International Journal of Hybrid Information Technology
Vol.8, No.6 (2015), pp.1-16
http://dx.doi.org/10.14257/ijhit.2015.8.6.01

Establishment of Knowledge Base for Decision-making of Handling Process for Port Heavy Lift Cargoes

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Abstract

Port is an important node of logistics and transportation for goods to reloading between shipping and traffic, port logistics has been developed as a national strategy of China. With the improvement of social productivity level, in order to meet the requirements of production, a rising number of heavy lift cargoes are loaded and unloaded in port. At present, the decision for port heavy handling process is made mainly by an artificial and traditional way. The studies on automatable decision of hoisting process in port are few. This paper presents the topic: establishment of knowledge base for decision-making of handling process for port heavy lift cargoes. Use the key technologies of knowledge engineering, including three aspects: knowledge representation, knowledge acquisition and knowledge utilizing, to improve the automatable degree of the decision process.

Keywords: *heavy lift cargoes handling, knowledge base, reasoning machine*

1. Introduction

Port is a main place to implement the change of goods between land and water. In addition, the port is an important hub which connects culture, economy, society, science and technology nowadays. With the rapid development of domestic social productivity level and increasing demand of production, more and heavier lift cargoes need to be transported between land and water in order to meet the requirements of the production. As shown in the following picture, the proportion of heavy lift cargoes is higher and higher.

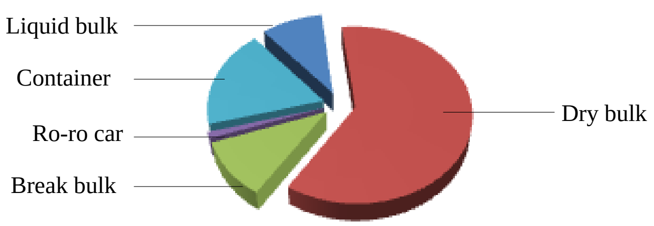


Figure 1. The Proportion of Main Kinds of Cargoes of National Throughput in 2011

ISSN: 1738-9968 IJHIT

The cost of port heavy lifting process is very high and sometimes even more than the value of the goods itself in port cargoes transportation. So it is urgent to apply the power of science and technology into the heavy cargo lifting to cut the transportation cost. According to the survey, typical break-bulk (coal and ore, cement, chemical fertilizer, grain, *etc.*,) and lifting of containers in domestic break-bulk port have some professional equipments and production lines, which has high level degree of mechanization and automation. However, the current process is mainly rely on artificial way for decisions in terms of port heavy lifting, which has low degree of automation. The studies on automatable decision of hoisting process in port are few. The level of automation and efficiency is low and the cost is high in the field generally, experience of experts in this field is difficult to be preserved and used in a better way, so it is necessary to carry a research. In recent years, studies based on knowledge are done in all walks of life, the key technologies of knowledge engineering, knowledge representation, knowledge acquisition and knowledge utilization, have great progresses. This method has a good application prospect. It not only can help to realize the preservation and application of knowledge, but also can provide auxiliary decision as the roles of many human experts in a certain extent.

The remainder of this paper is organized as follows. Section 2 is the literature review about knowledge base. Section 3 is the introduction of the knowledge of decision-making of handling process for port heavy lift cargoes. Section 4 introduces the establishment of knowledge base. Section 5 shows the design of inference engine of the knowledge base. Section 6 gives the case analysis and Section 7 gets several conclusions.

2. Literature Review

Existing studies based on knowledge are done in all walks of life. H.Z. Yang, etc.(2012) presented a knowledge-based engineering (KBE) methodology for ship hull structural member design. Iraj Mohammadfama, *etc.,* (2013) aimed to offer a knowledge base for the PEFs through adopting an ontological approach and then to use the proposed knowledge base for further applications particularly. Ying Liu, *etc.*, (2006) introduced a knowledge base for identification of residual solvents in pharmaceuticals. Tamara Varela Vila (2013) proposed the use of a Spanish and French comparable corpus to extract terminological and conceptual information on galactosemia followed by the construction of ontology to create a terminological knowledge base on this pathology. Ying-Han Wu, *etc.,* (2011) proposed a basic ship design knowledge-model for information storage and retrieval using a knowledge-based engineering (KBE) system. Jan Fagerberga, *etc.,* (2012) explored the knowledge base of the field, a database of references in scholarly surveys of various aspects of innovation. G. Forestiera, *etc.,* (2012) presented the building steps of a knowledge-base of urban objects allowing to perform the interpretation of HSR images in order to help urban planners to automatically map the territory. Zone-Ching Lin, *etc.*, (2010) used an overall knowledge framework concept to carry out engineering knowledge framework categorization for a door-shaped structure. Kwai-Sang Chin, *etc.,* (2003) developed a knowledge-based expert self-assessment (KES) training toolkit on measuring and assessing organisational performance based on the evaluation criteria of a renowned Business Excellence Model — the Malcolm Baldrige National Quality Award

(MBNQA).Andrew S. Howard, *etc.*, (2009) provided a geoscience knowledge base for geological survey organisations (GSOs).Nicolas Prat, *etc.*, (2012) proposed an MDA approach to knowledge engineering, centered on the CommonKADS knowledge model. Richard Curran, *etc.*, (2010) devised the KNOMAD methodology to better address the integration of multidisciplinary engineering knowledge within a knowledge based engineering (KBE) framework. Martina Freiberg, *etc.*, (2012) proposed Extensible Prototyping as a tailored prototyping approach and suggested its integration with the Agile Process Model for knowledge-based systems. Nayat Sánchez-Pi, *etc.*, (2011) described the design, definition and evaluation of a knowledge-based system using the CommonKADS (CKADS) methodology.

Based on above analysis, this paper presents the topic: Establishment of knowledge base for decision-making of handling process for port heavy lift cargoes. Use the key technologies of knowledge engineering, including three aspects: knowledge representation, knowledge acquisition and knowledge utilizing, to improve the automatable degree of the decision process.

3. Knowledge about Decision-making of Handling Process for Port Heavy Lift Cargoes

Knowledge sources of the port heavy lifting process mainly includes expert experience, relevant technical requirements and standards of the literature, used maintenance data of hoisting machinery and fittings and so on. In order to achieve further knowledge representation and application we need to study the induction, classification, generalization and abstraction of knowledge sources to a certain form and degree. According to the content of knowledge, port heavy lifting process has a variety of classification. For example, it can be divided into the ship loading and unloading operation knowledge and vehicle loading and unloading operation based on the process; Then it also can be divided into the vehicle assembly knowledge, complete sets of equipment assembly knowledge and so on according to the types of cargoes; Based on the source of knowledge it can be divided into the knowledge of expert experience and standards.

3.1 Knowledge Representation of Port Heavy Lifting Process

As we all know, production rules of port heavy lifting process including two types of contents, as shown in the Figure 2. Selection rules of tools is mainly about the selection of type, model and serial number, then the sling is chosen primarily for the length, specification, model and serial number.

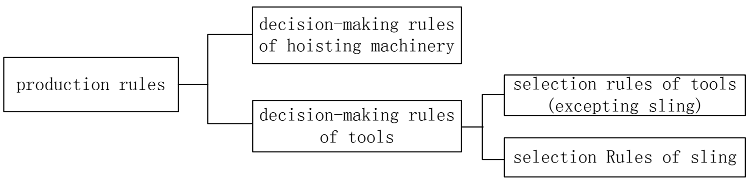


Figure 2. Classification of Production Rules of Port Heavy Lift Cargo

Handling Technologies

3.2 Knowledge acquisition of Port Heavy Lifting Process

According to research, more than 90% of the knowledge can be obtained from the literature. Artificial participation in knowledge acquisition is necessary, however completely artificial participation would be inefficient. Therefore a lot of repeated labor can be implemented by computer to improve the efficiency. This study combines artificial knowledge acquisition with semi-automatic knowledge acquisition and introduce the intelligent algorithm of matrix representation and mapping (MRM).

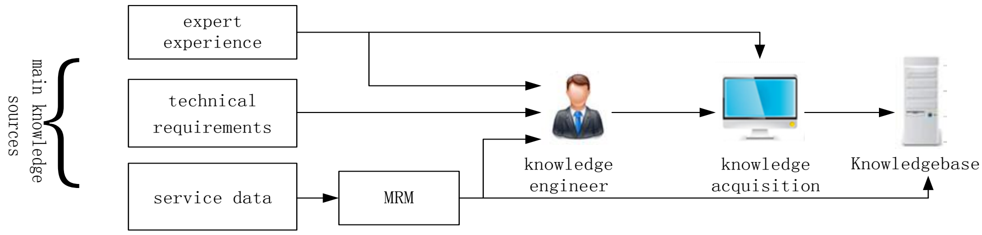


Figure 3. Methods of Knowledge Acquisition of Port Cargo Lifting Technology

As shown in the Figure 3, there are three ways to acquire knowledge, such as expert experience, technical requirements and standard specification documents and the number screening of a large number of sling, hoisting machinery.

Knowledge engineers can acquire artificial knowledge from the experts or the literatures, which is expressed as a suitable knowledge stored in knowledge base. A prototype system is mainly rely on this method. Automation part in semi-automatic knowledge acquisition has been realized mainly through the implementation of the man-machine interaction degree, and the knowledge stored in the appropriate form through the knowledge acquisition module directly. In this way, the work of knowledge engineers is eliminated. The extending of knowledge base mainly depends on the knowledge acquisition module to implement the increase of knowledge after the foundation of a prototype system. Intelligent algorithm MRM is mainly for the selection rules of the degree of the available for large sling and hoisting machinery.

4. Establishment of Knowledge Base

The steps of knowledge base system development are shown in the following figure 3. We need to identify relevant problems and determine which task we need to do and determine the resources and targets in the step of cognition; We also need to determine the types of knowledge structure, solving problems and constraints and the solving process and the strategies in the step of conceptualization; And then, in the step of formalization something we need to do is that formally show the concept, sub-problem and information flow; In addition, we have to determine knowledge representation, development tools and system structure in the step of realization; Then in the step of test there is a evaluation system to be established. These five stages are linked together and each stage needs to coordinate and modify repeatedly until the test reaches full satisfaction.

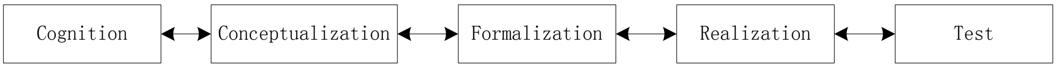


Figure 4. The Process to Develop A Knowledge Base System

4.1 Theory of Knowledge Base

Knowledge is a collection of facts and rules and it is can be expressed by the following formula (1). In the formula, KB means knowledge base and F means facts which contain a collection of facts, entities and a set of their attributes corresponding data. In addition, R means rules which include the domain knowledge or heuristic knowledge.

$$KB = F + R \qquad (1)$$

Knowledge base adopts a relational database to represent knowledge and the relationship between various tables express explicit structure of knowledge, including all of its antecedent pieces, consequent pieces, pieces of contact between them which are described in the contents of formula (1). Building the knowledge base is a systematic project. It contains knowledge representation, knowledge acquisition and the inference mechanism. After establish a knowledge base systems, it is necessary to have query and maintenance to knowledge. There into knowledge of maintenance includes update, delete and add of knowledge. Additionally, the detect of knowledge is involved in knowledge of maintenance. So it is urgent to establish the appropriate knowledge base management system to achieve the above functions based on data access technology.

4.2 The Structure Design of Knowledge Base

4.2.1 Structure of Knowledge Base: Knowledge base and inference engine work together to achieve knowledge utilization, therefore the building of knowledge base needs the matched inference engine at the same time. Figure 5 shows the structure of multi-repository, such as, the rule base and the framework library. Production rules are stored in the rule base; also the framework library is a storage place which stores knowledge. Multi-database structure has the following advantages. Firstly, it is easy to implement knowledge representation in different structures of knowledge base; Secondly, it makes knowledge management and maintenance convenient; Thirdly, the establishment of knowledge base management greatly improves the efficiency of knowledge search.

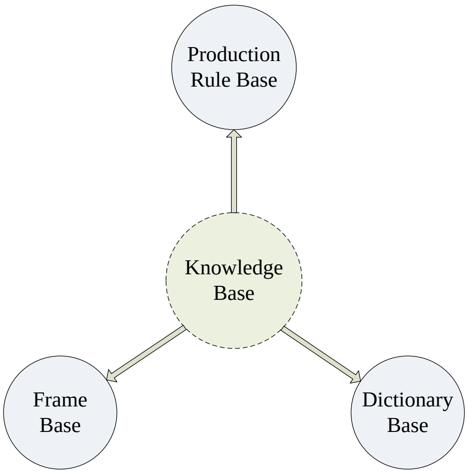


Figure 5. The Structure of Knowledge Base

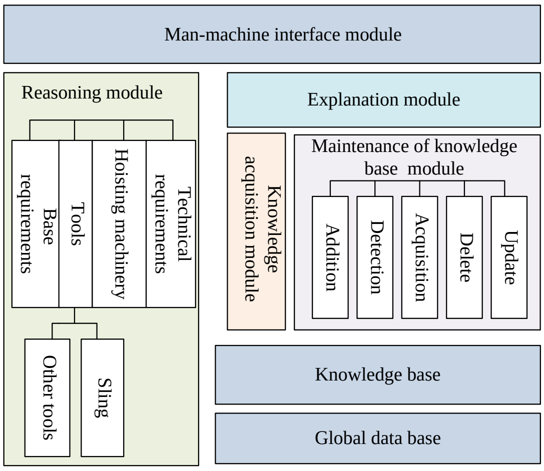


Figure 6. Main Function Module

Knowledge base of decision-making of heavy lifting process in terminal is mainly composed of five functional modules. The man-machine interface module is mainly the human-computer interaction interface, which realizes the login authentication, information input, plan presentation, information modification and the exit system, etc; Knowledge acquisition module is to transfer knowledge from knowledge source to knowledge base system.

4.2.2 Storage Tables of Knowledge Base: As we all know, it is necessary to establish relevant tables that Knowledge is realized to storage in a two-dimensional table. The types are shown in Table 1. Due to the knowledge base contains different content elements, here labels the sub-library name in order to facilitate the distinction. The selections of tools, slings, lifting machinery, basic requirements and technical requirements are increased corresponding table name suffix "_T", "_S", "_M", "_B", "_S" and so on. Framework and production rules related to the dictionary database table names were increased suffix "_F","_R". For example, such a rule base prefix is called "Rule" and the relevant tables of tools selection is recorded as "Rule_T".

Table 1. All Types of the Physical Storage Tables

Prefix name	Type	Illustration	Sub-repository
Rule	rule base	rule base	selections of hoisting machinery, tools and sling
Antecedent	antecedent base	antecedent rule base	selections of hoisting machinery, tools and sling
Consequent	consequent base	consequent rule base	selections of hoisting machinery, tools and sling
Relation	relation base	rule/ antecedent relation base	selections of hoisting machinery, tools and sling
Frame	frame base	frame base	Basic requirements, technical requirements
Slot	slot base	slot base	Basic requirements, technical requirements
Aspect	aspect base	aspect base	Basic requirements, technical requirements
Value	value base	value base	Basic requirements, technical requirements
Dictionary	dictionary base	dictionary base	Basic requirements, technical requirements

5. Design of Inference Engine

Reasoning based on knowledge is to solve how to choose and apply knowledge in the process of problems to realize the purpose of solving the problem. The knowledge in the knowledge base has huge power due to its ability to take advantage of knowledge. Inference engine is the core and soul of this realized function that it is a key difference from the general relational database.

5.1 Reasoning Strategy and Conflict Resolution in Production Rule

This section simply introduces reasoning strategy and conflict resolution in production rule. The way of reasoning, storage of data, control strategy and design of conflict resolution are shown in the following section.

5.1.1 The Way of Reasoning: This paper uses the forward reasoning which starts from the fact that users input and from the knowledge base to find the available knowledge. A conclusion got according to certain conflict resolution to choose a knowledge and then begin the process of reasoning, then the conclusion is introduced as a new fact added to the dynamic database and as fist facts in the next reasoning cycle, repeating this process until there is no possibility to use the knowledge, then the reasoning ends.

5.1.2 Data Storage: Memory storage is to store results in a database table or several in the solving process of problem, including both the initial state of input, the middle and the final result in the process of reasoning.

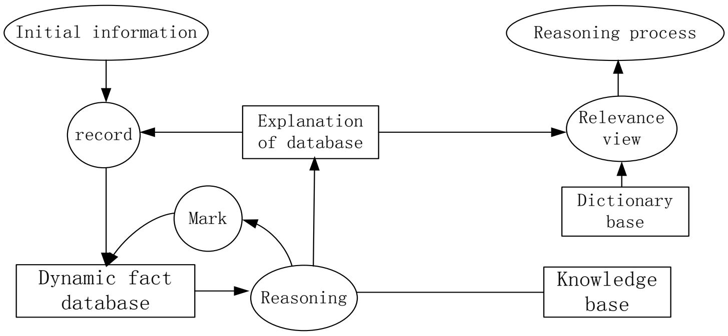


Figure 7. The Data Stored In the Reasoning Process

As shown in Figure 7, Initial information is recorded into the dynamic database and the reasoning results matched with knowledge reasoning in the knowledge base are recorded in the database. According to different reasoning process to choose tag field, this reasoning process is looped until the end of reasoning.

5.1.3 Control Strategy: Control strategy refers to the reasoning control in the overall process, including the classification of the problem, control of the process and end of the reasoning. Reasoning is a process that makes a match between facts and antecedent rules in dynamic database. To begin with, we can check the first antecedent rule and come to a conclusion if there exist available rules, otherwise we come to the second. The rest can be done in the same manner, until the last rule and fact have been checked.

5.1.4 Design of Conflict Resolution: Forward reasoning begins with the facts and conclusions are derived by the rule. In general we call the relationship between two rules "conditions includes, conclusion contains". In the following, there are two rules:

Rule 1: IF X1 THEN Y1

Rule 2: IF X1 AND X2 THEN Y2

Some errors may occur in the reasoning process of rules, then this study adopts the following methods in order to solve this problem:

1) Adding the tag field into rule base. We can get the matched rule through the match of the antecedent. When the antecedent rules get matched then NumLac value will minus 1and NumLac value equal to 0 expressing the selection rule.

2) Dividing the rules into different groups. Taking "Gro_Nu" as an example, it can eliminate the conflict due to the different levels of grouping.

3) Ranking the rules. We can rank the rules according to the ranking number, priority, rules number and so on.

4) Adding Tag field into the dynamic fact database.

5) According to the records of first-in and first-out sequence to selection rules. The

conclusions drawn from the first-in rule will be the premise fact of subsequent rule in the process of reasoning.

5.2 Design of Reasoning Algorithm in Production Rule

5.2.1 Reasoning Algorithm: In accordance with the chapter foregoing about the selection of reasoning model, the resolution strategies for conflict and the overall control strategy, this research design reasoning algorithm is as follows:

1) Selection of hoisting equipment selection

According to the ship ↔ yard、ship ↔ vehicle, vehicle ↔ yard information decision (As shown in Figure 8, each group can be ranked according to equipment priority, and regard that satisfied conditions as results and conduct the next set of reasoning. Rules of prioritization implied on the selection of hoisting machinery. Because when a piece of equipment after being selected, it should not be judged by the next rule. The selection of hoisting machinery numbers is similar with the selection of the designed sling numbers.

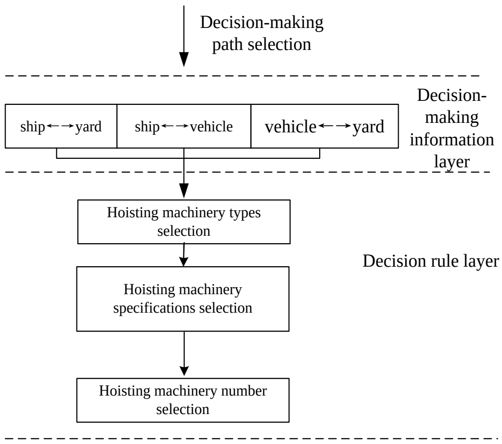


Figure 8. Groups of Hoisting Machinery Selection Rules

The rules of layer are shown in Table 2.

Table 2. Groups of Hoisting Machinery Selection Rules

Rule Group	Introductions
Rule group of hoisting machinery type selection	Equipment type selection, Sort through rules
Rule group of hoisting machinery specifications selection	Selection rules of various types of hoisting machinery specifications
Rule group of hoisting machinery number selection	The serial number of priority to choose between the same type

The algorithm steps are as follows:

Step 1 Read the first state facts of dynamic database as the facts of Active to match the first thing of current rule group;

Step 2 If the former fit the facts, find the antecedent number corresponding rulels_num, and find the number corresponding to the first line of the rule set, make the value of the corresponding line number for the number of NumLac rules minus one, then the fact is marked for 2, and skip to Step3; if the first component do not fit the facts, then turn directly to Step 4;

Step 3 If the NumLac is not equal to zero, then find the remaining lines of the rule group, and make the value of rules rows numbered NumLac of ls_num minus 1. Transferred to Step4; If the value of NumLac equal to 0, then read the corresponding second component, and insert explanation databases, dynamic fact base and mark the new fact state as active then turn to Step 5;

Step 4 If the current element is the last one, then turn to Step 5; if not the last one, then transfer to Step 6;

Step5 If it is the last one fact, then turn to Step 7; if it is not the last one fact, then read the next state of dynamic fact database as Active facts, and transferred to Step 6;

Step 6 Match first component of the group, turn to Step 2;

Step 7 If the current set of rules is not the last one, then turn to the next set of rules, and transfer to Step1; if this is the last set of rules, then transfer to Step 8;

Step 8 If interpreted database is not empty, then announce the conclusion, and end reasoning; If not, then announce no conclusion, and end the reasoning.

2) Selection decision of tools (outside of sling)

According to the tools selection requirements relating the standard of GB / T 27875-2011, the upper is set as information classification of interface guides and the lower rules layer (sort), as shown in Figure 9.

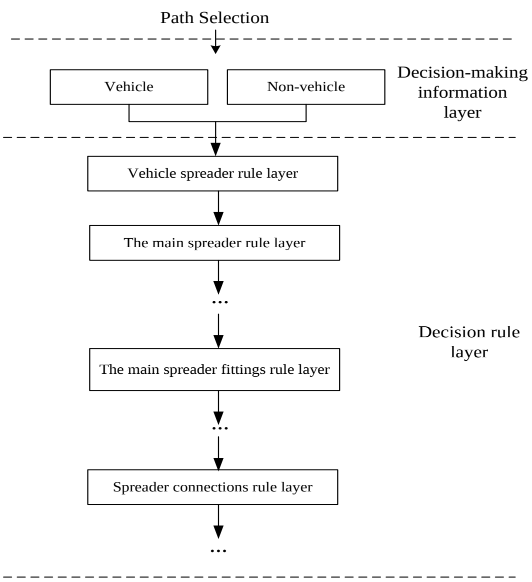


Figure 9. Hierarchy of Tools Selection Rules (Excepting Sling Selection Rules)

Sectional structures are as shown in Table 3

Table 3. Rule Groups of Tools Selection (Excepting Sling Selection Rules)

Rule Group	Introductions
Vehicle sling rule group	Vehicle spreader selection principal, vehicle network、hooks, *etc*.
Brace selection rule group	The selection principal of main bracket spreader
Matched parts selection rules group	The selection principal of matched parts, the braking device after adjusting balance, *etc*.
Connector selection rule group	Workers attachments connector selection rules, shackles, *etc*.

Through information classification, reduce reasoning conflicts caused by dynamic parameters redundancy; stratifying and grouping according to rules, each group can only be derived one or the same type of work attachment, and the order of the group are: different situations→ the general rule group of main work attachment→ the general rule group of connections working attachment. Since the rules or conclusions in the one group are alike, the can be transferred to the next group when a set of rules match with each other in a group, and it can reduce the number of searches and can improve the efficiency of reasoning. As the reasoning role of the front information and results, the inference matching of each group starts from the first fact of dynamic database.

3) Supporting decision of sling selection

Alike selection decisions of spreader types, it needs to guide and classify information in the user interface, and choose the path of realization, and this conclusion can be used to calculate sling length, size, type and number screening, rules packet structure is shown in Figure 10.

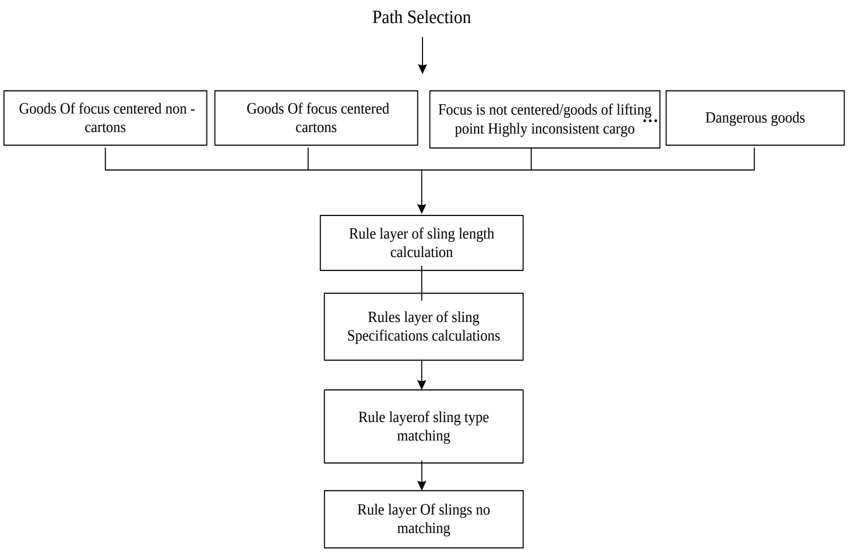


Figure 10. Sling Selection Rule Layers Structure

Table 4 shows the hierarchical rules, there are rules set、layer sorting、group sorting、prioritization rules、sequencing rule number and sorting of first component number, so that makes the rules sequencing in accordance with priority without increasing the rule layer fields come true.

Table 4. Sling Selection Rules Layers

Rule layer	Introductions
Rule layer of sling length calculation	Rule of sling length calculation L1,L2…
Rules layer of slings specifications calculation	Rules layer of slings specifications calculation P1,P2,…
Rule layer of sling type selection	Rule of sling type selection
Rule layer of sling number selection	Rule of sling number selection

5.2.2 Inference Results: Reasoning result can be presented as a process or a final conclusion, such as, the reasoning selection of Hoisting machinery and sling is the final result. The final result of lifting machinery is an optimal solution, shown in the last line in the database or reasoning results for the last time; The final result of slings selection is that all the available ones and the corresponding reference values, presented as the multiple rows of data; And the result of tools type decision is showed in explaining the database about all the intermediate and final results.

6. Case Analysis

According to the previous studies, it is feasible in theory to construct a knowledge base for decision-making of handling process for port heavy lift cargoes based on the knowledge engineering method, which has the value of application and implementation.

On the one hand, the development tools and running environment of this knowledge base system may need to meet the development of the prototype system; On the other hand, it has to be in harmony with the follow-up research of this project. This study adopts the Sybase PowerBuilder 11.5 and Microsoft Office Access 2007 database as the tool to develop this system. overall structure of the system is shown in Figure 11.

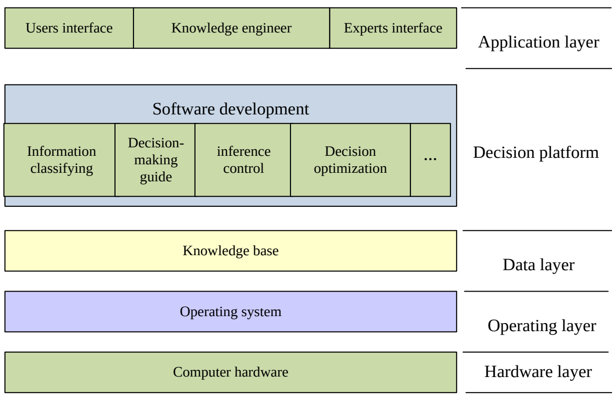
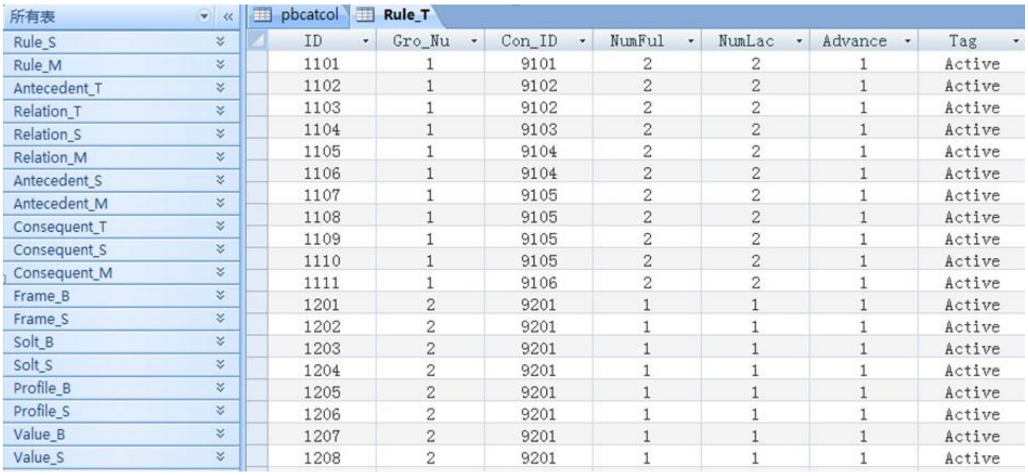


Figure 11. Overall Layers of Knowledgebase System

From the above, we can set up all the Tables in the two-dimensional Table of Access database. Shown as Figure 11, the left navigation section present the part of two-dimensional Tables and the right section shows an opened rule base Table — part content of the selection in rule base Rule_T.



ID	Gro_Nu	Con_ID	NumFul	NumLac	Advance	Tag
1101	1	9101	2	2	1	Active
1102	1	9102	2	2	1	Active
1103	1	9102	2	2	1	Active
1104	1	9103	2	2	1	Active
1105	1	9104	2	2	1	Active
1106	1	9104	2	2	1	Active
1107	1	9105	2	2	1	Active
1108	1	9105	2	2	1	Active
1109	1	9105	2	2	1	Active
1110	1	9105	2	2	1	Active
1111	1	9106	2	2	1	Active
1201	2	9201	1	1	1	Active
1202	2	9201	1	1	1	Active
1203	2	9201	1	1	1	Active
1204	2	9201	1	1	1	Active
1205	2	9201	1	1	1	Active
1206	2	9201	1	1	1	Active
1207	2	9201	1	1	1	Active
1208	2	9201	1	1	1	Active

Figure 12. Lots of Tables of the Knowledgebase

The connection of knowledge base and the platform is to establish user DSN through data source manager of the ODBC. It is important to add data source of users, select the knowledge base in the name of the database. To open the DB Profiles in PowerBuilde software and to create a new database in ODB ODBC. If the test is successful, then the new database and all the tables can be displayed in Objects navigation.

7. Conclusions

This paper launches a related work about "Establishment of Knowledge Base for Decision-making of Handling Process for Port Heavy Lift Cargoes" and mainly includes: analyzing the related study fields, designing knowledge representation, knowledge acquisition, knowledge utilization in detail, implying and verifying systematically, then conducting the following systematic conclusions:

1) The using of theory and technology of knowledge engineering in this field is feasible and can achieve the purpose, method has prospective application, well preserved and can well retain and use expert experience;

2) The using of production rules and frame representation can effectively represent the internal structure of different types of knowledge, and the establishment of rule base and framework libraries can facilitate the use of knowledge;

3) The using of forward reasoning can achieve the decision-making process, grouping of production rules, decomposition of granularity and sorting can help resolve conflicts; by calling algorithm design framework for knowledge, you can achieve the basic requirements and technical requirements for the use of knowledge; Classified information through the interface guide, you can simplify the process of reasoning, the design of

different reasoning algorithms for different knowledge can reduce valid reasoning and improve efficiency.

4) According to the different sources of knowledge and characteristic, adopting different methods of knowledge acquisition can improve the efficiency of gaining knowledge; The using of MRM algorithm can improve the automation degree of knowledge acquisition, and reduce the manual reworking.

5) The design for implementation of knowledge-based systems are maintainability and scalability, the separation of knowledge base and inference engine has good versatility and transformation.

These conclusions of this study can effectively improve the level of the decision-making process automation in harbor major pieces hoisting, verifying by a large number of instances, these conclusions have good reliability, and can replace the role of numerous experts in this field, and provide a supporting role to the actual production decisions.

Acknowledgements

This work is sponsored by National Natural Science Foundation project (71101090), Shanghai Top Academic Discipline Project-management science & engineering, Shanghai Yangfan Program (14YF1411200), Shanghai Municipal Education Commission Project (13YZ080, 14YZ112), Doctoral Fund of the Ministry of Education (20133121110001) and Shanghai Maritime University Research Project (20120102). We also thank anonymous referees and the editor-in-chief.

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