A Constructive Problem Solver Approach for Building Agriculture Disorder Treatment Task

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***Abstract*—**Expert systems development is a complex and expensive process that needs to be applied in an organized manner. This paper presents an approach for building a generic treatment model in the agriculture domain. This model increases the system reusability among many different crops types, minimize the effort and cost of expert system development. The proposed model is based on the commonKADS knowledge modeling and apply constructive problem solving approach.

Keywords— Expert system - Constructive problem solving – Treatment - Modeling.

I. Introduction

The aim of the disorder treatment expert system is to provide a complete advice about the treatment operation of the infected plant. The output of this system is a schedule of the treatment operation that should be applied to the infected plant. The idea behind building generic domain specific model is to capture knowledge and automatically generate or configure the target application in particular domain. The generic treatment model has been constructed by identifying and capturing all knowledge related to all treatment expert systems for vegetable crops that have been developed at the Central Laboratory of Agricultural Expert System (CLAES). This generic model and consequently the tool based on it have the ability to derive treatment for differently structured individual systems from the agriculture domain. Building one generic treatment model will increase the system reusability among many different crops types which minimize the effort and cost of expert system development. Section2 of this paper briefly review related research efforts, section3 presents the approach used in building the generic treatment model. Structure of this model is demonstrated in section4 and section5 conclude this paper and presents some ideas for feature work.

II. Related Research Efforts

This section gives a brief history about different expert systems that were developed in the agriculture domain. It also presents different expert systems that were developed based on constructive problem solver approach.

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A. Agriculture Expert Systems

Expert system technology has been applied to a variety of agricultural problems since the early 1980s. The following presents the recent research for agriculture expert systems .

CUPTEX [15] The main objective of this ES is to identify the cause of an observed disorder, its severity, and then proposes the appropriate remediation. The user can consult directly the remediation part if he knows the cause of the disorder.

PCEST [7] is a pest control expert system for tomato. It contains two phases, diagnosis and treatment. The diagnosis system determines disorders that affects the plants according to user complains, while the treatment system provides the appropriate treatment operations.

Developing domain specific models in the agriculture domains [5], [6] increase the usage of these models in building ES for different crops. The aim of these models and the tools that based on it is to facilitate the rapid development of irrigation and diagnosis agriculture expert systems by offering the system builder a template that can be easily filled.

B. Constructive problem solver

Expert systems tasks can be classified into two main categories: synthetic operation that construct a system and analytic operation that interpret a system [4]. The distinguishing feature of analytic operation is that the solution can be enumerated in advance. On the other hand, synthetic operations involves building a solution out of more primitive or basic components. Constructing a solution involves some model that contains knowledge concerning constraints. Tasks that require constructive problem solving are: planning, configuration , and certain kind of diagnosis. In planning task, solution elements are actions, and solutions are sequences of actions that achieve goals based on constraints of space and time. While the configuration tasks combine components (solution elements) to form a complex object that satisfies certain physical constraints. The following refer to different expert systems that apply configuration, planning or hyperid of them in their problem solving methods.

1) Configuration Expert Systems

One of the earliest expert systems that was developed based on constructive problem solver was R1/XCON [20], [11] a program that configures VAX computer systems by first checking the order is complete and then determining spatial arrangement of components.

The DOLMEN system [17] is designed to provide intelligent assistance during the preliminary design of multi-storey buildings. DOLMEN's Constructive problem solver uses a generate and test approach and incorporates an overall evaluation function which is used to limit the number of alternatives generated.

IDAX [3],[13]is a tool that supports the configuration steps. The task of configuration is to satisfy a functional requirement by assembling an artifact from a given set of basic components without violating any constraints imposed on the connection of those components. IDAX is mainly used as a prototype for AI-research.

Configuration Agriculture Irrigation Schedule (CAIS) tool [8] was developed to produce the configuration irrigation schedule design according to CommonKADS methodology. This tool contains two main modules, the first one produces intermediate irrigation KB through the knowledge acquisition process. The other one generates a configuration irrigation schedule design through the generation process.

2) Planning Expert Systems

OPTIMUM-AIV [1] is a planner used by the European Space Agency to help in Planning and Scheduling of Spacecraft Assembly, Integration and Test. It generates plans, and monitors their execution. Unlike a conventional scheduling tool, if the generated plan fails, the system can make intelligent decisions about which alternative plans will work and which will not.

CAPLAN [21] is an SNLP –like domain-independent planner that is build upon the generic REDUX architecture [14]. The task of CAPLAN is to find a *plan*,[16] that transform a given initial world state into a state in which the specified goals are achieved. During the planning process the initial plan is modified gradually until it becomes the solution plan.

A timetabling planning expert system for the Department of computer science and information engineering at national central university in Taiwan has been developed [9]. This system is based on the task based conceptual graph and uses CLIPS shell

3) Configuration and planning

The Scientist's Expert Assistant (SEA) [10] has been developed for the Next Generation Space Telescope (NGST) to reduce the manually intensive efforts of observing the specification and validating the detailed proposals for scientists observing with the telescope. From a set of five tools that constitute SEA, two expert system modules exist.

Instrument Configuration Expert System (ICES) is a rule-based expert system that guides the observer through the definition of instrument parameters and then providing recommended settings for the instrument. The first phase of ICES designs the interface and communication with other SEA modules. The second phase of the ICES expand the rules and capabilities of the system substantially.

Visit Planner Expert System (VPES) The VPES works to provide assistance in laying out multi-exposure "visits". Both observing scientists and Institute staff currently spend a great deal of time planning multi-exposure visits. The VPES system not only plans just the individual exposure times, but also the overhead time necessary to perform other tasks such as slewing the telescope, and reading the CCD buffers after an exposure.

III. AN APPROACH FOR BUILDING DISORDER TREATMENT TASK

The main goal of the plant disorder treatment expert system is to produce a treatment operation schedule that is applied to the infected plant to get over the affected disorders. Building one generic treatment model involves capturing all the knowledge related to the treatment task, determine the common knowledge that forms the generic model, and identify knowledge that vary from one crop to another. The proposed model is based on CommonKADS methodology [18],[19]. This section presents the global architecture of the generic disorder treatment expert system.

A. The generic disorder treatment model architecture

As described earlier, the treatment task generates a treatment schedule of the treatment operations that is applied to infected plant. Plants may be infected by one or more disorders. Each disorder is treated by a set of materials. A material can be used in the treatment of different disorders. Thus, the treatment task is considered as a configuration expert system which assembles treatment operation into an aggregate according to some goal specification and using expert knowledge. The process of assembling treatment operations into a configuration (treatment schedule) involves decisions concerning integration of common materials that are used in the treatment of different disorders into one treatment operation. After assembling of treatment operations, it is significant to ordering them according to seriousness of the affected disorders. Thus, the treatment problem solving method constructs one set of treatment operations by configuring the treatment operation from the original treatment operations set, then arrange them into a sequence according to the stated constrains.

B. The CommonKADS modeling approach

Building Expert systems has been seen as a modeling activity. The constructed model should offer similar results in problem solving for problems in the area of concern. The proposed generic treatment model is developed based on CommonKADS model of expertise that integrates the domain knowledge and the problem solving knowledge. Domain knowledge contains all knowledge about disorder treatment in the agriculture domain. The problem solving process has two main categories: knowledge about the problem solving steps, their interactions, and their relations to the domain knowledge; and task knowledge. The task knowledge represents how the problem solving process is controlled.

IV. GENERIC DISORDER TREATMENT SYSTEM DESIGN

A. Overall structure of generic treatment system

A major design goal of the generic treatment system is to construct one set of treatment operations which cover all disorders. To do so, the task begins by acquiring the affected disorders and determining the treatment operation for each individual disorder. Then, it refines these treatment operations to constitute the final treatment schedule. This process is divided into two main phases as shown in figure1. The first phase configures the initial treatment operation set according to the stated constraints (specify treatment operation). The second phase is responsible for arranging the treatment operations to form a specific order. This process is governed by a structured domain specific knowledge. The following sections describe different types of knowledge that are used in building the generic treatment system.

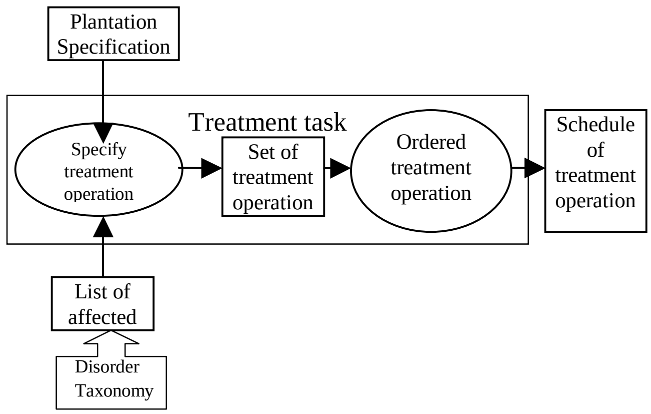

Figure1: The overall structure of treatment task

B. *Domain specific knowledge*

On the domain level, the main knowledge categories can be summarized as follows:

1) *General domain knowledge (Ontology)*

Containing knowledge about concept, attributes, and their values of different treatment systems for vegetables that has be developed by CLAES. The domain ontology consists of two main concepts ontology:

- *Plantation ontology:* contains concepts related to the plant environment such as: soil, water, climate, plant and plantation. These generic concepts can be reused across different task in the agriculture domain.
- *Crop ontology* This ontology contains concepts that represent the disorder taxonomy of each crop as well as treatment operation concepts of each disorder class.

2) *Domain model knowledge*

Domain model knowledge contains the required scheme of relationship between concepts attribute. The generic domain models consist of the complete relationship between concept attributes. While for specific domain models, we determine the input/output concept attribute pairs that can be used in building this model. The developer is free to fill this model with the appropriate knowledge.

C. *Problem solving knowledge*

The problem solving method (PSM) of treatment task describes how to arrange the solution elements (treatment operations) of each individual disorder to make up a final solution. This final solution (treatment schedule) must satisfy the following constraints:

- Non-repeatable material i.e. materials that are used in treatment of different disorders are collected in one treatment operation.
- Ordering of the treatment operations according to seriousness of the disorders

Thus, the PSM of treatment task can be distinguished into two main steps:

- Specify treatment operations
- Order treatment schedule

1) *Specify treatment operations*

This step aims at identifying the set of required treatment operations that can be applied to a plant in order to get over the affected disorders. Treatment operation has a set of attributes that describe it. These attributes are: disorder name, material name, material quantity, mode of entry, method of application, the tool used in the treatment operation, application time, and advice. The process of specifying the required treatment operations applies the generate and test approach [2],[12] used in solution of constraints satisfaction problem. It proceeds by determining the materials that is used in the treatment of each individual disorder. Then, combine common materials into one treatment operation. Finally, complete other treatment operation parameters. This can be achieved through the following steps.

- Specify material name.
- Combine common material
- Complete treatment operation attributes

a) *Specify material name*

A treatment material can be classified into two main categories: Obligatory material and optional material. A material is considered as obligatorily for the plant when it *should* be applied to it to get over the affected disorder. On the other hand, optional material means that there are many alternative materials that could be applied to the infected plant and the user can select one of them according to its availability. During this step, for each input disorder, the corresponding material name is generated using the specify material domain model.

b) *Combine common material*

The generate and test algorithm is applied during combining common material to form required treatment operations. For each generated obligatory treatment materials, the algorithm checks whether this material is used to treat other input disorders. Then, it store the material name and the combined list of affected disorder in one treatment operation to avoid repetition. On the other hand, for optional materials, when the user selects one of the materials, the algorithm will not allow any other lists containing this material to appear to the user again. This will satisfy the first constraints.

c) Complete treatment operation attributes

Other treatment operation's parameters like material quantity, mode of entry, method of application, the tool used in the treatment operation, and advice are fulfilled during this step. These parameters depend on other plantation factors like soil type, plant growth stage, etc. For example, to determine the material quantity we need to know the material name, the name of the disorder for which this material is used and the growth stage of the plant.

2) Order treatment schedule

The process of ordering the treatment operation is done according to the following constraints:

1. Seriousness of treated disorder (Some disorder should be treated before others).

2. Separation between application dates (Between each two adjacent treatment operation that uses the same application method, there should be 3 days difference).

The treatment operations list is arranged using the bubble sort algorithm. It proceeds by repeatedly comparing and adjusting the treatment operation dates until they arranged according to the above constraints.

D. The Generic Disorder Treatment Task

The generic treatment task contains 10 major problem solving steps (PSS) that are required for generting the treatment operation:

1. **Calculate plant age**
2. Determine plant growth stage
3. **Get treated disorder**
4. Specify materials
5. **Select material**
6. Specify material qty
7. Specify application-time and tool
8. **Order treatment schedule**
9. Specify advice
10. **Display the treatment schedule**

Bold PSS represents static procedure that are common all treatment tasks. While others PSS can be modified by the developer. Modifiable PSS apply domain models (relations) that vary from crop to other. Each of the modifiable relation is clearly described to the developer by identifying the set of input/output of that relation so she/he can easialy fill in the missing knowledge (mostly in the form of rule or tables).

V. Conclusion and Future Work

This paper presents an approach for building generic treatment model in the agriculture domain. The proposed approach for building this model is the result of accumulated experience gained through many years of developing expert systems in the agriculture domain by CLAES. The generic treatment model follows the CommonKADS model of expertise and applies the constructive problem solving method. A tool to implement this model is under construction. To improve the use of expert system domain specific models in the agriculture domain, this tool will contain modules for the knowledge acquisition and the explanation facilities.

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