Deploying Geospatial Analysis through Web Processing Service Based on pyModis and ZOO-Project

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ABSTRACT

Advanced technologies of broadcasting geospatial data via internet network has recently helped a number of effective work. One of the most well-known systems is the development of spatial analysis through a website which clients can access and search for the instance data, as well as analyze the data through web service operation which is involved with Service Oriented Architecture (SOA). The objectives of this study are to examine and develop the geospatial analysis through web processing service by using ZOO-Project Platform and pyModis library. The methodology has examined the spatial analytical process using 3 indexes to investigate Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Drought Index (NDDI) by applying satellite image data from MODIS/Terra via pyModis library to download and process the data with Python script. The process is aimed to build the service and work with WPS by using ZOO-Project Platform, the WPS 1.0.0 Protocol according to Open Geospatial Consortium (OGC) that can create and connect services with other data protocols through internet network. The results of the study were found that the system has been developed to be downloaded and could analyze the image data for spatial analysis under the co-operation between pyModis, ZOO-Project Platform, GRASS GIS, and GeoServer. These protocols have worked as the data processer and previewer of the map in Web Map Service(WMS). Therefore, clients can access the geospatial data through web-based application or a desktop GIS application effectively.

Keywords: *Web Processing Service, MODIS data, pyModis, ZOO-Project Platform, FOSS4G*

1. INTRODUCTION

Geographic Information Systems (GIS) is one of the well-known technologies since Google Earth has published the mapping technology on the internet. This is believed to be the beginning of the notation of GIS; and several organizations all around the world have emphasized and developed its operation by integrating with communicative and computer technologies to increase the effectiveness of the spatial data management in an organization. The highlight of GIS is being the tool that applies computer system to input, store, prepare, edit, manage, and analyze the data. The tool also shows the geospatial data in mapping format according to any identified purposes. However, the analysis and data processing still need an expert who is professional in space technology and geographic information science.

In the present, the development of Management Information System (MIS) has been integrated with Geographic Information Systems (GIS) which has been so widely famous that clients can access the spatial data conveniently and easily search for the data. It reduces the complexity of the data and the old operation. Also, it can be adapted in effective service system management and geospatial data distribution. The architecture format for the effective modern geographic information systems needs to consider the following factors: integration, connectivity, open standard, interoperability, security policy, monitoring, management, flexibility, and scalability. According to the advanced technology to distribute geographic information systems through continuous development of the network, especially Web Processing Service (WPS), there are the access to spatial analysis from web interface and cooperation with other information service protocols such as WMS, WFS, WCS, etc. that can receive and send data in the WSDL or JSON format through internet network (Choosumrong *et al.*, 2014). Clients do not adhere to the format and type of the software so it is easier to develop such things. The objectives of this study are to examine and develop the geospatial analysis through web processing service by using ZOO-Project Platform and pyModis library. The examination applied satellite image data from MODIS/Terra. The methodology has examined the spatial analytical process using 3 indexes to investigate Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Drought Index (NDDI) using pyModis library with GRASS GIS to download and process the data with Python script. The process is aimed to build the service and work with WPS by using ZOO-Project Platform, the WPS 1.0.0 and WPS 2.0.0 Protocols according to Open Geospatial Consortium (OGC) that can create and connect services with other data protocols through internet network.

2. METHODOLOGY

The researcher has chosen a Free and Open Source Software for Geospatial (FOSS4G) to examine and develop in this study, as shown in Table 1. The study emphasizes the development of spatial analysis process though WPS. The methodology consists of processes and development as following.

Table 1. Tools of the study

Tools	Name of software	URL
Operating System	Lubuntu 14.04 LST	http://releases.ubuntu.com/14.04/
Desktop Applications	GRASS GIS QGIS	https://grass.osgeo.org http://www.qgis.org
Geospatial Libraries	pyModis GDAL/OGR	http://www.pymodis.org http://www.gdal.org
Web Mapping	ZOO-Project GeoServer Leaflet	http://zoo-project.org http://geoserver.org https://leafletjs.com

After the implementation of the host server for a web service, the study has written the instruction for downloading the images taken by MODIS/Terra version 6 product (MOD13A2). This set of system is available in every 16 days with its spatial resolution of 1 km by pyModis library (Delucchi, 2017). The process applied *modis_download.py* module and selected grid tiling system of h27v07 and h28v07. The image data are stored in HDF-EOS (Hierarchical Data Format - Earth Observing System) format in which cannot be applied directly. Therefore, the HDF-EOS file is needed to change its format to be GeoTIFF in order to separate 3 bands by using Band 1 data (RED reflectance channel), Band 2 (NIR reflectance channel), and Band 7 (MIR reflectance channel) and change the projection to be WGS 84 (EPSG:4326) using *modis_convert.py* module.

The examination of WPS analyzes 3 indexes by using GRASS GIS. It began with the input of image satellite data by using *r.import* module and calculate the indexes by using *r.mapcalc* module (Neteler and Mitasova, 2008). The overall image data process was developed by Python scripts in GRASS.

NDVI calculation, Figure 2(a), is the result of the proportion examination between NIR and RED. The value is between -1 to 1; which -1 refers that there is no vegetation covering the area or no Chlorophyll from the plants, and 1 refers that there are dense plants or high rate of Chlorophyll in the area (Chen et al., 2005), as shown in Equation 1

$$NDVI = (NIR - RED)/(NIR + RED) \quad (1)$$

where *NIR* is the reflectance near infrared channel (841-876nm) and *RED* is the reflectance in the visible red channel (620-670nm).

NDWI calculation, Figure 2(b), is the result of the proportion examination between NIR and MIR. The value is between -1 to 1; which -1 refers that it is the area of water or moisture, and 1 refers that it is the drought area or area with no moisture (Gao, 1996; Chen et al., 2005; Gu et al., 2007), as shown in Equation 2

$$NDWI = (NIR\text{-}MIR)/(NIR+MIR) \quad (2)$$

where *NIR* is the reflectance near infrared channel (841-876nm) and *MIR* is the reflectance in the mid-infrared channel (2105-2155nm).

NDDI calculation, (Gu et al., 2007), as in Figure 2(c), is the result of proportion examination *NDVI* and *NDWI* for the calculation *NDDI*, as shown in Equation 3

$$NDDI = (NDVI\text{-}NDWI)/(NDVI+NDWI) \quad (3)$$

where *NDVI* is the Normalized Difference Vegetation Index and *NDWI* is the Normalized Difference Water Index.

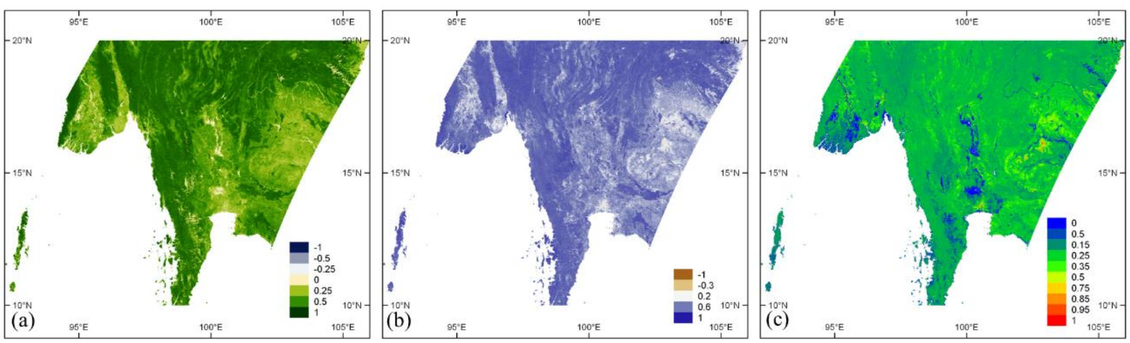

Figure 2. The results from calculation of NDVI (a), NDWI (b) and, NDDI (c)

In building a service to cooperate with WPS, it applied ZOO-Project open source platform including ZOO Kernel and ZOO Service. ZOO Kernel is similar to CGI program which cooperates with the server and process the spatial data with ZOO Service through ZOO Service Configuration File (ZCFG) and Service Shared Object (SSO) File (Fenoy et al., 2013). The operation can support writing a program in basic python language by using pyModis library and GRASS GIS and developing each library based on the WPS standard. The operation consists of 1) clients request for the processing service on WPS by executing or running service through ZOO Kernel, specifying ZOO Service titled "*modtool.zcfg*" which previews the service details; 2) ZOO Service will connect with the SSO file named "*modzoo.py*", which uses pyModis and GRASS GIS libraries; 3) pyModis will download and change the file type of MODIS by using modis_download.py and modis_convert.py modules; 4) GRASS GIS inputs the image satellite data by using r.import module into the Mapset, calculate the NDVI, NDWI, and NDDI indexes by using r.mapcalc module; 5)The ZOO Kernel will show the results of the analysis and transfer the process result in GeoTIFF file type to clients; and 6) GeoServer will show the map data in Web Map Service (WMS). Regarding the analyzed data, the map image will be sent to the Web Mapping developer to show the results through internet network, as in Figure 3. For the development of image from raster calculator, HTML and JavaScript has been employed to contact with clients in the framework of Leaflet and CSS of Bootstrap. Web Map Service (WMS) from GeoServer will preview the map on the internet.

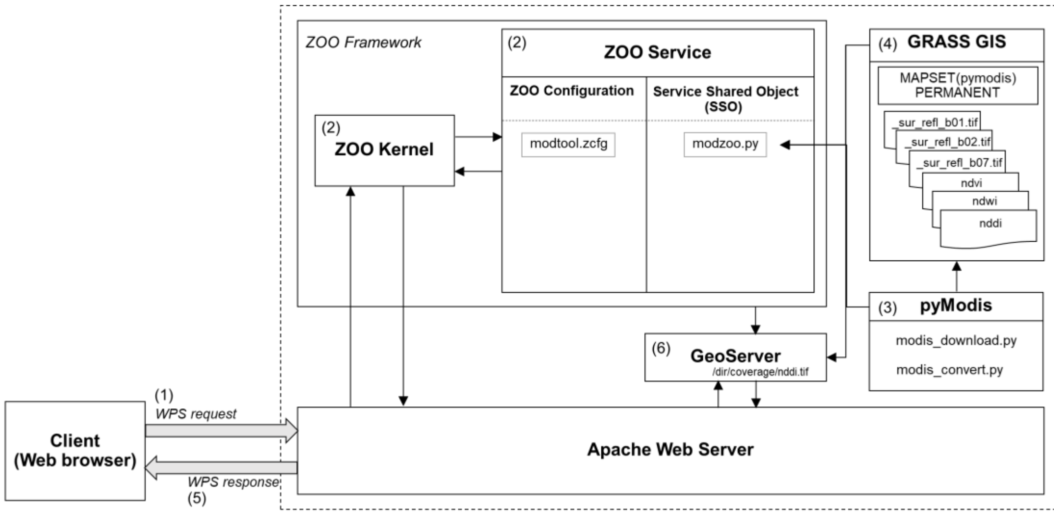

Figure 3. System Architecture

3. SYSTEM INVESTIGATION

The process of spatial data analysis has been investigated on the website by using the open source software including ZOO-Project Platform and pyModis library. Clients can do it directly on the internet and the results will be shown as an online map. Figure 4 shows the process when the client connects WPS instance by *GetCapabilities* to request for the Service Metadata. The service will let the client know about the available *ProcessOfferings*. Then the client will choose the desired Processing Feature by using the *DescribeProcess* instruction set in order to request for the details of identifying parameters. The client must select the Identifier to make a request for the process and the format of the results. After that, the client will *Execute service* for run service by identifying parameters for data processing as identified. Figure 5 shows that the system started to download the image data and convert the location system, and process the image data from the analysis of 3 indexes including investigate NDVI, NDWI, and NDDI by using GRASS GIS. The result from this instruction set is the Process Result in GeoTIFF file and WMS which allow the client to access and request for the service through the internet as shown in Figure 6.

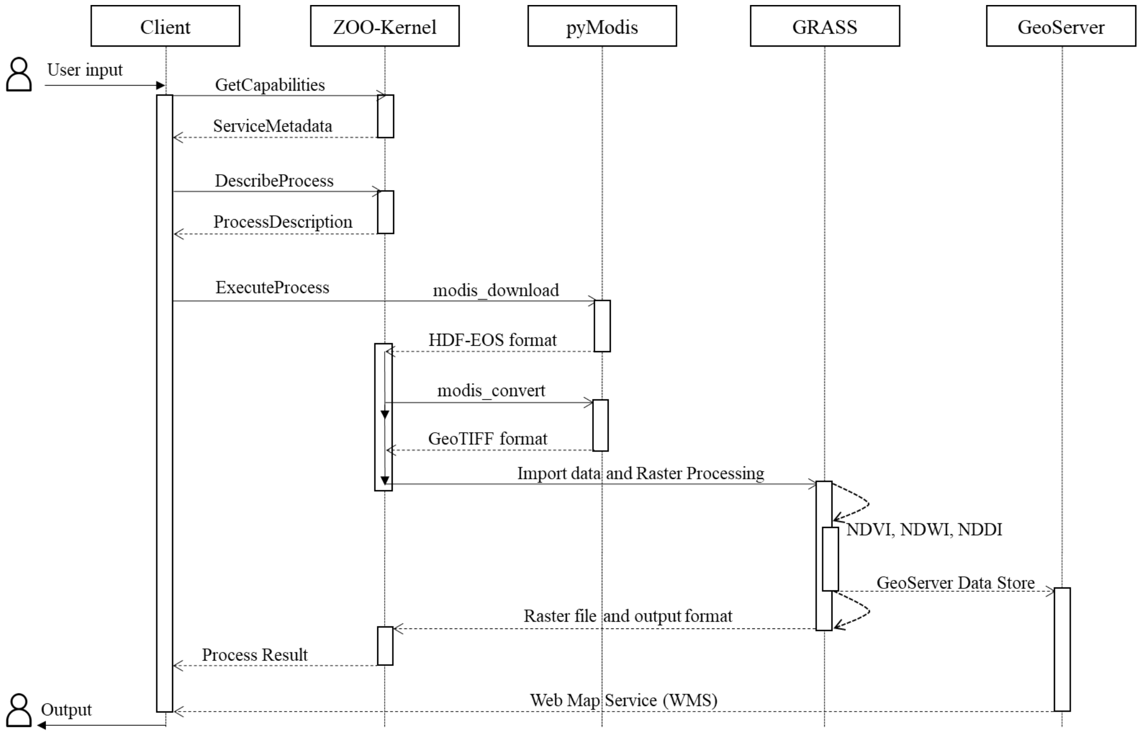

Figure 4. UML Interaction diagram workflow


```
Content-Type: text/xml; charset=UTF-8
Status: 200 OK
<?xml version="1.0" encoding="UTF-8"?>
<wps:ExecuteResponse xmlns:wps="http://www.opengis.net/wps/1.0.0" xmlns:ows="http://www.opengis.net/ows/1.1"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/wps/1.0.0 http://schemas.opengis.net/wps/1.0.0/wpsExecute_response.xsd"
service="WPS" version="1.0.0" xml:lang="en-US" serviceInstance="http://localhost">
  <wps:Process wps:processVersion="2">
    <ows:Identifier>modtool</ows:Identifier>
    <ows:Title>Deploying Geospatial Analysis through Web Processing Service Based on pyModis and ZOO-
Project</ows:Title>
    <ows:Abstract>pyModis and GRASS GIS based on WPS using ZOO-Project platform.</ows:Abstract>
  </wps:Process>
  <wps:Status creationTime="2018-09-28T07:51:56Z">
    <wps:ProcessSucceeded>Service "modtool" run successfully.</wps:ProcessSucceeded> <- Service Status
  </wps:Status>
  <wps:ProcessOutputs>
    <wps:Output>
      <ows:Identifier>Result</ows:Identifier>
      <ows:Title>Raster image result</ows:Title>
      <ows:Abstract>Raster image result from rastercal index in GeoTIFF format</ows:Abstract>
      <wps:Reference href="http://localhost//temp//ndvi_Result_102643.tiff" mimeType="image/tiff"/> <- Process Result
    </wps:Output>
  </wps:ProcessOutputs>
</wps:ExecuteResponse>
```


Figure 5. The XML result of request executed GeoTIFF file based on WPS

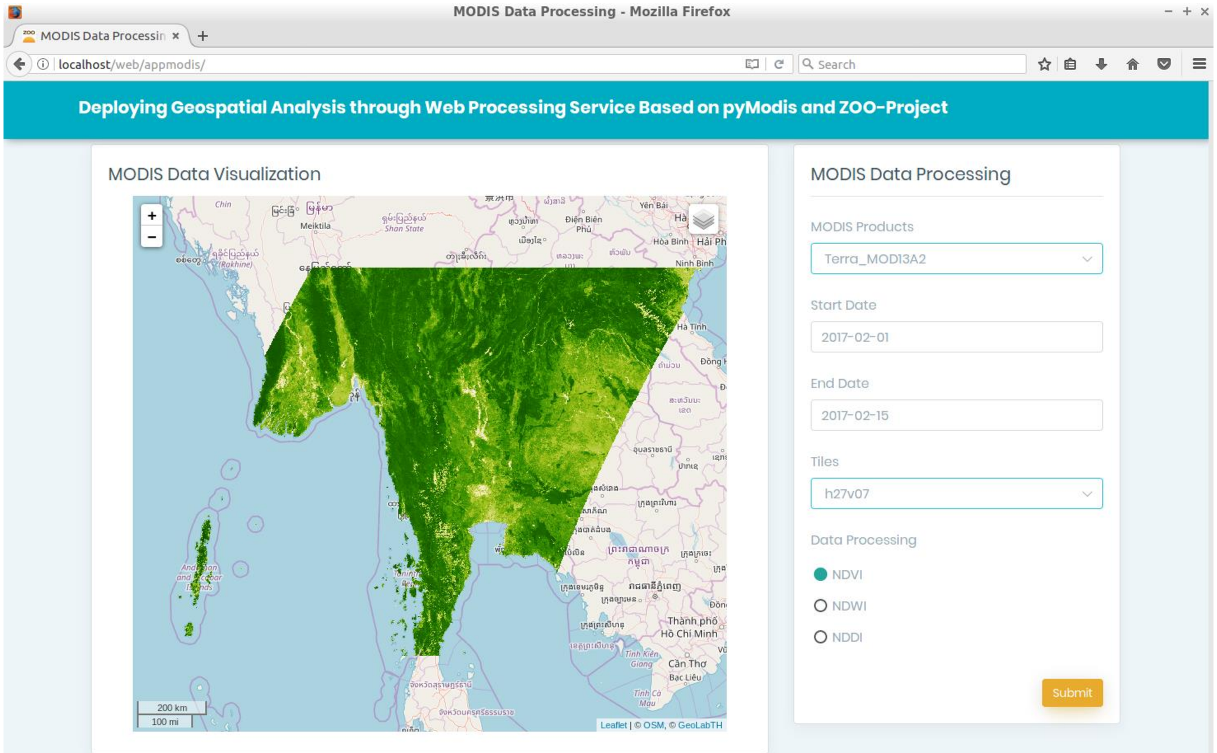

Figure 6. User interface for selecting and viewing data

4. CONCLUSION AND DISCUSSION

This examined and developed system has been developed from the open source platform which result in the low cost of both software and maintenance fees. It is different from other systems due to the fact that some systems need people to process the data which causes longer time and human resource. Some system even needs an expensive software to process, but the results are found similar or equal to this system which has been developed by free software.

This system can download and analyze the image data to automatically search for the area at risk of droughts or agricultural area. It employed the cooperation between pyModis, ZOO-Project Platform, GRASS GIS and GeoServer which processed and distribute the data in WMS format which clients can easily access the GIS data from a web browser or GIS programs.

Furthermore, this system is the primary model that introduces to the GIS developers via networks to understand the principles of the data processing on a website and the GIS data attribution service. The results of the development of the system can be applied to research studies about other kinds of spatial analysis because this system has been developed by the Free and Open Source Software for Geospatial (FOSS4G) according to the standard of OGC. Therefore, the system can be adjusted its equations or instruction for other purposes such as to analyze the risk of flooding, mudslide, or other appropriate analysis, which are based on the data analysis of GRASS GIS program.

In this study, the research team has focused on how to develop the Web Processing Service (WPS) that can automatically download image satellite data and the raster calculator tool allows you to create and execute map algebra expressions for NDVI, NDWI and NDDI. Like other geoprocessing tools. It does not investigate on the accuracy of the NDVI, NDWI and NDDI equation. In the future works, if researchers have a good equation about NDVI, NDWI and NDDI in each area, they can apply this system to implement the real-time drought, flood or agricultural area classification from image satellite.

5. ACKNOWLEDGEMENT

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