PROTOTYPICAL SENSOR WEB APPLICATION USING A PATTERN MATCHING SERVICE

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ABSTRACT

Till now analysis of digital remote sensing data needs specific knowledge and software tools. In addition, the user has to deal with a broad range of different data formats, which often leads to converting expenditure and lack of compatibility. To overcome this situation the international Open Geospatial Consortium (OGC) started the standardization initiative Sensor Web Enablement, SWE. The aim of this initiative is to develop standards for a fast and easy exchange and analysis of sensor data inside complex networks. This paper presents a first prototype of a standardized service architecture based on commercial analysis software which allows users to analyze remotely sensed data based on pre-defined classificators automatically. The user works in this service architecture with an easy to operate client provided via internet and needs no special knowledge for the analysis of the data. After introducing the architecture of the prototype the paper illuminates the applicability of the developments based on two selected use cases.

Keywords: sensor network, automatic feature extraction, analysis service, web notification service, SWE

1 INTRODUCTION

Since the early days of remote sensing when remotely sensed data was analyzed by hand until now when the interpreter has access to powerful but complex digital analysis tools, the interpretation of data needs a lot of specific knowledge and experience. Successful remote sensing analysis requires the human in the loop especially for accurate classification results. New developments try to increase the amount of automation in order to reduce effort and time during data analysis. Promising new analysis methods are leaving the pixel level through image processing and are focusing on objects, representing homogeneous pixel [1]. This avoids the so called “salt and pepper” effect and leads to new, better transferable classification rules, able to include also texture and shape information. Meanwhile commercial object based classification tools are available like *eCognition* from *definiens* (`http://www.definiens-imaging.com/`).

Beside this the wide variety of available sensors and data formats leads to a lack of interoperability. To surmount this situation the OGC started the standardization initiative Sensor Web Enablement (SWE). In addition to remote sensing sensors, SWE also takes into consideration al other types of sensors like temperature or water level sensors which should be made accessible over the Internet [2]. At the moment the following specifications are building the basis of SWE:

- SensorML, the so called Sensor Model Language defines an information model and XML encodings allowing description, discovery, query, and controlling web-resident sensors [3].
- O&M, the Observation and Measurement specification defines an information model and XML encodings for observations and measurements [4].
- SCS, the sensor collection service serves sensor data [5] as a web interface providing access to sensor data
- WNS, the web notification service provides XML based notifications to inform user and services about e. g. analysis progress [6].
- SPS, the Sensor Planning Services allows sensor maintenance and feasibility testing.

The paper will present a first sensor web solution enabling the automatic classification of remote sensing data over the internet with predefined classification rules. By using an object based analysis

service combined with a WNS and an easy to use client, this stable prototype has proven its potential in two different use cases.

2 ARCHITECTURE

The following section describes the architecture of the prototypic sensor network. Figure 1 shows a schematic structure of the implemented sensor web. The main components of the prototypical architecture are described below.

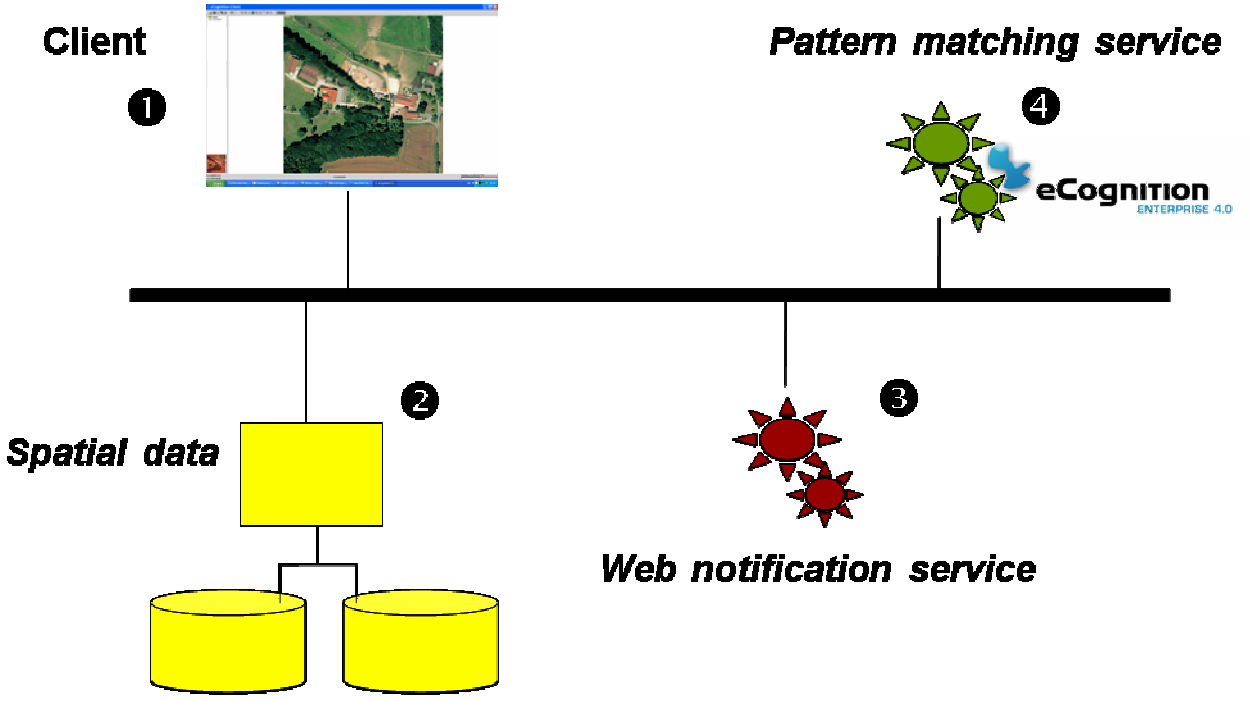

Figure 1: The schematic structure of the implemented prototypic sensor web.

2.1 THE CLIENT

From the final users point of view the client will be the main component with respect to usability and functionality inside a sensor web implementation. The user will use the client to extract necessary information and to operate inside the sensor network. In order to reduce the effort for training the client has to operate with an easy to understand graphical user interface with a limited set of functionalities.

The chosen client for the prototypical implemented sensor network was developed as a java web start application using the commercial MapObjects library for java from ESRI. Used for demonstration purposes only, the client could therefore be developed within very short time frames.

Beside the implemented MapObject based functionalities, Java Bean technology and Java Web Start technology helped to keep the demands on the client system rather low. A simple web browser combined with a Java virtual machine is all that is needed to start the semi-automatic remote sensing data analysis. It allows the user to define the data set for analysis and select the rule-set which should be used for processing. After finishing the basic steps, it is up to the user if he wants to wait until the processing has finished and the data will be delivered (following the typical pull-paradigm), or if he wants to make use of the asynchronous paradigm by using the Web Notification Service. (WNS, for further details see section 2.3). By using the WNS the user will be informed via Mail, SMS or Fax if the process is finished and the data is ready for download. Furthermore the user can observe the processing status of the data analysis job. After starting the process the user will receive a process ID which can be used as a reference link allowing to retrieve information about current process states. If the user decides to wait until the analysis process is finished the download of the data starts automatically. The data is transferred in compressed form to the pre-selected folder on the local end-device and will be automatically added to the data viewing component of the client. The classification results are stored and submitted as shape files. This allows the integration in most of the available GI-Systems.

2.2 THE DATA

The data inside the prototypically implemented sensor web is accessed on a hard disk using a flat file system. One of the next improvements will be the use of OGC compliant web services as data sources, i.e. Web Feature Servers, Sensor Collection Services, or Web Coverage Servers

At the moment, the processing service supports the following formats: Tiff, GeoTiff, Bitmap and Jpeg.

2.3 WEB NOTIFICATION SERVICE (WNS)

The Web Notification Service (WNS) is a service by which a client may conduct asynchronous dialogues (message interchanges) with one or more other services for long duration processes. This service is useful when many collaborating services are required to satisfy a client request, and/or when significant delays are involved in satisfying the request. This service was defined in support of SPS operations [2].

The WNS supports a broad range of communication protocols. The user may choose between automatic telephone calls, faxes, SMSs (Short Message Services), IMs (Instant Message) and email, to receive notifications about certain events. The additional HTTP protocol allows automatic service invocation; the WNS acts as a service or service chain initiator by sending a message to the registered URL [6].

Two communication patterns have to be distinguished. By sending a notification message it is intended to inform a user/client that an event has happened without requesting any reply. The communication message initiates a two way communication between the WNS and its message receiver in contrast. The user may use the same communication protocol or any of the other protocols supported by the WNS to send a reply to the message initiator. The WNS acts as a protocol switch and forwards the reply using HTTP.

2.4 PATTERN MATCHING SERVICE

The implemented pattern matching service uses the commercial software package *eCognition enterprise* from *definiens* as its backend. The realized pattern matching service classifies the remote sensing data sent from the client. The processing result is coded as vector layers for each class that are stored as georeferenced ERSI shape files. The response format is ESRI shape files as well. To ensure multi user service access, the service works with unequivocal process ID's. Per classification job the service selects an unequivocal process ID, which builds the basis for correct communication with the client.

As pointed out before, the core functionalities of the service are realized by using *eCognition enterprise* from *definiens*. By using this product an object based classification service was made available, which supports also the creation of ERSI shape files based on the received classification results. The main components of *eCognition enterprise* are:

- an analysis service responsible for the main analysis process of the different requests,
- a data control service responsible for storing and retrieving data from a RDBMS (at the moment the following RDBMS is supported: Oracle) and for managing the work flow,
- a client, called enterprise client for managing the database content, defining the work flow, and visualizing the analysis results as images or statistics and
- a Java Messaging service responsible for the XML based communication between the web frontend and the pattern analysis component.

3 IMPLEMENTED TEST USE CASES

To get a first impression of the functionality and usability of the implemented software the following two use cases have been realized: A land use classification and a cloud classification. The development of the two necessary rule sets was performed with *eCognition professional*. After reaching successful fitting rule sets for the use cases, both rule sets were exported from *eCognition professional* and imported into *eCognition enterprise*. Afterwards both rule sets were available for the developed pattern matching service. A short overview of the use cases and the received results will be given below.

3.1 LAND USE CLASSIFICATION

Based on the available aerial photos from the *Regionalverband Ruhr (RVR)*, a first rule set for detecting three classes (agriculture, forest and urban) was developed. The aerial true color data was taken in 2002 with a geometric ground solution of 30 cm. The *RVR* uses this data for their change detecting with respect to the Ruhr area for which the *RVR* is responsible focusing on land management and urban planning.

This rule set is based primary on different segmentation levels that were classified to discriminate the chosen classes. By using membership functions and neighborhood information, the quality of the rule set could be improved and the results are fitting the main demands of a first test case helping to examine the usability of the architecture.

Figure 2 (a) shows a result of the land use classification based on a subset of the available data.

3.2 CLOUD CLASSIFICATION

The second implemented use case is based on the sensor SEVIRI (Spinning Enhanced Visible and Infrared Imager) at the METEOSAT platform. By using the three channels one, four and nine a classification for the detection of cloud classes was implemented. Table 1 gives an overview of the implemented classes.

Table 1: Overview of the implemented classes for the cloud classification

Class	Description
Very early stage	Flat, relatively warm clouds
First convection	First convective cloud towers
First icing	Transformation in Cumulonimbus (thunderclouds)
Large icing	Peak of convection e. g. highest vertical expansion

Figure 2 (b) shows the classification results of a subset of the available SEVIRI data.

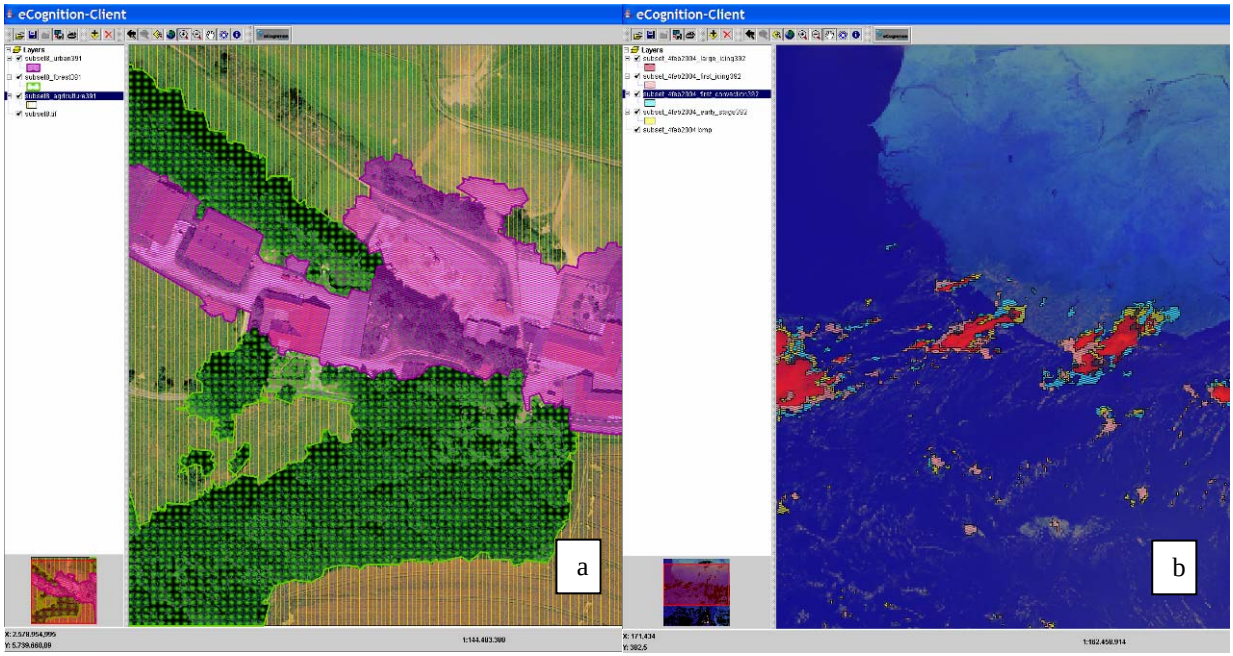

Figure 2: 2a results of land use classification (violet = urban, orange = agriculture, green = forest)

2b results of cloud classification (red = large icing, light red = first icing, blue = first convection, yellow = very early stage)

4 CONCLUSIONS

Easy to access, interoperable remote sensing data will play an important role for the world wide fast actualization of relevant digital geographic information [7] as well as for the efficient selection of images from very large databases that fulfill predefined criteria (e.g. a maximal cloud cover of five percent). Based on current standardization initiatives within OGC or ISO the floor for the development of complex sensor networks providing standardized access to data and information is laid. The implemented prototypical architecture of a sensor web application using object based classification functionalities could give a first impression of the opportunities and the usability of such a structure. Nevertheless there are still a lot of restrictions for an automatic classification of sensor data.

First of all the data needs a form which allows the classification by using a pre-defined rule set. Furthermore the band wide of the user internet connection is still a bottleneck with respect to the transfer of the remote sensing data which should be analyzed over the internet. Finally the standardization of necessary data analysis services is still in its infancy.

Nevertheless the available technical conditions allow a more automated use of remote sensing data over the internet and it will be one of the main spheres of work in remote sensing to support and develop this technique to bring it into practical work.

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