Map Overlay and Zooming for Satellite Images

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***Abstract*— Map overlay and satellite image zooming makes map reading more convenient. These techniques are the building block for various analysis operations in GIS. Map overlay is performed by layering maps in the form of shapefiles over a raster map. In this paper map overlay is performed using uniform grid method. The shapefiles are placed one over the other using the coordinate information attached with these files. Satellite image (Raster Map) zooming enable users to view the inner details of the map which will provide a real world view. The proposed system achieves this by first tiling the image and then generating an image pyramid with these tiles. While zooming, the system loads only tiles of the required portion of the image instead of loading the entire image.**

Keywords—Overlay, Grid, Pyramid, Tile.

I. INTRODUCTION

Many Geographic Information Systems (GIS) use map layers to organize and study the geographic features of an area. Map overlay and satellite image/raster map zooming are two spatial analysis problems that come under the raster model [1].

In map overlay every layer describes an aspect of the real world. A two-way map overlay involves unions and intersections of large number of polygons of each map. But many applications require more than two layers. This can be executed as a sequence of binary map overlay operations called multiple maps overlay [2]. The complexity of the operation depends on the number and size of the maps. The geospatial data are stored using two different but complementary models, raster and vector. Map overlay can be implemented both in vector and raster systems. In vector systems the intersection of two or more data layers produces new features (polygons). This is also called polygon overlay [3]. Here the attributes of intersecting polygons are combined. The raster implementation (grid overlay) combines attributes within grid cells that align exactly. This paper follows grid overlay. Map layers are stored as shapefiles. A shapefile is a digital vector storage format for storing geometric location and associated attribute information. This format lacks the capacity to store topological information [4].

Raster maps are very high resolution satellite images (.tif or .png) with large size (MB). Due to the huge size of image regular zooming techniques face difficulties like blurred or irregular view, slow loading etc. Hence the zoom/pan operations may not function properly. To overcome these difficulties a system is designed which retain the clarity of the image and enables fast loading. Basic idea is to generate image pyramids [5]. The image pyramids used by most zooming techniques are Gaussian pyramids [6] but they fail to retain the clarity of the image as they zoom in. To overcome this, a method called tiling is used and the pyramid is generated with these image tiles.

Rest of the paper is organized as follows: section 2 discusses concepts behind Map Overlay and section 3 Satellite Image Zooming. Section 4 and 5 include results & discussions and conclusion & future works respectively.

II. MAP OVERLAY

In map overlay each layer describes a certain aspect of the real world like rivers, city boundaries etc. It enables us to organize data from different sources. The input to our system is shapefiles and a raster map. Shapefiles spatially describe geometries like points, polylines, and polygons. These, for example, could represent water wells, rivers, and lakes, respectively. A table of records will store properties/attributes for each primitive shape in the shapefile [4]. A shapefile is a package of several files. The core data of a shapefile is stored in three individual files: .shp, .shx, .dbf. The actual shapefile relates specifically to the file with extension .shp, but it alone is incomplete for distribution. Associated with each shapefile we have the geographic coordinate details of every feature in the map. It's assumed that all maps are pre-aligned to the same geographic region and that all maps are region maps.

Data layers must be referenced to the same coordinate system (e.g., the same UTM and SPC zones) [8], the same map projection (if any), and the same datum (horizontal and vertical, based upon the same reference ellipsoid). Furthermore, locations must be specified with coordinates that share the same unit of measure.

A. Uniform Grid Method

In this method a flat, non-hierarchical grid is superimposed on the data. The grid adapts the data because the number of grid cells is a function of statistics of the input data. In our system the number of grid cells or resolution of the grid is computed as a function of the geographic co-ordinate system such that the entire system can be mapped into the grid. The grid is completely regular and hence dense regions are no different from other regions. Due to the simple data structure, the uniform grid data structure is also suited for execution on a parallel machine.

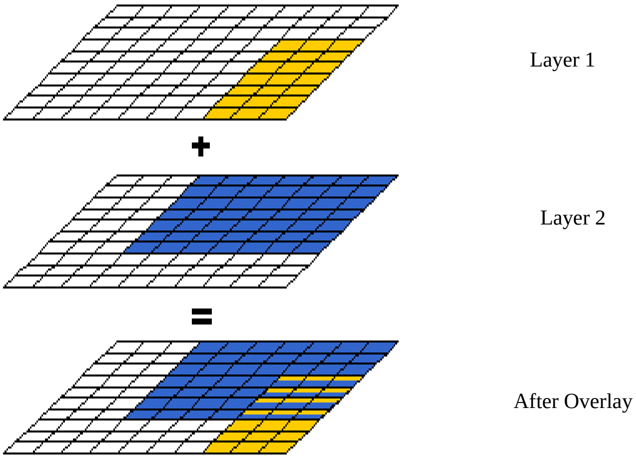

Fig 1: Uniform Grid Method

In order to perform map overlay points and edges of every layer are placed on the grid after performing a matching operation. First step is to identify cells representing points and edges. Next the common/intersecting edges and points of overlaid layers are identified. It's important that every feature of the overlaid layers is mapped correctly onto the grid. This is accomplished by extracting the co-ordinate details attached to the shape file.

In our system the overlay is performed on top of a raster map. So the grid defined should have the co-ordinates of that region. The raster image is assumed to already be in the appropriate map projection prior to displaying on the grid. The grid spacing is specified in projection units (normally meters), based on the reference pixel given in the image header file. The grid coordinates are labelled with the appropriate map coordinates.It is not necessary that the grid should represent the co-ordinates of the whole world. This reduces the need of unnecessary searching and matching operations. Also the grid would automatically scale up to a satisfactory level enabling better visualization.

B. Grid Coverage

Support for raster data is provided by the concept of a Grid Coverage. Programmers are used to working with raster data in the form of bitmapped graphics such as JPEG, GIF and PNG files. In geospatial area, a concept called Coverage is used. Coverage is a collection of spatially located features which is equated with a map. A Grid Coverage is a special case of Coverage where the features are rectangles forming a grid that fills the area of the coverage.

III. SATELLITE IMAGE ZOOMING

Zooming implies magnification of an image for a better view. Raster map zooming enables users to analyze the real world features. One major requirement is the speed of zooming, as slow zooming always exasperates the user. Also the sharpness of the image must be retained. i.e., regions should appear as distinct as in original image. Another requirement is smoothing. There must be continuity in the zoomed image.

The problem is approached by representing images using tiled image pyramids [5]. This allows us to grab only the portion of data that is necessary for a particular view of image. If an image is being zoomed out to it is maximum extend, then only a small thumbnail is needed to represent the image. However, for zoom in operation on a specified area of a large image require to download image tiles representing that region. This lead to very large bandwidth savings because as only some tiles of the large image are needed.

A. Image Pyramid and Tiling

The pyramids store an image of any size at many different resolutions and hence called multi-scale images. These different resolutions are divided into many parts called Tiles. The image pyramids can be considered as a result of space vs. bandwidth trade off. Clearly the image pyramid has a bigger file size than it is single image counterpart. Zooming becomes more efficient in terms of bandwidth since only few tiles need to be loaded at a time (not all tiles of the image). Each resolution of the pyramid is called a level where the base level contains high resolution image composed of multiple tiles and top level hold a low resolution image as a single tile.

Fig. 2: Image Pyramid and Tiles

Levels are counted from the 1x1 pixel as level 0. Tiles of each level is of size 2*(level) x 2*(level). Tiles of every level are stored in a separate folder. It also supports the concept of sparse images. Sparse images allow a user to create an image that has more resolution in some parts of the image than others. This is useful if a user wants to create an image with a fractal layout which can be zoomed in for more information.

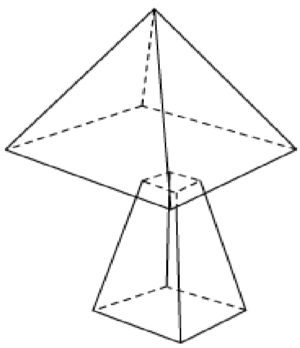

Fig. 3 Sparse Image

While tiling another factor included is the overlap attribute of one pixel per tile. The dimension of a single tile is extended by adding some pixels of it is neighboring tiles. When large images are reconstructed from much smaller image tiles, sometimes there occur visible artifacts between the tiles. These artifacts stem from rounding errors in their positioning. This problem is alleviated by using overlap between the tiles.

B. Number of Levels

General principle of tiling is to divide the image till we get an image of dimension 1x1. Parameter values of pyramid (number of levels and the tile size) can be set manually to control the data transfer. For determining the maximum level of a Zoom image following formula is used:

$$\lceil \log_2 \max \{width, height\} \rceil$$

First, identify the longer side of the original image and calculate the logarithm to the base two. This answer will most likely be a real number because the original image will most probably not have a power-of-two dimension. The result is rounded up in order to determine the number of times the image should be divided to reach the tile dimension of 1x1.

C. Loading

When zoomed image is viewed, the browser displays a scaled-up version of a low-resolution version of the image and then blends in higher-resolution images as they are downloaded. This is the reason for the blurry-tocrisp experience while zooming an image. It is also the reason that the Zoom images open quickly regardless of the file size of the image. With help of MultiScaleImage [7], tiles can be placed on the appropriate locations on the base grid used. The instances of this class identify the layer and hence the required tiles of the level and arrange them on the grid starting from the centre. Mouse handling events are additionally written for providing support for the same.

IV. Results and Discussions

It is observed that the overlay operation provide a result for all data sets chosen, irrespective of the referenced co-ordinate system (UTM or SPC or local grid reference). For example consider the case where three map layers are to be overlaid, out of which two layers follow UTM reference system [8] and one layer support grid reference. Here the overlaying operation would be performed but third layer will be positioned wrongly and hence lead to wrong map reading.

For satellite image zooming, the performance of the system can be evaluated by comparing it with other image viewers. Two satellite image samples (of size 36MB and 128MB) and two image viewers (Picasa Photo Viewer and Microsoft Office Picture Manager) are taken for this purpose. It is observed that the Satellite Image Zooming System takes a longer time for tiling and pyramid generation depending on the size of the satellite image. For zooming, our system loads only the tiles of the required portion whereas the other two systems load the entire image. When the satellite image is zoomed above 100%, the Picasa Photo Viewer shows an invalid image message and Microsoft Office Picture Manager take 10 to 15 seconds to load the image. It takes only less than a second for the Satellite Image Zooming System to display the zoomed image. Table 1 shows such a comparative study conducted on a system with configuration: Intel Core i5 processor, x64-based PC with a 4GB RAM.

TABLE 1: COMPARISON WITH OTHER IMAGE VIEWERS

Image viewer	Satellite Image Zooming System		Picasa Photo Viewer	Microsoft Office Picture Manager
	Image size	Time		
Tiling and Pyramid generation	36MB	3-4 hrs.	NA	NA
	128MB	14-15 hrs.		
Image Loading	Few tiles are loaded		Full image is loaded	Full image is loaded
Zoom in	0.5- 1sec Smooth zooming		Invalid image above 100% zoom	10-15 sec Not smooth

V. Conclusion and Future Works

The Map-overlay system is well suited for viewing several aspects of an area in a single frame. The system requires all chosen map layer to belong to the same co-ordinate system. The system could be extended to mark places on the map. The markers help users to find out information about the place just by pointing at them.

The Satellite Image Zooming system provides very smooth zooming of satellite images of high size. It also retains the clarity of the image while zooming. It is implemented using Microsoft Expression Blend with help of C# editor. The system can be made visually more interesting by introducing the spherical factor which give a curved look like that of the Earth. It could also be extended to represent objects like buildings, trees etc. in 3D.

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