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To cite this article: Wang Jingwei *et al* 2020 *J. Phys.: Conf. Ser.* **1635** 012056

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SMA-based simulation data demand acquisition in the field of mechanical equipment

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Abstract—In view of the complexity of the simulation system in the field of mechanical equipment and the difficulty in obtaining the simulation data, the idea of requirement engineering is adopted. After comparing the current common demand analysis methods, the comprehensive micro analysis method is introduced to analyze the data demand. In this paper, the application process model of the comprehensive micro analysis method is also constructed to describe the application process of the method.

1. Introduction

In the field of mechanical equipment, the application of simulation technology is more and more extensive, and simulation has played an important role in the design, performance and life of mechanical equipment. In each link of the simulation, a large amount of different data needs to be input or output at different times. The simulation process is essentially a process of data preparation, calling, processing, analysis and updating. It is not difficult to see that data is the core of simulation, and data demand analysis is the precursor and basis for all work[1].

Because of the angle problem between various levels, the data cannot be obtained comprehensively and accurately. In view of this, this paper adopts the idea of requirements engineering and introduces a comprehensive micro-analysis method to analyze the data requirements of the simulation of mechanical equipment.

2. SMA overview

In order to cope with the needs analysis of complex systems, Professor Ouyang Ying, an American Chinese physicist, proposed synthetic micro-analysis, which is a basic methodology for solving complex problems, emphasizing that the development process is From problem to solution, from general to local, from general to local, from general to specific, combining macro and micro analysis, the complex problem is decomposed into simple problems that have been thoroughly studied, and then starting from simple problems, get complex The answer to the question[2].

The comprehensive micro-method is a further development of the structured method, which embodies the principles of gradual refinement and information integration. The concept space of the



micro-plane and the macro-plane can achieve the purpose of communicating the two planes by analyzing the interaction between the two planes. This space is three-dimensional. As Fig1 shown below:

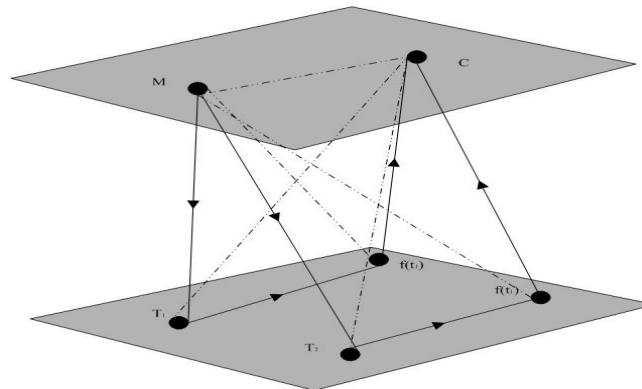


Fig. 1 SMA 3d concept map

Assuming that the macro mission is M , it can be decomposed into T_1 , T_2 , and the solutions corresponding to T_1 , T_2 are $f(t_1)$, $f(t_2)$, while $f(t_1)$, $f(t_2)$ are the smallest unit to solve the problem. By looking for the corresponding relationship between them, the demand goal C of the macro problem is finally obtained. A few notes about the three-dimensional diagram:

A. The upper level is the macro level of the problem, and the lower level is the micro level of the problem;

B. Node M can be understood as the mission task space or overall requirements in the requirements certification, the front section of the triangular prism (M , T_1 , T_2) constitutes the problem domain Q ;

C. The node $f(t)$ can be understood as the capability requirement system in requirement certification. The rear section of the triangular prism (C , $f(c_1)$, $f(c_2)$) constitutes the solution domain P .

D. The dotted line indicates that there is a conceptual connection between the two connected nodes.

3. Research status of demand analysis method

3.1. Current main demand analysis methods

At present, many experts and scholars have proposed task-oriented, capability-oriented, system-oriented, and entity-oriented ideas based on the characteristics of the professional field[3] [4] [5], and accordingly constructed corresponding data demand analysis methods. Each method has its own emphasis, and the methods and means are also not exactly. One is the task-oriented data requirements, the requirements for the content of the tasks undertaken by the equipment objects expected to develop in order to complete specific application goals. In engineering practice, in accordance with the general demand development model, the process of using task to pull action to obtain task requirements is usually also called task decomposition. Only by performing a comprehensive, in-depth and accurate analysis of tasks can we accurately carry out the tasks expected to be undertaken. Grasp; the second is the ability-oriented data requirements, the requirements for the ability of the equipment objects to be developed to meet the requirements of the mission, the ability is the fundamental guarantee for the completion of the mission, so it has the expected mission and its goals The direct relationship is the mapping object of the second level; the third is the function-oriented data requirements, the requirements for the system functions that the equipment should have in order to achieve the equipment's capability goals, the functions are conceptually opposite to the structure, referring to It is the characteristics and capabilities of a particular structured thing or system in internal and external connections and relationships. Function-based data requirements reflect the output characteristics of the internal structure of the equipment system. It is the direct support of equipment capabilities. The realization of an equipment capability requires the support of several equipment functions, and one equipment function may support multiple Ability realization.

The above three current main demand methods each have their own emphasis, and the methods and means are also different. According to the equipment demand theory, they can be roughly divided into three levels, corresponding to the decomposition and mapping process from tasks to specific indicators, respectively corresponding to Tasks, capabilities, and performance are essentially three levels of decomposition. Because of the angle between the various levels and the current system complexity in the field of mechanical equipment, it is not possible to obtain data comprehensively and accurately. And if this top-down structured analysis method is directly adopted, from top to bottom, from the overall to the partial, it will inevitably fall into a simple holism or isolation theory, so that the resulting data is one-sided, isolated, and not systematic. In view of this, this article suggests adopting the idea of requirements engineering and introducing a comprehensive micro-analysis method to analyze the data requirements of simulation in the field of mechanical equipment.

3.2. *Foreign research status*

As early as in the 1960s, the U.S. military implemented the "planning, planning and budgeting system" (PPBS), which used the theory of system engineering to analyze and study the demand problem, and closely combined the national security strategy, military demand and military construction; In the mid-1980s, a trinity procurement system was formed, that is, requirements generation system was added to PPBS, RGS) and acquisition management system, demand generation system determines what kind of equipment each service and arm needs. Acquisition management system ensures that such equipment can be designed, while PPBS system should limit the resources required for the design of such equipment within a certain range. In RGS, requirements are expressed mainly through mission requirements and operational requirements documents. The mission requirements statement describes operational requirements in general operational terms. The operational requirements document is more specific, and specifies specific parameters such as speed, duration, reliability, accuracy, and also includes threshold value (minimum value) and target value (expected value). According to RGS, Demand generation begins with various services. Each service continuously evaluates the current and future capabilities, and determines new requirements and new plans based on the assessment of existing defects (for example, after the air force evaluates the results of Desert Storm operations, it is found that there are still a large number of ideal weather conditions and missions have to be cancelled due to the lack of ability to find targets There is a need to provide an all-weather, accurate and low-cost capability to attack a variety of fixed and moving targets, resulting in a Joint Direct Attack Munition program.

In August 2003, the U.S. Department of defense adopted the OMT capabilities integration and development system, JCIDS (JCIDS) replaces the original RGS and emphasizes the capability building with joint operations as the core, providing support for the chairman of the JCIDS and the joint requirements oversight committee to assess and confirm the joint operational capability requirements. JCIDS is a rigorous analysis process to ensure that the requirements proposal meets the needs of future joint operations. If a service's demand proposal cannot moderately (or forcefully) support the operational capability required for joint operations, it will be rejected or returned to the service for replenishment.

4. Application of comprehensive microanalysis

4.1. *The complexity of mechanical equipment systems*

Since the third scientific and technological revolution, science and technology have developed rapidly, and technology has brought about tremendous changes to human life. In continuous changes, people have also created a variety of mechanical equipment for serving production and life. Aviation The complexity of aerospace, marine, automotive, CNC machine tools and other equipment has been unprecedented[6].

Its complexity is mainly reflected in three aspects. First, it is composed of many components (or subsystems). As we all know, the overall behavior (function or characteristic) is not the sum of the behaviors of its components, and the interaction between the components The method is very

complicated. Due to the uncertainty of the interaction between components, the overall behavior of the complex system is uncertain. Second, there are many functional requirements. To meet the needs, a set of equipment often has multiple performances, and each function, It is not done independently by a certain subsystem, it must be completed by the cooperation of each subsystem; third, there are many environmental requirements, the use environment of different equipment is very different, strong cosmic rays in space, sharp changes in temperature difference, deep in the ocean The high pressure, etc. The use environment places very high requirements on the equipment itself, making the mechanical equipment system a complex system.

The development and production of mechanical equipment is a complex system, and the comprehensive micro analysis method can overcome the various disadvantages of various demand analysis methods due to analysis angle problems. For complex systems, the demand analysis must be conducted under the guidance of the comprehensive micro analysis method .

4.2. Application process model

The requirement process of mechanical equipment simulation based on comprehensive micro-analysis method is a layer by layer decomposition based on mission tasks to obtain the minimum activity, and the corresponding capability elements are mapped in parallel on the same plane. The activities map capability atoms until each capability atom is obtained. The performance index set is the data demand system. As Fig2 shown below:

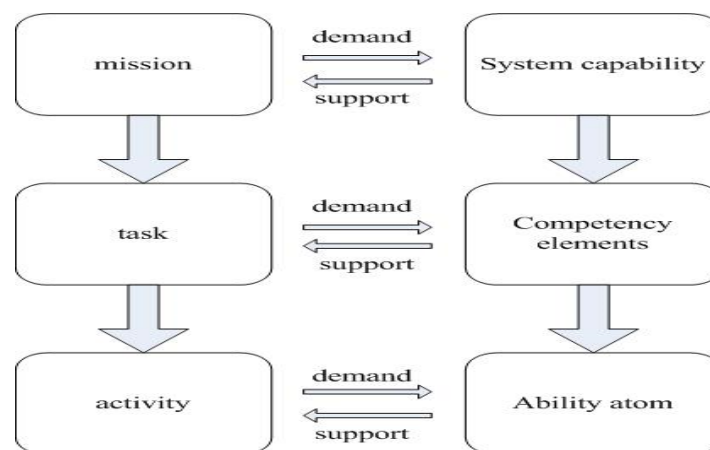


Fig2. Application process model

A process as shown in the figure, the specific process includes proposing the overall goal, mission task analysis, goal decomposition, demand mapping analysis, optimization and comprehensive analysis.

Step 1 Ask questions. The user proposes an overall goal. The user puts forward the overall requirements and the specific functions to be implemented. Corresponding to the goal M in the figure, the main task of the developer is to establish a clear and accurate mission task system and establish a conceptual connection between the functions.

Step 2 Target decomposition. After establishing the overall task, the goal needs to be decomposed. The first step is to decompose into tasks, and the task is subdivided into activities to complete the task. The ultimate goal of decomposition is to decompose the task into the smallest activity unit.

Step 3 Demand mapping analysis. According to the relationship between demand and support between activities and capabilities, and considering the macro, mission and system capabilities, capability elements and tasks, one by one is mapped until the capability atom is determined.

Step 4 Demand optimization and synthesis. The purpose of optimization and synthesis is to obtain a capacity system. There must be repetition between different capacity atoms. The optimized aggregation of data is used to filter out the repeated data to obtain the final capacity demand system.

4.3. Construction of mission activity system

Based on the above hierarchical decomposition process, the minimum activity atom can be obtained from the mission, so as to construct the mission activity system. As Fig3 shown below:

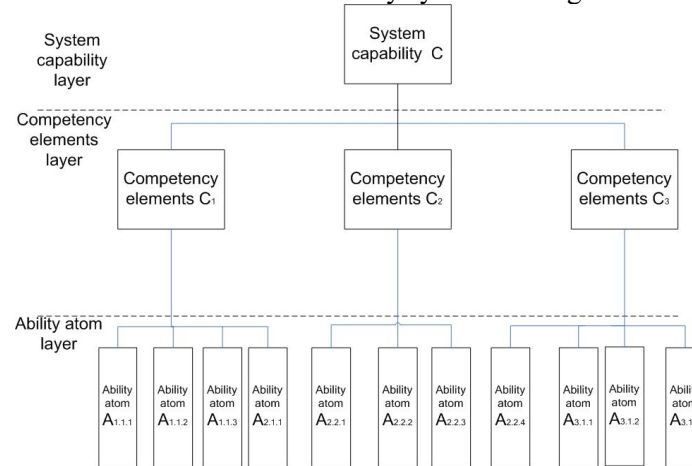


Fig3. Mission activity system

Similarly, based on the above-mentioned mission, activity, capability and capability atom, the capability system can be obtained by decomposing the above four elements to support the relationship between requirements. As Fig4 shown below:

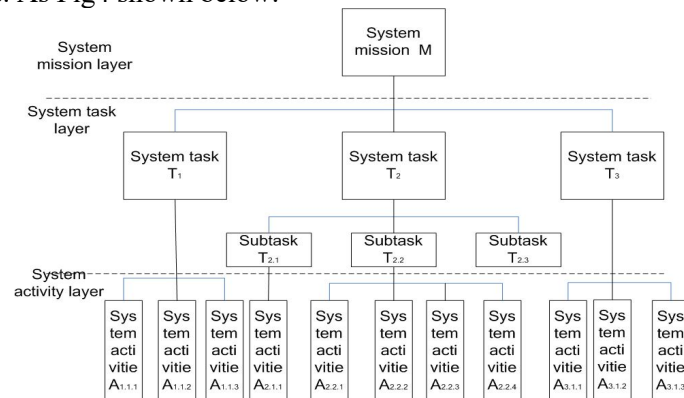


Fig4. Capability system

5. Application Innovation

After analyzing the common task-based, capability-based and function-based requirements analysis methods, this paper applies the comprehensive micro-analysis method in the field of mechanical equipment to establish its demand system in view of the uncertainty of the complex system of mechanical equipment. At the macro and micro levels, through top-down, layer-by-layer decomposition, and mutual mapping, this paper establishes a comprehensive micro-analysis application process model with detailed operability.

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