COMPUTER SYSTEM OF WALL DECORATION ON THE BASE OF PROGRAMMABLE DIRECT-X LIBRARY

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Decoration of walls by art plates of stone is aesthetically sensitive task where risk not to be fitted in customer's requirement is high. Solution in this case is development of Computer Modeling System of Art Designing (CMAD). CMAD in this case realize two main functions: generation of several decoration alternatives and 2D/3D visualization of wall and whole scene. Wall decoration is carried out by art plates of stones with different dimensions and textures. Therefore, corresponding algorithm responds to requirements coming from the heuristic rules and randomizes plates selection in rest of the cases. The paper presents detailed description of algorithm, the ways how output of algorithm is connected with programmable DirectX library and CMAD which was built at Georgian Technical University.

1. Decoration Requirements

Decoration is carried out by plates. Each plate is characterized by three main features:

- Shape
- Dimensions
- Texture of stone

Different combinations of mentioned above features sets the various classes of plates, which are joined in following categories:

Category A – *shape representation*

Class A1 – rectangular

Class A2 – non-rectangular

Class A2-1 – A2 with left-right edge#1 (*figure 1*)

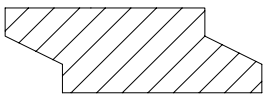

Figure 1

Class A2-2 – A2 with left-right edge#2 (*figure 2*)

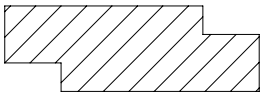

Figure 2

Class A2-3 – A2 with free form plates.

Category B – *Representation of dimensions*

Class B1 – A1 with free high and width

Class B2 – A1 with fixed high and free width

Class B3 – A2-1 with fixed high and free width
Class B4 – A2-2 with fixed high and free width
Class B5 – A2-3 with plates of 18 different dimensions
Class B1-1 – B1 with plates of 13 different dimensions
Class B1-2 – B1 with plates of 11 different dimensions
Class B2-1 – B2, with plates of 2 different dimensions
Class B2-2 – B2 with plates of 2 different dimensions
Class B2-3 – B2 with plates of 3 different dimensions
Class B3-1 – B3 with plates of 3 different dimensions
Class B4-1 – B4 with plates of 1 dimension.

Category C – *Representation of texture*
Class C1 – "Sasaxle", B1-1 with 48 textures
Class C2 – "Tlili", B1-2 with 38 textures
Class C3 – "Meseri", B2-1 with 11 textures
Class C4 – "Sopeli", B2-2 with 22 textures
Class C5 – "Shatili", B2-3 with 17 textures
Class C6 – "Pikali", B3-1 with 27 textures
Class C7 – "Eleganti", B4-1 with 9 textures.

In addition there are also special classes of plates:

- Angular plates, which are implementing to decorate the conjunction zones of two walls or column edge
- Windows/Doors edge decoration plates.

1.1 Heuristic rules

Heuristic rules are coming from the requirements to "hide" the plates in decorated walls and receive composition with maximum natural vision.

Rule#1: Minimize length of plates vertical and horizontal conjunction lines
Rule#2: Minimize number of cross conjunctions
Rule#3: Maximum randomization of plates
Rule#4: Minimize number of trimmed plates
Rule#5: Minimize "black holes", zones which are not covered by plate
Rule#6: Consideration of fixed plates – plates, which position is preliminary defined and unchangeable.

2. Description of Algorithm

Virtual decoration is carried out in two main steps:

1. Meshing
2. Texturing

2.1 Meshing

The meshing algorithm realizes the heuristic rules and built for the given class of plate, the mesh representation of selected wall. Therefore algorithm restricts plates combinations according to heuristic rules #1, #2, #4, #5, #6 and makes maximum randomization in rest of the cases (rule #3).

Four main steps are carried out for insertion of each plate in mesh:

1. Identification of insertion point
2. Dimensional analyze
3. Selection of plate
4. Insertion of plate.

Two objects, with its title “point” and ”stone”, permit to identify the current condition of meshing.

“Point” describes each point of plate in mesh and consists of 6 fields:

“Point”

x	y	a	b	c	D

x, y – point coordinates

a, b, c, d – Boolean variables, which identify free faces around the point (*figure 3*)

b	a
c	d

Figure 3

“Stone” describes each plate in mesh and consists of 5 fields and array of “point” objects

“Stone”

Id	t_l	t_r	b_l	b_r	{P}

Id – library number of plate

t_l, t_r – plates top, left and right points descriptions (“point” object)

b_l, b_r – plates button, left and right points description (”point” object)

{P} – points descriptions which are conjunct with plate along the edges (*figure 4*).

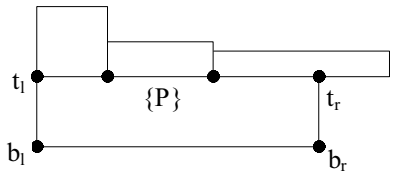

Figure 4

2.1.1 Identification of Insertion Point

Identification of insertion point of new plate in mesh is carried out in 2 main steps:

1. Selection of those points from the “stone” object which have only *one* free face
2. Selection of point from the selected array, which is nearest to the left button corner of the wall.

2.1.2 Dimensional Analyze

The purpose of dimensional analyze is identification of unmeshed area with restricted zones.

Analysis is done in 2 steps:

1. Separation of full unmeshed area
2. Identification of dimensional restrictions according to rule#2

2.1.3 Selection of Plate

The plate selection algorithm is given on *figure 5*. *Three* type of actions are done:

1. Exception of plate
2. Separation of plate array
3. Random selection of plate

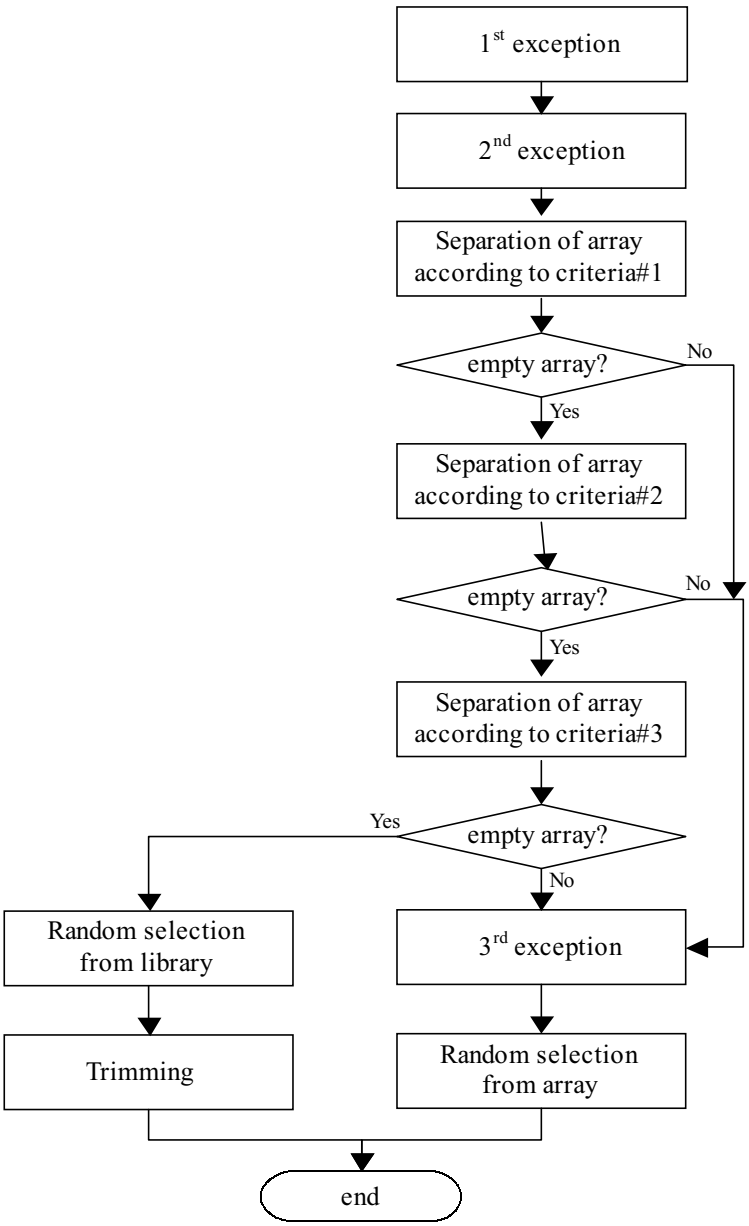

Figure 5

1st exception is done according to rule#3, while plates which are placed around the insertion point have not to be considered.

2nd exception is done in respect of dimensional restrictions coming from the rule#2.

3rd exception is done according to rule#3, while seldom-used plates have to be remained in selection.

Separation of plate is carried out according to 3 different criteria:
Criteria 1: Plates fully covered rest of unmeshed area.
Criteria 2: Plates fully covered rest of unmeshed area along the *one* of the *x* or *y*-axis.
Criteria 3: Plates are shorter then rest of unmeshed area.

2.1.3 Insertion of Plate

Insertion of selected plate in mesh is carried out in 2 following steps:

1. Creation of new “point” objects
2. Creation of new ”stone” object, corresponded to selected plate.

2.2 Texturing

The purpose of texturing is creation of 2D realistic representation of meshed wall and preparation of input data for DirectX module of 3D visualization.

Each plate in library is associated with *one* or more textures. They are selected according to rule#3. After texturing, according to DirectX requirements, whole meshed wall is presented as a *one* texture with its relative coordinates – 0,0; 0,1; 1,1; 1,0 and divided into triangles (*figure 6*). Optimal size of texture for DirectX is 128x128 pixel [1]. However, for resolution used in CMAD (1cm=4pixel) texture size is normally more then 1024x1024. Increasing of resolution or texture size considerably increase of hardware requirements.

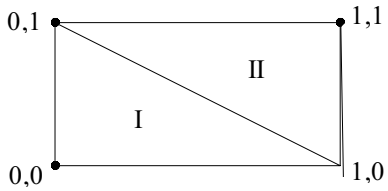

Figure 6

3. System Architecture

System Architecture consists of 3 main modules (*figure 7*)

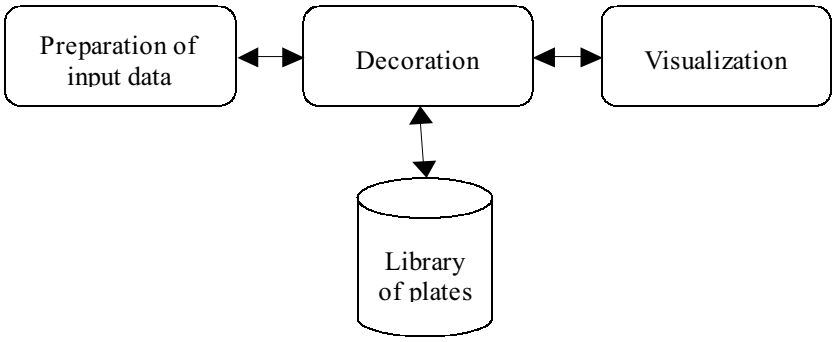

Figure 7

Four main steps are realized by input data preparation module:

1. Identification of whole scene components
   - Number of walls

- Floors
- Columns

2. Scene composition
   - Definition of walls positions
   - Definition of columns positions and types
3. Identification of components geometry
   - Editing of walls dimensions
   - Definition of wall shapes
   - Editing of floor dimensions
   - Editing of columns dimensions
4. Selection of plates for the decoration of each component.

Decoration module working out mesh and 2D representation of each component of the scene.

Visualization module executed 2 main functions:

1. 3D visualization of whole scene by Direct X
2. Documentation
   - Creation of file representations
   - Printing, mesh and 2D/3D models.

Conclusions

(1) Separation of restrictions, coming from the heuristic rules and possibilities for the maximum randomization of the solution have to be done in each case for creation of decoration algorithm.
(2) Considered algorithm can be used in the tasks of feature recognition in CAD [2].
(3) For the ordinary PC architecture, optimal solution of Direct X implementation is received for the resolution no more than 1cm=4pixel and texture size 1024x1024pixel.

References

[1] KRASNOV, B.I., Direct X in the projects of the Delphi, BHV, 2001

[2] SHARMAZANASHVILI, A. CAPP customization on the base of object-oriented approach, Tools and methods of competitive engineering, Fourth international symposium April 22 - 26, 2002, Wuhan, P.R. China