LIDAR based 3D Scanners

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Abstract : LIDAR is a remote sensing technology that measures distance by illuminating a target with laser and analyzing the reflected light. In this paper we have proposed a technique to design and implement LIDAR to scan an object and create its 3Dmodel. The codes for this technique were developed using MATLAB software. The aim of this thesis is to create 3D model of an object by extracting the information obtained during laser scan and identify any deformity in its shape. The design involves experimental setup which comprises of a laser, a glass rod, a rotating base, a camera and test objects. The laser illuminates the object placed on the rotating base and the camera captures the snaps of the object for its complete 360o rotation. The coding part involves extraction of laser illuminated portion from the images, arranging them in a page matrix and making a surface based on the matrix. The final model for objects having uniform shape and structure is exactly like the real object and the model for objects having non-uniform shape and structure shows blank spaces at the places of irregularity on the object which can be used for the identification of deformities.

Index Terms : LIDAR, target, laser, camera, reflected light, object, 3D model, deformity, experimental setup

I. INTRODUCTION

Light Detection and Ranging (LIDAR) is an optical remote-sensing technology that gives information of object by illuminating the object using pulses from a light source. This technology is based on the reflection property of light waves. Light reflected back to the receiver is the data. The data can be analyzed to give certain information about target object like position, shape, distance etc. [1], [2].

A 3D scanner is a device that analyses a real-world object or environment to collect data on its shape and possibly its appearance (e.g. color). The collected data can then be used to construct digital three dimensional models. The purpose of a 3D scanner is usually to create a point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). If color information is collected at each point, then the colors on the surface of the subject can also be determined [3]-[6].

II. MATHEMATICAL MODELLING

A basic LIDAR system and corresponding LIDAR equation for the received signal intensity is given below [7]-[9] :

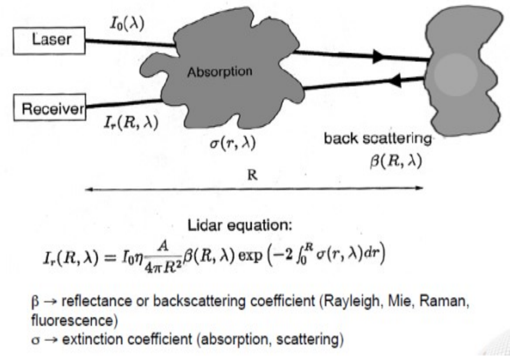

Fig. 1. LIDAR block diagram and equation

The received signal power from transmitted laser pulse after scattering/reflection from the target is given below

$$P_s(R) = P_\ell \frac{\rho_t A}{\pi R^2} \eta_o \eta_a^2$$

P_s = received signal power from transmitted laser pulse after scattering/reflecting from target

= power of the laser pulse

P_ℓ = "effective Lambertian" reflectivity of the target

A_r = effective collection area of the optical receiver

R = slant range to the target from "sensor"

η_o = optical transmission efficiency of all optical components in the ALS

η_a = transmission efficiency of the atmosphere between sensor and target (at range R)

= exp (-σR) (e.g. σ ~ 0.3/km for 10 km visibility)

Note:

$P_\ell, A_r, \eta_o \longrightarrow$ system hardware parameters

$\rho_t, \eta_a, R \longrightarrow$ operating environment parameters

III. PROCESSING

The image processing process was divided in three steps. For modelling purpose we used simple solid objects.

i) Desired areas i.e., areas illuminated by laser line, from each image are selected through coding and rest portions are rejected. The strips of images are arranged in a single test frame. Intensity information of these strips of images are gathered and put in matrices.

ii) The composite image is further processed to reduce complexity and noise.

iii) The final of step is reconstruction. The composite image is modelled into the shape of our object.

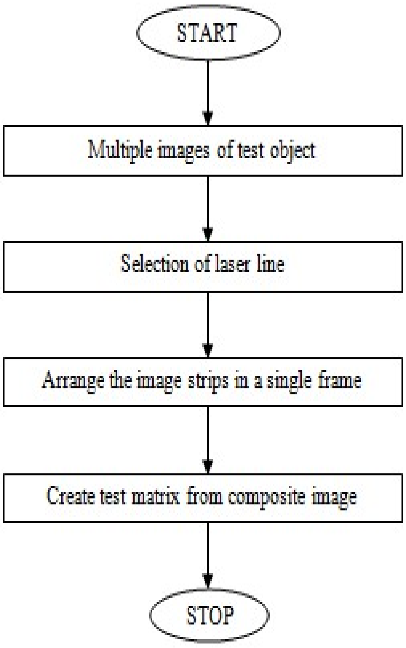

Fig. 2. Flowchart for data acquisition

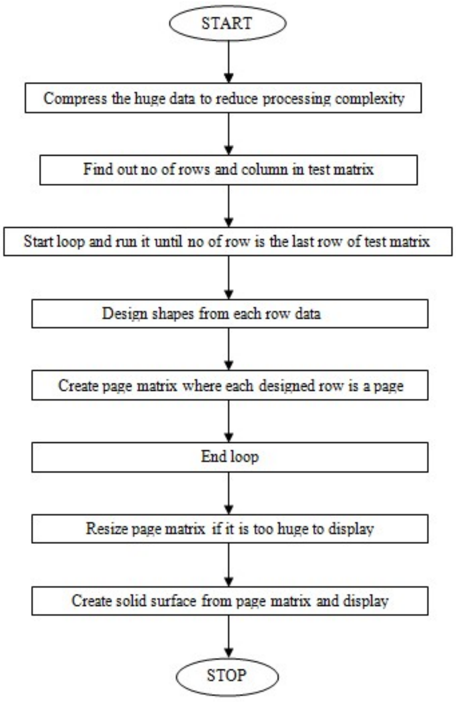

Fig. 3. Flowchart for modelling of object

IV. RESULTS

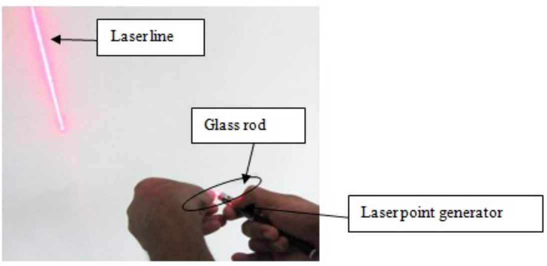

Fig. 4.LASER line generator

The above figure (fig.4) shows a laser line generated by passing the laser point through a cylindrical glass rod which diverges the point to a line. The generated laser line is used for scanning the objects.

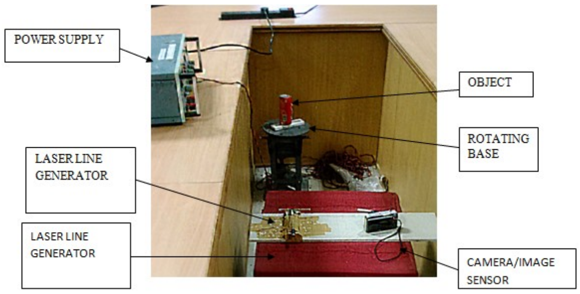

Fig. 5. Experimental setup

The above figure (fig.5) shows the experimental setup. The test object is placed on the rotating base which is illuminated by the laser line and the images are captured by the camera for complete rotation of the object.

4.1 Target 1: A cylindrical container:

Fig. 6:A cylindrical container

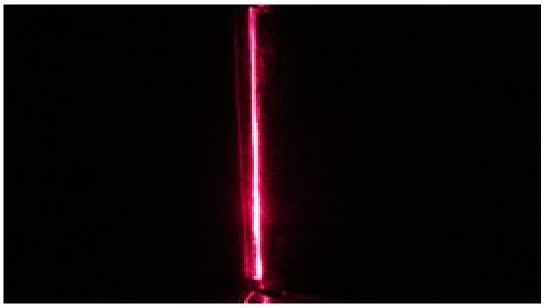

Fig. 7. Cylindrical container illuminated by laser as target line

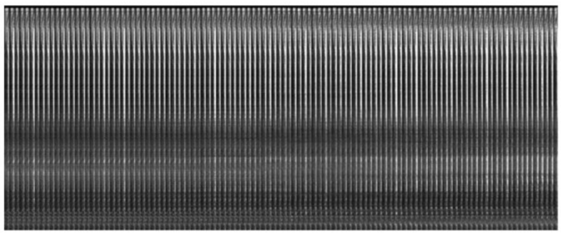

Fig. 8: Laser strip from multiple snap after complete rotation of the object and converted to gray scale

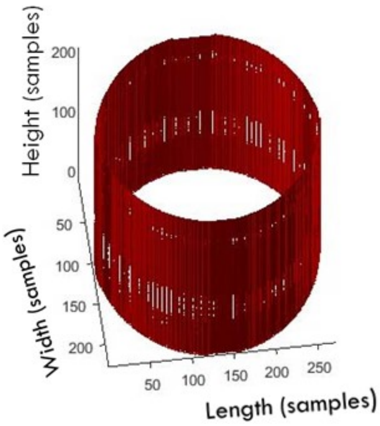

Fig. 9. Final 3D model

V. CONCLUSION

LIDAR is an effective technique for scanning and generating 3D model of an object.For objects with uniform shape and structure, the obtained 3D model is exactly same as the real object.For objects with non-uniform shape and structure, the distorted section is shown as a blank area in the 3D model which can be used for detecting any deformity in the shape.

REFERENCES

[1] Disa,MdN., Maarof,I., Latif, Z. A. and Samad,A.M (2011).LiDAR : A review on generating digital true orthophoto. IEEE 7th International Colloquium on Signal Processing and its Applications (CSPA).

[2] Tong, J., Zhou, J., Liu, L., Pan, Z., and Yan, H (2012). Scanning 3D Full Human Bodies using Kinects. IEEE Transactions on Visualization and Computer Graphics, 18(4), 643 – 650.

[3] Faltemier, T. C.,Bowyer K. W., and Flynn, P. J. (2008). A Region Ensemble for 3-D Face Recognition. IEEE transactions on information forensics and security, 3(1), 62-73.

[4] Curless,B. (2000). From Range Scans to 3D Models. ACM SIGGRAPH Computer Graphics, 33(4), 38–41.

[5] https://oceanservice.noaa.gov/facts/lidar.html

[6] Strobl,K. H., Mair, E., Hirzinger,G. (2011). Image-Based Pose Estimation for 3-D Modeling in Rapid, Hand-Held Motion. Proceedings of the IEEE International Conference on Robotics and Automation (ICRA 2011), Shanghai, China, 2593–2600.

[7] http://www.leica-geosystems.us/forensic

[8] Levoy,M.,Pulli, K., Curless, B., Rusinkiewicz, S., Koller, D., Pereira, L., Ginzton,M., Anderson,S., Davis,J., Ginsberg,J., Shade,J.andFulk,D. (2000). The Digital Michelangelo Project: 3D Scanning of Large Statues.Proceedings of the 27th annual conference on Computer graphics and interactive techniques, 131–144.

[9] Sören,L.,Kjellander, J.A.P. (2006). "Motion control and data capturing for laser scanning with an industrial robot". Robotics and Autonomous Systems, 54 (6), 453–460.