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A Latest Method for Improving Resolution in Three Dimension Imaging Light Detection and Ranging

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***Abstract* - Light detection and ranging (LiDAR) has recently emerged as a powerful tool for direct the three dimension (3D) measurement. 3D imaging LiDAR has found widespread applications in aerospace reconnaissance, deep-space detection, earth observation, disaster evaluation and so on. Here a latest method for increasing the resolution of 3D imaging LiDAR for target surface inspection is proposed. A new aspheric surface pre-collimation lenses system for the optical antenna of 3D imaging of LiDAR has been optimally designed and simulated by optical design software OSLO. In addition, four kinds of aspheric surfaces spherical lenses including the sections of spherical, elliptical, hyperbola and parabola have been researched. Also, a Cassegrain optical antenna with aspheric surfaces is designed and its performance is also to be tested using optical design software.**

***Index Terms* - Aspheric surface, Pre-collimation lenses system, Optical antenna, 3D imaging LiDAR.**

1. INTRODUCTION

The three-dimensional (3D) imaging LiDAR (Light Detection and Ranging) is an optical imaging system, which is used to measure the reflectance of the target surface [1]-[3], where several laser pulses are used to record the distance to the surface or objects. LiDAR is very similar to radar, the primary difference shorter wavelengths are used. LiDAR has many applications in environmental, civil, forestry, architecture constructions and ground surface modeling .It corresponds to the magnitude of the back scattered laser energy. Nevertheless, they are superior to several other remote sensing tools such as radar systems specifically in atmospheric studies since LIDARs operate at much shorter wavelengths. Hence, they are capable of higher accuracy and more precise resolution than radars perform within the microwave range of the electromagnetic spectrum. The technique integrates a laser range measurement system and a mechanical deflection system for 3D environmental measurements to realize the reconfiguration of the 3D target [4]. At present, the 3D imaging LiDAR with the low testing point density leads to a low spatial resolution, low accuracy and precision with range measurements of 3D imaging, which is not suited for covering the demands for more precise tasks in war field[5]-[6].

The laser beam emitting or receiving processing is studied numerically with optical theorem to realize the 3D high accuracy push-broom imaging in long distance. The research results possess potential applications in 3D high accuracy imaging LiDAR systems. For LiDAR systems, the laser beam must be expanded to reduce the beam divergence caused by diffraction. Expansion also increases the size of the beam spot on the target plane. Thus, a larger area can be scanned within a shorter time. Hence we turned our attention to use latest method for increasing the resolution of 3D imaging LiDAR for target surface inspection.

2. OPTICAL SYSTEM STRUCTURE FOR 3D IMAGING LIDAR

The optical system studied in this paper includes a collimation system and an optical antenna array (Fig. 1). The semiconductor array emits laser beams into the optical antenna array. The high precision collimation for long-distance target imaging detecting is a key technology to achieve high resolution for 3D imaging LiDAR.

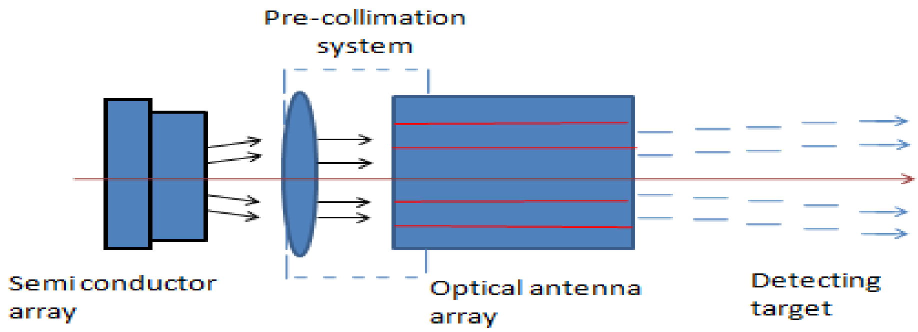


Fig: 1. Emitting optical system structure

As the development of array laser detecting technique, high-power laser with low pulse repetition frequency (PRF) can be used to 3D imaging via implementing the beam dividing emitting and array detecting techniques with non- scanning laser imaging mode.

2.1. Semiconductor Array

The semiconductor array emits laser beams into the optical antenna array. In order to make the light travel far enough and to retain the light intensity in a small area, many fields, including military and commerce, need the rays emitted from Laser Diode (LDs) to be parallel.

2.2. Pre-collimation System

The high precision collimation for long-distance target imaging detecting is a key technology to achieve high resolution for 3D imaging LiDAR. It is used to direct laser in a straight line. LDs emit less-collimate light due to their short wavelength and therefore higher collimation requires a collimating lens.

2.3. Optical Antenna Array

Optical antenna: a device designed to efficiently convert free-propagating optical radiation to localized energy and vice versa. Optical antenna array is the parallel emitting optical antenna with non-scanning laser imaging mode, here, high power laser with low PRF can be used to 3D imaging via implementing the beam dividing emitting and array detecting techniques.

3. METHODOLOGY

It describes the general methodology of the design and analysis of the optical antenna system. The optical surfaces of the designed systems are mostly designed aspheric surfaces. Section A discusses how OSLO is involved in the design and analysis steps of the optical systems. Section B presents the design approaches specific to the design for optical antenna.

3.1. Pre-Collimation System Structure

Based on the optical design software OSLO, a pre-collimation optical lenses system is designed, which is depicted in Fig. 2. It includes two aspheric cylinder lenses, which are perpendicular to each other.

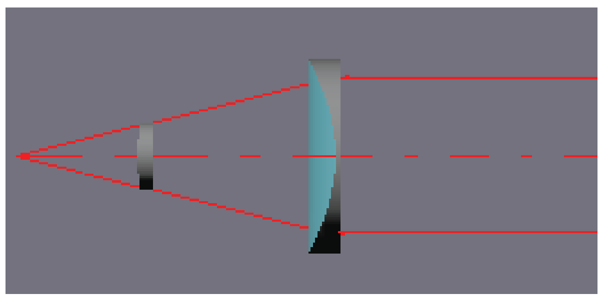


Fig: 2. Pre-collimation cylinder lenses system

The spot diagram for above Pre-collimation cylinder lenses system and the point spread function obtained by OSLO are shown in Fig. 3 and 4 respectively.

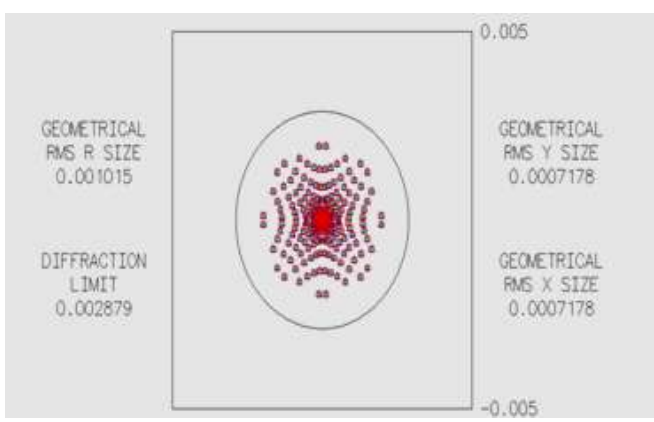


Fig: 3. Spot diagram of pre-collimation cylinder

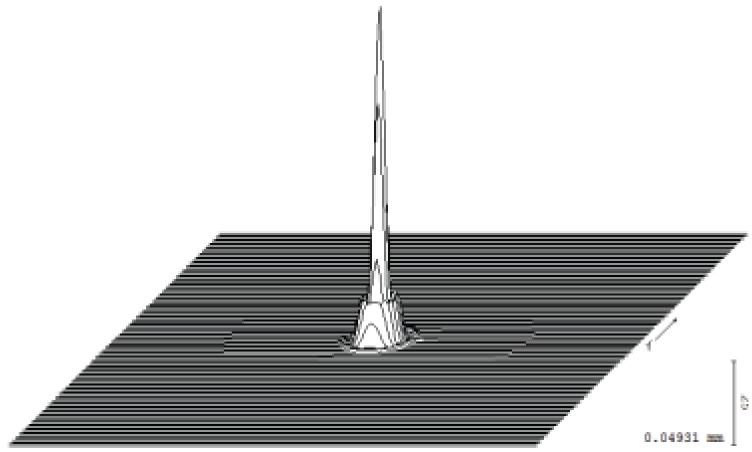


Fig: 4. Point spread function obtained by OSLO

Fig. 4 corresponding energy distribution function and Fig. 5

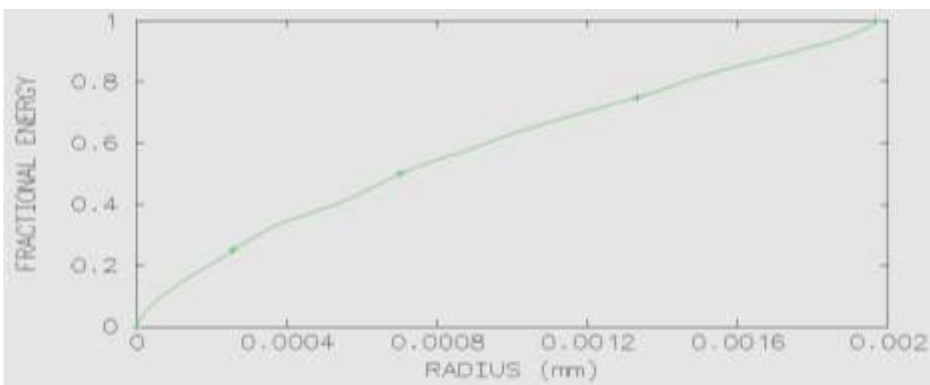


Fig: 5.

3.2. Optical Antenna Unit Design

One unit structure of the optical antenna array for 3D imaging LiDAR is revealed in Fig. 6 which includes the pre-collimation and the cassegrain optical antenna [7]. The optical system consists of two reflecting surfaces: a concave parabolic main dish and a convex hyperbolic secondary dish. This kind of optical antenna can obtain much higher gain than that of other kinds. It is useful for the long-distance LiDAR imaging system.

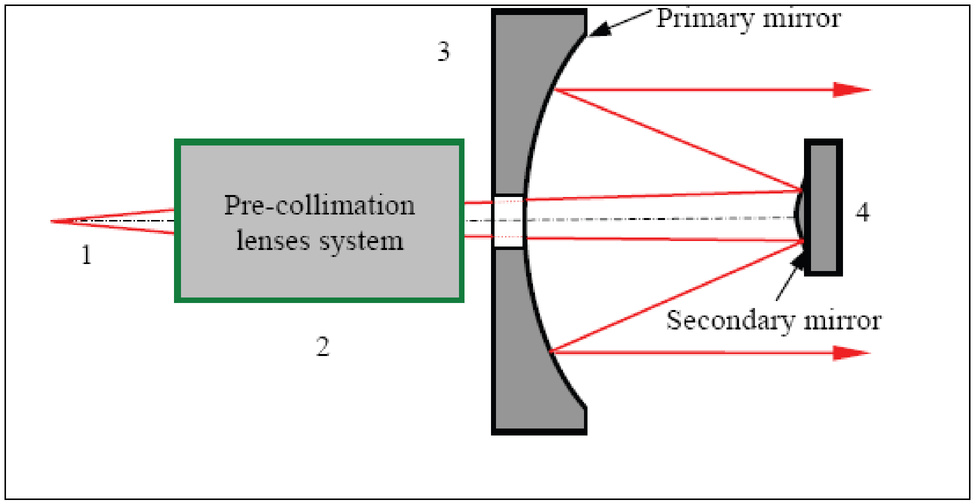
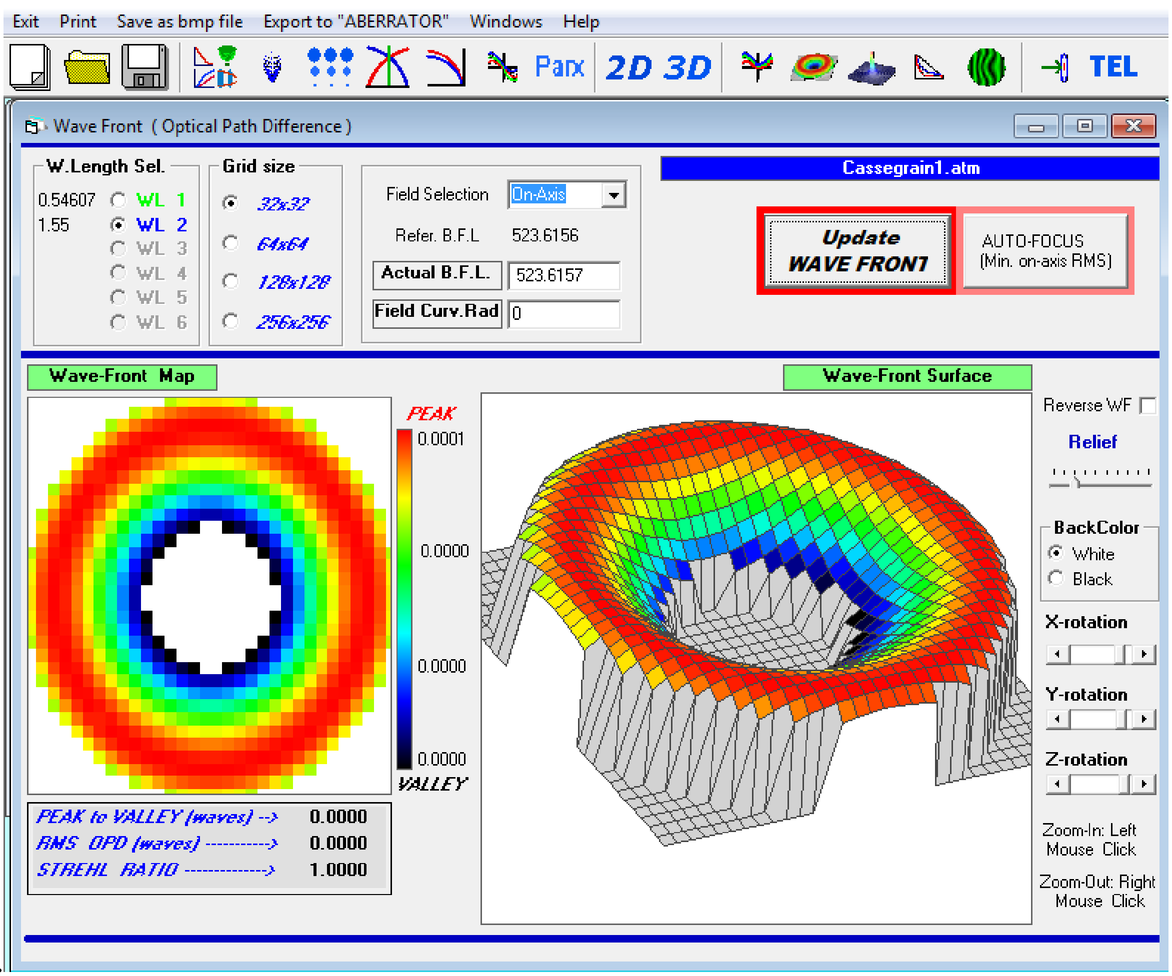


Fig: 6. One unit optical system structure

For the real optical antenna, the laser beam in one cross section is shown in Fig.



7.

Fig: 7. Wave aberration of optical antenna

4. Conclusion

Thus an optical antenna system for 3D imaging LiDAR is proposed to increase the resolution of LiDAR systems in the present study. A new aspheric surface pre-collimation lenses system for the optical antenna of 3D imaging of LiDAR has been optimally designed and simulated by OSLO. Four kinds of aspheric surfaces spherical lenses, including the sections of spherical, elliptical, hyperbola, a parabola, have to be researched by simulation. Cassegrain optical antenna with aspheric surfaces using optical design software is designed. The simulation results indicate that the elliptical cylinder lens possesses the best collimation angle for dot source semiconductor laser beam.

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