A Speed Measurement Method for Underwater Vehicle Based on Pulse Speedometer and Accelerometer

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ABSTRACT

Speed measurement of underwater vehicle has taken extremely important position in the field of both underwater robotic and marine platform engineering nowadays. However, it still faces great difficulties due to its complex technology, which also make high precision speed measurement of the underwater structure an innovative technology. In this paper, a novel speed measurement method is proposed on the background of underwater scientific experiment whose object is a wheeled test vehicle used for ocean development. The method is based on Kalman filtering algorithm to fuse data obtained by mechanical pulse speedometer and accelerometer, which heritage good filtering property and following feature of both algorithms, noise immunity has been enhanced as well. Laboratory digital simulation and test pool object experiment all validate the superiority of the method by showing better filtering speed measurement result.

KEY WORDS: Speed measurement of underwater vehicle; federated Kalman filtering algorithm; mechanical pulse speedometer; accelerometer.

INTRODUCTION

Currently, the speed measurement for underwater vehicles mainly relies on Patent Log, Electromagnetic Log, Doppler Log and Acoustic Correlation Log, or other apparatus, which all achieve good measurement effect in each applicable environment. In the present engineering test, high precision measurement of the speed of a wheeled test car applied to the certain underwater platform is required. The wheeled vehicle’s length is about 7m, whose width is 2.4m, height is 5m, and weight is about 5t, designing as streamlined shape, it runs on a flat straight track of the underwater platform driven by its own wheels. Due to the special application environment, all the measurement methods mentioned before present their own limitations, especially hard to achieve the high precision of the measurement result. In this paper, a novel speed measurement method applied to underwater condition based on multi-sensor data fusion theory is proposed considering the test object’s properties. Figure 1 shows the schematic diagram of the method.

METHODOLOGY AND MODELLING OF SPEED MEASUREMENT

Mechanical Pulse Speedometer

The mechanical pulse speedometer calculates to get the speed of vehicle by measuring wheel rotation frequency. Let the wheel radius to be R, and assume the number of pulses speedometer collects while the wheel rotates a circle is M, the corresponding distance of each pulse is then deduced as \( \frac{2\pi R}{M} \). Assume the number of pulses per unit time T is n, the speed of the vehicle then can be calculated as \( v = \frac{2\pi R n}{MT} \). Now introduce \( K_s = \frac{2\pi R}{T} \) as the scale factor of the mechanical pulses speedometer whose value is related to the diameter of the wheel. However, in the practical working conditions, friction and sliding of the wheel and bouncing of the body of vehicle all have some impacts on the precision of the mechanical pulse speedometer, thus the speed correction formula can be concluded as: