A STUDY OF COMPUTER AIDED LAYOUT DESIGN IN TAIPEI PRIMARY SCHOOL BY HIERARCHICAL ARTIFICIAL NEURAL NETWORK APPROACH

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Architecture layout design is diversified and complex problem. But designers usually can find out the answer with hierarchical and sequence schema effectively. However, earlier computer-aided architecture design, which problem solving only by binary-logic thinking is very different from human being. The pass decade Artificial Neural Network (ANN) is one of methods that process data like human being. This study is trying to propose a conceptual model of case-based reasoning in layout design approached by hierarchical artificial neural network method. At last, this research will deduce the knowledge of automatic design system from Taiwan's experience in computer

Keywords: Layout Design, ANN, CAAD, Hierarchy

1.The beginning and purpose

Planning and design is a diversified and complex problem, but the designer can appropriately analyze it with the concept of hierarchical and process and handle it effectively while face largely and problems of layout design. However, early computer-aided architecture design, which problem solving only by binary-logic thinking is very different from human being.

Some studies had ever use this rule-base to study about the computer-aided primary school's layout planning. And those systems often used rule-base to infer the answer, so those systems easier to make too many combinations and they can't adjust to match up the especially case by itself.

The Artificial Neural Network（ANN）applied in this research is one of the methods that process data like human being in the pass decade. It made computer not only binary-logic machines but powerful tool in knowledge learning, associative memory, error tolerance and image processing complex. Furthermore, Hierarchy is a theory which use the hierarchical logic to analyze the question of layout design and use the idea of support and infilling to add the elasticity of design.

The ultimate goal of this research, take case study in primary school as object, is to apply the trait of ANN and the hierarchical concept of to construct Hierarchical Artificial Neural Network（HANN）in Taiwan local style primary school. And to explore the ides of process in layout design and the possible hierarchical relationship, also to analyze scheme study in layout design. This is to be the base of automatic computer-aided architectural layout design.

2. Relative Theories

2.1 School Layout Design and Planning

Broad sense of school building includes buildings, campus, play grounds and facilities. [1]。After study of some relative researches about the school layout design, this researches divides school layout design into six simple phases that is included concept, planning, program, master design, detail design and building build. In this research will study two processes of that, one is the process become planning to program and the other one is the process become program to master design（Fig. 1）.

There are some studies of school automatic design system before, which usually use the structure of problem solving and the theories of hierarchy, a pattern language. Shape grammar…etc. A study of primary school [2] divided school layout design into three hierarchical.（Fig. 2） and this study will use it to be the structure. Those studies often used rule-base to infer the answer, so those systems easier to

make too many combinations and they can't adjust to match up the especially case by itself.

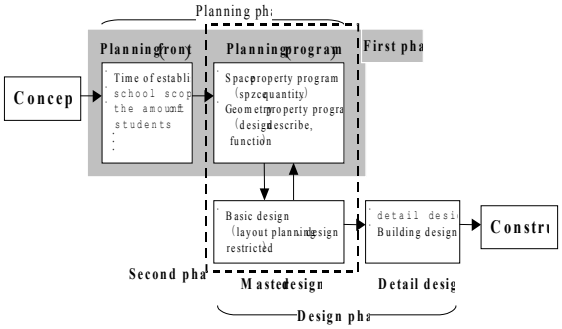


Fig. 1 School layout design phases

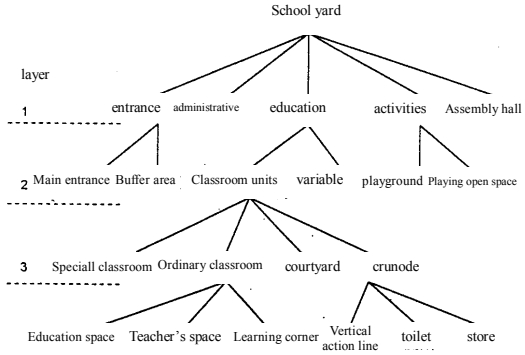


Fig. 2 School layout design into three hierarchical

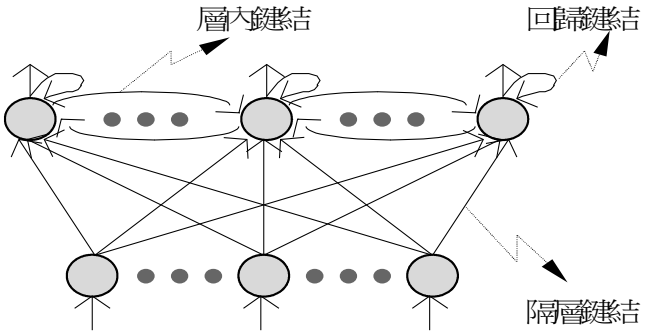
At last, in order to increase the possibility of this study, it will use the data of the book （Taipei Primary School material in 1998） which is edited by the department of Education in Taipei.[3]

2.2 Artificial Neural Network

Artificial neural network (ANN) is one of methods that process data like human being. It made computer not only binary-logic machines but powerful tool in knowledge learning, associative memory, error tolerance and image processing complex. [4] The main idea of that are something about processing element, layer, connection, function transformation and the type of the Neural Net. （ Fig.3 ） The count model of processing element（Fig. 4）.

(1) function transformation：

Suppose the connection between processing element to processing element is w_{ij} , and $x_i(t)$ is the output of the neural element（ i ）.The input of the



(2) The condition of neural element：

$$z_j(t+1)=f(z_j(t), u_j) \quad (2)$$

$f(.,.)$ is a non-linear function.

(3) The output of neural element：

$$yj=h(zj) \quad (3)$$

h( ) is a non-linear function.

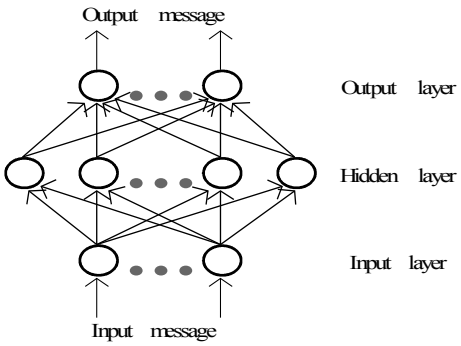


Fig. 3 ANN network

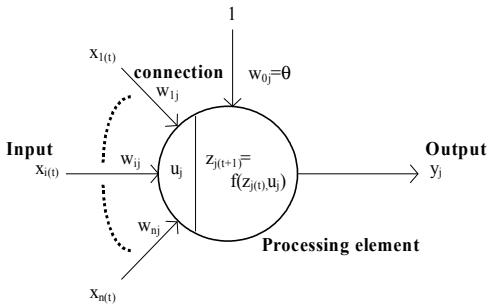


Fig. 4 Processing element

It will use Back-Propagation Network to be the tool in this study and there are two phases of the artificial neural network when we operate it. The first phase of it is learning , the second phase of it is retrieving phase.

Wen, Kuo-Chung [5] had ever studied the Case-based Reasoning in Architectural Design-An Artificial Neural Network Approach （1996） . The objectives of that thesis are （1） investigating CBR in architectural design,（2） building computer-aided design systems with CBR abilities, （3） applying ANN to CBR systems, （4） discussing design problem-solving under incomplete or uncertain information, （5） proposing new computer models

lesign innovation. Its main study is about the ing design but in this study we will try to study t the layout design.

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圖 10 神經元相互連接方式

3. Conceptual Model

3.3 Definition

By the way of study the theories and researches before, we can establish this research skeleton.（Fig. 5） First phase is the main study in this research.

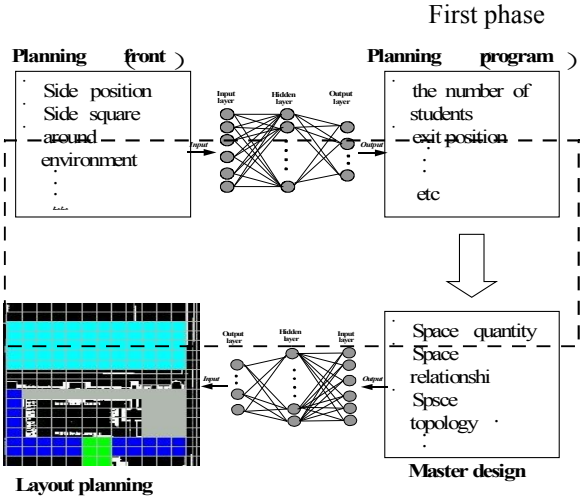

Fig. 5 Research Skeleton

3.2 Model Construction

(1) ANN Learning Model

ANN can imitate human to have the ability of knowledge learning, associative memory, error tolerance and image processing complex, so ANN will become the base theory in this study how to deduce the knowledge of automatic design system from Taiwan's experience in computer aided architecture design (CAAD).（Fig. 6）

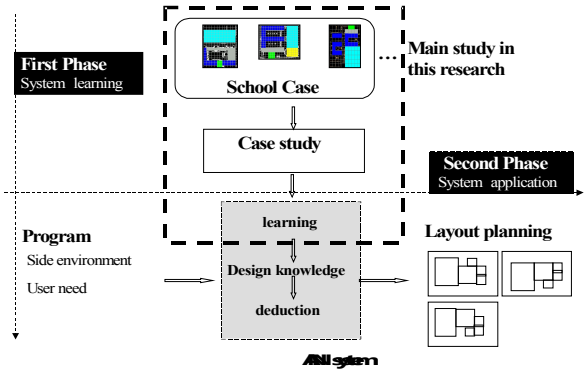

Fig. 6 Conception model of whole system

(2) The model of ANN system

A research [2] divided school layout planning into three hierarchies, and this study will use it to be the base of structure. The second layer is stand on the first layer and the third layer is stand on the second layer…etc.（Fig. 7）

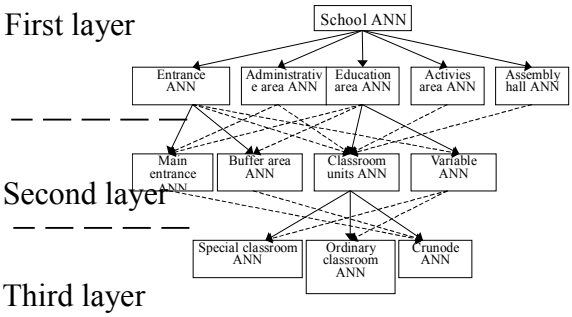

Fig. 7 The model of ANN system

4. Study Process

4.1 Program Inference

(1) Cases of Primary School

We will use the case of the book （Taipei Primary School material in 1998） which is edited by the department of Education in Taipei.（Fig. 8）

San-yu elementary school data			
School address	Taipei min- quan east road		
School area	14330.2m^2	All floor area	M^2
staff	95 people（manager：4 people ；teacher：74 people ； staff：9 people ；fellow worker ： 8 people）		
student	（kindergarten） 2031people		
All classrooms	50 classes（ordinary class：44 classes ；speciall class ： 1 class ；kindergarten ： 5 classes）		

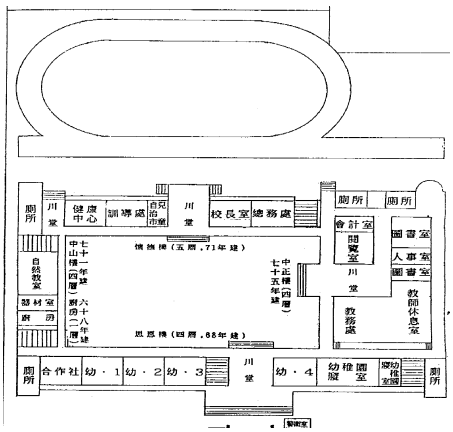

Fig. 8 The case of primary school

(2) Data processing

In this study we take sixth Taipei primary school's data to be the cases, and we will take one case of those to explain. Excel is the main tool we used to deal with the data. In this study we take two fashions to deal with the case: a. Classified Program, after class with the case, we transform the data become "1" and "0". b. Function Program, used the reality data of the case.

a. Classified Program

First, to class with the case（like the gray-net in Fig. 9）；than we can get the data matrix from the case. At last, we transform the matrix into a string of list, and put all of them to be a new matrix（Fig. 10）which we can put it into the ANN system to be operated.

Fig. 9 Classified Program

7	San-min	primary school	Song-chan area	
Established	1~20	21~40	41~60	61~80
Side area	1~10000	10001~20000	20001~30000	30001~40000
Floors area	1~10000	10001~20000	20001~30000	30001~40000
Number of students	1~1000	1001~2000	2001~3000	3001~4000
Number of classes	1~30	31~60	61~90	91~120
Number of classrooms	1~30	31~60	61~90	91~120
Assembly hall	N	Comprehensive building	Assembly hall	
Swimming pool	N	Y		
Playground	N	1~100	101~200	201~300
Max number of classrooms	1~30	31~60	61~90	91~120

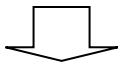

Fig. 10 A new data matrix which only made by "1" and "0"

7	San-min	primary school	Song-chan area	
Established	0	0	0	1
Side area	0	1	0	0
Floors area	0	1	0	0
Number of students	1	0	0	0
Number of classes	0	1	0	0
Number of classrooms	0	1	0	0
Assembly hall	0	1	0	0
Swimming pool	1	0	0	0
Playground	0	0	1	0
Max number of classrooms	0	1	0	0

b. Function Program

Direct to used the reality data of the case to make the matrix（Fig. 11）, and put it into the ANN system to be operated. This experiment is in order to check the system's ability of thinking back itself.

Fig. 11 Function Program

primary school	Established	Side area	Floors area	Number of students
School1	18	20063	21920	2084
School2	57	30390	19514	2786
School3	22	21743	17651	2033
School4	44	22075	20931	3931
School5	64	11060	13339	2039
School6	23	22978	26554	3094
School7	3	24925	13183	1287
School1	70	58	Comprehensive building	
School2	106	103	Comprehensive building	
School3	73	64	Assembly hall	
School4	109	109	Assembly hall	
School5	60	56	Comprehensive building	
School6	123	123	Assembly hall	
School7	46	54	Comprehensive building	

After deal with the data, we have to amend the system setting to match up the data type and quality. For example: study rate, the number of training cases…etc. After a series of studies, we can find that Fig. 12 is the best setting for this study. (This is the setting for the data of b.)

BPN - Back-Propagation Network

[0] Input (1-hidden<50, 2-hidden<40): 13
[1] Hidden 1 (1-hidden<50, 2-hidden<40): 6
[2] Hidden 2 (1-hidden<50, 2-hidden<40): 0
[3] Output (1-hidden<50, 2-hidden<40): 13
[4] Number of Train Examples: 40
[5] Number of Test Examples: 20
[6] Train Cycles (1-30000, usually 100): 300
[7] Test Period (usually= Number of Train Cycles/100= 1): 1
[8] Using Batch Learn (Yes=1,No=0, usually 0): 0
[9] Using Learned Weights (Yes=1,No=0, usually 0): 0
[10] Range of Weights (0.1-0.5, usually 0.3): 3.000e-01
[11] Random Seed (0.1-0.9, usually 0.456): 4.560e-01
[12] Learn Rate (0.1-10.0, usually 1.0): 1.000e+00
[13] Learn Rate Reduced Factor (0.9-1.0, usually 0.95): 9.500e-01
[14] Learn Rate Minimum Bound (0.01-1.0, usually 0.1): 1.000e-01
[15] Momentum Factor(0.0-0.8, usually 0.5): 5.000e-01
[16] Momentum Factor Reduced Factor (0.9-1.0,usually 0.95): 9.500e-01
[17] Momentum Factor Minimum Bound (0.0-0.1, usually 0.1): 1.000e-01

Fig. 12 BPN - Back-Propagation Network

4.3 ANN System Learning Process

After inferred program and established the system, we start to train the system by case study. We put input data and output data into the system to correct the setting value of connection. （Fig. 13） At last paragraph, we will check the effect of the system.

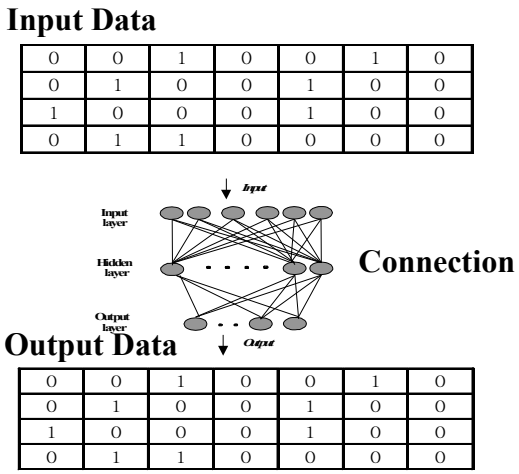

Fig. 13 Correct the setting value of connection.

4.4 Case Study and System Check

In this phase we lets system to proceed with case study. After system learns about sixth cases, this study will choose ten of the cases to check system's ability of learning. Afterwards is the process of check the system:

a. Classified Program

Use this way to class with the case is in order to simplify the process of analyze. In this study, we find that system cans associative memory and we can prove that the result of the experiment is also very well. （Fig. 14）

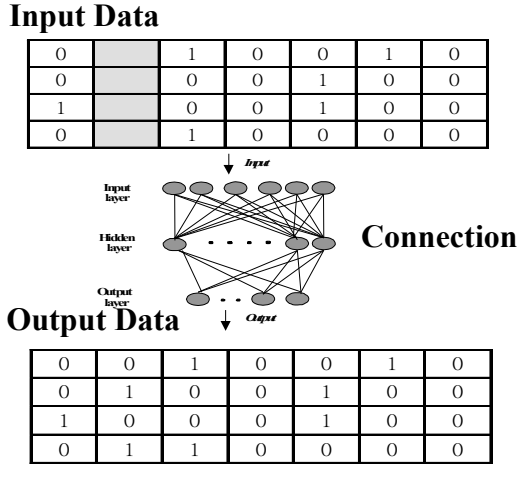

Fig. 14 Result of the experiment （ No data）

b. Function program

Direct to use the reality data of the case when we are going to doing the experiment, so we needn't to transform the result of the experiment. There is a part of the result of the experiment. （Fig. 15） We find the result are very close to the primary data, but the process of analyze is more complex than the other way.

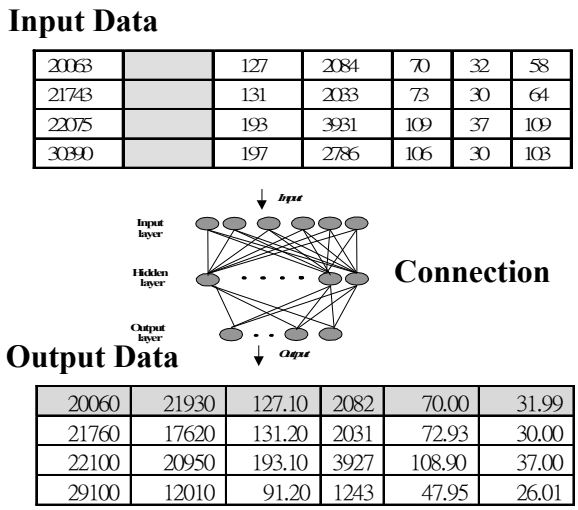

Fig. 15 Result of the experiment （ No data）

4.5 Result of the study

At last, this study will write the program of AutoLISP, We hope can express the result of the experiment in figure by AutoCAD.

In Fig.16 we chose the original case which the system had learned before to be the input, so we can proved the learning efficiency of system at this step. （Fig. 16） In Fig. 17 we put the case, which lost some data to be the input, so we can proved the reasoning efficiency of system at this step.After that we can know that the learning efficiency of system is better than the reasoning efficiency of system.

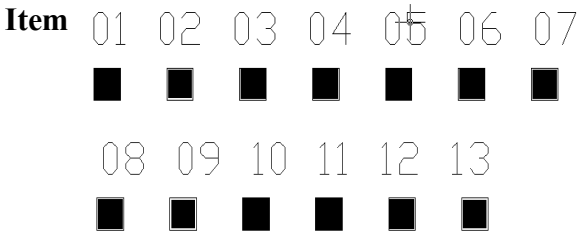

Fig. 16 Learning Efficiency of the system

Item

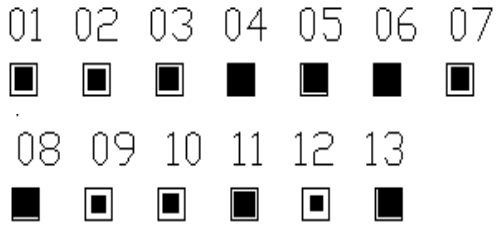

Fig. 17 Reasoning Efficiency of the system

5. Conclusion

After the process of studies and practical experiments, we can prove some conclusion of this research. We construted that Artificial Neural Network (ANN) can made computer aided architecture design not only binary-logic but in knowledge learning, associative memory.

A conceptual model of case-based reasoning in layout design approached by hierarchical artificial neural network method is provided. This study discussed the knowledge representation of layout design from the cases of Taipei Primary School, and this research deduced the knowledge of automatic design system from Taiwan's experience in computer aided architecture design (CAAD).

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