AN EXPERT SYSTEM AS A PROFICIENT TOOL FOR COMPUTER AIDED DESIGN AND EVALUATION OF HOUSING PROJECTS

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ABSTRACT

During the design stage the comfort evaluation of housing have not yet received an efficient help form computerized tools. An expert system tool which is developed from artificial intelligence (AI) technique can fill this gap by allowing to simulate the thought process of human experts in the evaluation of building design.

This paper describes the development of a prototype Expert System for Environmental Quality Evaluation (ESEQE) of the housing projects during the design stage. The overall architecture of this system is illustrated. Also, the potential benefits that can be gained by using an expert system in environmental quality evaluation are discussed.

Introduction

The internal environment of any place providing accommodations has to meet a number of specific requirements to achieve comfort conditions for the users. These comfort conditions are dependent on the standards of environmental control provided. The method of illumination and color emphasis, warmth or coolness of air temperature and surroundings, air freshness and movement, relative humidity and its level, pitch and variability of noise affect the comfort of the occupants (1). Therefore, careful analysis of the internal environment, control and comfort, is essential. A solution of this analysis may well be provided by the use of computer (2).

Nowadays the growing use of computer aided system permits and calls for the application of Computer Aided Design (CAD) methods in the design and evaluation of our housing projects. CAD methods can be applied to both the conceptual formulation for buildings design and to the analysis and evaluation of buildings (3).

Expert systems have been increasingly popular computer software approaches used to solve a wide variety of application problems in a specific domain, that are sufficiently complex as to require significant human expertise for their solutions (4). Expert system could be used to help the designer during the design stage to evaluate the environmental quality of buildings.

Expert System Approach

An expert system is a system that employs human knowledge captured in computer to solve problems that ordinarily require human expertise. Well designed system imitates the reasoning processes experts to solve specific problems. Such system can be used by non experts to improve their problem solving capabilities. Expert systems can also be used by experts as knowledgeable assistants. Expert systems are used to propagate scarce knowledge resources for improved, consistent results. Ultimately, such system could function better than any single human expert in making judgment in a specific, usually narrow, area of expertise (5).

Expert systems are best known as self contained entities which exist quite separately from other computer aided design system. Equally, if not more important is the notion of imbedding explicit knowledge of the kind that is encoded in an expert system within more general computer design tools (6).

The key to every expert system is knowledge. Because knowledge forms the core of expert systems, expert systems are often referred to as knowledge systems or knowledge based systems. The field of expert system is concerned with ways to acquire knowledge from human experts and represent it in a form compatible with computers. The computers perform a kind of knowledge processing when the user taps the knowledge (7).

Knowledge Engineer (KE) applies the tools of artificial intelligence to build expert system, i.e. the sophisticated computer system capable of solving complex problems within a particular domain expertise, that traditionally require both specialized knowledge and human reasoning (8). Also, KE helps the expert(s) structures the problem area by interpreting human answers to questions, drawing analogies, posing counter examples, and bringing to light conceptual difficulties (5).

Structure of Expert System

Expert systems are composed of two major parts: the development environment and the consultation (run time) environment as illustrated in FIG. 1 (5). The development environment is used by the expert system builder to build the components and to introduce knowledge into the knowledge base. The

consultation environment is used by a non expert to obtain expert knowledge and advice. The following components may exist in an expert system:

- Knowledge Acquisition System
- Knowledge Base
- Inference Engine
- Blackboard
- User Interface
- Explanation Sub-System

Expert system development tools contain two components that facilitate the creation of expert system. A way to store the expert's qualitative knowledge used to address a given problem, and an inference control mechanism that decides how the stored knowledge will be implemented (9).

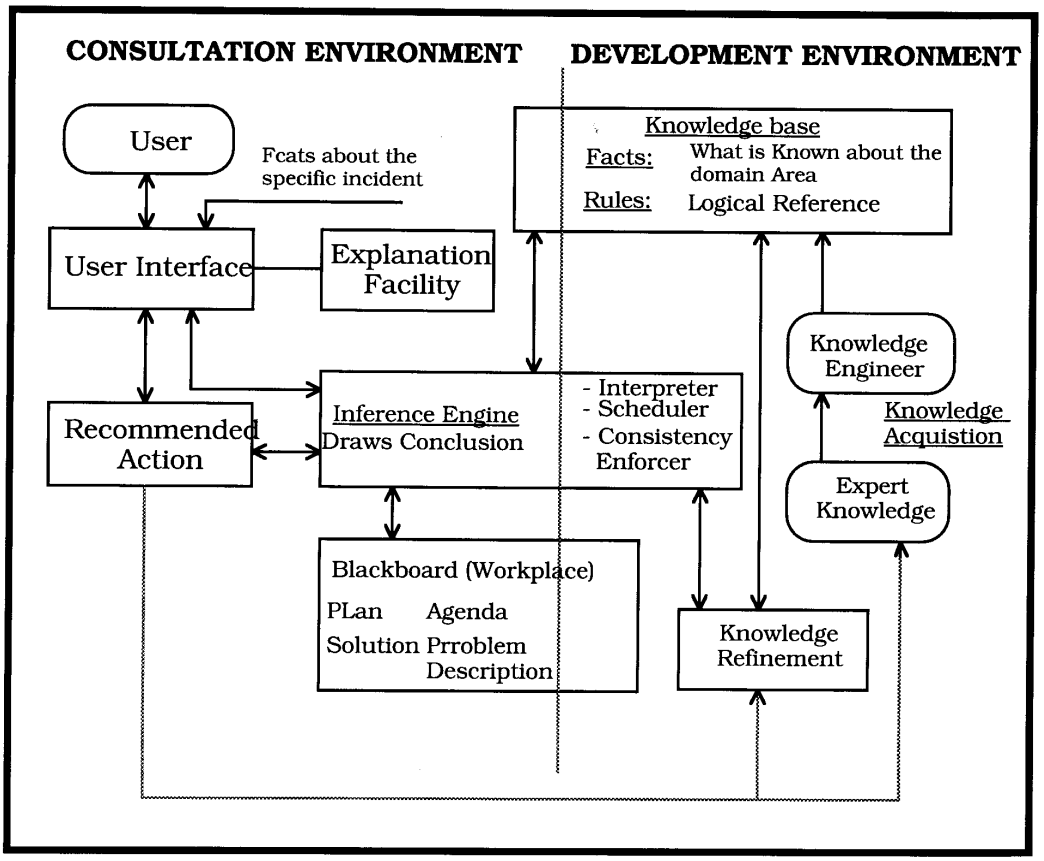

FIG. 1
Structure of an Expert System

Comfort Conditions for Livable Spaces in Housing

Livable space provides a healthful, happy atmosphere. Each generation has its own needs as tastes so that what was good for one is obsolete for another (10). So, comfort is subjective sensation. There is no such thing as a perfect combination of conditions of comfort since it is not possible to satisfy every one at the same time. Even when the optimum thermal conditions are achieved, only 50% to 70% of the population may feel comfortable, with the reminder feeling either slightly warm or slightly cool. A small proportion of the population may feel comfortable in conditions which must will feel either too warm or too cool (11). Despite the subjective nature of comfort, and the variability of individual response to the thermal environment as an example, the evaluation of comfort conditions is an essential input in the design stage.

An important element in evaluating housing types is the quality of livability within the unit. Although a somewhat elusive characteristic, livability has been defined as the capability of a residential space to meet the daily living needs of a family or house hold through its design, arrangement and construction (12). Therefore, the evaluation of comfort conditions at the design stage is an essential part.

Environmental Quality Evaluation (EQE) of Housing Projects

Environmental quality is the combination of environmental elements that interact with the building to enable that building environment to be best possible one for the activities that go on in it. Environmental quality in one building will not necessarily resemble environmental quality in another in every detail, but there are constants across building environments that can make difference between a good and poor quality environment in almost all buildings.

Environmental quality is a question of degree. Most buildings can be a degree or more better that they are now (13). As one of the basic components constitution community structure. Housing affects the health level of its residents as well as their productivity in a good way, when it provides safety and comfort (14).

Perceiving housing assessment as complex and noting the multiplicity of factors involved, it is apparent that they interact with one another as well as with another factors that may be introduced. The resulting interactions determine the ultimate situation. In a sense, it is analogous to the formation of a televised image in which the interaction of an electronic beam with thousands of tiny portions of a prepared screen results in an image which itself is consequently changing, and yet is meaningful to the viewer (15).

Environmental Quality Factors and their Performance Criteria

The environmental quality factors are lighting, acoustic, thermal and indoor air quality. The literature review indicated that the performance criteria that are used in evaluating lighting, acoustics thermal and indoor air quality are as follows in TABLE 1.

TABLE 1
The Performance Criteria for Environmental Quality Factors

A	**Lighting Comfort**	C	**Thermal Comfort**
1	Illuminance (light quantity)	1	Air temperature
2	Daylight Factor	2	Mean Radiant Temperature
3	Illuminance Ratio	3	Relative Humidity
4	Directional Strength	4	Air movement
5	Correlated color temperature	5	Activity Level
6	Color rendering index	6	Clothing Factor
7	Color appearance of light	7	Surface Temperature
8	Glare comfort	8	Temperature Shifts
9	light distribution	9	Predicted Mean Note
10	Surface reflecting	10	Comfort Zone Shift
B	**Acoustic Comfort**	D	**Indoor Air Quality**
1	Sound Pressure Level	1	Air Exchange Rate
2	Refraction Time	2	Indoor Air Pollutants
3	Impact Generated Sound	3	Odors
4	Generated Noise from HVAC	4	Air Distribution
5	Speech Interference Level	5	Air Filtration
6	Echo	6	Air Mixing Efficiency
7	Speech Intelligibility	7	Room Temperature
8	Sound Absorption	8	Air Velocity
9	Window Glazing	9	Ventilation Rate
10	Sound Insulation	10	Relative Humidity

Objectives and Capabilities of ESEQE Model

Many potential customers are looking for an inexpensive and efficient tool which will enable them to compare various solutions for every problem in their housing project. One of the most efficient tools is the electronic computer (16). Especially architects during design stage need to evaluate their design not only from functional and appearance point of view but also from environmental quality point of view. So, the aim of this research is the development of a model enabling the evaluation of environmental quality of housing projects. The capabilities of the model areas are as follows:

- Comprise all relevant factors affecting environmental quality.
- Interpret the results without ambiguity
- The presentation of the results is client friendly

Development of an Expert System for Environmental Quality Evaluation (ESEQE)

To develop an expert system for environmental quality evaluation, following stages are carried out:

Extraction the Required Data

At this stage, concepts, relations, and control mechanism are needed to describe problem solving in the EQE of housing projects. Also, sub tasks, strategies, and constraints related to the problem solving have to be investigated thoroughly.

The scales (subjective and objective) used for evaluating the performance criteria of lighting, acoustic, thermal and indoor air quality are extracted from academicians and practitioners who are considered experts in these areas through interviews. Structured questionnaires for each were developed and interviews were conducted with (21) academicians and (29) practitioners.

Formalization

At this stage, the key concepts and relations are expressed in some formal way, usually within a frame work suggested by an expert system language.

The design of any building begins with an analysis of the technical links defined by its concrete purpose and by the character of its productive, social and other process that will take place within it. The result of such an analysis will be a list enumerating all the necessary items of accommodation and other planning elements (17). The same processes have to be done after designing the building and before construction. These analyses aids the development of a building design which will meet the user need from environmental quality point of view. In the formalization stage, the graphical representation approach have achieved through decision trees which is a visual representation of the factors.

Selection of Appropriate Development Tool

The primary users of the proposed expert system for environmental quality evaluation are architects, where little or no knowledge of programming language is expected. The development tool must therefore be capable for providing a user friendly interface to the user. Exsys professional therefore was chosen as a robust shell that is capable of handling up to 3000 rules (18).

Implementation

The knowledge which formalized into a working computer language and computer program was developed. The problems of associating rules with the relationships converting all formalized knowledge into production rule format is referred to as implementation. In fact, all the environmental quality factors and their performance criteria are converted to build the knowledge base of ESEQE model.

The knowledge was loaded directly into the shell in the form of "IF", "THEN" rules. The rules are developed by creating a series of qualifiers. A qualifier has two parts: the first is an incomplete sentence ending with verb, and the second is associate values representing all the possible relevant situations to the qualifier. The IF part of the rule consists of one or more of the qualifier's value and conditions that can occur. The THEN part consists of another qualifier value or variable or choices and represents actions that must be taken (18). Examples of the rules of ESEQE are illustrated in FIG. 2.

Benefits of ESEQE Model

The developed ESEQE has many benefits some of them are listed below:

- ESEQE model allows the user to preserve the experts valuable knowledge and provides a new way to preserve knowledge.
- ESEQE model helps the user to understand how an expert system goes about solving a problem, or otherwise applying knowledge.
- ESEQE model saves the time and money by avoiding a costly mistakes and bad decisions.
- With knowledge readily available, good decision could be made quickly.

RULE NUMBER 1:

IF:	Illuminance in the living room is	>	200 lux
AND:	Illuminance in the living room is	<	300 lux
THEN:	Illuminance - confidence	=	4/10
AND:	[L] = 3 * 4/10		

RULE NUMBER :8

IF:	The background noise level in the living room is	> 35 dB
AND:	The background noise level in the living room is	<45 dB
THEN:	The background noise level - confidence = 8/10	
AND:	[SPL] = 5 * 8/10	

RULE NUMBER: 11

IF:	Air temperature differences between head and feet is very high.
THEN:	Air temperature differences confidence = 2/10
AND	[ATD] = 1.5 * 2/10

FIG. 2
Examples of the Production Rules of ESEQE Model

Conclusion

It was possible to develop a computerized model to evaluate the environmental quality of housing projects during the design stage. The use of the model speeds and simplifies the evaluation process for comfort conditions and the control of environmental quality factors of housing projects. Model users, specially architects, will benefit from such a model in producing more reliable and acceptable design for housing projects.

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