WEB BASED GEOPROCESSING TOOL FOR COVERAGE DATA HANDLING

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Commission VIII, WG VIII/13

KEY WORDS: Web Services, open source, WCS, WFS, WPS, Python, GDAL, PyWPS, and NDVI.

ABSTRACT:

With the advancements in GIS technologies and extensive use of OGC Web Services, geospatial resources and services are becoming progressively copious and convenient over the network. The application of OGC WCS (Web Coverage Service) and WFS (Web Feature Service) standards for geospatial raster and vector data has resulted in an opulent pool of interoperable geodata resources waiting to be used for analytical or modelling purposes. The issue of availing geospatial data processing with the aid of standardised web services was attended to by the OGC WPS (Web Processing Service) 1.0.0 specifications (Schut, 2007) which elucidate WPS as a standard interface which serves for the promulgation of geo-processes and consumption of those processes by the clients. This paper outlines the design and implementation of a geo-processing tool utilizing coverage data. The geo-process selected for application is the calculation of Normalized Difference Vegetative Index (NDVI), one of the globally used indices for vegetation cover monitoring. The system is realised using the Geospatial Data Abstraction Library (GDAL) and Python. The tool accesses the WCS server using the parameters defined in the XML request. The geo-process upon execution, performs the computations over the coverage data and generates the NDVI output. Since open source technology and standards are being used more often, especially in the field of scientific research, so our implementation is also built by using open source tools only.

1. INTRODUCTION

The web service standards have become an inherent part of geospatial services. OGC (Open Geospatial Consortium) is the foremost organization guiding the development of standards and specifications for geospatial services and is committed towards the interoperability of geodata and services over a distributed GIS network. OGC has a number of contributors globally involved in the development of open source and extensible API's (Application Programming Interfaces) for distributed GIS. OGC white paper for OWS (OGC Web Services) (Doyle and Reed, 2001) describes OWS as a standards based framework which provides for seamless integration of variety of geo-processing systems and services; interoperable framework for exploitation and visualization of multiple sources of geodata and geo-processing capabilities. With the advancements in GIS technologies, geospatial resources and services are becoming progressively copious and convenient over the network. The proclamation of Web 2.0 has played a major role in the increase in distribution of geospatial information over the web (Gong et al., 2009). The standard OGC Web Services for the dissemination of geodata over the network includes OGC WMS (Web Map Service) which delivers the geodata as maps i.e. an image of the data; OGC WFS (Web Feature Service) managing geospatial vector data; OGC WCS (Web Coverage Service) handles raster coverages including satellite images, digital aerial photographs, etc. The preliminaries for OGC Web Services are mentioned in OGIS (Open Geodata Interoperability Specification) for distributed access to geospatial data and geo-processing services. Open GIS refers to open and interoperable geo-processing, or the capability to share heterogeneous geodata and geo-processing services openly in a network. Web has become a distributed computing platform with geodata and geo-processes distributed over the network and accessible by clients when requested. The geospatial group discerns the significance of providing web access to the geo-processing systems for the blooming of geospatial infrastructure (Kiehle et al., 2007). The application of OGC WCS and WFS standards for geospatial raster and vector data has resulted in an opulent pool of interoperable geodata resources waiting to be used for analytical of modelling purpose. The issue of availing geospatial data processing with the aid of standardised web services was attended to by the OGC WPS (Web Processing Service) 1.0.0 specifications (Schut, 2007) which elucidate WPS as a standard interface which serves for the promulgation of geo-processes and consumption of those processes by the clients. Here, the 'geo-processes' comprises of algorithms, computations or models which work in relation with spatially referenced data. The geo-processing utility can be configured to provide various GIS functionalities to the users across the network, covering access to pre-defined models and algorithms. The swift growth of geo-processing services vanquished various geospatial challenges concerning the know-how of integration of GIS analytical or modelling functions with inputs from geodata over the network (Wang and Armstrong, 2006). The second challenge dealing with management of large volumes of distributed geodata and alleviating gridlocks of user interactions over the Internet (Yang et al., 2005). The third being connected to the adoption of open source technology and standards (Caldeweyher et al., 2006).

As the geospatial technology has fledged in the previous years, a vast number of resources and processing operations are accessible in the form of web services (Zhao et al., 2012). Different implementations of the geo-processing functionality has been carried out in research studies. One such study focuses on the availability and utilization of geo-processing services in the geoscience domain (Lopez-Pellicer et al., 2012), while the other focuses on the integration of WPS standards with 3D processing and analysis (Lanig and Zipf, 2010). Recent research on web services has been rigorous with aim to provide for ecological modelling using web services (Dubois et al., 2013; Skøien et al., 2013). The eStation (Clerici et al., 2013) system is a versatile and promising Earth Observation (EO) web processing service supporting ecological monitoring.

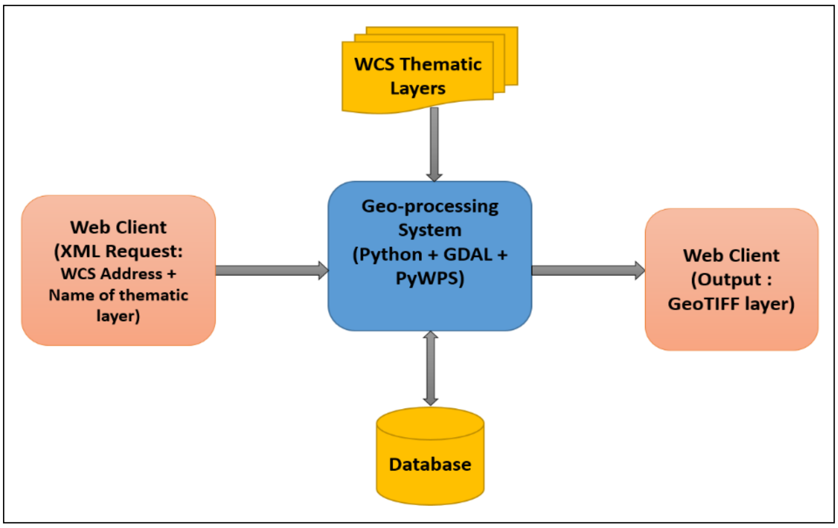

Figure 1. System Architecture

This paper outlines the design and implementation of a geo-processing tool utilizing coverage data distributed over the network, performing distributed geospatial analysis with emphasis on open source technology and standards.

2. SYSTEM ARCHITECTURE

The architecture (Figure.1) of geo-processing utility pursues a SOA (Service Oriented Architecture) approach i.e. the intrinsic algorithm used is accessible as a processing utility over the network as per OGC WPS standards.

The key element of WPS specification is the conception of a process which is a geospatial computation with precise inputs and outputs (Garnell et al., 2009). This involves: realization of datasets fit to run the algorithm, instigate the process and availability of results to the clients. The three main operations as defined by the specifications are: *GetCapabilities*, *DescribeProcess* and *Execute* (Schut, 2007) (Figure 2).

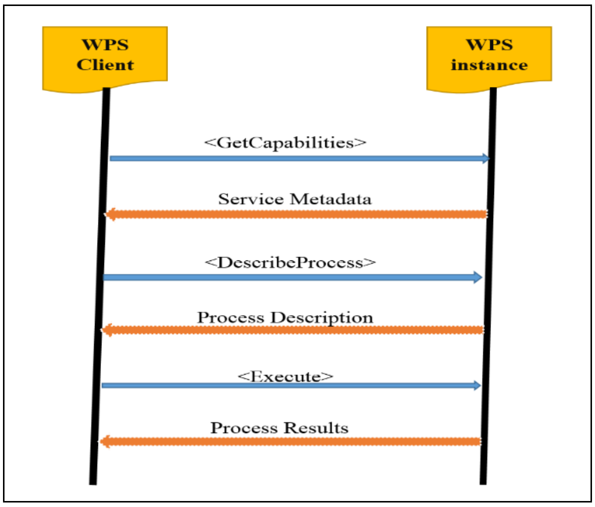

Figure 2. WPS client server interaction

The operation *GetCapabilities* return the metadata XML document describing the abilities of the specific server implementation. *DescribeProcess* return a detailed description of the process along with the inputs required, formats allowed and outputs that can be produced. *Execute* instigate the selected geoprocess with the necessary input data. The WPS instance runs the computations and returns the results back to the client.
There are several open source implementations of the WPS specification including *Deegree* (Kiehle et al., 2007), PyWPS (Cepicky and Becchi, 2007), 52° North (Schaeffer and Foerster, 2007), ZOO Project (Fenoy et al., 2013). The system expects some mandatory and optional parameters (for accessing the WCS server) in the form of XML requests (Figure 3).

```
<WCS_GDAL>
  <ServiceURL>http://localhost:8090/geoserver/ndvicalc/wcs?</ServiceURL>
  <Version>1.0.0</Version>
  <CoverageName>nir</CoverageName>
  <supportedCRSs>EPSG:4326</supportedCRSs>
  <PreferredFormat>image/tiff</PreferredFormat>
  <BandCount>1</BandCount>
```

Figure 3. Snippet of XML Request

The system is implemented using the python modules and supporting libraries like GDAL (Geospatial Data Abstraction Library) and PyWPS (Cepicky and Becchi, 2007). Using the python bindings for GDAL, the geo-process ingests and outputs the GeoTIFF layers to the web clients.

3. SYSTEM IMPLEMENTATION

The fundamental purpose of geo-processing is the manipulation of geospatial data using GIS functions and self-regulation of GIS tasks in progress. Geo-processing takes an input dataset, implements a geo-processing function (raster or vector) and returns the out-turn of processing. The system is realised using the Geospatial Data Abstraction Library (GDAL) and Python. The tool accesses the WCS server using the parameters defined in the form of XML requests. The geo-process upon execution, performs the computations over the coverage data and generates the required output. Since open source technology and standards are being used more often, especially in the field of scientific research, so our implementation is also built by using open source tools only.

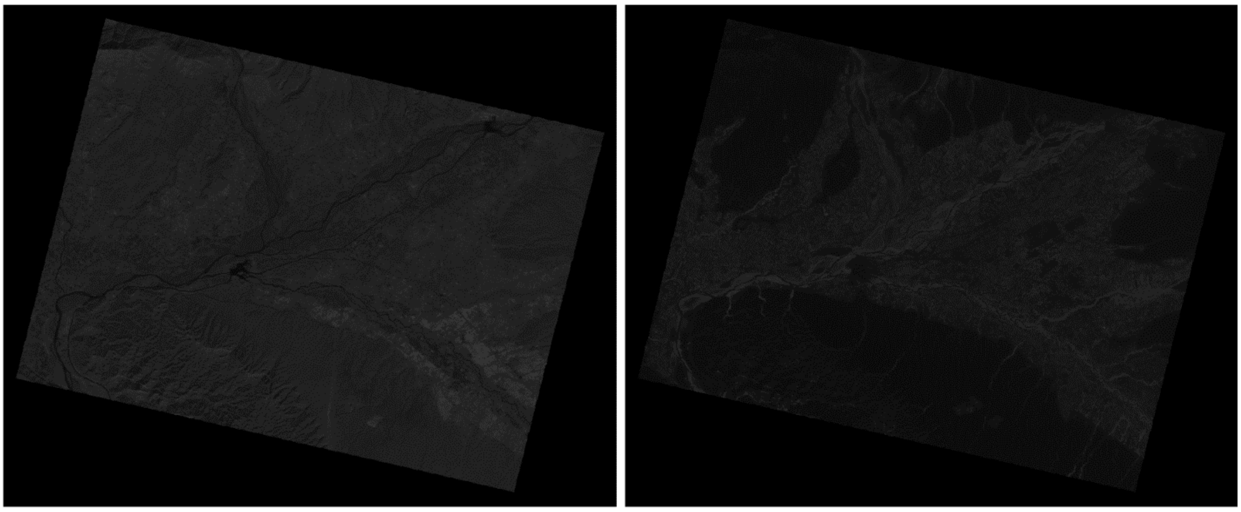

Figure 4. NIR and RED bands extracted from IRS LISS III imagery of Paonta region, Himachal Pradesh, India.

3.1 Algorithm for Implementation

The geo-process selected for application is the calculation of Normalized Difference Vegetative Index (NDVI) (Rouse et al., 1974), one of the globally used indices for vegetation cover monitoring. The NDVI algorithm is implemented based on the generic equation (1) given by Rouse et al. (1974):

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}} \qquad (1)$$

Where, NIR and RED denotes the spectral reflectance measured in Near Infrared and Red regions of spectrum respectively.

3.2 Datasets Used

The datasets used for input to the process are NIR and Red bands extracted from IRS LISS III GeoTIFF imagery (Figure. 4) of Paonta, Himachal Pradesh, India acquired at 23.5m spatial resolution, with 4 spectral bands, namely Green, Red, NIR, and SWIR. The datasets are kept on a server configured to provide WCS services. Access to the datasets is achieved in the form of XML requests by the web clients.

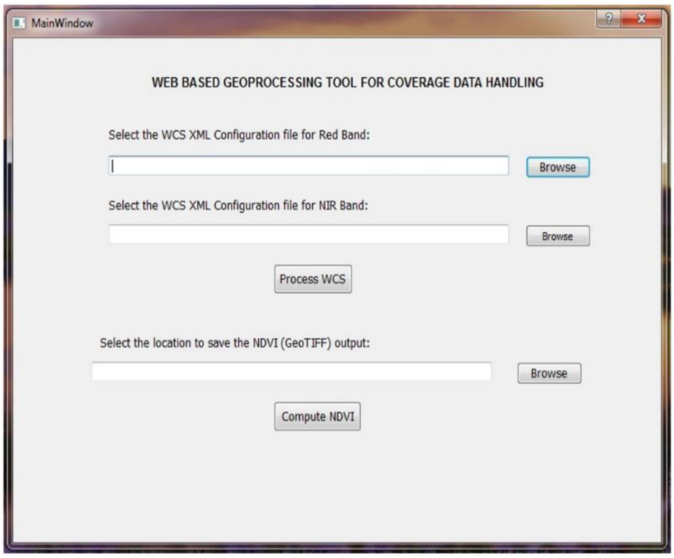

Figure 5. User Interface

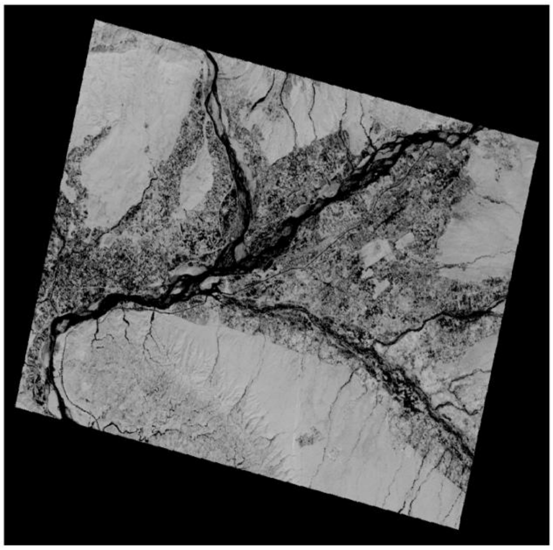

Figure 6 NDVI Output

3.3 Process Implementation

The algorithm is implemented using the python modules and supporting libraries like GDAL (Geospatial Data Abstraction Library). For web processing capabilities, PyWPS is used. The graphical user interface for the tool (Figure. 5) is designed using the PyQt framework. The tool asks for a service description file comprising of XML request for coverage service URL, WCS version and name of the coverage to be accessed. Through this XML request, the coverage is located over the servers on the network. This includes a client that accepts any Web Coverage Service as an input. This option is important, considering the dramatic increase in the number of available geospatial datasets over the internet. The tool accesses the coverages, to be used as input datasets, by interpreting the parameters defined in the XML requests. The geo-process upon execution, performs the computations over the coverage and returns the out-turn of processing NDVI (Figure. 6).

4. RESULTS AND DISCUSSION

Permitting geospatial information on the web is being recognized as a topical goal for research and applications. Web based geo-processing services serves as a means to realize this vision. This paper demonstrate the feasibility of employing web services for geospatial tasks and data handling. Setting apart the concern for voluminous datasets, we have described how web services can be connected for self-regulation of geo-processes utilizing raster data. The complete computation process can be done by using the application interface (Figure. 5) to use the web client. The geospatial service described in this paper is flexible enough as the client request is an XML document defining the WCS server URL and coverage dataset to be accessed and used. Connecting the web services with these datasets greatly reduce the necessary time to download, and use the datasets for processing or modelling. On the other hand, this architecture is still depending on a reasonably good access to the Internet, an issue that should not be neglected in developing countries or in remote locations. As immediate and on-demand geoinformation and processing is the overall goal, we find that performance is a key issue.

5. CONCLUSION

Web services are propitious while accrediting SDI's (Spatial Data Infrastructures) as web based environment for geo-information processing, which is well accentuated by this NDVI geo-processing utility. The applications of web services has resulted in an opulent pool of geospatial resources but has also added to the problems of data heterogeneity. Research for interoperability and implementation are the need of the hour for the integration and interoperability of the geospatial resources. The capability to process geospatial data in a distributed environment is of great significance for spatial data infrastructures and finding the suitable geo-processing services is therefore, a major challenge. Present-day keyword-based approaches to service discovery are implicitly limited by the ambiguities of ordinary or natural language, so the focus has now moved to Ontology-based approaches. With the advent of Web 3.0, data semantics and geo-ontologies concentrated on semantic interoperability between the OGC services (Kuhn, 2005). The Web Ontology Language (OWL) has been recommended as the standard Web ontology language by the W3C (World Wide Web Consortium).

In a distributed geo-processing environment it has been affirmed that performance is one of the major concerns when implementing the geo-processing tasks (Granell et al., 2009). Nevertheless, several issues and flaws relating to big data handling, different data formats, etc., have been raised and require further considerations in order to build efficient and reliable service. Network bandwidths, transportation and validation of data are likely gridlocks while dealing with voluminous datasets. Customizations are being made to improve the performance while working with large data.

To conclude it seems gruelling for professionals working with dynamic geospatial data, to adjust their work in a web based environment having spatial infrastructure integrated with WPS applications.

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