TITLE :

USING GRAPH GRAMMARS FOR GENERATIVE PROCESS RECREATING WARSAW'S TRADITIONAL FLOOR TILING

(Paper)

Topic: Design

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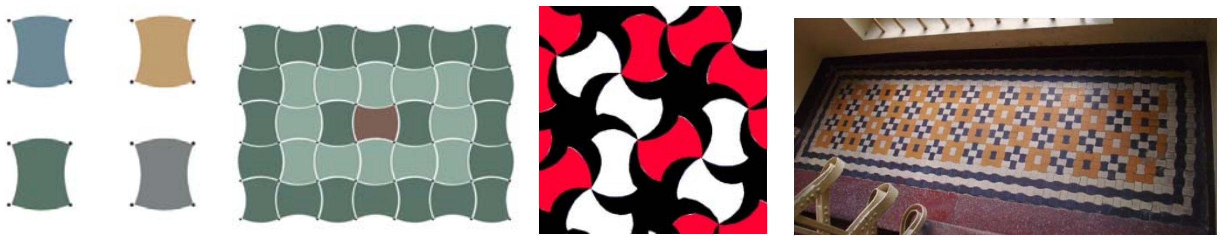
Abstract

The paper presents the advantages of using a graph approach to the design of tile layout patterns.Decorative tilework, known also as tile art has been known since ancient times. It has to be clearly distinguished from mosaic art, which is based on using huge number of, usually small, irregular pieces. In case of tiling the elements used are usualy larger and much more regular. There may be a set number of tiles used in a given project or just one. During the interwar period in Poland (1918-1939) a distinctive type of tiles called “corset” (Polish “gorsecik”) became very popular. It has a shape of a curvelinear quadrangle with two convex and two concave edges (Fig 1a). Despite their simple form they allow for the generation of a large number of patterns. Two, three or multi-coloured arrangements of corsets, which form stripes, chessboards, crosses, slices, and also complex designs, frequently occurred on the floors of kitchens, bathrooms, verandas, staircases, in cafes and craft workshops. In Figs1b and 1c two examples of possible designs are depicted and in Fig.1d photograph of a part of tilnig of the staircase in a building at Okrag 3 Street in Warsaw is shown. As the result of war and postwar neglect, and the renovation of old houses, large part of these designs has been either lost or damaged. In recent years there has been a growing interest in saving this part of national culture as well as in adapting it to modern times.



a b c d

Fig.1 a)“Corset” tiles in different colors b) and c) two types of flooring designs, d) staircase in a building,Okrag 3, Warsaw (photo copyright WarszawskiePosadzki).

To make the generation of new designs both easier and more precise we propose to describe the design process with a formal grammar. Using a graph-based representation allows us to express both mutual orientation of corsets and their attributes (like color, material, size, price etc.) and most importantly relations between tiles. Tile layouts in the form of graphs give the opportunity to represent the process of generating them as the derivation process in a graph grammar. By using different initial graphs and by applying various rules of the graph grammar a number of different tiling patterns can be obtained, yet preserving the traditional style of Warsaw's flooring designs.

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Key words: graph structures, floor panelling, traditional tiling patterns

Main References:

[1] ***Hanna Faryna-Paszkiewicz i Zuzanna Frub*** , Warsaw's disappearing floor tiling (in Polish:), Nisza, Warsaw 2013

Using Graph Grammars For Generative Process Recreating Warsaw's Traditional Floor Tiling

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Abstract

This paper deals with using graph-based methods in generating decorative tile layout patterns. Tile layouts are represented in the form of graphs, while the derivation process in graph grammars leads to creation of tile patterns. Graph grammar mechanisms allow us both to recreate Warsaw's traditional floor tilings and ***to*** create new tile patterns on the basis of the previously existing ones. The approach is illustrated by examples of designing tile patterns composed of one or two motifs.

1. Introduction

The paper presents the advantages of using a graph approach to the design of tile layout patterns. Decorative tilework, known also as tile art has been known since ancient times. It has to be clearly distinguished from mosaic art, which is based on using huge number of, usually small, irregular pieces. In case of tiling the elements used are usually larger and much more regular. There may be a set number of tiles used in a given project or just one. During the interwar period in Poland (1918-1939) a distinctive type of tiles called "corset" (Polish "gorsecik") became very popular. It has a shape of a curvelinear quadrangle with two convex and two concave edges (Fig 1a). Despite their simple form they allow for the generation of a large number of patterns. Two, three or multi-coloured arrangements of corsets, which form stripes, chessboards, crosses, slices, and also complicated designs, frequently occurred on the floors of kitchens, bathrooms, verandas, staircases, in cafes and craft workshops. In Figs.1b and 1c two examples of possible designs are depicted and in Fig.1d a photograph of a part of tiling of the staircase in a building at Okrag 3 Street in Warsaw is shown. As the result of war and post-war neglect, and the renovation of old houses, large part of these designs has been either lost or damaged. In recent years there has been a growing interest in saving this part of national culture as well as in adapting it to modern times [1].

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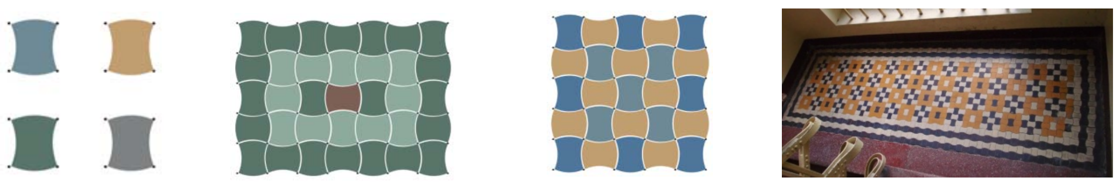

Fig.1 a)"Corset" tiles in different colours b), c) two types of flooring designs, d) Okrag 3, Warsaw (photo copyright WarszawskiePosadzki).

To make the generation of new designs both easier and more precise we propose to describe the design process with a formal grammar. We propose to use a graph-based representation of tilings as it enables us to express both mutual orientation of corsets and their attributes (like colour, material, size, price etc.) and most importantly relations between tiles. Tile layouts in the form of graphs give the opportunity to represent the process of generating them as the derivation process in a graph grammar. By applying various rules of graph grammars a number of different tiling layouts can be obtained, yet preserving the traditional style of Warsaw's flooring designs.

The approach is illustrated by examples of designing tile layouts composed of one or two patterns arranged alternatively or repeating in every second row. The user can define motifs of the size 2x2, 3x3, 4x4, or 5x5 composed of tiles in various colours. The system automatically generates various plane divisions using these motifs.

2. Graph-based representation of designs

In this paper both the tile motifs and the tile patterns are represented by means of labelled and attributed graphs [2]. Graph nodes represent tiles, while edges express their adjacency. Attributes assigned to graph nodes specify the orientation of tiles and their colours.

Example 2.1. A graph shown in Fig.2b represents the structure of a tile pattern composed of 25 tiles shown in Fig.2a. Each node represents one tile and has two attributes 'orientation' and 'colour' assigned to itself. The value of the attribute 'orientation' for every second node of the graph is equal to *horizontal*, and for the others to *vertical*. The value of the attribute colour assigned to the node representing the middle tile is set to *green*, to the other inside tiles it is set to *white*, while for the border tiles it is set to *navy blue*.

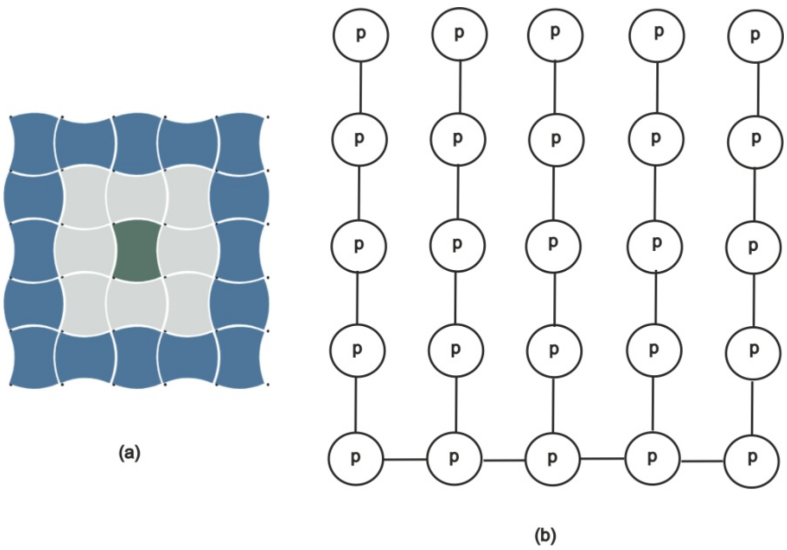

Fig.2 a) A tile motif 5x5 in three different colors b) a graph representing the structure of this pattern

3. Graph grammars for plane divisions

To generate graphs representing structures of tile patterns context-free graph grammars are used. A *context-free graph grammar* consists of a finite set *P* of *productions* of the form $p = (y,r)$, where y is a node with a nonterminal label and r is a graph composed of nodes with terminal and/or nonterminal labels, and an *axiom* named x, which is a node with nonterminal label. The application of the production $p = (y,r)$ to the graph c consists in substituting r for a node v of c, where v is isomorphic with y, and replacing connections of v with connections of r. Graphs representing structures of tile patterns are derived using specified sequences of graph grammar productions.

Example 3.1. The border composed of four tiles of two different colours arranged alternatively in each row is shown in Fig.3a. A graph grammar generating structures of such borders is presented in Fig.3b. The grammar consists of the set of productions $P = \{p_1,p_2,p_3\}$ and the axiom being a node with label S. The connection place of the right-hand side of a production which corresponds to the connection place of the left-hand side is denoted by an arrow.

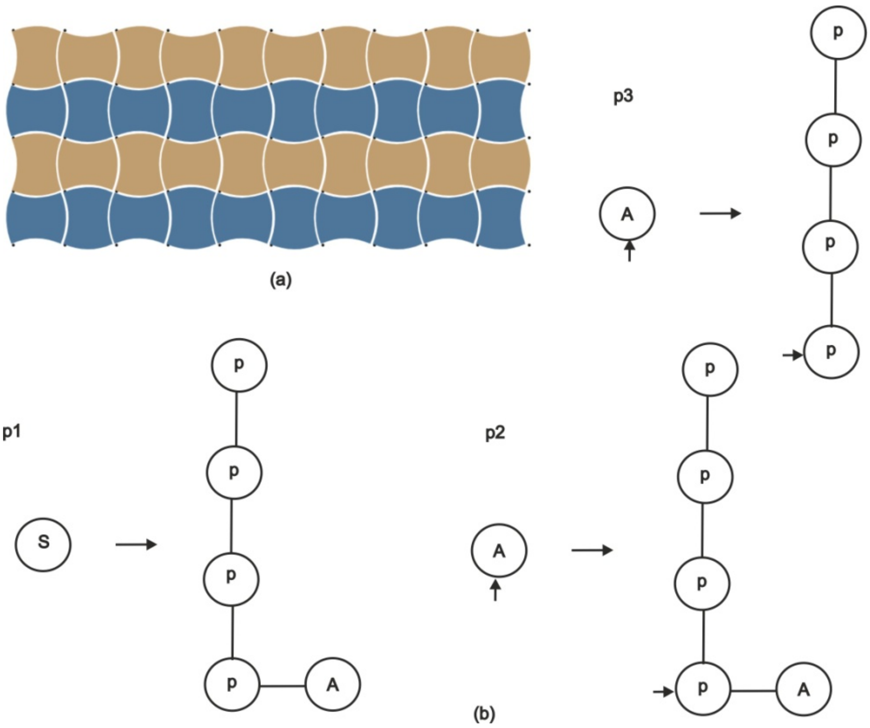

Fig.3 a) A border tile pattern b) a graph grammar generating representing the structure of this pattern

Fig.4 and Fig.5 present the graph grammars used to generate more complex tile patterns. In this case the process of designing starts by selecting the size of tile motifs by the user. It can be 2x2, 3x3, 4x4, or 5x5. In the next step the user defines the colour of tiles for one or two motifs of the chosen size. Then, if only one motif has been defined the rules of the graph grammar in Fig. 4 are applied. If two motifs have been defined both graph grammars are used. The nodes with nonterminal labels *N1* and *N2* are replaced by graphs representing two different patterns or the same one if the only one has been defined.

One motif of the size 5x5 is presented in Fig.1a, while two motifs of the size 3x3 are shown in Fig.6. The grammar from Fig.4 generates graphs representing structures of tile patterns composed of the same tile motif in every second row (see Fig.8c). The grammar from Fig.5 generates graphs representing structures of layouts where tile motifs are arranged alternatively in each row (see Fig.8b).

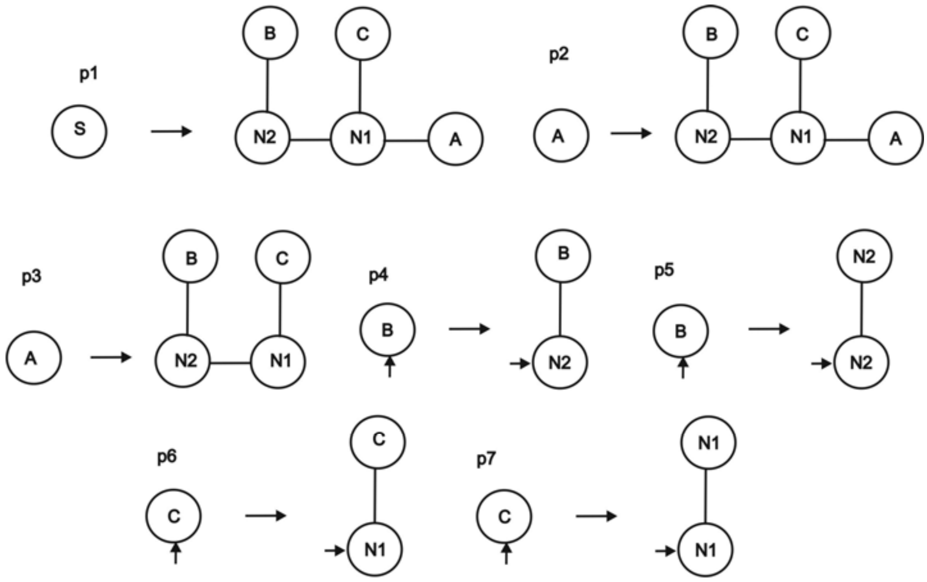

Fig.4 A graph grammar generating structures of patterns composed of the same tile motifs in every second column

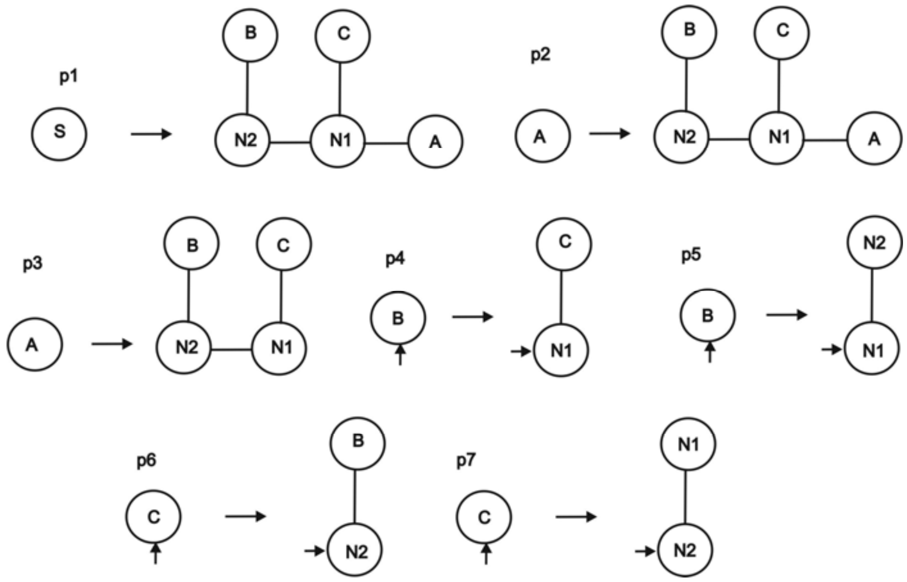

Fig.5 A graph grammar generating structures of patterns with tile motifs arranged alternatively in each row

When a graph representing the structure of a tile layout is created an interpretation of this graph should be specified. The interpretation determines the way in which the tile patterns are transformed in respect to each other. It should be noted that one graph can represent structures of different tile layouts corresponding to various interpretations.

In case of motifs of the sizes 2x2 and 4x4 each motif that should be matched to the motif which is directly under it, can be rotated through 90º or left unchanged. In case of motifs of the sizes 3x3 and 5x5 each motif that should be matched to the motif which is directly under it, has to be rotated through 90º. However it can be rotated as a whole or each tile of the motif can be rotated separately. Therefore if one motif has been defined two different patterns are obtained, and if two motifs have been defined four different patterns are obtained.

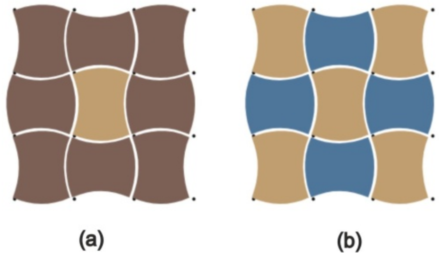

Fig.6 Two tile motifs of the size 3x3

Example 3.2. Tile patterns composed of one motif are shown in Fig.7 and Fig.8a. In patterns in Fig.7a and 7c tile motifs of the size 2x2 and 4x4, respectively, are left unchanged while they are adjusted to the lower motifs. In patterns presented in Fig.7b and 8a every second motif up the row is rotated through 90°. In Fig.8b and 8c two patterns composed of the motifs of the size 3x3 presented in Fig.6 are shown. In both of these patterns every second motif up the row is rotated through 90°, however in Fig.8b motifs are arranged alternatively in each row, while in Fig.8c the same motif occurs in every second vertical row. In Fig.9 another two patterns composed of 3x3 motifs shown near them (Fig.9c) are presented. In the pattern in Fig.9a each tile in every second motif up the row is separately rotated through 90°, while in the pattern in Fig.9b the whole every second motif up the row is rotated through 90°.

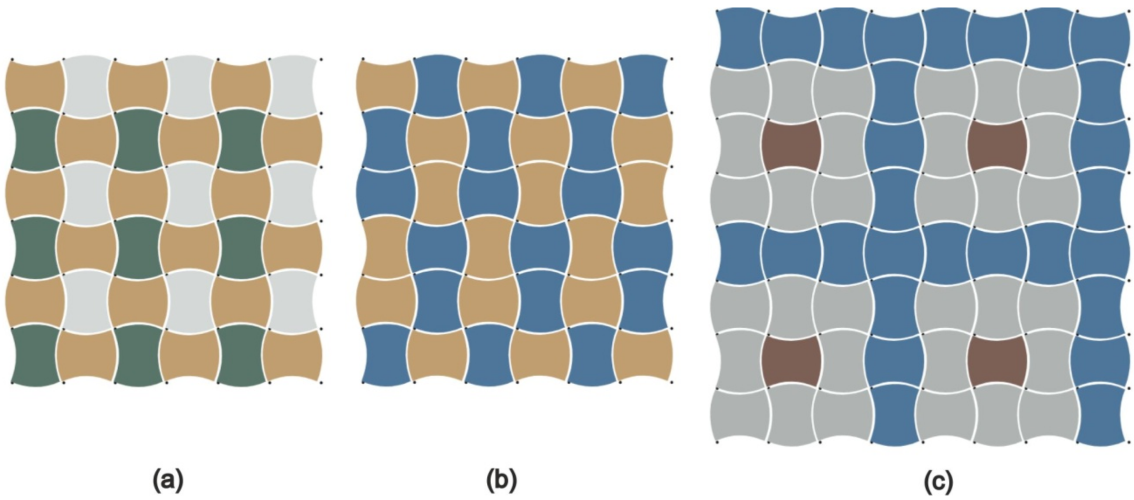

Fig.7 Three tile patterns, each composed of one motif

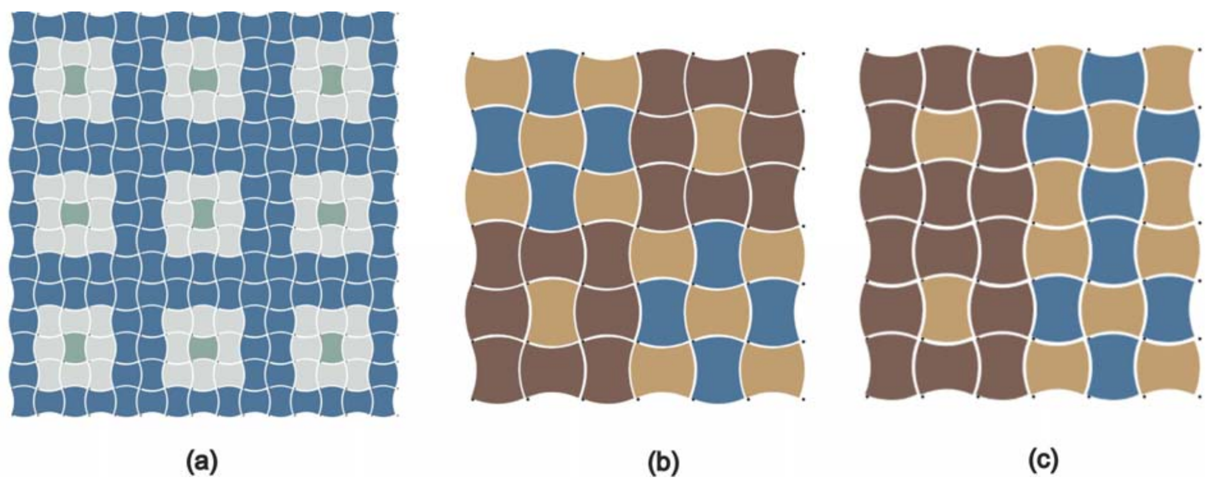

Fig.8 a) A one-motif tile pattern with every second motif up the row rotated through 90°, b) c) two tile patterns composed of motifs from Fig.5, which are arranged alternatively in each row or repeat themselves in every second vertical row

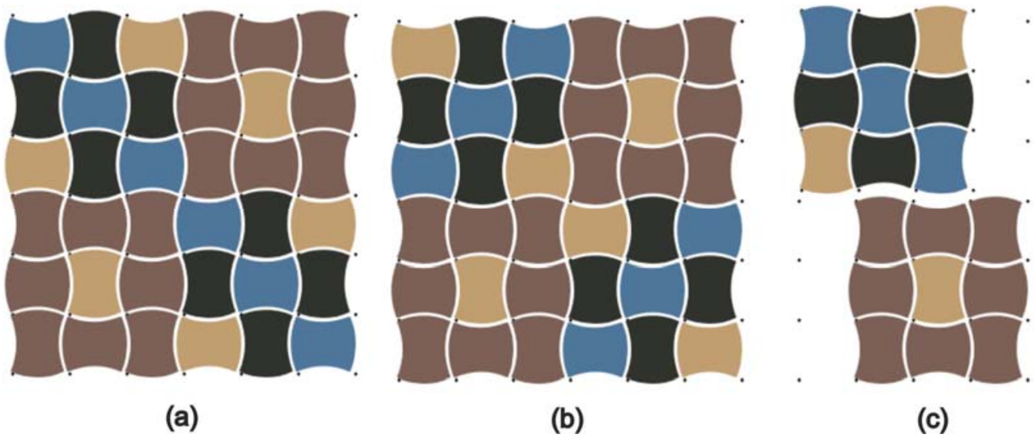

Fig.9 a) A two-motif tile pattern with each tile rotated separately in every second motif up the row, b) a tile pattern with the whole every second motif up the row rotated through 90°, c) two originally defined tile motifs

Plane divisions filled by tile patterns can be based not only on quadrilateral grids but also on triangular grids [3]. The example of filling such a grid by tiles with two different colours is shown in Fig.10. It can be seen that in this case the defined tiles do not fill the whole plane leaving black empty spaces. The emergent black shapes can constitute an inspiration for the designer, who can not only reconstruct the former existing layouts but also create new ones on the basis of the previously existing ones.

Fig.10 A tile pattern with emergent shapes

A big challenge for designing corset tile patterns is a rich range of colours. Thanks to many colours, unusual shapes may be created as motifs. Fig.11 presents the multi-colour corset tile pattern with a floral motif. The basic colour motifs with the palette of colours are shown in Fig.12. The graph grammar generation process of the tile pattern shown in Fig.10 is two-step. In the first step a new pattern consisting of basic motifs is generated. The pattern presented in Fig.12 is a motif for the second step of the generation.

It is worth noticing that a corset grid treated as a layout is a source of inspiration for creating new motifs (see: Fig.14). An example of a corset tile pattern with these motifs is presented in Fig.15.

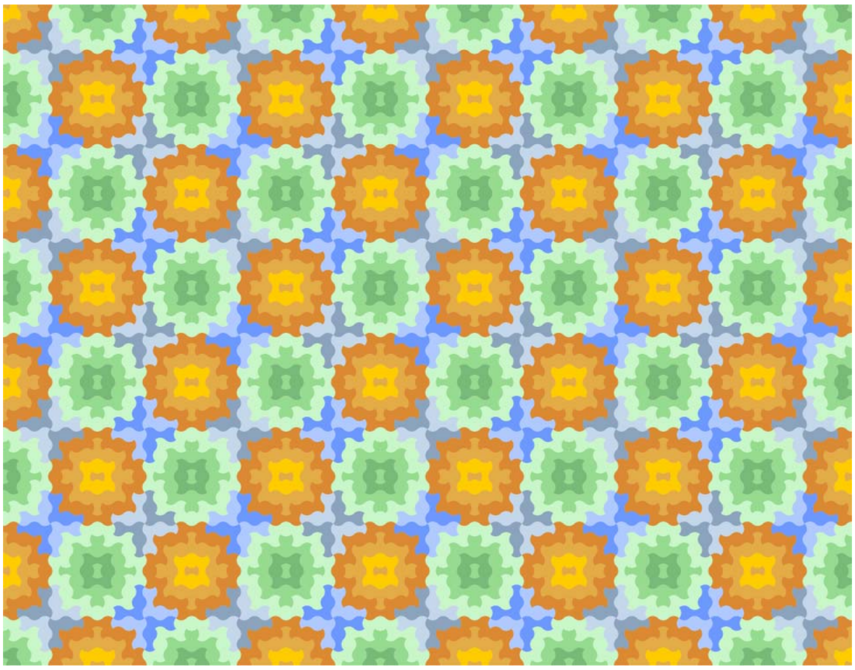

Fig.11 A multi-colour corset tile pattern with a floral motif

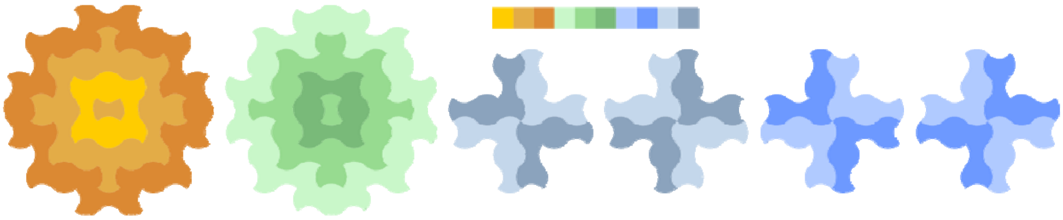

Fig.12 Colour motifs with their pallete of colours

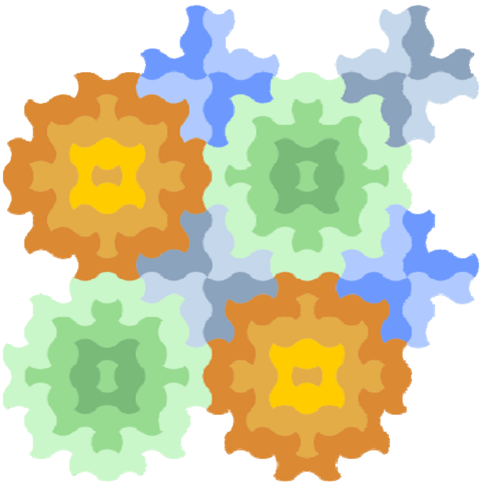

Fig.13 The colour motif for the second step of generation

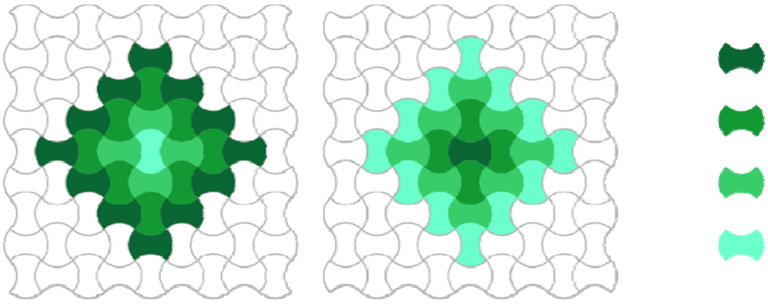

Fig.14 Motifs created on a corset grid

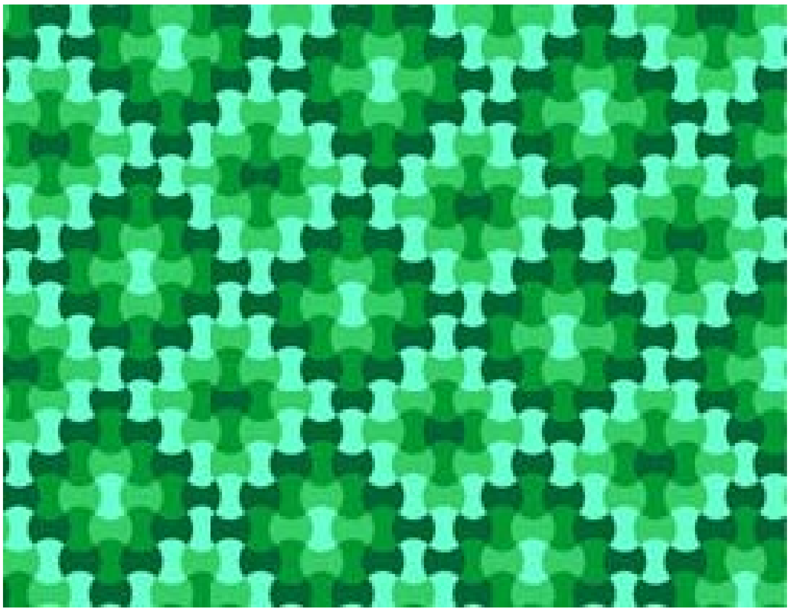

Fig.15 The corset tile pattern with the motifs shown in Fig.14

5. Conclusion

Applying graph-based methods to the design of tile patterns allows us to create a wide range of artefacts. It can be used to assist a designer during the conceptual phase of design. The work presented in this paper can be further developed by proposing a user friendly interface.

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