A STUDY OF AUTOMATIC LAYOUT DESIGN BY GENETIC ALGORITHM APPROACH

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Abstract: This research has shown the difficulties associated with the design information and the search through the huge design space generated during the design process. This research presents an approach to these problems by utilizing a search process whose concept is derived from natural genetics. Genetic algorithms (GAs) have been introduced in the optimization problem solving area by Holland (1975) and Goldberg (1989) and have shown their usefulness through numerous applications. The advantages that observed from these applications motivate the use of GAs in this design area. We will construct computer-programming tool of the genetic algorithm to simulate combination of plan of apartment house in Taipei.
Keywords：Computer Aided Architecture Design (CAAD), Genetic Algorithms (GAs), Layout Design.

1.FOREWORD

The traditional Computer-aided Architecture Design (CAAD) systems are seen as a kind of problem solving of productive searching with rules of IF...THAN. Those's concept are finding all probable answers so must face difficult problem of combine explode. Usually, those problems are straightened out by some heuristic rules and search strategy.

These production systems are applied by knowledge-based. The Design is thought as a production tree [1] (see figure1). It was believed that a reasonable tree existed could be mapping. The goal of design is finding out the reasonable tree could be matched. The context of design knowledge is controlling and searching the paths and the nodes to conform to design need on tree. The only way to find out the tree just is try and error.

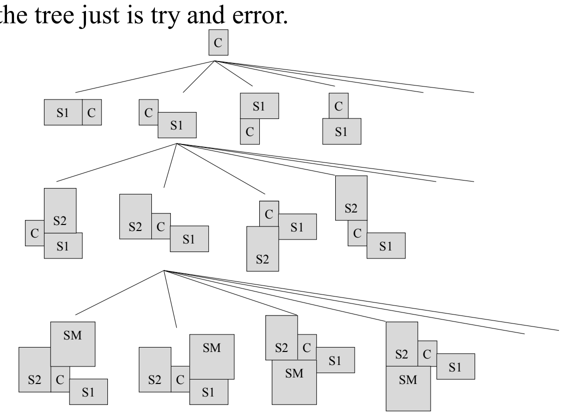

Figure 1. Productive Tree of Layout Design

The figure 1 is a productive tree of architecture layout design system. The node is the result of combination of layout. The path is the way of combination of rule. There are two questions in a good answer of design, one is how is deign rules decided in the design process, other is how is evaluated process or answer of good design. These are the important subjects in this study.

2.REFERENCE AND METHOD

John Holland proposed genetic algorithms (GAs) in 1795. This is an optimization of problem solving and technologic of machine learning. It is enlightenment from creature evolution process. The answer of every problem expresses a chromosome that present an individual creature. A group of creature were evolution by Darwin's evolutionism compete and select. The fitting creature exists that present the good solution survival the bad eliminates through competition. The new solution of new generation also to model creature propagate by survival's individual copulation and mutation [2].

There are four different points between GAs and traditional way of optimization and search.

(1). GAs deal with whole set of solution, not only solution itself

(2). The search of GAs starts from a group of population fitting well and scattering beginning, not from a point.

(3). GAs is objective function, not differentiation or others assist knowledge.

(4). GAs leads the direction of search only by hands around rule of probability [3].

It is a series process of self adjusts in search control of design reasoning of GAs by view of computer-aided architecture design [4]. The combination of design reasoning rules could be a chromosome of one of design solution. Every set of chromosome is whole result of inference path generated by probability. These evolution from parents and generate next generation were selected by environment conditions. That is constantly adjusted through heuristic rules and search strategy, stop until solution fit need. The whole process of evolution is the process of finding out answer. The final result of inference paths, evaluative rules and design solution is important design knowledge of design inference.

The one of aims of this study is construct self-evolution system of design rules. It can improve erroneous judgement of evaluation in design inference process of productive system. Advance, this study discusses variations of design solution by design reasoning, heuristic rules and search strategy. This study also simulates and tests probable evolution to aim development of draft in design process. More reasonable method of design reasoning is developed in this study. For automatic architecture design this study no matter what system development, theory refined and evaluation of computer simulation all are important. About design theory like design thinking, knowledge representation, design sequence and design developed all are conferred in this study.

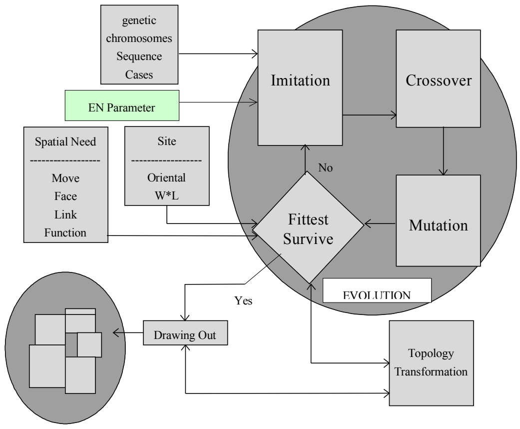

Figure 2. System structure of evolution of layout design

Spatial Name	symbol	Spatial Name	symbol
Entrance	E	Sleep Bal.	As
Living	L	Master	Sm
Living B	Al	Bath M.	Bm
Dinner	D	Sleep I	S1
Kitchen	K	Sleep II	S2
Kitchen B	Ak	Sleep III	S3
Balcony	C	Bath	B

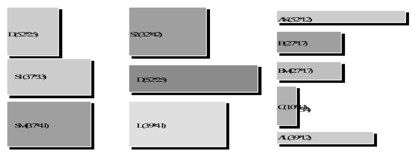

Figure 3. Knowledge representation of spatial unit and function name

3.EVOLUTION SYSTEM STRUCTURE

The Architecture Layout Design Evolution System (ALDES) (see figure 2) includes five parts. There are (1). Input of site environment condition and space function demand, (2). Layout sequence and layout type of combination structure of chromosome, (3). Evolution of layout design, (4) topology transformation and (5). Output of layout design. There are four procedures in evolution of layout design. There are mutations, crossover, imitation, evaluation. The mutation procedure is a sudden change chromosome in the next generation by random. The crossover procedure is copulation by any others by random. The imitation is copy from parents by random. The evaluation is a fitness function to evaluate every layout to set probability by sorting.

4.KNOWLEDGE REPRESENTATION

The knowledge representation is the key of whole system of design inference of layout. There are spatial unit and function name (see figure 3), spatial function link (see figure 4), spatial topology link (see figure 5), transformation between geometry and topology (see figure 6), layout sequence (see figure 7), and generate rules of layout (see figure 8, 9, 10).

((AL L)(L D)(D K)
(K AK)(D S2)(D C)
(C S1)(C B)(C SM)
(SM BM))

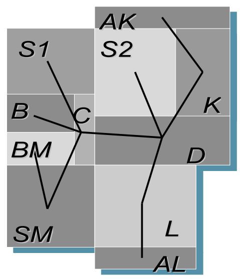

Figure 4. Knowledge representation of spatial function link

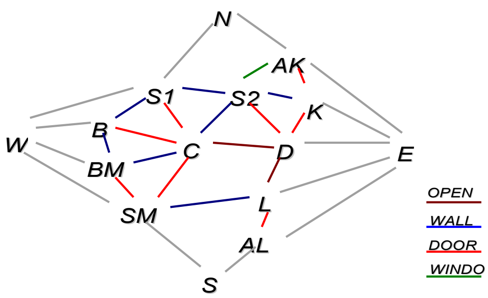

Figure 5. Knowledge representation of spatial topology link

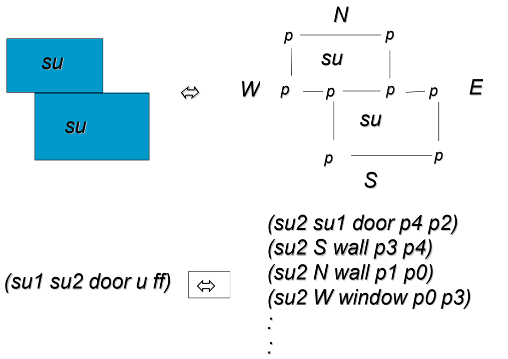

Figure 6. Transformation between geometry and topology

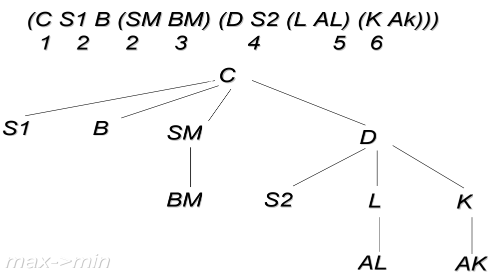

Figure 7. Knowledge representation of layout sequence

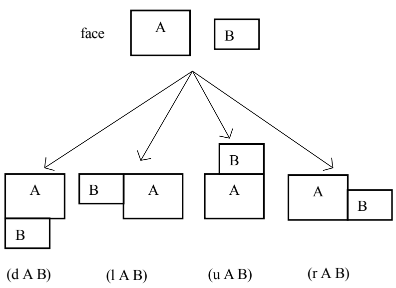

Figure 8. Generate rule of face layout

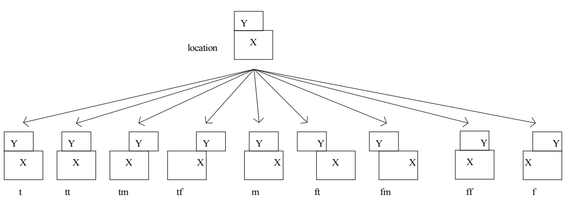

Figure 9. Generate rule of location layout

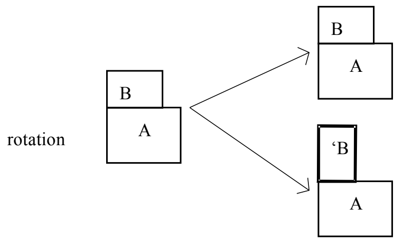

Figure 10. Generate rule of rotation layout

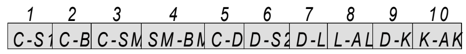

Figure 11. Chromosome of layout sequence

Figure 12. Chromosome of layout type

交換前 before crossover

LAYOUTA: 1,111,220,……,321
LAYOUTB: 0,251,170,……,441

交換後 after crossover

LAYOUTA: 1,111,170,……,441
LAYOUTB: 0,251,220,……,321

Figure 13. Rule of crossover between two chromosomes

5. PARAMETER OF EVOLUTION LAYOUT DESIGN

The parameter of evolution layout design include environment parameter, structure chromosome and fitness function.

There are five environment parameters.

(1). Degree of fitness (DF): This value calculates from fitness function, transform survival probability at every case. The formula as below:

ALIVEi = Dfi / Σj DFj, (i : the i'th case, j = 1 to n, n is number of all cases.)

(2). Population number (PN): The maximum number of case could be survival in environment. This is environment parameter to control maximum individuals.

(3). Imitation rate (IR): The rate of copy from whole parents. Whether an individual could be copy or not, according to probability of survival. The probability of survival is higher, the more chance to copy, the more chance to survival in next generation.

(4). Crossover rate (CR): The rate of exchange chromosome in parents.

(5). Mutation rate (MR): The rate of individual chromosome change by itself.

Structure chromosome include layout sequence, layout type and crossover rules between two chromosome.

Fitness function is rules of evaluating case and setting case weighting. These are tool to sieve out cases good or bad, in order to find out not adapted case to eliminate through competition. There are overlay function, co-points function and constrains function etc.

The key point of mutation depends on spatial unit itself in whole layout good or bad in the process of evolution. That is aimed spatial unit for all individuals through evolution in whole cases whom is estimated the worst ones, must be modify.

After that the layout of score from whole evaluation as higher as probability may be imitation in next generation again, stop until the layout solution fit need (see figure 14, 15, parts of evolution results)

In the process of evolution may find out the local best not the globe best. Unfortunately a phenomenon of cycle of evolution usually happens. That meaning the function of fitness must be modified. However one of very important key points in this study is how to mapping between function and form. This is until a very difficult problem in CAAD. Not only we use symbol to execute evolution, but also geometry is transform symbol to evaluate. It is not one to one mapping in form transformation. It is many to many mapping.

6.Conclusion

These are different inference mode between production and evolution. The strategy of these two systems is also not same. It is difficult to compare these two systems. Therefore the main purpose of this study is not to compare these two systems. It is to construct the system of evolution by itself in design process. It can improve erroneous judgement of evaluation in design inference process of productive system. Advance we hope to develop a more reasonable method in design inference. No matter what in system development, theory refined and computer simulation all are necessary for CAAD.

Besides the concept of design thinking, a representation of design knowledge, a setting of design sequence and a development of design concept are also discussed in this research. We hope the achievements of this study could be help for research and development of CAAD. The preliminary result of this study may immediate be application to production system and modify evolution system. The concept of these two systems may be combined to development a more suitable system of layout design. This study is a basic research for CAAD. It leads machine learning theory into the developmental field of automatic design theory.

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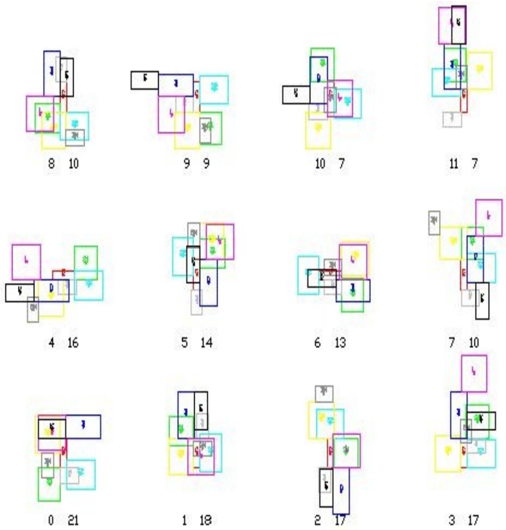

Figure 14. One of evolution results

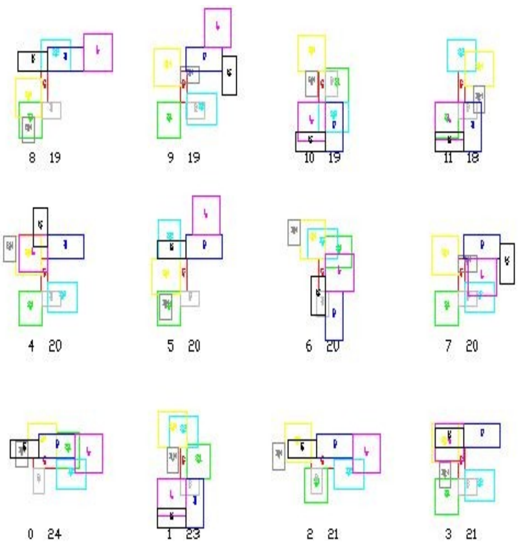

Figure 15. Another one of evolution results