Decision Support System for the Phalaenopsis Orchids Care by Means of Rule Based Reasoning

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Abstract. This paper describes the development of a prototype web based expert system, programmed on CLIPS and implement on JESS, for the growing-up and care of one of the most beautiful and worldwide-appreciated specie of orchids "the Phalaenopsis" or butterfly orchid. The prototype system represents an initial step towards efficiently providing an automated solution regarding the expert orchids care for the grow-up-bloom cycle application problem, i.e. selecting a proper frequency of watering, fertilizer and its frequency, or the appropriated percent of shadowing which is applicable to the problem at hand. The feasibility of using expert system technology to aid in the selected problem is demonstrated.

Keywords: Web based Expert System, Orchids care, Orchids Expert System

1. Introduction

The popularity of orchids has increased tremendously in recent years. Fresh cut stems of spray orchids are being produced by the hundreds of thousands in places like Hawaii and Thailand. Orchid plants are regularly featured in the interior layouts of shelter magazines, and more and more flower shops are carrying them on a regular basis [FlowerShop 2005]. Once reserved for wealthy gentlemen gardeners (the sexual overtones of the blooms were considered too shocking for Victorian women), orchids can now be bought at nurseries, supermarkets, and department stores at affordable prices. According to a 2003 USDA Floriculture Crops Survey, orchid sales are second in potted flowering plants (behind poinsettias), and their popularity continues to increase as gardeners discover orchids are not quite as difficult to grow as commonly believed [Oliver 2004].   In fact, growing orchids isn't really that hard if you choose the right varieties. Some are quite durable and resilient.

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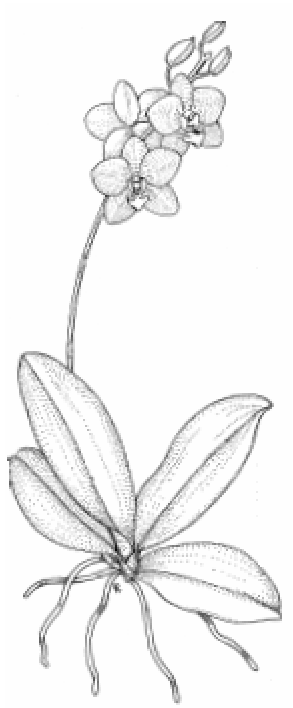

Fig. 1. A phalaenopsis orchid blooming [AOS 2006]

One of the easiest orchids to care for is the phalaenopsis (fail-an-OP-sis) [AOS 2006] - see Figure 1-sometimes called the Moth or Butterfly Orchid. The phalaenopsis orchid produces flowers with a broad, flat petal on either side, resembling the open wings of a butterfly. These orchids are most often seen in a crisp white color with a lemon-yellow throat, although many other colors and patterns are grown, with new ones appearing on the market all the time. Purple, pink, and peach shades are prevalent. Some varieties have minute speckles on a contrasting background color. Others have flashy pinstripes on their petals. The flowers usually range from about 2 inches to nearly 5 inches wide. Depending on the variety, a phalaenopsis orchid can produce a scape (flowering stalk) with anywhere from 3 to 20 flowers on it, and older, mature plants may have 3 or 4 scapes in bloom at one time. The plant also grows elongated, often rounded leaves that lie more or less flat in two ranks on top of the growing medium. Wiggly, silver-gray aerial roots are also produced, which serve to draw moisture from the air or from the potting mix [FlowerShop 2005].

Now, it is evident to us, the economic importance of orchids, but besides admiring the beauty of these plants, our intention is to build a Decision Support System (DSS) for the phalaenopsis orchids care to support production at green houses, help novice and improve skills of orchid lovers at home or workplace. In next section we define the problem at hands; on second section we explain how Rule Base Reasoning works. On the third Section, we describe the implementation of the Expert System, why we selected CLIPS as development tool, and the way we implemented reasoning rules and the user interface. At the end of this paper, we present our preliminary results, our future work and conclusions.

1.1 The problem

One of the objectives of Artificial Intelligence (AI) is to simulate and apply a human's cognitive thinking ability towards solving problems. Often, researchers incorporate artificial intelligence within other disciplines (i.e. Engineering, physical, botanic and life sciences, etc.) In order to develop automated systems for solving problems in those domains [Al-Gharabat et al. 1996, Giarratano and Riley 2001] such as we want to present in this paper: We want to provide a low cost, user-friendly software tool to support the phalaenopsis orchids care for beginners, average and advanced users.

Keeping this problem in mind, we develop an automated system that would encode the Orchids Expert's (Orchidiot: in Spanish “orquidiota”, a person living, breathing, thinking all time just in orchids) wisdom on how to grow-up and bloom phalaenopsis orchids, by means of simple questions-answers shown in an user-friendly interface, so that any non-expert can use the system and get reliable help for accomplishing this task. Our contribution on this project is the implementation of a low cost DSS, by means of rule base reasoning, that can be easily implemented on stand alone or web based basis, to support the production of phalaenopsis orchid plants.

2. Rule Based Reasoning

Rule-based reasoning is one of the knowledge representation schemes for artificial intelligence. A rule is composed of an IF portion and a THEN portion. The IF portion of the rule is the condition or premise, which tests the truth-value of a set of facts at every stage of the reasoning process [Gonzalez and Dankel 1993]. Testing a rule premise or conclusion can be as simply as matching a symbolic pattern in the rule to a similar pattern in the assertion base, this process is called pattern matching [Turban and Aronson 2002]. The THEN portion of a rule is the set of actions to be executed when the rule is applicable [Giarratano and Riley 2001].

Table 1 shows the variables (IF part) and the criteria (THEN part) considered for the creation of the rules. They are the result of our continuous research work in the phalaenopsis orchid cares in: Books (i.e. [Lecoufle 2005]), journals [FlowerShop 2005 and Oliver 2004], scientific papers [Espinosa et al. 2000], dozens of orchids related web pages (i.e. [AOS 2006 and Tahí 2006]), and three years of experience at our greenhouse.

Table 1. Variables to be considered on the Rule Base Reasoning System

Category	Variable	Used Metric or Criteria
Basic-high priority	Temperature	Grades Centigrade
	Relative Humidity	Percentage
	Shadowing	Percentage / Luxes

	Watering	Litters
	Movement of air / Air rotation	Null (Unhealthy) Soft air (Healthy) Strong air (not necessary)
Enhanced criteria	Substrate Porosity	Low/Medium/High
	Color	Green Lettuce (healthy) Yellow (lack of water) Purple (lack of fertilizer) Green with small black stains (excess of sun)
	Odor	Rotten (unhealthy) Strong-Chemical (fertilizer and insecticide)
	Visual approach	Leaves rotten Dry leaves Dry plant
	Plagues	Small holes on leaves Visible small holes on roots Sad Leaves Visible insects
	Blooms	Small holes on stalk Small holes on flowers Finish of blooming
Chemical Products	Fertilizer / Insecticide Fungicide	Portion per gallon of water or grams

2.1 Backward and forward chaining

There are two types of rule-based reasoning mechanisms, namely, the forward reasoning (chaining) and the backward chaining. Backward chaining is a goal-driven approach in which you start from an expectation of what is going to happen (hypothesis) and then seek evidence that supports (or contradicts your expectation. In backward chaining, if the current goal is to determine the correct conclusion, then the process attempts to determine whether the premise clauses (facts) match the situation. Meanwhile, forward chaining is a data-driven approach. We start from accessible information as it becomes available or from a basic idea, and then we try to draw conclusions. In forward chaining, if the premise clauses match the situation, then the process attempts to assert the conclusion [Turban and Aronson 2001].Backward reasoning is as well a more favorable approach for applications involving diagnosis or identification [Al-Gharabat et al. 1996]. However, our implementation is with the forward reasoning approach. This is because the identification of requirements for the phalaenopsis orchid care involves gradually narrowing down the possibilities by checking different discerning external features of these plants. Thus the natural flow of control is toward the forward direction.

3. The Decision Information System Implementation

One of the results of research in the area of artificial intelligence has been the development of techniques that allow the modeling of information at higher levels of abstraction. These techniques are embodied in languages or tools, which allow programs to be built that closely, resemble human logic in their implementation and are therefore easier to develop and maintain [CLIPS 2006].

3.1 Why CLIPS?

CLIPS is a forward-reasoning, pattern-matching knowledge-based system shell. The Artificial Intelligence section of the Johnson Space Center of NASA developed it. Its name stands for C Language Implementation of Production System. CLIPS is extremely popular because it is highly portable, low cost, and easily integrated with external programs developed in C [Giarratano and Riley 2001]. This expert system tool provides a mechanism, called the inference engine, which automatically matches facts against patterns and determines which rules are applicable. The actions of applicable rules are executed when the inference engine is instructed to begin execution. The inference engine selects a rule and then the actions of the selected rule are executed (which may affect the list of applicable rules by adding or removing facts). The inference engine then selects another rule and executes its actions. This process continues until no applicable rules remain [CLIPS 2006].We selected CLIPS due it represents forward flow of reasoning extremely. And with so many intended uses of this system, the low cost, low memory requirement, portability, reusability of the knowledge base, availability of interface with C and Java [JESS 2006], and object-oriented programming capability are other major reasons for our choice.

3.2. Rules for the Decision Information System

Our objective was to provide a hierarchical rule-like structure for conducting the diagnosis and providing enough elements to support the phalaenopsis orchids care. We decided to handle single questions and a binary tree structure to guide users.

In Figure 2, the first column represents the current state in the program; the second column the question to guide diagnosis; the third column (Yes) the next state or action identifier (id) in case of affirmative response; the fourth column (No) the next state or action id in case of negative answer; the five column (a) the action to be done or advice in case of positive response; and the six column (b) the action or advice to be done in case of negative response.

State	The Phanelopsis Orchid Cares V1.0			(a)	(b)
		Si	No		
0	Some problem?	1	0		
1	**Start Program**	2	2		
2	Sleves are Yellowish?	8	3		
3	Plant lost some sleves?	19	4		
4	Roots are outside pot?	21	5		
5	Stop blooming?	5a	6	Cut stalk of the blooms at 2.5 inches from base of plant, fertilize and wait	
6	Can not bloom?	22	6		
7	Has any plague?	27	8		
8	The sleves shows brownish stains?	8a	9	Your plant is receiving a lot of sun light, search for a more shaded place or with indirect light	
9	Sleves are showing folds?	13	10		
10	Sleves are not developed or coiled?	13	11		
11	Some sleves are rotten/ filled with water?	11a	12	Your plant has roots rotten, cut them off, wash very well, use fungicide, change substrate and water, do not water for two weeks, and wait for new roots	
12	**Finish Program**			Your plant is healthy	
13	Watering frequency is each 1/2 week?	14	16		
14	Do you live in a hot climate?	15	14b		Your plant is receiving a lot of sun light, search for a more shaded place or with indirect light

Fig. 2. A segment of the Expert System Knowledge Base created by means of rules

Once we tested the resulting Knowledge Base, we proceeded to code the rules in CLIPS programming language, as shown in Figure 3.

```
(defrule determine-orchid-state ""
   (not (orchid-state orchid ?))
   (not (repair ?))
   =>
   (if (yes-or-no-p "Does the orchid have a problem (yes/no)? ")
       then
       (if (yes-or-no-p "Does the phalaenopsis orchid have yellow sleves (yes/no)? ")
           then (assert (orchid-state orchid yellow-sleves))
           else (assert (orchid-state orchid normal)))
       else
       (assert (orchid-state orchid normal))))

(defrule determine-sleves-state ""
   (orchid-state orchid yellow-sleves)
   (not (sleves-state orchid ?))
   (not (repair ?))
   =>
   (if (yes-or-no-p "Does the orchid lost its sleves (yes/no)? ")
       then
       (assert (sleves-state orchid sleves-lost))
       (assert (roots-state orchid verify-roots))
       else
       (assert (sleves-state orchid does-not-lost-sleves))
       (assert (bloom-state orchid verify-blooms))))
```

Fig. 3. Figure 3. Rules code in CLIPS programming language

The rule "determine-orchid-state" is the initial state of the ES and is the first step to identify if the orchid has a problem. The first condition to check is the state of the sleeves -rule "determine-sleeves-state"-, if the orchid lost its sleeves then diagnosis is conducted to verify why, else the inference engine proceeded to process the next symptom.

3.3. Users Interface

To run the resulting program in the CLIPS 6.23 environment, is necessary to enter to the tool, and then load the .clp (CLIPS) extension program threw the File Menu (See Figure 4), and then execute it using consecutively the commands (reset) and (run). The result of one single query to the DSS is presented in next Figure.

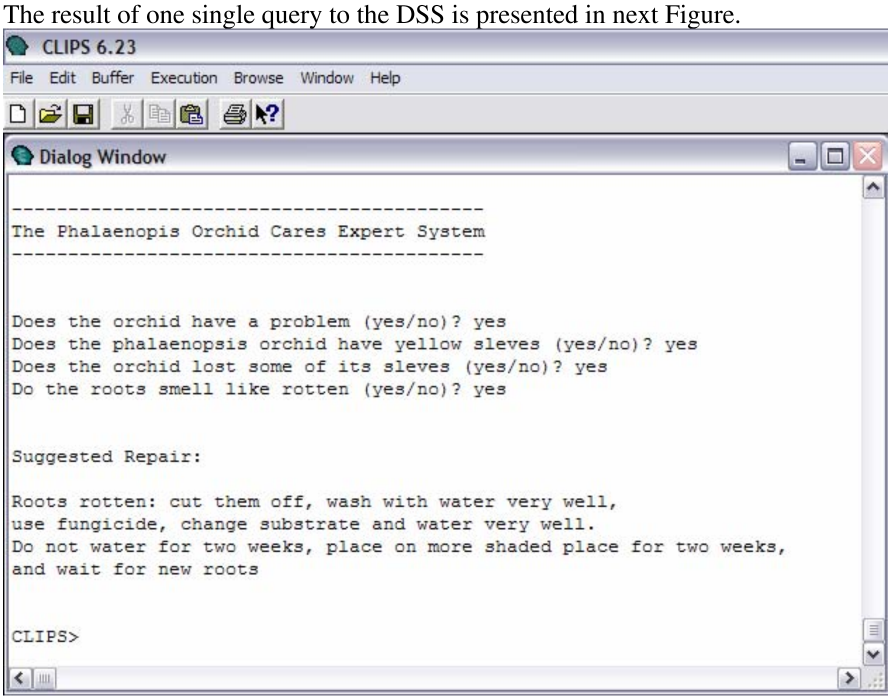

Fig. 4. The user interface

3.4. Related Work

The state of the art on agricultural Expert Systems has been conducted on middle-east and Asia, particularly on Egypt and China [Hua-Yang et. al 2006]. On Egypt the research is held at The Central Lab for Agriculture Expert Systems [CLAES 2006], this institution has developed and improved during years ES for the production of plants and fruits. On Table 2 we make a comparison of two representative systems of this Lab with our DSS. The reasons why we have selected these systems are: first, they were designed considering the same variables that in our project (diagnosis, treatment, irrigation, fertilization, pest control and plant care). And second, they were implemented using similar technology. Regarding the number of functions (diagnosis, treatment, etc.) our system is more complete than Cuptex or Limex, the first does not include pest control functions, and the second lacks of diagnosis and treatment functions. Most of recent agricultural ES are on line, however they are oriented to support animal ES [CLAES 2006 and Fu et al. 2005], so we found as an opportunity area: the generation of online ES for plants production. In Table 2 we noticed that system platforms are DOS or Windows; however we are working with the JVM and JESS to produce a platform independent web based expert system. That was the reason why we decided not to use WX-Clips, despite the user-interface can be improved, platform dependent software is produced.

Table 2. Comparison of Expert System for plants production (– Not mentioned)

	Cuptex	Limex	Phalaenopsis Orchid Care DSS
Domain Field	Agricultural (Cucumber growth production)	Multimedia Expert System for Lime Production	Horticulture (Orchid growth production)
Functions			
Disorder Diagnosis	Yes	-	Yes
Disorder Treatment	Yes	-	Yes
Irrigation Scheduling	Yes	Yes	Yes
Fertilization Scheduling	Yes	Yes	Yes
Pest Control	-	Yes	Yes
Plant Care	Yes	Yes	Yes
Hardware	80486 MIC. 8 MB RAM.,10 MB HD of free HD, CPU in real mode (work only on DOS)	Pentium II, 128MB RAM	Pentium III. 256MB RAM
Software	MS-DOS 3.1 or higher. MS-DOS arabization S/W or its equivalent.	CLIPS Ver. 6.0, Borland C++ 4.02	Java Virtual Machine (JVM) V5.0, Netscape, CLIPS 6.2 Windows 2000/Xp and MacOS (stand alone version). JESS for web based version
Use of images	Yes	No	Work in progress
Use of Multimedia (videos)	No	(Yes)	Work in progress

3.4. Preliminary Results and discussion

The efficacy of our expert system has been tested and proved in house. Our first production of orchids started at November of 2004, without the aid of the Expert System, we obtain 22 high quality (ready to sell) blooming plants. The last year we started the implementation of the DSS for phalaenopsis orchids care and we obtained 41 high quality blooming plants. We learned from our errors and improved our knowledge base, this year we expect to triplicate our earlier results (60 high quality blooming plants), the firsts spikes of the season are appearing right now at our greenhouse.

The DSS Knowledge Base (KB) can be reused in other compatible systems like JESS. KB can be improved by adding new rules as new knowledge (more know-how) is obtained. We believe the user interface at this early stage works very well. However, current version needs to be reviewed.

4. Future work

We want to improve the treatment of plagues by using non-artificial remedies, like the combination of some plants and species (i.e. alcohol + onion + garlic) to achieve the ecologic production of orchids. Therefore, we are planning to introduce this knowledge on the DSS. Now the DSS is working in a stand-alone basis, in the short time we plan to move on a web based DSS. We are working also with some other species of orchids (i.e. catteleyas, dendrobiums); and our intention is to reuse some reasoning rules, and then extend the knowledge base to deal with these other species. Finally, we believe the use of images and videos could improve the understanding of facts and diagnosis in the DSS, and now we are working on that direction too.

5. Conclusions

The best results to build an expert system are obtained when knowledge engineers, involved in the project, became experts in the problem's domain also. The DSS for the phalaenopsis orchids care has demonstrated its effectiveness to grow up and bloom orchid plants at home and under greenhouse conditions. Rule base reasoning provides the possibility to implement Expert Systems and reuse their KB. It means, by modifying the system's knowledge base the production of several plants can be supported.

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