Grid Coverage Component Development Reusing Existing Grid Coverage Components

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Abstract: Remote sensing data processing and analysis system can be developed based on the Grid Coverage Specification and this kind of system is also can be easily interoperate with GIS systems conforming OpenGIS specification. This paper proposes a method to implement easily and quickly the new grid coverages that provide new operations, or services, by reusing the existing grid coverage components, which is based on the fact that the pipeline constructed by grid coverages can be represented in one grid coverage. This method complements easily the deficiency of the existing grid coverage components and enables quick implementation of the new grid coverage that provides complex processing operations.
Keywords: Remote Sensing, GIS, Integration, Grid Coverage.

1. Introduction

Integrating remote sensing and GIS technologies significantly strengthen our abilities to handle geographical information. The remotely sensed data have the potential to improve both the quality and quantity of data available to GIS's. In back direction, GIS's can provide remote sensing image analysis system with reliable ancillary data, which may considerably improve analysis accuracy[1].

Although the significance of the integration was pointed out two decades ago, little practical integration has been achieved. In a GIS, it was difficult to interrelate raster remote sensing data to other type of spatial data. In a remote sensing image analysis system, it was difficult to incorporate vector data from a GIS into digital analysis processes[2].

The Grid Coverage Specification and the Distributed Catalog Services Specification combined with the Simple Feature Specification released by OGC(Open GIS Consortium) provide the means for unprecedented interoperability between systems that use geospatial data. In OGC, "Grid Coverage" refers to satellite images, digital aerial photos, digital elevation data, and other kinds of data represented in a grid cell or "raster" coordinate system that is tied(or not tied) to an earth coordinate system. "Simple Feature" refers to "vector" geodata, or digital map information represented in polygons and lines. The Simple Feature Specification and the Grid Coverage Specification use the same procedures to communicate details of geodesy and geometry, so data of both types can be "georeferenced" or overlaid using the same spatial reference system[3].

The Grid Coverage Implementation Specification provides interfaces for basic access to images between systems and performing basic kind of analysis. For many cases, the basic level of interoperability provided by interfaces conforming to this specification is sufficient for a wider range of image operations. Data access through interfaces that implement the OpenGIS Grid Coverage Specification may consecutively be used in a complex image processing and this kind of system is also can be easily interoperate with GIS systems conforming OpenGIS specification.

Implementing and testing even a simple image processing operation in the grid coverage interfaces that conform the OpenGIS Grid Coverage Specification are, however, not easy because they must be able to handle grid coverages with various characteristics accommodated by the specification. Moreover, if the image processing operation to be implemented in the grid coverage is complicated, it becomes more difficult to implement and test the grid coverage.

This paper proposes a method to allow for quick and easy implementation of grid coverage interfaces by reusing the existing grid coverage components, which is based on the fact that the pipeline constructed by grid coverages already has the implemented interfaces to satisfy the Gird Coverage Specification.

2. Feature, Coverage, and Grid Coverage

In the OpenGIS Abstract Specification, "feature" is an abstraction of a real world phenomenon. It is a geographic feature if it is associated with a location relative to the earth[4]. Vector data consist of geometric and topological primitives used, separately or in combination, to construct objects that express the spatial characteristics of geographical feature. GIS coverage, a special case of (or a subtype of) feature, is two-(and sometimes higher) dimensional metaphors for phenomena found on or near a portion of the Earth's surface. The power of coverage is its ability to model and make visible spatial relationship between, and the spatial distribution of, earth phenomena. Grid coverage, a special type of coverage, is fundamental to many semantically different environments and can include digital orthorectified images, elevation matrices, and computer display window. Modification of grid coverages is recognized as various services, such as radiometric correction, noise removal, contrast enhancement, multi-band image manipulation, spectral transformations, and so on[3].

The Grid Coverage Implementation Specification can accommodate grid coverages with the following characteristics.

- Variable number of bits per grid value
- Band values can be ordered by dimension
- Handle a wide range of grid data from raw to thematically classified grid value
- 1 to N number of bands and dimensions
- Allow for georeferencing methods
- Support for a variable number of “no data values”
- Various color model
- Support for efficient access to very large datasets
- Support for overviews (or pyramid) and tiles.

The fact that the grid coverage has wide range of characteristics means not only that the grid coverage enables to treat various remotely sensed data but also that when you implement grid coverage to perform image processing operations you have to consider the variety of characteristics of source grid coverages, which may take at least as long, in real terms, as the time involved in implementing the processing algorithm itself. For example, if you try to develop a simple “resample” operation, many cases of the source grid coverage such as the number of bands, existence of no data values, and band packing type must be considered. In addition to this heavy burden, many methods up to 50 need to be implemented exactly to conform the specification.

3. The Pipe-Line Manner

The optional interface in the Grid Coverage Specification, GP_GridCoverageProcessor, provides operations for different ways of accessing the grid coverage values as well as image processing functionality. This interface has been designed to allow the adaptations to be done in a “pipe-line” manner. The interface operates on GC_GridCoverage to create new a GC_GridCoverage. The interface does not need to make a copy of the source grid data. Instead, it can return a grid coverage object which applies the adaptations on the original grid coverage whenever a block of data is requested. In this way, a pipeline of several grid coverage can be constructed cheaply[4]. Fig. 1 illustrates the creation of a grid coverage from a grid coverage exchange interface and how to perform a simple grid processing operation. When grid values are retrieved for the new grid, the new grid coverage will fetch grid values from the source grid coverage, process, and return them to the client.

The pipe-line manner has the clue to implement grid coverage interfaces easily as well as the advantage that it makes no intermediary file or memory block in consecutive processing. Fig. 2 shows an example of the pipeline constructed by 3 grid coverages – BIP grid, float grid and HIS grid. When the client retrieves grid values for the HIS grid, this pipeline fetches grid values from the first source grid coverage, change their traversal order to pixel interleaved order, change their data type to float type, perform color model transformation on them, and then return the processed grid values to the client. This pipeline can be considered as one grid coverage that performs these 3 operations in it. The output grid coverage

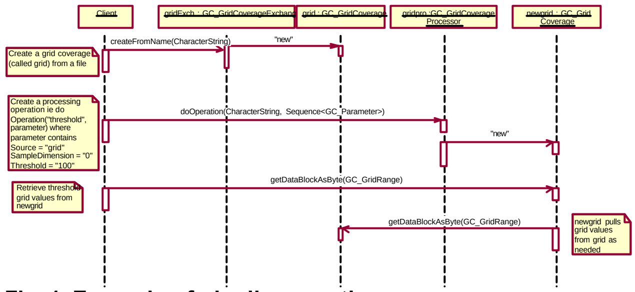

Fig. 1. Example of pipeline creation

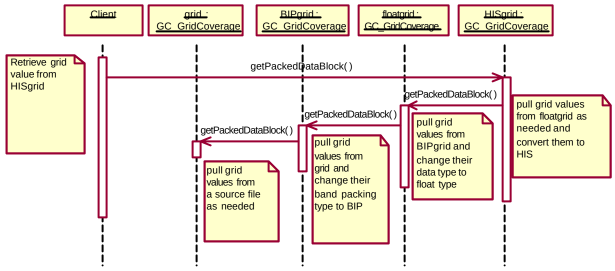

Fig. 2. Example of pipeline to complement restrictions of the existing grid coverage component.

object returned by the grid coverage processor to be developed is identical to the HIS grid object in the pipeline. Thus, if the pipeline is used for implementation of new grid coverage that performs the same operation as the pipeline performs, at least 3 mandatory interfaces of the grid coverage(CV_Coverage, GC_GridCoverage, and CV_SampleDimension) do not need to be implemented again in the implementation of the grid coverage. The only interfaces to be implemented are optional interfaces - GP_GridCoverageProcessor and GP_Opeartion. GP_GridCovreageProcessor just have to be implemented so as to construct the pipeline with the source grid coverages, input parameters, and the existing grid coverage components, as shown in below pseudo code. GP_Operation implementation only provides descriptive information of the newly implemented operation.

```
GC_GridCoverage NewGridCoverageProcessor::doOperation(GC_GridCoverage grid1)
{
//create pipeline and return the result grid coverage object of the pipeline
GC_GridCoverage BIP_Grid =
   OldGridcoverageProcessor1.doOperation(grid1, “ChangeBandPacking”, “BIP”)
GC_GridCoverage Float_Grid = OldGridcoverageProcessor1.doOperation(BIP_grid,
   “ChangeSampleDimensinType”, 32BIT_REAL)
GC_GridCoverage HIS_Grid =
   OldGridCoverageProcessor2.doOperation(Float_grid, “ChangeColorModel”, “HIS”)
return HIS_Grid
}
```

4. Supplementing the Existing Grid Coverages

Placing restrictions on characteristics of the source grid coverages enables simple and quick implementation of the stable grid coverage and makes the test of the implemented grid coverage easier because the number of cases to be considered decreases. For example, when the new grid coverage that performs color model transformation between RGB and HIS is about to be implemented, it is much easier and faster to implement it under such restrictions that band packing type and data type of source grid coverages must be BIP and 32 bit real type each.

The new grid coverage component that releases from these restrictions can be easily implemented with other grid coverage components. If the existing grid coverage components that can change traversal order of the grid values and data type are available, the new grid coverage component that performs color model transformation operation on any grid coverages with any band packing type and any data type and conforms the Grid Coverage Specification can be implemented by using the properly constructed pipeline as shown in Fig. 2.

5. Gird Coverage Containing a Complicated Pipeline

A pipeline constructed by the complicatedly connected grid coverages can be used in a new image processing operation. Fig. 3 shows an example to merges SPOT panchromatic data and Landsat TM data using the HIS(Hue Saturation Intensity) technique. Originally, the grid coverages used in the pipeline were not developed for data merging. Instead, they have been designed and implemented for raster data format conversion and color model transformation. Although they have restrictions on the characteristics of the source grid coverages, once they construct a pipeline properly, they perform a new and complex processing operation and the pipeline can implement a grid coverage component easily as shown in Fig. 3. and Fig. 4.

6. Conclusions

Developing and testing the grid coverage interfaces that conform the OpenGIS Grid Coverage Specification are not easy tasks because grid coverage implementations must be able to handle grid coverages with various characteristics. Moreover, if the processing operation to be implemented in the grid coverage is complicated, it becomes more difficult to develop and test the grid coverage component.

This paper proposed a method to implement easily the grid coverage that provides new operations, or services, by reusing the existing grid coverage components. It is based on the fact that the pipeline constructed by grid coverages already has the implemented interfaces necessary to convert it into a grid coverage. Developing grid coverages with the pipeline is very easy because the mandatory interfaces are already implemented in the pipeline. The proposed method enables to wrap a complicated pipeline in one simple grid coverage component. Also it enables easy development of the new grid coverage that complements the restrictions of the existing grid coverage implementation.

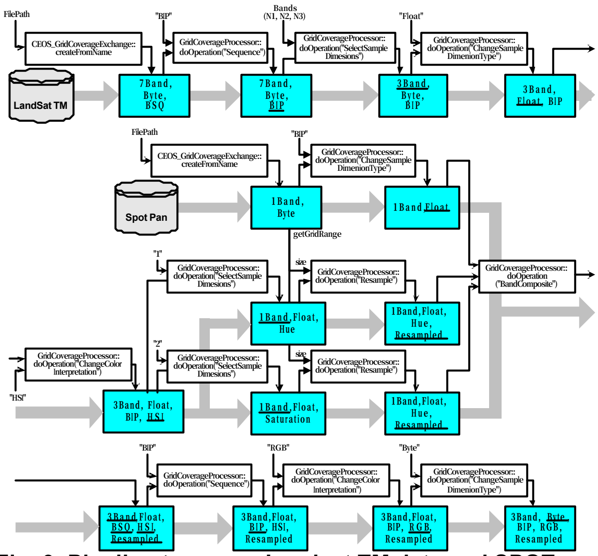

Fig. 3. Pipeline to merge Landsat TM data and SPOT panchromatic data.

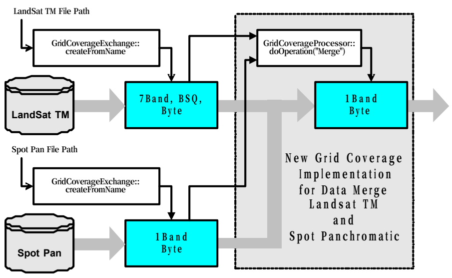

Fig. 4. The new grid coverage implementation developed with the pipe line shown in Fig. 3

References

[1] Fangju Wang, Integrating GIS' s and remote sensing image analysis system by unifying knowledge representation schemes, *IEEE Trans. Geosci. Remote Sensing*, vol. 29, no. 4, pp656-664, July 1991.

[2] Open GIS Consortium, available at: http://www.opengis.org/pressrm/pressrlease/19990818_open_tech_web_pr.htm.

[3] Open GIS Consortium, *OpenGIS Abstract Specification : Topic 6. The coverage type and its subtypes*, 1999.

[4] Open GIS Consortium, *OpenGIS Implementation Specification : Grid Coverage*, 2001.