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The Prototype To Control The Rotational Motion Applied To An Inertial Navigation System Equipped With An Autonomous Underwater Vehicle

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ABSTRACT

Generally, an autonomous underwater vehicle (AUV) has some navigation systems in order to cruise autonomously without communications from the outside world. One of them is an inertial navigation system (INS) which is composed of accelerometers and gyros. The INS outputs the absolute position and posture of a moving object equipped with it. However its output includes some error owing to drift-bias errors of the sensors; accelerometers and gyros. And the position accuracy of it is reduced because the error is accumulated with time-series. So the method has been proposed to improve the performance of the INS owing to the rotational motion. And the effect of the method was confirmed in experiments that were carried out in static condition. And the prototype of the rotation control system to apply the method to an AUV was designed. This system controls the rotational speed and direction in accordance with the AUV's motion. In this paper, the method and the control system are described, and experimental results carried out to confirm effects of them on land are shown.

KEY WORDS: Inertial Navigation System, Autonomous Underwater Vehicle, Rotational Motion, Position Error.

INTRODUCTION

Currently, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) tries to research a new AUV which is capable of very long range cruise. As know well, it needs not only a high density energy source but also a high performance navigation system in order to give the AUV such capability. If it is equipped with only the energy source, it can't get useful and effective observation results. Because, unless it detects its own accurate position at any time, it can't cruise autonomously and correctly along the pre-designed course. So it is very important to develop the high performance navigation system. Now, we are researching on method to improve the performance of an INS. The intended type of it is the strap-down type. This type INS has the three-dimensional coordinate system (INS coordinate system) fixed the inside, and a gyro and an accelerometers are set on each axis in the coordinate. The gyros measure angular velocity of the AUV and the accelerometers measure its inertial force is equipped with the INS. And the INS calculates absolute position of the AUV using these data in real time. However the position data includes the error caused by the drift-bias errors of the gyros and the accelerometers, and it increases with the passage of time. So it is very difficult that the AUV cruises for a long time dependent only on the INS. Because of this, we have proposed the method to improve the performance of the INS. In the method, it is rotated around an axis of the INS coordinate system according to some rules and consequently the bias-drift errors of the sensors are reduced. The effect brought about by this method was tested in static condition, and the position accuracy was increased by the error reduction. So, it is necessary to design the system which controls the rotational motion in accordance with AUV's motion.

POSITION ERROR OF INS

The strap-down INS is mainly composed of a sensor part and an arithmetical part as shown in Fig. 1. The sensor part has three accelerometers and three gyros, and an accelerometer and a gyro are set on each axis of the INS coordinate system, as mentioned above. The accelerometer and gyro measure acceleration and angular velocity in each axial direction and axial rotation of the INS coordinate system, respectively. And the arithmetical part makes the coordinate transform matrix, which indicates the posture relation between the INS coordinate system and the Earth coordinate system, using the angular velocity values. Then each acceleration value is transformed by the matrix consequently the accelerations in Earth coordinate system can be got. And velocity values in the coordinate system are calculated because they are integrated. And moreover, they are integrated again consequently the three-dimensional distances in the coordinate system are calculated. The current absolute position is derived because they are accumulated from the initial position with time-series. So, the position accuracy depends strongly on the precisions of the accelerometers and the gyros. And most of the INS's position error is caused by their drift-bias errors. In order to increase the INS's position accuracy, the drift-bias errors must be reduced.