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Web-Based Photogrammetric Image and Geospatial Services – an Overview

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ABSTRACT

This paper gives a short account on the status of web services in photogrammetry, remote sensing, and geospatial science. After a short introduction, the terminology of the field is discussed, and the most important services standardized by the Open Geospatial Consortium are introduced. The paper continues with a presentation of different types of services, distinguishing retrieval services from those, which enrich, integrate and manipulate different sets of geospatial data. The OGC Sensor Web Enablement initiative is mentioned along with a discussion about semantic interoperability and the semantic web. Finally, some conclusions about the future of photogrammetry and geospatial web services are given.

1. INTRODUCTION

The legendary success of the internet has led to major changes in our life. Among other things, we have come to see and understand the deeper meaning of the slogan “the net is the computer” promoted by SUN Microsystems already two decades ago. The internet and the underlying computer network technology have changed many of our daily communication and production channels, and also their speed: the number of emails (business, private and spam) has increased exponentially over the last few years and probably inversely proportional to the number of postal letters; the importance of fax machines has greatly diminished. We have now reached a state, where – as somebody put it recently – we can of course be reached by email 24 h a day, but if somebody should take notice of our message, we should better send a fax, and if we wanted the other person to react, we should write a letter – letters have nearly reached the state of singular events.
Part of the success of the internet lies in its ease of use and its standardization. Especially interoperability is seen by many as a key component of any sustainable service. Thus, in order to participate in the internet success, these basic requirements need to be met by any field.
The geospatial sciences incl. photogrammetry and remote sensing have participated in the growth of the internet, and have developed various services which are available over the “net”. The most well-known activities are probably those of the Open Geospatial Consortium (OGC), the recent availability of remote sensing imagery in the Google environment has also attracted much interest (e. g. HAZ 2005).

In this paper, we first look at some of the terminology used in the geospatial “net language” to establish a common ground for our discussion. We then put a structure to the various photogrammetric image and geospatial services and give a few examples of existing services incl. the sensor web. We also discuss geospatial portals and European developments with regard to the INSPIRE[1] initiative of the European Union. Through INSPIRE and the related programme EuroSpec (Luzet, Land 2004; Murray 2004) the National Mapping and Cadastral Agencies (NMCA) are establishing the European Spatial Data Infrastructure (ESDI; Grünreich 2004), which comprises many national and international geospatial services. Finally, we will draw some conclusions about the future use and need of web-based services in photogrammetry, remote sensing and the geospatial sciences.
In this paper we will not deal with eLearning which can also be considered a web service, because it is dealt with in another paper of this conference (Schiewe 2005). Also, we will not examine

[1] Infrastructure for Spatial Information in Europe, see http://www.ec-gis.org/inspire/

business models for web services (see e. g. Fritsch 2001; Reiss 2001) and more technical issues like the necessary band width for offering a specific service, the related coding and compression techniques, and aspects about software and hardware architecture; partly because the actual hardware and network performance figures tend to become outdated very fast – Moore's law still holds – and partly, because these issues are beyond the scope of this paper.

2. WEB SERVICE TERMINOLOGY

In order to establish a common ground for the discussion, we first review some of the definitions of the field. We use those promoted by OGC, since OGC in conjunction with the International Standards Organisation ISO has emerged as the most authoritative body (see also Schilcher 2005).

According to the OGC glossary (OGC 2005),

- A **service** is "a computation performed by a software entity on one side of an interface in response to a request made by a software entity on the other side of the interface. (It is) a collection of operations, accessible through an interface, that allows a user to evoke a behaviour of value to the user."
- A **web service** is "a self-contained, self-describing, modular application that can be published, located, and invoked across the web. Web services perform functions that can be anything from simple requests to complicated business processes. Once a web service is deployed, other applications (and other web services) can discover and invoke the deployed service."

Thus, services require an interface between two software entities. Often, the client-server architecture is used to set up services. For web services, one of the software entities (the client) is a web browser, and all communication occurs through the web. Note, that in concert with our natural understanding of *service* the definition requires that the service result should be of value to the user. Note also, that neither the programming language (e. g. Java) nor the computing capabilities of the client are specified. Sometimes, a distinction between "thin" and "thick" clients is found in the literature, referring to the degree to which the client acts as a computer monitor only, or also performs local computations.

There are a number of proprietary and open source software solutions for geospatial web services available on the commercial market. In order to achieve interoperability[2] the OGC has standardized a number of them, more specifically the interfaces between the two software entities. The two most important ones are

- The **Web Map Service WMS**: an "OpenGIS specification that standardizes the way in which web clients request maps. Clients request maps from a WMS instance in terms of named layers and provide parameters such as the size of the returned map as well as the spatial reference system to be used in drawing the map."
- The **Web Feature Service WFS**: an "OpenGIS specification that supports *insert, update, delete, query*, and *discovery* of geographic features. WFS delivers GML [Geographic Mark-up Language, an XML (eXensible Mark-up Language) encoding for spatial data] representations of simple geospatial features in response to queries from http [hyper text transfer protocol] clients. Clients access geographic feature data through WFS by submitting a request for just those features that are needed for an application."

[2] Interoperability, in the context of the OpenGIS specification, is software components operating reciprocally (working with each other) to overcome tedious batch conversion tasks, import/export obstacles, and distributed resource access barriers imposed by heterogeneous processing environments and heterogeneous data (OGC 2005).

Whereas the WMS produces maps of geospatial data for viewing purposes, generally in image representation (raster format), the WFS delivers geospatial data encoded in GML (in vector format), useful e. g. in updating and analysis tasks.

3. TYPES OF WEB SERVICES

In principle, web services can be distinguished into two different groups: either pre-existing information is being searched for, possibly followed by a download or an order operation, or information is being generated by enriching, integrating and/or manipulating pre-existing information available on the net. Obviously, many existing web services combine aspects of both groups into one service. Whereas most services return the results on-line, ordering is of course an off-line service.

The *first group of services* relies on search engines, which in most cases retrieve information based on metadata. Such metadata can be provided as a separate entity (e. g. the age, acquisition method, geometric accuracy etc. of geospatial data), but can also be key words contained in a web site. Whereas the first possibility is often used to create metadata catalogues, the second one is the one usually employed when web authors are interested in reaching a high visiting rate for their pages. In both cases, search is done *by name*, not *by content*. The difference becomes very apparent when images are being searched for: A *search by name* returns all images with a particular key word[3]. An image retrieved through a *search by content*, on the other hand, contains the object, which is described by the search term. A *search by content* for all images with the key word "buildings", for instance, returns images actually displaying buildings, and not all those images which were classified as displaying building by some external source.
It is immediately clear that a *search by content* is much more complicated than a *search by name*. In order to carry out a *search by content*, automatic image analysis (sometimes called automatic image retrieval) must be performed virtually in real-time for all images at hand – a formidable task well out of reach of today's possibilities.
An example of a service of the first group is provided by a photogrammetric company (Aerowest 2005). The service allows for placing an order for having the size of roof tops determined based on aerial images. This off-line service was designed for roofers who need to determine the number of tiles necessary for a specific job. Other examples relevant in the area of photogrammetry, remote sensing and geoinformation are the Google Earth Explorer (Google Earth 2005), and the various aerial and satellite remote sensing image catalogues (see list at the end of the paper).

The *second group of services*, which comprises the WMS and the WFS, does not only present available information to the user for inspection, download or purchase. In addition, specific enrichment, integration and manipulation tasks are being carried out to generate new information (e. g. a map), which is subsequently transmitted to the user. Technically, the service request from the client can take the form of a list of input parameters, and all computations are carried out on the server; alternatively, the server can send applets and data to the client and the computations are carried out locally, various combinations between these two possibilities also exist.
One of the first photogrammetric web services is the Arpenteur project developed by Grussemeyer and Drap (2001). The authors have developed a remarkable set of photogrammetric software tools which can be used across the web. Based on standard programming tools they have thus demonstrated that web-based photogrammetry is indeed feasible. Obviously, the network band

[3] In this regard it is instructive to search e. g. for images containing the key word „photogrammetry" on the web.

width does not currently allow the fast transfer of large aerial image data, but this is only a technical, not a functional limitation of web-based photogrammetry.

An activity, which has recently found an increasing interest in the area of web services, is the OGC *Sensor Web Enablement* (SWE) initiative. SWE consists of services of both groups mentioned above; the two most important parts are *SensorML* and *Oberservation and Measurement*. *SensorML* (Sensor Model Language) is an information model and XML encoding for discovering, querying and controlling web-resident sensors (Botts 2002). *SensorML* describes the characteristics and calibration parameters of static and mobile sensors, from gauge meters to thermometers and video cameras. *Observation and Measurement* (Cox 2003) provides a consistent way to encode the sensor observations, from temperature and pixel grey values to three-dimensional location and time.
In the SWE each sensor is linked to the web and is able to report at least position, observation data, and time of observation. Based on additional SWE services a user can access, manipulate and integrate remotely stationed sensors in real-time. It is also possible to plan and task sensor observations, and to request alerts, if certain critical observations have been made. The SWE thus provides a standardized way for on-line monitoring on demand of arbitrary remote areas using a multi-sensor network.

A major obstacle for interoperable web services is the fact that different definitions and meanings one and the same term exist in different areas (e. g. Hübner et al. 2005). Current developments of the so called *semantic web* (Berners-Lee et al. 2001; Egenhofer 2002) address this problem by adding a well defined and computer-readable layer of metadata based on ontologies[4] to each information in the web. In essence, this means that metadata consistent with the general meaning of a term are created for each information. Presently, the Web Ontology Language (OWL) is used to formally express these metadata. In this way, also the semantics of images can be described, and real-time image analysis of large numbers of images can be avoided (see above). Such solutions also need to be employed in the SWE, since the different sensor observations must usually be interpreted in a common way in order to yield meaningful information (Schade 2005).

4. WEB SERVICES AND GEOSPATIAL DATA INFRASTRUCTURE

In order to maximize the gain of web services on a broader level, the different services (see section 3) are increasingly being combined in portals. In particular this development can be observed on a national and a trans-national scale, where such a portal serves as the entrance point of the geospatial data infrastructure (GDI)[5], see for example the German Geoportal (2005), a prototype of which has been presented at Cebit 2005 in Hannover (Grünreich 2004; Fehling 2005). Such portals include a metadata search engine, a set of services to enrich, integrate and manipulate data, and a (often distributed) database containing the actual data. It should be pointed out that in such portals data of different theme layers (topographic mapping, forestry, agriculture, transportation, hydrology, etc.) are presented in a consistent form, which requires among others semantic and geometric interoperability between the different data sets.

A particularly relevant project in this regard is the contribution of EuroGeographics, the association of the European NMCAs, to the ESDI, entitled EuroSpec. EuroSpec is “a structured approach to providing to pan-European and cross-border users of reference geographic information the means to

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[4] According to Guarino 1998, *ontologies* are content theories, identifying classes of objects and relations that exist in a certain domain addressed by an information system.

[5] Besides web services a GDI also comprises organisational agreements between the different players, relevant standards, geospatial data and metadata (Grünreich 2004).

locate, select, access and download the data they need from distributed sources at the NMCAs across Europe. It is also the collective contribution of the European NMCAs to the ESDI and the INSPIRE initiative, being a concerted major step towards interoperability – technical and business – of reference geographic information" (EuroGeographics 2005). All communication with and about the geospatial data is to be carried out through the web, and based on OGC standardized web services. All NMCAs remain responsible for their own geospatial data, and translators to a common EuroSpec schema are being developed in order to provide a consistent set of data to the end user (see figure 1). Again, a common portal will enhance access to this pan-European data set.

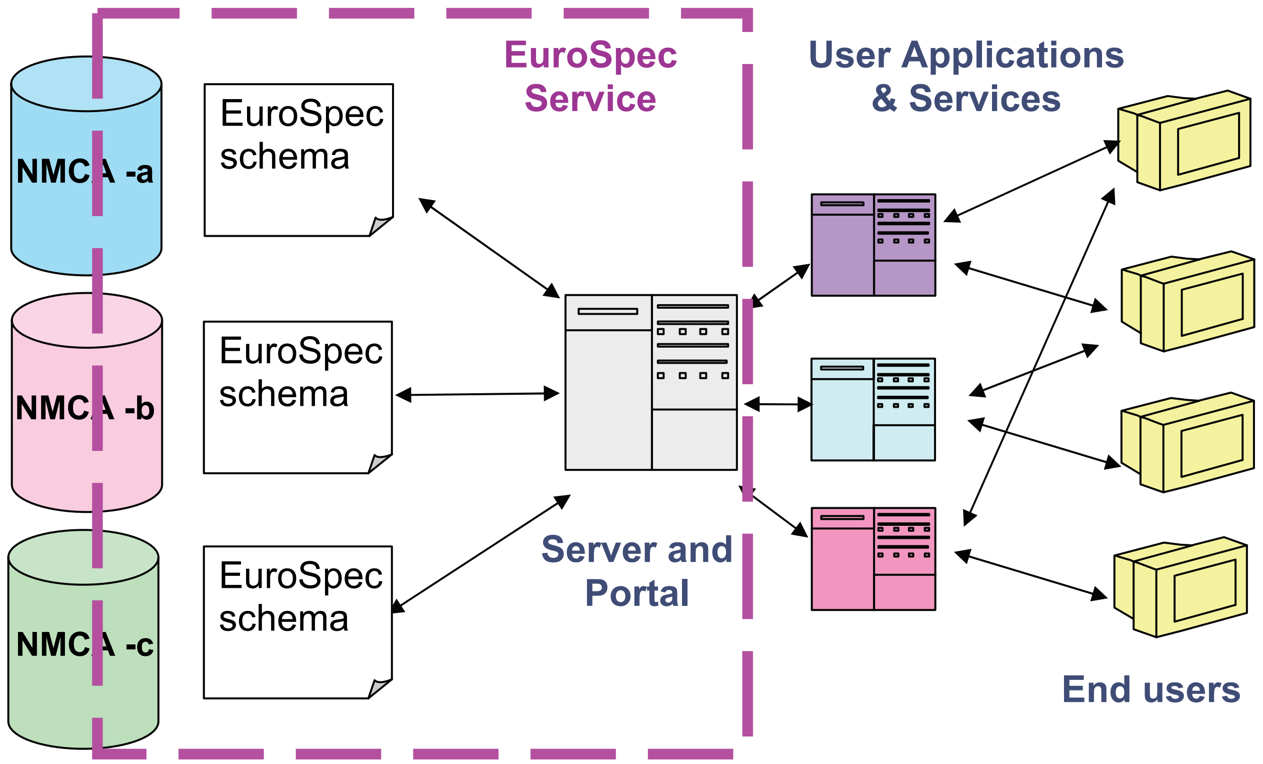

Figure 1: General set-up of EuroSpec (EuroGeographics 2005)

5. CONCLUSIONS

The internet and web-based services have an increasing impact on nearly all aspects of our life, and certainly on photogrammetry, remote sensing and the geospatial sciences. First examples of web-based photogrammetry and web-based photogrammetric stations and services have already been realised, the further spread is currently more hampered by the network band width across the web than by anything else. Intranet solutions based on the web, however, are already feasible today, the management tools of the commercial photogrammetric software companies such as TerraShare from Intergraph (Rosengarten 2001) can be considered as a first step in this direction.
Location based services have not been addressed in this paper, but since no distinction was made with regard to the type of communication channel, all mentioned services can also be invoked from mobile devices. Mobile users with constantly changing position will have a larger need especially for geospatial services involving positional information than many static users, thus location based services will benefit largely from the standardization and thus the wider spread of web services (in fact, they already do).

The SWE initiative is of high relevance to photogrammetry and remote sensing. Whereas *SenorML* encodes among other information the parameters of interior orientation of cameras, *Observation and Measurement* describes the grey values used as primary measurements in our field. The SWE initiative thus provides major opportunities for our community, ranging from documenting and mapping remote areas to on-line monitoring of environmental, traffic and homeland security applications. Equally important is the fact that it provides a direct link between photogrammetry; remote sensing, and the geospatial sciences, thus adding to an even closer connection between the different fields.
Also the computer games industry will have an increasing impact on photogrammetric and geospatial web services. An example for a service yet to be developed is an on-line game based on the sensor web and thus life images, whether through a tool like Google Earth or a selection of web cameras. Such a scenario may sound a little bit unrealistic today, but it may very well be a standard application before too long. The data management, the information retrieval and presentation, and thus inner workings of such services have a lot to do with photogrammetry, remote sensing, and the geospatial sciences – it is time now to play an active part in these areas. Also, we should certainly prepare our students to be able to also succeed in such environments.

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http://www.spaceimaging.com/quicklook/collection2_city.asp
http://www.spaceimaging.com/gallery/international/index.htm
http://www.terraserver.microsoft.com/