GeoQuadTree

What is GeoQuadTree ?

GeoQuadTree is an open format for storing georeferenced images.

It works on image tiles. The source image is partitioned into squared non-overlapping blocks in a process called tiling. Each of these tiles is compressed independently in PNG format, and organised in a hierarchical structure of folders.

What are the benefits of GeoQuadTree ?

- Scalability

  It allows any extent, any resolution, only limited by storage capacity. Multiple sub-images can be stored inside the same GeoQuadTree (for instance, we could store different versions od maps in the same GeoQuadTree).

- Simplicity.

  It's very easy to import any georreferenced image into the GeoQuadTree format, using the gqt command-line utility. Any image format supported by GDAL can be imported.

  This utility can also be used to export a part of a GeoQuadTree into any format supported by GDAL.

- High quality

  The images are stored in PNG format, i.e. lossless compression. The PNG format allows an alpha channel, this can be used to represent non-data pixels.

- Efficiency

  The compression used in PNG format requires low CPU usage. Other image formats can achieve higher compression factors, but at the expense of lossy compression, and higher CPU usage. Higher CPU usages implies higher response times, and lower performance on the same hardware.

- Multiple access

  This format can be accessed in different ways: by means of command line utilities, the GeoQuadTree Viewer, the GeoQuadTree WMS Server, or any software that can read GDAL sources.

- Freedom

  The GPL license gives the user freedom to use, copy, study, modify and redistribute without restriction.

- OGC WMS

  An OGC WMS service is available, featuring changes of Spatial Reference System (SRS) using the PROJ.4 library.

- GDAL driver

  A GDAL driver is available, so any software that can read from (or write to) GDAL sources can use images in this format.

What is a QuadTree?

The QuadTree is a tree data structure in which each internal node has up to four children. QuadTrees are most often used to partition a two-dimensional space by recursively subdividing it into four equal quadrants.

A GeoQuadTree image is stored on disk using a QuadTree, in which a node is a tile image. The tile image is stored as a PNG image file, and the children nodes are stored as subfolders. The four quadrants are named “1” (top left), “2” (top right), “3” (bottom right) and “4” (bottom left).

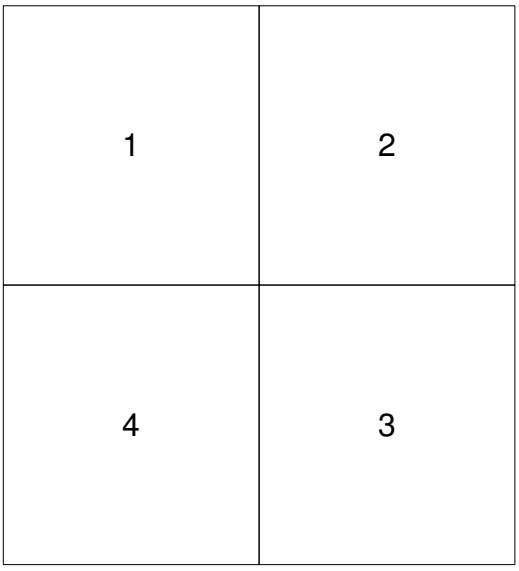
GeoQuadTree Format

A GeoQuadTree image is composed of an XML metadata file and a set of folders and image files.

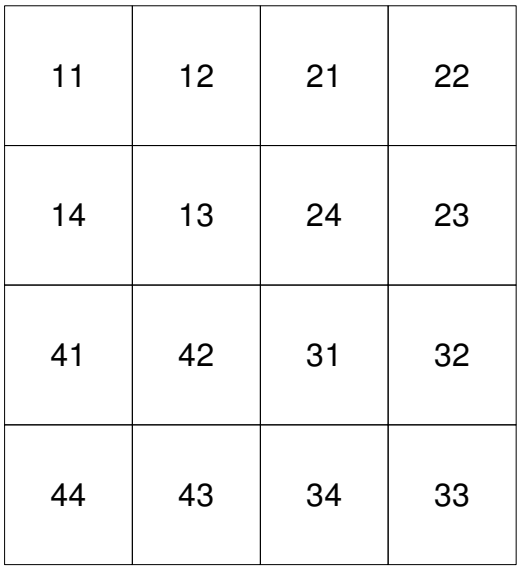
Structure of folders

Each tile is compressed independently in PNG format, and organised in a hierarchical structure of folders. Each of these folders always contain an image file, and possibly up to four subfolders containg quadrants at a ahigher resolution, named “1” (for top left), “2” (for top right), “3” (for bottom right), and “4” (for bottom left). The “1” folder contains the image of the top left quadrant, the “2” folder contains the image of the top right qudrant, and son on.

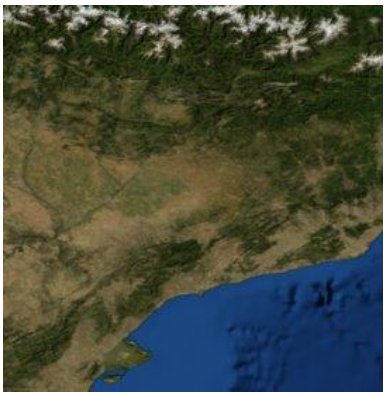
All the tiles in a GeoQuadTree image have the same size in pixels. The GeoQuadTree WMS Server can combine images with different tile size.



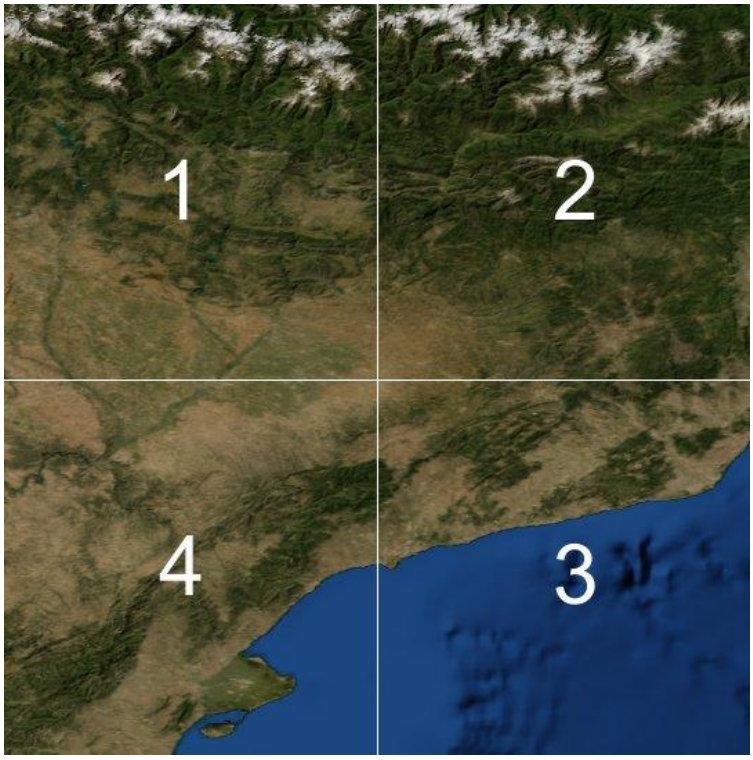
Level n+1



Level n+2



A tile is divided in 4 subtiles...



...the 4 subtiles are named "1", "2", "3" and "4"

XML metada file

The XML metada file is located at the top folder, and its DTD is the following:

```
<!ELEMENT GeoQuadTree (EMPTY) >
<!ATTLIST GeoQuadTree
    levels CDATA #REQUIRED
    resx CDATA #REQUIRED
    resy CDATA #REQUIRED
    tilesizex CDATA #REQUIRED
    tilesizey CDATA #REQUIRED
    minx CDATA #REQUIRED
    miny CDATA #REQUIRED
    maxx CDATA #REQUIRED
    maxy CDATA #REQUIRED
    srs CDATA #REQUIRED>
```

The **levels** parameter defines the number of levels in the pyramid of overviews.

resx and **resy** specify the size of the pixel on the SRS. For instance, in the case of Blue Marble Next Generation at 240 arc seconds per pixel, **resx** and **resy** should be 240/60/60=0.06666666 arc degrees.

tilesizex and **tilesizey** defines the size of the tile in pixels.

minx, **miny**, **maxx**, **maxy** specify the coordinates of the minimum bounding box containing the image (excluding non-data pixels).

The **srs** is the code of the Coordinate Reference System (CRS), expressed in the notation defined by the European Petroleum Survey Group, e.g. “EPSG:4326”.

The defined space can be calculated with these formulae:

$$space\_minx = -resx * tilesizex * 2^{levels}$$

$$space\_miny = -resy * tilesizey * 2^{levels}$$

$$space\_maxx = resx * tilesizex * 2^{levels}$$

$$space\_maxy = resy * tilesizey * 2^{levels}$$

An example of XML metada file is the following one:

```
<?xml version="1.0"?>
<GeoQuadTree levels="9" resx="0.004166666666666" resy="0.004166666666666" tilesizex="270" tilesizey="270"
minx="0.000000000000000" miny="0.000000000000000" maxx="0.000000000000000"
maxy="0.000000000000000" srs="GEOGCS[&quot;WGS
84&quot;,DATUM[&quot;WGS_1984&quot;,SPHEROID[&quot;WGS
84&quot;,6378137,298.257223563,AUTHORITY[&quot;EPSG&quot;,&quot;7030&quot;]],AUTHORITY[&quot;EPSG
&quot;,&quot;6326&quot;]],PRIMEM[&quot;Greenwich&quot;,0,AUTHORITY[&quot;EPSG&quot;,&quot;8901&quot;]
],UNIT[&quot;degree&quot;,0.01745329251994328,AUTHORITY[&quot;EPSG&quot;,&quot;9122&quot;]],AUTHORI
TY[&quot;EPSG&quot;,&quot;4326&quot;]]"/>
```

Software – The gqt command line utility

Creating a GeoQuadTree

With the option -c we can create an empty GeoQuadTree image:

gqt -c

-g *path_GeoQuadTree_XML_file*

Path to the GeoQuadTree XML file (recommended extension is .gqt).

-s *SRS_type*

Type of the SRS definition (can be 'WKT', 'EPSG', or 'PROJ4').

WKT stands for OpenGIS Well Known Text. The Open GIS Consortium has defined a textual format for describing coordinate systems as part of the Simple Features specifications. This format is the internal working format for coordinate systems used in GDAL. The name of a file containing a WKT coordinate system definition may be used a coordinate system argument, or the entire coordinate system itself may be used as a commandline option (though escaping all the quotes in WKT is quite challenging).

EPSG means here that the definition of the SRS it is in the EPSG:n format.

PROJ4 means that the definition of the SRS it is in the PROJ.4 format.

-S *SRS_definition*

The SRS definition, in the format specified with -s.

Examples:

-s WKT -S "GEOGCS["WGS 84",DATUM["WGS_1984",SPHEROID["WGS 84",6378137,298.257223563,AUTHORITY["EPSG","7030"]],AUTHORITY["EPSG","6326"]],PRIMEM["Greenwich ",0,AUTHORITY["EPSG","8901"]],UNIT["degree",0.01745329251994328,AUTHORITY["EPSG","9122"]],AUTHORITY["EPSG","4326"]]"

-s EPSG -S EPSG:4326

-s PROJ4 -S "+proj=latlong +datum=WGS84"

-l *number_of_levels*

Number of levels in the pyramid of overviews.

-r *resolution_x,resolution_y*

Size of the pixel in world coordinates.

-t *tile_size_x,tile_size_y* (optional, default 256, 256)

Size of the tile, in pixels. If it is not specified, it is 256,256 by default.

-v verbose (optional)

With this option, a lot of information it is printed on standard output.

Importing an image in another format into a GeoQuadTree

gqt -i

-g *path_GeoQuadTree_XML_file*

Path to the GeoQuadTree XML file (recommended extension is .gqt).

-f *path_file_to_import*

Path to the file to import. It can be in any of the formats supported by GDAL.

-n *sub_image_name* (default 'gqt')

Name of the sub-image. It can be any string. If its no specified, its is 'gqt' by default. This name is the same as the name of the tile image file.

-d *red,green,blue* (color used for non-data, optional)

If specified, this is the red, green and blue components of a color used for non-data pixels.

-m *blur_factor* (>1 for blurry, <1 for sharp, default 1.0)

-k *resampling_filter*

0 - Undefined, 1 - Point, 2 - Box

3 - Triangle, 4 - Hermite, 5 - Hanning

6 - Hamming, 7 - Blackman, 8 - Gaussian

9 - Quadratic, 10 - Cubic, 11 - Catrom

12 - Mitchell, 13 - Lanczos (default)

14 - Bessel, 15 - Sinc

-v verbose (optional)

Exporting part of a GeoQuadtree to an image in another format

gqt -o

-g path_GeoQuadTree_XML_file

-f path_file_to_export

-n sub_image_name (default 'gqt')

-s SRS_type

-S SRS_description

-b min_x,min_y,max_x,max_y

-t width_in_pixels,height_in_pixels

-v verbose (optional)

Software - GeoQuadTree Viewer (geoquadtreeviewer.php)

This PHP script allows navigating through a GeoQuadTree image, with the only requirement of a web browser on the client side, and a web server on the server side (PHP enabled, of course). It's so simple that a developer can use it to write the fastest web application to navigate through full screen maps.

Software - GeoQuadTree WMS Server (geoquadtree.fcgi)

This is a FastCGI program that serves map images using the OGC WMS specification. It has a unique requirement, a FastCGI-enabled web server. For example, *Apache Web Server* with the *mod_fastcgi* module.

Software - GeoQuadTree GDAL Driver

Example - Importing NASA's Blue Marble Next Generation

In this example we are going to import NASA's *Blue Marble Next Generation* (BMNG) image into *GeoQuadTree* format. This is a series of images that show the color of the Earth's surface for each month of the year 2004 at a resolution of 15, 60 and 240 arc seconds (500 m, 2km, and 8 km approximate spacing at the equator).

First of all, we must download the image at 15 arc-seconds per pixel (86400x43200 pixels at this resolution). It is free available at NASA's *Visible Earth* website (see References).

The BMNG is available as 8 image in PNG format or in JPEG format, or as a unique file as “raw data”. We are going to use this last format (its size is about 2 or 3 GB).

References

GDAL – Geospatial Data Abstraction Library

http://www.gdal.org/

GDAL is a translator library for raster geospatial data formats that is released under an X/MIT style Open Source license by the Open Source Geospatial Foundation. As a library, it presents a single abstract data model to the calling application for all supported formats. It also comes with a variety of useful commandline utilities for data translation and processing.

Open Geospatial Consortium, Inc. (OGC)

http://www.opengeospatial.org/

The Open Geospatial Consortium, Inc. (OGC) is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services. Through our member-driven consensus programs, OGC works with government, private industry, and academia to create open and extensible software application programming interfaces for geographic information systems (GIS) and other mainstream technologies.

European Petroleum Survey Group (EPSG)

http://www.epsg.org/

Integrated in OGP Surveying and Positioning Committee since 2005.

The OGP Surveying and Positioning Committee, through its geodesy sub-committee, maintains and publishes a dataset of parameters for coordinate reference system and coordinate transformation description. The EPSG Geodetic Parameter Dataset has been included as reference data in UKOOA and SEG positioning data exchange formats, the GeoTIFF interchange format for georeferenced raster imagery, the IHS Energy Iris21, PPDM and POSC Epicentre data models.

PROJ.4 - Cartographic Projections Library

http://www.remotesensing.org/proj/

PROJ.4 is a cartographic projections and datum shifting library written in C. It includes support for many (100+) projections, including Transverse Mercator and Lambert Conformal Conic. Included is a command line program for reprojecting points. It was originally written by Gerald Evenden of the USGS, and is in active use in various commercial and freeware software.

libpng.org

http://www.libpng.org/

Home of PNG, MNG and JNG image formats, and libpng library.

Independent JPEG Group (IJG)

http://www.ijg.org/

IJG is an informal group that writes and distributes a widely used free library for JPEG image compresion.

FastCGI

http://www.fastcgi.com/

FastCGI is a language independent, scalable, open extension to CGI that provides high performance without the limitations of server specific APIs.

NASA's Visible Earth

http://visibleearth.nasa.gov/

A catalog of NASA images and animations of our home planet