Analysis of 3D Laser Range Finder for Defense Applications

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Abstract- In this paper, we are analyzing reliable, lightweight 3D laser range finder for the fast acquiring of 3D images of the target on defense applications. For scanning the target, we use algorithms such as LENCOMP , HOUGH & LINMER for line and surface detection of the data. So that the 3D image of the target can be retrieved. The optimum distance and angle by which the range finder could find the target is also analyzed.

Index Terms—Laser range finder, Tanker, Triangulation method.

I. INTRODUCTION

A Laser Range Finder is a device that is used to determine the distance of the target by using laser beam. Distance can be measured by interferometry, time of flight and triangulation methods. For high precision triangulation method is used. A Laser Range Finder can also provide elevation and azimuth measurements. Laser range finders have numerous applications in various fields like military, 3D modeling, forestry, sports, industrial production process, laser measuring tools, etc. In the field of military the lasers used for the purpose of range finding undergo various disadvantages. One of the main disadvantage is that the efficient lasers are under class 4 safety by IEC 60825-1 standard. In order to overcome this problem there arises need for eye safe lasers without compromising its efficiency. The military forces continue to be confronted with the problem that during laser operation, without using attenuation filters, the observer is required to keep specified NOHD(Nominal Ocular Hazard Distance)for both aided and unaided viewing. Eye-safe lasers are important in the military range finders mainly because they can be used in the training of troops unprotected individuals can become exposed to the laser radiation. Modern tanks are strong mobile land weapons platforms, mounting a large- caliber cannon in a rotating gun turret. They combine this with heavy vehicle amour providing protection for the crew of the weapon and operational mobility, which allows them to position on the battlefield in advantageous locations. Here, We project a laser range finder on the tanker to get the 3D image of the target. Eye safety can be a tough problem when laser beams must be transmitted through the open air.

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It's difficult to completely avoid human exposure in applications such as laser radar, remote sensing, range finding, target designation, laser countermeasures, and high-energy laser weapons. So the use of lasers at so-called "eye-safe wavelengths," particularly 1.4 to 1.8 μm, is increasing. Laser rangefinders for consumers are laser class 1 devices and therefore are considered eye safe. Some laser rangefinders for military use exceed the laser class 1 energy levels.

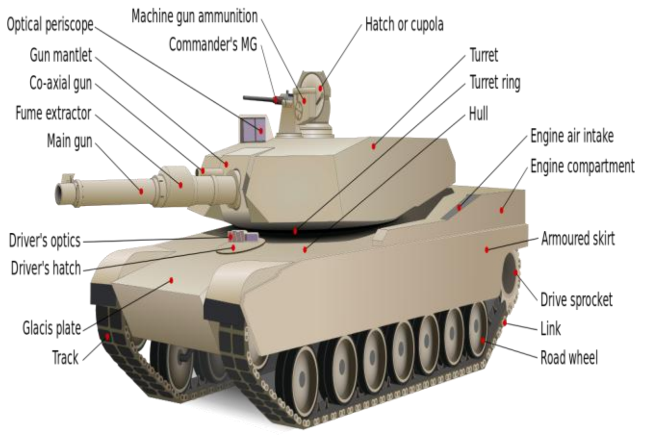

Figure-1[1]-Modern Tanker.

II. PROCEDURE FOR PAPER SUBMISSION

Triangulation is the process of determining the location of a point by measuring angles to it from known points at either end of a fixed baseline, rather than measuring distances to the point directly.

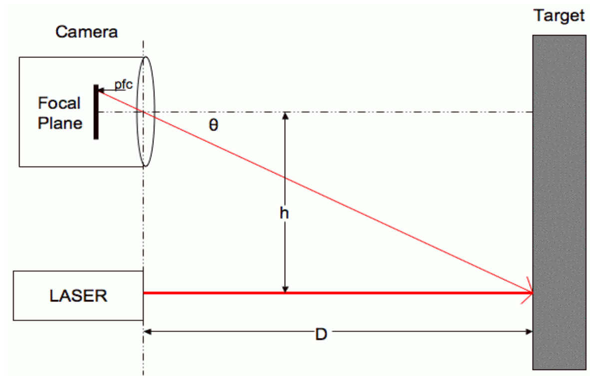

Figure-2-Triangulation Method

$$D = \frac{h}{\tan\theta}$$

To solve this equation, the value of h is to be known, so a constant h is fixed as the distance between your laser pointer and camera, and theta. Theta is calculated by using the formula,

$$\theta = pfc * rpc + ro$$

Where:

pfc = Number of Pixels From Center of Focal Plane

rpc = Radians per pixel pitch

ro = Radian offset (compensates for allignment errors)

Firstly, Get a webcam, get a laser , fix the webcam in place but leave the laser alone for now. The reason for using a webcam and a laser is because using an ultrasonic sensor does not provide precise readings of gaps due to its large viewing angle, the Sharp IR sensor is another option but it produces a noisy output. Here we use a webcam and laser, eventually mounting it on a robot. From the top equation we know that the distance to the object equals the distance between the webcam and laser , divided by the tan of theta. The next step is to work out how theta relates to the pixels contained in the webcam image. To work out theta we need to find the radians per pixel pitch of the webcam and the radian offset. These are constants for a particular webcam, the pixels from focal plane will change depending on how far away the image is. (pixels from focal plane just means how many pixels the laser is from the centre of the image).

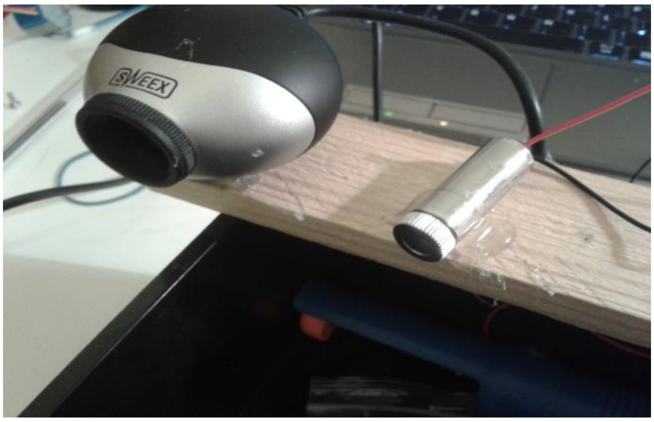

Figure-3[2]-Experimental Setup

The laser has to be in the center of the image at its max distance. In my case it was the wall of my room, 2.35 meters away. So I lined the laser up to the center of the image and then glued it in place. The way I calibrated it was by getting a measuring tape and holding the notepad at a known distance from the webcam. I then write down the distance in centimeters and the distance from center pixel readout on the screen.

Table-1

Actual_distance(cm)	Pixel_distanc e
180	13
160	16
140	20
120	25
100	33
80	44
60	63
40	103

We have two of those variables available to us, pfc was measured and theta can be worked out using inverse tan of h/d. If these two sets of numbers are plotted on a graph, the two constants rpc and ro can be obtained from the equation of the line. Here are the two sets of numbers:

Table-2

Pixel_distance	Theta(radians)
13	0.029602
16	0.033300
20	0.038053
25	0.044387
33	0.053249
44	0.066526
63	0.088600
103	0.132466

III. MATH

Now plot them on a graph, put a trendline throught the points and display the equation of the trendline:

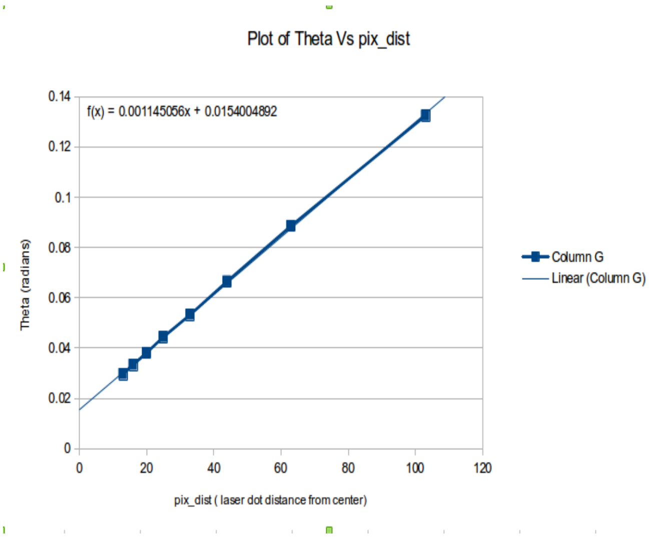

Figure-4-Plot of Theta Vs pix_distance

By comparing equations, rpc = 0.001145 and ro = 0.0154. Now we can work out theta for a given pfc (laser dots distance from center). From here just fill into the equation D = h / tan(theta), job done.

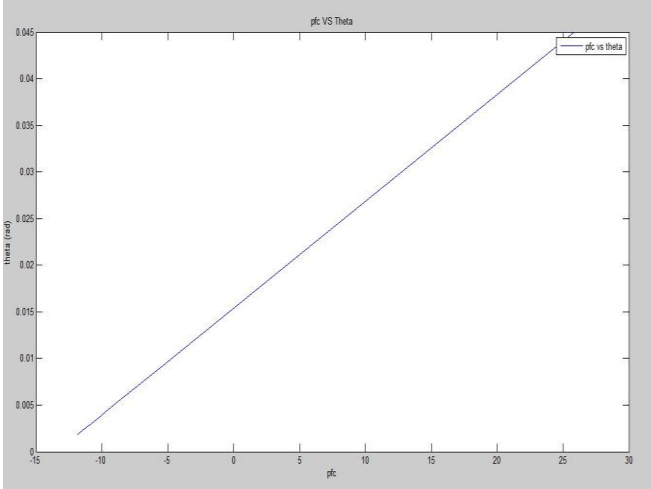

Figure-5-Plot of Theta Vs pfc

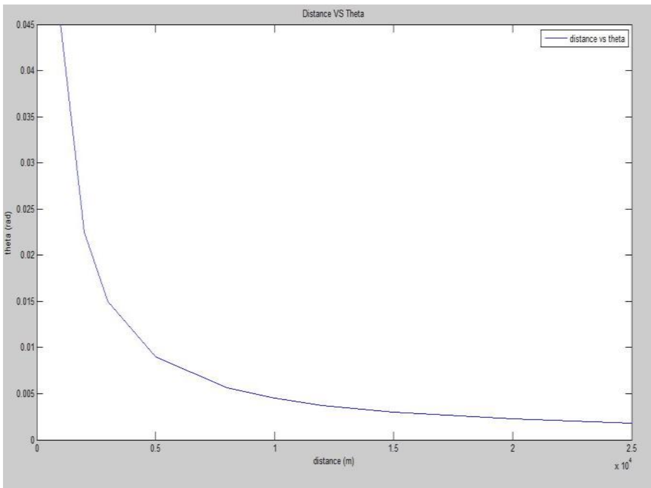

Figure-6-Plot of Distance Vs Theta

After finding the distance between the target and the laser, we need to scan the target using some online detection algorithms. One of the most effective algorithm is HOUGH Transform used for line detection of data. The Hough transform is a technique which can be used to isolate features of a particular shape within an image. Because it requires that the desired features be specified in some parametric form, the *classical* Hough transform is most commonly used for the detection of regular curves such as lines, circles, ellipses, *etc*. A *generalized* Hough transform can be employed in applications where a simple analytic description of a feature(s) is not possible. Due to the computational complexity of the generalized Hough algorithm, we restrict the main focus of this discussion to the classical Hough transform. Despite its domain restrictions, the classical Hough transform (hereafter referred to without the *classical* prefix) retains many applications, as most manufactured parts (and many anatomical parts investigated in medical imagery) contain feature boundaries which can be described by regular curves. The main advantage of the Hough transform technique is that it is tolerant of gaps in feature boundary descriptions and is relatively unaffected by image noise. The Hough transform can be used to identify the parameter(s) of a curve which best fits a set of given edge points. This edge description is commonly obtained from a feature detecting operator such as the Roberts Cross, Sobel or Canny edge detector and may be noisy, *i.e.* it may contain multiple edge fragments corresponding to a single whole feature. Furthermore, as the output of an edge detector defines only *where* features are in an image, the work of the Hough transform is to determine both *what* the features are (*i.e.* to detect the feature(s) for which it has a parametric (or other) description) and *how many* of them exist in the image. In order to illustrate the Hough transform in detail, we begin with the simple image of two occluding rectangles,

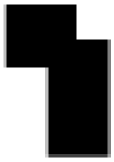

Figure-7

The Canny edge detector can produce a set of boundary descriptions for this part, as shown in

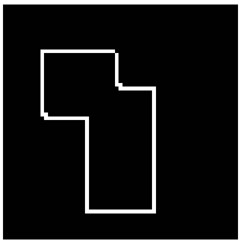

Figure-8

Here we see the overall boundaries in the image, but this result tells us nothing about the identity (and quantity) of feature(s) within this boundary description. In this case, we can use the Hough (line detecting) transform to detect the eight separate straight lines segments of this image and thereby identify the true geometric structure of the subject. If we use these edge/boundary points as input to the Hough transform, a curve is generated in polar (r,θ) space for each edge point in Cartesian space. The accumulator array, when viewed as an intensity image, looks like

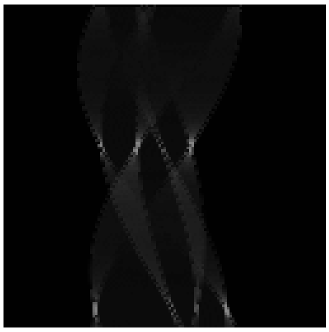

Figure-9

Histogram equalizing the image allows us to see the patterns of information contained in the low intensity pixel values, as shown in

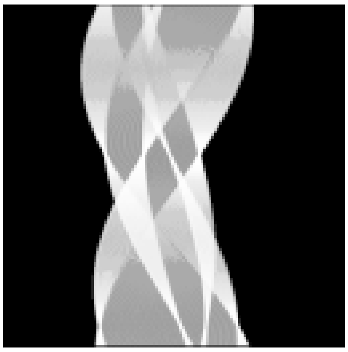

Figure-10

Note that, although r and θ are notionally polar coordinates, the accumulator space is plotted rectangularly with θ as the abscissa and r as the ordinate. Note that the accumulator space wraps around at the vertical edge of the image such that, in fact, there are only 8 real peaks. Curves generated by collinear points in the gradient image intersect in peaks (r,θ) in the Hough transform space. These intersection points characterize the straight line segments of the original image. There are a number of methods which one might employ to extract these bright points, or *local maxima*, from the accumulator array. For example, a simple method involves thresholding and then applying some thinning to the isolated clusters of bright spots in the accumulator array image. Here we use a *relative threshold* to extract the unique (r,θ) points corresponding to each of the straight line edges in the original image. (In other words, we take only those local maxima in the accumulator array whose values are equal to or greater than some fixed percentage of the global maximum value.). Mapping back from Hough transform space (*i.e. de-Houghing*) into Cartesian space yields a set of line descriptions of the image subject. By overlaying this image on an inverted version of the original, we can confirm the result that the Hough transform found the 8 true sides of the two rectangles and thus revealed the underlying geometry of the occluded scene

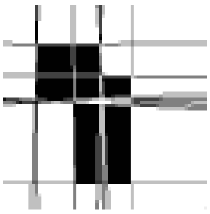

Figure-11

Note that the accuracy of alignment of detected and original image lines, which is obviously not perfect in this simple example, is determined by the quantization of the accumulator array. (Also note that many of the image edges have several detected lines. This arises from having several nearby Hough-space peaks with similar line parameter values. Techniques exist for controlling this effect, but were not used here to illustrate the output of the standard Hough transform.)

Note also that the lines generated by the Hough transform are infinite in length. If we wish to identify the actual line segments which generated the transform parameters, further image analysis is required in order to see which portions of these infinitely long lines actually have points on them. To illustrate the Hough technique's robustness to noise, the Canny edge description has been corrupted by 1% salt and pepper noise

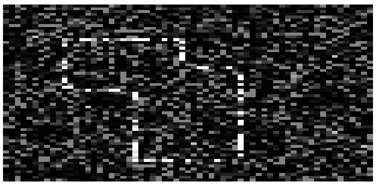

Figure-12

before Hough transforming it. The result, plotted in Hough space, is

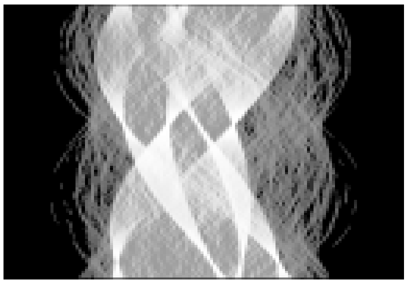

Figure-13

De-Houghing this result (and overlaying it on the original) yields

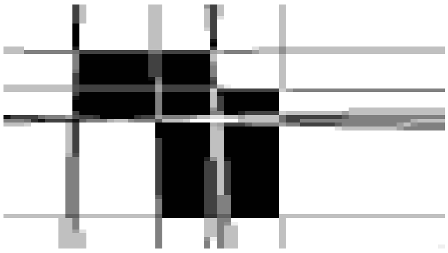

Figure-14

The sensitivity of the Hough transform to gaps in the feature boundary can be investigated by transforming the image

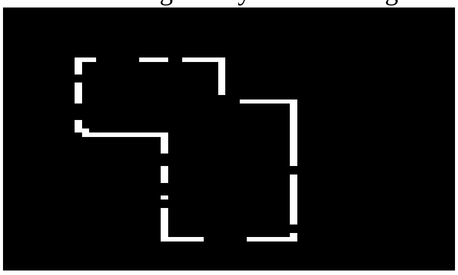

Figure-15

which has been edited using a paint program. The Hough representation is

Figure-16

and the de-Houghed image (using a relative threshold of 40%) is

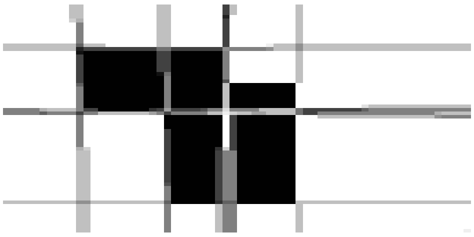

Figure-17

IV. DISCUSSIONS

Figure-5 shows us the graph between pfc(Number of pixels from center of focal plane) and theta. This is obtained by calculating the values of rpc = 0.001145 and ro = 0.0154. These values are constant for a given laser in an experiment. The graph between pfc and theta is linear graph. As pfc increases, the value of theta also increases. This means that pfc is directly proportional to theta. This result will be very helpful in finding the accurate distance. Figure-6 shows us the grah between distance and theta. This graph shows us that distance is inversely proportional to theta. As distance increases, theta value increases and vise-versa. Also, we have proposed using of Hough transform for line detection of the target. We showed an example how Hough transform works. Using this transform, we can scan the image of any object.

V. CONCLUSION

As a conclusion from our analysis it can be seen that laser range finder can be used in military applications to retrieve the 3D image of the target. The possibility of imaging the target in three dimensions is more using surface and line detection techniques.As a future work, we can apply different surface detection algorithms to the output of Hough transform so that we will get the 3D image of the target. As our project can be used in defense purpose, this will be a great service to our nation

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