IAF ASTRODYNAMICS SYMPOSIUM (C1)
Virtual Presentations - IAF ASTRODYNAMICS SYMPOSIUM (VP)

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FAULT DETECTION AND ISOLATION METHOD OF REDUNDANT INERTIAL MEASUREMENT UNIT FOR SLOWLY-VARYING FAULT BASED ON NEURAL NETWORK

Abstract

The fault detection and isolation (FDI) of redundant strapdown inertial measurement unit (RSIMU) is critical for ensuring the reliability of the guidance or navigation system. Although knowledge-based approaches such as neural network, expert knowledge, fuzzy logic reasoning, and deep learning are used widely, it is impossible to detect the slowly-varying fault in RSIMU. The traditional method based on neural network is the idea of classification which is carried out according to multi-dimensional sample data, network modeling is carried out through multi-dimensional data at a certain moment, and an independent sample data is used for testing. However, the slow-varying fault changes gradually with time. The data is time series, which can only be revealed after a period of time. The conventional method of establishing a network model using fault data at one time cannot be applied. This paper aims to solve the problem that conventional neural network method cannot detect slow-varying fault. Therefore, training data of network model is the core of the method in this paper. The training data of input adopts the method of fault injection, which includes three factors: the time of fault occurrence, the slowly-varying fault amplitude and the serial number of fault sensor. For each training data, the vector of redundant inertial measurement unit at each sampling time is expressed as: n×1−dimensional vector (n is the number of sensors), each training data is expressed as: n ×1×m three-dimensional array (m is the number of samples). The training data of output is set as 0 for working and 1 for fault. Then, the corresponding data of output is n ×1×m three-dimensional array. Monte Carlo simulation is carried out. Results on the one hand show that when the gyro noise is 0.05°/h, the slowly-varying fault of 0.2°/h can be detected within 10s, with the fault detection accuracy rate is over 99 percent. On the other hand, the results also indicate that the network structure parameters including hidden layer, maximum training times, learning rate and training accuracy all affect the training time, with the training accuracy having the greatest impact, the hidden layer having the second effect, and the maximum training times having the least impact. However, the influence of network structure parameters on fault detection results is limited. The proposed FDI method can provide a theoretical reference for slowly-varying fault of RSIMU.