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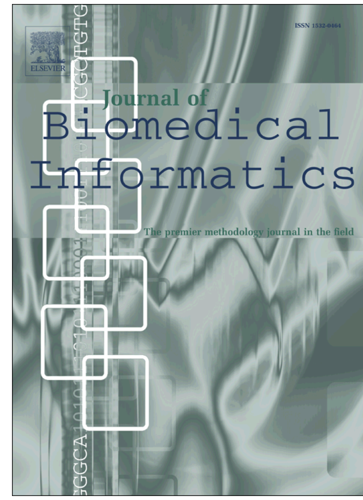

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Comparing efficient data structures to represent geometric models for three-dimensional virtual medical training.

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Abstract

Data structures have been explored for several domains of computer applications in order to ensure efficiency in the data store and retrieval. However, data structures can present different behavior depending on applications that they are being used. Three-dimensional interactive environments offered by techniques of Virtual Reality require operations of loading and manipulating objects in real time, where realism and response time are two important requirements. Efficient representation of geometrical models plays an important part so that the simulation may become real. In this paper, we present the implementation and the comparison of two topologically efficient data structures – Compact Half-Edge and Mate-Face – for the representation of objects for three-dimensional interactive environments. The structures have been tested at different conditions of processors and RAM memories. The results show that both these structures can be used in an efficient manner. Mate-Face structure has shown itself to be more efficient for the manipulation of neighborhood relationships and the Compact Half-Edge was more efficient for loading of the geometric models. We also evaluated the data structures embedded in applications of biopsy simulation using virtual reality, considering a deformation simulation method applied in virtual human organs. The results showed that their use allows the building of applications considering objects with high resolutions (number of vertices), without significant impact in the time spent in the simulation. Therefore, their use contributes for the construction of more realistic simulators.

Keywords: Data Structures, Compact Half-Edge (CHE), Mate-Face (MF), three-dimensional objects, neighborhood relationships

1. Introduction

Data structures are widely explored, developed and improved to solve several problems in computer applications. Systems that demand processing large volumes of data in a short time are interesting problems to apply efficient data structures. One of these applications include three-dimensional (3D) medical training using Virtual Reality (VR) technology, which provides interactive and immersible systems involving users in a real-time computational simulation [1].

VR attempts to immerse the users senses so that the virtual representation of life is as close to reality as possible. The use of three-dimensionality and interaction in real time makes VR an even more attractive proposition for training and simulations in health area, once it gives the user the possibility of exploring and repeating several different procedures without any wear and material maintenance costs.Obtaining realism in this type of system requires the use of models with appropriate colors, textures and lighting, as well as high resolution.

These objects usually are composed by a large number of vertices and cells that are manipulated in real time, for example, to detect collisions and simulate deformations arising from user interaction. Methods for these and other functionalities work with meshes by manipulating sets of vertices, changing their positions within the Virtual Environment (VE), so that they can simulate changes that occurred in the objects considering their properties [2]. The computational costs of these iterative methods are normally high, especially in terms of processing time.

Considering the paradox between precision and computational cost, as well as the need for feedback in real time (essential in the case of interactive 3D environments applications), the study of Data Structures (DS) to enable the efficient storage and recovery of data for representing flexible objects is a key factor. When the subject is executing simple operations on static meshes there are efficient alternatives [3, 4]. However, the problem complexity increases as we consider real time interaction, which is the problem that we propose to contribute in this article. In medical training applications where we need to perform deformation in 3D objects, it can be necessary the access to several ring neighborhood in order to simulate the procedure with realism. Thus, it is not only a problem that an additional representation of a vertex's neighborhood could solve. This search is recursive and it can involve many vertices.

Within this context the purpose of this work is to compare the Data Structures known as *Mate-Face* [5] and *Compact Half-Edge* [6], considering as basic parameter the processing time, and analyzing their behavior within and out 3D VEs for medical

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