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A Jewelry Modeler for Carved Bangles

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ABSTRACT
A parametric voxel-based jewelry modeler is developed for designing carved bangles of sophisticated craftsmanship. Carved jewelry is the form of jewelry having small internal repeated cavities as engraved with a thin sharp tool on the surface of sheet metal. The parameters' values are defined by the user and modeling of the jewelry design is carried out by the modeler based on the specified values of the parameters. The modeler combines multiple copies of a parametric voxel element to deliver more number of jewelry designs. Voxel is a building block of a design model and defined by parameterized geometry and attributes. A voxel library is created from which voxel elements are selected. The jewelry modeler supports diverse integrated manufacturing through computer controlled manufacturing.

Keywords
Parametric, Voxel, Jewelry modeler, Bangles

1. INTRODUCTION
In India, bangles made from gold have a religious connotation and a deep social significance. Gold bangles are part of traditional jewelry, usually worn by women on arms. Mostly, gold bangles have been studded with precious diamonds, gems and pearls or carved in low relief with decorative designs. These styles of exquisite bangles are very expensive because of having precious stones and heavy weight. Therefore, this work is towards the modeling a style of light-weight bangles with a number of deigns with even higher numbers of variations. In particular, this paper makes the technical contribution of developing a parametric voxel-based jewelry modeler for designing carved bangles (Figure 1). Carved jewelry is the form of jewelry having small internal repeated cavities as engraved with a thin sharp tool on the surface of sheet metal. Parametric modeling is incorporated to capture the designer's intent, to get the variation in jewelry designs and to support customized jewelry design process.

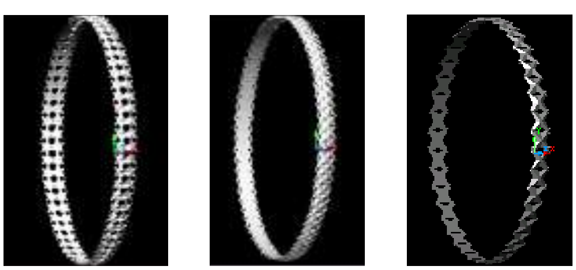


Figure 1: Carved Bangles

All commercial systems for jewelry designing have capabilities of good rendering and exporting models to rapid prototyping machines [1-4]. But in majority of these systems, designing is performed manually using various tools and usually the design steps cannot be programmed to be executed automatically. This means that each different piece of jewelry would have to be created basically from the beginning. Some parametric systems have been developed where the jewelry design is expressed by a set of parameters and constraints and the user's participation in the design process is through the dentition of the parameter values. ByzantineCAD has been developed for the designing of pierced medieval Byzantine jewelry [5-6]. A parametric voxel based approach has been presented to produce for stretch-formed and carved jewelry [7-8]. A jewelry modeler has been created for designing fret-worked jewelry [9]. A feature based CAD approach to re-engineering jewelry has been presented [10-11]. Moreover, an aesthetic driven approach to jewelry design has also been presented which proposes a CAD tool to automate jewelry art form generator [12].

2. THE JEWELRY MODELER
The jewelry modeler provides the design tool in the hand of user by eliminating the formal designer. It produces CAD models supporting diverse integrated manufacturing. It is able to generate a wide range of design models. It is capable of producing real and tangible artifacts directly from 3-D CAD models. The modeler provides two options for fabricating jewelry prototype. First is based on CNC machining and second is rapid prototyping [13-15]. The parameters' values are defined by the user and modeling of the jewelry design is carried out by the modeler based on the specified values of the parameters. The modeler combines multiple copies of a parametric voxel element to deliver more number of jewelry designs. Voxel is an integral part of modeling and is defined by a set of parametric attributes. Voxels are created by using the sketching approach which uses 2-D entities to sketch a profile followed by 3-D operations such as extrusion. Some of the profiles and voxel elements created from these profiles are shown in Figure 2 [9]. These voxel elements are grouped in the voxel library that is an open-ended catalogue to which new elements can be added. The possible variations in designs of jewelry depend upon the richness of voxel elements in voxel library.

The user's interaction is directly turned into 3-D solid jewelry models with selection of a voxel element from a group of predefined voxels and descriptions of the modeling parameters that refer mostly to the appearances, size and content of the final design. During the design process a parametric voxel is created, its multiple copies are configured and joined into a type of jewelry (bangle).

3. MODELING PARAMETERS
The modeling coverage of jewelry designs depend upon the richness of voxel elements and a variety of voxel elements can be modeled with the appropriate definitions of modeling parameters.

The geometry, size and carving aspects are defined as a collection of parameters. A voxel element is described with a signature which is a set of modeling parameters and represented as P/L/H/δ/X/Y/R. For an example, a voxel element of signature 9/10/1/60/2.5/2.5/2.5 is shown in Figure 3. All of these modeling parameters are illustrated in Figure 4 [8].

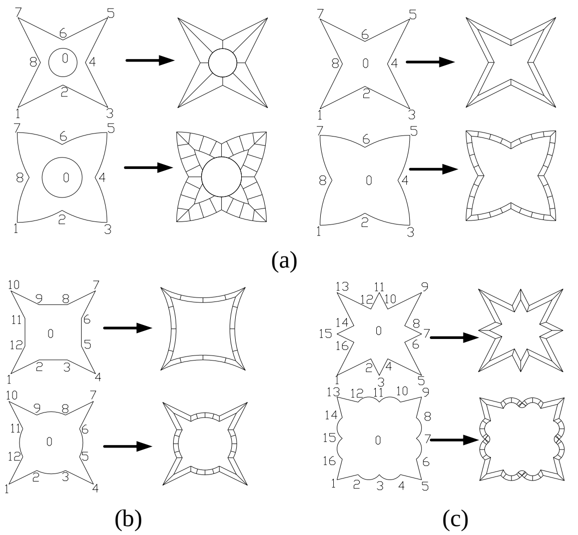


Figure 2: (a) Voxel elements with nine valid points (b) Thirteen valid points (c) Seventeen valid points.

1. Valid points (P): This parameter defines the class of a voxel and hence the type of carving effect. It represents maximum number of valid points from which voxel is created. It may be nine, thirteen, or seventeen. The profile of voxel element is assumed to be inscribed in a square. The center and four corner valid points of the square are fixed. The rest of valid points are variable. Figure 3 shows a voxel with nine valid points i.e. from 0 to 8. Points 2, 4, 6, 8 are variable points and points 0, 1, 3, 5, 7 are fixed. Variable points 2, 4, 6, 8 can vary between points 0 to a, 0 to b, 0 to c, and 0 to d respectively.

2. Size of voxel (L): This parameter represents the size of the voxel element and hence the width of carved bangle (Figure 5). It is equal to the size of square in which voxel profile is created.

3. Thickness of voxel (T): It is the height of extruded voxel. This parameter is responsible for the thickness of jewelry bangles (Figure 5).

4. Inclination of side surface (δ): This represents taper angle of extrusion process along Z-axis. This parameter is responsible for giving carving effect to the jewelry type.

5. Variant (X & Y): These are defined as distances between fixed point and next/previous variable point in horizontal and vertical direction. Variants are used to get different profiles of a voxel class and hence variation in jewelry designs. The relations $L/8 \leq X, Y \leq 3L/8$ and $R < L/2 - Y$ are used as constraints for the class of voxels having nine valid points.

6. Radius of center hole (R): Voxel elements may be classified as with or without hole at the center with radius R.

7. Size of bangle (S): It is size of bangle which suits the wrist of the arm of the user (Figure 5). It is the distance between the inner side of the voxel in YZ side plane and the axis of rotation along X axis passing through a point.

8. Number of overlapped voxels (N): Multiple copies of a voxel are required to be overlapped about a polar axis for producing the carving effect in bangles. Higher the number of voxels, finer is the carving effect.

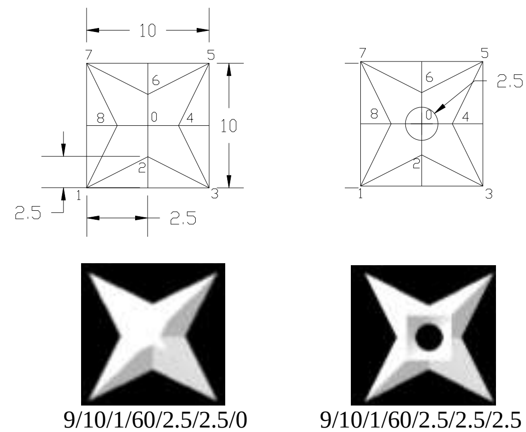


Figure 3: Voxel elements with and without hole

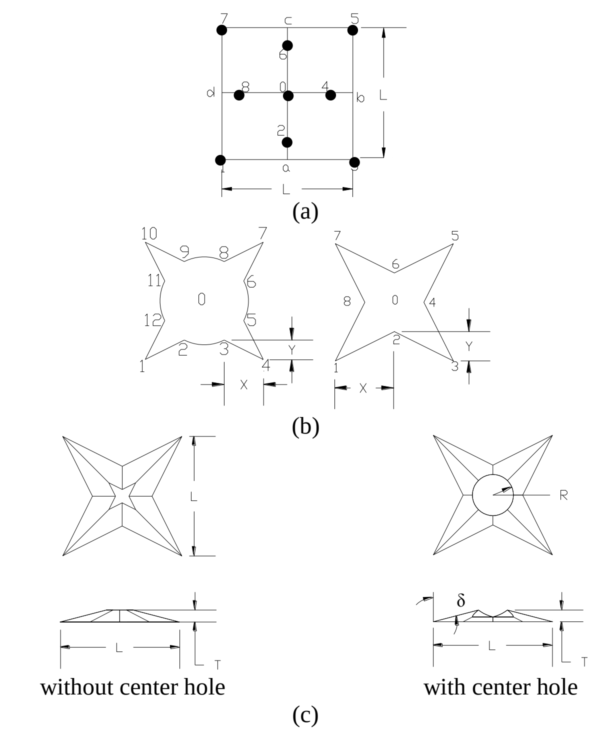


Figure 4: Modeling parameters (a) Valid points (b) Variants (d) Dimensions of voxel and inclination angle of side surface

4. MODELING PROCESS

A signature (9/10/1/60/2.5/2.5/0) is defined for modeling the voxel element in XY front plane. The generated voxel is transformed to YZ side plane as shown in Figure 5. Multiple copies of the transformed voxel are partially overlapped in the same plane (YZ plane) about an axis of rotation passing through a point along X axis. This axis of rotation is at a distance equal to the size of bangle ‘S’ from inner side of voxel. Horizontal coordinate of this point is equal to size of bangle ‘S’ and vertical coordinate equal to vertical coordinate of valid point ‘0’ (i.e. L/2). As one coordinate of this point is fixed, jewelry designs do not change at all by changing this point with keeping number of overlapped voxels ‘N’ constant. This only changes the size of the bangle. But designs will change by varying the number of overlapped voxels. Some of such types of design models are shown in the Figure 6.

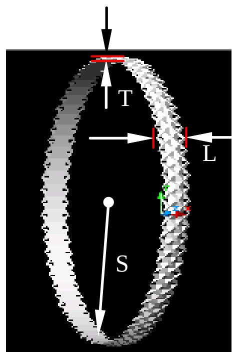
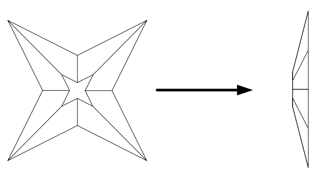


Figure 5: Dimensions of a bangle



(a) (b)

Figure 6: (a) Voxel (9/10/1/60/2.5/2.5/0) in XY front plane
(b) Voxel in YZ side plane

N= 40 N=50 N=60

Figure 7: Variation in appearances of bangles with the change in number of overlapped voxels

5. IMPLEMENTATION

This paradigm is implemented under the ActiveX and Visual Basic Application (VBA) programming environment using AutoCAD. AutoCAD is capable of creating STL file, which can be submitted to rapid prototyping machine to create the jewelry master pattern.

6. CONCLUSION

This approach creates jewelry designs using the parameterized voxels. The usefulness of the approach relies on the use of standard tool by CAD system and parameterization of voxels. The goal of generating a jewelry modeler for the carved bangles has been achieved through a parametric voxel based CAD paradigm. This paradigm provides the capability of designing custom jewelry using the parametric design concept that gives a large number of variations in the designs. The geometric modeling techniques used in this work are quite simple, yet their results are very beautiful and inspiring.

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