Remotely Sensed Image Processing Service Automatic Composition

Xiaoxia Yang
Supervised by Qing Zhu
State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University
430079 Wuhan, China
yangxx2003@126.com

Abstract: Aiming at the correctness, quality and efficiency of remotely sensed image processing service composition for geospatial applications, a remotely sensed image processing service composition approach is proposed. It includes three main algorithm: (1) remotely sensed image processing service chaining based on heuristic search to composite services into a meaningful order; (2) knowledge navigated remotely sensed image processing service classification and selection, which using data mining to select an appropriate service for specific user requirement; (3) remotely sensed image processing service selection with response time to meet the response time requirement from user.

1 Introduction

As the world changes more rapidly, the demand for up-to-date information for resource management, environment monitoring, urban planning, crisis management and emergency response are increasing exponentially. Remote sensing technology has been widely recognized for contributing to geospatial information efforts. As remote sensing technologies become ever more powerful with multi-platform and multi-sensor, hundreds of terabytes of image data is available daily. But in many cases, raw remotely sensed images are not directly useful without further processing. There are more and more needs to aggregate remotely sensed image processing to satisfy the increasing demands of various applications. Because the remotely sensed image processing demands large-scale, collaborative processing and massive storage capabilities, the effect and efficiency of the remotely sensed image processing is far from the user's expectation. More intensive and more complex tasks make us "data-rich but analysis-poor"[1].

The emergence of Service Oriented Architecture (SOA) may make this challenge manageable. The SOA allows cooperation of data and process components among different organizational units and supports reusability and interoperability of components through the network to satisfy more and more complex applications. Remotely sensed image processing services are modular components of remote sensing applications that are self-contained, self-describing and can be published, located and invoked across a network to access and process remote sensing data from

a variety of sources[2].

The service composition on demand has become a hot topic. It is urged to encapsulate all processing function into services and recombine them with service chain. Service composition, the process of creating the service chain through composing a collection of services, is required. The various requirements of users can be achieved by combining different existing data and services into a value-added service chain. Automatic service composition, if successful, can be of great value to the geospatial user community.

Remotely sensed image processing problems usually involve large and heterogeneous data and multiple computation steps and service providers. The composition approaches are illustrated by an example from the domain of remote sensing based change detection. Figure 1 illustrates the process of change detection with remotely sensed image, which generally consists of such steps as image acquirement, pre-processing, image registration, and change detection.

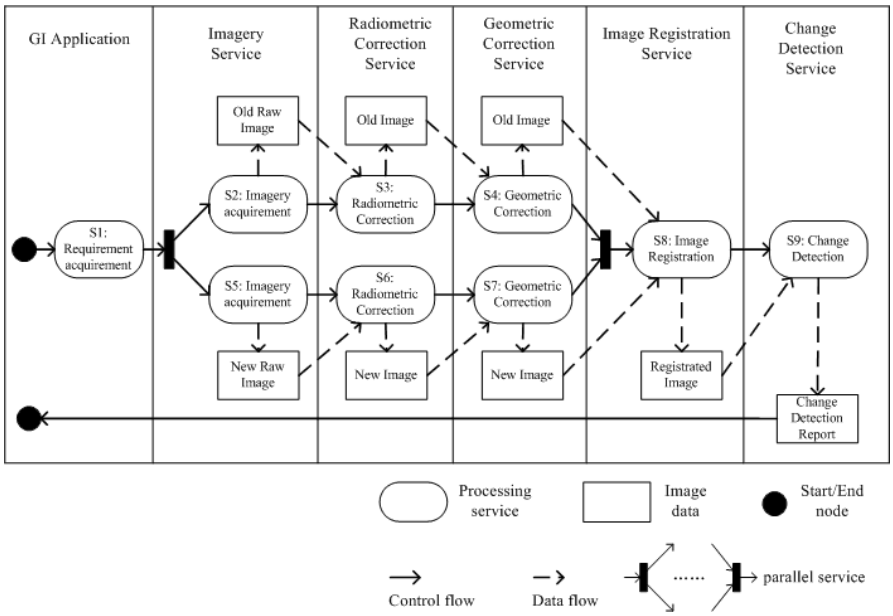

Fig. 1 Change detection service chain

2 Problem

The key to achieve automation relies mainly on solutions to three issues[3]:

(1) How to make remotely sensed image processing services interoperable both syntactically and semantically;

(2) How to automatically select, based on the syntactic and semantic descriptions, the most appropriate data and services;

(3) How to assemble them to build the service chain.

Various users require composition of different processing services in a meaningful order to solve specific problem. A key challenge in promoting widespread use of remotely sensed image processing services in the geospatial applications is to automate the construction of a chain or process flow that involves multiple services and highly diversified and distributed data.

For remotely sensed image processing service chaining, an important problem is finding suitable services and to select the most suitable one according the task requirements. Because of the lack of the adequate knowledge of remotely sensed image service selection, most existing keyword-based and ontology-based service selection approaches are not very effective and efficient.

Quality of service(QoS) is an important factor that should be considered in the process of service composition. In general, there would be many individual processing services offering similar functionality but with different qualities. In current QoS-based service research, the response time is commonly considered as a certain value [4]. As to remotely sensed image processing services, it is difficult to estimate and manage response time for two additional reasons: in most remotely sensed image applications such as in case of emergency, the requirement for response time of the service chain is very rigorous; to allow for a dynamic network environment and the uncertainty of processing service QoS, response time will vary within a range rather than being a specific value.

3 Proposed solution

Aiming at the correctness, quality and efficiency of processing service composition for remote sensing application, a remotely sensed image processing service composition approach is proposed in the dissertation.

Table 1. The basic idea of service composition

Service level	Question	Basic idea
Abstract service	How to assemble them to build the service chain	Remotely sensed image processing service chaining based on heuristic search
	How to automatically select the most appropriate services	Knowledge navigated remotely sensed image processing service classification and selection
Concrete service		Remotely sensed image processing service selection with response time

Remotely sensed image processing service chaining based on heuristic search construct service chain through two steps: 1) dynamically constructs a complete service dependency graph for user requirement on-line; 2) AO* based heuristic searches for optimal valid path in service dependency graph. These services within the service dependency graph are considered relevant to the specific request, instead of overall registered services. The second step, heuristic search is a promising

approach for automated planning. Starting with the initial state, AO* uses a heuristic function to select states until the user requirement is reached.

It is a major challenge to select appropriate remotely sensed image processing services to satisfy both functional and non-functional requirement. In an attempt to facilitate and streamline the process of service selection, selecting services involves two main selection processes, abstract service selection and concrete service selection. Abstract service selection pick out a service to perform certain remotely sensed image processing function. Concrete service selection choose from among a set of functionally equivalent ones for each abstract service.

At the abstract service level, a novel service selection approach, knowledge navigated remotely sensed image processing service classification and selection, is proposed in the dissertation. It consists of three main steps: service cluster pre-process, knowledge discovery and service selection. In the pre-process, the similar candidate services are grouped into clusters called service clusters as the objects to be selected to distinguish services detailed and sharp down the search space. In the second step, decision–tree, a classification method, is used to discover the latent relation between specific task and services. Finally, the knowledge is used to decide which service clusters to perform the task. By learning from domain experts' interactions and other analysts' experiences with various services, the approach will help analysts determine what service set most satisfies the immediate problem at hand.

At the concrete service level, based on the probability theory, we constructs the probability response time estimation model to construct the constraint between the expected value, the variance, and the user's requirement of response time. By using the critical path method (CPM), some critical services which have direct and crucial effects on the response time guarantee are picked out. To satisfy the constraint, a service selection algorithm of service selection is proposed to reselect appropriate remotely sensed image processing services. Thus, the optimized service chain can meet the response time requirement of the user with higher probability than before.

4 Conclusion

Our work includes two main contributions. The first is a remotely sensed image processing service chaining algorithm. The second contribution is a service selection algorithm on two levels. Three algorithms are described in this work: (1) remotely sensed image processing service chaining based on heuristic search to composite services into a meaningful order; (2) knowledge navigated remotely sensed image processing service classification and selection, which using data mining to select an appropriate service for specific user requirement; (3) remotely sensed image processing service selection with response time to meet the response time requirement from user.

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