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RESEARCH ARTICLE

A HIERARCHIC REPRESENTATION SCHEME FOR GENERATING DECORATIVE PATTERNS

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ABSTRACT

This work proposes a representation scheme that uses CAD as a design tool for generating two-dimensional decorative patterns. The proposed scheme is hierarchical and represented as a tree with nodes corresponding to different shapes of pattern. In this work, decorative patterns are viewed as a set of shapes created at three hierarchical levels which are labeled as: Primitive, Motif, and Compound-motif. This CAD paradigm helps the designers/artists to manipulate a set of fundamental shapes (primitive, motif and compound-motif) by transformation rules and to arrange them into some definite order for generating a decorative pattern.

INTRODUCTION

Decorative patterns are defined in terms of abstract entities called shapes. While generating patterns, it is necessary to have a realization that how more complex patterns can be created from simpler shapes. In this view, this work proposes a hierarchic representation scheme for generating two-dimensional decorative patterns in order to use in textiles, furniture, perhaps more prominently in embroidered works. A lot of research has been done in order to generate decorative patterns. Many techniques have been proposed for generating world's famous traditional Islamic star patterns, and all are successful in various ways [1-8]. Many attempts have been made to produce computer-generated decorative patterns. A long time back, Chua [9] described a method of generating patterns aligned along a circular arc with a set of parameters. He implemented his work as supplement to a basic CAD/CAM system so as to benefit application users in various fields. Kaplan [10-11] presented a process for creating computer-generated Islamic star patterns, acknowledging a technique described by Hankin. Kedar [12] proposed a geometric model for generating two-dimensional patterns. The proposed model is hierarchic and represents pattern as a tree. He implemented the model in a program that reads in a shape description, builds a tree of shapes and renders the pattern. Shrivastva [13] made an attempt to develop three dimensional model of a specific variety of parametric Rangoli and Phulkari patterns. He developed macros to generalize the parametric patterns and to allow the user for developing these types of design features with minimum requirement of expertise in this field. Trivadi [14] presented an application of CAD, Rapid Prototyping and Reverse Engineering for brassware products. He proposed a software where several motifs can be made using various primitives. Using this software it is possible to make many designs motif with lot of variation and take lesser time than traditional handwork. Gulati [15] developed a parametric CAD modeler for designing Islamic star patterns. He used the rendered star patterns as a fundamental resource to archive decorative effects. The rendered patterns were employed for computer-controlled manufacturing to produce traditional latticed screens.

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Representation scheme

The proposed scheme is hierarchical and represented as a tree with nodes corresponding to different shapes of pattern. Decorative patterns are based on the repetition of shapes positioned at regular, or measured, intervals. Shapes are neither overlapped nor separated at awkward distances with respect to pattern. Here in particular, decorative patterns are understood as a set of shapes created at three hierarchical levels which are labeled as: Primitives, Motifs, and Compound-motifs. In formal sense, this understanding corresponds to view the patterns in terms of vocabulary of Primitives/Motifs/ Compound-motifs along with transformation rules between them. The basic idea of proposed representation scheme is to capture the symmetry amongst the patterns that are realized as a symmetric arrangement of similar or different shapes in planar map. Symmetry deals with transformations such as translation, rotation, reflection, glide reflection etc. (see Figure 1) that defines positions of shapes with respect to pattern in a two-dimensional plane.

This representation scheme uses CAD as a design tool that helps the designers/artists to manipulate a set of fundamental motifs and to arrange them into some definite order for generating a pattern. This tool reduces the effort and time of the designer/artist by minimizing unnecessarily tedious or repetitive tasks.

Hierarchical levels

Hierarchy of this shape representation scheme is of multilevel nature. In the particular domain, shapes are defined at three hierarchical levels. High-level shapes consist of one or more than one consequent low level shapes. The modeling coverage of the patterns depends upon the richness of shapes created at different levels. At the first level, the term primitives are created with a meaning of atomic geometric objects/entities required for the representation of next level shapes i.e. motifs or compound-motifs. Primitive is the geometry made from the 2-D analytical entities such as polyline, circle, polygon, arc, conics, curve, etc. It is in the form a planar map having a set of points whose coordinates are defined in terms of parameters. At the next level, motifs are created. Motif is regarded as a collection of primitives having a particular position in the 2-D plane. Motif's construction can be seen as a two stage process, where in the first stage the primitive is defined, and in the second it is repeated under symmetry transformations. Further, compound-motifs are designed with a special theme of aligning motifs along a circular arc or line or specified path. The aesthetic sense of the compound-motif is derived from its geometrical symmetry.

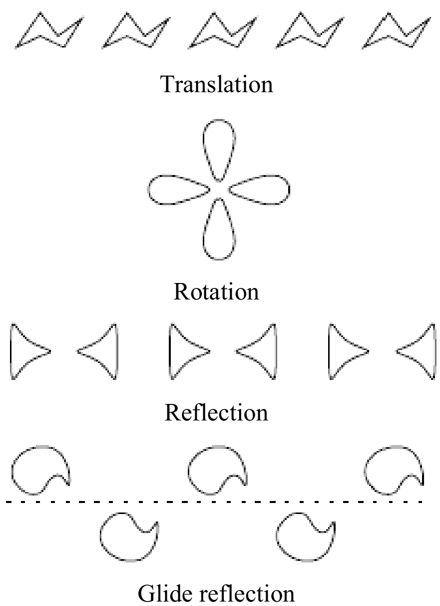


Fig. 1: Transformation rules

Paradigm 1: Star patterns

In this CAD paradigm [15], the idea is to create a rich source of star patterns using parametric modeling and with the description of shapes at primitive, motif and compound-motif levels. Here, primitive is a collection of two line segments joined with each other at their end points. Line segment is defined with two points whose coordinates are devised in terms of the modeling parameters (n, r and θ). Further, star shaped motif is characterized as a polar array of the primitive.

At the next level, compound-motifs are designed with a theme of having a star shaped motif surrounded by other star motifs (see Figure 2). From aesthetic point of view, it is realized that three same or different types of motifs are positioned (one at centre and two at its surroundings) in a compound-motif. Same types of star motifs are placed at alternate positions around the central motif of having only even number of rays. From structure point of view, all compound-motifs are viewed as a connection of motifs where each of the surrounding motifs is in contact with the central motif and it's neighboring one. The connection is through the star/rosette rays and/or sides of polygon (Figure 3). This connection depends upon the algebraic sum of interior angles of boundary polygons of three motifs. If algebraic sum is 360^o, only then each surrounded motif is in contact with its neighboring one and central motif.

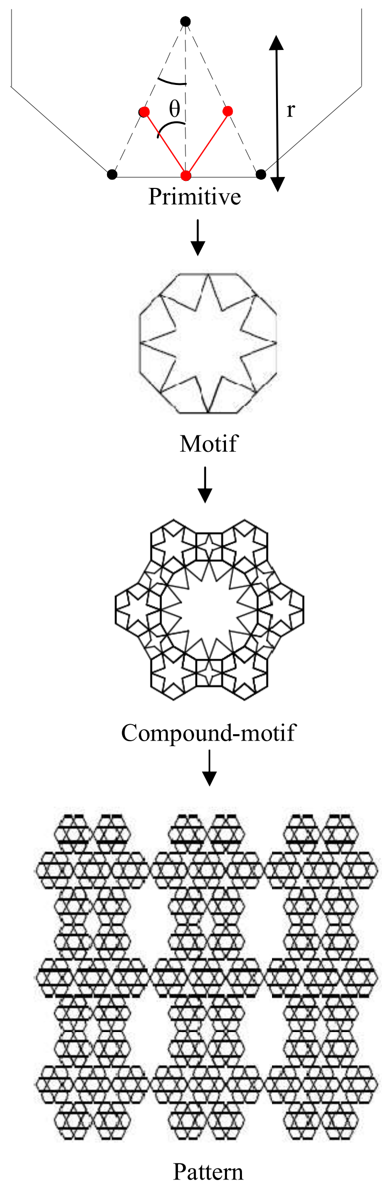


Fig. 2: Hierarchy of Star Patterns

Paradigm 2: Floral patterns

An example of floral border is discussed here for illustration. Petal is the primitive used for floral patterns. Geometrically, it is a collection of two curves joining at their start and end points. A curve is defined with start, end and a number of fit points. The position of fit points decides the shape of the petal. Flower is the motif created from the two motifs i.e. circle and petal.

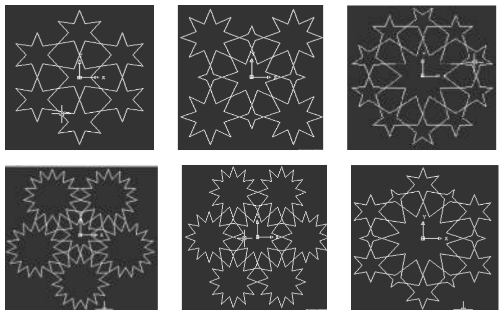


Fig. 3: Rendered Compound-motifs

A number of petals are symmetrically placed around the circle in such a way that one end of the petal touches the circle (see Figure 4). Compound-motif has been designed by aligning floral motifs along a line in such a manner that motifs are neither overlapped nor separated at irregular distances. Further, transformation rules allow the arbitrary placements of compound-motif to create the floral pattern in the form of a rectangular border.

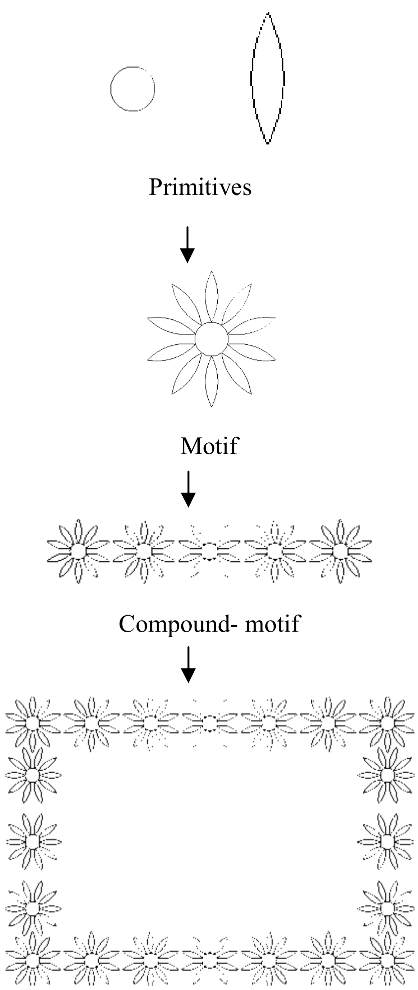
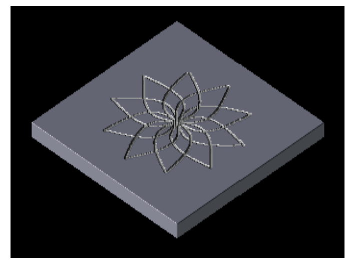


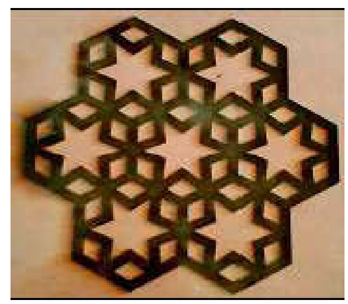
Fig. 4: Border Floral Patterns

Concluding remarks

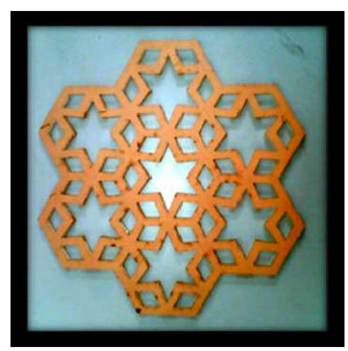
This concept provides generic mechanism for defining, manipulating and representing shapes at different levels i.e. primitives, motifs, compound-motifs and patterns. The idea of using the field of computer aided geometric modeling towards pattern representation has been succeeded. The proposed representation scheme is able to produce computer understandable 2-D patterns that can be transferred to computer controlled manufacturing for creating various types of artifacts (Figure 5).



Engraved Floral Motif for Stamp Block



Carved Star Shaped Compound–motif on Wood



Lattice-worked Star Shaped Pattern on Wood

Fig 5: Artifacts created using Computer Controlled Manufacturing from the Rendered Representations

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