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PARAMETRIC 3D MODELING OF I-SHAPE KITCHEN

Abstract: *Interior design is the science and art of enhancing the interior of a space in order to achieve a more aesthetically pleasing and functional environment. Furniture as an important element of space decoration can be ready-made or custom-made (goal - maximal use of space). Kitchen design requires many elements disposition rules to be respected in order to get functional space. Therefor interior designer has to spend time on solving this functionality problems and have less time for creative aesthetic work. We developed an algorithm for automatic I-shape kitchen organization on the basis of available kitchen dimensions. This algorithm automatically generates kitchen disposition and makes a parametric 3D model. Developed algorithm is implemented and tested using SketchUp dynamic components.*

Key words: *Parametric modelling, kitchen elements, interior design, 3D modelling.*

1. INTRODUCTION

Interior design is the science and art of enhancing the interior of a space in order to achieve a more aesthetically pleasing and functional environment for the people using the space [1]. The process of interior design is performed by professional interior designer in close collaboration with owner and future user of the space. The professional interior designer is qualified by experience, education and examination to enhance the quality and function of interior spaces for the purpose of improving the life quality, increasing productivity, and protecting the safety, health and welfare of the public [2].

Physical components that make one interior design complete consists out of the basic components [3]. Furniture will play a crucial, probably the most crucial, part in the refinement of the new installation and the physical interaction between interior elements and those who use them. It should comprehensively fulfil its practical obligation to support human activity without compromising efficiency or comfort, but it should also meet a less tangible obligation to stimulate and satisfy the aesthetic appetites of those who use it, regardless of how utilitarian or how hedonistic the activity it supports may be[4].

Furniture as an important element of interior space decoration can be:

- Ready-made (sofa, chair, table, etc.) or
- Custom-made (closet, kitchen elements, etc.).

For custom-made furniture, the goal is a rational use of space by taking maximal available width and height of the space. Kitchen represents a space with great importance for one family. That's why the goal is to have a kitchen with best possible organization, maximal space use and aesthetic appearance in accordance with owner's taste. In order to meet these criteria, homeowners in most cases decide to create fully custom made kitchen. This requires many elements disposition rules to be respected in order to get functional space. Therefor interior designer has to spend time on solving these functionality problems and have less time for creative aesthetic work.

The aim of this paper is to present and propose a method for automatic kitchen 3D model generation, which may be used in interior design.One approach for automatic 3D model creation, is parametric modelling [5, 6, 7]

In order to make functional organisation easier, we developed an algorithm for automatic I-shape kitchen organization, on the basis of available space dimensions.Virtual generation of I-shape kitchens were based on parametric analysis of the important space parameters and kitchen elements organization. For the purposes of the analysis presented here the spatial characteristics of the space and kitchen were transformed into measurable parameters. Parameters were further used to determine the kitchen elements style, type and disposition.Developed algorithm for parametric I-shape kitchen is implemented and tested using SketchUp dynamic components.

2. MATERIALSAND METHODS

Creation of automatic kitchen 3D model requires a solution for kitchen layout which requires an appropriate kitchen element position in interior space, with respect of certain interior design rules and existing space.

The main principle of kitchen layout design is that the elements should be organized to ensure a safe and comfortable cooking environment. Therefore the working triangle (Figure 1) principle was developed in the 1940's by the University Of Illinois School Of Architecture which defines rules for mutual position between kitchen elements.

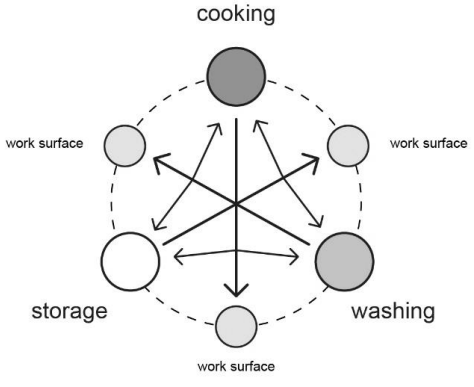

Fig. 1 Working triangle

The work triangle is the imaginary line drawn between the 3 major work stations in a kitchen, separated with work surface:

- Cooking (stove),
- Storage (refrigerator) and
- Washing (sink).

The criteria applied to a triangle design are [2]:

1. distance between work stations is 1.2m - 2.7m;
2. the sum of all distances is 4m - 7.9m;
3. obstacles such as cabinets should not intersect the triangle by more than 30cm and
4. there shouldn't be traffic through the triangle.

2.2Interior space influence

Another important factor for layout design is existing interior space and important elements which determinate desirable positions of some kitchen elements:

- Door – fridge (storage of new groceries).
- Water pipes and canalization – sink.
- Extractor pipes – extractor fan and stove.

Interior space also defines possible kitchen type. Kitchens can be classified into sixth basic types according to shape that elements form in the floor plan (Figure 2):

- I-Shape
- II-Shape
- L-Shape
- U-Shape
- G-Shape
- With island

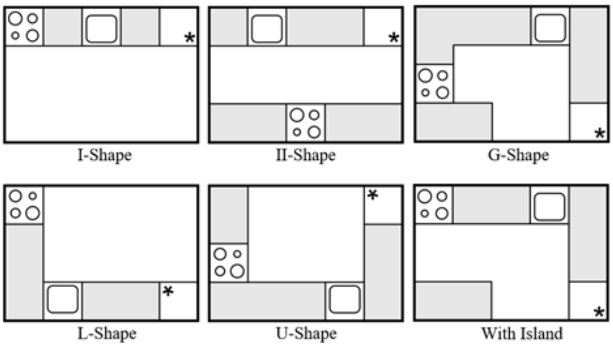

Fig. 2 Kitchen types

For the purpose of this research, we chose to create parametric models for first, I-Shape kitchen type. This approach for creation of a parametric model for automatic I-Shape kitchen 3D model consist several phases:

1. defining rules for mutual element's position;
2. defining possible types and sizes for all three major work stations in the kitchen;
3. defining rules for elements position in different kitchen layouts depending on length;
4. development of algorithm for automatic I-shape kitchen organization;
5. development of a parametric 3D model in SketchUp using dynamic components.

3.PARAMETRIC ANALYSIS

Mutual element's position in the I-Shape kitchen layout is not possible to define using working triangle because it is linear (one dimensional) disposed. The assumption is that the door is on one edge of the I-Shape kitchen so storage (fridge) position is there. Design goal is to create space where home owner have to walk as less is possible through the kitchen in order to store groceries into the fridge. Stored groceries have to be washed and at the end of the process be cooked. So starting from the kitchen, entry door, element disposition will be: Storage – Washing – Cooking, with Work surface between them (Figure 3).

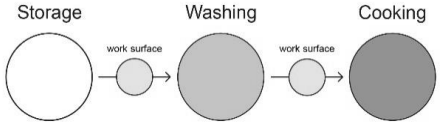

Fig. 3I-Shape kitchen layout organisation

3.1. Kitchen elements

Standard types and sizes for all three major work station elements in the kitchen are defined.

For Storage (Figure 4) there are four different types of fridge (width X height X depth):

- S1 - 60 X 90 X 60
- S2 - 60 X 180 X 60
- S3 - 90 X 180 X 60
- S4 - 120 X 180 X 60

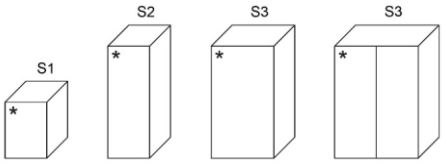

Fig. 4 Storage elements type

For Washing (Figure 5) there are four different types of sink (width X height X depth):

- W1 - 30 X 90 X 60
- W2 - 60 X 90 X 60
- W3 - 90 X 90 X 60
- W4 - 120 X 90 X 60

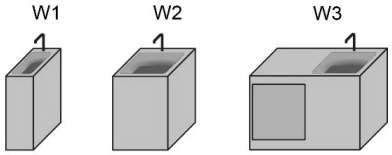

Fig. 5 Washing elements type

For Cooking (Figure 6) there are three different types of stove (width X height X depth):

- C1 - 30 X 2 X 60
- C2 - 60 X 90 X 60
- C3 - 120 X 180 X 60

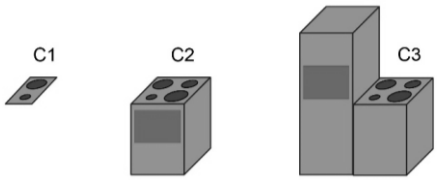

Fig. 6 Cooking elements type

3.2. Layout

Using created rules for elements' position and types of major work stations, different kitchen length layout is created (Figure 7). Smallest kitchen taken into consideration is 90cm and biggest 480cm length. The assumption is that entry, kitchen door is on the left side of the kitchen and that side, we consider as a beginning of a kitchen. Another assumption is that in each case we have the ideal position of kitchen installation. On the basis of all previous factors types and position for Cooking, Storage and Washing elements are defined (Table1) for different kitchen lengths.

Table 1–Kitchen elements type and position

Kitchen length	Cooking		Storage		Washing	
	Type	Pos.	Type	Pos.	Type	Pos.
90	C1	0	S1	0	W1	60
90-119	C1	0	S1	0	W2	60
120-149	C1	0	S1	0	W2	60
150-179	C2	d-60	S1	0	W2	60
180-209	C2	d-60	S1	0	W2	60
210-239	C2	d-60	S2	0	W2	60
240-269	C2	d-60	S2	0	W2	60
270-299	C2	d-60	S2	0	W2	60
300-329	C2	d-60	S3	0	W3	60
330-359	C2	d-60	S3	0	W3	60
360-389	C2	d-60	S3	0	W3	90
390-419	C2	d-60	S3	0	W3	150
420-449	C3	d-120	S3	0	W3	150
450-479	C3	d-120	S4	0	W3	150
480+	C3	d-120	S4	0	W3	180

Based on Table1, rules for Storage (Table 2) and Cooking (Table 3) stations: type, width and position are defined. In the case of Cooking station type and width are defined (Table 4) while position have to be calculated.

Table 2–Storage elements type and position

Case (d)	C_{type}	C_{with}	C_{pos}
90 ≤ d < 150	C1	30	0
150 ≤ d < 420	C2	60	d-60
420 ≤ d	C3	120	d-60

Table 3–Cooking elements type and position

Case (d)	S_{type}	S_{with}	S_{pos}
90 ≤ d < 210	S1	60	0
210 ≤ d < 300	S2	60	0
300 ≤ d < 450	S3	90	0
450 ≤ d	S4	120	0

Table 4–Washing elements type

Case (d)	W_{type}	W_{with}
90 ≤ d < 120	C1	30
120 ≤ d < 300	C2	60
300 ≤ d	C3	120

In order to create a 3D model of I-Shape kitchen it is necessary to create an appropriate kitchen elements disposition (Figure 8). Based on kitchen length and using rules for Storage, Washing and Cooking stations it is possible to define a type, and position for all, except the position of Washing station.

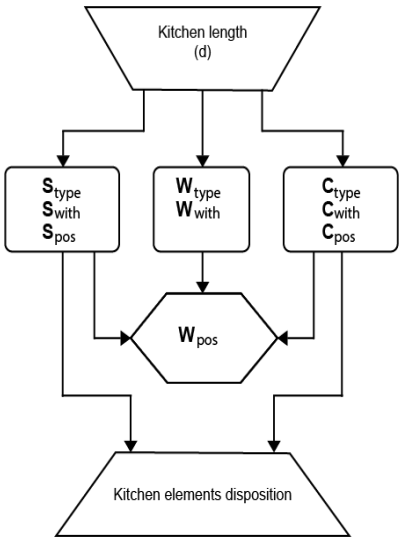

Fig. 8 I-Kitchen elements disposition algorithm

Position of Washing station have to be calculated on the basis of: kitchen length, Storage station width, Washing station width and Cooking station width (Figure9).

Inside I-Shape kitchen, Washing station is positioned in the middle, between Storage and Cooking. Separated from them with working surfaces. Goal is:

1. to have similar length of working surfaces on both sides of Washing station;
2. work surfaces should be modular (width = 60 cm);
3. only one work surface element can be non-modular;
4. length of work surface between Washing and Cooking station always has to be equal or longer than the length of working surface between Washing and Storage station, in order to ensure more safety environment.
5. To calculate total working surface length (*WSl*), from the length of the kitchen, Storage station width, Washing station width and Cooking station width was subtract. Then the number of modular work surface elements is calculated as *WSn*. The length of additional work surface which can't be part of modular elements are calculated as *WSr*. Number of modular working surface elements between Washing and Storage station are calculated as *WSnl*, while number of elements between Washing and Storage station are calculated as *WSnr*. In order to achieve a work surface goal number 4, number of modular elements on both sides of Washing station are compared and position (W_{pos}) is calculated.

4. RESULTS

Created algorithms for automatic I-Shape kitchen elements disposition is implemented inside SketchUp.

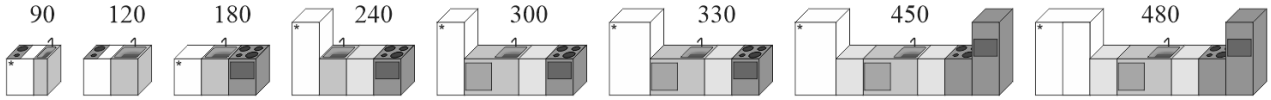

Fig. 7 I-Shape kitchen elements organisation

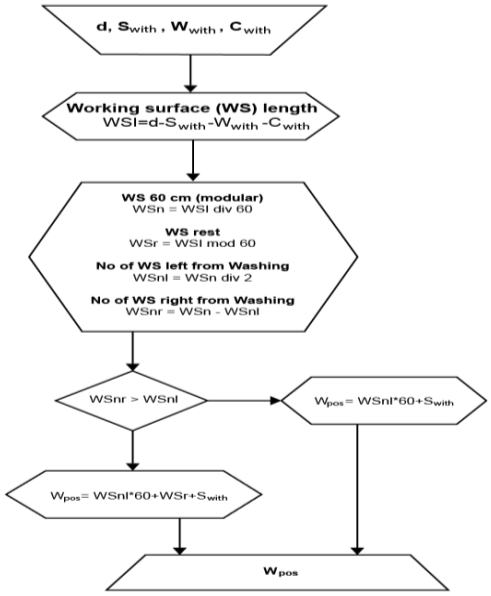

Fig. 9 Washing station position calculation

Kitchen elements defined in section 3.1 are created using SketchUp standard tools for 3D modelling and integrated as a dynamic component.

An algorithm for elements disposition is connected with dynamic components resulting with a parametric 3D model of I-Shape kitchen.

Parametric model is based on the idealistic interior space element's position. The assumption is that entry, kitchen door is on the left side of the model and that side, we consider to be a beginning of a kitchen. Another assumption is that in each case we have the ideal position of kitchen installation (weather pipes, ventilation, etc.).

Created a parametric model of I-Shape kitchen allow user automatic creation of a 3D model in SketchUp. Based on user input of total kitchen length 3D model of kitchen is automatically generated and presented. Results of testing for different kitchen length are presented in Figure 10: a) I-Shape kitchen – 90 cm length, b) I-Shape kitchen – 210 cm long and I-Shape kitchen – 330 cm length.

5. CONCLUSION

In this paper parametric 3D modelling of I-Shape kitchen is proposed and applied inside SketchUp 3D modelling software. Kitchen design rules are quantified, transformed into the algorithm for elements disposition and applied into SketchUp dynamic components.

Created parametric model allows automatic creation of I-Shape kitchen 3D model, allowing user faster final result by saving time for 3D modelling. Algorithm for automatic elements disposition organisation presents very useful component for users without previous knowledge and students in the process of learning. Created model, with an idealistic approach for interior elements' position limits for the real life use. However, it is a basis for further improvement.

Future research in this area should address improvement of the algorithm for I-Shape kitchen by taking into calculations installations position. Based on this paper, parametric models for other types of kitchen should be developed.

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