USING ESTA TO DEVELOP EXPERT SYSTEM FOR THE NATURAL RESOURCE MANAGEMENT

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ABSTRACT: In this paper we describe role of expert systems in the natural resource management and present the utility of prolog based expert system shell ESTA (Expert System shell for Text Animation) in the development of such an expert system. ESTA programming is based on logic programming approach. The ESTA programme has some advantages compared to other available expert system shell such as the C Language Integrated Production Systems (CLIPS). It is easy to use, fast, and requires little programming experience. Expert system development for natural resource management has been explored through presenting in details development of knowledge base ,using hypothetico-deductive diagnostic reasoning, for the visual image interpretation of IRS-1B based standard false color composite (FCC) image.

1. INTRODUCTION:

The discipline of remote sensing is concerned with the collection of information related in some way to the earth's natural resources or environment without coming into physical contact with them, through analysis of the acquired data [1]. In the modern age of computing our most of the activities is influenced directly or indirectly by a computer. The days when computer were confined to only scientific community to do hard calculations are gone. This era is the era of expert skill. Everywhere in every domain relevant expertise is the most wanted thing. The major problems in accessing a human expert in a particular field are unavailability and scarcity of real experts and if a human expert is available then there may be problem for common people in making contact with him. Consultation may be very expensive and human expert may feel the repetitive job uninteresting. This in turn may affect expert's efficiency. The other major problems that are being faced by a human expert are the limitation of his memory and processing inability of all the essential knowledge and information required in the process of decision-making. As a result of researches and developments, day by day, new knowledge in enormous amount is being added in every discipline and thus more relevant and accurate advice can be taken from a human expert if his/her own knowledge is accordingly updated which is not an easy task. Human experts are bounded by some humane limitations and it is quite impossible for a human expert to consider all the essential factors while taking decision. Something is always escaped and remained unconsidered. Thus some computer based tools or assistances like Decision support system, Decision making system, Expert system etc. are needed even for an expert to update his knowledge and get help in decision-making process. In this respect expert system has been proved to be a very useful tool. Expert systems of today support many problem solving activities such as decision making, knowledge fusing, designing, and planning, forecasting, regulating, controlling, monitoring, identifying, diagnosing, prescribing, interpreting, explaining, training etc. using different techniques and it is expected that future expert systems will support even more activities. In the beginning, expert systems were developed in the chemical and scientific domains and by the end of 1970s expert systems were operating in the medicine, chemical, education, natural resources and science domains. Expert system started to gain popularity in the early 1980s[2]. The announcement of successful operational systems like PROSPECTOR a natural resources system that evaluates geographic sites for potential mineral deposits of commercial interest, MYCIN, medical consulting system, etc. catalyzed the expert system technology [3,4]. The availability of powerful tools to develop expert system has made possible creation of large number of expert systems in different domains in general and for the natural resource management in particular [5]. Multi spectral Remote Sensing data are used for land use and land cover classification. A simple visual interpretation of remotely sensed imagery can reveal considerable detail on the nature and distribution of land use and land cover in the area of interest. To visually interpret digital data such as satellite images, individual spectral bands must be displayed simultaneously in the form of a color composite. For example, IRS-1B bands 1,2,3 (or Landsat TM bands 1, 2,3) broadly represent the blue, green and red parts of the electromagnetic spectrum (ES). When these bands are fed through the corresponding blue, green and red "color guns" of a computer monitor, the resulting image strongly resembles what our eyes would see. Such images are called *true color composites* (TCC). Data taken in some other bands contains more information, which may not be explicit in these visual bands. Such non-visual bands are arbitrarily assigned one of the three primary colors (Red, Green, Blue) of visual bands. The images so produced do not resemble to true color of the ground reality and are called FCC images. However, false colors can still be related to land use and land cover of interest. In general, multi spectral data contains more channels and only three of them are required for the false color image. This results in unused information (channels) of the original data. So usually multiple FCC images are used. However it is possible to generate an image that is capable to reflect all the channels of data based on compression of multi channels into three channels [22]. Two types of classification techniques for FCC images exist: automated classification and visual interpretation. Visual interpretation is usually carried out based on a false color image. Visual interpretation is the identification of features based on their color, tone, texture and context within the imagery.

In this paper our main concern is with visual photo interpretation method of IRS-1B based standard FCC and representation of such knowledge in hypothetico-deductive framework. We implement the same in the development of a rule-based expert system, using expert system shell ESTA (Expert System shell for Text Animation), for beginners to learn the visual interpretation skill for the purpose of land use & land cover mapping.

2. EXPERT SYSTEM AND VISUAL INTERPRETATION OF FCC IMAGE:

The development and application of expert system in any discipline is governed by different factors like the availability of human experts, scarcity or rareness of experts, need of finding solution of problems unsolvable to single expert etc. Many image interpretation systems have been developed in the past. These systems are different in number of ways like the knowledge representation scheme, control strategy, application area etc. Most of them are based on spectral features of the image. Very few systems have been developed for developing visual interpretation skill. In the field of land use /land categorization using satellite data a rule based expert system [6] was developed using visual interpretation keys developed by NRSA (National Remote Sensing Agency), India. In other development an expert system for the landform study has been created, in the Prolog language, for landform type identification and classification in automated and user interactive way [7]. Majority of systems have been developed for automatic image interpretation e.g. the system SPAM [8] for aerial image interpretation is based on production rules. The system MESSIE [9] has used production rules as well as semantic nets. In AIDA system [10] semantic nets and rules has been used to represent knowledge base while ERNEST [11] uses semantic net only. SIGMA [12] contains three expert modules based on frame and rule representation. Recently Jenson et al [13] in his neural network based photo interpretation approach have emphasized use of hybrid approach i.e. visual interpretation and digital interpretation. However, in the neural network based system the classification rules are hidden in its weight and is not useful for a user for learning point of view.

3.EXPERT SYSTEM DEVELOPMENT IN ESTA:

Expert systems are domain dependent computer programme that use knowledge and inference procedure of domain specific human expert to mimic his/her problem solving capability and way in which they solve. In the beginning, the expert system development was mainly carried out by the AI people using sophisticated inference engine and search techniques. However, later it was found that the expert system developed by non-AI (domain expert) people using simple inference engine and search techniques outperformed those developed by AI people [14]. This led the

AI people to realize the fact that the quality of knowledge highly influences the quality of expert system, which in turn led to the separation of knowledge module from inference and control strategies**.** This gave a great leap in the expert system technology and resulted in the development of expert system shell. An expert system in the context of expert system shell may be defined as follows**:**

EXPERT SYSTEM=KNOWLEDGE BASE + EXPERT SYSTEM SHELL (Control &Inference +User Interface).

The separation of the *control* and *inference* parts in the knowledge base is a fundamental feature of an expert system shell. ESTA is also an expert system shell developed by PDC (Prolog Development Center), Denmark. By providing with it a knowledge base, as shown in Fig.4, of a specific domain an expert system can be created. Thus

KNOWLEDGE BASE +ESTA= EXPERT SYSTEM.

ESTA system has several advantages over other expert system shell like CLISP**.** According to PDC, ESTA is easy to use and a great stand-alone environment for constructing advisory and decision making systems.

Building advanced knowledge base with ESTA requires no previous programming experience and it is suitable for many problem domains. ESTA is the perfect tool for structuring of knowledge. It includes explanation facilities for the

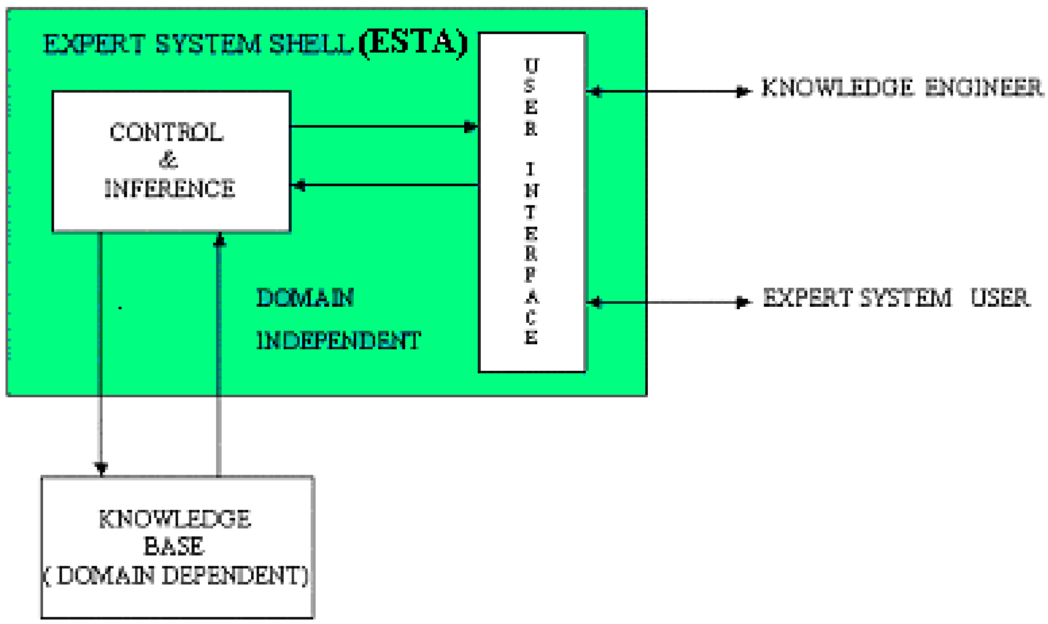


Fig.1 Expert system shell to expert system

question being asked and for given advice. Details about ESTA can be found in the reference [15,16] or at the homepage of PDC. The knowledge base of the ESTA consists of rules, in forward or back chaining, represented in its own syntax. It has all the inbuilt facilities to write the rules that build the knowledge base from if then rules written in high-level language.

3.1 Knowledge Base Development:

As shown in the Fig.1, for a knowledge engineer expert system shell ESTA works as an excellent tool to create knowledge base and from user side it is used to consult the created knowledge base. Palpably, the task of developing expert system using ESTA, a domain independent module, is centered at developing a domain specific knowledge base, which is a multi-step process. These steps are problem identification, knowledge acquisition and knowledge representation in accordance with the syntax of ESTA.

3.1.1 Problem Definition and Expertise Modeling

IRS-1B Collects ground data using solid state LISS (Linear Imaging and Self-scanning Sensor)-I & II sensors in four bands. The used four bands are B1-0.42-0.52(Blue), B2-0.52- 0.59(Green),B3-0.62-0.68(Red), B4-0.77-0.86(near IR).Standard FCC image is produced by assigning blue to B2,green to B3 and red to B4 band. The problem of visual interpretation of FCC image can be considered as a diagnostic problem solving. As mentioned earlier a human expert identifies land use and land cover in the FCC image based on certain symptoms or features (shape size, pattern, tone, texture, shadow, site etc) related to basic picture element. Diagnostic problem solving [17] is knowledge intensive process. Basically in the diagnostic problem solving an expert is exposed to situation and is asked to find what is wrong and how it can be mitigated. A human expert, to does so, recognizes patterns of problems in the data elicited from the situation, provides diagnoses and suggests remedy if there is. Thus in a human expert diagnostic expertise can be characterized as

(i) ability to solicit appropriate situation information
(ii) ability to recognize specific patterns and their interaction in the elicited information

Obviously the process of diagnosis requires procedural as well as heuristic diagnostic knowledge. The computer based diagnostic problem solving e.g. one addressed in this paper, requires these cognitive formalities to be implemented. Diagnostic problem solving has been one of the areas of active research in the applied AI right from the evolution of the expert system technology and diagnostic problem solving program has been the first expert system. Since then various theories have been proposed to formalize and capture the notion of diagnostic problem solving expertise and have been implemented in different diagnostic computer programs. Reviewing the related literatures it can be concluded that there is no unique theory of diagnosis, different formalization and approaches have been adopted to solve different problems, however in all theories diagnostic problem solving has been formalized in the process of abduction, deduction and induction in the light of hypothetical reasoning [18]. This has been shown in Fig.2.In the abductive phase human expert generate candidate solution hypothesis from abducted observation using empirically proven association between observation and solution. In the deduction phase necessary consequence are deduced. In induction phase generated hypothesis is rejected or accepted and the whole cycle continues until termination. In the deductive inductive phase deep domain knowledge is exploited to test the candidate hypothesis with respect to diagnostic knowledge and observed findings. All those hypotheses passing the test are accepted as diagnoses and failure in test or test abortion rejects the hypotheses. The important conceptual models of diagnosis proposed so far are have been based on the type of used domain knowledge and are termed as model based approach, heuristic diagnosis, set covering theories etc. The choice of particular diagnostic framework depends on problem domain and knowledge to be used. Model based approach of diagnosis exploits explicit models of problem domains. Such models include knowledge of structural, functional, causal interactions among the modeled objects. Heuristic reasoning uses empirical classification rules elicited from the domain expert. It is logical deduction in data driven approach.

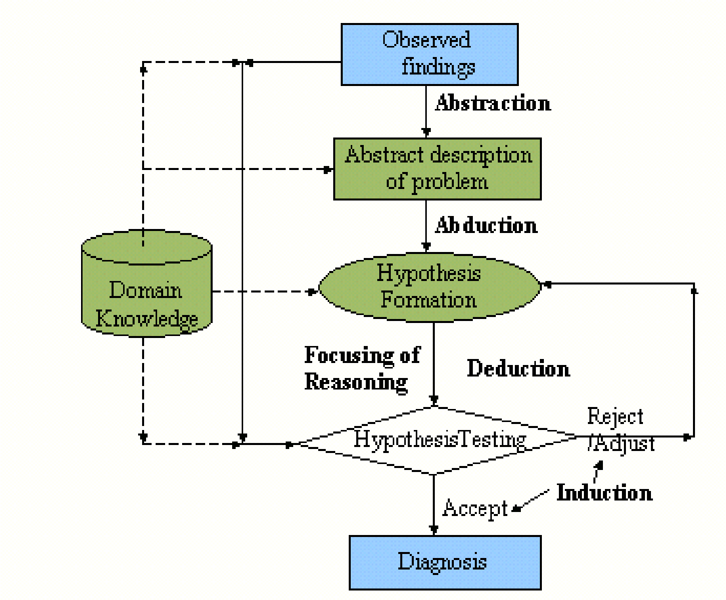


Fig. 2. An epistemological model of diagnostic reasoning

Here we have used hyothetico-deductive approach [19] to formalize knowledge of visual photo interpretation. Based on some basic abstraction system first forms hypothesis about different land use and land cover categories and then goes on search for features in details for a particular category. Here associative knowledge about landforms and features is matched to do classification. This is shown in the Fig.3.

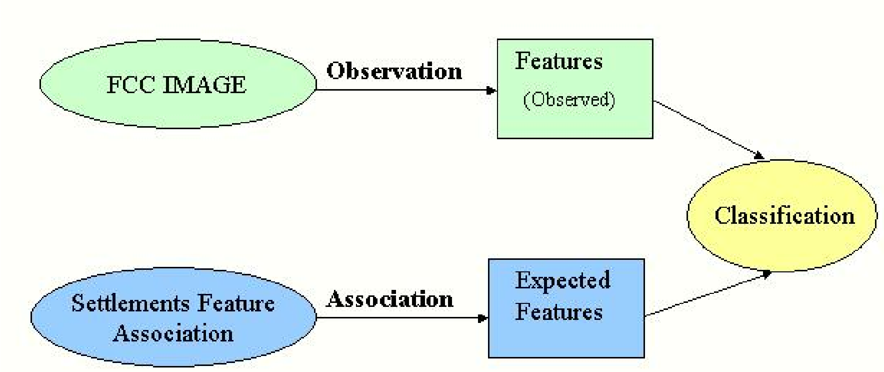


Fig.3: Hypothetico-Deductive diagnosis framework

3.2.1 Knowledge Acquisition:

Knowledge acquisition is one of the most important phases of the expert system development cycle in which domain specific knowledge elicited from human expert or other related sources are transferred to the knowledge engineer. The acquisition of knowledge for the proposed system has been carried out by making consultation with human experts and standard literature referenced above. The key features of each land use and land cover category were discussed in details. Efforts have been made to collect more and more heuristic knowledge about their identification. Details of it can be found in [20].

3.2.2 Knowledge Representation

Logic has been one of the oldest tool for diagnostic problem solving and logic based different diagnostic approaches like abductive diagnosis, deductive diagnosis, consistency based diagnosis etc have been developed [21]. ESTA also supports rule based knowledge representation in the logical paradigm. From acquired knowledge identification rules for different land use and land cover categories were developed. For example following rules have been included in the knowledge base to identify

Rule 1.If there occur white patches along the river
Then identify sand.

Rule 2.If there is bright blue or dark blue long non-linear long lines (thick/thin)
Then identify them as river.

Obviously, when system will trigger rule1 first it will look for the identification of the river. Thus while triggering rule 1 system first fires rule2. There are two major knowledge representations in ESTA namely Section and Parameters. Section is top level of knowledge representation and contains the logical rules that directs ESTA how to solve problem, actions to perform such as giving advice, going to other section, calling to routines etc. The first section is always named as start section. Parameters are used as variable and it decides the flow of control among the sections. ESTA accepts four types of parameters namely Boolean or logical, Text, Number and Category parameters. These parameters serve different purposes. The Boolean parameter is used when the answer to asked question is either Yes, No, or Unknown. Text parameters are used for text object. Number parameter is used to represent numerical values. Category parameters are used when variable takes more than one values. The value for any of the parameter is calculated from end-user's response to a question, through other parameters or as a result of application of rules. Any parameter consists of declaration of field, type field and number of optional field such as explanation field, rules field, picture field, question field etc.In the screen short of Fig.4 all such fields a Boolean parameter agri_q2 (name is arbitrary) of agricultural use section (a class of land use and land cover) is Shown. Each land cover and land use category has been represented in the separate section. The screen shot from the implemented system are shown the Fig.5 and Fig.6.Fig.5 shows interface of the system for the user which also shows details of each option in the figure window. Fig.6 represents internal representation of the rules in a section that transfer controls in accordance with the user's response. Each section contains classification rules placed in first come first serve order. The feature corresponding to FCC interpretation keys are placed in these backward chained rules including parameters. Each parameter contains explanation for questions, if needed rules to decide value of parameters, question statements and picture related to the said

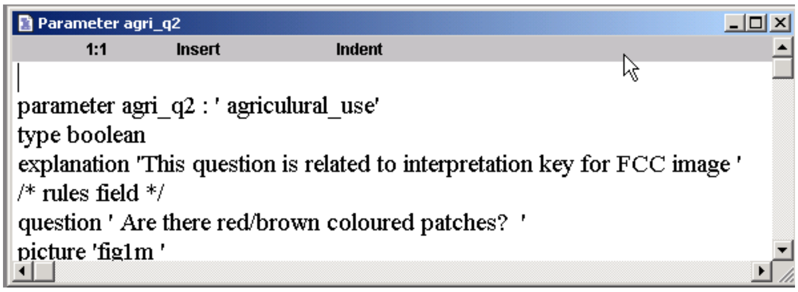


Fig.4 Screen shot of a parameter agri_q2

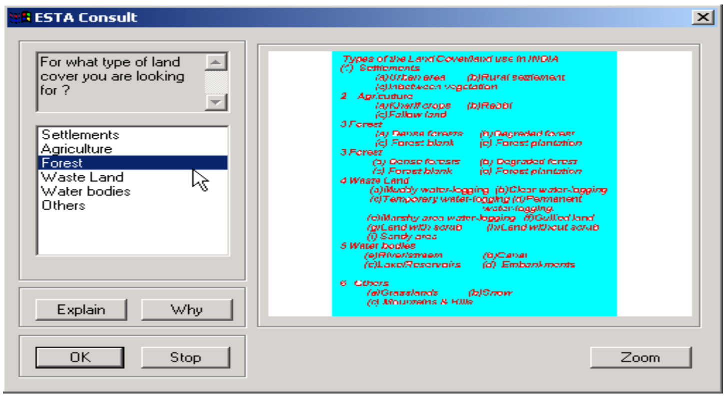


Fig.5 Screen shot showing different land used and land cover categories

question. These all are shown in the screen shot of Fig.6.Design of the system follows top-down design approach.The developed knowledge base is stored in the compiled mode for faster consultation.

4.Consultation and Result:

The system has been used to interpret IRS-1B based FCC image,as shown in Fig.7, of the Lalganj area of the district of Vaishali in Bihar. The classified land use and land covers are shown in the Fig.8. The result shows consistency of the knowledge base and suitability of diagnostic reasoning in representing visual photo interpretation skill of FCC images. Since the system is developed in symbolic techniques so the rules used by the system can be seen and line of reasoning can be understood. Such system is especially useful for newcomers in the area of visual image interpretation and remote sensing.

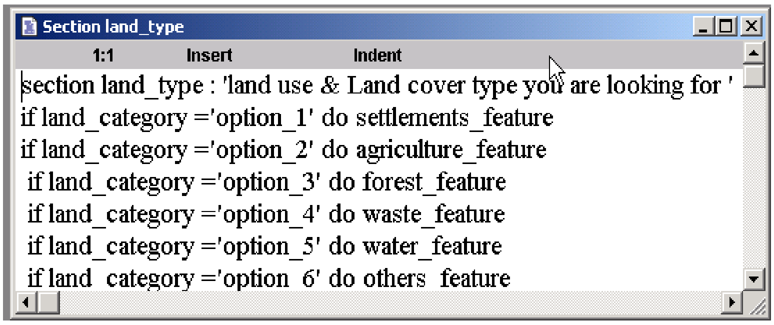
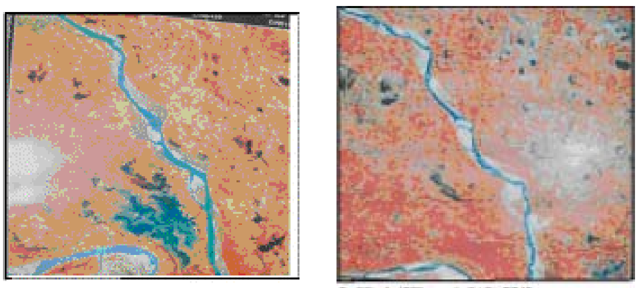


Fig.6 Screen shot showing a section



IRS-1B (Oct.1998) IRS-1D (May 1999)

Fig 7 FCC image taken by IRS-1B and IRS-1D

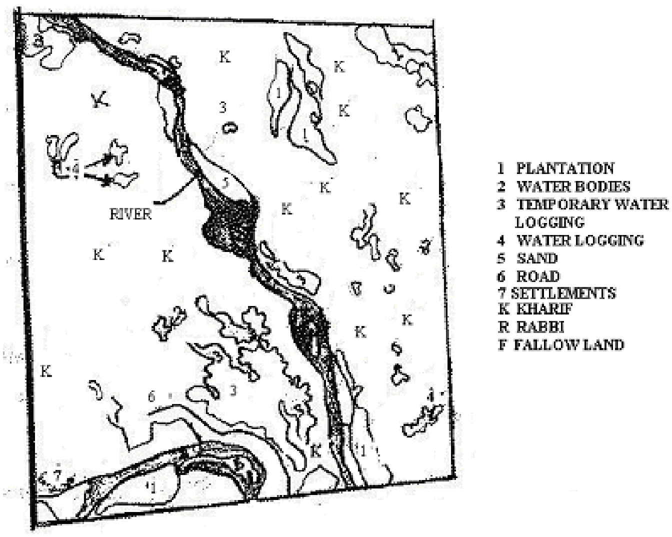


Fig.8 Identified Land use & Land cover categories

References:

1. Jensen J. R.(2000). Remote Sensing of The Environment: An Earth Resource Perspective, Prentice- Hall,Inc., Upper Saddle River, NJ,
2. Eramine , J.L.,(1997) "Expert System Theory and Practice.," Prentice Hall of India, New Delhi
3. Simon, G.L.,(1995). " Expert System and Micros" NCC Publication, Manchester,
4. Shortliffe, E.,(1976). "Computer Based Medical Consultation: MYCIN," Elsevier, New York.,
5. Deekshatulu, B.L(1991)" Management of Natural Resources -Use of AI," In AI and Expert System Technology in Indian Context", Ed. By V.V. Sharma, Deekshatulu,
6. Ramani, K. & Gautum, N.C., (1990) " Expert System, for Identification of Land Use/Land Cover Categories from Satellite Data", Proceedings of the Seminar on AI, Expert System & Knowledge Based System, ISRO Hqts., Bangalore, India.

7 Rao, D.P. (1991). Management of Natural Resources using Expert System Preliminary Result of Some ase Study, Expert system Technology in Indian Context Ed. by V.V. Sharma, Deekshatulu, Vishwandhan, TMH, New Delhi.

8 McKeown, D., Wilson, A. & McDermott, J. (1985). Rule-Based Interpretation of Aerial Imagery. IEEE Trans. on Pattern Analysis and Machine Intelligence

9 Clement, V., Giraudon, G., Houzelle, S. & Sadakly, F. (1993). Interpretation of Remotely Sensed Images in a Context of Multisensor Fusion Using a Multispecialist Architecture.IEEE Trans. on Geoscience and Remote Sensing 31(4): 779{791.

10 Liedtke, C.-E., B□uckner, J., Grau, O., Growe, S. & T□onjes, R. (1997). AIDA: A Systemfor the Knowledge Based Interpretation of Remote Sensing Data. 3rd Int. Airborne Remote Sensing Conference and Exhibition, 313{320, Copenhagen, Denmark.

11 Niemann, H., Sagerer, G., Schr□oder, S. & Kummert, F. (1990). ERNEST: A semanticNetwork System for Pattern Understanding. IEEE Trans. on Pattern Analysis andMachine Intelligence 12(9): 883{905.

12 Matsuyama, T. & Hwang, V.S.-S. (1990). SIGMA: A Knowledge-Based Aerial Image Understanding System. New York: Plenum Press, p. 277.

13 Jensen J. R., F. Qiu and Patterson K, (2001), A Neural Network Image nterpretation System to Extract Rural and Urban Land Use and Land Cover Information from Remote Sensor Data,Geocarto International, Vol 16,No.1,Hong Kong.

14 Al-garni, A.M., Al-sari (1994) Remote Sensing Geology and Expert System, ASPRS/ACSM, Annual Convention & Exposition, Baltimore, Vol.1, pp47-59.

15 Introduction to ESTA (Expert System Shell for Text Animation), Prolog Development Center, Denmark

16\. C.Bowerman,ESTA for Windows, School of Computing and Information System,1994

17 Peter Lucus ,(1997),Symbolic diagnosis and its formalism,Journal of Knowledge Engineering Review,12(2),109-146,1997.

18 L.Ironi,(1990),Qualitative Models in Medical Diagnosis, Journal of Artificial Intelligence in Medicine,2,85-101.

19 P.Lucus,(1998),Analysis of notion of diagnosis, Journal of Artificial Intelligence ,Vol.105.,1998

20 Prasad R.K &A.K.Sinha, IRS-1B Based FCC Image Interpretation For Land Use and Land Cover Mapping: An Expert System Approach,,Proc. of Map India 2002, NewDelhi

21 D.Pool,(1994),Representing diagnosis knowledge, Annals of Mathematics and Artificial Intelligence,Vol.11,33-50,1994

22 J.Suzuki & E.Shimizu,(1996), Multi spectral, Remotely Sensed data compression method using neural networks ,Proc. of ACRS 1996.