Journal of Material Science and Mechanical Engineering (JMSME)
p-ISSN: 2393-9095; e-ISSN: 2393-9109; Volume 3, Issue7; October-December, 2016 pp. 479-484

http://www.krishisanskriti.org/Publication.html

Production of Traditional Twisted Wire Jewelry Designs using Mathematical Shapes

Vishal Gulati[1] and Sonu Mathur[2]

[1,2]Mech. Engg.Deptt.Guru Jambheshwar University Of Science And Technology, Hisar GJUS&T, Hisar
E-mail: [1]vishal_gulati_in@yahoo.com, [2]sonu.mathur87@gmail.com

Abstract—*The present day parametric modelling plays a central role for making CAD/CAM systems from the purely mathematical and computer science viewpoint and is effective in users' design and it provides a useful foundation for a variety of applications, like product designing, jewelry designing, animation and virtual reality. Twisted wire jewelry is a traditional craftwork and unique in aesthetic aspect. In order to extend the range of twisted wire jewelry designs, a variety in parametric geometrical decorative shapes are required. Therefore, this work is towards the exploration of parametric mathematical decorative curves/shapes which yield a wide range of variation in shapes/motifs, hence, in wide range of jewelry designs in this particular class. The application programming interface (API) of CAD system offers a great opportunity to access their functionally using programming environment to make a customized CAD tool for twisted wire jewelry.*

Keywords*: Parametric Modeling, CAD, Jewelry.*

1. INTRODUCTION

Twisted wire jewelry is a traditional craftwork and unique in aesthetic aspect. Twisted wire jewelry technique involves entwining precious metal wires to form a lacy structure. Creating this artwork requires a specialized skill for the present-day jeweler, in ancient times this completely handcrafted technique was a customary skill of all jewelers. Over the past few centuries, this jewelry has been constructed in many cultures and varied in form and pattern.

The worldwide developments have taken place in graphics capabilities of computers enormously during the last decades. Therefore art and crafts sector can be empowered with the new tool and technology. Product innovation and improvements in design technologies is necessary for keeping this sector economically sustainable. The use of the computer in a designer/maker practice is not changing the fundamentals of the concept of the craftsman; instead this should be seen as an opportunity to develop traditional skills with new processes and aesthetics. Furthermore, in the past hundred years, our understanding of the mathematical structure of ornament has increased.

Here, we present approach to develop a mathematical basis for jewelry design creation, software tools that combine interactive and automatic design, and technology for applying digital manufacturing of traditional twisted wire jewelry.

Fig. 1: Traditional Twisted Wire Jewelry Design

2. RELATED WORK

The jewelry industry has traditionally been regarded heavily craft-based. CAD and RP technology in jewelry designing and manufacturing offers a significant breakthrough. Commercial CAD systems are widely used in jewelry designing and manufacturing. In CAD systems library various tools and predefined shapes helps the designer in jewelrymodeling.

Wannarumon et al. developed a framework of intelligent computer system to generate the primitive jewelrydesigns[1]. The intelligent computer system provides a tool for designers to generate design alternatives according to designer's preferences. ByzantineCAD [2] is an automated, parametric CAD tool for designing and producing pierced Byzantine jewelry. This CAD tool provides capacity to the designer to create custom-designed jewelry rapidly, based on the preferences of the customers. A feature-based approach to re-engineering of small object is presented in [3]. Art forms used in jewelry are represented by using Iterated Function Systems (IFS) fractal for jewelry ring's ornaments [4]. IFS are encoded in form of chromosomes. Modeling and fabrication of artistic products based on IFS fractal representation is presented in [5]. Fractal geometry has been employed for modeling natural objects that cannot be described easily by Euclidean geometry. Forming tools can be used to create traditional style of stretch-formed jewelry [6] on thin sheet metal by raising an ornamental jewelry pattern in the course of stretching the sheet metal beyond elastic limit. A parametric voxel-based jewelrymodeler has also been developed for designing carved bangles and pendants [7]. Wannarumon et al. has developed an automatic computer-aided design system (Jewelry Art Generator shown) for jewelry design based on Expert System and Evolutionary Algorithm [8]. Art forms are represented using fractal geometry.

Parametric jewelrymodeling in Visual Basic Applications (VBA) under programmable control of AutoCAD through the ActiveX Automation interface is presented in [9]. A Sketch-based modelling approach used in which shapes are represented by Fourier descriptors and shape parameters[10].

3. TWISTED WIRE JEWELRY WORK

Twisted wire jewelry is a delicate kind of jewelry made with twisted threads of metal usually of gold and silver. It is made using a technique of twisting, bending, wrapping and braiding plain precious metal wires (gold and silver). Standard forms of jewelry produced in filigree are earrings, bracelets, brooches, pendants, chains, necklaces and buttons. Wire work consists of two parts: One is the border wire and the other is the filling wire. Traditional hand-made twisted wire jewelry includes geometric shapes, rosettes, flowers and figures of animals especially butterflies and birds.

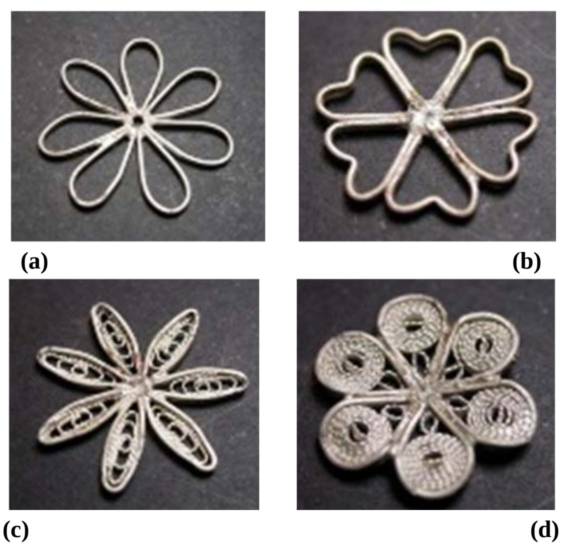


Fig. 2: Traditional components used by local craftsmen (a) & (b) Frame Wire (c) & (d) Compound Motifs

4. CONCEPTUALIZATION OF JEWELRY DESIGN

The shapes constituting the design can be identified by the visualizing the traditional jewelry designs and mathematical form of primitives constituting the jewelry design can be defined. The individual primitive shape account for the underlying design concept in the functional aspect of the new design creation and also can not only the individual primitive constitutes the design but also all possible concatenated transformation can be applied for creating a distinct design. Thus a new conceptual block can be derived by the combination of two or more primitive belonging to the jewelry.

5. PARAMETRIC FORM OF CURVES

For simplicity of implementation, every commercial system treats any geometric entity such as a point or a curve as a form feature irrespective of feature semantics. It is very difficult to set relations between the variables in the graphical applications due to the complexity of the equations. For this reason, the parametric equations have been used in graphing systems.

Table 1: Various Mathematical Form Used in Computer Graphics

Type	Form	Example	Description
Explicit	$y=f(x)$	$y=mx+b$	*Line*
Implicit	$f(x,y)=0$	$(x-a)^2-(y-b)^2=r^2$	*Circle*
Parametric	$x=\frac{x(t)}{w(t)}$, $y=\frac{y(t)}{w(t)}$	$x = a + r\,cost$ $y = b + r\,sint$	*Circle*

Parametric equations are obtained by setting coordinates equal to functions of a third variable. Points on a graph can be represented by two separate equations for the *x* and *y* coordinates in terms of a third variable (usually called *t*), instead of a single equation. The variable *t* represents time in many applications, which makes parametric equations useful for describing the location of objects as a function of time. Simply a parametric equation of circle is:

$$x = r * \cos(t)$$
$$y = r * \sin(t)$$

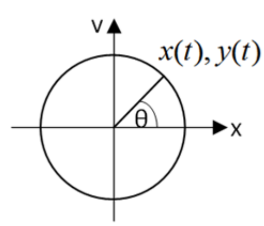
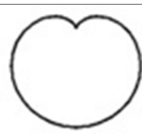
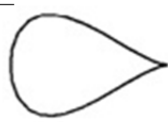


Figure 3: Circle

Both coordinate *x* and *y* have the same domain for the independent variable *t*. At each value of time we sketch a particular point *(x; y) =[x(t); y(t)];* as time moves forward, we trace out a curve.

Table 4.2: Mathematical Shape for Twisted Wire Jewelry and Their Modeling Parameters

Name of Curve	Sketch of the Curve	Parametric Equations	Modeling Parameters
Sine Curve		$x = lt$ $y = h\sin(2\pi N_c t)$	l length of the curve h amplitude of curve N_C no. of revolution in sine curve
Arch. Spiral		$x = rt\cos(2\pi n_1 t)$ $y = rt\sin(2\pi n_1 t)$	r Outer Radius of Spiral n_1 no. of coils in spiral
Logarithmic Spiral		$x = r_i \cos(2\pi n_1 t)\, e^{bt}$ $y = r_i \sin(2\pi n_1 t) e^{bt}$ $b = \log(\frac{r_o}{a})$	r_i inner radius of Spiral r_o outer radius of Spiral n_1 no. coils in spiral
Heart		$x = 13a\sin^3(2\pi t)$ $y = a(13\cos(2\pi t) - 5\cos(4\pi t) - 2\cos(6\pi t) - \cos(8\pi t)$ $a = r/(13\,cos(\pi) - 5\,cos(2\pi) - 2\,cos(3\pi) - cos(4\pi))$	r radius of circumscribed circle
Apple Curve		$x = rcos(2\pi t)(1 - \cos(2\pi t))$ $y = rsin(2\pi t)(1 - \cos(2\pi t))$	r radius of Inscribed circle
Pearl Curve		$x = acos(2\pi t)$ $y = b\sin(2\pi t) sin^c(\pi t)$	a width of pearl curve b height of curve c is measure of curvature
Petal Curve		$x = a\sin(2\pi t)$ $y = b\sin(4\pi t)$	a length of petal b width of petal

6. DESIGNING OF TWISTED WIRE EARRING

The process of making a twisted wire jewelry product is very peculiar in character; for it does not involve carving, engraving or molding a block of metal into jewelry, rather, building the piece bit by bit, by joining thin metal wires. For any construction twisted wire jewelry the first step is to identify the various basic geometric shapes. The shapes which make the model can be present in mathematical shape vocabulary or can be made by the combination of basic geometric shapes.

In our model there are three different shapes. The basic geometric shapes of the traditional piece are parameterized and added shape vocabulary. The next step is to identify the various feature operation which correspond to create motifs and compound-motifs and various placement features.

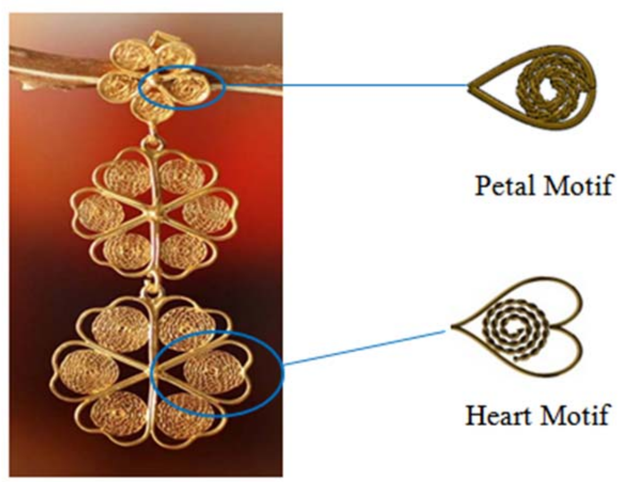


Fig. 4: Motifs in the Twisted wire Earring

The component in the fig.(4) is comprises of two level shape i.e. motif and compound motif patterned in floral shape. The hearts and petals pattern acts as guide curve for the placement of next level components. A single wire strand is used to create the pattern outline. The basic shape is heart and petal that is pattern around the center point or origin. The wire pattern is the base element to support the whole elements in the model so it is made of single wire. Spirals are filled inside the base geometry. This pattern has 6 hearts and petals in each segment over 360° angle.

6.1 Spiral Geometry

Spiral is locus of a point moving in a circle with constant speed. It starts in the origin and makes a curve with un-winded arms. The equation of the Archimedean spiral in parametric form:

$$(x, y) = [rt\cos(2\pi nt), \quad rt\sin(2\pi nt)]$$

where

r=radius of spiral,

n=no.of turns in spiral,

t= varies from 0 to 1

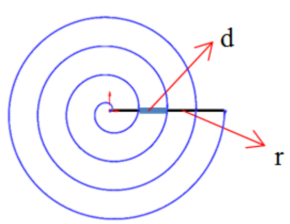


Fig. 5: Spiral Geometry

Affecting parameters in geometry of spiral are *r*,*n* and *d*. The number of turns n is lies inside a circle of radius *r*. The distance between the two adjacent turns is equal to *r/n*.

6.2 Petal Geometry

The petal shaped curves are formed by using different types of curves. The equation of the petal in parametric form is as follows:

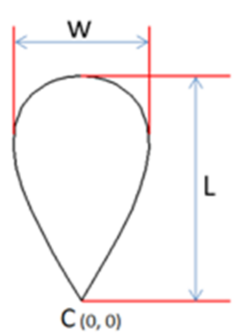


Fig. 6: Petal Geometry

$$(x, y) = [l\sin(2\pi t), w\sin(4\pi t)]$$

where

l=length of petal

w= width of petal

The size of petal has been defined by a circumscribed rectangle of width *w* and length *l*. The parameters *r* and *d* have been conceptualized as *w/2* and *(l-w/2)*.

6.3 Heart Geometry

The heart curve is a closed curve, which has the shape of a heart. It is difficult to produce this type shapes by spline or by combinations of different curve. The parametric form makes it possible to draw this shape.

The parametric equation of the heart shape is:

$$(x, y) = [16\, a \sin^3(\pi t), a(13\cos(\pi t) - 5\cos(2\pi t) - 2\cos(3\pi t) - \cos(4\pi t))]$$

$$a = [r/(13\cos(\pi t) - 5\cos(2\pi t) - 2\cos(3\pi t) - \cos(4\pi t))]$$

where

r=radius of circumscribed circle

t= varies from 0 to 1

a define height and is calculated with r.

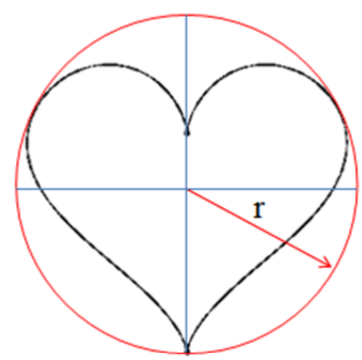


Fig. 7: Heart Geometry

6. Exploring Design Capabilities

A wide range of geometric shapes or element can be generated by using mathematical equation in the API development environment of CAD package which enables the designers to explore possibilities of creating a wide range of jewelry design. The design process through parametric equations of complex shapes is faster and easier than using traditional methods of drafting/sketching. The complex shapes can added to the design library using programming codes that can generate different shapes by changing even with a single variable. Shapes generated using parametric methods have a wide range of variations and often yielded surprising outcome. This method offers a new approach to draw and explore the understanding of geometry and the generation of geometric shapes. These generated geometric shapes range from simple shapes like rectangles and circles, to more complex shapes like lattice patterns as well as organic forms similar to the shapes and forms in the nature like flowers and stars. Although, such process may seem cumbersome and time consuming, but in return the wide range of shapes generated are quite interesting. These geometric shapes can provide a vast library of different shapes that can be useful and interesting for various design applications.

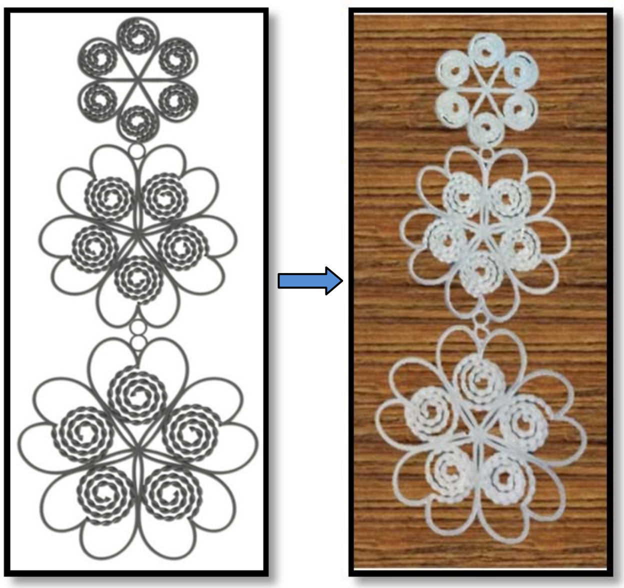


Fig. 8: Twisted Wire Earring (a) CAD Model (b) Solid Model Generated by RPT Machine

7. CONCLUSION

The customization capabilities of a CAD system are used to make it a real design tool and to implement a mathematical modeling in the shape generation for the twisted wire jewelry. These capabilities of CAD system can be used in the real design practice, can be improved as follows. First, the reverse engineering can be used to identify more shape designs from the traditional class of jewelry and can extend the design library. Second, the automated design generation using mathematical modeling provides a more realistic approach than a traditional sketch based modeling as these provides a real shape. The capabilities mentioned above are used in design process and a large portion of the design process is guided by a automated user interface for this particular class of jewelry.

REFERENCES

[1]. S. Wannarumon, K. Unnanon and Erik L. J. Bohez, "Intelligent Computer System for Jewelry Design Support", *Computer-Aided Design and Applications,* Vol-1, Issue 1-4, Jan 2004, pp. 551-558.

[2]. V. Stamati, I. Fudos. "A parametric feature-based CAD system for reproducing reproducing traditional pierced jewelry". *Computer-Aided Design,* Vol-37, (2005), 431–449.

[3]. I. Fudos, "CAD/CAM Methods for Reverse Engineering: A Case Study of Re-engineering Jewelry", *Computer-Aided Design & Applications,* Vol. 3, No. 6, 2006, pp 683-700.

[4]. S. Wannarumon and Erik L. J. Bohez, "A New Aesthetic Evolutionary Approach for Jewelry Design", *Computer-Aided Design & Applications,* Vol. 3, Nos. 1-4, 2006, pp 385-394.

[5]. S.C. Soo, K.M. Yu, W.K. Chiu, "Modeling and fabrication of artistic products based on IFS fractal Representation", *Computer-Aided Design*, Vol. 38, 2006, pp 755–769.

[6]. V. Gulati, P. Tandon, "A Parametric Voxel Oriented CAD Paradigm to Produce Forming Components for Stretch Formed Jewelry", *Computer-Aided Design & Applications,* Vol. 4, Nos. 1-4, 2007, pp 137-145.

[7]. V. Gulati, P. Tandon, H. Singh, "A parametric voxel based unified modeler for creating carved jewelry", *Computer Aided Design and Applications,* 2008; 5(6):811-821.

[8]. S. Wannarumon, "An Aesthetics Driven Approach to Jewelry Design", *Computer-Aided Design & Applications,* 7(4), 2010, 489-503.

[9]. V. Gulati, "Parametric Jewelry Modeling in AutoCAD using VBA". *International Journal of Computer Applications,* 1(2), Feb. 2012 pp 158-164.

[10]. Long Zeng, Yong-jin Liu, JinWang, Dong-liang Zhang, Matthew Ming-Fai Yuen, "Sketch2Jewelry: Semantic feature modelling for sketch-based jewelry design", *Computers & Graphics,* Vol-38 (2014), 69–77.