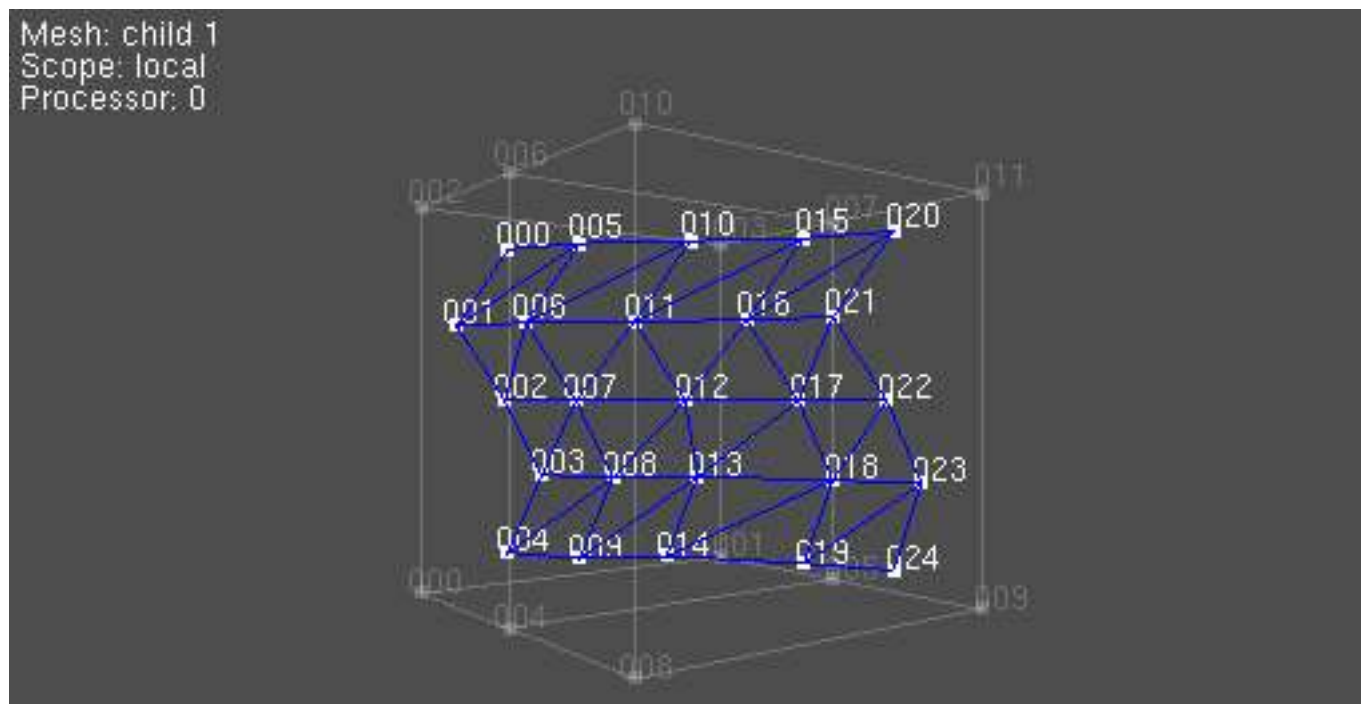


Modelling Surface Discontinuities in Planets and Moons



Student(s): Luke Hodkinson

Association: Victorian Partnership for Advanced Computing

Supervisor(s): Patrick Sunter (VPAC), Louis Moresi (Monash Cluster Computing), Steve Quenette (VPAC)

Discipline:

Research Objective

Modelling surface discontinuities in planets and moons; the aim of this project was to construct a tool for use in the problem of surface discontinuities in the context of the StGermain framework. An additional class in StGermain was to be created, embodying the information required to describe an irregular surface, that being the geometry (node positions) and topology (node interconnects), which will not necessarily adhere to any regular convention, ie. being irregular. This new class was to be used in conjunction with existing applications, such as Snac and Snark, providing the means to model surface discontinuities and their effects in a geological context.

Motivation / Significance

Earthquakes and volcanoes; these geological phenomena occur mainly with close proximity to fault lines in the Earth's surface. Fault lines exist as a result of tectonic plates gradually shifting, grinding along each other and occasionally slipping, generating earthquakes in the process. Plate tectonics tells us that 90 percent of earthquakes occur near plate boundaries, but only a detailed study of the boundaries themselves will yield information about *when* they will occur.

An important aspect of modelling/simulating the motion of the tectonic plates as a result of mantle convection, is keeping track of the subsequent motion and deformation of the plate boundaries. The completion of this project provides a

SI0310 Modelling Surface Discontinuities in Planets and Moons - VPAC Case Study

(Vpac graphic)

foundation for simulating these boundaries, the basic functionality being available through the StGermain framework.

Science Background

Geometric methods were employed throughout the majority of the project. Although not complicated, they served as the basis for a substantial amount of the calculations required by the irregular surface addition.

Parallelisation techniques and the use of MPI proved to be important in testing and debugging. Although MPI is not explicitly used in the irregular surface additions, it is a part of the underlying structure on which the additions were made, and as such understanding how this affects the new code is quite useful.

Methodology

The following process was observed:

- Met with all project collaborators.
- Examined and analysed the existing StGermain mesh code.
- Added initial irregular surface code.
- Constructed tests for the initial code.
- Added support for finding the intersections of an irregular surface with its parent mesh.
- Constructed tests for new additions.
- Added a class (EmbeddedSurface) to allow access to the functionality of the irregular surface layout.

Coding Aspects

StGermain is written primarily in C, and as such the additions required of this project were also written in C. The same object oriented approach was adopted for the code additions, making use of the class structure included in StGermain.

Although PETSc was not explicitly used in the project, it is used throughout StGermain and Snac and hence is an essential library. The MPI libraries are also required of StGermain, and are needed for the basis of the MeshLayout structures.

Results

The main goals of the project were completed with a high degree of success. Although there is no benchmark for performance, all tests constructed for the added components pass, and visual demonstrations perform well.

In addition to the main goals:

- a visual debugging tool was created,
- the method by which the nodes belonging to an element were stored in the mesh layout system was altered to suit the finite element method used elsewhere in StGermain, and
- a complete reorganisation of the mesh layout system was performed.

Discussion:

The software created as a result of this project can now be used as the basis for modelling surface discontinuities in a variety of applications. Various geometric functions, as discussed in the above sections, are now accessible in a concise class structure.

Due to the nature of StGermain, there are really no 'specific' applications the code is limited to; simply inheriting the basic classes allows for any number of advanced surface classes to be created.

Conclusion

Through meetings with Louis Moresi it has been determined that the functionality provided by the irregular mesh implementation is satisfactory for current needs. An irregular mesh in the form of an embedded surface can now be created, and basic geometric queries can be performed, these being: finding the intersections of the irregular surface with its parent mesh and finding the shortest distance from an embedded surface to an arbitrary point.

References

Spall, H. (2003) *Earthquakes and Plate Tectonics* [online]. Abridged from Earthquake Information Bulletin (2003), vol. 9, no. 6. Reston, USGS. Available from: http://neic.usgs.gov/neis/plate_tectonics/rift_man.html [Accessed 24th February 2004]