An Architect/ An Architectural Language and A Shape Grammar

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SUMMARY
Every architect, whose goal is to create valuable artifacts, should own a unique architectural language. This language is composed of a vocabulary and a set of grammar rules to combine them. In this study, a number of ground and first floor plans of single-family houses designed by an individual architect are analyzed. Plan lay-outs are decomposed into their components, and the composition rules are examined. Vocabulary elements, and geometric and semantic relationships among these elements are specified and a shape grammar is formed. Finally, different design possibilities are generated in terms of the defined language rules.

KEYWORDS: Architectural Language, Shape Grammar, Vocabulary,

INTRODUCTION

The purpose of this paper is to demonstrate that by the decomposition of a design, the rules that combine its elements can be searched and with the extracted grammar rules new designs can be achieved in the architectural language of the original design. In this research a well-known Turkish architect Y_lmaz Sanl_ is selected for analysis. This analysis has been restricted to the ground and first floor plans of the two story houses which the architect has designed during various periods of his professional life.

This research is composed of three parts. In the first part, the collected twenty-seven house plans are analyzed in terms of the vocabulary elements and grammar rules. At the end of this thorough analysis of geometric and topological features such as the global form, entrance position, symmetry, and design system,
the unchanging characteristics are collected to be classified systematically. In the second part, following this geometric, formal, and organizational analysis, a parametric shape grammar is targeted to generate a certain group of ground floor plans with 3X2 grids. The last part of the research includes another shape grammar which generates upper floor plans based on the generated ground floor plans.

1. ANALYSIS AND DECONSTRUCTION OF PLAN LAYOUTS

The main mutual characteristic of the ground floor plans is the strict geometric organization of their compositions. Classification of these compositions can be based on shape schematically; however, it should also be stated that this classification is directly related with function.

In the first step the ground floor plans are classified in two groups according to their spatial organization:
(a) The first group consists of the floor plans which can be defined with the underlying grids (Figure 1):

![Figure 1 Definition of the plan layouts with grids](image)

(b) The second group consists of the floor plans in which the elements are parts of an additive L-shaped system (Figure 2):

![Figure 2 Definition of the plan layouts with L-shaped system](image)

In this work the floor plans with underlying grids are selected for further examination and in this category three sub-groups are formed based on the type of the grid (Figure 3):
(1) 2x1 GRID SYSTEM

(2) 3x1 GRID SYSTEM

(3) 3x2 GRID SYSTEM
The grids of the plan layouts are defined in terms of the three functional zones: entrance (E), service groups (S1, S2), and livingroom (LV) as shown above. The entrance zone is composed of a hall (H) and the staircase (sometimes the stairs are outside the entrance zone). Kitchen (K), WC, study-room (SR), diningroom (DR), hall (H), maid's room (MR), guest-room (GR), bathroom (BT), and sometimes the staircase compose the service zones. Finally, the livingroom zone may contain a diningroom, a study, or the main staircase.

Following the description of the grid types, all the plans are introduced in terms of their underlying grids. Next, all of the plans are decomposed into two or three zones and the spatial relationships are explored within the plans in terms of the three grid types and finally layout schemes are drawn for each plan.

In the first stage of this research, in addition to the exploration of a set of grammar rules, through the decomposition of the collected plan layouts, a vocabulary of elements is prepared for each zone of a 3X2 grid system to generate new compositions as shown in Figures 4, 5, and 6, respectively. Also, based on the information derived from the decomposed plans of 3X2 system, area ranges, proportional and dimensional limits are all listed in various tables in order to be stored as input knowledge within the targeted program later.

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Figure 4 Livingroom compositions derived from plan layouts with 3X2 grids
Figure 5 Service zone compositions derived from plan layouts with 3X2 grids

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Figure 6 Entrance zone compositions derived from plan layouts with 3X2 grids

In the next step, the upper floor plans of these ground floor layouts with 3X2 grids are again defined in terms of their underlying grids and the zones. These plans have 3X1 grids as shown in Figure 7. There are two sleeping zones (SL1, SL2) composed of bedrooms (children's room (CBR) and parents' room (PBR)), bathrooms (BT), dressing rooms (CL), and sometimes corridors (CR) or halls (H). The third zone is the middle part (M) which is either completely open with only the staircase and a whole around it, and used as an upper floor livingroom or its front section is added to the sleeping zones. A vocabulary for the compositions of these zones are shown in Figure 8.

Figure 7 Definition of the upper floor plan layout with a 3X1 grid
2. GENERATION OF THE GROUND FLOOR PLAN BY A SHAPE GRAMMAR

In the second stage of this work a parametric shape grammar which generates ground floor plans with 3X2 grid is introduced. This shape grammar is prepared in a general structure which can also be used for 2X1 and 3X1 grid systems with little modification.

The steps that define the generation of the ground floor plans are:

a. Definition of the grid
b. Selecting a value for total area
c. Selection of the view direction
d. Placement of the axis of symmetry
e. Dimensioning the plan
f. Generation of the livingroom
g. Selecting the alternatives for the service groups
h. Controlling the position of the main staircase
i. Generation of the service groups
j. Generation of the entrance hall

The architectural language defined by this parametric shape grammar is introduced as an algorithm of a computer program. Accordingly, the whole procedure starts with an abstract grid and continues with the application of successive grammar rules, and ends with a generated floor plan.

Figure 8 Sleeping zone compositions of a 3X1 system

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a. Definition of the grid:

The initial image is the undimensioned grid that defines the selected group (Figure 9).

![3X2 grid](#)

Figure 9  3X2 grid

b. Selecting a value for the area:

In order to dimension the rectangle defined by this grid, a value for the area should be selected. The range for this area is extracted from the collected examples (95 sq. meters- 211 sq. meters).

c. Selection of the view direction (Figure 10):

![Scheme for the selection of the side with the best view](#)

Figure 10  Scheme for the selection of the side with the best view

In the plans with 3X2 grids, once the scenery position is established, the positions of all the functional zones are obtained. On the ground floor the living room and on the first floor the parents room are directly positioned on the side with the best scenery.

d. Placement of the axis of symmetry:

On the 3X2 grid, due to the symmetric composition, once the livingroom is placed on the plan, the other zones take place in the system directly. Following the positioning of the livingroom in the plan, the lateral symmetry axis that dissects the livingroom is obtained and it is extended along the plan in order to place the entrance door as shown in Figure 11.
e. Dimensioning the plan:

The global form of the ground floor plan is a rectangle. The range for the proportions of its dimensions is already determined based upon the formal analysis (0.80-1.00). Once this value is entered, and since the area is already known, dimensions are directly evaluated (Figure 12).

![Diagram showing the 3x2 grid with zones defined, entrance door, and lateral symmetry axis.]

Figure 11. Definition of the zones on the 3X2 grid and locating the entrance door and the symmetry axis

At this point the grid is established, the rectangle is dimensioned, and the zones are defined. Next, compositions for all the zones will be selected and generated with the application of successive rules and possible combinations of these alternatives will be searched as shown in Figure 13.

![Diagram showing the rectangle with dimensions YA and XA, total area, width, and length calculations.]

Figure 12 Dimensioning the rectangle that defines the ground floor plan
Once the 3X2 grid is defined, the next step is to place the units in the plan. Accordingly, the predetermined elements are positioned in the cells of the grid and the design of the plan is completed.

f. Generation of the livingroom:

First, the compartment that defines the livingroom on the grid is established and its dimensions are defined as shown in Figure 14. The second step is the evaluation of the livingroom area.
Dimensioning of the rectangle that defines the livingroom is completed with this step. However, the proportion of these dimensions should be controlled.

livingroom width (YA2) / livingroom length (XA)= 0.40-0.70

If the evaluated value does not pass this control operation, a new value is needed to be selected. The next step is the selection of a livingroom alternative (Figure 15). With simple arithmetic operations, the alternative is generated by the program. Next, the alternative replaces the abstract rectangle and the generated livingroom takes place in the plan.

Figure 15 Livingroom alternatives

g. Generation of the service zones:

As in the case of livingroom, the elements composing S1 and S2 zones are already determined as shown in Figure 16. These compositions are defined by undimensioned sub-grids, and based on the type of the sub-grid, the alternatives are classified in two groups. The alternatives selected for each zone S1 and S2 should belong to the same group for the coordination between them.

Figure 16 Service zone alternatives
Following the selection of the alternative, there are certain conditions to be controlled. For instance, if the livingroom selected contains a diningroom, a study-room, or a staircase, it should be checked that the service zone does not have these elements.

| If the livingroom alternative = LV2, THEN S1 and S2 $\neq$ SG2, SG6 |
| If the livingroom alternative = LV6, THEN S1 and S2 $\neq$ SG2, SG3, SG8 |
| If the livingroom alternative = LV5, THEN S1 and S2 $\neq$ SG2 |

Following the selection of an alternative for S1, the next step is the selection for S2. Again the harmony between the two zones is checked and the placement of two kitchens, or two dining-rooms, or the lack of a kitchen is avoided. In addition, sub-pograms which take horizontal or vertical symmetries of compositions are also included in the program.

In order to simplify the wording of the targeted algorithm, a certain coding system is prepared for service zones as shown in Figure 17.

![Figure 17 Codes which define the service zones](image-url)
Before the generation of the selected alternative, the position of the staircase is defined:

M1 = when the stairs are in the entrance hall \((XA_1=XA_2=XA_3=XA/3)\)

M2 = when the stairs are in the service zone \((XA_2 > 1.50 \text{ m.})\)

M3 = when the stairs are in the living room \((XA_2 > 1.50 \text{ m.})\)

Small sub-programs are required within the main program for repeating operations such as the dimensioning of units composing the zones like the kitchen, staircase, WC, study, etc. The generation of each zone is very similar. In this context, an example will be given for the generation of a service zone alternative.

First image is again an abstract grid which represents the service zone as shown in Figure 18. If one of the SG3, SG4, or SG5 alternatives is selected, the coding is \(P(1G,A21)\).

Through the usage of subprograms, the dimensioning of the units is completed and they are placed within the zone and the generation is completed. An example of a possible combination of elements is shown in Figure 19.
h. Generation of the entrance zone:

The last group of units to be added to the plan constitute the entrance zone. The generation process is directed by the position of the staircase.

![Figure 19. The ground floor plan in the case of P(M1,1G,A21,SG3)](image)

Figure 20. Entrance hall alternatives in the case of P(M1)

In the case of M2 and M3, there is only one solution; accordingly no selection. However, in the case of M1 the alternatives are listed as shown in Figure 20. Following the selection, the alternative is again represented by the sub-grid and the generation of the zone is completed through the sub-pograms similar to the other zones (Figure 21).

![Figure 21. The entrance hall scheme in the case of P(M11)](image)
3. GENERATION OF THE UPPER FLOOR PLAN BY A SHAPE GRAMMAR

In the last part of this paper, another parametric shape grammar which is prepared for the generation of the upper floor layouts is introduced. This grammar is directly based on the output of the first grammar. The successive generation steps are similar:

a. Definition of the grid
b. Definitions of the zones
c. Controlling the position of the main staircase
d. The dimensioning of the upper floor plan
e. Generation of the sleeping zones
f. Generation of the middle section

a. Definition of the grid:

The initial image is again the undimensioned grid that defines the upper floor plans of ground floor layouts with 3X2 grid (Figure 22).
b. Definition of the zones (Figure 23):

Figure 23  Positioning of the zones on the upper floor layout

M1 POSITION:
In this case the stairs are in the entrance zone and there are six alternatives as introduced before. Based on the selected one, the position of the stairs changes. These different positions are coded as M11, M12, M13, M14, M15, and M16.

M2 POSITION:
If a service zone alternative with the staircase (SG6) has been selected, then M2 defines the position.

M3 POSITION:
If a livingroom alternative with the staircase (LV2) has been selected, then M3 defines the position.

d. The dimensioning of the upper floor plan:
At this step the projection of the upper floor out above the ground floor becomes essential. There are two cases coded as T4 and T2 as shown in Figures 24 and 25.

**Figure 24 T4 case**

**Figure 25 T2 case**

**WIDTH OF THE RECTANGLE (YU) = b + YA + c**

b = 1.20 meters-1.50 meters  
c = 1.00 meters-1.50 meters

**LENGTH OF THE RECTANGLE (YU) = a +XA + a**

a = 1.00 meters - 1.20 meters

e. Generation of the sleeping zones:

In order to determine the sleeping zone alternative to be used on the upper floor, the conditions on the ground floor should be defined clearly as shown in Figure 26.
f. Generation of the middle section:

The last zone to be generated in the lay-out is the middle section. Actually this section is mostly generated due to the formation of the entrance hall downstairs and the sleeping zones upstairs.

The generation process of these zones is similar to the other zones. The selected alternative from the presented vocabulary in Figure 27 is first defined by a sub-grid and dimensioned through the usage of sub-programs and the completed composition is placed in the grid of the floor lay-out.
The first alternative may be that this section is used as an upper floor livingroom with the character of a "sofa" which is a traditional Turkish house element. The most outstanding unit is the staircase and it is already placed due to the generated entrance hall. There is usually a whole around the stairs providing the relationship with the ground floor. The second alternative is that the section on the scenery side is divided in two parts and used equally by the two rooms on two sides. The back part is again used as a small livingroom. There is of course again a staircase and a whole around it. The third alternative is that the parents' room is extended to this middle section on the scenery side. Another alternative is that this section is completely formed as a void and there is only the staircase and a bridge that connects the two sleeping wings. Another form of this middle section is that this part is used as a gallery opening to the livingroom downstairs.

Figure 28 Examples for generated upper floor plan layouts

CONCLUSION

In this algorithm the possible combinations for each zone are presented and selection among various alternatives is required. This selection has been checked through various control systems and the selected compositions are dimensioned and generated through the usage of simple arithmetic operations. Next, the generated ground floor plan is represented with codes based on various aspects of the layout and an appropriate upper floor plan is generated with a second grammar. As a summary, following the decomposition of the plan layouts, by the extracted grammar rules, it is tried to put the components together in other possible combinations which may not have been used by the architect, but in harmony with the constructed architectural language.
REFERENCES


ACKNOWLEDGEMENTS

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BIOGRAPHY

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Associate Professor at Maçka Faculty of Architecture, Istanbul Technical University 1978-1982
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Professor of Architecture at Faculty of Architecture, Istanbul Technical University 1988-
TÜB_TAK_NTAG (Scientific and Technical Research Council of Turkey) Member of the Executive Committee 1991-1994
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Vice Dean of Faculty of Architecture,  
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Chairperson of Architectural Design Group,  
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Vice Rector of Istanbul Technical University  
1992-1995

Rector of Istanbul Technical University  
1996-2000

Rector of Istanbul Technical University (re-elected)  
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President of ITU Development Foundation  
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President of Turkish Association of Architectural Education

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University of Cambridge, Department of Architecture  
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Visiting scholar (1 year)  
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Visiting Scholar (6 weeks)  
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The Martin Centre for Architectural and Urban Studies  
Visiting Scholar (6 weeks)  
1991

Queens University of Belfast, Department of Architecture  
Visiting Professor (external examiner)  
1993

Open House International, Member of International Editorial Board  
1996-

MEMBERSHIPS

The Turkish Chamber of Architects  
1967

CIB Working Commission,  
W55 Building Economics  
1983

CIB Working Commission  
W78 Computer Aided Design  
1983

IAPS International Association for The Study of People And Their Surroundings  
1989

ENHR European Network For Housing Research  
1989

ISA International Sociological Association, Research Committee on Housing and the Built Environment  
1990

ACADIA Association for Computer-Aided Design in Architecture  
1991

Scientific and Technical Research Council of Turkey  
Member of Executive Committee  
1991

EAAE European Association for Architectural Education  
1992

EAIE European Association for International Education  
1996

CMU Community of Mediterranean Universities  
1996

RMEI Reseau Mediterraneen des Ecoles d’Ingénieurs  
1996
EDUCATIONAL ACTIVITIES

I. Courses

Undergraduate Courses

Architectural Design Courses
Architectural Design Studios
Diploma Studio
Computer Applications in architecture
Architectural Design Theories and Methods
New approaches in Architecture (Elective)
Theories and Logic Models of Architectural Design
Housing for Low – income Groups

Graduate Courses

Architectural Design Courses
Computer-Aided Architectural Design I
Computer-Aided Architectural Design II
Logic Models of Architectural Design

II. Master Thesis Supervised


Oncel, “An Algorithm for Three Dimensional Spatial Allocation Problem”, ITU, Faculty of Architecture, 1990


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Sema Eser
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COMPLETED RESEARCH PROJECTS


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AWARDS
First Prize in the Architectural Competition of the Aydin-Ku_adasi Tourism Complex, Organized by the Ministry of Public Works. (20,000 m_ ) (with collaboration of H. Yürekli, F. Yürekli, A. Özsoy), 1983.


CIB, 1980. 8th CIB Congress, Oslo, 1980

DAAD, 1981. 9th Triennial Conference on Operational Research, Hamburg, 1981.

British Council, 1991. Visiting Scholarship (6 Weeks)
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INTERNATIONAL CONFERENCES ATTENDED

2th CIB Congress, June 1980, Oslo CIB Bursu ile bildirili olarak katılma.


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CMU (Community of Mediterranean Universities) annual meetings.

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Orhan Karakullukçu Villas, Zigana, 1983.
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