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Optical Circumferential Scanning Azimuth Measurement Method

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Abstract. End defence is the last barrier to active protection system, which is a hot topic in recent years. As the multi-radiation program, partition program and partition scanning program need a plurality of lasers and laser receivers, and the synchronous scanning program has a complex structure, these four schemes are all hard to apply directly in compact system. A new type of laser detection system has been developed for the position measuring (≤15m). Unlike traditional static gaze detection manner, we use biaxial micro-motor to drive laser dynamic scanning, and the solver of the distance and azimuth was achieved by laser and magnetic. Based on the static detection, we conduct the experiment of dynamic rotation scanning detection. In each scan cycle, the system can effectively detect the target echo and accurately solver target azimuth, which verifies the feasibility of laser proximity circumferential detection methods. The system contains only one laser and laser receiver, which is small enough to measure proximity target distance and azimuth.

1. Introduction

End defence is the last barrier to active protection system, which is a hot topic in recent years. Quickly and accurately positioning technology of proximity (≤15m) targets is the key technology [1]. Laser has directionality, monochrome, high brightness and coherence characteristics, so it can be used in detecting targets by echo analysis [2]. Laser detection system has been used wildly in weapons, such as American AGM-88 high-speed anti-radar missiles, Sweden RDS-70 missile and so on [3, 4]. In order to increase laser detection coverage, laser detection system requires omnidirectional detection, rapid identification and accurate positioning features [5, 6]. Laser orientation detection system is mainly involved in four common beam layout programs [7, 8]. As the multi-radiation program, partition program and partition scanning program need a plurality of lasers and laser receivers, and the synchronous scanning program has a complex structure, these four schemes are all hard to apply directly in compact system [9, 10].

In our work, we propose a new type of laser proximity detection method by using biaxial micro-motor to drive laser dynamic scanning to improve the traditional static gaze[11], only one laser and laser receiver are used to achieve a 360 °circumferential proximity detection.

2. Description of the system

We have designed the detection system shown in Figure 1.

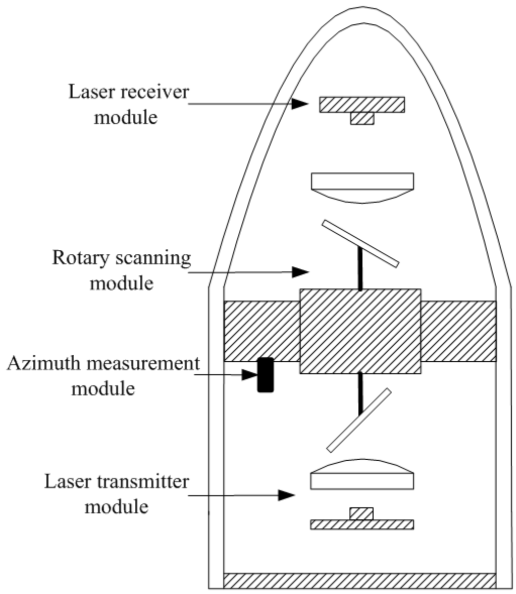

Figure 1. The detailed setup of the Laser proximity azimuth measurement system

The rotary scanning module includes biaxial micro-motor and all-trans plane mirror. The upper and lower total reflection plane mirror is driven by biaxial micro-motor to do the scanning, so that the laser proximity circumferential detection comes true.

The laser transmitter module includes laser drive power, semiconductor laser and collimating lens. Laser drive power makes semiconductor laser send out the initial laser beam, the original pulsed laser beam is shaped by collimating lens and then the beam is exited.

The laser receiver module includes focusing lens, photoelectric sensor and signal processing circuit. Target echo signal reaches photoelectric sensor after it through the focusing lens, then, optical signal is converted to electric signal and processed by signal processing circuit.

The magneto resistive sensor is the core device of azimuth measurement module, this module includes magneto resistive sensor matching circuit and induction magnetic core, and periodic scanning magnetic signals are recorded by this module.

3. Experimental results

The shaft length of biaxial micro-motor is S, the angles between the upper and lower total reflection plane mirror are σ_L and σ_r

$$P_R = \frac{\rho P_L T_E T_R A_R \cos\beta}{\pi R^2} \cdot e^{-2\sigma R} \tag{1}$$

Hypothesis: Target surface area is greater than the laser spot size. For extended target, For extended target, laser echo power equation is represented by formula (1).

ρ is target reflectivity, P_L is peak optical power of the laser, T_E is transmittance of emission optical system, T_R is transmittance of receive optical system, σ is atmospheric attenuation coefficient, β is the angle between the target reflective surface normal and the optical axis, A_R is aperture area of receive optical system, R is received power for system, R is the target distance. According to this formula, the target distance is solved.

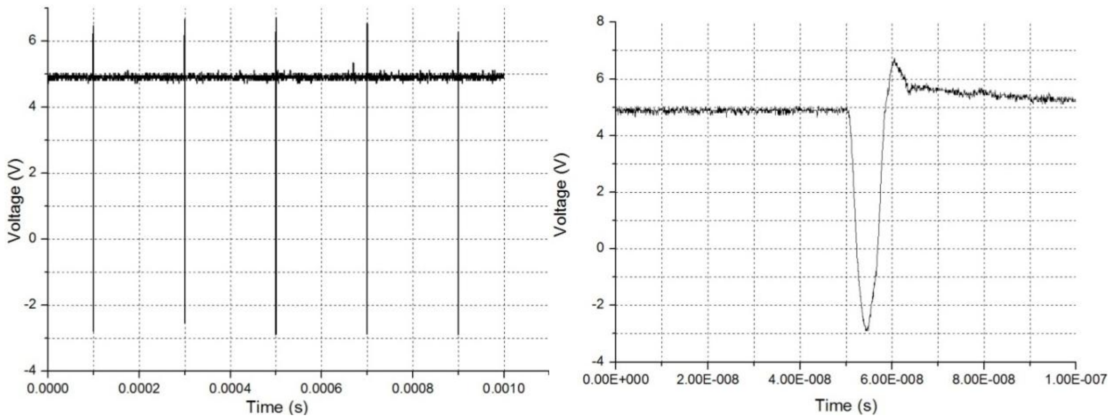

Figure2. The curve of echo pulse

The voltage output curve of APD detection system shown in Figure 2, when the detection distance is 10m, the repetition rate of echo is 5KHz, the pulse width is nearly 5ns, the amplitude is about 8V, in addition, echo signal amplitude and circuit noise satisfy processing requirements of the subsequent circuit.

Assuming that the target azimuth angle is the angle which is between x axis positive and the line from the target location to system axis. Magnetic induction signal is at peak when induction diskette and magnetic sensor are alignment at Zero time.

Signal processing system does A/D converter to the analog output signal of the sensor; using software comparison to find out peak time (T_1(s) and T_3(s)) of the goal appears period in the A/D conversion data, and temporarily stored in the microprocessor.

When the output signal of the laser receiver module is judged as the target echo signal, extract T_1 and T_3, the motor speed in real time can be calculated as:

$$n = \frac{2\pi}{T_3 - T_1} \tag{2}$$

The azimuth angle of the target is:

$$\alpha = \frac{2\pi\left(T_2 - T_1\right)}{T_3 - T_1} \tag{3}$$

T_2(s) is the time when the target is detected.

If receiver module has no signal output when a peak occurs in the next time, then the microprocessor discards T_1, T_3 and records the next peak time, prepare for the target which appears at any time.

The azimuth detection methods used in this paper is based on the motor speed of the target appears cycle, it only be affected by the target appears cycle speed variation, A/D conversion frequency and system fuzzy delay. The circuit has the characteristics of simple structure, strong real-time and small interfering by external electromagnetic environment.

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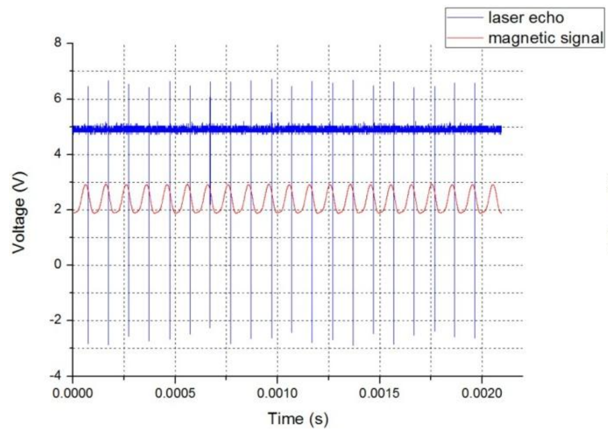

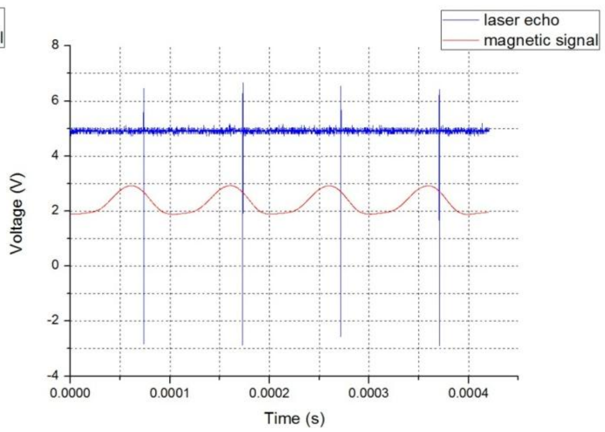

Figure3. The composite waveform of laser and magnetic **Figure4.** Expanded view of the composite waveform

Based on the static detection, we conduct the experiment of dynamic rotation scanning detection. Run the rotating scanning system so that the laser is driven to realize the proximity circumferential detection. Placed the target in different directions, rotate scan signals and the target echo signals were recorded. When the target located at a distance of 10m and an azimuth of 45°, Figure 3 and Figure 4 show the composite waveform of laser and magnetic signal while the target's distance is 10m and azimuthal angle is 45°. According to the algorithm to calculate the first test results, $T_1=6.1019\times10^{-5}$s, $T_2=7.3503\times10^{-5}$s, $T_3=16.1018\times10^{-5}$s, $\alpha=\frac{2\pi(T_2-T_1)}{T_3-T_1}=44.94°$, Figure 5 shows 20 test results, the maximum and the minimum error were -2.48° and -0.06°, the average of test results is 44.39°. In each scan cycle, the system can effectively detect the target echo and accurately solver target azimuth, which verifies the feasibility of laser proximity circumferential detection methods.

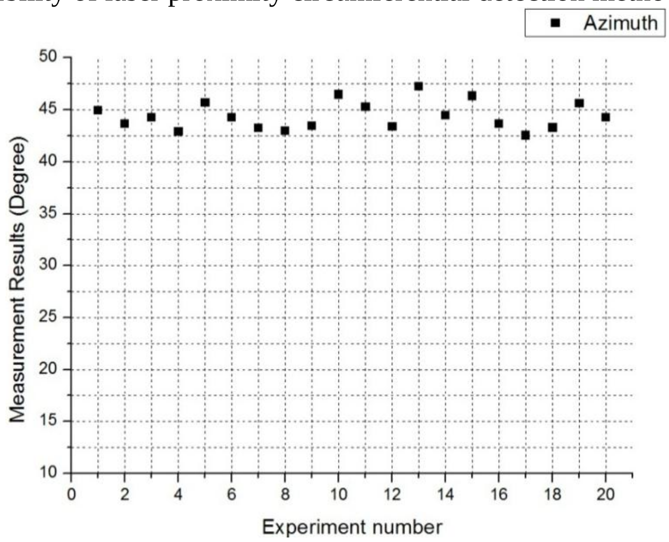

Figure5. The distribution of the experiment results

4. Conclusion

We propose a detection method which compound laser and magnetic. To compensate for the lack of traditional proximity detection methods, we complement advantages of laser and magnetic detection, use laser and magnetic measure distance and angle information of short-range target. This method is suitable for fast and accurate measurements of proximity target position in different environments.

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