Leica Geosystems

Optimizing IMAGINE VirtualGIS Performance

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Geospatial Imaging, LLC.
Norcross, Georgia

Leica Geosystems Geospatial Imaging, LLC
Worldwide Headquarters
5051 Peachtree Corners Circle
Norcross, GA 30092-2500 USA

Phone: +1 770 776 3400
Fax: +1 770 776 3500 (general inquiries)
E-mail: info@gi.leica-geosystems.com

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VGIS Performance Enhancement

Overview

IMAGINE VirtualGIS' powerful three-dimensional (3D) capabilities are most impressive when they are running at top speed. Its performance can be optimized through the correct use of preferences, settings, and options. These adjustments typically make trade-offs between speed performance and display quality and vary depending on data, application, and system type.

What affects VirtualGIS performance?

- Amount and complexity of geometry to render
- Amount of texture mapping to perform (process of applying an image to the 3D geometry)
- Graphics card used (will affect geometry rendering & texture mapping speeds)

See Choosing a Graphics Card.

When may adjustments have to be made in order to improve VGIS performance?

- Using very large files (large DEMs, large Raster overlays)
- Using a large number of files (several adjacent DEMs and Raster overlays)
- Using Virtual Worlds with large datasets
- Using a high Level of Detail (ex: downtown DEM at 100 % LOD for line of sight analysis)
- Using many complex DXF models, vector coverages, and annotation layers
- Running VirtualGIS on a low-end machine

Where can adjustments be made to improve performance?

- IMAGINE and VirtualGIS Preference settings
- Scene Properties settings
- View menu options settings
- Using Virtual Worlds
- Virtual World settings

Amount and complexity of geometry to render

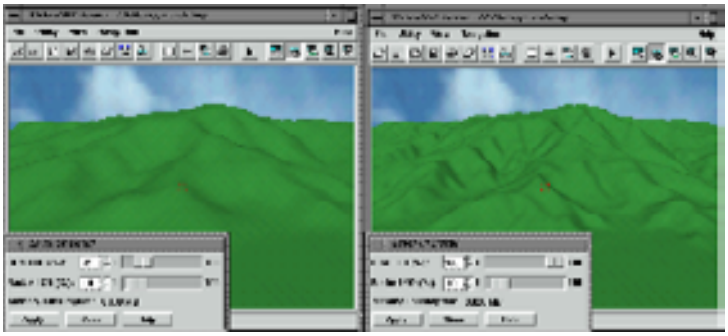
The amount and complexity of geometry that VirtualGIS must render depends on the following:

DEM size and LOD used

The use of larger DEMs (rows/columns) and higher Level of Detail % settings, translates to more geometry to render. Performance will thus be affected.

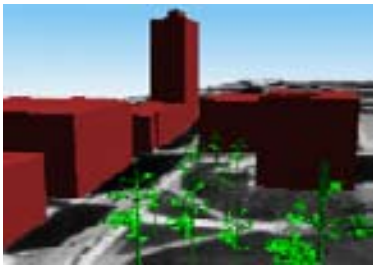
What can be done to improve performance?

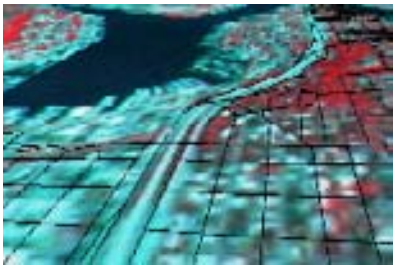
When using very large DEMs (without use of Virtual Worlds), performance can be enhanced by decreasing the Level of Detail %. When a DEM is first opened in the VirtualGIS Viewer, the default LOD % provides good performance, at the cost of degraded terrain detail (see Using Virtual Worlds).



Use of 3D Models, vector coverages, and annotation layers

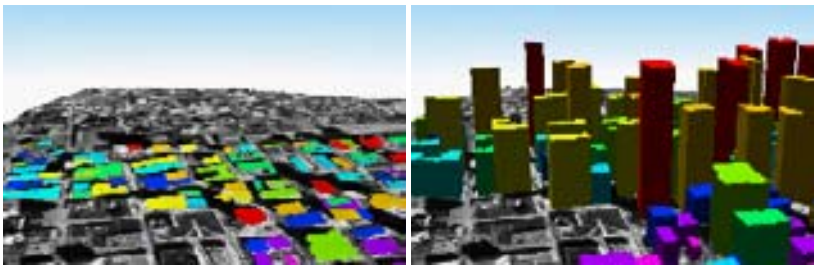
The use of 3D models, vector layers, and annotation results additional 3D geometry to render and thus decreased performance. The following ramifications occur when using 3D models, vector layers, and annotation layers.





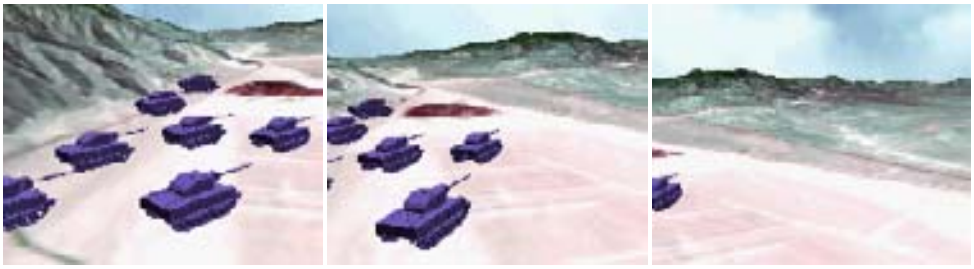
Use of draped or extruded vector layers

- For vector coverages & annotation, the more vertices present, the greater the performance impacts
- Draped vectors and annotations will only be rendered (& slow you down) only when they are in view. Therefore, once they drop from view, their performance impacts will be reclaimed.
- Height extruded vector & annotation layers always affect performance (regardless of if they “in view”)



Use of 3D models

- Models such as 3D DXF objects will only be rendered (& slow you down) when they are in view. Therefore, once they drop from view, their performance impacts will be reclaimed.
- 3D objects with more vertices incur higher performance impacts
- The more 3D models used, the higher the performance impacts
- Duplicates of 3D models incur less impacts than several unique models



What can be done to improve performance?

- Texture mapped billboards can be used as an alternative to DXF models (e.g. use of billboarded tree images, instead of DXF tree models), as they have much lower performance impacts
- Use vector & annotation layers with fewer vertices
- When draping vector and annotation layers optimize the “Use Stencil Buffer” and “Use Polygon Offset” preferences to suit the specific graphics card (see preferences below)
- Use 3D models with fewer vertices
- Other 3D model formats, such as Multigen’s OpenFlight, use texture maps to simulate surface features, thereby reducing the number of vertices and increasing performance.
- Use less 3D objects, vector coverages, and annotation layers

Amount of texture mapping to perform

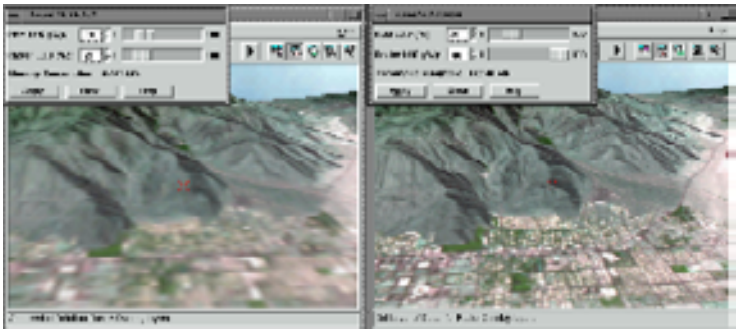
The amount of texture mapping (process of applying an image to the 3D geometry) that VirtualGIS must perform will affect performance. Also, the graphics card will determine texture mapping speeds (see Choosing a Graphics Card for VirtualGIS paper). The amount of texture mapping to perform is dependant on raster overlay size and LOD used.

Raster Overlay size and LOD used

The use of larger Raster Overlays (rows/columns) and higher Level of Detail % settings, translates to more texture mapping to perform. Performance will thus be affected.

What can be done to improve performance?

- When using very large Raster Overlays (without use of Virtual Worlds), performance can be enhanced by decreasing the Level of Detail %. When a Raster Overlay is first opened in the VirtualGIS Viewer, the default LOD % provides good performance, at the cost of degraded image detail (see using virtual worlds).
- Make sure to set the Raster tiling preference to “good” (see preferences below)
- Turn on the Texture Mipmapping preference (see preferences below)



Preferences affecting performance

Several ERDAS IMAGINE and VirtualGIS preferences can be modified to improve the performance of IMAGINE VirtualGIS. Some preferences in IMAGINE VirtualGIS make a trade off between rendering speed and display quality. These changes may affect other applications running within the ERDAS IMAGINE environment.

IMAGINE Preference Settings

Memory: Directory for the External Memory File

Specify a directory on a local file system with greater than 20MB available. IMAGINE VirtualGIS will create a file in the specified directory to use before any system memory is consumed. This will improve the performance when rendering large Virtual Worlds in IMAGINE VirtualGIS.

Memory: Total Size of External Memory in Megabytes

Should be set to greater than 20MB.

ERDAS IMAGINE Image Files (Native): Memory Map File Size Limit

Should set to 0.000.

ERDAS IMAGINE Image Files (Native): Memory Map Segment Height

Should set to 0.000.

These will disable memory mapping. Some Virtual Worlds built in the Virtual World Editor could be greater than the defaults displayed. This preference may have large impacts when using large Virtual Worlds if it is not set to 0.

IMAGINE VirtualGIS Preference Settings

Raster Tiling Quality

Set to Good (default is Best) for approximately 10-20% improvement in performance.

This preference defines the quality of the seams between the segmented image sectors used to render an image in IMAGINE VirtualGIS. If this preference is set to **Good**, the edges between the tiles may be visible when the image is magnified. If this preference is set to **Best**, the edges between the tiles will not be visible, no matter how magnified the image, but it will require more texture memory and slower performance. Setting this preference to good will also reduce the amount of memory consumed by VirtualGIS by approximately 65%.

Allow Color Fallback Mode

Set to OFF (default ON) for small to medium performance improvement.

This preference allows you to use the Shaded Color fallback quality to view at a lower resolution when moving through a rendered scene in IMAGINE VirtualGIS. This allows faster movement on slower graphics systems. However, more memory is used by IMAGINE VirtualGIS when this fallback quality is used. High-performing graphics systems should disable this preference to use less memory when navigating through. This option will increase the memory usage of VirtualGIS. If memory consumption is a concern, or you will not be using fallback modes, then this preference should be turned off. Turning this preference off will also disable the use of the “Save To VRML” option. If you wish to use the VRML option then turn this preference on. The default is on.

Use Elevation Angle LOD

Set to ON (default is OFF) for medium performance improvement.

Allows VirtualGIS to use lower resolutions of the terrain when viewing Virtual Worlds from an orthogonal direction. This preference increases performance with large DEMs with medium to high relief.

Maximum Allowed Elevation Error

Increase this value (default is 3) for medium performance improvement.

Higher the elevation error values give better performance. However, a high elevation error also degrades the visual quality of the DEM. When you are zooming towards a terrain feature (like a mountain) this will update the quality (detail) of the terrain as you approach, This preference governs at what point the detail is updated. If set to high, the terrain may appear general and then suddenly pop into a noticeably higher detail.

Use Texture MipMapping

Set to ON (default OFF) for small to medium performance improvement.

Allows VirtualGIS to create multiple levels of detail for imagery (similar to Virtual Worlds). This preference enhances the visual quality of the display by removing the aliasing artifacts that can be seen when using large imagery and marginally increases the amount of memory used for rendering. This preference may speed up performance whether you are using a Virtual World or loading the imagery directly into VirtualGIS. However, if this preference is turned on black seams may appear in the terrain if the graphics card does not support the GL_SGIS_texture_edge_clamp, GL_EXT_texture_edge_clamp, or GL_SGI_texture_edge_clamp OpenGL extensions.

Use Multi-Threading

Should always keep enabled for medium to large performance improvement.

Preference defines whether IMAGINE VirtualGIS uses separate processes for file I/O and graphics I/O. When enabled, this preference allows the interface and the motion within a IMAGINE VirtualGIS scene to continue without waiting for data from the disk. This is especially useful for displaying imagery over a network.

Use Display List Rendering

Should Always keep enabled on SUN Solaris Creator 3D and Elite 3D graphics cards for medium to large performance improvement.

Preference defines whether IMAGINE VirtualGIS OpenGL display lists to rendering the terrain and textures. This will provide a 10X increase in performance on the two graphics cards described above.

Scene Properties settings affecting performance

Scene Properties settings can be adjusted to give performance improvements.

DEM tab

Viewing Range

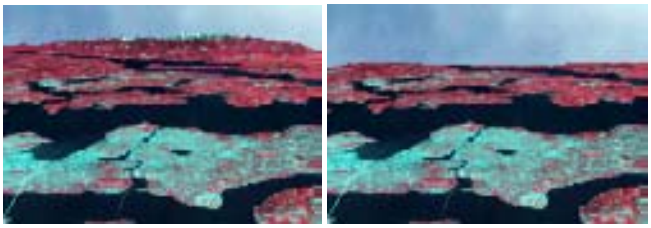
Decreasing the Viewing range can give large performance gains, especially when using very large datasets. Set this value to your desired viewing range. You can use the exponential fog option to hide the “edge” of the viewing range for added realism. For example, you may only need to see 10miles, though your dataset covers 50 miles. The viewing range can typically be reduced from the default settings by 75% and still retain most of the imagery; however, modifying the viewing range may cause the image to completely disappear when resetting the Scene to the default position (i.e. viewing the entire data set). Setting viewing range using the following equation can get you into a reasonable range:

[0.5 to 1.5] x [image scale] x [(1 for meters) or (3.281 for feet)]

For example, with a 1:40,000 scale image,

(0.75) x (40,000) x (1) = 30,000 meters <or> (0.75) x (40,000) x (3.281) = 98,430 feet

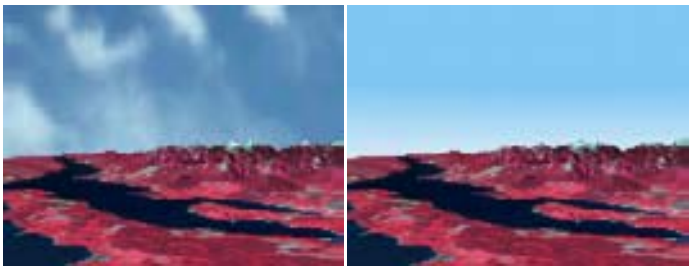
(If you don’t know your image scale, use IMAGINE viewer’s Scale Tool)



Background tab

Background Type

Setting the background to “Solid Color” or “Fade Color” (instead of “Image”) can give small to medium performance improvements over using “Image”. The amount of benefit varies depending on the system and graphics display.



View menu options affecting performance

View menu options can be adjusted to give performance improvements.

Sun Positioning: Use Lighting

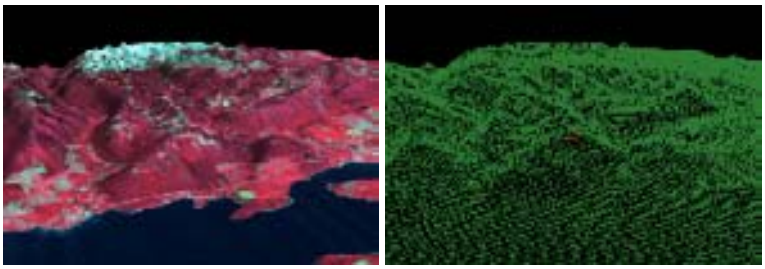
Switching off the Use Lighting option can provide some speed improvements. When using image overlays, this option may not be needed since the image already contains natural shading from the sun. The amount of benefit varies depending on the system and graphics display. However, disabling this option when using large DEMs in a Virtual World could provide significant speed improvements.

Level Of Detail: DEM LOD (%), Raster (%)

Reducing the Level of Detail for the DEM and Raster Overlay can give large speed improvements. These values should be reduced to an acceptable level to obtain the best speed vs. resolution ratio. Using the default settings upon opening the DEM & Raster files will give good performance, but at the cost of reduced image and terrain detail.

Fallback Mode

If not concerned with rendering the image while in motion, using the fallback mode can give large speed performance benefits during movement. Once movement has stopped, the raster image overlay will be rendered (texture mapped) to the terrain.



Using Virtual Worlds

A Virtual World can be used to open and archive several layers of geographic raster and vector data simultaneously, while improving VGIS performance when using very large data sets. Also, by rendering images with multiple resolutions, you can exploit the imagery's full resolution, while maintaining a high degree of performance.

Virtual World Advantages

- Improved performance when using very large datasets
- Use of multi-resolution allows use full resolution while maintaining performance
- Increased performance handling of vector and annotation when they are not in view (i.e. increased "not in view" performance benefits over just using the VirtualGIS Viewer to open the layers<non world>)
  - All data layers can be opened simultaneously as a Virtual World
  - Automatically reprojects all data sources into one Projection.

Sector Size / Number of Sectors

The smallest number of sectors possible should be used, while minimizing the amount of sector space that is partially filled with data (additional calculations are performed for partially filled sector space). A sector size should be chosen to achieve this. The Sector View Tool can be used to visually determine the number of sectors and partially filled sector space (for a selected sector size).

Other reasons for minimizing the number of sectors include:

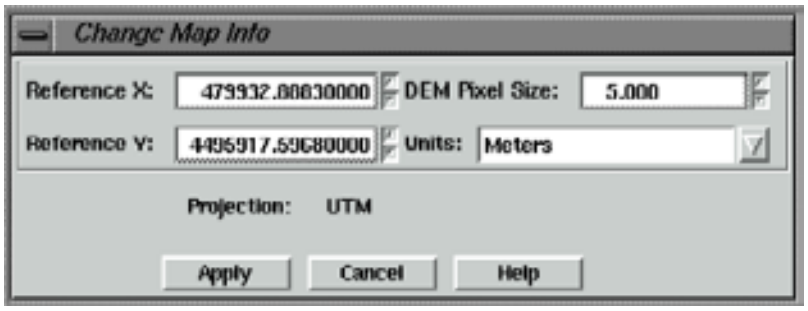
- Machine OS specific "number of files open" limits. Using a large number of sectors will results in a large number of files open at once, which may exceed this limit.

- Access to data layers in specific sectors (Manageability). When many layers of data are present, it may become difficult to manage which data layers are available in which sectors. When trying to access a data layer (ex: query vector coverages for attributes), the appropriate sector must be selected.

Resolution

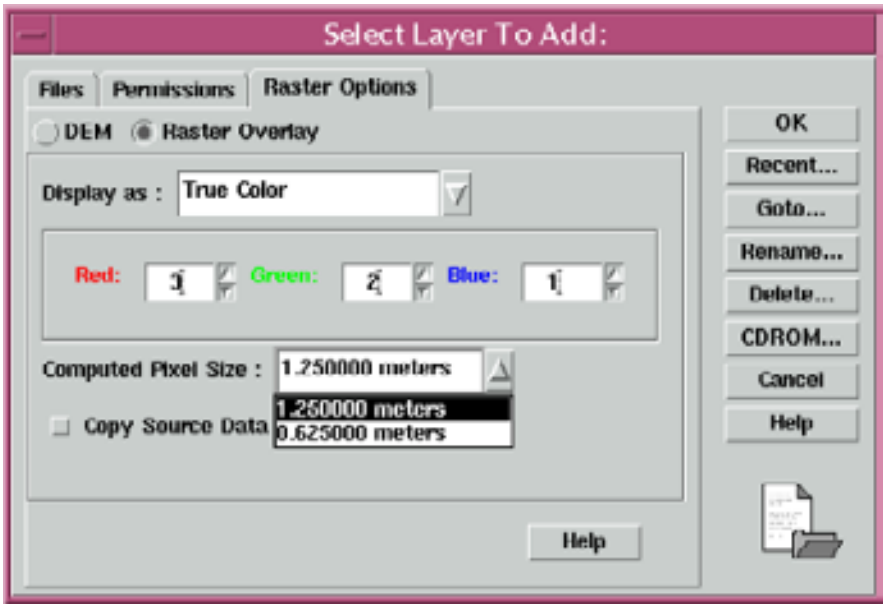
Virtual Worlds can be setup to use reduced resolution versions of the DEMs and Raster overlays, thereby improving performance. This should be done if the full resolution of the DEM and Raster Overlay is not needed.

The resolution used for the DEMs can be set from World Info tab. Using lower resolutions will improve performance. For example, if you are using a 5 meter DEM, but only require 20 meter resolution for the application, using 5 meter resolution will unnecessarily decrease performance.



- When a Raster Layer is added, the Raster Options tab will allow you to select from one of two Computed Pixel Sizes. Unless the higher resolution is needed, the lower resolution should be chosen. The resolutions displayed represent values that are multiples of two from the DEM resolution, which is required by the Virtual World Database.

- If the actual resolution of the image is desired then multiply or divide the image pixelsize by 2 until you reach the approximate pixelsize of the DEM. Then change the DEM Pixel Size to this value. (e.g. the image pixelsize is 10 and the DEM pixelsize is 30. Multiply 10 x 2 x 2 to produce 40. By setting the DEM pixelsize to either 20 or 40 you will have the option to display the image at a pixelsize of 10.



Tile Size

The “Tile Size” setting, which is available in the World Info tab under the DEM OPTIONS section, specifies the actual size in file pixels of the tiles of raster imagery that are read from disk while viewing a Virtual World in the VirtualGIS Viewer. When working with large amounts of raster imagery or elevation models you may want to increase this value in order to reduce the number of times the disk is accessed to retrieve imagery. Within the display you may notice larger areas of imagery changing resolution as you fly thru the scene. The "Tile Size" feature also has a very large impact on the footprint of the Virtual World in memory when it is read by the VirtualGIS viewer. Previously the "Tile Size" was set at 64,which has proven to be adequate for Virtual Worlds under 200 MB. However, with Virtual Worlds larger than 200 MB a "Tile Size" of 128 has increased the rendering speed by 3X. For Virtual Worlds over 2 GB in size you may want to increase the tile size to 256. For large Virtual Worlds (over 1 GB) the Tile Size option has increased the performance by 10X. Changing the value of "Tile Size" will require a re-build of the Virtual World.

Once the World is Opened in the Vgis Viewer

Once the Virtual World is opened in the VirtualGIS Viewer, further adjustments to previously mentioned options may have to be made to improve speed performance, if not adequate (see following example). Specifically:

- IMAGINE and VirtualGIS Preferences
- View menu settings: Level of Detail – decrease % (DEM and Raster)
- Scene Properties settings: Viewing Range – decrease the Viewing Range
- Turn off Sun Shading

Virtual worlds with vector layers, annotation, and DXF objects will have the following performance behavior:

- DXF objects, draped vectors, and models will only be rendered (& slow you down) only when they are in view. Therefore, once they drop from view, their performance impacts will be reclaimed.
- Virtual Worlds have increased performance handling of vector and annotation when they are not in view (i.e. increased “not in view” performance benefits over just using the VirtualGIS Viewer to open the layers<non world>)
- There is no increased “out of view” performance benefits for DXF objects (over the VGIS Viewer)
- Height extruded vector & annotation layers will always affect performance, regardless of if they are in view.
- Vector coverages & annotation with more vertices, will cause increased performance impact
- DXF objects with more vertices, will cause increased performance impact

Using VGIS on Low-end Systems

On some graphics cards, there is no support for OpenGL at all. In this case all of the 3D processing occurs in software as opposed to the graphics hardware. Thus, the performance will be entirely dependent on the speed of the central processing unit (CPU). IMAGINE VirtualGIS will work with this level of OpenGL support, but real-time manipulation of the viewing geometry will require the use of fall-back modes. Also, further adjustment of previously mentioned preferences and options will help (LOD %, Viewing Range, etc).

Summary of settings to improve speed

The settings and preferences that affect performance are listed here.

Scene Properties

DEM tab: *Viewing Range*

Set to a reasonable viewing range value. Setting viewing range using the following equation can get you into a reasonable range:

[0.5 to 1.5] x [image scale] x [(1 for meters) or (3.281 for feet)]

For example, with a 1:40,000 scale image,

(0.75) x (40,000) x (1) = 30,000 meters

(0.75) x (40,000) x (3.281) = 98,430 feet

(If you don’t know your image scale, open the image in an IMAGINE viewer (at default zoom) and bring up scale tool)

Background tab: *Background Type*

Use Solid Color or Faded Color instead of Image (default is Solid)

View menu options

Sun Positioning dialog*: Use Lighting*

Switch off (default is On)

Level Of Detail dialog: *DEM LOD (%), Raster LOD (%)*

Use default settings upon opening the DEM & Raster files <and/or> reduce % values as appropriate

Fallback Mode

Switch to Off (use *On Motion* or *On Demand* if real-time texture rendering is not needed during movement or for non-OpenGL cards) (default is Off)

IMAGINE Preferences

Failing to set these IMAGINE preferences to 0 can have large performance impacts with large Virtual Worlds and may even cause "out of memory" errors.

Memory Map File Size Limit

Set to 0

Memory Map Segment Height

Set to 0

VirtualGIS Preferences

Raster Tiling Quality

Good(default is Best)

Allow Color Fallback Mode

Set to Off (default is On)

Use Elevation Angle LOD

On (default is On)

Maximum Allowed Elevation Error

Raise (default is 3)

Use Texture MipMapping

Using this option with a graphics card that supports the GL_texture_edge_clamp OpenGL extension will remove the aliasing artifacts that are typically seen in the distance.

Use Multi-Threading

On (default is On)

Force Texture Environment

Off (default is Off)

Theh effectiveness of the next three preferences depends on the graphics card.

Use Polygon Offset

On (default is Off). This preference is used when displaying vector or annotation layers as draped. This preference may be changed without re-opening a VirtualGIS Viewer.

Use Stencil Buffer

On (default is On). This preference is used when displaying vector or annotation layers as draped. This preference may be changed without re-opening a VirtualGIS Viewer.

Use Display List Rendering

Off (default is Off). Turn this preference on only for SUN Creator 3D and Elite 3D graphics cards.

Performance Comparison Example

Using a Virtual World to visualize a large DEM (5249 x 3985) & large multi-band overlay (14853 x 11612 <522 MB>).

- All Preferences, Scene Properties, and View menu settings are at default values
- Pyramid layers are present for both the DEM and Raster Overlay

1. Open data layers in VirtualGIS Viewer:

   Each file is opened in VirtualGIS Viewer, with default LOD settings. You will notice that the dataset can be navigated with good speed performance, but at the expense of greatly reduced DEM and overlay resolution

2. Create a Virtual World for the dataset:

   The same dataset will be opened using a Virtual World to increase the visual quality and detail while maintaining performance

   The Virtual World Editor is started from the VirtualGIS toolbar and a new Virtual World is created

3. Add DEM Layer and set pixel size for the World to use:

   The Add DEM Layer button is used to add the DEM file to the world

   Under the World Info tab, the Change Map Info dialog is used to change the DEM resolution (that the Virtual World will use) from 2.5 meters to 5 meters. (For this example, suppose you have a 2.5 meter DEM but only need 5 meter resolution for your application)

4. Add Raster Overlay and choose pixel size to use:

   The Add Raster Overlay button is used to add the raster overlay layer to the world

   In the Raster Options tab (of Select Layer To Add dialog), the two options available for the Computed Pixel Size are 1.25 meters and 0.625 meters. The”1.25 meters” size is choosen (Let’s say, for this example, that you don’t need the 0.625 resolution).

5. Set Sector Size:

   The World Info tab is selected and it is seen that the default Sector Size is 1025 pixels

   The Sector View Tool is started (under Utilites menu) to assess the number of sectors and amount of partial sector space. It is seen that there are 24 sectors for the 1025 pixel sector size

   From the World Info tab, the Change DEM Options dialog is started. The sector size is changed from 1025 to 2049 pixels.

   In the Sector View Tool, it is seen that the number of sectors has now been reduced to 6. It is also seen that the amount of partially filled sector space remains about the same.

   We now have fewer sectors, with about the same amount of partially filled sector space.

6. Build All Virtual World files:

   Under the Process menu, we will now select “Build All” to create all needed world files.

7. Open the Virtual World in VGIS Viewer:

   In the VirtualGIS Viewer, open the Virtual World file

   Notice that the speed performance, during motion, is very slow.

Changes to improve performance

Make the following changes and repeat the steps above to observe the improvement in performance.

The Following Preferences are changed:

- IMAGINE Image Files (native): Memory Map File Size Limit - set to 0
- IMAGINE Image Files (native): Memory Map Segment Height - set to 0
- VirtualGIS: Raster Tiling Quality - set to Good (default is Best) approx 10% impact
- VirtualGIS: Allow Color Fallback Mode - set to OFF (default ON)
- VirtualGIS: Use Elevation Angle LOD - set to ON (default OFF)
- VirtualGIS: Maximum Allowed Elevation Error - raise to 10 (default 3)

The following Scene Properties are changed:

- DEM tab:Viewing Range - reduce the value (reduced to 10,000 from 26240 meters)

The following View menu Options are changed:

- Sun Positioning: Use Lighting - set to off (default on)
- Level of Detail Control: DEM LOD% - reduced to 70% (defaulted to 80%)

- Level of Detail Control: Raster LOD% - reduced to 90% (default 100%)

Now good visual quality and detail is achieved while greatly improving speed performance.

Choosing a Graphics Card

Introduction

The release of IMAGINE VirtualGIS™ for the Windows platforms has raised questions about which graphics cards will provide the best performance. This section is intended to provide basic knowledge and background information on the features to look for when purchasing a graphics card for running IMAGINE VirtualGIS.

IMAGINE VirtualGIS was developed using a graphics library called OpenGL. Originally developed by Silicon Graphics, Inc., OpenGL is now available across a broad range of UNIX and PC platforms and operating systems. However, there are varying levels of support for OpenGL among graphics cards, prompting the question as to how to identify the most cost-effective card for your application.

On some graphics cards, there is no support for OpenGL at all. In this case, all of the 3D processing occurs in software as opposed to the graphics hardware. Thus, the performance will be entirely dependent on the speed of the central processing unit (CPU). IMAGINE VirtualGIS (and the Image Drape utility in IMAGINE Essentials™) will work with this level of OpenGL support, but real-time manipulation of the viewing geometry will require the use of fallback modes.

At the next level, the graphics card can provide OpenGL drivers but only accelerate some OpenGL functionality. In this case some specific commands in OpenGL may be accelerated while others will still be performed in software (e.g. rendering triangles may be accelerated while rendering textured triangles is not). This is the most frequently encountered situation with a graphics card. Many of these graphics cards have a software control panel that allows you to select the OpenGL options you want accelerated based on the needs of the applications you are using. This allows the driver to be tuned to the needs of the application. Unfortunately, the options available in the control panel vary from one card to the next. To summarize, when reviewing a graphics card, in addition to determining if it supports OpenGL, verify which OpenGL features are supported by the hardware and which are supported only in software.

OpenGL Features important to VirtualGIS

3D Geometry Rendering

The most basic feature of IMAGINE VirtualGIS is the ability to render 3D geometry. If running IMAGINE VirtualGIS in "wire frame" mode (by turning on Fallback Mode) with an elevation model displayed, you will see that the terrain is generated using a series of triangles based on the elevation postings and map information from the image. These series of triangles (sometimes called "triangle strips") represent the 3D geometry of an IMAGINE VirtualGIS scene. 3D geometry, or more specifically 3D triangle acceleration and performance, should be the first feature to look for in a graphics card. For faster rendering, geometry processing may be off-loaded to a specialized integrated circuit termed a geometry processor chip. Performance is sometimes expressed in 3D triangles per second or tps (or sometimes 3D Gouraud shaded triangles per second, which is what IMAGINE VirtualGIS uses when the Sun option is enabled).

To give some perspective on performance numbers NVIDIA Geforce 3 based cards produce 31 million tps and the Intergraph Wildcat 5110 produces 15 million tps. (Note that these are peak values for tps, and that the Wildcat 5110 is better able to maintain its peak tps output than the Geforce 3, which means that in many cases it can perform as well as, if not better than, a Geforce 3).

Texture Mapping

IMAGINE VirtualGIS also heavily uses what is known as "texture mapping." Texture mapping is the process of applying an image to the 3D geometry. For IMAGINE VirtualGIS this is what occurs when one or more satellite images (or other raster data) are draped over the terrain. Accelerated texture mapping is supported even on relatively inexpensive graphics cards. As with 3D geometry, there are performance numbers that can give you an idea as to how well the texture mapping has been implemented. These numbers (called the texture fill rate) are usually measured in billions of pixels per second (GP/sec) and divided into three categories: nearest neighbor, bilinear, and trilinear interpolation. IMAGINE VirtualGIS uses trilinear interpolation (otherwise known as anisotropic filtering) for all of the textures. Again to give some perspective on these numbers, the NVIDIA Geforce 3 Ti 500 is about 0.96 GP/sec and the ATI Radeon 8500 is 1.0 GP/sec.

Texture Memory

In addition to accelerating texture mapping, most graphics cards come with dedicated texture memory. The texture memory is used for storing textures locally on the graphics cards. Modern graphics cards also contain what is referred to as frame buffer memory that is usually only a few MBs and is used for rendering the scene on the graphics card. These cards provide additional physical memory (RAM) and provide the best texture mapping performance.

Because it has a large impact on both geometry processing and fill rate, another important factor to consider is the bandwidth between the graphics card's memory, and the graphics processing chipset (GPU) located on the card. In fact, fill rate is usually directly proportional with the memory bandwidth of the graphics card's onboard memory. Double Data Rate (DDR) memory can send twice as much data for a given clock-speed, and is effectively twice as fast as Single Data Rate (SDR) memory. Another factor to consider is the width of the bus that lies between the graphics chipset and onboard memory. A bus is a set of wires connecting the memory to the GPU. A 64-bit bus will typically have at least 64 wires connecting the memory to the GPU for the transmission of at least 64 bits of data per clock cycle. DDR RAM will have a 128-bit bus with 128 wires going from the chip to the memory transmitting 128 bits of data per clock cycle. Finally, the speed of the RAM must be considered. RAM running at 1 GHZ will provide twice the bandwidth of the same RAM at 500 MHZ.

The following equation is an example of a calculation for bandwidth for a graphics card with a 128-bit bus, running at 500 MHZ DDR: (128-bits/cycle)*(1 byte/8 bits)*(500,000,000 cyles/second)*2 = 16,000,000,000 bytes/second or 16 Gigabytes per second of bandwidth. The reason for multiplying by two in the above equation is because the RAM is DDR.

Other OpenGL features

In addition to 3D geometry and texture mapping, IMAGINE VirtualGIS also uses these OpenGL features:

- Z buffer,
- Gouraud shading,
- Fog,
- Alpha Blending,

- Stencil buffers,
- Stereo buffers, and
- Double-buffering.

The Z buffer and stencil buffer come in various precisions (e.g. 8 bit, 16 bit, 24 bit, or 32 bit). A minimum of 24-bit precision should be chosen. The Z buffer stores the depth value of each 3D object, which determines whether the object is visible or hidden behind another object.

The stereo buffer allows IMAGINE VirtualGIS to use the Stereo-In-A-Window option. If the card supports stereo, it will provide a connection on the card itself to connect to a Stereo Graphics emitter (or other device for synchronizing the screen display with some device worn over your eyes). Some graphics cards that support stereo include the Elsa Gloria III, the Elsa Gloria DCC, and 3D Labs Wildcat 4110 and 5110 cards. Double-buffered color depths allow the frame buffer memory to be divided in two so that two consecutive frames can be buffered.

Double-buffered windows allow IMAGINE VirtualGIS to render a 3D scene in the background and repaint the area within the window on the screen with the results. If the scene were rendered in the window, the user would be able to see each element of the scene being rendered individually. Double-buffered windows allow smooth animation when flying through a scene.

Alpha blending allows one object to become transparent to varying degrees so it reveals an object behind it. In 24-bit color, most boards offer an additional 8-bit "alpha" channel to control 256 levels of transparency. At 15-bit color (32,768 colors), an additional bit provides two levels of transparency or opacity, also referred to as overlay. Boards that offer 16-bit color, fall back to 15-bit color when using the overlay bit for transparency control.

Gouraud shading provides realistic shading to 3D scenes by blending colors across the face of each polygon to achieve smooth lighting effects.

Many boards can also calculate fog and other atmospheric effects so that pixels that should be seen as distant appear fainter or are otherwise realistically modified. Fog is a feature that can be accelerated in hardware. Most implementations of fog do not use this built in routine; however, it can still be used to provide a realistic fade effect.

Again, a card that offers these OpenGL features in hardware is preferable to having to rely upon a software implementation.

Other Considerations

Some other factors that should be considered when purchasing a graphics card:

- What operating systems does it support?
- What screen resolutions are supported while maintaining full OpenGL acceleration?
- Does it support AGP?

Some graphics cards are only supported under one operating system, while others support several. Some graphics cards may require you to lower their screen resolutions in order to achieve optimum performance. The Accelerated Graphics Port (AGP) is a widespread technology that is incorporated into all of the new Pentium IV systems and Athlon systems. AGP, a port similar to the PCI bus, is supposed to remove the need for dedicated texture memory by allowing faster access to main system memory as well as speedup transfer of other information that is sent to the graphics card from the CPU.

Since the graphics card manufacturer can always put a higher performance memory on the graphics card than that which is used for system memory, it is likely that dedicated texture memory will always be required. However, AGP does provide some much-needed bandwidth between the system and the graphic card. This allows the system to quickly upload textures to the graphics card, and to also send commands to the card more quickly. It is also important to remember that AGP runs at different speeds. The current fastest implementation of AGP is AGP 4x, which provides four times the speed of the original AGP specification. When purchasing a new system, one should make sure that both the video card and system motherboard support AGP 4x.

Finally, DirectX 8.1, Microsoft's graphics programming interface originally intended for games, has matured and is being used by more and more applications that extend outside of the gaming market instead of, or in addition to, OpenGL. At the current time, IMAGINE VirtualGIS does not directly use Direct3D. It can however use its features through the OpenGL interface. Future enhancements to IMAGINE VirtualGIS will be built to take advantage of the functionality provided by cards that are DirectX compliant. At the time of the publishing of this document, only the NVIDIA Geforce 3, NVIDIA Quadro DCC (or referred to as ELsa Gloria DCC), and ATI Radeon based cards provide full support for DirectX 8.1. The 3Dlabs Wildcat series of cards, and some other professional OpenGL cards, do not currently support DirectX. As a result of not having DirectX 8.1 compliance, these cards may be missing some performance features of DirectX 8.1 compliant cards.

There are a wide range of OpenGL accelerated graphics cards that are available today priced from $150 to $2000. Fortunately most of these graphics cards use chip sets from only a hand full of chip manufacturers. This is useful because graphics cards that are built using the same chip sets will have similar performance. The phrase "similar but not exact" must be stressed. This is because the graphics card vendor provides the graphics driver for the card and the overall performance of the card will depend heavily on how optimized the graphics driver is for OpenGL operations. Our experience has shown that some drivers from graphics card vendors do not properly implement certain OpenGL features that IMAGINE VirtualGIS utilizes. This is why IMAGINE VirtualGIS should be qualified on a graphics card before we can recommend its use. For example we have seen that on cards using the Evans & Sutherland RealImage chipset, the target mode (moving the scene around a fixed pivot, rather than manipulating the observer location) does not work correctly because this mode has not been implemented in the graphics card driver.

Although we are working with the card manufacturers in solving these known problems, to ensure performance quality, you should plan to evaluate the graphics cards yourself before purchasing to make sure the card is capable of fitting your needs.

For initial ideas on a graphics card to choose please refer to the IMAGINE VirtualGIS Graphics Card Benchmark (V3) document, available through the ERDAS web site (www.erdas.com).

Sources of OpenGL information

The following is a list of web sites to reference when comparing different PC graphics cards:

http://www.opengl.org/

http://graphics.tomshardware.com/graphic/20010615/index.html

All details are subject to change without notification. Leica Geosystems does not endorse any specific graphics card, nor does it offer technical support on graphics cards.