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Idealising mesh modelling for haptic enabled services and operands

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Abstract. Communicating the knowledge and science of product engineering, analysis and manufacturing planning is an area of continued research driven by the digital economy. Virtual Reality (VR) is a generally accepted interactive digital platform which industry and academia have used to model engineering workspaces. Interactive services that generate a sense of immersion, particularly the sense of touch to communicate shape modelling and manipulation, is increasingly being used in applications that range from Design For Manufacturing and Assembly (DFMA) and Process Planning (PP) to medical applications such as surgical planning and training. In simulation, the natural way for solid modelling is the use of primitive geometries, and combinations of them where complex shapes are required, to create, modify or manipulate models. However, this natural way makes use of Booleans operands that require large computational times which make them inappropriate for real time VR applications. This work presents an insight on new methods for haptic shape modelling focused on Boolean operands on a polygon mesh. This is not meant as a contrast to point/mesh-editing methods, instead it is focused on idealising polygonal mesh modelling and manipulation for use with haptics. The resulting models retain a high level of geometric detail for visualisation, modelling, manipulation and haptic rendering.

Keywords: Mesh modelling, Boolean operations, Haptic rendering, Process Planning.

1 Introduction

Through the years, the simulation has been a tool used to attempt to model real life situations through a computer program. Traditionally, system modeling was done using a mathematical model, which attempts to find analytical solutions to problems trying to predict the behavior of a system[1]. There are many different types of computer simulation; the common feature that they all share is the attempt to generate a sample of representative scenarios for a model and all possible states of that[2].

Object modelling is a tool that is used for the design of parts in engineering mechanics [3]. Actually the simulations play an important role during the product design and it is a tool used to reducing the need for expensive prototyping and reduces the product development cost [4]. Most software on the market dedicated to modelling focuses on the visual editing, but supplemented with the haptic manipulation is added realism and ability to involve the user experience, and allows irregular geometries to model at will **Error! Reference source not found.**. The precision and accuracy are desired characteristics in these systems, the problem is directly dependent on the computational capabilities of the machine in use and the amount of data that have the model that is modelled, the more data, more specific is the model [6]. The slowness of the process is a subject of study and methods currently used as the Boolean Operations and implicit functions [7] that are usually very slow. This paper presents an algorithm developed for editing objects type mesh manipulated by haptic devices and Boolean operations. This edition is based on doing the union, intersection or difference only in the contact area between the two objects and thus speeds up computer processing to move closer to a real-time manipulation. The implementation is done in VTK [8] with collision libraries of VTKBioEng [9] programmed in C++.

2 Related Work

The editing and manipulation of 3D models has been a constant in different research and applications, one of the most important is the CAD as shown in [9] where they make a list of the techniques that are relevant for physics-

based simulations problems and to characterize them based on their attributes of successful techniques for fully-automatic or semi-automatic simplification of CAD models for a wide variety of applications.

Other option for modelling is presented by [10] where show a set of interactive free-form editing operators for direct manipulation of level-set models that supports the creation and removal of surface detail by operators implemented with specialized speed functions, which are incorporated in to the level set partial differential equation (PDE).

As said [11] the triangular mesh using the 3D object modelling is the major importance in all the engineering and the context of industrial maintenance activities requiring fast modifications of meshes without going back to the CAD model for to solve critical problems in very short time. In this work presented an algorithm for removes the intersecting faces in an n-ring neighbourhood so that the filling of the created holes produces triangles whose sizes smoothly evolve according to the possibly heterogeneous sizes of the surrounding triangles.

Regarding the formation of new models from primitive objects, the work of [12] where present techniques for rendering implicit surfaces which are rendered using point based primitives.

An option of modelling in real time is presented [13]. They describe a modelling approach using signed distance functions for objects, handling with surface manipulations. That scenes defined can be stored compactly and rendered directly like an interactive application with immediate visual feedback for the user.

An new method for modelling is presented [14]. This method described sharp features (edges and vertices) of implicitly defined surfaces augmented by adding new types of implicit representations defined with circular splines to describe these edge curves. Also describe an algorithm for detecting the sharp curves and approximated by circular splines, in order to define the edge and vertex descriptors.

The Boolean operations are a source used for create, model, edit and create polygons for surfaces and 3D objects. In the work presented by [15] introduced a Boolean operation based CAD modelling applied to construct heterogeneous material objects. The new model can be readily implemented with advanced CAD/CAE/CAM software for integrated design, analysis and simulation. Other work is the present by [16] that developed new algorithm to calculate intersection, union and difference, valid for general planar polygons based on a formal representation system using algebraic operations for to calculate the intersection between general polygons. Other example is the presented by [17] where described a robust algorithm for Boolean operations on polyhedral solid representations using approximate arithmetic for to connect in the input guarantees correct connectivity in the output. Also describe a data-smoothing process to the output to remove artefacts.

A work on haptic editing of 3D models is presented by [18] who investigated the integration of Virtual Reality (VR) and Computer-Aided Design (CAD) making possible intuitive and direct 3D edition on CAD objects using model B-Rep in modelling in CATIA and haptic help by a grid and extrude commands.

According with the previous literature review, it can be concluded that simulation with mesh models, haptic fast edition and manipulation of the 3D models using open source libraries and multi haptic devices isn't an area exploited in other research of the 3d modelling.

3 Metodology

The purpose of this work is to model objects type mesh 3D with haptic interface by Boolean operations, breaking up the model (Object 1) in regions and manipulating with the haptic cursor or tool (Object 2) for create a new model.

Figure 3.1 presents the methodology proposed in this paper haptic modeling of meshes. This methodology has been implemented in C++ language using Visualization Toolkit libraries (VTK 5.6.1), Open Source Haptics H3D v2.1.1 is the standard platform for programming the haptic devices used in this platform (Phantom Omni or Novint Falcon). The collision detection has been implemented using VKTBioEng v5.0.1. The computes used have 1.73 GHz speed of processor, 2.0GB of RAM and Windows XP like Operating System.

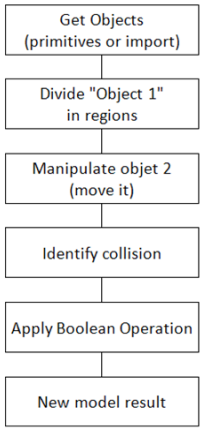

Figure 3.1. Modeling methodology

1. - Get objects: The modeling start with the definition of the objects in the scene (objects 1 and object 2) that it can be design with VTK libraries (primitives figures) or importing of some modeler software like STL format for example.

2. - Divide "Object 1" in regions: The base of the method purpose in this work is the optimization in the

speed process when the Boolean operation is applied. This step is very important for the method because is necessary break up the model in parts and identify each. We can to divide the piece for number of elements wish or number of points in one area.

3. - Manipulate "Object 2": As stated earlier, the object 2 is the cursor haptic. It is necessary to move the haptic device desired (Omni or Falcon, since they are supported in this application with the bookstores HAPI) to the area that you wish to modify, in addition to being in collision with object 1 the editing process starts.

4. – Identify collision: The algorithm takes all the regions of the object 1 that are in touch with the object 2 and sends only the "polydata" selected to the Boolean operation function.

5. - Apply Boolean operation: In this part the Boolean operations is applied and selected between the Union, Intersection or difference. After this the new section is added to the object 1.

6. - New model result: Joins the original mesh of object 1 and the new piece result Boolean operation process and creates an actor to be rendering in the VTK window.

The Figure 3.2 show the object 1 after to be divided in regions (colors) and the object 2 (sphere white) or haptic cursor, before apply the boolean operation.

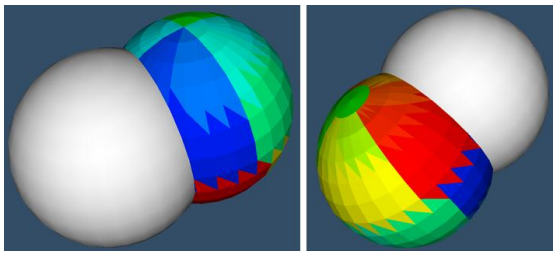

Figure 3.2. Objects for the haptic modeling

The optimization method of this work is based in the selection of the region that are in contact with the haptic cursor for process only this data and not the full model. To carry out this process, the algorithm shown in the Figure 3.3 is used.

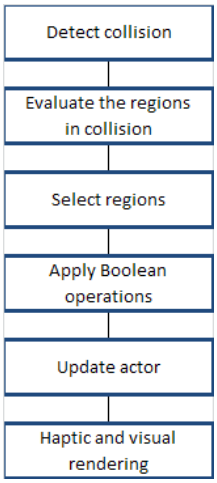

Figure 3.2. Objects for the haptic modeling

5 Results

Difference in time between the normal Boolean operation method (union, intersection, difference) and the new method by collision detection and regions. (comparative graphs)

6 Conclusions

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