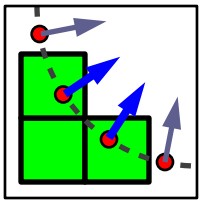
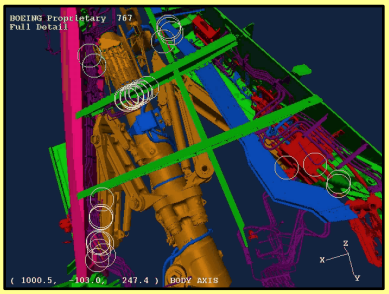
Voxmap PointShell™



High Performance Volume Sampling Software

CASE STUDY

Voxmap PointShell™ applications during the design and analysis of the 767−400 main landing gear.



Collision / proximity detection:

VPS based collision and proximity detection has been used at Boeing in the FlyThru© visualization system for over two years. It is used in the voxel accuracy mode as well as exact polygon mode, for both interactive and batch processing.

The complex kinematic motion of the 767−400 main landing gear was analyzed by the VPS collision detection module in FlyThru at several stages of its design. Early designs were checked for polygonal collisions and later designs to assure appropriate clearances. This particular system was analyzed in minutes using VPS instead of hours using previous methods.

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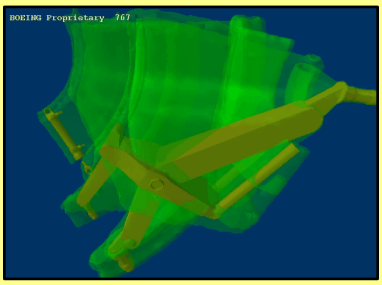

Swept volume generation:

The VPS swept volume creation module was added to the Boeing FlyThru visualization system in late 1997 specifically to aid in the 767−400 main landing gear design. In order to meet deadlines, the landing gear project was in need of a faster method for creating swept volume models from kinematically defined part motion. These swept volumes were used in the design process for assembly and maintenance access analysis.

It was estimated that hundreds of man hours were saved for the swept volume aspect of this project by using VPS instead of using previous CAD based methods.

Voxmap PointShell™ (VPS) is a library of functions that use volume elements (voxels) to solve spatial geometry problems. VPS includes source code for several complete modules along with many auxiliary functions. An efficient memory architecture has been developed to allow very fast data access with a relatively low memory footprint.

The primary VPS modules are: collision/proximity detection, swept volume generation, and force modeling. Other potential uses include: spatial query, occlusion culling, real−time shadows, and volume intersection.

Collision and Proximity Detection

The primary use of VPS is for collision detection. The collision detection engine has two modes: polygon level accuracy and voxel level accuracy. The voxel accuracy mode is extremely fast, performing up to 600,000 collision tests per second on a SGI Octane (R10000−250Mhz). When higher accuracy is needed the polygon level collision detection mode of VPS can be used. Although slower than the voxel mode, the VPS spatial partition search allows for very fast polygon culling.

The basic VPS collision detection function is also capable of proximity calculations −− useful for distance measurements as well as for geometry offsetting needs.

Swept Volume Generation

The VPS swept volume creation functions can be used to generate solid models from the paths that objects take through space based on user defined motion. A swept volume surface offset capability is also included. The VPS meshing function takes advantage of local voxel space topography to quickly generate polygonal models.

Force Modeling

By generating object interaction forces, the built in force model can be used as the basis for physically based simulation. Its speed makes VPS ideal for haptics work where fast and consistent update rates are required to maintain stability.

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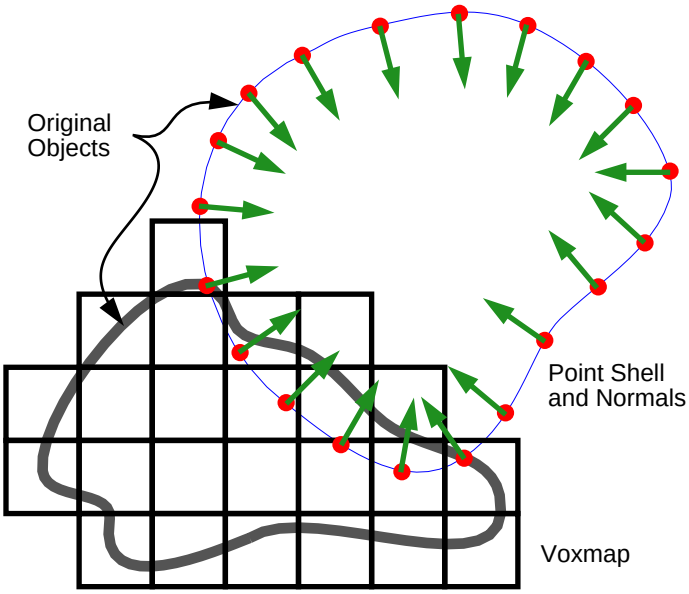
VPS Method Details

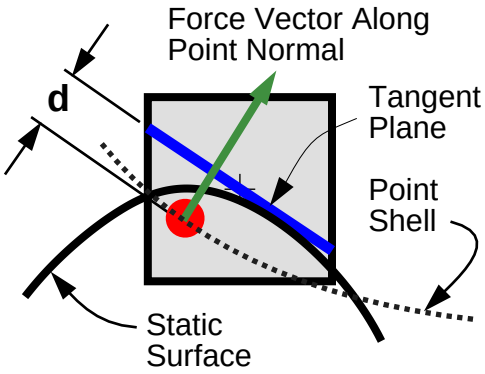
The VPS method is based on discretization of the space occupied by polygonal objects into a set of voxels. The approach can be applied to all polygonal models. All voxels within the volume of an object are designated as 'filled', and a simple Boolean test can then be performed against the object's voxel map to determine whether a point lies within or outside the object. Reduction of the collision detection problem in this way produces a consistently fast and reliable algorithm for detecting contact between two objects.



Collision / Proximity. Collision and proximity tests are performed by testing each point in the pointshell against every voxel in the voxmap. The voxmap represents all static (non−moving) objects, while the pointshell is the collection of surface points that represents the dynamic (moving) object. If both objects are in motion the relative transformation is used.

Swept Volume Generation. Voxel based methods are ideally suited to create swept volumes. The method used by VPS takes advantage of local voxel position information to aid in the generation of the mesh. This allows for fast swept volume creation that avoids degenerate surfaces.

Force Modeling. The force generation model used in VPS is a penetration−based technique that has been tuned to minimize processing. The method uses a plane that pivots about the the center of the voxel based on the direction of the normal of the point in contact. The depth of penetration, *d*, is measured and used to generate the reaction force.



Memory Usage. The memory footprint depends on the size of the voxels used. The only limitation is the amount of memory available on the computer. A unique voxel storage method, based on the generalization of the octree method, is used to increase memory efficiency and to reduce tree traversal time.

Other Features. Source code for many types of applications are included, for example: physically based modeling, haptics, and file translators. Operating systems: UNIX/Linux and Windows NT/2000.

For more information on VPS visit the Boeing web site or contact us in person:

www.boeing.com/assocproducts/vps

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