

## **Laser Distance Measurement by using web camera**

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**Abstract:** - In this work the near distance measurement system was presented .The system are consist from transmitter and receiver .The transmitter is used as semiconductor laser at wavelength 526 nm and the power 5 mw and the receiver are consist of optics part and web camera .The concept of operation is transmit a pulse of laser and then is received the reflected pulse from the object .The software program was written in C# language to calculate the object distance .The accuracy of the measurement distance is high. The error in the distance measurement reach to  $\pm 3\text{cm}$ .

**Keywords:** - *distance measurement, laser distance measurement*

### **I. INTRODUCTION**

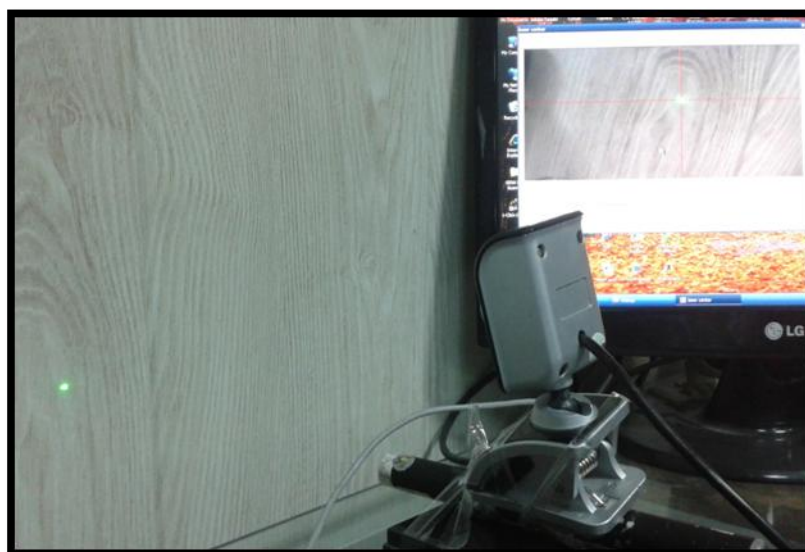
Any self-respecting mobile robot requires some sort of distance measurement sensor or range finding mechanism. Among the most accessible are ultrasonic range finders, which time the propagation and reaction of a sonic pulse. ultrasonic rangers, especially when placed in ring configuration, are plagued with fundamental difficulties that make them unattractive for serious localization.

At the other end of the spectrum are high-end laser rangefinders, which use light instead of sound to determine distance from time-of-light. These are often bundled with precision optics and mechanisms that allow one to infer 3D point clouds over large and small " human" distances. Their precision and reliability makes them ideal for industrial and research applications, but their cost is prohibitive to the hobbyist or researcher on a low budget.

To solve the problem of optimizing user cost vs. sensor precision and reliability, we consider a different sensor design. Here, the only materials needed are a laser line generator and a camera (e.g, a cheap webcam). The principle of operation is simple: one points the line generator and the camera in the same direction, but of sets them some known distance  $d_{off}$  ( $\sim 10\text{cm}$ ). The camera sees the laser line, filtered from the rest of the environment based on brightness and color, which is of set whenever it strikes an object. By calculating the of set distance from the expected position of the laser line, the distance to the object can be inferred.

### **II. RANGE SENSOR DESIGN**

Figure( 1 )shows the arrangement of the webcam and laser pointer. This configuration allow us to maintain in parallel position both of components, there by facilitating a quick calculation of real distances from a simple model.



Fig(1) The photograph image of laser distance measurement setup.

### III. GEOMETRY OF THE MODEL

In Figure( 2) the scheme used for the calculation of distance is showed. The distance between the webcam and laser pointer is defined by H (in centimeters). The distance between the scanner and the object is defined by D (in centimeters).

Also note that the representation of the scene in the image formed by the webcam lens is the size A "B " , where AB represents the same scene in real size. On the other hand, the distance between the center of the image to the location of the beam projected in the images can be defined as pfc (pixels from center), where  $\Theta$  represents the angle of vision (in radians) formed by projection of the laser beam projected onto the image.

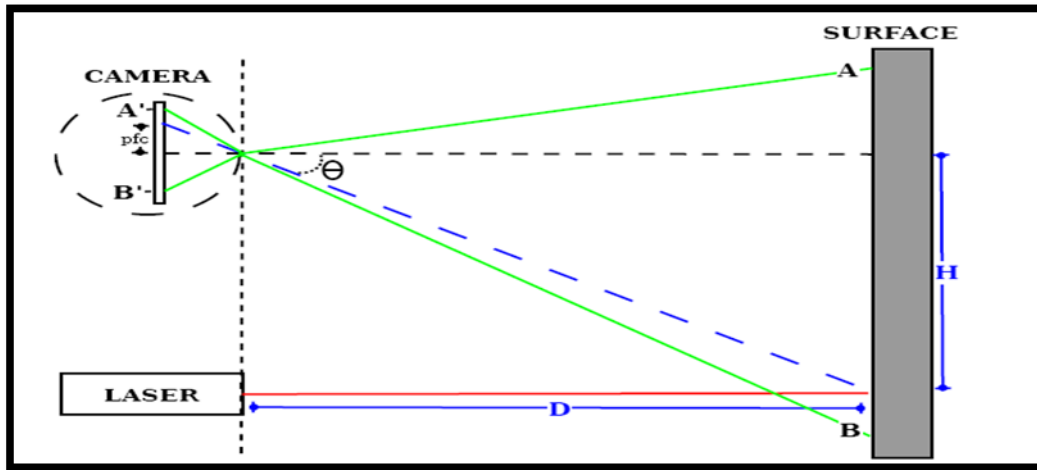


Fig. 2. Scheme of the arrangement of the camera-laser.

The distance D is obtained from the projection of the laser dot on the surface of the object.

With this scheme we can establish the following relation:

$$D = \frac{H}{\tan \Theta} \quad (1)$$

The relationship can be raised to obtain the total of pixels per degree of incoming light, here called rpc (radian per pixel pitch), thus converting each pixel in the image to its corresponding value in centimeters. The following equation shows rpc in relation with  $\Theta$ :

$$\Theta = \text{pfc} * \text{rpc} \quad (2)$$

Due to the existence of lens deformations on the webcam, in Equation 2 we consider a parameter which allows us the correction of alignment, here called ro (radian offset):

$$\Theta = \text{pfc} * \text{rpc} + r_o \quad (3)$$

To obtain the values of rpc and  $r_o$  we use a model of linear regression to find the relation between a dependent variable Y with k explanatory variables  $x_k$ , which generate a hyper plane of parameters  $\beta$ . Usually this linear model is defined as:

$$Y = \sum_{k=0}^n \beta_k X_k + \epsilon \quad (4)$$

where  $\epsilon$  is a random variable that deals with those uncontrollable factors. The model satisfies the following general equation:

$$Y = m X + b \quad (5)$$

With

$$m = \frac{n \sum xy - \sum x \sum y}{n \sum x^2 - (\sum x)^2}, \quad b = \frac{\sum y - m \sum x}{n},$$

where n, is the total of samples used; m, is the slope of the regression line (rpc); b, is the value originated by uncontrollable factors (r<sub>o</sub>) and Y represents Θ.

In order to obtain the distance to the object, we introduce the Equation 3 into the Equation 1, each of one in centimeters:

$$D = \frac{H}{\tan (pfc * rpc + r_o)} \quad (6)$$

We called this formulation as the Equation of distance calculation.

We define laser beam as the light project by the laser pointer onto the object and captured by a webcam. For our work, we use a laser pointer that emits green light and its localization onto the images is considered as a form of introduce the depth information into the image. The process of localization is nuanced by (i) the presence of illumination into the environment; (ii) the texture of the object pointed by the laser beam, and (iii) the size of the laser beam projected onto the image (the size of the projected beam depends of the proximity between the scanner and the object).

#### IV. RESULTS AND CALCULATIONS

To calibrate the system, we will collect a series of measurements where the range to the target, is known. The number of pixels the dot is from the centre of the image each time is also needed. Example data is set out below:

Table 1

Pixels from Centre	Actual D (cm)
103	29
81	45
65	58
55	71
49	90
45	109
41	127
39	159
37	189
35	218
Calibration Data	

Using the following equation, we can now calculate the actual angle based on the value of h, as well as actual distance for each data point.

$$\Theta_{\text{actual}} = \arctan (h / D_{\text{actual}})$$

where:

$$\Theta_{\text{actual}} = \text{Actual Angle}$$

$$D_{\text{actual}} = \text{Actual Distance to Measured Target}$$

Once we have a Theta actual for each value, we can discover the relationship that lets us calculate theta from the number of pixels from image centre. To use a linear relationship, the gain and offset are required. Though this works well, it does not take into account that the focal plane is a 'plane', rather than curved at a constant radius around the centre of the camera lens[4].

From the calibration data, we can calculate both Offset & Gain :

$$\text{Offset (r}_o) = -0.056514344 \text{ radians}$$

$$\text{Gain (r}_{pc}) = 0.0024259348 \text{ radians/pixel}$$

Using:

$$D = \text{height} / \tan (pf \text{ times } r_{pc} + r_o)$$

We can calculate distances, including a error value from the actual distance using the calibration data above:

**Table 2( Actual and Calculated Range Data)**

Pixels from centre	Calc D (cm)	Actual D (cm)	% Error
103	29.84	29	2.88
81	41.46	45	-7.87
65	57.55	58	-0.78
55	75.81	71	6.77
49	93.57	90	3.96
45	110.85	109	1.70
41	135.94	127	7.04
39	153.27	159	-3.60
37	175.66	189	-7.06
35	205.70	218	-5.64

## V. CONCLUSIONS

One possible improvement that can be made to this camera based Laser range finder is to use a laser that projects a horizontal line rather than a dot onto a target. With this type of Laser, we could calculate the range for each column of pixels in the image, rather than just one column as done here. This type of set-up could be used to locate areas of maximum range as places that a vehicle could steer towards. Likewise, areas with readings of minimum range would be identified as obstacles to be avoided.

From my initial experiments, the green laser's dot can be hard to distinguish at distances greater than 2 meters. Also the dot tends to blend into light backgrounds in well lit situations. I feel that a Green Laser may go a long way to solving these two issues.

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