The Design of Intelligent Fault Detection System for an Automatic Loader

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Abstract. The fault characteristic of automatic loading system is analysed, the fuzzy-immunity mixed fault diagnosis method is put forward, and the programme of fuzzy-immunity fault diagnosis is given, the math model of fault diagnosis is established, the fault diagnosis is resolved in the lack of prior knowledge. The precision fault diagnosis is realized for the automatic loading system.

1. Introduction
The fault diagnosis of weaponry has always been paying important attention by the national armed force. Especially, the fault of automatic loading system has random city and fuzziness, several intelligence fault diagnosis methods, such as single neural networks and fuzzy diagnosis methods, do not daily satisfy the need of automatic loading system fault diagnosis, though these methods take on a little superiority on the fault knowledge training and ration diagnosis, the "bottleneck" exists on acquirement of fault knowledge, especially dynamic and on-line fault knowledge. So, according to the characteristic of fault mode for automatic loading system and the superiority of intelligence fault diagnosis methods, the fault diagnosis tactic of automatic loading system based on fuzzy-immunity mixed method is put forward.

2. The Overall Programme of The Diagnosis Tactic
The structure analysis of automatic loading system is the basis of studying the fault mechanism and fault characteristic in the system fault diagnosis, the automatic loading system includes revolving ammunition conveyer, lift mechanism rammer, gun lock mechanism, ejector opening-window mechanism, and other parts. After the structure form analysis of automatic loading system, the fault characteristic of automatic loading system is summarized as follow:

1. Because of the complexity of the system, every part system contains some subassembly, so the system fault category is various, and the random fault is also engendered.

2. The relation between the fault symptom and fault cause is wondrously anfractuous, viz. The same fault symptom has some fault cause, and the same fault cause also brings kings of fault symptom.

3. The system fault has relativity and uncertainty. If the assembly of the system exits the fault, which leads to change for the correlative assembly, much fault possibly occurs at the same time. The problem of the uncertainty for the fault exits because of subjectiveness and objectivity.

In the fault diagnosis of automatic loading system, acquirement of prior knowledge for fault, lack of the fault samples and improvement of fault diagnosis efficiency have been widely studied. On the basis of the research of the fault mechanism and fault characteristic, the paper combines the each strongpoint...
of the two methods, the fault diagnosis tactic of automatic loading system is given, and the overall programme is shown as the Figure 1.

![Programme of Fuzzy-Immunity Fault Diagnosis of Automatic Loading System](image)

**Figure 1.** The programme of fuzzy-immunity fault diagnosis of automatic loading system

In figure 1, the fault diagnosis tactic of automatic loading system has main characteristics as follow:

1. The tactic is fit for complicated weapon system. The weapon system is daily intelligence and every part system contains some subassembly, which can be high demanded for the fault diagnosis method, but the tactic whether fuzzy or immunity arithmetic is doing according to the fault character of complicated weapon system.

2. The tactic which has realized ration calculation instead of the traditional qualitative discursion. Traditional fault diagnosis methods mostly qualitatively analyse and ratiocinate the fault cause based on experts' experience and a great deal cases, so in determination exists, and the fuzzy relation between the fault symptom and fault cause cannot be resolved, the relation may be made clear by adopting fuzzy math theory, then the exact and rational diagnosis is realized.

3. The tactic can resolve the problem that the fault knowledge is difficult to be obtained. The acquirement of fault knowledge is the primary problem in the fault diagnosis, it is prodigious efficient that many academicians adopt artificial immunity system to resolve lack of prior knowledge for fault. The tactic has reference to nature immunity system theory, obtaining dynamic and fault knowledge sample, increasing the fault prior knowledge, recombining fault fuzzy diagnosis technology, then the fault diagnosis can rapidly and truly realized for automatic loading system.

3. The Theory and Method of Fuzzy-immunity Diagnosis Tactic for Automatic Loading System Fault

On the base of the study for the fault mechanism and fault characteristic of automatic loading system, according to the fault diagnosis tactic programme shown as the figure 1, fuzzy-immunity arithmetic theory and realization process of fault diagnosis for automatic loading system is studied, idiographic diagnosis process as follow:

Through special checking equipment of automatic loading system, the status signal of automatic loading system that we collect is carried by data pretreatment, according to status messages characteristic, the fault information is compartmentalized to the known fault and unknown fault, the known fault is directly disposed by the fuzzy diagnosis method, the relation between fault symptom and cause is made clear, the fault class and fault cause is ascertained by the fuzzy math mode, the relatively quantificational diagnosis result is given. The fault knowledge information of unknown fault is obtained.
by the immunity method, then the fault database is updated, so at a certain extent the problem of lack of the database samples is resolved.

Thereinto, the immunity diagnosis method is given.

Based on the negative-selection theory of AIS. The fault is identified by a mass of detectors which are stochastically made and check the status signal of the automatic loading system, the detector is availability detector sets by immunity training, i.e. if the status signal is high matching with the detectors in checking, so the known fault exists in the system, or Unknown fault. The immune-learning is also immunity recognition process, the signal feature information of the unknown fault is updated to the fault data base by the clone of immune-learning, if this fault reappears, it is first checked. The theory is shown as the Figure 2.

In the negative-selection theory, it has two important matters: one is to produce the mature detector; the other is the mechanism of immunity study. The both fulfil the function of the fault diagnosis on the basis of the negative-selection theory of AIS. The efficiency of producing the detector and availability degree of the detector is quit important for realizing the fault diagnosis of the entire system. The immunity study is the important method for resolving the lack of prior knowledge, the fault database is continually updated, and the fast diagnosis is realized for the system fault.

The fault diagnosis method is a diagnostic process for the fault by use of the fuzzy math theory. First, the fault symptom set and fault cause set are established, the membership between every fault symptom and fault cause is ascertained, it is shown by membership degree, the fuzzy relation matrix is made of the membership degree, the relatively quantificational diagnosis result is given by the math mode.

Fuzzy math mode as follow: \( Y = X \circ R \), it is shown by matrix:

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Y = X \circ R = (x_1, x_2, ..., x_m) \circ R = (y_1, y_2, ..., y_n)
\]

In the formular, the fault cause \( Y \) is calculated by the fault symptom \( X \), \( R \) is the fault diagnosis relation matrix. The matrix \( R \) is a key to obtain the diagnosis result, when the fault symptom is known, the fault cause \( Y \) may be given by this math mode.

![Figure 2. The flow chart of the negative-selection theory of AIS](image-url)
4. Conclusion
The paper uses the fuzzy-immunity diagnostic method to diagnose the fault of an automatic loading system. It not only resolves the problem of updating and consummating the database, but also can do quantitative analysis for the diagnosis results, so the efficiency and veracity of the fault diagnosis for weapon malfunction is greatly enhanced. It is a new diagnostic tactic for the study of fault in other fields.

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