Data Processing and Analysis Method of Electronic Countermeasure Test Based on Rule Engine

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Abstract. The electronic countermeasure test data processing is the premise and basis of realizing equipment performance evaluation. At present, the uncertain problems of electronic countermeasure test data processing had been a major factor which would restrict the development of test evaluation means. This paper presented a graphical data processing and analysis method based on the procedure analysis of electronic countermeasure test data process. This method realized the custom design of electronic countermeasure data processing flow chart through flow analysis, procedure decomposition, graphical modeling, parameter configuration and flow resolving. The method based on rule engine used the rule modeling and resolving technology to realize the custom design of matching rules of electronic countermeasure test data; used the procedure data template to store the input, output and result data, which realized the traceability of results for data analysis and data processing based on the procedure.

1. Introduction
The technical approaches of evaluation for electronic countermeasure equipment performance test is the process for evaluating the overall performance of electronic countermeasure equipment, which used both test data and equipment technical indicators by signal parameter comparison, countermeasure behavior determination, data statistics, calculation of indicators, results evaluation and so on. The contents, standards and methods of evaluation for various types of equipment test are quite different due to the purpose, the object, the topic and so on. It is necessary to develop data processing programs in a targeted manner, which would impose a heavy burden on the evaluation for test. The uncertain problem in the data processing of equipment test had been a major factor which restricted the development of evaluation means construction of electronic countermeasure equipment test.

Data matching is the core function of data processing. The flexibility in matching rules setting is the key to determine the practicability of data processing. At present, the rule-based business system generally uses the technology of rule editing and rule resolving base on rule engine. Rule engine is a software component of explaining and executing rules, which completely separates business rules logic from the program code, expediently the edit and managing of business rules for users. Aiming at the uncertain problem in the data matching rules of data processing, This paper investigated the techniques of description, modeling and resolving on data matching rules for electronic countermeasure equipment test, referring to the technology of representation and executing of rule in rule engine of CLIPS[1].

Taking into account the flexibility of flow creation and the simplicity of user operation, this paper used graphical programming technology to graphically design the data processing to form a flow
design window similar to the flow chart based on the analysis of test data processing flow of electronic countermeasure equipment, which would allow user add, view and modify the flow data processing. Aiming at the uncertain problems such as input data and matching parameters of electronic countermeasure equipment data processing, this paper realized the custom design of electronic countermeasure training data processing by configuring the input parameters of functional components of data processing flow.

Aiming at the problems that it is difficult to analyze and find cause in the evaluation of equipment performance by using data processing results, this paper realized the data analytical method of process-based electronic countermeasure equipment performance test evaluation based on the design of data processing and design of matching rules, through the way of designing the class of procedure data to store the logistic procedure data of data processing.

2. Rule Modeling and Resolving Technology

2.1. Rule description

The rule is a declarative description of transactions or activities. Operational standards, business processes, regulations, bylaw, and industry standards are all known as rules[2]. At present, there is no unified classification standard for rules in the academic circles. The classification of rules differs according to the research background or research object, but the classification methods are generally biased toward the business level. At the business level, the classification of rules refers to the classification of rules from a business perspective. The rule on business level is representatively summarized for five representative types, such as structural rules, integrity constraint rules, derivative rules, responsiveness rules and responsibility authority assignment rules. The description of a rule usually consists of three parts of type, condition and attribute. A rule may include multiple conditions or not. A condition indicates a dualistic operation or an unary operation, condition operators include "=", ">", "\geq", "\leq", "\times", "\div", "AND", "OR", "NOT" and so on. The part of rule properties defined in this paper can be considered as a conclusion of conditional operations and the statistical action to be performed. The data matching rules mentioned in this paper are integrity constraint rules, which mainly refer to reconnaissance or interference signal matching rules of the electronic countermeasure equipment test and are used to determine the effect of reconnaissance or interference behavior. A matching rule may consist of a number of data items matching conditions.

2.2. Rule modeling

Rule modeling is a process that developers classify map the rules at the business level to formats that system can identify, which currently mainly includes two kinds of directive encoding and declarative encoding. Directive encoding is a way of describing business rules with programming statements, which is more suitable for software systems with simple and stable rules and which can reduce the complexity of many implementations. However, the relational codes of software system need to be modified when rules change, which will lead to the software system not flexible. Declarative encoding is a way of describing the logical structure of rules during calculation rather than controlling its structure, which focuses on the task that rules will accomplish, rather than how to accomplish them. At present, typical forms of declarative rules describing are UML/OCL, SQL, CLIPS, XML and so on[3].

Aiming at achieving the statistics of matching results of data items and rules and learning from the modeling ideas of CLIPS’s custom rules, The data matching rules described in this paper take the allowable match error values of electronic countermeasure equipment countermeasures activity signal parameters as the condition operands of the parameter matching rules, which is defined as data matching rules base.

2.3. Rule resolving technology
Referring to the rule resolving technology based on rule engine of CLIPS method, this paper presents a test data processing method of electronic countermeasure equipment based on rule engine and the technology approach is shown in Figure 1.

**Figure 1.** The technology approach of electronic countermeasure rule resolving

Based on defining data matching rules of all kinds of electronic countermeasure equipments, the method used rule management tools to design rules according to data processing requirements and rule engine to analyze and executing data matching rules designed by users.

3. The Graphical Modeling Method of Electronic Countermeasure Equipment Test Data Processing

3.1. Data processing analysis

As the difference between signal types of different professional electronic countermeasure equipment, there is a big difference between signal parameters and matching standards. Data items of radar countermeasure equipment data processing usually include carrier frequency, repetition frequency, pulse width, signal pattern, target interference level, target anti-jamming effect and so on; Data items of photoelectric countermeasure equipment data processing usually include wavelength, signal type, signal cycle, the target interference situation and so on; Data items of communication countermeasure equipment data processing usually include interference pattern, interference frequency, interference bandwidth, target interference situation and so on.

In order to facilitate the design of data processing rules and data analysis, the test data processing of electronic countermeasure equipment is usually divided into reconnaissance data processing and interference data processing on the basis of distinguishing radar countermeasure, communication countermeasure and photoelectric countermeasure. Reconnaissance data processing is the process that count the number of signal released by signal source, electronic countermeasure reconnaissance signal number, electronic countermeasure equipment to correctly identify the signal and the signal parameters of matching results and so on according to the work records of signal sources and electronic countermeasure reconnaissance equipments. Interference data processing is the process that count the number of interference signal released by electronic countermeasure equipment, target equipment interference situation, the interference level, the interference time and so on according to the work records of electronic countermeasure and target equipments.

The basic steps of data processing of electronic countermeasure equipments mainly includes reading the signal data of target equipment one by one, reading the signal data of test equipment one by one, checking the signal parameters are correct one by one, count the matching error and matching result of each parameter, rating calculation equipment performance test evaluation index and so on[4], as shown in Figure 2.
Start
Initialize data and variables

Load and filter target equipment data
Load and filter trained equipment data

Match signal parameters are correct
NO
YES

Count and record errors and results data

Whether the data processing is completed
NO
YES

Index results calculation
End

**Figure 2.** The basic steps of electronic countermeasure data processing

### 3.2. Process decomposition

Based on the analysis of data processing and basic steps of all kinds of electronic countermeasure equipments, this paper divides the logical structure of data processing into some functional modules such as red data, blue data, result data, data screening, screening conditions, data matching, matching rules, relationship connection and so on and users could configure parameters of each function module such as the input data, matching parameters, matching rules. Table 1 shows the various functional modules.

| NO. | Name               | Function                                                   |
|-----|--------------------|------------------------------------------------------------|
| 1   | Red and Blue Data  | Configure input and output the equipment data, select data items to be compared |
| 2   | Data Filter        | Filter data based on the filter conditions                 |
| 3   | Filter Conditions  | Configure the filter conditions                            |
| 4   | Data Matching,     | Matching according to the data matching rules              |
| 5   | Matching Rules     | Configure the matching rules                               |
| 6   | Result Data        | Count data matching results                                 |
3.3. Graphical modeling
Aiming at the uncertain problem of data processing, this paper used graphical modeling and visual technology to model the logic function modules of data processing as a process component based on the decomposition of logical structure[5], which taking fully account of flexibility of process creation and simplicity of operation, guided by the modeling theory based on business process, realizing the custom design of electronic countermeasure equipment test data processing. Users can realize the logical structure customization of data processing by selecting, dragging and adding the components, and solve the uncertain problems of data processing by configuring the input data and matching rules in the processing component. The logical structure of electronic countermeasure equipment test data processing was shown in Figure 3.

![Graphical representation of data processing logic](image)

Figure 3. The logical structure of electronic countermeasure equipment test data processing

Users can bind the output data of data processing to the evaluation index according to the calculation requirement of electronic countermeasure equipment test evaluation index after designing of the logical structure customization and configuring of uncertain problems, and get evaluation results according to the calculation method of evaluation index at last.

4. The data analysis method of electronic countermeasure equipment performance test evaluation
At present, there were some problems in the performance test evaluation of electronic countermeasure equipment such as weak correlation between the result data and the original data, the untraceability of processing results, the data opaque of process procedure, the data analysis limitation by the evaluation index results and so on, which make it difficult to analysis and find problems in the evaluation of equipment performance test according to processing results[6]. In order to solve this problem, this paper presented a method of process-based data analysis based on the custom design of data processing and matching rules. Aiming at all the configured procedure logical nodes of the data processing custom design such as input data, data filter items, data matching items and so on, this method designed a formatted process data storage template class to store he input data, the output data and the statistical data of logical nodes of each matching rule so as to provide procedure data support for result data analysis during the procedure of rule engine resolving and executing matching rules. The procedure-based data analysis method of electronic countermeasure equipment test evaluation was shown in Figure 4.


Figure 4. The process-based evaluation data analysis method of test evaluation

5. Conclusion
This paper researched on the modeling and resolving technology of rule engine-based rules, the processing decomposition and modeling methods based on graphical programming, the test evaluation requirement analysis of electronic countermeasure equipments and so on, and presented a rule engine-based data processing and analysis method of electronic countermeasure test, aiming at some uncertain problems in the test data process of different electronic countermeasure equipments such as input data matching parameters, matching standards, etc. The method solved the uncertain problems of the data processing and the matching rules of electronic countermeasure equipment test, achieved the custom design of data processing, matching rules and data processing results. The procedure-based data analysis method enhanced the traceability of results.

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