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THE POTENTIAL OF EXPERT SYSTEMS IN FACILITIES PLANNING

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ABSTRACT

This paper discusses the use of "non traditional" techniques for solving facilities planning problems, especially where a large amount of heuristic data must be analysed. The application of expert systems in optimizing the planning of facilities and other computer based models are discussed and evaluated in order to determine the effectiveness of these systems.

The future of expert systems is evaluated for use in solving large logistic problems and present application directions for expert systems are determined.

The short, medium and long term application of expert systems as well as a case study of a system presently being used for facilities design are discussed. The integration of an expert system with simulation and design modelling techniques is investigated.

1. INTRODUCTION

Facilities planning can be an extremely complex undertaking. The layout of a typical facility could be influenced by a number of factors including :-

- * Throughput, input, output, load size, mass, variation, package shape, etc.
- * Building restrictions, building regulation, land areas, services, fire protection, access ways, etc.
- * Available financial resources, inflation, tax, cash flow, financial climate, government incentives, etc.
- * Political climate (internal and government), company strategic objectives, internal squabbling, etc.
- * Available technology, services, skill resources, personal resources, backup, etc.
- * Computer systems, data acquisition, data retrieval, etc.
- * Market conditions, market trends, sales policy, etc.
- * Forecasts, production requirements, manufacturing needs, etc.

To incorporate all these factors into traditional industrial engineering models would be extremely difficult if not impossible. Certainly it may be possible to optimize any facility planning problem if one had enough data and time to analyse this data by traditional means.

In solving facilities planning problems, experts make use of:

- * Traditional industrial engineering techniques, such as those used for locating facilities.
- * Simulation modelling, in testing and analysing designs.
- * Design models, for generating and selecting appropriate designs.

These systems are "numbers" based approaches and factors such as political problems and company strategy may be almost impossible to incorporate in these "numbers" based models. In order to incorporate human experience one needs an additional tool that is able to sort and "crunch" knowledge, in comparison to the "numbers" base approach, where systems sort and "crunch" numbers.

Expert systems provide a unique ability to incorporate information of an heuristic nature into a decision making model, and allow human experience and "gut feel" to become part of the facilities planning exercise.

2. EXPERT SYSTEMS

Expert systems are essentially a subset of artificial intelligence and provide a relatively new approach to problem solving by attempting to duplicate the consulting process.

An expert system will allow anyone with some expertise to create an outline of the process used to solve a particular problem. This outline can be used to generate a series of questions that lead a non-expert through to the solution of similar problems, thus, in an expert system, the machine queries the human which is the reverse of traditional design systems, where the human queries the machine.

Many different techniques are used to present an outline of expert knowledge. One method currently employed is the use of IF..THEN sentences (called rules), to make factual statements about the problem area.

Thus an expert system is a computer program that attempts to solve difficult and complex problems normally solved only by applying human experience and "gut feel". At present, expert system technology is regarded as having immediate commercial promise. Expert systems thus have wide application and some systems and prototypes have been designed and used in the fields of :

- * Medical diagnosis
- * Mineral exploration
- * Computer configuration
- * Financial and management decision making
- * Analysing chemical compounds
- * Teaching and training of personnel
- * Engineering, where expert systems have been used for:
 - the design and control of Flexible Manufacturing Systems
 - maintenance of equipment
 - fault diagnosis
 - production setup

The prime objective of expert systems is to collect massive amounts of personal expertise and make this data available to a larger number of people, thus tapping the experience and capabilities of world authorities in a specific field. Expert systems may be a solution in countries where there is a shortage of expertise.

Typically, three components constitute an expert system :

- * A knowledge base which consists of the rules (some heuristic in nature) and facts that are utilized by an expert to solve a particular problem. The rules used in an expert system consultation depend on the user response. Thus some rules may be used a number of times and other rules may not be used at all.

- * An inference engine which continues the line of reasoning used by a human expert to arrive at a conclusion in the view of the rules and facts stored in the knowledge base. The inference engine makes an intelligent search of the knowledge base by either using forward or backward chaining or a combination of both chaining methods, in solving a problem.

- * A dialogue system by which it is possible for users to communicate with the knowledge base through the inference engine. The dialogue system allows the user to query the system. The user may ask the system :
 - how it solved a problem.
 - to explain answers.
 - to give alternative solutions.
 - how a specific response may alter the solution.
 - why the system is asking a question.

Expert systems accept task-specified data from a user, may select and utilize a suitable inference logic for the knowledge base, and then reach a conclusion for a problem in the appropriate domain.

There are a number of benefits in using expert systems. Some of the benefits are :

- * to preserve expert knowledge.
- * to "clone" an expert mechanically.
- * to place knowledge in an active form.
- * to create a non-failing mechanism that will not fail through fatigue and thus ensure that knowledge flows.

There are many dangers of using expert systems, and one should not use them merely because they are fashionable.

3. FACILITIES PLANNING - A TYPICAL EXAMPLE

Consider the design of a large warehouse holding 10000 pallets and a movement of 500 pallets in and out each day. If one could design such a system from a greenfield development, numerous possible technology choices are available. One could, based on "pure numbers" arrive at a totally different choice to a decision based on "gut feel". On the other hand, to be able to analyse all the alternatives (eg. height, width, technology, service) one would need to use some computer based technique that allows for the inclusion of the above mentioned factors.

The following graphs show the use of a computer based design model to evaluate the facility described above.

Figure 1 shows a typical plot of the capital investment required for six different warehouse technology types against building height. Figure 2 shows a three-dimensional graph of some influencing variables.

These graphs show graphical solutions towards optimizing the facilities layout. They give appropriate size and the model could even be used to produce a plant layout (figure 3) or check the sensitivity of the planning study (figure 4).

The major problems with such a computer based system, are :

- * The design model ignores other influencing factors (eg. political problems, skills available, etc.).
- * It is vital to ensure that the input data is accurate, and representative of the real life situation.

WAREHOUSE WITH 10000 PALLETS STORED

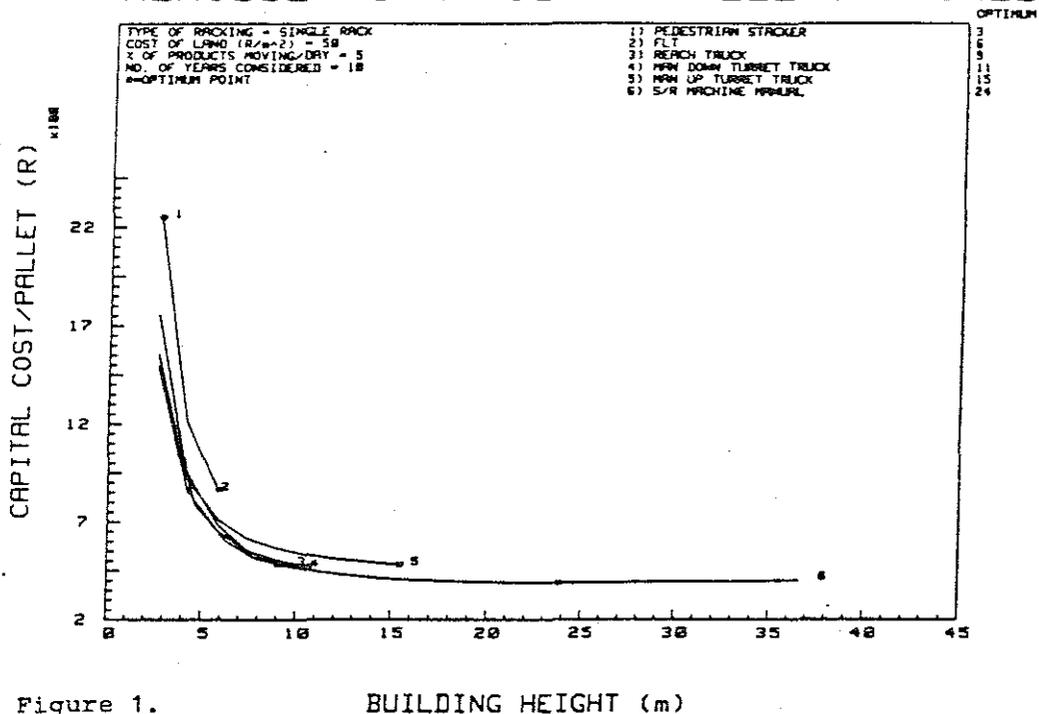


Figure 1.

WAREHOUSE WITH 10000 PALLETS STORED

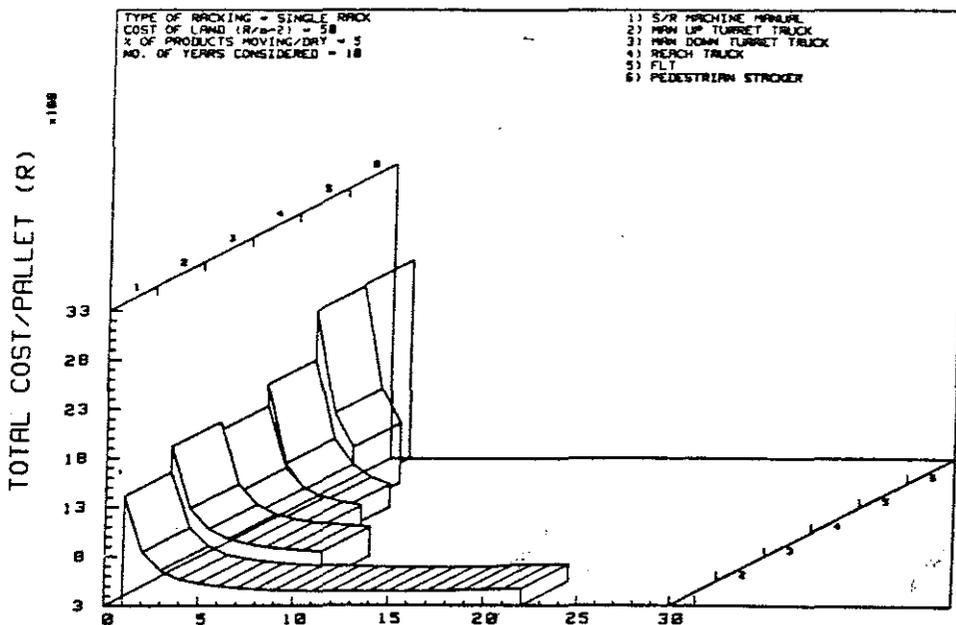


Figure 2.

NO. OF RACKS HIGH

WAREHOUSE WITH 10000 PALLETS STORED

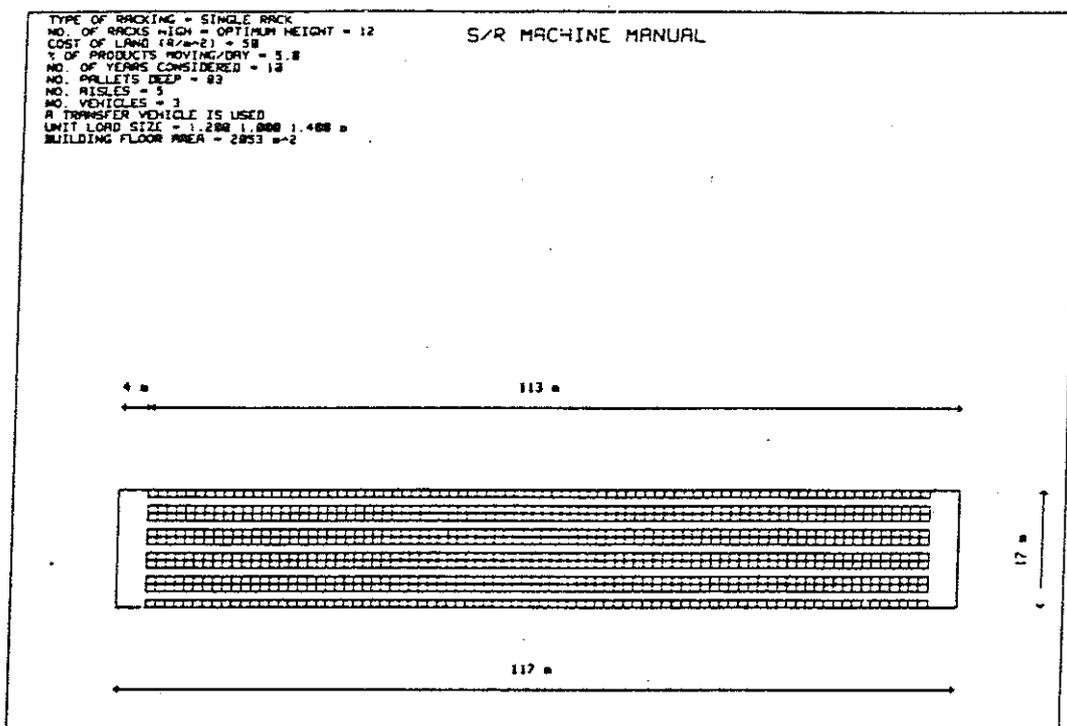


Figure 3.
 WAREHOUSE WITH 10000 PALLETS STORED

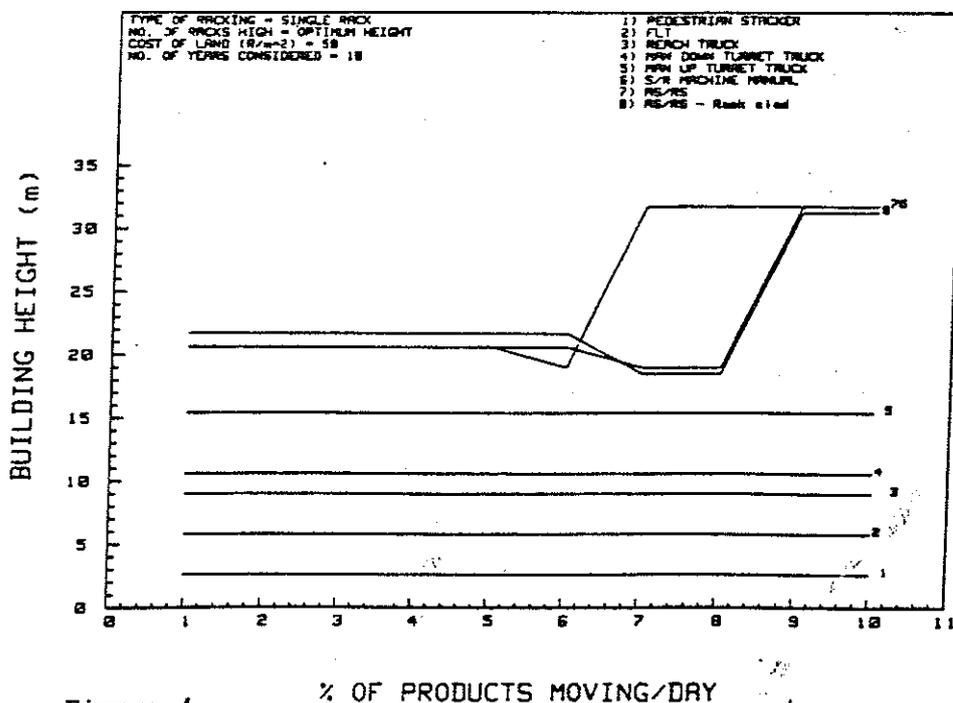


Figure 4.
 % OF PRODUCTS MOVING/DRY

4. COMPUTER BASED DESIGN SYSTEMS

Simulation modelling has been extensively used in facilities planning and has been found to be an excellent tool in testing and evaluating the design of facilities. However, simulation models do not generate designs or solve problems. Design models on the other hand, have been created to generate and analyse designs, in order to "home in" on the optimum solution.

As mentioned above, models can not analyse all the factors encountered in facilities planning exercises. It is best to combine numerical and heuristic driven systems in order to analyse all possible factors, thus expert systems and models compliment each other.

Expert systems may be interfaced with simulation and design models to:

- * Help in building models or in selecting the appropriate model
- * Select the appropriate inputs to models
- * Help run models
- * Help analyse the results of models

By combining expert systems and models it may be possible to increase the speed of trial and error modelling. Expert systems can also provide judgmental elements to models, thus improving the productivity of the designer and leading to an optimal facility.

There are however, a number of problems in developing and using expert systems. Some of these problems are :

- * One needs to develop appropriate rules (often heuristic in nature) and collect appropriate data.
- * One may require an enormous amount of manpower, time and money in developing expert systems.
- * One may encounter great difficulties in testing and debugging large expert systems.

However, if one can set up a system with enough knowledge, and enough accurate data, it may be possible to create a design method based on an expert system, that will eventually be able to optimize a facilities

planning problem. Initially any computer based design method will be an interactive process involving the expert designer, but as the "system learns" (in theory) the designer can eventually be replaced and the design system can be operated by a non-expert in that field. This may lead to expert systems becoming more frightening to white collar workers than industrial robots were to blue collar workers.

5. CONCLUSION

We are unlikely to see the expert system replacing the skilled designer in the next decade, but expert systems can provide the designer with an excellent tool to help him optimize a facility using a vast number of complex inputs which could never be incorporated in a straight forward "number crunching" exercise. Expert systems are ideal for facilities planning exercises which tend to be difficult to undertake using traditional techniques, and will have a greater role to play in this field in the foreseeable future.

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