NEW HORIZONS
IN AGRICULTURAL
INFORMATION MANAGEMENT

PROCEEDINGS
OF AN INTERNATIONAL SYMPOSIUM
MARCH 13-16, 1991
BEIJING, CHINA
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Esta serie incluye ponencias de reuniones, informes internos y documentos técnicos que pueden posteriormente conformar la base de una publicación formal. El informe recibe distribución limitada entre una audiencia altamente especializada.
New Horizons in Agricultural Information Management

Proceedings of an International Symposium,
March 13-16, 1991, Beijing, China

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Sponsored by
International Development Research Centre

Organized by
Scientech Documentation and Information Centre
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Expert Systems for Agricultural Use: Recent Developments and Applications

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ZADI
Bonn, FRG

Abstract

Expert systems for agricultural problems are getting more and more important. The definition of the sense and substance of expert systems is followed by many references to documents on research projects in this area.

Indexing of the AGREP system using a personal computer serves as an example of agricultural documentation. The automatic analysis of project titles and abstracts using vocabularies and classification schemes helps to simplify the intellectual work of indexing and exemplifies an expert system with artificial intelligence.

1. What is an expert system?

By "expert" we understand a highly trained and informed person in a special field who gives skillful advice in subject-related problems at a low cost level. This information is arranged in expert systems in away that a non-expert can use the knowledge base of the expert to advantage. In general, the information can be provided in printed form, such as a vocabulary, a manual or a dictionary, easy to read by the user to solve the problem at hand.

Modern information technology helps to prepare computer-assisted expert systems for many users. The dialog between user and expert system in the computer consists of five main program steps. (Figure 1.)

1.1 Knowledge base

The knowledge base represents the encoded substantial expert knowledge, and means more than facts or factual data as is found in database units. The formulation of rules is required on the basis of experience gathered during many years and in accordance with laws of probability rather than of determination. The formulation of a rule may be as follows:

IF
food_plant_producing (oil)
AND
oil_is_in (seed)
AND
seed_is (achene)
FIG. 1

EXPERT SYSTEM

USER

KNOWLEDGE BASE

EXPERT

KNOWLEDGE REFINING PROGRAM

INFEERENCE MACHINE

NATURAL LANGUAGE PROCESSOR

EXPLANATION PROGRAM
AND
plant_is (composite)
THEN
plant_is (sunflower)

The expert can formulate this or other rules for storing into the knowledge base by the computer programmer.

1.2 Inference machine
In order to enable users to employ the knowledge base, an inference machine is required so that facts and rules can be brought into conformity with the search question. (Figure 2.) Proceeding from the goal the user will search groups of objects first and then single objects using their so-called attributes along a decision tree. Following the decision tree from the base, to the objects, upwards to the goal, the user will select object groups by the probable attributes of the objects in view. (Figure 3.) Food plants can be classified by their producing chiefly starch, or oil, or protein, etc., and by the plant organs in which these products are found. See for instance, the following attributes for rape:

Rape (Brassica napus L.)

- oil producing plant
- oil in seeds
- seeds in siliqua
- cruciferae

Analogous definitions of food plants, forage plants, and non-food engineered plants with their attributes are also stored in the computer.

1.3 Knowledge refining program
This section of expert systems enables the user to include experience and new knowledge of the subject field into the program for updating.

1.4 Natural language processor
The natural language processor, an integrated part of the program, is often called a "user shell" and is meant to ease the man/machine communication for non-experts.

1.5 Explanation program
In interacting with the expert system the user may possibly be in doubt about the attributes assigned to an object. Using the explanation program he or she can retrace the documentation of the whole dialog to that point.

To exemplify the above, an expert system on crop plants, especially food plants, was developed. The system starts at the beginning of the knowledge base and proceeds in sequential operations until the searched objects are found according to their attributes.
FIG. 2

DECISION-TREE OF THE INFERENCE MACHINE IN AN EXPERT SYSTEM

GOAL

P_1

P_2

P_3

OBJECT GROUPS

OBJECTS

PROBABILITIES

OBJECT GROUPS

OBJECTS

GOAL

PROBABILITIES

OBJECT GROUPS

OBJECTS
Other strategies are possible, but this procedure has proven to be the best for an inference machine. The knowledge programmer however is prepared to place the data in more of less useful arrangements. Objects searched rarely should not always be scanned first. There is the possibility of separating that part of the decision tree which contains the objects searched most often. After all it is difficult to define in a comprehensive knowledge base the attributes with the greatest utility. Consequently, statistical aspects are also relevant in verifying an expert system, because the relative frequencies of object searches contribute to the best structure of the knowledge base. The whole area of organizing the knowledge base is called "knowledge engineering."

2. Applications of expert systems in agriculture

Due to modern specialized diversification of farm production, expert systems and special knowledge will increasingly be of consequence. Just the restriction to special production engineering often entails the need to use a specific knowledge base assisted by computer implementation. In addition, databanks as subunits of the system, with graphs and windowing techniques are incorporated into complete expert systems. This applies likewise to plant and to animal production. Farm management refers to both lines and is in many cases very important.

The EDP-specialist, or the knowledge engineer in the case of expert systems, is dependent on the consultant to the projected knowledge system for designing the rules to be implemented in the computer. In case no permanent collaboration is feasible, at least a draft of the "human expert" should be available for including knowledge and experience into the computer program. Both experts are responsible for the correct performance of the system prepared.

In case two different experts see a specific problem under opposite aspects, it will be difficult to decide which of the two is the competent expert. If conflicting expert opinions are included, the user of the expert system is forced to make a decision and the system will then be deficient of authority and not be verifiable.

The first expert system -- MYCIN -- which proved very successful was prepared at Stanford University in the mid-1970s. The system enables a doctor to diagnose bacterial diseases in humans. To diagnose diseases either in humans or in animals or plants means to compare the symptoms in patients with those in the expert system's descriptions and to check their conformity. The MYCIN system proved a rapid and reliable aid for the doctor in identifying bacterial diseases.

Expert systems are often used in error detection of defective machines.

For a survey of knowledge-based systems in agriculture see the paper published by J.M. Pohlmann and A. Mangstl (Ref. 8). New projects are listed below:

2.1 Plant production
2.1.1 Dr. M. Strapper, Australia
Fig. 3: A sample decision-tree for food plants (backward chaining)
New Horizons in Agricultural Information Management

SIRAGCROP -- Bestandesführung im Getreide (Ref. 3)
2.1.2 Dr. LaRaw Maran, USA
WEAS -- Pflanzenschutzberatungssystem (Ref. 3)
2.1.3 Prof. Dr. I. Amir, Israel
CROPLIT -- gezielte Schlag- und Fruchtfolgeentscheidung (Ref. 3)
2.1.4 F. Le Corféc, France
ZEA -- Bestandesführung im Mais (Ref. 3)
2.1.5 S. Tolosa, France
PILAR -- Aufbau und Darstellung einer Wissens- und Regelbasis für die
Bestandesführung (Ref. 3)
2.1.6 J. Le Renard, France
SEPV -- Diagnose im Pflanzenschutz für 17 Kulturarten (Ref. 3)
2.1.7 T. Hoshi, Japan
Krankheits- und Schädlingsdiagnose bei Tomaten (Ref. 3)
2.1.8 R. Cervo, Italy
Diagnose von Krankheits- und Schädlingsbefall bei Oliven (Ref. 3)
2.1.9 M. Rackert, U. Voges, J. Frahm, FRG
WIFEX -- Winterweizen Fungizid Expert / Ein wissensbasier-basiertes System
zur Ermittlung des Einsatzpunktes von Fungiziden gegen die
Halmbrucherkrankung in Winterweizen (Ref. 5)
2.1.10 S. Poths, J.M. Pohlmann, FRG
FROTEX -- Prototyp eines Expertensystems zur Planung umwelt gerechter
Fruchtfolgen (Ref. 5)
2.1.11 J.M. Pohlmann, FRG
HERB-OPT -- ein Expertensystem zum umweltgerechten Einsatz von Herbiziden
(Ref. 5)

2.2 Animal production
2.2.1 P. Leuschner, FRG
Klimaregelung in Broilerställen (Ref. 3)
2.2.2 E. Vrankem, Belgium
Entscheidungshilfen in der Schweinehaltung (Ref. 3)
2.2.3 Dr. O. Kroll, Israel
Herden- und Fütterungsmanagement in der Milchproduktion (Ref. 3)
2.2.4 Dr. A.A. Dijkhuizen, The Netherlands
Herdenmanagement in der Sauenhaltung (Ref. 3)

2.3 Farm management
2.3.1 Prof. Dr. W.G. Uhrig, USA
Die Auswahl geeigneter Vermarktungsalternativen bei Getreide (Ref. 3)
2.3.2 Prof. Dr. B. Öhlmer, Sweden
Die Wirtschaftlichkeitsanalyse für einen landwirtschaftlichen Betrieb (Ref. 3)
2.3.3 Datev eG
Expertensystem für Finanz- und Steuerplanung (Ref. 3)
2.3.4 R.B.M. Huirne, The Netherlands
Wirtschaftlichkeitsanalyse für die Schweinehaltung (Ref. 3)
3. Automatic indexing with thesauri and classification schemes

The AGREP database (AGricultural REsearch Projects in the European Communities) is based on the English-language research projects of the EC-member countries. The problem is to include the project titles and abstracts so that they are easily retrievable with a technical index. A four-facet classification scheme has been introduced recently:

- Facet A: Activities
- Facet B: Subject areas
- Facet C: Fields of science
- Facet D: Fields of research

and the AGRIS/CARIS Categorization Scheme.

These classification schemes are intended for AGREP indexing.

On behalf of the EC Commission a PC program was prepared at Datacentralen, Copenhagen, which is to support the still intellectual indexing work of experts responsible in the EC-member countries. The heavy searching in thesauri and vocabularies is done much more quickly with the help of a personal computer. (Figure 4.)

The CABI (Commonwealth Agricultural Bureaux International) vocabulary is the largest English-language agricultural thesaurus in existence. It serves as the basis for analyzing project titles and abstract texts after the removal of stopwords, which are supplied by a special list. Words found neither in the CAB Thesaurus nor in AGROVOC (the FAO thesaurus) are simply skipped. The indexer marks the composite English terms first, the so-called noun-phrases, for example "animal breeding," and then begins with the automatic text analysis.

The CABI descriptors are arranged in parallel with the corresponding AGROVOC terms. This concordance list shows that general terms from AGROVOC have been assigned repeatedly to many different descriptors of the CAB Thesaurus. But since AGREP indexing needs AGROVOC terms, these are taken as controlled terms. After automatic determination of the controlled terms, additional terms can be added or some of them can be deleted manually. All of them should be AGROVOC terms as these are connected in a list with the subject areas (B-facets), fields of science (C-facets) and fields of research (D-facets).

<table>
<thead>
<tr>
<th>AGROVOC Descriptor</th>
<th>Facet</th>
</tr>
</thead>
<tbody>
<tr>
<td>dogs</td>
<td>B4920 (Domestic pets and zoo animals)</td>
</tr>
<tr>
<td>climatology</td>
<td>C2500 (Meteorology and climatology)</td>
</tr>
<tr>
<td>recycling</td>
<td>D4440 (Transport and handling)</td>
</tr>
</tbody>
</table>
PHASE
V
IV
III
II

DETERMINATION WITH AGREP-rules

AGRIS/CARIS CATEGORIES

A-FACETS

MORE D-FACETS

B-, C-, D-FACETS

UNCONTROLLED TERMS

AGROVOC-TERMS

CABIVOC-TERMS

CONTROLLED TERMS

CONCORDANCE LIST

CONCORDANCE LIST

WORD ANALYSIS

DATA:

PROJECT TITLE AND -ABSTRACT

FIG. 4 AUTOMATIC INDEXING OF AGREP
In the following phrases logical rules are applied to find more D-facets and activities (A-facets) as well as AGRIS/CARIS categories.

Phase III

IF

B3 (Crops)
AND
B5910 (Specific non-domestic plants)
THEN
D2430 (Weeds and weed control)

Phase IV

IF

B6 (Man-made resources)
AND NOT
D4 (Engineering, technology, harvesting, storage, processing, transport)
THEN
A4100 (Determination of properties of products)

Phase V

IF

B3 (Crops)
AND
C3600 (Population biology, population dynamics, population genetics)
OR
C3700 (Ecology - aerobiology, bioclimatolog, hydrobiology, symbiosis)
THEN
F40 (Plant ecology)

After each of the five indexing phases a prescribed sequence of facets and categories can be initiated by hand, or performed automatically before the project is put into the READY status. The program although in a test stage is very promising. It has a large user shell. Besides, both concordance tables CAB-AGROVOC and AGROVOC-Facets B, C, and D as well as all the other simple classification schemes can easily be displayed and marked during indexing so that they are included in the project field.

The CAB-AGROVOC concordance index which was developed cooperatively by the AGRIS Processing Unit in Vienna and the National Agricultural Library in the United
States, is especially useful for intellectual indexing. A simple special program enables the search of descriptors in one or in both vocabularies at the same time. It will likewise prove a helpful tool in descriptor search for information retrieval in the three English-language agricultural databases AGRICOLA, CAB Abstracts and AGRIS.

4. References