WHEN THE TERM GIS STAND FOR GEOGRAPHIC INFORMATION SERVICE: A CASE STUDY OF WEB-BASED SPATIAL DATA ANALYSIS FEASIBILITY

Chang Cheak Lim*[a] and Kuo-Cheng Chang[b]

[a] Graduate student, Department of Geography, National Taiwan Normal University, 162, HePing East Road Section 1, Taipei, Taiwan; Tel: +886-9-88492187; E-mail: 698230281@ntnu.edu.tw

[b] Associate Professor, Department of Geography, National Taiwan Normal University, 162, HePing East Road Section 1, Taipei, Taiwan; Tel: +886-2-7734-1642; E-mail: kcchang@ntnu.edu.tw

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ABSTRACT: For the last decade, spatial information technique had overcame many difficulties to integrate with world wide web to represent digital spatial information. And now, we are entering the next stage of the development of web-based spatial information application. This study is trying to implement spatial data analysis through world wide web with both vector and raster type data which based on service oriented concept. To achieve the objective above, our study scope focus on the modularization of spatial data analysis and the SOA (service oriented architecture) based on web service. First, an automated land cover change detection model had been developed to provide as a web-based service. In the other hand, a SOA system architecture design will be discussed to complete our implementation.

1. INTRODUCTION

Generally, spatial information was one of knowledge representation form about space (Robinson et al., 1995). The spatial information techniques are briefly divided into four works, included the measurement, storage, representation, and analysis of spatial data. Each work had its own individual technology history through integrated various techniques and creation of concepts to foster its evolution. Before the mid-twentieth century, those visual representation of spatial information which was called maps or even airborne remote sensing imagery were both passive representation form of spatial data. All the analysis works of such spatial information are depend on users themselves. Only users who possessed related experiences and knowledge can bring those spatial information value into full play. Therefore, most of the spatial information are underused. Even the GIS had been developed in the end of last century, and the digital spatial information can be analysis through computer operation. However, the high cost of software and the complexity of operation cause the use of digital spatial information are still limited to few people. Until the development of Web-based GIS, users begin to interact with digital spatial information through world wide web.

For the last decade, spatial information technique had overcame many difficulties to integrate with world wide web to represent digital spatial information (Longley et al., 1999). And now, we are entering the next development of web-based spatial information application. Web-based GIS will not only to represent spatial data anymore, but also interact with users. The web-based spatial data will be analyzable through end users' operation online. To achieve the trend toward above, the relation between end users and web-based spatial information should be changed conceptually.

This study is trying to implement spatial data analysis through world wide web with both vector and raster type data which based on service oriented concept. To achieve the objective above, first we focus our study scope on the knowledge regularization of web-based spatial data analysis implementation. In past, providers output spatial information as a product no matter what form of spatial information, such as maps, RS images, etc. In this study, spatial information will form as a GIService to provide to the end users. Users will no need to buy the spatial information as a map or image, what they get will only the visually display through the web. The role of spatial information providers will like a functional planner who provide their clients different style of idea to hold an event, clients need not to participate the design, purchasing and arrangement of the venue except setting conditions. The same, spatial information providers will serve their clients with different analysis project, such as LCCD(Land Cover Change Detection), USLE(Universal Soil Loss Equation), etc. Here, we will choose Land Cover Change Detection as a thematic GIService to implement our study.

2. METHODOLOGY

First, the feasibility of web-based spatial data analysis is identified as a problem. The key factors of the solution are deconstructed into spatial data analysis and the web deployment, both tasks are implemented relatively independent. Our study scope focus on the modularization of spatial data analysis and the SOA (service oriented architecture) based on web service. An automated land cover change detection model was choose as a thematic spatial data analysis to provide the web deployment as a service interface. Images of FORMOSAT-2 of 2005 and 2008 are using for the imagery resources of model experiment. Those were the suburban areas of Taipei where the land cover change was frequently occurred. Finally, the automated analysis model will be published on a Web-based GIS platform with a SOA system architecture design.

3. KNOWLEDGE REGULARIZATION

3.1 Modularization of Land Cover Change Detection

To make those implementation feasible, the regularization of conceptual knowledge and operation experiences are the priority work of the research process. There are a lot of steps to complete the modularization of land cover change detection. Various operation techniques are tested before the modularization to complete the full operation procedure with a certain accuracy. Three main techniques are tested separately, included spectrum enhancement technique, image classification technique, and change detection technique.

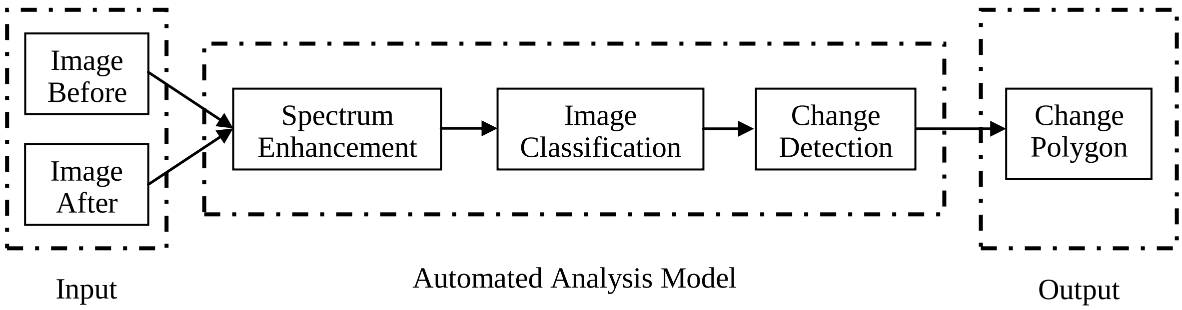
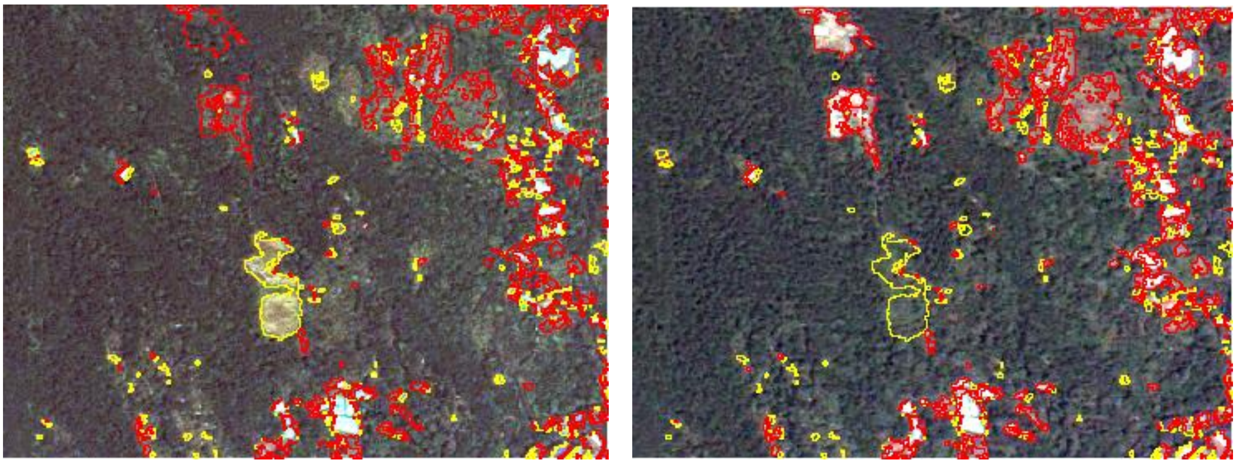


Figure 1. The flowchart of LCCD model

Spectrum enhancement is mainly to enhance the spectral characteristics of the input RS image, and improve the spectral separability between surface features of the image. Such as Normalized Difference Vegetation Index (NDVI)(J. W. Rouse et al., 1973) is to enhance the vegetation characteristic of input image. Through the vegetation characteristics of high reflectivity to solar radiation in the near-infrared band and low reflectivity to red band, Rouse et al. exploit the strong differences in vegetation reflectance to determine their spatial distribution in satellite images. Besides, there are several spectrum transformation techniques to transform the input RS image into a new raster dataset. Principle Component Analysis (PCA) (Lillesand et al., 2004; Lu et al., 2003) is to transform a multivariate inter-correlated raster data set into a new uncorrelated raster dataset called principle components. This algorithm is mainly to simplify the multispectral ortho image. There are other spectral transformation algorithms includes Spectral Mixture Analysis (SMA), Independent Component Analysis (ICA), etc. Those spectrum enhancement and transformation techniques which are listed above had been tested to a part of the land cover change detection model.

The techniques of image classification is to determining the land cover identity of each pixel in an image through those quantitative techniques which involves the analysis of multispectral image data and the application of statistically based decision rules(Lillesand et al., 2004; Lu & Weng, 2003; Liu et al., 2002; Manandhar et al., 2009). The most popular classification algorithms currently are include Minimum-distance-to-means Classifier, Parallelepiped Classifier, Maximum Likelihood Classifier, ISODATA Classifier (Iterative Self-Organizing Data Analysis), Neural Network Classifier, Object-oriented Classifier, etc. Nevertheless, the best algorithm for image classification remains unanswered. To succeed the automation of model, an unsupervised classification method is preferred. In this part, Minimum-distance-to-means Classifier, Parallelepiped Classifier, Maximum Likelihood Classifier, and ISODATA Classifier (Iterative Self-Organizing Data Analysis) had been tested and compared to get the best result. ISODATA Classifier is finally been chosen for the method of image classification of the model.

Change detection refer to the process of identify the changes of an object or phenomena through temporal information comparison. It is particularly important to environmental monitoring and management (Lu et al.,2003; Singh, 1989). Lu et al. had reviewed various techniques of land cover change detection in 2003, and discussed both advantages and disadvantages between the techniques in detail. In conclusion of the review, it shows that no single method is suitable for all research cases. Thus, the products of several detection techniques are often used to compare to each other for a specific study area. In this study, we detect the change of land cover from the results of image classification, and transfer the result from raster to vector type data for further calculation.

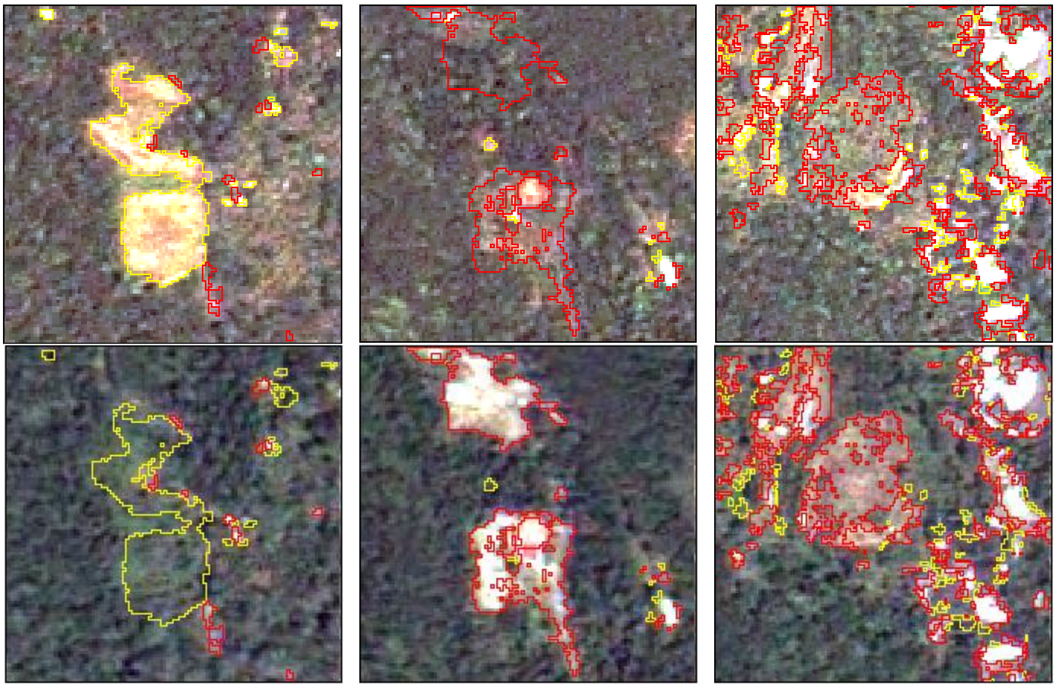


(a) (b)

Figure 2. Image of the suburban area of Taipei in 2005(a) & 2008(b) with the automated LCCD (Land Cover Change Detection) analysis result.

With the whole process of land cover change detection we exploited, we then continue to generalize the operation procedure. There are a lot of standardization works such as threshold setting need to be consider before further modularization of the land cover change detection. Each detail setting of the procedure will affect the success of the creation of automated analysis model. Besides, one the most important detail of the analysis model should be considered are the

ill-condition of problem. Due to the ill-condition will largely affect the accuracy of analysis result, therefore it need to be regularized and make it well-posed to minimize its effect.
The results of the automated land cover change detection analysis model implementation showed in figure 2, the output of the model as a vector polygon which mark out the change areas between the two date input images. Through the automated land cover change detection, the model will converted the data type of change areas from raster layer to vector polygon for display visually. The result showed that the model could detect the change of land cover efficiency, it could also separate the different type of change. In figure 3a, the yellow polygons showed the areas of vegetation restoration. Those were areas of landslide, bare land, or even buildings in 2005(upper image), and had been restored to vegetation in 2008(lower image). That means those new restorations where the vegetation is relatively weak. Thus, there are still the potential landslide areas. The red polygon(see figure 3b and 3c) showed the deforestation areas between 2005 and 2008. Those were vegetation areas in 2005, and had be deforest or developed into buildings in 2008.



(a) (b) (c)

Figure 3. Different type of change detected by automated Land Cover Change Detection (LCCD) model in 2005 (upper image) & 2008 (lower image).

3.2 System Deployment based on Service Oriented Architecture (SOA)

This study is now in the last stage of implementation, which to complete the spatial data analysis through web-based network. The key to realize web-based spatial data analysis was the deployment of the system architecture over the web. Therefore, we need to have an advance planning in detail before the deployment. After several related reviews, our study here preferred a Service Oriented Architecture (SOA) to complete our implementation. Generally speaking, SOA is a structure pattern of computer system for building business applications that utilize common services to bridge the communication gaps between consumers and providers (ESRI, 2007). It guides business solutions to create, organize and reuse its computing components to support business functions (Tsai W., 2010). To make those functions more flexible, it requires a loose coupled computing environment. Thus, SOA separates functions into distinct services, and foster the reusability and consolidation opportunities of such computing components. There is no fixed structure pattern for system deployment. Nevertheless, SOA possesses higher collocation flexibility with its distributed properties.

Web service refers to a software system designed which support interoperable machine-to-machine interaction over a network (Haas & Brown, 2004). It has an interface described in a machine-processable format such as WSDL. Other systems interact with the Web service in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. By definition above, there is no conflict between Web service and SOA. According to those conceptual principles, Web service can be used to implement a Service Oriented Architecture which can successfully realize the high level spatial data analysis the web-based network.

Figure 4 showed the concept view of the SOA based on Web GIService. Those represented a complete architecture that support Web GIService functions. With its distributed characteristic, each of the application server provide specific service components with consolidate related operations. The architecture of this study is defined as a fully web-based analysis service, users will not access any raw spatial data into/out from the system database. Therefore, the raw spatial data here is support by the data warehouse which maintains its functions in staging layers. In the integration platform, ESRI has classed the common services of SOA into five support functions that use to maintain the service platform. Users can successfully invoke the service components through utilizing those commons services based on web service standards, and of course OGC standards. This study here has to decide which services to expose and the trade-offs between security and easy availability, and finally integrate service components into an end users interface to meet the spatial data analysis service purposes. Due to the creation of services that are highly standardized and reusable in SOA, it can be orchestrated to support various devices over related protocol standards and programming languages such as SOAP and WSDL. Currently, this study is scope on the orchestration for web browser through personal computer.

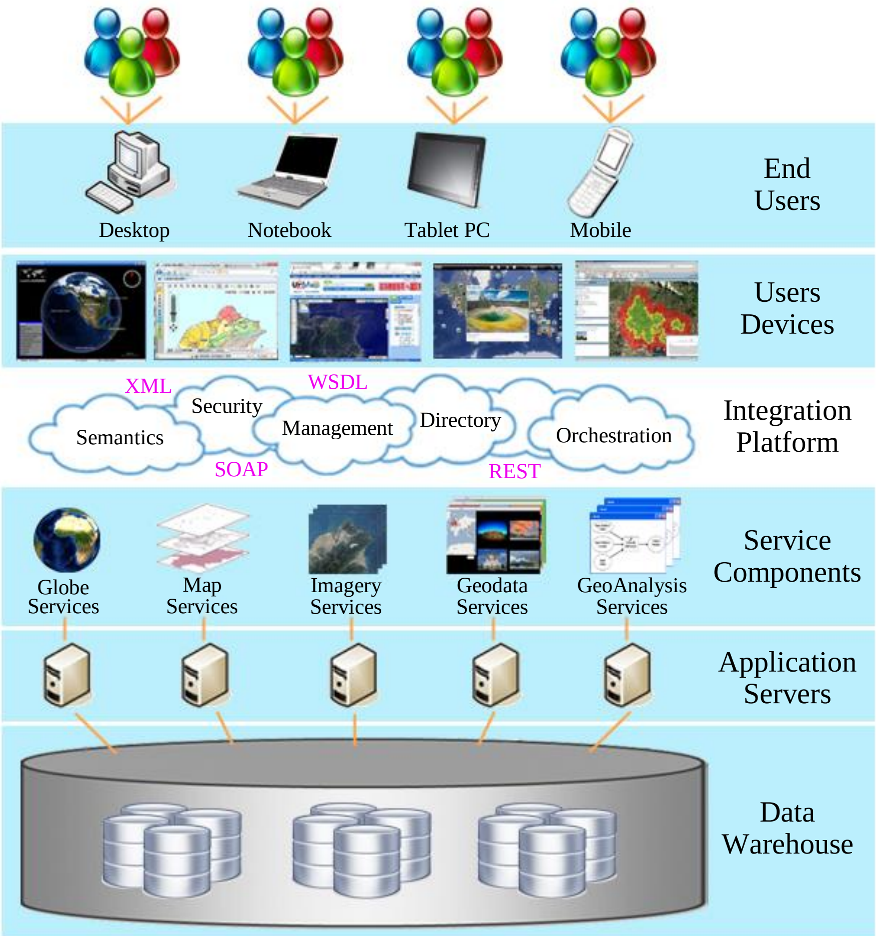


Figure 4. A Service Oriented Architecture Based on Web GIService

4. CONCLUSION

Today, spatial information are widely been used in various fields. To face the large accumulation of spatial data, it is necessary that practical solutions be found to simplify the spatial data processing of complexity and change the using form between users and spatial data. Those solutions are expected to maximize the application value of spatial data and minimize the cost of data storage and system maintain. Through integrated with world wide web, spatial information represent a brand new interactive mode and change the passive spatial data representation form into a dynamic interaction between users and spatial data. And now, it will further improve the functionality of web-based spatial data - to analysis spatial data online. Actually, it is not the problem of whether spatial data analysis online feasible, but how it works efficiently. The key to success our implementation are the knowledge regularization of problem solving. Both the modularization of automated analysis processing and the deployment of web-based system architecture. And the coming next, spatial information technology will trend toward the high efficiency web-based analysis processing development.

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