

Proposal of an Optical Linear Sensor Using One-Side Frosted Glass

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Abstract. Sensors that detect the distance and the position of an object are used in a lot of fields. Among of them, the sensors that measure the shift value of an object are a large scale system, furthermore, an accurate mounting of these sensors is required. To solve these problems, this paper proposes an optical linear sensor using one-side frosted glass. This sensor can detect the position of the light irradiation point only by putting it directly on the target. For a parallel light, it is irrelevant to the distance between this sensor and the source of light because the size of light beam is unchanged according to the distance. This sensor assumes that the sensor's surface irradiated roughly vertical with the light, and does not need a high accurate mounting. Therefore, it can be easily used.

Introduction

Sensors that detect the distance and the position of an object are used in a lot of fields. It is known as an indispensable existence of nowadays. For instance, it is necessary detecting the train stop position accurately because even a little overrun of a train is thought to become the trigger of a large disaster [1]. There are an optics type sensor [2,3], a supersonic wave type sensor [4,5], and a magnetism type sensor [6,7] as the contactless stuff. Most of these sensors are used to measure the distance between the transmitter and receiver along the signal's direction. On the other hand, linear sensors such as the magnetic tape type sensors and the rotary encoders exist as the sensors that measure the shift value to the vertical direction of the traveling direction. The gap between the measurement object and the sensor should be kept constant. Moreover, these are mechanisms moving along the rail, and devices are large scale. In addition, the light receiver and the light transmitter need to be mounted in a very short distance to the object accurately.

To solve these problems, this paper proposes an optical linear sensor using frosted glass. This sensor can detect the position of the light irradiation point only by putting it directly on the object. For a parallel light, it is irrelevant to the distance between this sensor and the source of light because the size of light beam is unchanged according to the distance. This sensor assumes that the sensor's surface irradiated roughly vertical with the light, and does not need a high accurate mounting. Therefore, it can be easily used.

Linear Sensor Using Frosted Glass

The linear sensor consists of a laser line marker, frosted glass, and two photodetectors as shown in Fig. 1. The phototransistors are set up at both ends of the frosted glass. The laser line marker is arranged at the position in which line laser light is vertically irradiated to the frosted glass. The position of the laser light irradiated to the frosted glass can be presumed by measuring the laser light intensity that reflects in the frosted glass with two photodetectors. For example, if the laser is irradiated to the center of the frosted glass as shown in Fig. 2 (a), the outputs of two photodetectors become equal. When the laser line marker is moved right as shown in Fig. 2 (b), the output of the right photodetector becomes high, and the output of the left photodetector becomes low. When the laser

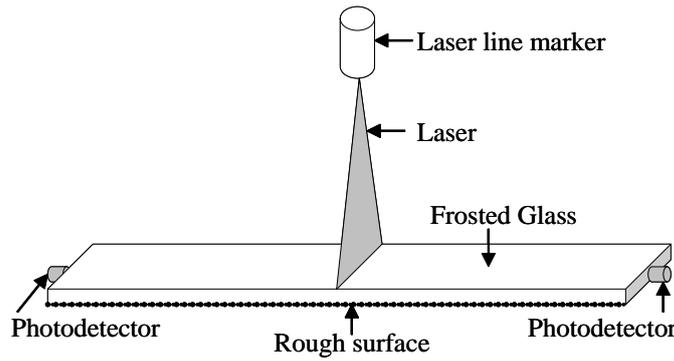
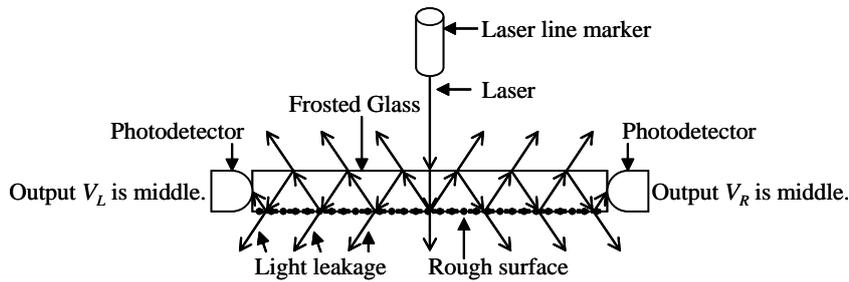
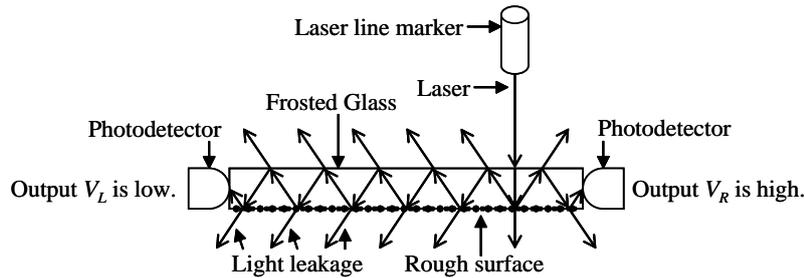


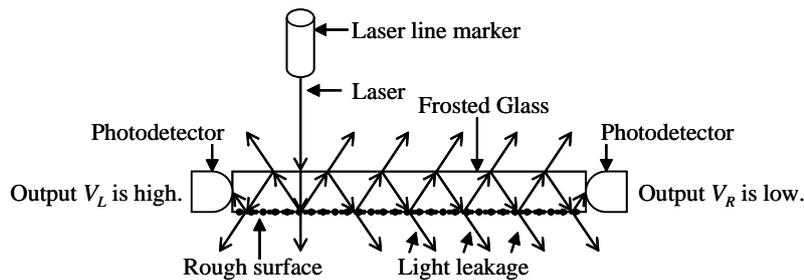
Fig. 1. Structure of the linear sensor using frosted glass.



(a) The laser is irradiated to the center of the frosted glass.



(b) The laser is irradiated to the right of the frosted glass.



(c) The laser is irradiated to the left of the frosted glass.

Fig. 2. Appearance of reflection in the frosted glass.

line marker is moved left as shown in Fig. 2 (c), the output of the right photodetector becomes low, and the output of the left photodetector becomes high. Thus, the position in which the laser is irradiated can be presumed from the outputs of two photodetectors.

Line length and stroke width changeable type laser line marker (Audio-technica, SU-63C) is used in this paper. The phototransistor (TOSHIBA, TPS601A) is used for the photodetector. The frosted glass of the size ($l=100[\text{mm}]$, $w=10[\text{mm}]$, $d=5[\text{mm}]$) shown in Fig. 3 is used.

If the position in which the laser is irradiated is the same even if the light intensity of the laser line marker and the gain of the amplifier of this sensor are changed, the output is standardized to obtain the

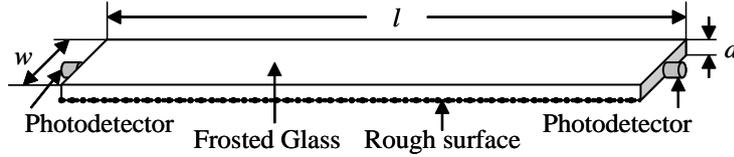


Fig. 3. Dimension of the frosted glass.

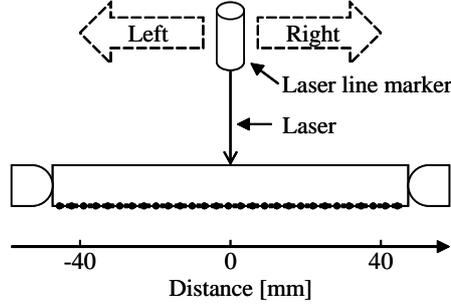


Fig. 4. Experiment method.

same output result. The standardized output S of the following equation is defined as the output of the liner sensor.

$$S = \frac{V_R - V_L}{V_R + V_L} \quad (1)$$

In the equation, V_R and V_L are right and left outputs of photodetector respectively. In addition, distance D is calculated by the following equation.

$$D = f(S) \quad (2)$$

Where function $f()$ is presumed from the experimental result.

Experiments

Examination of the characteristic of this sensor. The characteristic of this sensor was examined as follows. It experimented in the darkroom to lose the influence of the lighting. First of all, the laser was irradiated to the center of the frosted glass (0 [mm]) as shown in Fig.4, and the output voltage of the right and left phototransistor (V_R and V_L) was equated by adjusting the gain of the amplifier. Next, the laser of the laser line marker was irradiated from -40 to 40[mm] every 5[mm] as shown in Right and Left of Fig.4. V_R and V_L in each distance were measured, and the standardized output S of this sensor was calculated. The center of the frosted glass is assumed to be 0[mm], the area from the center to the left side is assumed to be a minus region, and the area from the center to the right side is assumed to be a plus region. The experimental result is shown in Fig.5. As a result, it is thought that it is possible to gauge distances from S because S increases monotonously. Then, Eq.2 that calculated the distance D from S was requested by using the least squares method. Since the graph of the result had shape like the cubic function, it was approximated to the following cubic functions as one example of the approximation functions.

$$D = k_0 S^3 + k_1 S^2 + k_2 S + k_3 \quad (3)$$

Each coefficient is as follows.

$$k_0 = 30.1408 \quad (4)$$

$$k_1 = 0.957526 \quad (5)$$

$$k_2 = 31.2815 \quad (6)$$

$$k_3 = -0.490254 \quad (7)$$

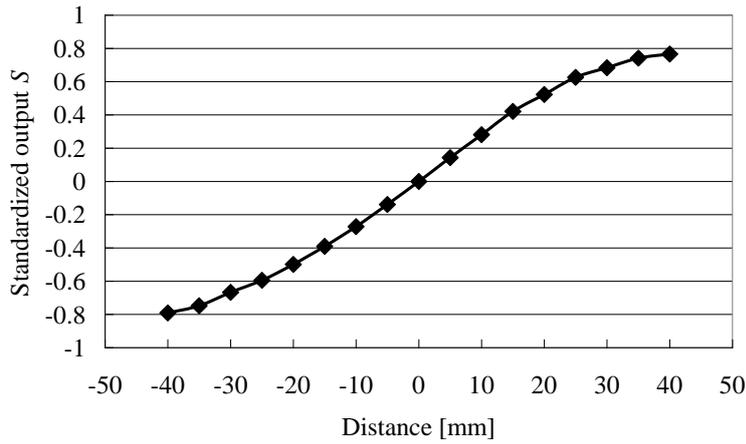


Fig. 5. The relation between the distance and the standardized output S .

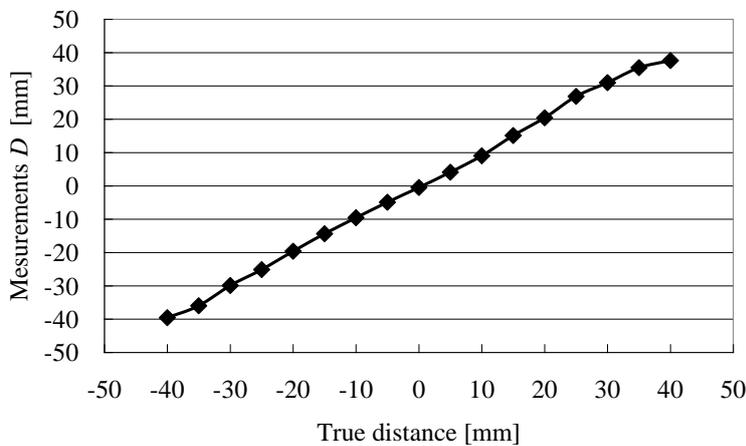


Fig. 6. The relation between the true and measurement distance.

The relation between the true and measurement distance is shown in Fig.6. As a result, the distance can be measured accurately. Therefore, the position in which the laser was irradiated can be measured by using this sensor.

Operation check of this sensor. Next, operation check of this sensor was performed in this experiment. It experimented in the darkroom to lose the influence of the lighting. The laser of the laser line marker was irradiated from -40 to 40[mm] every 5[mm] as shown in Right and Left of Fig.4, and the distance D was measured. The relation between the true and measurements D of the distance is shown in Fig.7. As a result, the distance can be measured accurately as well as Fig.6.

Influence of the lighting. In this experiment, the influence of the lighting was confirmed because there are lightings in daily life. The laser of the laser line marker modulates (1[kHz]) to distinguish the laser and the lighting. The experiment is performed on the following conditions: Lighting of 0 (Darkroom), 500 (Ordinary indoor), and 1000 (Bright lighted indoor) [lux]. The laser of the laser line marker was irradiated from -40 to 40[mm] every 5[mm] as shown in Right and Left of Fig.4, and the distance D was measured. The relation between the true and measurements D of the distance is shown in Fig.8. As a result, the accuracy is decreased a little by the lighting, but the distance can be measured as well as Fig.6. It is a cause of decreasing accuracy that the influence of the lighting was not completely removed with the filter because the modulating frequency (1[kHz]) is near the frequency of the lighting (50 or 60[Hz]). The influence of the lighting can be decreased more by improving the filter or making the modulating frequency high.

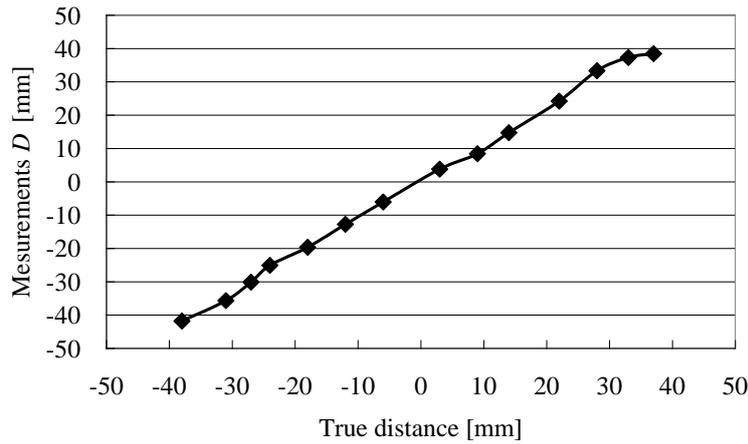


Fig. 7. The relation between the true and measurements D of the distance.

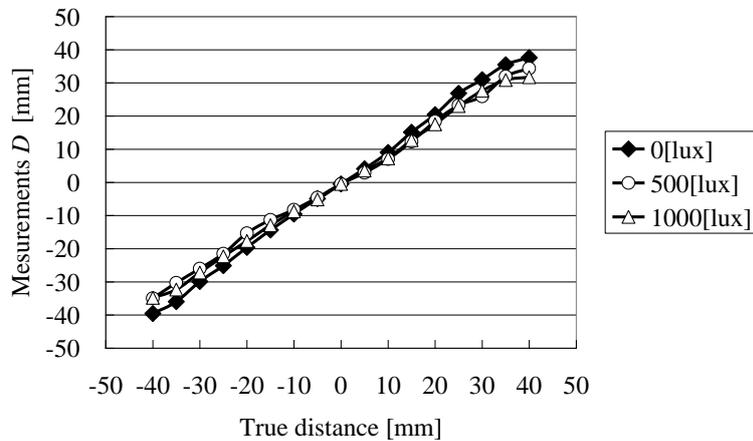


Fig. 8. The relation between the true value and measurements D of the distance.

Conclusions

In this paper, we proposed an optical linear sensor using one-side frosted glass. Put directly on the target object, this sensor can detect the position of the spot irradiated from the source of light. As for parallel light, the distance between this sensor and the source of light is irrelevant, the only requirement is the source of light should irradiate to the sensor's surface roughly vertical. Therefore, this sensor can be easily used.

Future tasks are to improve accuracy, and to lengthen the distance that can be measured. In addition, it is scheduled to develop a two dimension position measuring device by extension of this technique.

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