IMPLICIT MODELLING: FROM TARGETING TO MINING (21)

Expositor	Día	Hora	Sala
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Implicit Approach Concept

Traditional explicit modelling methods for developing three-dimensional wireframes based on engineering CAD-methodologies have been replaced in the most dynamic industry sectors such as medicine, movie making, video games, automotive engineering, etc. Sectional interpretation and triangulation linking have been replaced by fundamentally different approaches based on various mathematical tools. Such modelling technologies have only recently come in to the service of the mining industry, but already have a significant competitive advantage over traditional methods including modelling speed, consistency, flexibility, resolution, and the potential to model complex geological frameworks.

Implicit modelling methods are based on interpolation algorithms using radial basis functions (RBF), which allow for the fast interpolation of various numeric datasets and subsequent building of dynamically updated wireframe solids or surfaces.

The combination of RBF interpolation parameters with the underlying numeric dataset allows for almost infinite freedom in generating wireframes of any complexity. Two widespread methods of surface generation are described below.

Modelling Methods

Wireframe modelling using an implicit approach can be separated into two major groups. First, the point-based method involves relatively simple surface-like shapes and represents a close alternative to the triangulation based classic wireframe models developed by a traditional explicit approach. Application include topography surfaces, lithological contacts, faults, pit shells etc. Second, the values-based method involves the generation of complex closed volumes by using the three-dimensional spatial distribution of different numeric parameters such as grades, RQD, or GSI from drilling or surface and underground workings.

Point-based implicit wireframes require a set of points in three-dimensional space. With a traditional explicit approach, the points are directly triangulated to create a surface (points are separated) or closed wireframe solid (points are grouped to polylines which are linked together). The process is usually manual and requires a significant amount of digitizing and editing. Implicit algorithms assign “0” values to the original point dataset and also add two additional points for each original one: positive (for example “+5”) on one side and negative (for example “-5”) on the other. The sides are chosen to be aligned along the normal of the modelled surface with the number typically representing the distance from the original point. These distance values are being interpolated in three-dimensional space to create a surface based on the “0” value. Using interpolated surfaces instead of conventional sectional polyline-derived surfaces allows for smoother and more realistic shapes. Interpolated surfaces are not limited to the coordinate extent of the edge points as the modeller can extend the surface to any required distance. The resolution of the modelled surface is solely dependent on the resolution of the interpolation grid which can vary depending on the data spacing and modelling purpose. The advantage, compared to traditional explicit triangulation, is the generation of realistic and consistent shapes in sparsely spaced point data sets.

Values-based interpolated shapes are modelled when complex morphology wireframe are required. The interpolation algorithm is not significantly different from the one used for point-based implicit wireframes (in most commercial software the radial basic functions are used). However, the input data already contains the values to be interpolated. Values-based RBF interpolation methods are commonly used in the modelling of sample grades (resulting in grade shells), distance values (volumetric intrusion-type wireframes), geotechnical parameters, or indicators. Also, the most commercial software allows editing of the derived surfaces by varying the interpolation parameters or by adding points or polylines manually.

Implicit Modelling Examples

Implicit modelling is beneficial to almost every stage of project development, from early exploration to active mining and operational support.

Early exploration work commonly requires significant input from structural geology, geophysics, and geochemistry. Faults and lithological domains are efficiently modelled using the implicit toolbox. Simple-shaped domains and surfaces can be constructed with point-based wireframes whereas complex shape domains are modelled with values-based interpolated shapes. The latter, especially with grade and indicator shells, provide good visualizing and data analysis support in the interpretation of mineralized trends using geochemical and geophysical data.

Implicit modelling tools are used for resource wireframe modelling. Closed volumes constrained by hangingwall and footwall surfaces (e.g. veins, stratigraphy, coal seams) are modelled with point-based wireframes (Figure 1). If the domain complexity is high, volume-points (distance) interpolants are an option that provide many customization possibilities including manual adjustments, if required, while remaining tightly constrained to the original data.

In more advanced stages of project development, the combination of structural, lithology, alteration and geotechnical inputs is used for hydrogeological or geotechnical engineering models. They can include both large-scaled domains modelled using point-based surfaces as well as the visual distribution of the different rock mass parameters such as GSI or RQD modelled with values-based shells.

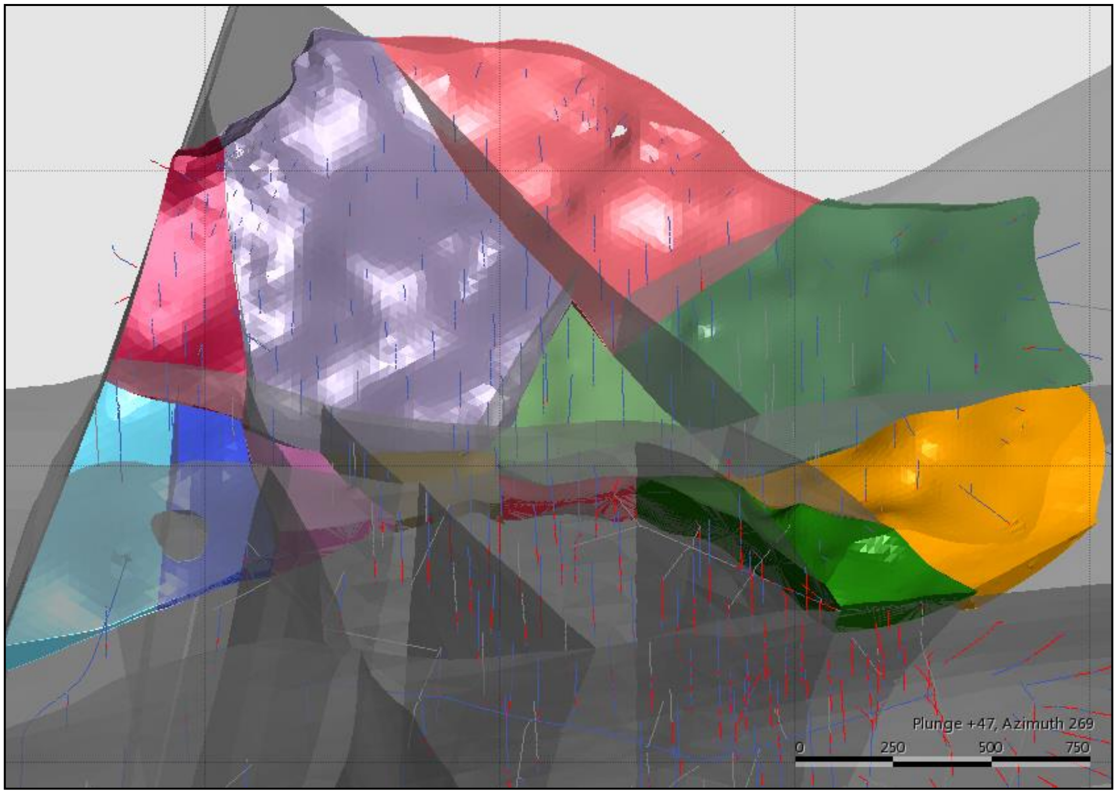

Figure 1. Resource domains modelled from drilling dataset split by a complex fault network

For active mining operations, the benefits from the implicit modelling approaches are many. Full three-dimensional modelling based on large datasets (e.g. ore shapes derived from grade control data used for mine planning) can serve as a good alternative to the classic two-dimensional contouring or unconstrained block interpolation. New data can be integrated and validated quickly instead of taking weeks or longer to manually modify models.

Conclusions

Implicit modelling is now the fastest developing technology in the field of geological modelling and is being increasingly applied throughout the mining industry. Its popularity is due to the relative ease and speed in which wireframe models can be developed and subsequently updated or adjusted to new input data compared to outdated time-consuming traditional explicit modelling methodologies. The level of achievable complexity using implicit modelling is significantly higher than that possible by other modelling methods. Nevertheless, care must be taken in selecting an appropriate implicit modelling methodology which will adequately reflect the geological interpretation and input data.

With implicit modelling techniques becoming more widely applied in the mining industry, appreciation is required to understand that these techniques need to be used cautiously and appropriately to avoid black-box solutions. This will be of greater importance in the next decade as implicit modelling methodologies will become the industry benchmark for modelling geologically complex terranes and deposits.

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