A spatial data infrastructure concept for precision farming tasks

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Abstract: The GeoWebAgri-project evaluates the use of spatial data in precision farming tasks. A service-oriented spatial data infrastructure working with standards could identified as optimal environment for the users' needs. Using standards of OGC, ISO and W3C help to increase the functionality, usability and accessibility of spatial based applications in agriculture.

1 Introduction

The relevance of spatial information in agriculture is increasing, especially for precision farming tasks. Such tasks require high resolution data, acquired in the field or from external data sources. Additionally, spatial rules and knowledge can support the farmer's work [NWN+ 11]. Beside the farmers, other groups act with identical datasets in modern agriculture. A collaboration of heterogeneous user groups from different backgrounds needs access to spatial data being created and maintained throughout different systems, located either on farm machinery and local offices or being accessible through the web. The GeoWebAgri project has faced these challenges and developed a spatial data infrastructure concept for precision farming. Results are presented in this contribution.

2 Spatial data management options

State-of-the-art systems Present Farm Management Information Systems (FMIS) and precision farming tools are used for documentation needs and to increase the efficacy of field work by a lower input and decreasing negative influence to the environment. The basic data for sub-field-level management decisions is based on spatial information. A lot of data sources already exist or there are ideas about new possibilities of integration to gain a better knowledge about the within-field variability. In the web there are new agricultural portals that serve as clients for spatial data, e.g. https://fiona.landbw.de for

farmers subsidy applications. Unfortunately their service is restricted to the exchange of data between institutions and farmers, while a machine-oriented transfer is still missing. On the other hand software for machinery operations is often part of closed FMIS of special manufacturers, mainly supporting predefined tasks. The complexity of precision farming tasks and new developments integrating different data sets induces a conflict with the usability and accessibility of the software, which is known as an important obstruction for the acceptance of the user. Experts of different background need to work together on the same data to develop optimised management strategies.

User requirements In the context of precision farming typically access at geo-data is required by: farmers, farming machinery, scientists, agricultural consultants, public authorities, companies & manufacturers and external service providers. Every group is a potential data provider (e.g. machinery with sensor equipment, companies providing satellite data, authorities with thematic maps) and can be consumer of such data sets. These groups use individual hardware and software components [NKB09]. The specific need for data sets differs according to the specific view on precision farming and used tools, but sharing data sets is a key issue for a collaboration. Therefore, additionally to local data, a centralised data storage and data management is recommended, providing access for many users. If such systems interoperate based on standards, the advantage is an increased interoperability between user's different components [NSK10]. Tools for farm management and precision farming today support these needs only partially.

Spatial Data Infrastructure (SDI) The ongoing GeoWebAgri project evaluates the handling of spatial data within an extensible SDI infrastructure. An SDI consists of components, users and data, as well the network and in-between interfaces ([IPW03]). To serve spatial data to the users, localised at different places, with several special interests and data access needs, a web service based client-server-architecture is recommended [Kra07].

Since data sets may have restrictions on availability for certain users, levels of data security between the users (providers and consumers) are necessary. A user management is needed, including a process of authentication and authorisation. This construction is called the SDI's policy and should be realised with only one identification step per user. Further requests in the same session should share the authentication of the user. The main configuration of rights has to be done for groups, to which users are associated. Basic groups in the implementation consist of the user groups mentioned previously, with a finer granulation into subgroups with specific rights. Due to a tree-like structure of group memberships, even complex authorisation schemas are possible. Such schemas have to be developed and implemented for the services outlined in the following.

Standards The machine standard ISO 11783 (ISOBUS) demonstrated the positive effect of a standardisation approach in the agricultural domain. To prevent problems of incompatibility, GeoWebAgri proposes to work with existing standards defined by international organizations and consortia where possible. Standardisation is needed to realise highly complex service chains [KGH06]. The most important standards for this context are developed by the World Wide Web Consortium (W3C), the international standardisation organisation (ISO) and the Open Geospatial Consortium (OGC).

W3C-Standards W3C offers well known standards, which are widely used in the world wide web, like the HyperText Transfer Protocol (Secure) HTTP(S) and the eXtensible Markup Language (XML). Further meaningful for precision agriculture are rules and their integration in web based system environments. Rule Interchange Format (RIF), Web Ontology Language (OWL), Simple Knowledge Organisation System (SKOS) and Resource Description Framework (RDF) are suitable for the interchange of rules and a unified semantic between systems.

ISO-Standards Relevant standards published by the ISO are the standards of the ISO 19100-series and the already mentioned ISO 11783. The ISO 19100-series deals with spatial information. Some of them originate from OGC standards and were transferred to ISO standards. For example the ISO 19115 describes the composition of a meta data set, which is necessary to search for data effective by standardized requests. Details about these and further spatial ISO-standards are summarised in [KF04].

OGC-Standards OGC published several standards interesting for precision farming data. The main important ones are:

GML (Geography markup language): GML is a markup language describing features with geographic properties. A feature is an abstraction of an object in the real world. The description only defines the basic types, while a more specific formulation is called a GML application schema. The agreement on same application schema allows to exchange domain specific spatial data with clear semantics [Ree11]. Additionally to its function for object definition, GML is used as a format for requests to and responses from OGC web services.

WMS (Web map service): WMSs provide presentations of geodata (maps as images). The service renders the raw geodata and publishes them as a raster graphics (e.g. png, jpg), and can provide feature information for a location. In addition the service offers a description of the layers, optionally a legend, and the render styles can be customised.

WFS(-T) (Web feature service [transactional]): The WFS offers access to vector data, in transactional mode possibilities to manipulate geographic features exist (change requests). Data is received in GML or other formats like GeoRSS, KML etc. [Ree11]. Its vector based characteristics and the possibility to get structured object features are important for an automated interpretation on machinery and in on-farm-processes.

WCS (Web coverage service): A WCS offers interfaces and operations to request data excerpts from a specific area. The data may be multivalued, e.g. containing several temporal or thematic layers.

WPS (Web processing service): WPSs can execute GIS functionalities or apply algorithms to geodata. Interfaces to geospatial processes, as well as information about their discovery and binding, can be published and used by networks to work on local or connected data [Ree11].

3 Results

The project already identified the need for a higher interoperability between components in precision farming dealing with spatial information. Client-server architectures offer the option of flexible data storage and transfer. Precision farming with its many applications and users can benefit from implementation of components a de-central service structure. Each SDI component can then interoperate with others, based on clearly defined standards. The mentioned components are essential for an efficient spatial data infrastructure for precision farming applications.

In the GeoWebAgri project such an infrastructure were built up and evaluated on a spraying use-case. To simulate the complexity of real farming conditions, the infrastructure components were built up de-centrally at different locations. In the use-case a task controller on farm machinery requested data from a geo-database via WFS and WMS.

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