論 文
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전문가 시스템소프트웨어 유지 보수에 있어서 프레임워크에 관한 연구
(The study on frame work of developing and modification with expert system program software)

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Abstract

The summary of this paper is as follows. The literature on existing expert system maintenance software technique are reviewed in Module program, a case of assembly line process problem at construction industry and planning expert system to solve this problem at construction as a standard configured process system are discussed. the regenerative expert system approach for the construction process expert system and its example for the assembly line construction process appear in the research also, this paper shows the architecture and some feature of the CES.(Construction Expert System), which is a prototype implemented for the regenerative expert system approach. the paper introduce the framework of the regenerative expert approach as a general framework of developing and maintaining a large-scale expert systems.

요 약

이 논문은 모듈 프로그램 안에서 전문가 시스템 소프트웨어 유지 보수에 관한 기존 논문을 분석하고 건설 라인 공정의 문제점을 표준 시스템을 적용, 전문가 시스템으로 해결하는 과정에서 전문가 시스템 소프트웨어 프로그램의 재생성 모듈을 기술하였다.
끝으로 CES(Construction Expert System)라는 프로그램 타입 시스템을 적용 검증했고 전문가 시스템 소프트웨어 프로그램을 통해 대형 건설 과정의 유지 보수에 대한 프레임을 제시하였다.

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I . Introduction

1.1. The expert systems is critically important but very difficult like most conventional software systems. the focus of most expert system maintenance has so far been concentrated on the maintenance of knowledge bases. However, the maintenance of many industrial expert systems such as construction process expert systems incorporates not only the knowledge base but also the inference engines and program modules. Therefor, the maintenance of expert systems calls for the development of software and maintenance methodologies such as the software reuse. The program modules have to be changed accordingly to let assembly line flow smoothly.

1.2. Research Focus

The main focuses are on the maintenance specification and expert modification. The objectives of this research can be summarized as the sub objectives.

1.2.1 The basic idea of the regenerative expert system approach is that an existing expert system can be modified by means of specifying the problem change.

1.2.2 The regenerative expert system approach involves defining the specification variables to describe the characteristics of construction problem and the representation scheme to express expert system design.

1.2.3 To generalize a regenerative expert system approach as a framework of developing and maintaining expert system.

II. Expert system

The expert systems offer signification new capabilities and flexibility since these systems explicitly represent and reason with knowledge supported by human expert. As a challenge work applying AI technology to a practical construction problem. Fox developed a knowledge-based construction expert system called ISIS (Fox et al., 1989;Fox and Smith, 1984) The system has an order-based perspective and a resource-based of the problem. Most expert systems for construction system are rule-based system(Steffen,1986).

Bruno et al., (1986) developed an expert construction system for construction parts in a flexible manufacturing environment. From the structual point of view, the construction system consists of two subsystems: expert system for construction process generation, and simulation system for construction process evaluation. PAMS (Lee and Suh, 1988) is a domain-specific knowledge-based construction system for parallel machine construction problems which can deal with a wide variety of events that many occur under the dynamic manufacturing environment.

2.1. Software reusing technique

Reusing software is the modification of software to make it more reusable. The usual procedure is to find software parts, rebuild the, and then put them into a reuse library. Several authors describe processes for finding and reusing parts (Anold, 1991; Caliera, 1988). Prospecting metrics and heuristics are described in Arnold(1990), Reynold(1990), and Caldiera(1991). Specific techniques for making existing software reusable are described in Bailey(2002). Re engineering code into more object-oriented is related to reuse engineering.

2.2. Expert System Maintenance Methodology

In general, maintaining a sophisticated expert system requires more effort than its development unless it is not systematically supported. For example, in the case of Matias system by Kontio (1991), the maintenance work for two years required more resource than the original development. According to Holden (1992), most of people considered expert system maintenance an implementation issue rather than a design issue. but at the operational phase, it changed such that maintenance should be the responsibility of the system design (King, 2002).

2.3. Application of S/W engineering technique

Prerau et al. (1990) offers solution to common problems faced by knowledge engineers trying to apply software engineering principles to the development of rule-based systems.

Most of the researches about the expert system maintenance focus on the rule base maintenance whereas the demands for maintenance of an expert system can occur from various sources such as changes in the problem factors, change in user functionality, and change in domain knowledge etc.

Ⅲ. Maintaining expert system design

3.1. System architecture

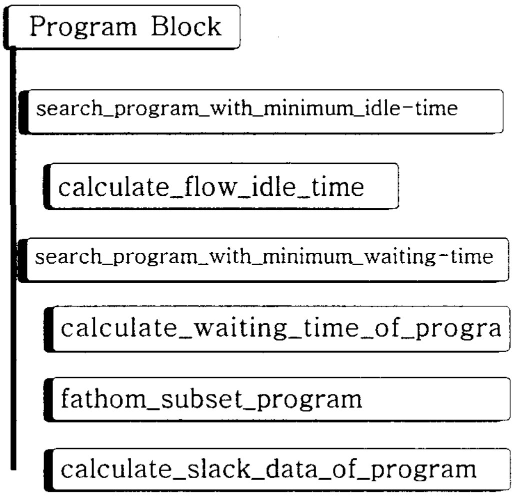
Main line resource controller divides the search space of the problem solving onto the resource allocation subproblem as many as the number of resource unit. The subproblems are created successively while searching the solution because time resource does not discrete in main line construction.

Architecture of Assembly Line Maintaining Expert System When the insertion of a new job in the sequence proposed by the heuristic fails, then the remaining positions for insertion are enumerated and checked by imposing constraints.

3.2. Module structure chart

The program modules are represented by structure chart and I/P/O diagram.

Submodules of which program module consists are hierarchically appeared in structure chart of each program module as shown The figure shows structure chart of program module named "Program Block" in system architecture as an example. The I/P/O diagram is used to describe each program modules and its submodules.



<Figure 1.>Program Module Chart

```
{{ Main-Line-Resource-Controller
    is-a : construction-engine
    connect-module : block-combination
            unsatisfied-schedule-detection
                    cycle-manager
    .........
}}

{{ Line-Flow-Sequencing
    is-a : program-module
    connect-module :
   .........
}}
```

ⓐ

a

```
{{Block-Combination
   is-a : program-module
   connect-module : block-evaluation
```

```
connect-knowledgebase :line-flow-seque
  .........
}}
                ⓑ

                b `
{{Block-Evaluation
   is-a : program-module
   connect-module : block-combination
   submode :
search_block_with_minimum_idle_time
        calculate_slack_data_of_block
        .........
    connected-knowledge :
line-flow-sequencing-knowledge-base
    .........
}}
                ⓒ
                ↓
                c `
{{search_block_with_minimum_idle_time
    is-a : program-module
    module : block-evaluation
    .........
}}
{{search_block_with_minimum_waiting_time
    is-a : program-module
    module :
    .........
}}
                    ⓓ

                ↓   d `
{{Line-flow-sequence-knowledge-base
   is-a : rule-base
   connect-module : block-combination
                 block-evaluation
   rule : .........
   .........
}}
```

<Figure 2.>Object -oriented Representation of System

Ⅳ. Implementation of expert system program

The standard system CES is implemented using the tool U-OBJECT (an object management system), U-FWD (a forward chaining rule based system), and C++for construction engine and user interface modules. There are 80 rules and 2,520 object type data records.

A rule that checks the off-line area capacity constraint is illustrated as follows:

```
(RULE ALAT "Allow Longer Assembly
Time"
 IF (control-board main board^step (equal 2)
   (schg-assem ^level (isonef 'medium'
sub)
                 ^cs-area (equal 1)  ;;
True
                 ^cs-mh (equal 0) ;; False
                 ^frame-name <assembly>
          ^assembly-start-data <start>
          ^assembly-finish-data <finish>
          ^stanard-duration (equal
             (get-duration<start><finish>))
          ^assembly-place <location>
^area(satisfy-area<location>(<start>-1))
^manhour(satisfy-manhour<location>(<start
>-1)<finish>)
THEN
(new-value<assembly>'assembly-start-data(
<start>-1))
(new-value<assembly>'cs-mh 1) ;;True)
```

Object-oriented representation of expert system The system architecture consists of construction engines, program module, knowledge bases and their connectivities. Object-oriented representation too, such as

U-OBJECT, is suitable to expression of the components their relationship.

4.1. Representation of program modification

The syntax for representation scheme for the system modification is shown as follow. The commands for the system modification are classified into 4 groups by the level of a modified system parts. (The world capitaized means reservation command.)

4.1.1. System architecture level

CONNET | DISCONNEECT module TO module
ADD | DELETE module
REPLACE | module WITH module
CONNET | DISCONNEECT rulebase TO module
REPLACE | rulebase WITH rulebase

4.1.2. module structure chart level

ADD | DELETE submodule IN module
REPLACE submodule WITH submodule IN module

4.1.3. module I/P/O diagram

ADD | DELETE argument OF module [IN module]
REPLACE argument WITH argument OF module [IN module]

4.1.4. knowledge base level

ADD | DELETE rule [IN rulebase]
REPLACE rule WITH rule [IN rulebase]

V. An Example of Expert System Maintaining

The operation characteristics may determine the construction strategy.
For example, when the cycle time is controlled dynamically and when the key construction process objective is to minimize idle time, it is desirable to accomplish the main line construction by the resource-based perspectives. On the contrary, in case the cycle time is fixed and the construction process seeks the minimization of block waiting time, the activity-based strate is more effective. The following construction strategy proposition rule is applied to the given example.

IF CHANGE flexibility of cycle time
FROM dynamic TO fixed
AND CHANGE construction
objective FROM minimize line idle
time TO minimize block waiting
time
THEN CHANGE main line construction
perspectives FROM
resource-based TO activity-based

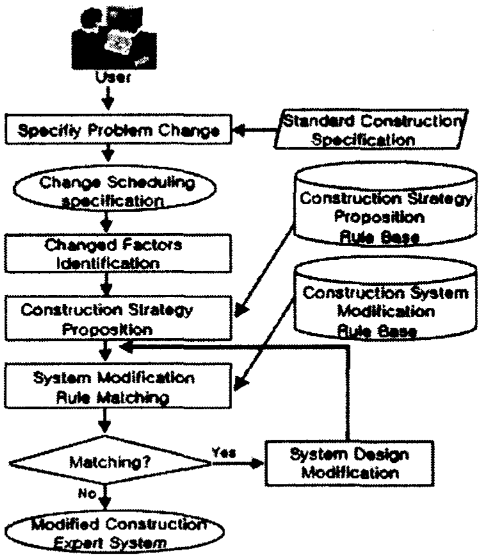
5-1 Expert system modification

1) Construction process engine and program module modification (system architecture level)

The following rules shoe the system design modification caused by the change of specification: flexibility of cycle time is dynamic and construction process objective is minimization of block waiting time.

IF CHANGE assembly line construction
perspective
FROM resource-based TO activity-based
THEN REPLACE construction ENGINE
Main-Line-Resource-Controller
WITH construction ENGINE
Main-Line-Block-Controller
AND CONNECT MODULE
Line-Flow-Sequencing
WITH construction ENGINE
Main-Line-Block-Controller

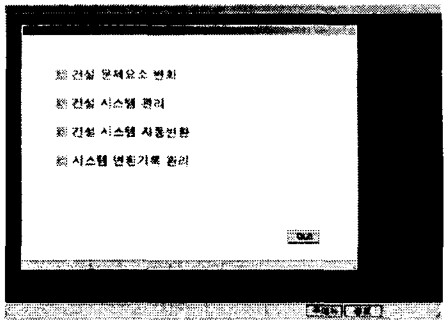
AND DISCONNECT KNOWLEDGE BASE
Line-Flow-Sequencing.
WITH MODULE Block-Combination
AND CONNECT KNOWLEDGE BASE
Line-Flow-Sequencing
TO MODULE Line-Flow-Sequencing



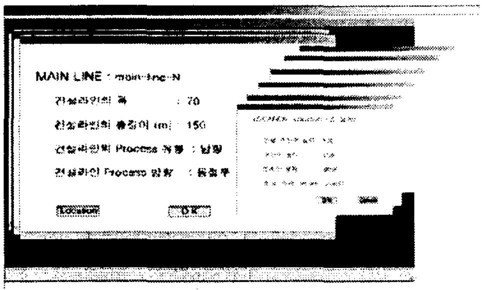
<Figure 3> Regeneration Process for Construction Expert System

5-2 The prototype of Expert System

We will explain the illustrative screens for the regeneration process of CES(Construction Export System) dividing into three parts: first part is screens of the change of problem specification variables, second part is screens of the graphical representation for the expert system and the expert design management,



<Figure 4> Main Menu Screen of REGENESYS



<Figure 5> Change of Modification of Construction process

Ⅵ. Conclusion

We have developed a generic regenerative expert system approach and a tool CES which helps the development of standard expert system and its modification according to the changed specification. The major contribution of this research can be summarized as follow:

Develop the regeneration expert system approach for the maintenance of an existing expert system.
The regenerative expert system approach brings up the methods that modify the existing expert system by means of the

problem specification which expresses user's maintenance requirements.

For the maintenance of a large-scale construction expert system, the regenerative expert system approach is applied by defining the specification variable for the assembly line construction problem, expressing the assembly line construction expert system design, and identifying the regeneration rules to maintain construction expert system including construction expert system construction strategy proposition.

The regenerative expert system approach is suggested as a general framework for the development and the maintenance a large-scale expert system.

In spite of this variety ,however, most construction problem has a similar structure that is composed of resources to the task satisfying the constraints and pursuiting the objects.

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