# DEVELOPING AN ADAPTIVE TOPOLOGICAL TESSELLATION FOR 3D MODELING IN GEOSCIENCES

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*The value of Geographic Information Systems (GIS) is widely known in a variety of geoscientific applications ranging from water resources management to the study of global warming impacts. GIS can provide geoscientists with strong computing platforms for spatial data management, visualization, querying, integration, and analysis. However, representation and management of geoscientific phenomena which are usually 3D and heterogeneous mostly require a 3D optimal spatial tessellation. An optimal tessellation is characterized by well-shaped and well-spaced elements that provide an accurate representation of topological and geometrical information. In this paper, we discuss the limitations of current three-dimensional spatial tessellation methods that are used in 3D geological modeling, 3D interpolation, and 3D fluid flow simulations, etc. Then, we propose an automatic refinement algorithm based on Delaunay tetrahedralisation and its dynamic operations. Finally, we present and discuss the results and the performance of the algorithm.*

*La valeur des systèmes d'information géographique (SIG) est grandement connue pour un ensemble d'applications géoscientifiques variant de la gestion des ressources en eau à l'étude des répercussions du réchauffement planétaire. Les SIG fournissent aux géoscientifiques des plates-formes de calcul rigoureuses pour la gestion, la visualisation, les requêtes, l'intégration et l'analyse des données spatiales. Toutefois, la représentation et la gestion des phénomènes géoscientifiques qui sont généralement tridimensionnels et hétérogènes exigent une tessellation spatiale optimale en 3-D. Une tessellation optimale est caractérisée par des éléments bien modélisés et bien espacés qui fournissent une représentation exacte de l'information topologique et géométrique. Dans le présent article, nous discutons des limites des méthodes de tessellation spatiale tridimensionnelle actuelles qui sont utilisées pour la modélisation géologique 3-D, l'interpolation 3-D, les simulations de l'écoulement des fluides 3-D, entre autres. Ensuite, nous proposons un algorithme de raffinement automatique basé sur la tétraédralisation de Delaunay et ses opérations dynamiques. Enfin, nous présentons et discutons des résultats et du rendement de l'algorithme.*

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## 1. Introduction

Geographic Information Systems (GIS) are widely used for modeling, representation, management, and analysis of spatial data in many disciplines. In particular, geoscientists increasingly use these tools in many environmental applications ranging from water resources management to the study of global warming impacts. *Raines* [2007] presents a very interesting review on the variety of applications of GIS-based spatial modeling to the problems in geosciences. In most environmental applications, geoscientists need to deal with the third spatial dimension $z$. For example, in geological modeling, structures such as faults cannot be represented by 2D or even 2.5D modeling tools where for each horizontal location several $z$ values exist. Therefore, 3D modeling is more appropriate to deal with these kinds of phenomena.

Measurement techniques in geosciences, such as seismic profiling, magnetic or gravity surveys and borehole drilling in geology, and the uses of weather balloons and probes in metrology, often result in points in 3D space $x,y,z$ with irregular distribution. Each data point is defined by its location in 3D space, and can have one or more attributes attached to it. To represent a spatial object from a set of discrete samples, it is necessary to tessellate the objects into finite elements such that the union of all elements completely fills the object [*Raper* 2000; *Worboys and Duckhum* 2004]. To each element of the tessellation, a set of attributes such as mass, porosity, etc., can be assigned in order to characterize the local nature of the object.

In some geoscientific applications such as geology, the shape and distribution of the objects can be highly irregular and complex. Therefore, the tessellation elements must not only be well-shaped, but also should represent the complexity of the objects as accurately as possible. In fact, the tessellation elements are used to form an approximation