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A CAD Paradigm to Produce Traditional Wooden Chip-Carvings

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Abstract

CAD and digital technology is naturally a important element in preservation of traditional work. Chip-carving is a traditional art form, usually utilized for decorating wooden flat surface in a single piece. A craft-specific CAD tool presents new opportunities for novice user to participate in design process. The geometric shapes are based on the repetition of shapes positioned at regular, or measured, intervals. chip-carving patterns have been realized as periodic and repeated arrangement of incised motifs. This work present a parametric CAD modeling of chip carving designs. Carving element are parametrized in form of carving incisions.

Keywords: CAD/CAM, Chip Carving, Parametric Modelling

1. Introduction

Indian handicraft sector includes production of delicate handicrafts using diverse raw materials in different parts of the country, majorly jewelry designing and manufacturing, stone work, wood carving, glass etching, clay work, metal and leather work, textile printing and embroidery etc. Carving is technique to reduce wood using carving tools by the craftsman's. Chip-carving is a traditional art form, usually utilized for decorating wooden flat surface in a single piece. This art form is being used in decoration trade, particularly in home furnishing items. This is executed by making very precise, angled cuts. It is a type of carving in which knives or chisels are employed to remove small chips of wood. It creates of a series of angular incisions into the surface that leave a decorative pattern behind. Its traditional method of making starts with pencil drawing of a pattern, then follows with chiseling of the pattern to create angular incisions and finally ends with removing chips of wood. This is a very labor intensive and time consuming task even performed by the skilled craftsmen. As a result this traditional art form is currently fading due to lack of indigenous knowledge and interest of forebears. Therefore, in order to preserve its traditional production method for descendants and persons who are interested to generate signature work of chip-carvers with minimum requirement of expertise, this work presents a paradigm to produce traditional piece of wooden chip-carvings using computer aided geometrical modelling techniques.

In the design world, the driving force of computation tools of modern computer is moving towards to expertise craftwork and customization offers new paradigms for modelling and manufacturing of traditional artifacts. A craft-specific CAD tool presents new opportunities for novice user to participate in design process. A computational tool in hybrid conjugation with digital manufacturing is turning towards to become an integral element of professional art and design, as these are compatible with traditional crafts. Recently, developed CAD/CAM technologies are employed more and more in industry to increase efficiency and speed up product development time meanwhile craftsmen tend to their practices using CAD/CAM technologies.

(a) (b) (c)

Figure 1: Wooden chip-carvings

2. Related Work

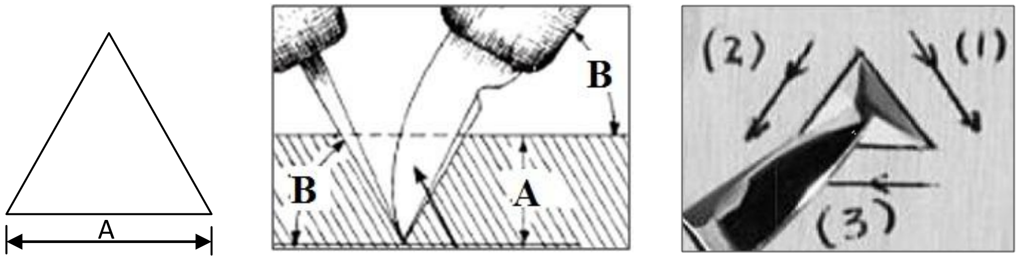
The traditional crafts are the living tradition of peoples/societies and not fixed by inherited or costly items. Today, the complexity is increasing in designs of the objects which create a distance of craftsman from construction of specialized items. CAD not only enhances the product quality but also provide a opportunity to refine/redesign the results (Cheng. 1995). The designs of chip carving are produced as a result of transformations to a geometric shape that conform a featured pattern. A CAD paradigm to produce traditional zillij style of geometrical pattern is developed by Gulati et al. (2010). A digitally controlled milling device is developed for creating 3D objects (Zoran and Paradiso. 2013). A integrative approach to 3D modeling is presented by Chen et al. (2008). This method gives a modelling approach to create 3D surface from 2D patterns using normal distribution and distance function. The tools is developed so that there is user involvement in milling process. A CAD paradigm is developed by Kaplan et. al. (2004) to integrate NC machining into casual woodworking for non-technical users. A semi-automatic design tool is developed for fabrication of static models and also allows the alteration in design directly or parametrically (Zoran et al. 2013). A CAD tool for the modeling of ornamental products is presented by Gulati et al. (2009).

3. Traditional Geometrical Incisions

Many types of tools, differs in size and shape are used to create different surfaces such as flat, grooved or round and so on. The depth of cut is controlled by slant angle of chisel and hand push. Traditionally, there are four styles of geometrical incisions that have been universally and widely used in wooden chip-carvings.

3.1 Three-sided Deep Incision

This style of incision is created with three equally angular and deep cuts in a triangle (Figure 2). These triangles can vary in size and shape, with some being long and thin, while others are short and fat. All of the three cuts converge at a point. The incision is of reversed triangular pyramidal shape (Figure 2c). Dimension ‘A’ of the triangle represents both depth and width of the cuts. Angle ‘B’ corresponds to the angle of knife entering into the piece of wood for all the three cuts that varies from 45 to 60 degrees (Figure 2b).



(a (b) (c)

Figure 2: Three-sided deep incision

3.2 Three-sided Shallow Incision

In this style, there are two vertical cuts on the two sides (1 and 2) of triangle and a taper cut at the triangle‘s point which decreases in depth towards the triangle’s base. In Figure 3, Dimension ‘A’ is equal to the depth of the chip at the triangle‘s point. Angle ‘B’ is equal to the angle of the taper cut.

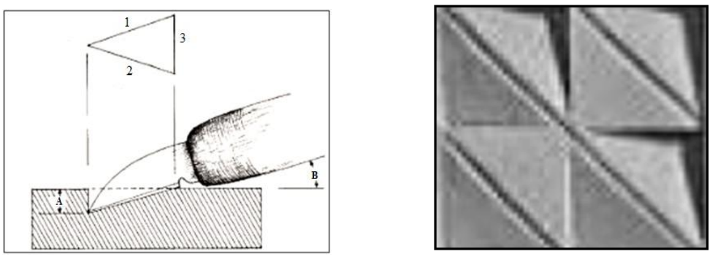


Figure 3: Three-sided shallow incision

3.3 Four-sided Deep Incision

In this style, there are four equally angular cuts in a rectangle/square/parallelogram/rhombus (Figure 4). All of the cuts converge to same depth. Dimension ‘A’ represents both depth and width of cuts. ‘B’ represents angle the angle of knife entering into the piece of wood for all the four angular cuts that varies from 45 to 60 degrees.

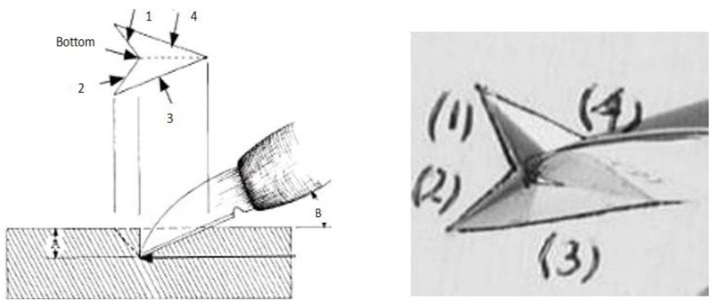


Figure 4: Four-sided chevron shape incision

3.4 Chevron Shaped Incision

This style of incision is in the shape of a chevron. It consists of two angular (for sides 3 and 4) and two vertical cuts (for sides 1 and 2) (see Figure 4). All of the four cuts converge at a point called bottom. ‘A’ and ‘B’ are equal to depth of cut and angle of cut respectively for the sides 3 and 4.

4. Modeling Approach

Decorative patterns are defined in terms of abstract entities called shapes which are neither overlapped nor separated at awkward distances with respect to pattern. These are based on the repetition of shapes positioned at regular, or measured, intervals. While generating decorative patterns, it is necessary to have a realization that how more complex patterns can be created from simpler shapes. In this view, a hierarchic representation scheme has been proposed in this work for generating two-dimensional decorative patterns. The basic idea of the 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 through the use of transformation rules such as translation, rotation, reflection, glide reflection etc. that defines positions of shapes with respect to pattern in a two-dimensional plane. In particular, decorative patterns are understood as a set of shapes created at three hierarchical levels which are labeled as: (i) Primitive (ii) Motif (iii) Compound-motif. In formal sense, this understanding corresponds to view the patterns in terms of vocabulary of primitives, motifs and compound-motifs along with transformation rules between them. This representation scheme has used CAD as a design tool for creating parametric motifs and arranging them into some definite order.

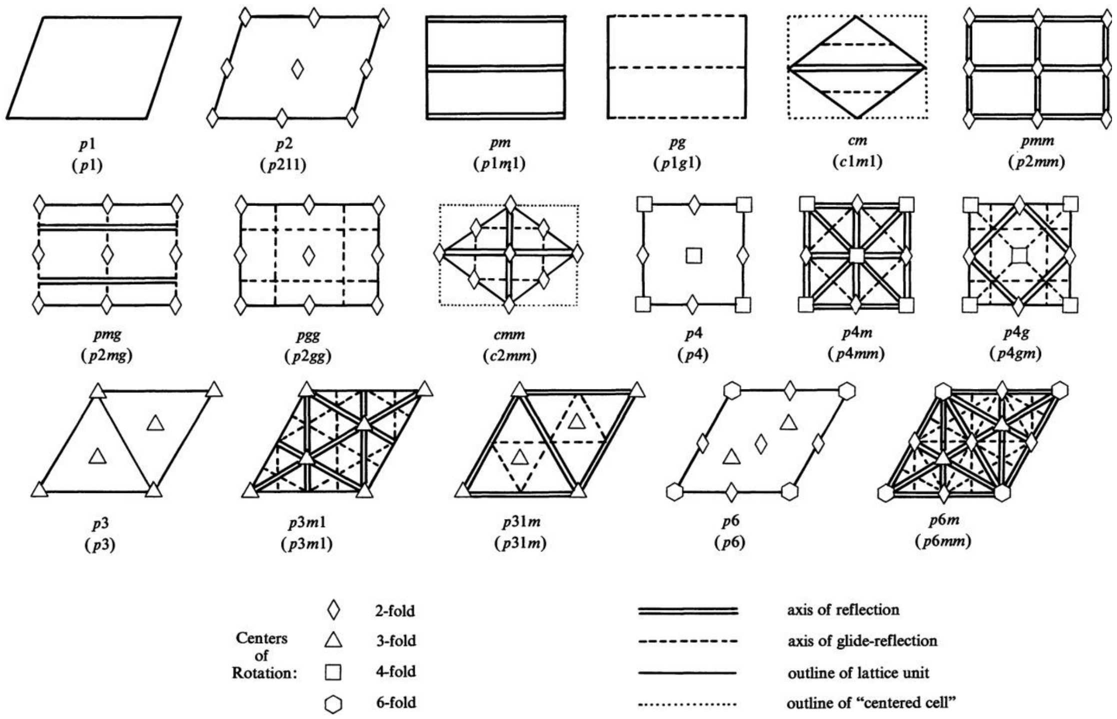


Figure 7: Possible Symmetry Group

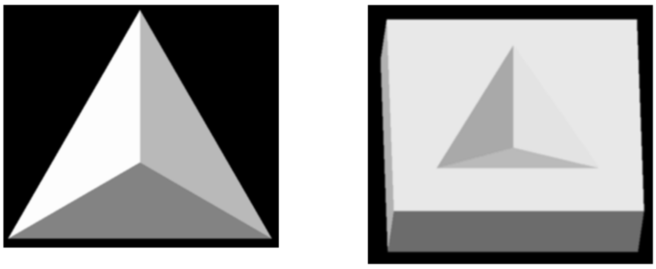
From symmetry point of view, chip-carving patterns have been realized as periodic and repeated arrangement of incised motifs. Further, a motif is viewed as an array of same or different traditional incisions (Figure 4). All of the chip-carving patterns are worked in a line design which is in the form of a grid having triangles, chevron shapes, and 4-sided regular polygons. Through positive and negative spaces it is possible to create different chip-carving patterns from a grid. Positive space for chip-carving is the shape (triangle, chevron shape, and 4-sided regular polygon) that is to be incised within the grid. Negative spaces therefore become those areas that are not to be carved. For instance, Figure 1 shows a beautifully intrigue chip-carving pattern in which every possible area is considered for incision. This pattern contains no negative spaces.

The motif of the pattern contains four three-sided angular and deep incisions created in the four triangles shown in the grid with different colors.

Mostly, the geometric chip–carvings are classified into 17 groups by symmetry and their motif shape (Fig. 7). In their definitions, a group contains at least one of the characteristics of translational, rotational, reflectional and glide-reflectional symmetries [8]. These groups are named as p1, p2, pm, pg, cm, pmm, pmg, pgg, cmm, p4, p4m, p4g, p3, p3m1,p31m, p6 and p6m, where letter p denotes a primitive while c is a face-centered cell. The integer that follows p or c indicates the highest order of rotational symmetry that is 1-fold, 2-fold, 3-fold, 4-fold or 6-fold. Symbol m refers to reflectional symmetry while symbol g refers to glide-reflectional symmetry. A glide-reflectional symmetry means that a pattern can reflect in one line and translate along a certain distance, in order toare get exactly the same pattern.

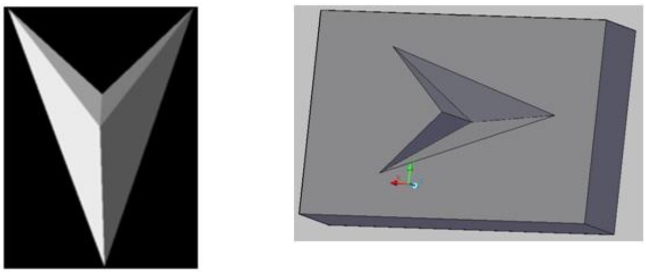
5. Conceptualization Traditional Incisions

Geometrical chip-carvings can be viewed as an array of a fundamental element, called motif, along with four types of isometrics namely translation, reflection, rotation and glide-reflection. As chip-carvings are the repetition of incised geometrical motifs so, these motifs are defined in terms of A set of shapes created at geometric level.



(a) (b)

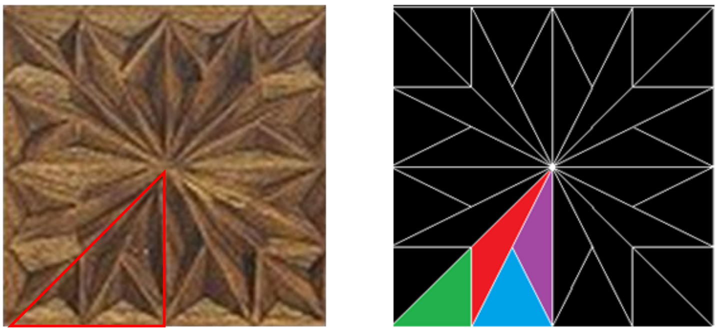
Figure 5: Three-sided deep incision



(a) (b)

Figure 6: Four-sided chevron shape incision

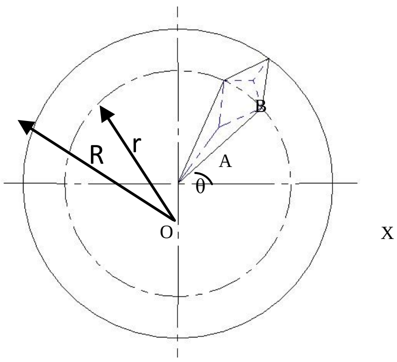
For instance, the chip carving (shown in Figure 8.) having a polar array can be decomposed into a number of atomic geometric shapes called primitives. Comprise of a number of same or different styles of incisions. All traditional incisions are in the form of a recess as carved with a sharp knife on flat surface. The shape of recess is different for each incision. For instance, in three-sided deep incision, the recess is of reversed triangular pyramidal shape.



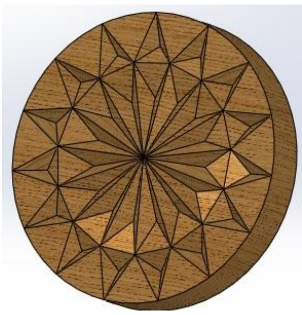
(a) (b)

Figure 8: Parameterization according to symmetry

Modeling strategy for this style of incision is to generate a triangular pyramid of sufficient depth and get subtracted from the basic constructive rectangular block (see Figure 5 and Figure 6). The sketching approach is employed for creating the triangular pyramid, which makes use of a triangle profile in XY plane followed by extrusion operation to depth ‘A’ and taper angle ‘B’ in Z direction.



(a)



(b)

Figure 9: (a) Paramerization of Three-Sided Incision Chip in a rosette Pattern (b) CAD Model

6. CAD Modeling

The modeling of the chip carving depends on type of incision cuts. The modeling steps of incision carving are as:

1. Elements for incision is parameterized as set of modeling parameters depending on type of incision(two sided, three sided or four sided) and main parameters are as *w, b, H, R, r, θ, N* and *t.*
2. A two sided chip is defined by width *w* and base *b* of a rectangle and incision cut is defined by t .
3. A three sided chip is defined by base *b*, height *H* and depth of incision t. The shape removed from block as an inverted pyramid shape. According to depth of cut *'t'*, the incision angle changes. A low angle makes a shallow chip, a steep angle cuts a deep chip.
4. In a rosette pattern, the incision cut are defined by angle *θ* and number of leafs *N*. In double incision two radius are defined as *R* and *r* (Figure 9) .
5. A four sided chip is defined rectangle parameters as width *w* and base *b* and depth of incision '*t'*.
6. Compound-Motifs/patterns are defined according to arrangements of motif as N_x and N_y in case of rectangular array and by *θ* or *N* in polar array.

7. Conclusion

CAD and digital technology is naturally a important element in preservation of traditional work. Digital tools are useful in extending traditional work and enhancing traditional skills, without replacing tradition. This work is towards development of CAD tools for traditional wood carving work. Carving element are parametrized in form of carving incisions. Traditional crafts are highly unique and have vast potential which needs to be capitalized to create intersection between technology and tradition. Today, CAD/CAM software has ability to design and manufacture the complex geometries that previously were not possible with traditional manufacturing. Digital manufacturing with the appropriate craft-specific helps people preserve their tradition and support existing traditional techniques and create new designs.

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