Dynamic Path Planning of Underwater Vehicle Based on Pulse Lidar Profiler

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Abstract. In the underwater environment, the speed of light is much faster than that of sonar, so it can be used to sample and detect more intensively in space and high frequency in time. A better strategy is to integrate sonar and lidar into an integrated device. In military affairs, lidar sonar system is used for identification of underwater artificial works and fixed-point blasting. In the civil field, aquaculture, scientific research and sampling, and underwater infrastructure exploration are the main areas. This paper analyzes the application of pulse lidar profiler system integrated with multiple detection methods in the dynamic path planning of underwater vehicle. Three colors of "red, orange, red sauce" were used as the warm color light source group, and three colors of "blue, green, purple" were used as the cold color light source group. Through matrix operation, underwater objects with almost all colors can be quickly reached and superimposed. The speed of sound wave is slow, but the bypass performance is very good, which fully supplements the blind area of light source.

Keywords: Lidar; profiler; Point cloud computing; Underwater vehicle.

1. Introduction
Most of the water bodies contain a lot of suspended solids and organic matter, and the illumination of the bottom is often not enough, which brings great difficulties to the detection of the bottom of the water. The scanning results of pulsed lidar profiler are point clouds. Since the laser has the characteristics of high precision and almost no diffusion, its original design goal is the missile aiming of the anti-missile system. However, the recent research on this topic is more inclined to the civil field. The latest frontier achievements in this field involve laser scanning water depth\(^1\) and wood volume estimation technology on water surface\(^2\), 3D scene modeling\(^{[1-7]}\), aircraft attitude control and path planning\(^{[5-7]}\). Although the pulse lidar profiler can measure the point cloud clearly in the air, the polychromatic spectrum technology and stereo imaging technology must be used to obtain the accurate point cloud data in the polluted water system.

2. The Research Framework
Table 1 shows the status of the equipment under test. In order to be responsible for the health of users, the light intensity of the laser must be harmless to human eyes, and the application scenario is underwater, so the parameter environment with certain turbidity and low illumination is set.
In addition to the features listed in Table 1 above, active and passive point cloud disposal is also the core technology of high-resolution lidar.
Table 1. Operation parameter setting and system features.

| Parameter                              | VALUE               |
|----------------------------------------|---------------------|
| Laser grade                            | Eye safety level    |
| Turbidity                              | 37.8 (mg/l)         |
| Illuminance                            | 98 (lx)             |
| Number of pulse lidar profiler cameras | 2                   |
| The equipment combined with sonar      | Yes                 |
| Multi color light fusion technology    | Yes                 |
| Stereo imaging technology              | Yes                 |

3. Active and Passive Information Extraction from Point Cloud Data

Due to the increasing demand of underwater vehicles and the improvement of detection accuracy, especially in scientific research and military occasions, the point cloud density and accuracy of pulsed lidar profiler system must be maintained at a high level in low illumination and high turbidity environment. This requires integrating the advantages of active extraction and passive extraction in data processing.

- As the light source is made into multi-component beam actively, it can make good feedback to many situations;
- Passive mode information extraction can be understood as a data-driven imaging technology. It is based on the shadow data in the feedback information as the core, and reversely deduces the subject matter and the position of the light source, so as to present the 3D model of the measured object.

3.1. Warm Light and Cold Light Multicolor Light Source System

Since both warm and cold light sources are polychromatic, this design sacrifices weight, volume and economic cost. In other words, in order to get better 3D point cloud return data, the whole device becomes heavier, larger and more expensive.

But correspondingly, in the color transition region, that is, the color gradient area, and the shadow area, we can get a good reflection signal. The weak reflection signal in the shadow area is the key signal needed in the second step calculation: 3D texture calculation and 3D model carving calculation of the measured object.

3.2. Backtracking Calculation Module Based on Shadow Area Data

In this part of the study, we focus on the following aspects:
- This is a part of the calculation module driven by the formation of local point cloud data;
- The shadow representing the texture is closely related to the dark field point cloud data;
- The geometric relationship between the light source and the object is constructed from the elevation information and multiple shadow superposition information of the measured object, and the 3D model is refined.

Thus, it can be seen that the contents of part 3.2 are based on the work of part 3.1, and they are a whole of mutual promotion and interdependence.
Figure 1. Workflow of high definition sensing system based on pulse lidar profiler.

Figure 1 clearly shows the work flow of the high-definition sensing system based on pulse lidar profiler. The biggest difference from the conventional system of the same kind is that:

- Two sets of multicomponent signal source system composed of warm light source and cold light source respectively;
- Shadow analysis and texture extraction system.
4. Conclusion

This paper mainly describes the intelligent sensing system of underwater walking robot based on pulse lidar profiler system in low illumination and high turbidity underwater application scenarios. To be specifically:

- A high-definition imaging system based on pulse lidar profiler system breaks through the limitation of high turbidity and low illumination;
- The method of multi-component light source integration and superposition is adopted: the probe of each micro area can effectively return to the real and reliable points, and then the accuracy and reliability of the overall point cloud data are higher. In short, this effectively breaks through the low return rate limit of monochromatic light, and makes the sensing system become a high approximation imaging system;
- Due to the shadow analysis method, the point cloud data analysis module can backtrack the illumination direction and modify the 3D model of the object to be measured, thus effectively breaking through the 2D limitation and becoming a realistic stereo imaging system;
- Multi means are used to improve the clarity, accuracy and stereo of the sensing system, which makes the system particularly suitable for autonomous navigation path planning robots or underwater vehicles;
- Through multi type data fusion technology, the light source information and acoustic source information are organically integrated, and the high-definition shape calibration of underwater objects is accurately completed by using the physical complementary characteristics of the signal.

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