

# Development and Control of Unmanned Floating Observer (UFO) for Inspection of Irrigation Tunnel and Canal

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## 1 Introduction

Many major irrigation tunnels and canals in Japan have been deteriorated for more than several decades after construction. In order to efficiently maintain and manage these waterways in the future, it is essential to periodically investigate the shape of the entire waterway by visual inspection survey, and to evaluate it based on the survey results[1].

However, there are facilities that are watered all year and cannot be easily cut off, and periodic inspections are difficult. Therefore, robots have been developed for inspection of waterway, which is difficult to cut off water. It is assumed that the investigation by the present robot is releasing the robot from the upstream entrance of the irrigation tunnel and collecting it at the downstream opening. In the conventional robot[1], the rotation of the hull is controlled so that the camera faces always directly against the side wall and the top wall surface, but it is not equipped with a thrust device, and the position in the waterway is not controlled. To improve the reliability of diagnostic data, an angle control for heading the flow direction of the waterway and a position control for positioning in the center of waterways are needed, as shown in the Fig. 1.

Therefore, we have developed a robot on water that can move in all directions for self-position control. Target waterways are closed facilities such as tunnels. So, it is difficult to obtain location information by GPS. Therefore, self-position control is performed based on the shape of the waterway. Since the shape of waterways may be complicated due to landslides and plants, a self-position estimation method that corresponds to curves and irregularities is required.

## 2 Developed Robot System

The developed robot “UFO” is shown in Fig. 2(a). The robot is equipped with LRF and PC for self-position estimation. In addition, the robot is controlled by four thrusters attached to the lower part of the robot based on the self-position estimation result. The arrangement of four thrusters is shown in Fig. 2(b). It is possible to move forward, back, left,

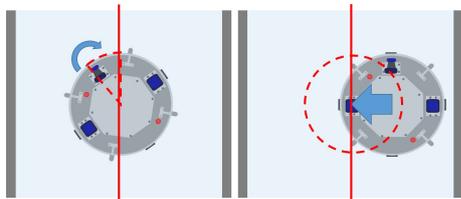


Fig.1: Control angle and position of the robot

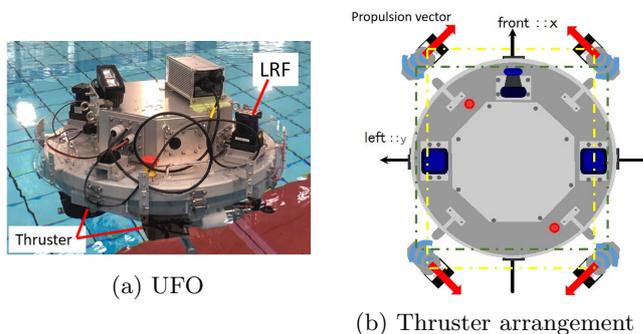


Fig.2: Developed robot

and right, and rotate on the spot by combining the propulsion vectors.

## 3 Self-position Estimation Method

### 3.1 Previous method

Fig. 3 shows the self-position estimation method in the previous study[2]. First, a linear approximation is performed for point cloud data on the left and right. The difference between the slope of the center axis of the robot and the slope of the obtained approximate straight lines is the relative angle between the robot and the wall surface. In other words, the robot should be controlled so that the approximate straight line is parallel to the center axis of the robot. Second, the distances from the center point of the robot to the approximate straight lines corresponding to the two walls (distances 1 and 2) are calculated. Then the difference between distances 1 and 2 means a deviation from the center. Therefore, the robot should be controlled so that distances 1 and 2 are equal. In this method, however, it is necessary to approximate the point cloud data in a straight line. If it is applied to the curved wall, an inadequate estimation would be obtained.

### 3.2 Proposed method

Fig. 4 shows a new self-position estimation method to accommodate curved walls. First, diagonal points between robots are connected as shown in Fig. 4(a). As a result, various diagonals can be obtained through the center of the robot, such as diagonal lines 1 to 3. Second, we focus on the shortest diagonal (diagonal 2) such as Fig. 4(b). This diagonal line is always perpendicular to the flow direction of the canal. Therefore, the angle between the diagonal 2 and the center line of the robot is the relative angle between the robot and the wall surface, and the robot can face the flow direction of the canal

