along the photographing direction. That is, pixel counts between the reference points in images will be different if the digital camera moves along the photographing direction. By establishing a relationship between the displacement of the camera movement and the difference in pixel counts between the reference points in the images at different photographing distances, it can measure the distance of a remote object. Here in using this approach a precise distance between the reference points is not required. Two arbitrarily selected points by the user on the CCD panel covered by the viewing angle of the camera can be adopted as the reference points in achieving a reliable measurement. In measurement based on variation of pixel counts of CCD Images some steps are needed which are finding Relationship between distance and variation of pixel counts then Selection of reference after that Determination of the optical origin for CCD cameras and then Hardware design for realizing distance measuring System Added-on circuit in implementing the distance measuring system Experimental results have shown that the measurement accuracy using this method is comparable to that of an ultrasonic rangefinder for short-distance measurement, overcoming the problems and difficulties encountered in conventional image-based distance measuring methods. As shown in the paper, the proposed measuring system has demonstrated itself as a simple way in measuring distances while simultaneously recording images for applications which require short-distance measurement. But laser beam based distance measurement system able to measure long distance measurement up to 10 meters with using eight mega pixel camera which is high resolution as compare to digital camera and gives good picture quality without losing information.

1.7 Distance measuring based on stereoscopic pictures:

In 2008 by JernejMrovlje and Damir Vrancicoffers et. al. [2] introduced a method using two cameras for measuring distance Generally there are two ways of measuring the distance to some objects which can be divided into active and passive ones. The active methods are measuring the distance by sending some signals to the object [2, 4] (e.g. laser beam, radio signals, ultra-sound, etc.) while passive ones only receive information about object's position (usually by light). Among passive ones, the most popular are those relying on stereoscopic measuring method.

The main characteristic of the method is to use two cameras. The object's distance can be calculated from relative difference of object's position on both cameras [6]. Stereoscopic pictures allow here to calculate the distance from the camera(s) to the chosen object within the picture. The distance is calculated from differences between the pictures and additional technical data like focal length and distance between the cameras. The certain object is selected on the left picture, while the same object on the right picture is automatically detected by means of optimisation algorithm which searches for minimum difference between both pictures. The calculation of object's position can be calculated by doing some geometrical derivations. The accuracy of the position depends on picture resolution, optical distortions and distance between the cameras. Stereoscopic means two cameras placed adjacent to each other can provide depth or distance or height information using its stereo vision. Processing the data received from a camera is difficult for a robot with minimal processing power and memory. If opted for, they make a valuable addition to your robot. There are other stretch and bend

sensors which are also capable of measuring distance. But, their range is so limited that they are almost useless for mobile robots. Problems in Stereo-vision are Correspondence, calibration, synchronization, shadow & sunlight problem. Basic advantages are Robustness, use to calculate shape of object, Human motion detection is possible and disadvantages are the system must be pre-calibrated, has to be used in indoor environment, shadow and sunlight present in the experimental area makes difficult in distance calculation.

1.8 Pixel Area Based Target Distance Estimating and Corresponding Target Hitting Force Calculating Autonomous Robot Using Single Video Device:

In 2011 by Astha Jain et. al. [1] developed robot works on an easier algorithmic to estimate the distance of associate object by using one camera. Actually this paper presents a basketball playing robot works on white line algorithm estimates distance & calculating hitting force to basket the ball. Simply, When Robot is a basketball player and if there is a target to do goal by robot, so how robot will use its vision and mind to estimate distance of that basket to do goal.

Distance measurement term basically used here. So, on measuring distance, robot vision system uses orthodox White Line Tracing algorithm & for working of mind MATLAB programming is used .For White line Tracing algorithm we need to draw a broad white line or we have to use pole of white colour in front of black background vertically and horizontally both and a normal camera is also needed because both methods depends on pixel counts so for pixel count image is compulsory and for image, camera is essential.

On the 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

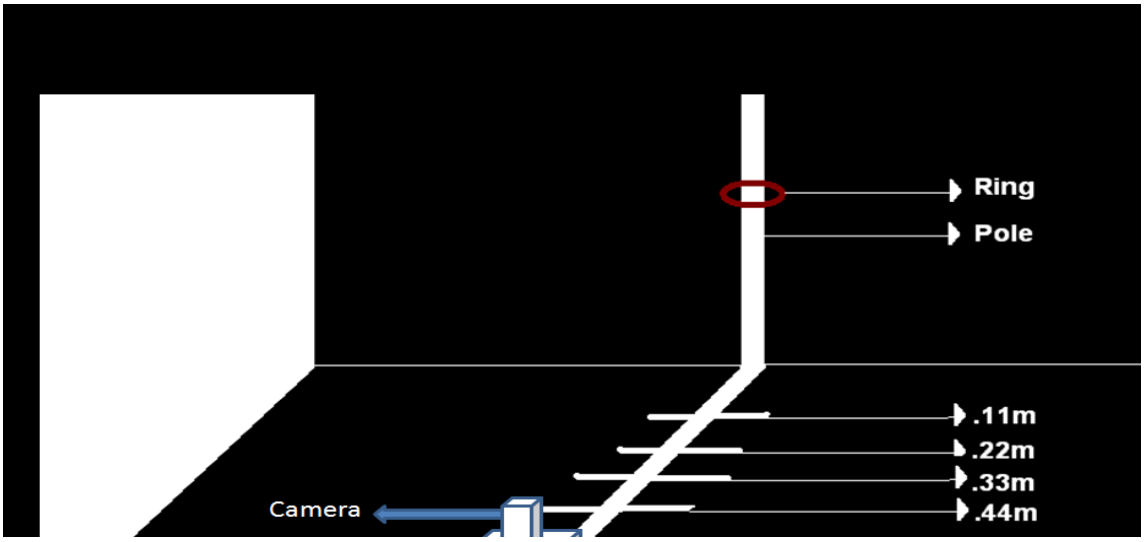

Fig. 1 Arena for practical run

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 WLT Algorithm:

Under this 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 either 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.

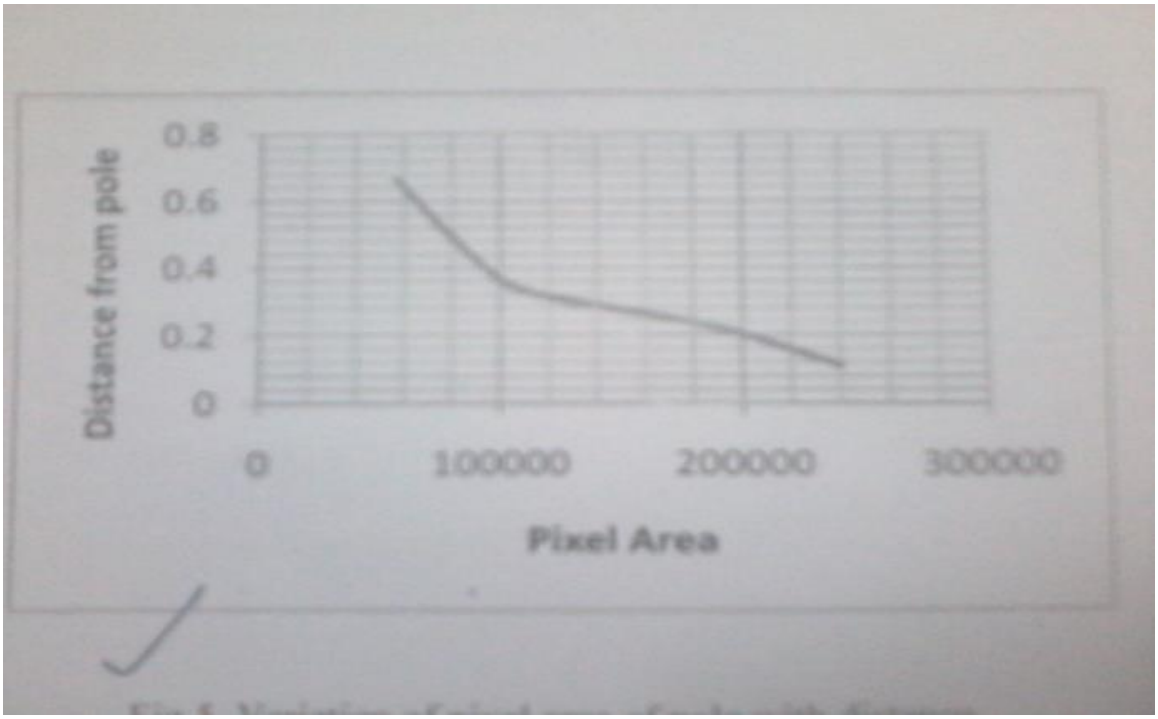

Fig. 3 Variation of pixel area of pole with distance

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, we know the area of the pole from the desired point. 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 pixel area of pole verses distance graph and 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 in image from which we are obtaining pixel count. There are some limitations in earlier paper that are : - 1) It was not able to measure distance more than 1 meter. 2) It was totally indoor.

2. PROPOSED METHODOLOGY

This method, LBPA i.e. laser beam pixel area with Image based Distance Measurement Technique in Robot Applications presents a distance measurement method based on pixel count in images taken by 8mp cameras by referencing to two laser-projected spots in the object/target/wall using Green laser pointer, to make this experiment less costly ,commonly available camera of 8 megapixels and very commonly available green laser pointer will be experimental tools. Here camera is fixed from where images are taken of both laser projected spots ,and this image is going through a programme made in MATLAB using image processing tool box which will able to give us pixel count of that images as we have made our objective function as distance is a function of pixel count. By establishing a relationship between pixel counts and distance we get two different distances, through which we can measure height of the object, wall or target as these distances are base and hypotenuse of right angle triangle. One of the advantages in using the proposed measuring approach is that it can make 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 more than 1 meters. 2) Previous techniques were a hardware based research of distance estimation but this is semi hardware programming 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 framework of this method is as shown in Fig 4.

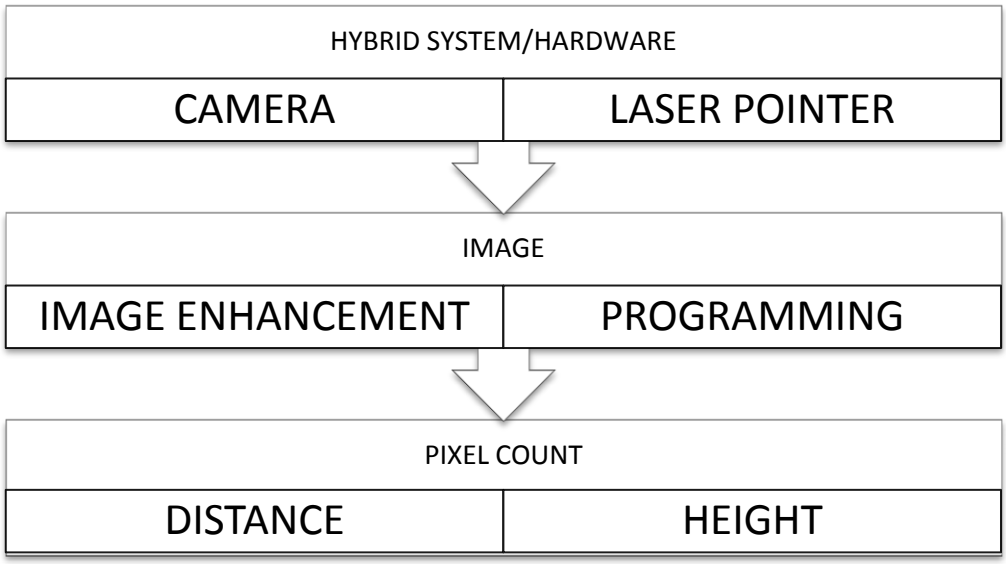

Fig. 4 Framework of the system

So algorithm is based on distance= f(pixel count), which is our research objective. Our 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. This methodology will go through experimentation and results with available stuff.

3. CONCLUSION

This paper presents an introductory concept of various methodologies used to measure distance by ultrasonic based, laser based, image based, white line tracing based algorithms for robot applications Laser beam pixel area Image based algorithm along with literature review of research work on distance measurement. The paper may help the new researchers expeditiously with a brief idea of distance measurement based on laser beam and image processing program and various paper studied may give a quick approach to the new researchers.

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