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Diagnostic Expert System Development in ESTA for Agricultural Application

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Abstract

The paper deals with representation of different types of diagnostic knowledge in the framework of **Expert System Shell** forText Animation (ESTA)to develop diagnostic expert system for the Horticultural applications.

Like other Expert System Shells, it contains inbuilt control and user interface module and provides open framework for knowledge representation. Such structuring of system makes its use easier for people familiar with AI (Artificial Intelligence) techniques as well as for the domain experts to develop expert systems.

Diagnostic expert system can be useful in the area of orchard management. The diagnosis of ailments of trees can be done using different knowledge such as visual symptoms, chemical tests etc. Use of visual symptoms for diagnosis of ailments is important and can be done immediately.

This paper examines in details different types of logical modules such as abductive and deductive used in diagnosis and their representation in ESTA.

The expert system based on the visual symptoms can be especially helpful in fruiting season when diagnosis process should not take time and remedy should be applied immediately to stop losses.

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Introduction

Expert System (ES) are intelligent computer program developed by encoding human expertise of a domain in a computer program to solve problems by a computer just like the human experts.

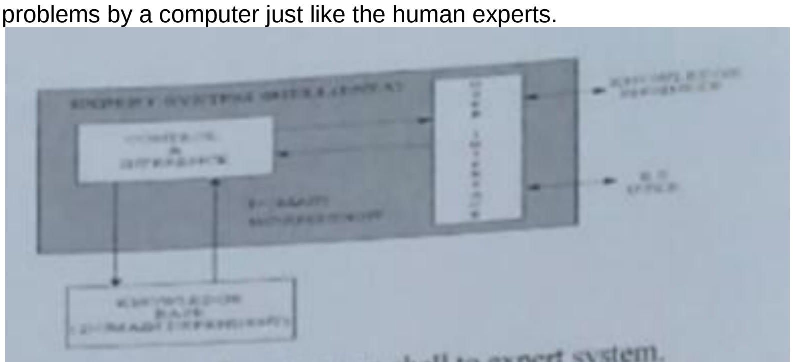

Figure 1 Expert system shell to expert system.

ES technology became conspicuous among the AI Researchers due to recognition of its particular use which in turn made it the first going on and the spectrum of application of this technology is widening [4]. Expert system isknowledge based system, however every KBS is not an expert system as shown in Fig.2. The development of expert system requires coordination of Doman experts and knowledge engineers (AI people). Domain experts provide expert knowledge required to solve the problems while knowledge engineers formalize the elicited knowledge to represent in the syntax of the used AI language. In the beginning the expert system developed was mainly carried out by the AI people using sophisticated inference engine and search techniques. However later it was found that the non-AI people can also develop better expert system using simple inference engine and search techniques.

Many of such ES could beat those developed by AI people which in turn made the AI people to realize the power of knowledge of ES performance. This fact led to the separation of knowledge module from inference and control strategies. Such a system contains everything needed for ES except knowledge base (KB) and was called Expert System Shell (ESS). ESS gave a great boost to ES technology and started active involvement of domain experts. An expert system in the context of ESS may be defined as follows –

ES = KB + ESS (CONTROL & INFERENCE + USER INTERFACE)

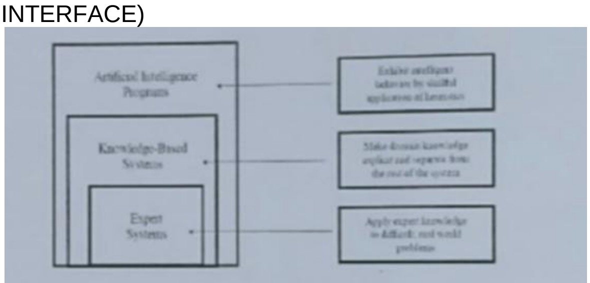

Figure 2 Expert system and knowledge based system.

ESTA Shell

The separation of the control and inference parts in the knowledge base is fundamental feature of an Expert System Shell. ESTA is also an expert system shell derived by PDC (Prolog Development Centre).

Denmark [6]/ By adding with a knowledge base as shown in Fig 1 of a specific domain an expert system can be created. Thus, under ESTA or any ESS expert system can be defined as

KNWLEDGE BASE + ESTA (or ESS) = EXPERT SYSTEM

ESTA is not only available ESS. There are numerous ESSs such as CLISP, JESS7, a fuzzy logic based ESS is FLOPS, Fuzzy Shell, and ACQUIRE etc.

Each system has its own merits and demerits over other ESSs. ESTA come with AI language prolog.

The models of ESTAare shown in Fig 3. According to PDC, some of the important features of ESTA are [6].

ESTA is easy to use. It does not require previous programming skills in building knowledge-based system.

All language-specific parts of ESTA are stored in a special file that lets you make your own version of ESTA in any language with a minimum of effort. It is a prolog based standalone environment for the development of expert system and decision support system. It is a good tool for structuring knowledge. It has inbuilt explanation facility for query made and advice given by the system.

The knowledge base of ESTA consists of rules represented in its own syntax. It has all the inbuilt facilities to write the rules that build the knowledge base, A knowledge base in ESTA has a hierarchical structure from which a tree display is automatically drawn which is helpful in getting overview of KB. Such trees provide direct access to KB for editing too. The knowledge is automatically translated, and syntax checked when editing is finished, and errors are pointed out directly into source code. Furthermore, ESTA has a validate command allowing to check for type errors, circular references, undefined or unused knowledge elements.

The capacity and functionality of ESTA can be expanded by expert programmers as it includes interface to visual prolog or other program such as spreadsheets, databases, word processors etc.

ESTA includes facilities for the knowledge base to call general purpose routines written in PDC Prolog and thereby also routines written in C, Assembler or other languages.

In addition to knowledge representation, ESTA includes useful features from traditional programming languages such as procedure calls and mathematical functions. It can be used as a prototyping tool. This greatly helps in the development process of ES.

The user interface is simple and easy to use. Asked questions and explanations can be accompanied by pictures from picture base.

ESTA also includes facilities to explain why a question is being asked or what an answer has been given or to repeat advice given earlier in a consultation. In addition, advice can be given as a few simple sentences, large text files, graphic pictures or even using Windows hypertext help files.

ESTA includes provisions for generating royalty-free, consultations-only version of the system which may be distributed to the end-users.

ESTA is configurable- menus, startup-pictures and other UI functionality can be customized to match the needs of the specific applications. ESTA is designed so that a dialog with and expert system running under the shell resembles having a char with an actual expert in the subject area. The user initially provides some information in the form of replies of questions posed by the system and then he receives the appropriate advice. A record of the dialog can be logged in a window and it can storein a file for later reference. ESTA also enables the user to suspend the dialog, change the answer to a previously asked question or bring up new questions (which has not yet been asked) to answer.

ESTA has also facility to elaborate asked questions with the help of pictures and texts. Other technical details can be found in help files.

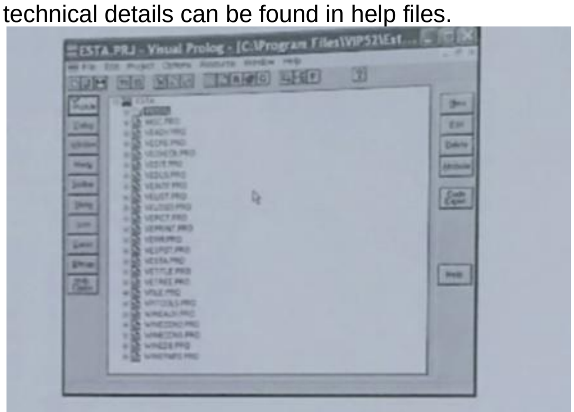

Figure 3 The program modules of the ESTA.

Diagnostic Expert System

Diagnostic Expert System (DES) have played crucial role in revealing practical face of AI.

Perhaps, a DES has been starting point of the ES technology. Diagnostic problem solving is a knowledge intensive process. This term diagnosis is a Greek word and can be broken into dia (means by) and gnosis (means knowledge).

Thus, diagnostic problem solving requires expert knowledge or expertise. In the simplest way diagnosis or diagnostic problem solving can be described as the process in which a human expert is presented with a system situation with problem or abnormal observations and asked to find out its cause or reasons. Human experts recognize pattern of abnormal observations and normalcy in the data elicited from the situation and provide diagnoses and advice remedy. Such pattern-based classification tasks need ability of finding similar among dissimilar and dissimilar among similar to recognize specific pattern and their interaction in the elicited information.

Obviously diagnostic skill requires procedural as well as heuristic diagnostic knowledge. The representation of domain specific diagnostic expertise in a computer is of great use for automatic diagnosis. Such a knowledge-based computer program is called DES.

DESs are not new things but have been in focus of studies by different scientists and knowledge engineers and there have been developments of many theories of diagnosis. The MYCIN and related shell EMYCIN were developed in 1970s [2], for the representation of any expertise in ES, expert's methods of problem solving and studies. An Expert's ways of problem solving can be understood by analyzing his/her problem-solving methods. Expertise in human is domain specific, many expertise in one is not impossible and supposed to be distributed in three layers of knowledge namely – domain layer, inference layer and task layer.

Domain layer provides domain specific knowledge. It is static knowledge describing facts, concepts, knowledge structure in particular domain. The inference layer provides procedures applied during problem solving and represents somewhat institutional ways of the expert for using domain specific knowledge in problem solving. The task layer defines ordering of steps taken in problem solving activities. The quality and level of expertise in a human expert depends on quality of cooperation, coordination and communication between these layers [19], [13].

The development of DES requires study of all these factors in details for their modeling and representations. As stated, above study and research on computer based diagnostic problem solving started in much past and there have been development of many theories for its formalization and modeling. Different researchers have captured notion of diagnosis from different angles for different problems solving [9], [10], [11], [12], [13].

The common thing among these theories of diagnosis is that they all have formalized diagnostic problem-solving as the cyclic process of abduction, deduction and induction in the light of hypothetical reasoning [11]. Such formalization of diagnosis is shown in Fig. [4]. In the abductive phase of diagnosis human expert generate candidate solution hypothesis from the adduced observation for the specific problem. An expert further refines these primary hypotheses to develop globally coherent hypothesis. In this phase, empirically proven associations between observation and diagnostic solutions are exploited.

Association is the logical process of finding similar among dissimilar among similar. In the deductive step necessary consequences are deduced. In the induction phase, generated hypothesis is rejected or accepted and the whole cycle continues until the termination.

The deductive-inductive phase uses deep domain knowledge to test the candidate hypothesis with respect to diagnostics knowledge and observations. In fact, associational knowledge between the ailments and symptoms are also used in the deductive inductive phase. All those hypotheses passing the test are accepted as diagnoses and failure in test/tests results in rejection of the hypotheses.

Thus, the formal characterization of computational diagnosis needs adoption of suitable models of the system under diagnosis as well as notion of diagnosis and diagnostic reasoning.

Some of the important conceptual model of diagnosis proposed by different researchers is model based approach, set covering theories and heuristic diagnosis etc. [11].

The choice of diagnostic framework depends on the domain of application and knowledge to be used e.g. model based approach uses models, which includes knowledge of structural, functional, causal interaction among the modeled objects of problematic system.

Model based approach has been widely used in the development of diagnostic systems. The modeling of the system to be diagnosed is important in the model-based diagnosis. However, for all the systems such models cannot be developed or not available. Such diagnostic method is useful for the artificial systems because their functional models are available.

For the natural systems such agriculture, horticulture such precise functional and structural models involving fundamental principle of the system functioning are not available and thus model-based diagnosis cannot be used. However instead of using a functional model, causal models of the ailment and symptoms can be used to develop diagnostic system for the natural systems.

Also acquisition of such logical models from expert is easier and can also be easily put up as a rule. From such logical model diagnoses can be obtained by abductive and hypothetical-deductive or heuristic diagnosis. Both of these method usages same knowledge. Causal relation between the ailments and symptoms, however, the process of reasoning differs. The process of abductive diagnosis can be expressed as the following causal relation

Ailments -> Symptoms

However, in the deductive or heuristic diagnosis empirical classification rules acquired from the domain expert are used. Such classification rules can be expressed as

Symptoms -> Ailments.

So, the significant difference is that in the abductive diagnosis human expert has some tentative ailments in the mind and looks for the verifications of the related symptoms where as in the deductive diagnosis reasoning starts from given symptoms to deduce the diagnose. The abductive diagnosis is more powerful and natural way of reasoning.

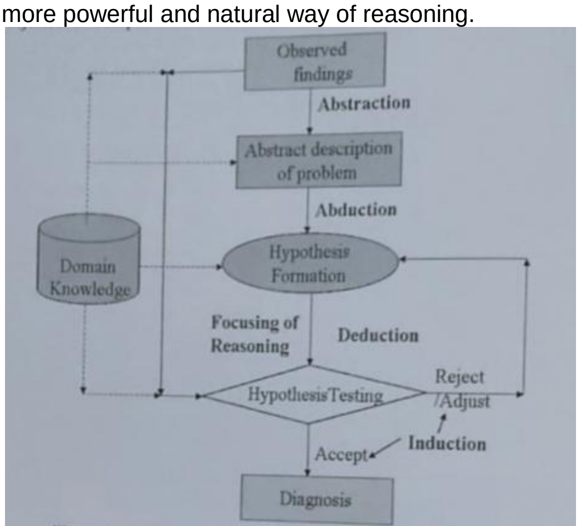

Figure 4 An epistemological model of diagnostic reasoning.

Consider for example following causal relation for the mango tree "Anthracnose produces symptoms of black spot on fruits and leaves". The other known disease Alternaria rot (black spot) also produces black spots on the leaves and/or fruit.

In the abductive diagnosis an expert perceives the case (of anthracnose) as "anthracnose causes black spots on the leaves" whereas in the deductive diagnosis the same situation is perceived as "black spot on leaves are CLASSIFIED as anthracnose" [14].

Next in the paper we deal with representation of heuristic diagnosis in the ESTA. In the deductive diagnosis it is assumed that single symptom is not related with many diseases, however, such cases can also be tackled by managing control of flow or rule placement in the program. As a logical model we will consider visual symptoms and related ailments.

Knowledge Representation in ESTA

ESTA supports rule-based knowledge representation. The logical models of the ailment-symptoms can be expressed as if-then rules in backward or forward chaining.

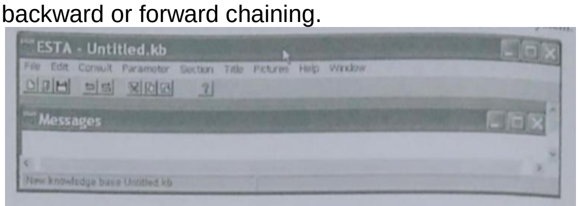

Figure 5 Screen shot of ESTA with new KB.

The backward reasoning process is goal directed and pinpointed. In the backward chaining an ailment is taken as the tentative diagnose its symptoms and looked for. Thus, verification space for symptoms is restricted to aailment only. It avoids consideration of irrelevant symptoms. Thus, backward chaining is more suitable for the diagnostic system.

However, ESTA supports both ways of reasoning. These logical rules are placed in ESTA through Section and Parameters. A section represents top level of knowledge representation. Any KB in ESTA starts with a section known as the main section and the starting section is names as start. Consultation starts from the main section. A section consists of a name, a textual description and several paragraphs. ESTA deals with paragraphs in a section working from top to bottom, one para graph at a time. Also, if there are rules in the paragraph they fire in order of placements. Parameters are used as variable and they decide flow of control among the sections. In ESTA, four types of parameters namely – **Boolean, Text, Number and Category** parameters are used.

The Boolean parameter is used for binary responses, either Yes, No or Unknown.

Text parameter are used to represent text objects and number parameter is used to represent numerical values. Category parameters are used when a variable takes more than one values. Since all of these parameters are related with questions to be asked by ES to end users, their values are assigned or decided by response of the user.

Thus, through parameters system looks for verification of facts/symptoms related to a tentative goal. Thus, by placing symptoms related to a particular ailment in parameters, user can be approached for verification and such inputs from user can be used in classification rules to find out diagnose. The parameters consist of declaration field, type field and number of optional fields such as explanation field, rules field, picture field, question field etc. The access in parameters and sections is available through menu as shown in Fig 5. In order to exemplify the process of knowledge representation in ESTA we consider here representation of the fungus disease powdery mildew. Which is caused by the fungus odium and is highly (up to 90%) disastrous for mango orchard. One of the visual symptoms of the ailment is [14].

"The appearance of whitish, powdery growth of fungus on panicles and young fruit."

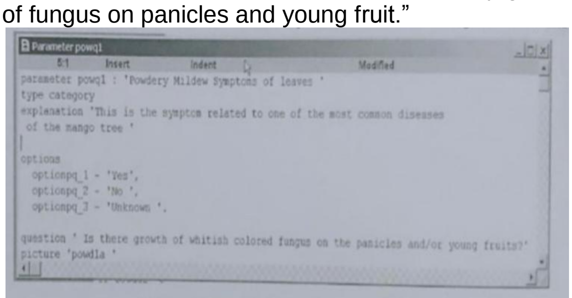

Figure 6 Example of a section for diagnose

The simplest plan for entering knowledge can be to create separate section for each of such disease in which classifications rule for the same are placed. Thus for the above situation a new section names powdery_mildew is created through section menu as shown in Fig 6. The logical classification rules are related with symptoms so for each symptoms a new parameter is created.

Here again domain expert and knowledge engineer have to place a crucial role to break the symptom complexes into simpler form so that user can understand easily on what the system is asking for. There will be many ways for breaking the system complexes into simpler form, however this greatly depends on the level of users for which system is being developed and number of classification rules. The above single symptom of powdery mildew can be asked in one question as follows –

"Is there growth of whitish colored fungus on the panicles and/or young fruits? "

For this symptom a new parameter can be created using parameter menu. Inside the parameter this question can be entered and obviously this will be binary parameter. The related pictures and explanations can be entered in the parameter fields which can be accessed by users while making consultation with the system. Example of test parameter is shown in Fig 7.

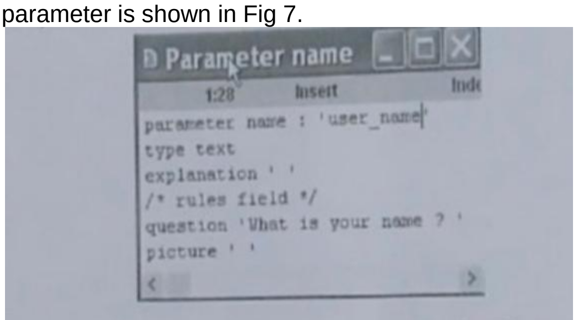

Figure 7 Example of the text parameter taken from knowledge base for AMRAPALIKA.

Related pictures are placed in the picture database in BPM format. ESTA provides hot spot editor to highlight the specific area of picture relevant to asked questions. Pictures can be used with title, advice and explanation of the question. From one parameter, other parameters can also be called. The developed knowledge base can be stored in compiled format to optimize the performance.

Conclusions

In this paper we have presented diagnostic expertise modeling in details and suitability of causal models for ailments diagnosis in the horticulture applications.

We have also investigated potentiality of ESTA as a tool for developing diagnostic expert systems for horticultural application using causal relation of ailments and visual symptoms.

In future our plan is to develop a diagnostics ES using such logical model for other plants.

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