et LE_LISP pour se déplacer dans les arbres de connaissance suivant le principe du chaînage arrière : la progression du raisonnement est dirigée par le but à atteindre.

Nous disposons aujourd'hui d'un Moteur d'Inférences parfaitement adapté à la classe de problèmes relatifs aux deux premières applications. Des extensions sont en cours en ce qui concerne les Choix des Revêtements de Façade, problème plus complexe pour lequel nous devrons pouvoir gérer des listes ordonnées de solutions simples ou composées (combinaisons de revêtements).

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An Expert System on Bioclimatic and Energy Efficient Building in Hot/Humid or Hot/Dry Climates

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KEYWORDS

Expert Systems, Hot/Humid, Hot/Dry, Energy Efficient

ABSTRACT

The Construction Engineering Research Lab of the Army supported this project on a bioclimatic and energy efficient expert system. The goal was to indicate to a user through an interactive expert system the optimal ways of building, energy efficiently, for comfort in hot humid or hot dry climates. An empty expert system was used initially for a designer to indicate decision conditions, external conditions and goal conditions. This offered a minimal interaction with information given only at the beginning stage. Because of the morphology of the information and the necessity for strategizing, the authors felt it necessary to develop a very interactive mode for the user. This was done. The results given by the interactive strategizing expert system were more appropriate than the minimally interactive expert system for the cases tested.

Un système spécialisé pour les constructions bioclimatiques utilisant leur énergie efficacement, dans les climats chauds et humides ou bien chauds et secs

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MOTS CLEFS

Systèmes spécialisés, chauds/humides, chauds/secs, utilisation efficace de l'énergie

SOMMAIRE

Le Laboratoire de Recherches de Construction Mécanique de l'Armée a sanctionné ce projet de système spécialisé bioclimatique, utilisant efficacement l'énergie. Le but était d'indiquer à l'usager au moyen d'un système spécialisé interactif, la méthode la meilleure pour construire dans les climats chauds et humides ou bien chauds et secs, avec confort et en utilisant l'énergie efficacement. Au départ, on utilisa un système spécialisé vide, pour permettre à l'inventeur d'indiquer les conditions de jugement, les conditions extérieures et les conditions d'aboutissement. Cette méthode offrit une interaction minimum avec l'information onnée seulement au strade initial. A cause de la morphologie de l'information et des contraintes stratégiques, les auteurs furent d'avis qu'il fallait développer un mode extrêmement interactif pour l'usager. Ce fut accompli. Le système spécialisé à stratégie interactive a donné des résultats qui s'a ppliquèrent mieux aux cas examinés, que le système spécialisé à interaction minimum.

The Construction Engineering Research Laboratory of the Army sponsored a study on the optimum ways of designing energy efficient buildings in hot humid, hot dry, or tropical upland climates, which culminated in a computerized expert system of recommendations based on the various influencing factors. The design recommendations based on comfort conditions for the different climates were developed by comparing the author's experience with many texts and articles to ascertain areas of disagreement and to form a general stateable understanding of the principles from which to decide the areas of dispute. Carolyn Dry chose the text books and expertise materials to use as models. They had to offer a reasonable and coherent basis of understanding, in particular an emphasis on human comfort.

A empty expert system, designed by Prof. John Dickey of VPI&SU, was used to create a prototype of the expert system. This "Computer Consultant" has four sections: decision conditions, external conditions, intermediate conditions, and goal conditions. In the example shown, climatic data of Baghdad were fed in as the external conditions. The form of this information is as follows:

CURRENT INFORMATION ON THE STUDY AREA IS:
CASE NAME: baghdad
LOCATION: Baghdad, Iraq
LONGITUDE: 44 Deg 24 min E.
LATITUDE: 33 Deg 20 min N.
ALTITUDE: 34 m

TABLE OF RELATIVE HUMIDITIES (%)

MONTH	Max am	Min pm	Avg.	Group
January	87.0	50.0	68.5	3
February	78.0	41.0	59.5	3
March	74.0	35.0	54.5	3
April	68.0	27.0	47.5	2

TABLE OF RAINFALL (mm) and WIND (Prevailing & Secondary)

MONTH	RAINFALL	WIND PRE	WIND SEC
January	24	NW	SE
February	25	NW	SE
March	28	NW	N
April	15	NW	N

TOTAL ANNUAL RAINFALL IS 150 mm

TABLE OF COMFORT LIMITS (DEGREES CELSIUS) & THERMAL STRESSES

MONTH	DCUL	DCLL	NCUL	NCLL	DSTRESS	NSTRESS
January	29.0	23.0	23.0	17.0	C	C
February	29.0	23.0	23.0	17.0	C	C
March	29.0	23.0	23.0	17.0	C	C
April	31.0	25.0	24.0	17.0	O	C

The goal conditions were based on human comfort conditions. The decision conditions were based on the environmental interventions recommended to accomplish the goals set under the external circumstances. For the Baghdad example some of the environmental intervention recommendations might be as follows:

Layout: Compact Courtyard
- Court in center with water and planting
- Wall around court
- Compact building plan

Neighborhood Plan: Compact
- Ventilation encouraged
- Sidewalks shaded
- Buildings lowered in soil possible if soil cool
- Placement of water on ground

Air Movement: No Provision Required
- Vent cool only at night
- Do not vent h/d air into insulated building

Openings: Very Small, 10-20%
- Shade openings
- Windows operable
- Windows oriented to court

Walls: Heavy External and Internal
- Insulated
- Thermal lag materials
- East-west walls painted white
- South wall painted dark

Roofs: Heavy
- Sloped toward court
- Periphery with solid parapet and gutter
- Painted white
- Operable roof insulation
- Water on roof possible
- Under roof ventilation

Out-door Sleeping: Space Required

Rain Protection: Not Necessary

The model for these decisions on design with climatic information was largely based on the Mahoney charts and work as found in Otto Koeningsberger´s , "Manual of Tropical Housing and Building, Part I, Climatic Design".

For each recommendation, visuals, done with PC Paint, and the text of recommendations, explaining the particulars, appeared on the computer screen.

Problems with the noninteractive system

Upon testing with cases, there were several problems with this noninteractive approach, with front-end-loaded information only. Because of these limitations as well as the form of the information, Carolyn Dry and Baruch Givoni developed a very interactive system which addresses all of the following drawbacks and needs.

I. Climatic data is often unobtainable in the desired terms, i.e., in numbers, but people can describe their climate, if given the appropriate choices and allowed to interact with the program in this system. That interaction takes this form:

Climatic Information

General descriptions of various climatic types will be displayed and the user will identify the type most representing his site.

For example:

Display: Hot Dry Climate (data from Phoenix, Arizona)
General description of extreme seasons:

Mid-Summer:
- Daytime temperatures above 100°F, often above 105°F
- Night-time temperatures 65-75°F
- Daytime relative humidity below 30%, except in August
- Wind direction mainly from the West
- No rains, except in August
- Clear to partly cloudy sky conditions

Mid-Winter:
- Night temperatures 30-45°F
- Daytime temperatures 45-60°F
- Rainy season in winter
- Wind direction mainly from the West
- Annual rainfall 10-20
- Cloudiness varies from clear to overcast
- Sequence of cloudy days last for 4-7 days

Question: Does this description represent your site:
Yes ( )   No ( )
If No then the next climate descripton will be displayed.

2. A choice by the individual user is required for factors such as personal aesthetic preference for sun porches or water walls, cultural biases for social interaction types and building types, and the choice of conventional heating and air conditioning or solar and use of natural energies. This interaction type can be seen in the following section of our expert system.

Passive Solar Heating Systems Applicable to Specified Climate and Building Type
- Direct gain
- Thermal storage walls (masonry)
- Water walls
- Insulated collecting walls
- Sun spaces

Input: Design details of the applicable passive solar systems in the given region (detailed design guidelines will be provided separately)

Water Walls
- Containers, opaque (metal) or translucent (plastic), are filled with water and placed behind the south glazing. For summer, cooling glazing should be operable at night.

Insulated Collection Walls
- The south wall is well insulated (2-4"). In front of it, glazing is provided with a 4" air space.

Thermal Storage Trombe Walls:
- A south masonry wall, made of concrete or solid bricks, about 12" thick painted with dark color and glazed, with an airspace (2")
- Provisions for external shading of the glazing in summer, to prevent overheating of the room behind the wall.

Sun Spaces-Sun Porch
- Vertical openable glazing at porch, indented inside (4´) and projectin outside (2-3´)
- Preferable location in the middle of the dwelling unit, so the porch is surrounded on three sides by rooms. Large doors or windows connecting the porch with the rooms.
- Walls between porch and rooms can be of different types:
  - Insulated walls with large connecting door.
  - Massive dark colored walls
  - Glazed operable walls

Question: Knowing the summarized design details required, are you interested in using passive solar heating?

Input: Yes ( ) No ( )

Question: If yes, choose one or a combination of applicable systems (combination preferable)

Input: Direct Gain ( ) Thermal Storage Walls ( ) Insulated Collecting Wall ( ) Sun Porch ( )

Output: Passive cooling system applicable in specified climate and building type.
Comfort ventilation; convection heating.

Output: Design Implications of the applicable passive cooling systems.
etc.

3. The user may need more information on the consequences of his choices on other areas of decision making before making his "best" choice, such as impact on cost or appearance. This interaction type can be seen in the following section of our expert system.

Shading Devices for Windows

Whenever possible provide external operable shading. Fixed overhand in combination with white internal shading can be used for southern and northern windows. Special fixed external shading can be designed for eastern and western windows. Insulated shutters over large windows offer special advantages and are recommended whenever practical.

Explanation: Only external shading is effective in reducing substantially solar energy penetration through windows. All types of internal shading devices would provide insufficient protection in hot climates. For Southern windows horizontal overhand can prevent direct radiation in June-July, but may provide insufficient protection in May, August and September. A combination of external overhand and internal white shading may be considered, although performing such a combination would still be less effective than using operable external shading. For east and west windows the only effective solution with fixed shading would be a vertical opaque panel open to the south-east and south-west. External operable shading devices can reduce the solar heat gain by up to 80%. External insulating shutters, with small glazed areas for natural lighting, can reduce the total heat gain through windows by up to 80%.

Question: Do you want more information on shading devices and their design details? Yes ( ) No ( )

Comment: If yes than various shading devices will be displayed and discussed.
Window Sizes
Recommendations

If windows are equipped with external insulated shutters then large windows (20-35% of the room´s floor area) have special advantages in this climate. Windows equipped with operable external shading (not insulated) should be of medium-size (10-15% of the room´s floor area).

Explanation: Windows, even double glazed, have much lower thermal resistance than reasonably insulated walls. Therefore, even if shaded from solar radiation, they form the major source of heat gain in hot regions, where the outdoor temperature can be 20-35^{o}F higher than acceptable indoor temperatures. If not protected effectively from indirect solar radiation, both diffused and reflected from the ground, as well as from direct radiation they cause considerable solar gain. Consequently, with ordinary windows, increased size of windows in air-conditioned buildings, increases the energy demand of the building.
(program continues on here)

Question: Do you want more information about the effect of window size in different designs of the windows and the shading devices?
Yes ( ) No ( )

4. Some decisions are incompatible with each other. For instance, some passive heating decisions are incompatible with some passive cooling decisions. This interaction can be seen in the following section.

Output: Compatibility between various passive solar heating and passive cooling systems.

- Convective cooling is compatible with all the applicable solar systems. Compatible details will be specified.
- Comfort ventilation can be compatible with the applicable passive heating systems. Compatible details will be specified.

Input: Knowing the design details, are you interested in passive cooling? If yes indicate which system. Consider compatibility (if chosen).
Yes ( ) No ( )
Comfort ventilation ( ) Convective cooling ( )

5. Each decision affects the overall strategy; by the same token, some decisions such as the type of use and activity required from the building as well as its layout may be factors which cannot be altered while influencing further decisions. In our expert system that information is entered as follows:

BUILDING INFORMATION INPUT

Question: What is the use of the building (mark one).
Residential ( ), Office ( ), School ( ),
Industrial ( ), Other ( )

Question: Number of persons for which the units are intended:
Singles ( ), Two ( ), Three-Four ( ),
Five-Six ( ), Above six ( )

Question: Number of rooms in Unit (excluding kitchens and bathrooms):
One ( ), Two ( ), Three ( ), Four ( ), Five ( ), Above five ( )
<u>Comment</u>: the above information classifies the density of occupation, with impacts on ventilation requirements, etc.

Advantages of the interactive system

The interactive strategic expert system gives more appropriate results, for the cases of users tested, than the minimally interactive expert system. This interactive strategy expert system is not only appropriate for different individual uses, but could be utilized by several different whole categories of users because of its varied levels of information. Each of the choices are displayed visually, their impact on other choices traced, their attributes explained, and most importantly, a complete, in depth, written and visual description can be given. The latter may serve to train someone to actually design or build a chosen structure (a video could also be developed for that purpose). Thus, the system can be used by management to select any materials and building techniques in accordance with the various constraints, by military field officers to make decisions and build with the following guidelines, and by laborers, trainees or owner/builders to use as a training device. (Of course, the topics for choice making may be different for different these groups of users.)

In terms of computer time and money necessary to develop an interactive working expert system, one needs several years and $150,000 - $200,000 according to the expert systems division people at Texas Instruments. This is the major disadvantage of such an interactive mode, the main advantage being that everyone using it, at whatever level in a hierarchy, has access to expert knowledge and can make good decisions.

Perhaps the most surprising benefits of an expert system are those accrued by the person who designs an expert system. He or she, of necessity, must carefully clarify his/her understanding. The expert/designer must: 1) already know or else learn the field very well and be able to explain it, 2) see clearly the areas of conflict or contradiction in the knowledge, 3) identify the areas without enough knowledge, and 4) find those areas needing research.

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A Knowledge Engineering Approach to the Analysis and Evaluation of Vertical Construction Schedules

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KEY WORDS:

Artificial Intelligence, Construction, Construction Management, Expert Systems, Knowledge Engineering, Scheduling.

ABSTRACT

The success of any construction project relies heavily on the manager's ability to identify and synthesize diverse factors, to form judgments, to evaluate alternatives, and to make sound decisions. In sum, to apply years of experience and acquired wisdom to the problem at hand. The objective of this knowledge engineering project is to extract, formalize, and articulate the construction expertise needed to develop a useful, intelligent computer system. The primary goal is to emulate the reasoning process of experienced project managers in the context of construction schedule analysis. This knowledge base consists of scheduling decision rules, construction common sense knowledge, and construction knowledge developed or used by experts when planning a project. The system's development environment includes a LISP machine, which houses an expert system shell and a relational database management system, and a Personal Computer, which hosts a project management system.