Chapter 8: Discussion and Analysis of the System

The chapter deals with the analysis and interpretation, discussion of the findings of research work.
Discussion and Analysis of the System

8.1. Introduction

This chapter presents the discussion and result analysis of the developed system in the diagnosis process of rice plant diseases which occurred during their life span. It also describes the advantages of the developed expert system in the diagnosis process of diseases. Expert System is a complex task which takes time and requires highly qualified and well experienced expertise. Knowledge is not always readily available. Helps is often required from knowledge engineers who are themselves rare and expensive to develop, maintain and upgrade. Difficulties may be arising to solicit the knowledge from humans who are uncooperative. In addition to this, the approaches of each expert may be different though they are correct in their field. At the same time, most experts have no independent ways of means for assessing whether the work of conclusions are reasonable as a means of their systems success or failure. Researchers who include Eom (1996) [11], Guimaraes et al. (1996) [18], Kunnathur et al. (1996 [25], Tsai et al. [53] and Yoon et al. (1995) [59], have indicated why expert systems succeed and fail in practice. Usually, the expertise takes a long duration to achieve and seldom got when they are about to retire. Besides these, the
knowledge experts are hardly in numbers, busy, and expensive to employ especially in under developed country. Therefore, the system carries comparable advantages to other diagnostic expert systems, such as AMRAPALIKA, Wheat Expert System, Tomato Expert System and POMI, which were designed to diagnose infectious diseases of different agricultural areas and suggesting possible control measures.

Expert Systems are prompt in dealing the problems, identifying, diagnosing and brings accurate way out for infectious diseases in different agricultural fields. Human beings are error prone and often contradictory which is not in the case of expert systems. For this reason, it is likely to create confidence in users of such systems for efficient results. Furthermore, due to their portability, expert systems can be used in different geographical areas with minimum user training and they would not pose a big problem as they guide to reach conclusions whenever queried. Lastly, the study system tends be educative through its explanatory portions and the various notes in the system interfaces. This present study will bring constructive measures for the farmers to make better decisions for their problems in the farm.

8.2. Existing Expert Systems in the field of Agriculture

Many expert systems are used in agriculture domain by capturing the experience and knowledge of a human expert in the
form of rules and facts which are used to solve the problems by answering questions on many diversified topics, for example, in pest control and disease diagnosis. Now-a-days, expert systems in agriculture are employed more for diagnosis and management of economically significant pest problems like diseases and insects of crop plants. Here some of the existing expert systems in the area of agriculture for diagnosis of disease are discussed and analysed in the following.

8.2.1. Wheat Pakistani Expert System

This is a web-based expert system for wheat crop in Pakistan [114]. The rule-based expert system covers two main classes of problems namely diseases and pests, normally encountered in wheat crop. The expert system is constructed using e2gLite™ expert system shell available freely on the internet. This web-based expert system shell allows a JAVA interface to process its input and output sets. The expert system can act as a powerful tool with extensive potential in agriculture especially in situations where agricultural specialist assistance is not readily available when the farmers need it. This expert system aimed at help the farmers, researchers and students and provided an efficient and goal-oriented approach for solving common problems of wheat. The Wheat Pakistani Expert System expert system gives results that are correct and consistent. Several
diseases are reported to occur in wheat crop in Pakistan. The major wheat diseases occurred in wheat crop in Pakistan is Black Stem Rust, Leaf Rust, Bacterial Leaf Blight, Flag Smut, Bunt, Root Knot and Bacterial Leaf Streak [115].

8.2.2. Mango Expert System: AMRAPALIKA

The Mango Expert System: AMRAPALIKA is for diagnosing 14 different pests including eight diseases and six insects in Indian mango variety. The expert system is developed for important diseases like Powdery mildew, Black spot, Anthracnose, Red rust, Die back, Bacterial spot, Sooty mould and Malformation and insects like Shoot-borer, Red ants, White ants, Mealy bug, Mites and Fruit fly. They emphasized application of expert system in Indian fruit culture and described development of a rule-based expert system, using expert system Shell for Text Animation (ESTA), for the diagnosis of the most common diseases and insects occurring in Indian mango. The expert system makes diagnosis on the basis of responses of the users made against queries related to particular symptoms. The knowledge base of the system covers knowledge about symptoms and remedies of 14 pests of Indian mango tree appearing during fruiting season and non-fruiting season [116].

Diagnostic problem solving has been formalized in a cyclic process of abduction, deduction and induction in the light of
hypothesetical reasoning. Logic has been one of the oldest tools for diagnostic problem solving. There are many logic based different diagnostic approaches such as abductive diagnosis, deductive diagnosis, consistency-based diagnosis, etc. This expert system uses logical models of visual symptoms and ailments as the classification rules expressed in the syntax of ESTA. The rule-based strategy has been successfully used, in several other diagnostic expert systems. The rule based approach in backward chaining for knowledge representation has been chosen in their system. The choice of backward chaining is due to the fact that it is goal directed and resembles the reasoning process of the diagnosis [115].

8.2.3. Tomato Expert System

A web based tomato crop expert information system was developed by Babu et al. (2010) in India [117]. The expert advisory system aimed at a collaborative venture with eminent Agriculture Scientist and experts in the area of tomato plantation with an excellent team of computer engineers, programmers and designers. This tomato crop information expert system deals with different varieties of tomato crop, identification of various diseases and pests generally occurs to tomato crop based on the symptoms.

Using the techniques of ID3 Algorithm and some optimization algorithms, the rule based expert system validates the symptoms of
the tomato crop. This is a web based expert system with Java Server Pages (JSP) as the front end and MySQL as the back end. The program is divided into two aspects; Information System and Advisory System. In Information system, the user can get all the static information about different pieces, Diseases, Symptoms, chemical controls, Preventions, Pests, Virus of Tomato fruits and plants. In Advisory System, the user is having an interaction with the expert system online. The user has to answer the questions asked by the Expert System. Depends on the response by the user the expert system decides the disease and displays its control measure of disease.

Features expected in web application are as follows:

- It helps in updating information to the users from time-to-time at their doorsteps regarding diseases, virus and its control measure, which leads to good yields.
- It contains four major sections: Information Systems of Tomato crop, Tomato Advisory System, services related to web application and an additional feature links to other agriculture systems.
- The web directory service, articles and the discussion forum services provided in the website will help the tomato fraternity
in a greater way to interact each other so as to produce better findings in the area of tomato field.

### 8.2.4. Rapeseed-Mustard Expert System

An image based rapeseed-mustard expert system was developed in India by Vinod et al. (2008) [118]. The diagnosis and control measures of diseases (Alternaria blight, white rust, white rot, downy mildew complex, powdery mildew, and white rot) for mustard plant were effectively performed by using Rapeseed-Mustard Expert System. It is estimated that, on average harvest seed yield losses range from 5-15% and can reach 47% due to *Alternaria* blight [119]. In case of White rust in B. juncea, yield losses of up to 47% [120]. Recently, it had seen that Rot has become important disease in India and elsewhere with high disease incidence which causes up to 40% yield losses leading to discouragement of farmers [121].

Published materials and human experts were consulted to collect the knowledge about the rapeseed-mustard diseases on different part of plant and their management practices. Plant diseases appearances were classified into six classes’ viz., flower, stem, leaves, pods, root and whole plant. The high quality colored images and video clip of various symptoms of diseases were captured by using modern digital/video cameras. Visual symptoms of pests and plant diseases can be captured by electronic devices for quick
diagnosis. System design composed of several basic components: a user interface, a database, a knowledge base and an inference mechanism. It usually proceeds through several phases including problem selection, knowledge acquisition, knowledge representation, programming, testing and evaluation [118].

Design methodology and system implementation knowledge base dealt with information like data of characteristic of diseases, photographs of symptoms of different diseases on different parts and the data of management of these diseases were collected from the scientists especially pathologists, extension workers as well as published literature and then coded with the object oriented programming language such as Visual Basic 6.0 as front-end, and MS Access- 2000 as backend, has been used to develop the software.

8.3. Comparison of Developed System with Existing Expert Systems

The comparisons of the developed expert system with the presently existing systems are discussed here. The major concern in the development of all the existing expert systems is the identification of input problem. In any expert system, knowledge base is the core component of the system. Knowledge Acquisition is the first task to perform in the process of knowledge base development.
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It performed to obtain facts and rules from the domain expert so that the system can draw expert level conclusions. Some commonly used approaches in the knowledge acquisition process are interviews, observation and analysis of the acquired knowledge with domain experts. Different types of knowledge acquisition techniques are being used for the knowledge acquisition of the different expert systems as described above.

In the proposed developed system of the research work, the knowledge acquisition is performed through a series of interacting sub modules integrated with the coordinating module mainly for creating the knowledge database until the best conclusion is obtained. To develop the knowledge base, different types of expert system shell are being used for different systems. The knowledge is represented using either forward or backward chaining techniques or both the techniques of the existing expert systems to represent the fundamental reasoning approaches. The acquired knowledge is represented using the JESS expert system shell for knowledge base development of this system. The main differences or the comparisons between the develop expert systems and existing system are given below.
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Expert Systems</th>
<th>Study Area</th>
<th>Language/Shell Used</th>
<th>Components of the System</th>
<th>Problem Covered</th>
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<tr>
<td>1.</td>
<td>Our Proposed System</td>
<td>Manipur, India</td>
<td>JESS, JAVA, SQL</td>
<td>User Interface Component, Application Component, Database Component</td>
<td>Common Diseases in Rice plant</td>
</tr>
<tr>
<td>2.</td>
<td>Wheat Expert System</td>
<td>Pakistan</td>
<td>E2glite expert system shell</td>
<td>Diagnostic Problem solving, Knowledge acquisition and Knowledge representation</td>
<td>Diseases and pests, normally encountered in wheat crop.</td>
</tr>
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<td>3.</td>
<td>Rapeseed-</td>
<td>India</td>
<td>Visual Basic</td>
<td>User interface,</td>
<td>Alternaria blight,</td>
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<th>Mustard Expert System</th>
<th>front-end and Microsoft Access -2000 as backend Software.</th>
<th>Database, knowledge base and an inference mechanism.</th>
<th>white rust and White rot, downy mildew complex, powdery mildew, white rot of rapeseed mustard</th>
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<tr>
<td>Tomato Expert System</td>
<td>Hyderabad, Andhra Pradesh, India</td>
<td>Information system, Advisory system, rule based system</td>
<td>Common diseases in tomato</td>
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<td></td>
<td>Java Server Pages (JSP)as front end and MySQL as backend</td>
<td></td>
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<tr>
<td>AMRAPALIKA</td>
<td>Bihar, India</td>
<td>Expert System Shell for Text Animation (ESTA) Tool</td>
<td>Problem definition and Diagnostic expertise modeling, Knowledge acquisition, Knowledge</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>14diseases in Indian mango tree</td>
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<th>representation using simple if-then rules in backward chaining.</th>
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**Table 8.1: Comparison of Different Important Expert Systems with the proposed system**
8.4. Analysis and interpretation of the proposed system

The prototype of this expert system in order to diagnose and manage the diseases occurring in rice plant during their life span is proposed by this thesis. It is an architectural framework of an expert system in the field of agriculture. It also describes, design and develops the rule based expert system by using the shell JESS for the knowledge base development with NetBeans 7.0 and SQL used as the Database engine for the system. The JESS file is called in the NetBeans Environment and the Database also. The designed system is then intended for the diagnosis of common diseases occurring in the rice plant. While interacting with the developed system, the response of the domain found to be successful and promising.

The proposed expert system acts as a diagnostic tool which help the farmers in the diagnosis process of the diseases occurred in the rice plant during their life span. In this system, the diagnosis process is in two stages. In the first stage of the diagnosis, the users have to select a particular symptom. Depending on the symptom selection the system provides a related picture. With these inputs the user clicks the “search” button which is shown in Figure 7.7. Now, the JESS platform performs the necessary knowledge evaluation to determine the expected result. If the user confirms that the generated disease against the selected symptom with the related
picture is only a particular disease he/she is facing, then the user can go for the details of the disease by clicking the "disease details" button. This is shown in Figure 7.8. If the system has suggested are more than one disease against the selected symptom with the related picture, the user will have two options and this is the second stage of the diagnosis.

In the first option, the user can select the entire row of the one of the disease generated and then go for the details of the disease by the help of "disease details" button which is shown in Figure 7.13. And in the second option, the user can go for the further diagnosis of the disease by clicking the "search by description" button if the system has suggested more than one disease. After clicking this button, the user can go for further diagnosis of the disease by providing the complete details of the symptom and the related parameters in the format given by the system. In this process, the farmer will obtain the disease occurred in his rice plant. This is shown in the Figure 7.15.

In Figure 7.7, the selection of a particular symptom “Circular or oval, dark brown to purplish-brown spots are found” and the related picture of the symptom are provided. By selecting the symptom and the related picture, we are clicking the “search” button and then JESS platform performs the necessary knowledge evaluation to determine
the diagnosed disease. The disease diagnosed against the selected symptom is Brown Spot disease which is shown in the Figure 7.8. Further, we can get the complete details of the disease and its control measure by selecting the entire row of the generated output and then by clicking the “disease details” button which is shown in the Figure 7.9 and 7.10.

The selection of a particular symptom “Lesions turn brown to greyish white then dry” and its related picture is shown in the Figure 7.11. The generated result by the diagnosis against the selected symptom and the related picture is shown in the Figure 7.12. Here, the two diseases “Narrow Brown Spot” and “Bacterial Leaf Streak” are generated against the selected symptom. From this, we can get the complete diagnosis of the disease by clicking the “Search by Description” button and then by supplying the complete details of the symptom and related parameter. The process is shown in the Figure 7.15. In the Figure 7.16, the disease details of “narrow brown spot” disease of the rice plant and the photograph of the disease is shown after the diagnosis.

After discussing, the advantages of the system are hereby illustrated as below:
8.4.1. Dynamism of the System

A good expert system is expected to grow as it learns from user feedback. Feedback is incorporated into the knowledge base as appropriate to make the expert system smarter. The dynamism of the application environment for the developed expert systems is based on the individual dynamism of the components. This can be classified as follows:

- **Maximum Dynamic:** The contents of the *knowledge database* change with each problem situation. Consequently, it is the maximum dynamic component of this system, assuming, of course, that it is kept current.

- **Temperately Dynamic:** *Knowledge base* of the system is temperately dynamic because it need not to be changed unless a new piece of information arises that indicates a change in the problem solution procedure. Changes in the knowledge base should be carefully evaluated before being implemented. In effect, changes should not be based on just one consultation experience.

- **Minimum Dynamic:** Because of its strict control and coding structure of the *inference engine*, changes are made only if absolutely necessary to correct a bug or enhance the inferential process.
8.4.2. **Updating and Extendibility facility of the System**

The developed system has the self-extending and updating capability of the knowledge base by incorporating the new information about the symptoms and predisposing factors of the diseases of the rice plant. The valuable aspect of self-extending and updating of this system is the ability to remain up-to-date the information changes about the diseases from time to time. In this case, the new information may be likely to conflict with the old information about the diseases. In such a situation, the appropriate handling of the “conflicting” information is one of the positive features of this system.

The system is easy to extend the system by adding more diseases, disease categories and production rules. Extendibility means the ability of the system to add new input parameters for example, the symptoms of new added disease to the system and new output for example, the details of the newly added disease to the system and the expert advice of the added disease over time, and how easy these additions are to make.

The developed system is able to cope with a wide variety of application areas and the application domain is customised by an expert for non-expert to use. New applications are created by specialising existing ones. New solutions are also incorporated in the...
system without modifying the knowledge base and the solutions are employed when appropriate.

8.4.3. **Self Learning of the System**

The main feature of the developed expert system provided is to check the completeness and correction of the knowledge base. The program is developed based upon the results of actions it performs in such a manner that the system extracts rules from the set of input-output data pairs and keeps on correcting its rules. In this chapter, the capability of self-learning, self-correcting and also self expanding of the developed expert system are mentioned. Following are the salient features of the system.

1. To predict the values of output process variables based upon values of input process variables.
2. Self learning and correction according to the new diseases and symptoms provided.
3. Generates the rules for the knowledge base automatically.
4. Solve contradictory rules with conflict resolution facility.
5. Deletion facility of outdated data from database.

The first two features represent the main objective of the expert system while the other features describe the automation required for the system to self developing. This self developing expert system offers numerous benefits as given in the following:
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1. Scope of the expert system can be expanded according to the requirements.
2. Minimum human involvement would be required for updating knowledge base.
3. Higher precision upon more utilization of expert system.
4. No requirement of optimal formation of rule base and automatic generation of rules.

8.4.4. Faster processing of the System

The developed system has many rules which cover the fungal, bacterial and virus caused diseases of rice plant. The system uses only the appropriate rule set during the consultations. For example, for the diagnosis of a particular disease “Brown Spot”, the system has fired the appropriate rule set of the disease.

(defrule symptom-35
  (?s <- (Symptom {symptomID == 35}))
  (answer (symptom abnormal_elongation_of_plants_in_seedbed) (text yes))
  (answer (symptom reduced_tillering_and_drying_of_leaves) (text yes))
  (answer (symptom partially_filled_grains) (text yes))
  (answer (predisposing presence_of_infected_seeds) (text yes)))
The above example shows the diagnosis of the “Bakanae” disease of rice plant by firing the appropriate rule of the particular symptom we have supplied.

8.4.5. **Feasibility of the System**

Majority of the farmers often rely on agricultural specialists and advisors to provide information for decision making to get rid of problems of diseases in rice crops. Sometime in remote areas, due to non availability of agricultural experts, the decision making process is delayed. At such point of time, the losses of the crop production
problems increase. Therefore, with time saving, solving of problems which arises related to rice plant diseases and immediately making decision will bring effective by using this expert system. It had already being proved that application of expert systems in agricultural field help a lot in increasing the crop production and reducing the yield losses. The successfully developed expert systems should be demonstrated to farmers for the benefit of them. The impact studies of expert systems in different crops are required to be incorporated in due course.