

HPC-ICTM: the interval categorizer tessellation-based model for high performance computing*

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The paper presents the results obtained by a parallel implementation of the interval tessellation-based model for categorization of geographic regions according to the analysis of the relief function declivity, called ICTM [1]. A discussion of the performance of the parallel model and a comparison with the sequential implementation is also presented. The analysis of the relief declivity, which is embedded in the rules of the model ICTM, categorizes each tessellation cell, with respect to the whole considered region, according to the (positive, negative, null) signal of the declivity of the cell. Such information is represented in the states assumed by the cells of the model. The overall configuration of such cells allows the division of the region into sub-regions of cells belonging to the same category, that is, presenting the same declivity signal. In order to control the errors coming from the discretization of the region into tessellation cells, or resulting from numerical computations, interval techniques are used [5]. The implementation of the model is naturally parallel since the analysis is performed on the basis of local rules. An immediate application is in Geophysics, where an adequate subdivision of geographic areas into segments presenting similar topographic characteristics is often convenient. See [4], for other applications related to the analysis of the relief. This work evolved directly from the analysis of the work [3]. The tessellation-based model performs a bi-dimensional analysis of the declivity, using local rules for creation and categorization of sub-regions, giving the relative situation of each sub-region with respect to the whole area, according to the states assumed by the cells. The ICTM Model uses a structured mesh to constitute its tessellation. A structured bi-dimensional mesh is often simply a square grid deformed by some coordinate transformation. Each vertex of the mesh, except at the boundaries, has an isomorphic local neighborhood. In three dimensions, a structured mesh is usually a deformed cubical grid. Structured meshes are simpler than the non-structured ones, and require less computer memory, as their coordinates can be calculated, rather than explicitly stored.

Structured meshes offer more direct control over the sizes and shapes of elements. Considering that the evaluation of each cell (a work unit) is independent of the others, this problem maps very well into the Single Program Multiple Data (SPMD) class of parallel applications. Our proposal is an implementation taking advantage of such characteristic, using the MPI standard on top of a distributed processing cluster. The speed-up obtained is expected to be close to linear. The tessellation was divided to be processed separately using an algorithm inspired by the Schwarz algorithm [2] for overlapping domain decomposition. Domain decomposition methods are techniques for solving partial differential equations based on a decomposition of the spatial domain of the problem into several subdomains.

References

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