Fault Diagnosis Analysis of Large Scale AUV Hydraulic Steering Gear Based on Multi-information Fusion

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ABSTRACT

Steering gear is an important actuator to ensure safe and stable operation of AUV. Based on the characteristic information collected by sensors, a fault diagnosis method of hydraulic steering gear based on multi-information fusion is proposed. Based on the collected data, the feature evidence space is constructed, and the initial diagnosis of the evidence space is carried out by using radial basis function neural network, and the preliminary diagnosis results of each evidence body are fused by the weighted evidence fusion theory. The diagnosis result shows that it has high reliability, low uncertainty, and it can accurately identify the fault.

KEY WORDS: AUV; hydraulic steering gear; radial basis function neural network; weighted evidence theory; multi-information fusion; fault diagnosis

INTRODUCTION

In recent years, many research institutions at home and abroad have applied multi-source information fusion technology to the field of fault diagnosis and analysis, and achieved some results. SafiZadeh et al. (2014) used multi-source information fusion method to diagnose the vibration fault of rolling bearing; Cai et al. (2014) used Bayesian neural network information fusion method to diagnose the heat pump; Basir et al. (2007) used multi-source information fusion method based on DS evidence theory to diagnose the fault of engine. Autonomous Underwater Vehicle (AUV) is a new type of platform with autonomous navigation ability. The steering gear is an important actuator for AUV, especially for underactuated AUV, which plays an important role in ensuring the safe and stable operation of AUV. Rudder is the main component of AUV to maintain heading and control direction in underwater operation. Therefore, once the rudder fails, it will bring a greater threat to the operation safety of the whole AUV. The failure of the steering gear (such as stuck rudder, only one-way rudder, slow speed of rudder turning, sluggish rudder, rushing rudder and running rudder) will seriously affect the navigation performance of AUV and even endanger the navigation safety of AUV. Therefore, it is necessary to analyze the operation principle and common faults of the steering gear, and ensure the safety of the ship operation by mastering the faults accurately and solving them in time. The fault diagnosis method of hydraulic steering gear is mainly based on the feature extraction and analysis of performance parameters. The features of different faults are reflected in different types of feature signals, and the uncertainty of diagnosis depends on a single feature signal is high.

In this paper, the multi-source information fusion technology is applied to the fault diagnosis of the hydraulic steering gear. By using the multi-source information fusion technology to fuse a variety of data parameters of the AUV hydraulic steering gear, the fault diagnosis of the hydraulic steering gear is realized, and the problems of low accuracy and high uncertainty of diagnosis relying on a single feature signal are solved. At the same time, it studies the weighted evidence theory algorithm, and uses its fusion radial basis function neural network to diagnose the single signal feature, and obtains the fault diagnosis result after multi-source information fusion. Finally, a set of fault diagnosis method of large-scale AUV hydraulic steering gear based on multi-source information fusion technology is proposed, and the method is verified by the simulation fault test data of hydraulic steering gear.

INFORMATION FUSION THEORY

Dempster (2008) put forward a theory of information fusion DS evidence theory in 1967, which was expanded and developed by Shafer. Its three basic points are: basic probability assignment function m, trust function Bel, likelihood function pls. Evidence theory is an excellent method to deal with uncertainty. Compared with the traditional probability and statistics method, it can grasp the uncertainty and unknown of the problem better.

Let Θ be the recognition framework. If set function m: 2^Θ→[0,1] (2^Θ is the power set of Θ) satisfies Eq. 1.

\[ m(\emptyset) = 0 \quad \text{and} \quad m(\Theta) = 1 \]

\[ m(A) \leq m(B) \quad \text{for} \quad A \subset B \]

\[ m(A) + m(A^c) = 1 \]

\[ m(A \cup B) = m(A) + m(B) - m(A \cap B) \]

\[ m(\bigcup_{i=1}^{n} A_i) = \sum_{i=1}^{n} m(A_i) - \sum_{i<j} m(A_i \cap A_j) + \sum_{i<j<k} m(A_i \cap A_j \cap A_k) - \cdots \]

\[ m(\bigcap_{i=1}^{n} A_i) = \prod_{i=1}^{n} m(A_i) \]