Title:
Computational Support to Design and Fabrication of Traditional Indian Jewelry

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Introduction:
The primary objective of this work is to propose a geometric modeling schema so as to help develop traditional Indian ornamental designs. The goal of the work is to automate the generation of user specific designs of traditional Indian jewelry in convenient manner and their quick and easy fabrication. The work involves development of mathematical models and algorithms that can develop novel traditional Indian ornamental designs and in the process to simplify their design process. This approach can improve design and fabrication of ornaments, particularly repeatable products like ornamental jewelry. The objective also includes the reduction of dependence on the formal designers and provides the design tool in the hand of the users capable of generating a large number of traditional designs of their preference. This work is directed towards incorporating artistic and traditional sense and imagination into the design tool so as to facilitate even the persons having least imaginative and artistic skills to design designer jewelry. The design tool and additive manufacturing technology can improve the efficiency as well as productivity of the jewel-smiths. These tools would be effective in significantly shrinking the effort and time required for designing and creating ornamental products.

A large number of parametric and feature based systems have been developed for jewelry designing with excellent rendering capabilities, such tools are being used for artistic and aesthetic applications. In these applications, the aim is not only to realize certain geometries and patterns but a main concern is the achievement of overall aesthetic appeal. For this purpose, examples are present in [4], where parametric pattern generated are implemented to create and modify artefacts and to evaluate the final results. A few software tools have been developed for designing and creating CAD jewelry models such as Art CAM Jewel Smith, Delcam Designer, Rhinoceros, Matrix 3D Jewelry Design Software, Jewel CAD and Jewel Space. In addition, the majority of these systems have the competence to export the CAD models of jewelries to rapid prototyping (RP) machines. Stamati et al. [6, 7] introduce Byzantine CAD, a parametric CAD system for the design of pierced medieval Jewelry. Byzantine-CAD is an automated, parametric CAD system for designing and producing pierced Byzantine Jewelry where the user-designer sets some parameter values and Byzantine-CAD creates the Jewelry model that corresponds to the specified values. A parametric approach to creating carved Jewelry is also presented in [1].

Main idea:
Most of the jewelry manufacturers use traditional methods for jewelry design. The elements of ornamental designs can be divided into various categories like those based on geometrical elements (both analytical and synthetic) such as curves, lines, circle, polygon; nature, e.g. plants, star and on artificial objects like shields, ribbons, etc. This work aims to associate advantages unfolded by Computer Aided Design (CAD) technology in geometric modelling of traditional Indian Jewelry design and manufacturing. The work beings with pattern design methods. This is the first step to create patterns on a surface. The profile is the basic sketch for pattern design. The cluster is made up of profile. The cluster type depends upon the profile arrangements. The patterns are generated on the

surfaces. The user can execute each of the pattern design methods. The user employ CAD tool to facilitate the concept design process. CAD implementation eliminates the need of a formal designer and provides the design tool in the hand of the user by generating design of his/her choice. Finally, the prototype is generated through RP machine by taking the output in .STL format from the software.

At the first step, different profiles are created in line with the ancient traditional Indian Jewelry designs and they are differentiated based on their shapes and usage; like Jau, Chand, Heart and Bund. A profile consists of line, circle, arcs, etc., whose behavior is controlled by geometrical and dimensional constraints. Geometrical constraints are applied on the unit and these constraints are further used to define the relationship between two entities as collinear concentric, equal length, equal radius, and midpoint, tangent and vertical align. These constraints are applied as per the profile development requirement. The profiles are created using the parametric equations.

Profile- Jau: Profile Jau made up of two arcs as shown in Figure 1.

Arc1: $p_x(\theta, t) = x_{1c} + r\cos(\theta)$ $\theta \in [0, \pi]$

$p_y(\theta, t) = y_{1c} + r\sin(\theta)$

$p_z(\theta, t) = z_c + t*H$ $t \in [0,1]$

Arc2: $p_x(\theta, t) = x_{2c} + r\cos(\theta)$ $\theta \in [\pi, 2\pi]$

$p_y(\theta, t) = y_{2c} + r\sin(\theta)$

$p_z(\theta, t) = z_c + t*H$ $t \in [0,1]$

The parameter r varies from 0 to 2π.
The parameter t varies from 0 to 1. H is thickness of profile.

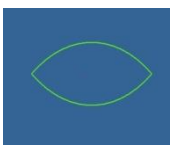

Fig. 1: Profile- Jau

After creation of profiles, in second step**, c**ombinations of different profiles are arranged in certain orders to form the clusters (circular cluster and rectangular cluster). After the formation of cluster, the next step is pattern formations. Patterns are generated on both, two-dimensional or three-dimensional surfaces. The pattern creation is of three types' i.e. rectangular pattern, circular pattern and curve driven pattern. The main phase in the process of Jewelery design is to implement these patterns on the surfaces. In this process, parametric feature based technique and bubble packing technique are used.
The term parametric includes dimensional parameters, location parameters and the associated constraints. Making changes to the parameters and reevaluating the constraints and relations can easily create new models [3]. Surfaces are mathematically represented explicitly, implicitly or parametrically. The bubble packing method [2,5], based upon the physical concept of packing bubbles inside a given domain, has been introduced as a promising technique. In this method, bubbles move in a domain until forces between bubbles are stabilized, and the Delaunay triangulation is then applied to generate a mesh connecting the nodes defined by the bubble packing. The parametric bounding box of surface and 3D Cartesian space is used to determine optimum feature position. Bubbles are packed on geometric entities namely points, curves, and surfaces in ascending order of dimension. These geometric entities are corresponding to vertices, edges, and faces, respectively.

Implementation:
In the process of traditional jewelry design and manufacturing, design modeler is developed as ADD-ON inside Autodesk inventor. The aim of this Jewelry add-on is to develop three dimensional thin patterns of traditional jewelries on the surfaces. Add-ons are a set of programs that can interact with Inventor API either as in process or as external-process to Inventor as a stand-alone program. Autodesk is capable to create the .STL file, which can be forwarded to the RP machine for creating jewelry patterns. This work has been validated by fabricating the rendered traditional Jewelry design by adaptive manufacturing process.

Result discussion and Conclusion:
The paper proposes a new dimension to the field of jewelry design to improve its fabrication. The aim of generating add-on jewelry modeler for design and manufacturing of traditional Indian jewelry is achieved. The add-on uses parametric design based concepts that provide a large variation in the designs. Standardization as well as automation has been included in the work through the integration of CAD-CAM tools. The geometric modelling techniques used in the work are simple and innovative. Jewelry design fabricated on a curved surface is shown in the figure 2(a) and (b).

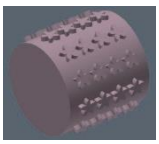

Fig. 2(a): The designer sketch.

Fig. 2(b): Jewelry design model after rendering.

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