Interdisciplinary research and education in a virtual cultural landscape laboratory

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Summary

In recent years the transfer of old documents (books, paintings, maps etc.) from analogue to digital form has gained enormous importance. Numerous interventions are concentrated in the digitalisation of library collections, but also commercial companies like Microsoft or Google try to convert large analogue stocks such as books, paintings, etc. in digital form. Data in digital form can be much easier made accessible to a large user community, especially to the interested scientific community.

The aim of the described research project is to set up a virtual research environment for interdisciplinary research focusing on the landscape of the historical Mecklenburg. Georeferenced old maps from 1786 covering complete Mecklenburg should be combined with current geo-information, satellite and aerial imagery to support spatial-temporal research aspects in different scales in space (regional 1:200,000 to local 1:25.000) and time (nearly 250 years in three time steps, the last 30 years also in three time slices).

The Virtual Laboratory for Cultural Landscape Research (VKLandLab) is designed and developed by the Chair of Geodesy and Geoinformatics, hosted at the Computing Centre (ITMZ) and linked to the Digital Library (UB) at Rostock University. VKLandLab includes new developments such as wikis, blogs, data tagging, etc. and proven components already integrated in various data-related infrastructures such as InternetGIS, data repositories and authentication structures. The focus is to build a data-related infrastructure and a work platform that supports students as well as professional researchers from different disciplines in their research in space and time.

1   Motivation

Modern knowledge and information society with its various possibilities of efficient communication and easy access to very large amounts of information and powerful computing technology is a new challenge to science. The chances to achieve better scientific results, both qualitatively and quantitatively, with the new methods have increased considerably in parallel, but also the difficulty to control such distributed, dynamic system components. Under the heading "e-science" a network-based science, "grid-based science" or "digitally enhanced science" is becoming increasingly established. This requires the systems development and the organizational structures of a network and middleware infrastructure, with which computational resources, information resources,

application programs can be offered, requested and allocated for community-specific applications (BMBF Science Management 1/2005).

With the promotion of virtual research environments the German Research Foundation (DFG) aims to further develop integrated information infrastructures for grid-based research. The new communication technologies and publication procedures permanently change the existing information infrastructure and the traditional publication process. Digital information and communication networks provide the technical requirements for time-and location-independent collaboration. Essential for the development and effective use of new communication and publication networks are powerful tools and infrastructure to support the scientific work processes. These include the virtual research environments, platforms for network-based collaborative work processes that support new forms of cooperation and result in an easier access to scientific data and information. They provide both a central access to each subject-specific resource, data and document as well as the necessary conditions for a substantive link between the various information units.

2   Cultural Landscape Research

The cultural landscape analysis - as an example of historical-geographical, land use change and land improvement research - requires the modeling of landscape and socio-economic processes over time in their history. In assessing the sustainability of landscape developments the spatial distribution patterns and the mosaic of key elements in the landscape need to be considered. For this purpose, the cultural landscape research uses historical data sets. Large amounts of data collected in electronic form over the last decades and centuries in statistical offices, museums, archives and numerous historical and geographical research projects can be set in value using modern IT methods. For questions of landscape monitoring (NEUBERT/WALZ, 2002, WALZ U.A., 2004) or for inventarisation of the cultural landscape (PLÖGER, 2003) since many years historical maps are investigated with modern IT methods.

2.1   Historical maps and geo-information data sets in Mecklenburg

For over a decade the professorship of Geodesy and Geoinformatics is dealing with the exploitation of historical maps (sometimes also called old maps) in digital form as a source of interdisciplinary landscape research. Around the year 2000 for the first time an attempt started to offer maps on the area of the historic Mecklenburg in a homogeneous digital form. Scanning the old maps of Wiebeking (1786-1788, 48 sheets, 1:24.000) and Schmettau (1788, 16 sheets, 1:50,000) and the topographic base maps (1877-1889, 168 sheets, 1:25,000) made available the oldest topographic maps of large parts of the federal state Mecklenburg-Vorpommern (more precisely, of the duchies of Mecklenburg-Strelitz and Mecklenburg-Schwerin) in an excellent quality (GROßE/ZINNDORF, 2001, GROßE, 2003). KREßNER, 2009 evaluated these scanned maps in terms of their quality and their geometric origin. He investigated the thematic suitability for scientific analysis, especially in relation to landscape research issues. These old maps are georeferenced and their geometric quality is described. They can be deployed and integrated into GIS in the sense of historical digital primary research data holdings of the science. This is the main data set for the designed virtual research environment for the modern cultural landscape research.

With a territorial extension of 13,000 square kilometers and a time horizon of around 225 years, there is nothing comparable in the world. Combined with the spatial data of today (digital topographical maps in raster (DTK 10) and vector form (DLM) from the Authoritative Topographic-Cartographic Information System (ATKIS)), and embedded in modern information and communication technologies (ICT), new research avenues and forms of access for cultural landscape research are becoming available. The potential of such a virtual platform for cultural landscape research is illustrated by KREßNER, 2009 with small case studies and student projects on spatial-temporal changes in the region of Ribnitz, a small city in Mecklenburg.
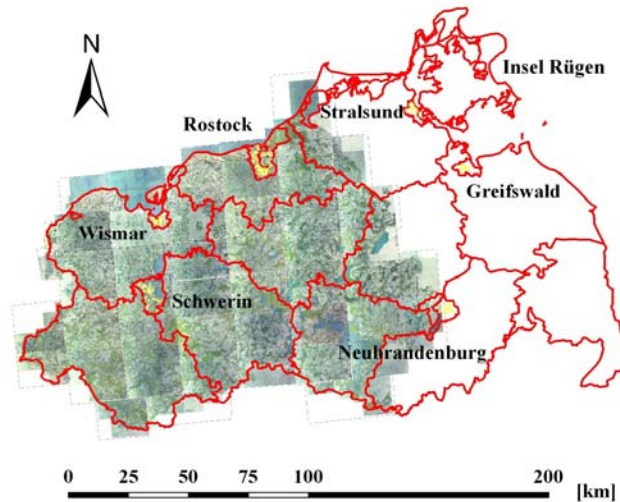

Fig. 1: Area coverage of Mecklenburg from 1786 in the today's boundaries of Mecklenburg-Vorpommern.

3   The project VKLandLab

3.1 Technology partners in the project

The research project VKLandLab is processed by several partners in common. On the one hand, the underlying technology is designed and developed from the chair of Geodesy and Geoinformatics (GG). As infrastructure units the University Computing and Media Centre (ITMZ) and the University Library (UB) are participating. ITMZ provides network-based central and distributed information and communication services for university research, teaching and administration. Here, various database applications are operated and maintained, including a central image database and the digital library of the University. This ensures a full provision of online documents such as digital research data and results, literature of the library, and online databases.

At the University Library (UB) the Digital Library is developped as a central, important strategic infrastructure component of the university. The document server RosDok (http://rosdok.uni-rostock.de) as part of the digital library – a joint project and cooperative service of the University Library, the ITMZ and the department for databases and information systems of the university – includes all forms of electronic publications to be researched, presented, and permanently archived. RosDok's available documents are accessible by metadata and are free (open-access) on the Internet. Digitised sets of historical documents are also stored and structured according to the METS format, allowing them to be integrated and visualised in the developed viewer. For the exchange of metadata with OAI search engines, the OAI-PMH interface can be used. A conversion to common metadata formats (eg. Dublin Core, XMetaDiss) can be done. To increase the visibility of the documents they are registered in the catalogue of the library and in the catalogue of the Common Library Network (GBV).

3.2   Research partners in the project

The technological platform is evaluated and used by an interdisciplinary team of students and researchers for their research lines. Different scientific disciplines of the University of Rostock are involved:

Historical sciences interrelate a database for Mecklenburg census of 1819 in the Grand Duchy of Schwerin to Schmettau`s maps and a census of 1867 in the Grand Duchy of Schwerin on the first topographic maps of the Prussian surveying and mapping.

Settlement planners and experts for preservation of monuments dedicate themselves to the investigation of village forms, e.g. parish forms and farmyard types. For the region a canon of typical, representative and satisfactory phenomena (local forms and their stages of development) should be derived and prepared for a systematic and appropriate generalization.

Landscape ecologists, dealing with the analysis of areal distribution, severity and location of the Woodland and marshland in Mecklenburg over time, try to edit and create a basis for large-scale analysis of the structure (biodiversity) and function (humus storage) of forests and moor.

Landscape planners study the implication of the historical-genetic cultural landscape development in the tools of today's spatial planning and management of historic landscape features. The dynamics of land changes is an important basis for defining sustainable models and general principles for spatial planning and regional policy.

Hydrologists generate hydrometeorological and hydrological relevant basic parameters for further analysis in the cultural landscape, such as for grass reference evapotranspiration, the climatic water balance, the expansion of drainage systems and water development. This will create the basis for the coupling with model-applications (eg. water and nitrogen balance models).

Geodesists and geomorphologists investigate the kettle holes, hollow forms (Sölle), caused by melting out of an enclosed sediment block and distributed especially in the younger Pleistocene areas. In Mecklenburg-Pomerania about 90,000 hollow forms occur, nevertheless their form of origin and development is under discussion.

The spatial-temporal analysis of the development of habitat fragments, the analysis of the spatial distribution pattern of these kettle holes in their historical development, the floristic inventory of selected hollow forms particularly is of interest to *biologists*. The comparison

with existing historical data and the analysis of the relationship between landscape dynamics (eg reduction in the number of kettle holes) and floristic composition of plant communities in kettle holes may allow to derive long-term preservation strategies of species-rich communities in kettle holes.

4   Concept and implementation

4.1   Components of the platform

Following the basic principles of e-science the technical objectives of the project are to create a central portal application, that support researchers in their collaborative work with essential tools and resources for dealing with spatial data. A central component in addition to components of communication and workflow management is a spatial data infrastructure (SDI), which includes a basic collection of technologies, policies and comprehensive agreements in order to make spatial data consistently available and accessible (BILL, 2010). The Open Geospatial Portal Reference Architecture defines a SDI as a central access point to geographic information resources. One of the intended project objectives is to provide the opportunity to investigate, view, generate and administer content and spatial information for different user groups at one (virtually) central location. The OGC reference architecture is thus a good basis to formulate technical demands on the development and coordination of the portal application. The components of the total information system (see Figure 2) can be divided into the following categories:

Portal services provide a central entrance point and access to all relevant functions and tools of the portal application. In addition to the aggregation and abstraction of all available resources, they also allow access to management and administration of the portal itself. To implement this functionality, combined with the design of fixed and variable content of the web site of the project, a free Content Management Framework (TYPO3) is used. In addition to predesigned layouts in the corporate design of the University of Rostock, the flexible PHP framework supports the embedding of dynamic visualization and processing components of the portal application.

Data services and view services allow the provision of spatial data for processing by the users and their visual map-based treatment as a foundation for a detailed assessment of the content. Therefor the open source WebGIS framework kvwmap is used (BILL, R., KORDUAN, P., RAHN, S., 2008). kvwmap is built on top of the UMN MapServer development for collecting, processing, analyzing and presenting geospatial information. The user interface of a Web-based client offers similar functionality as desktop GIS for viewing and processing of spatial objects and specialized describing data.

Catalogue services permit the discovery of spatial data based on searchable parameters for the data theme, origin, and appearance. The search in a central meta information directory put users in the position to identify and allocate necessary data and make them accessible independent on type and location of their storage. For this purpose the free web-based application catalogue GeoNetwork Open Source is used. Portal users can query metadata to existing research records and create own metadata for new records. Metadata records can be presented in various standardized forms. For geospatial information this means the use of ISO 19115/19139 (with any possible INSPIRE compliance).
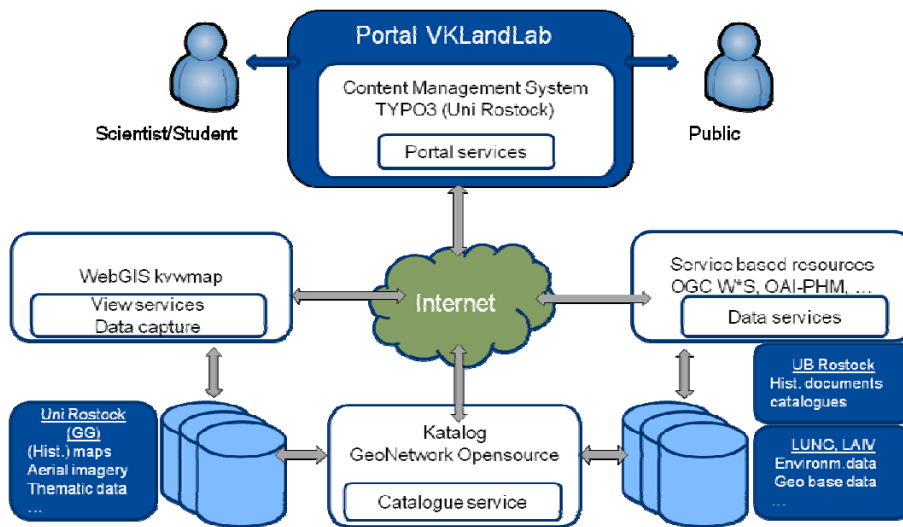
Fig. 2:   Portal components with related services and data sources (following the OGC Geospatial Portal Reference Architecture).

Furthermore, in the database of the catalogue references are kept to historically-documents from the holdings of the University Library. This is achieved through a continuous alignement between GeoNetwork and the catalogue of the library system through the OAI-PHM protocol.

All the above mentioned components are available as standalone applications, but they can also be integrated strongly intertwined with each other because of their consistent and standardized approach to service-based OGC / WWW interfaces. Thus, a higher-level abstraction is achievable for user applications. The modularity of the individual application also enables future flexibility and scalability of the entire portal for sharing and modification of individual components.

At present, another component of the category data services, but here treated separately as a special feature of the historic nature of the portal application listed, is in the design and development phase. This is a *historical place names directory*. Local references do exist in metadata records of many cultural and historical projects or reference to catalogues of libraries. Nevertheless their existing query mechanisms for place names, both geographically and chronologically, are less suitable for visualization and automated analysis. Within the project a Web-based local name service (a *gazetteer service*) is implemented in compliance with relevant interface standards (Web Feature Service). This service should provide a high resolution search in time and space in Mecklenburg for local historical terms and synonyms over the last 250 years. Ambiguities are resolved here in as much detail as possible and links to current/recent official administrative units are produced. The underlying data set is combined from a series of freely available contemporary (such as genealogienetz.de), administrative (State Office of Internal Administration (LAIV) MV, Federal Agency for Cartography and Geodesy (BKG)) as well as historical name inventories (Wossidlo Archive, Historical Census composed 1819/1867). Due to the resulting spatial referencing it is possible to link records to spatial

research services giving users expanded opportunities for access. Furthermore, the automated integration into higher level data infrastructures of the geoinformation and library community is possible.

In addition, ICT-related resources for project coordination, internal communication and workflow management, such as Microsoft Sharepoint and mailing lists are available.

4.2 Data sets and data modeling

The InternetGIS kvwmap retrieves data, both from a local PostGIS spatial database system as well as from external data services (according to the OGC-based standards such as Web Feature and Web Map Service (WFS / WMS)). At this time data offered include more than 30 layers (Fig. 3) of basic data sets as well as special thematic data, historical maps, and 12 environmental thematic layers embedded via WMS / WFS of the State Office for the Environment, Nature Conservation and Geology (LUNG) and LAIV Mecklenburg-Vorpommern. Further resources are various historical data sources, such as Digital Atlas of the Historic Mecklenburg on land use and settlement pattern in the 18th Century and census data for the Census in Mecklenburg-Schwerin in 1819 and 1867 (based on original cards) in the treatment.
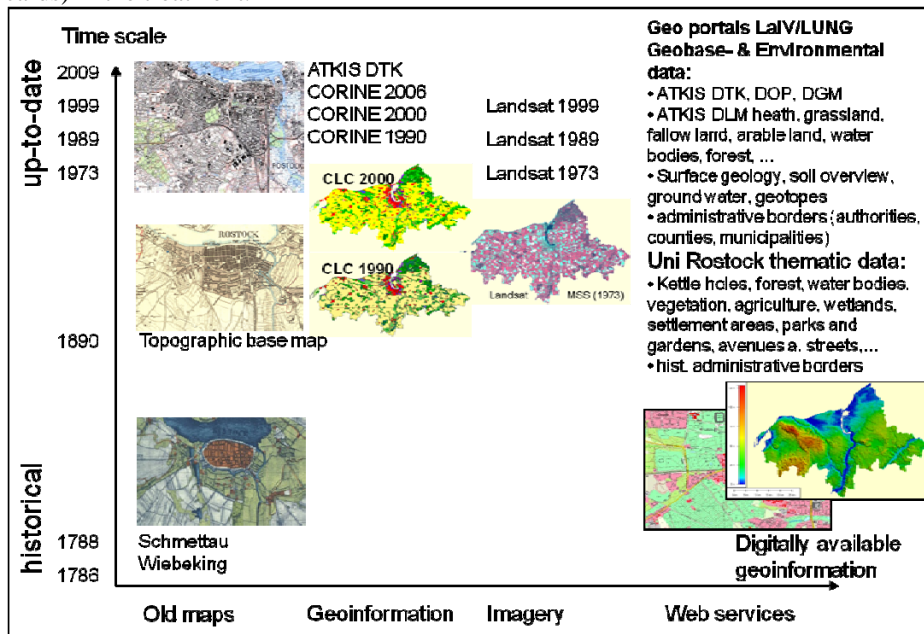

Fig. 3: Used base maps and data sources.

The individual layers of the subject-specific research topics are based on 13 technical data models (see Figure 4 on the example Forest areas), which include for example attribute values on time section of the captured cards to the scientific information. To date, in research and student projects over 32000 categories of spatial objects are digitized.
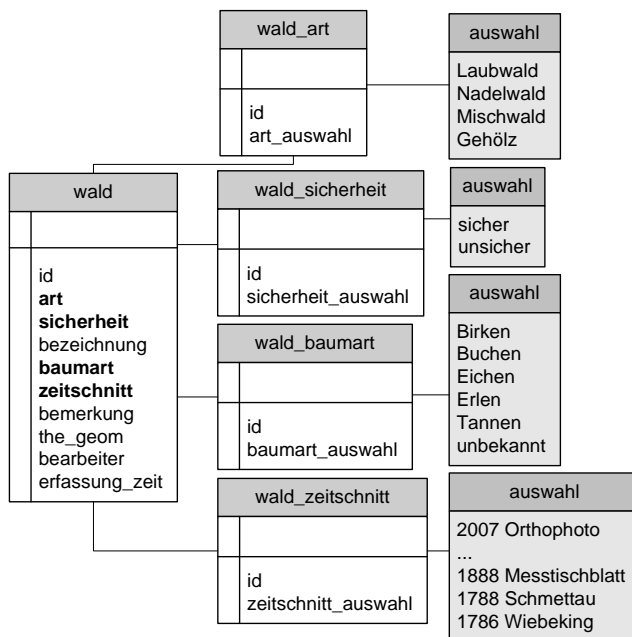
Fig. 4: Data modeling for theme Forest areas.

5   Students case studies

The virtual research platform was used in master student teaching and student training activities in this winter term in the module "Geoinformatics" in the specialisation "Integrated local planning" (Figure 5 and 6). Each student had to digitize a tile size of 10*10 kilometers in Mecklenburg. Different objects, such as the settlement area, the wetlands, vegetation and agricultural use for the 3 time slices were captured within the virtual research laboratory and the InternetGIS kvwmap. Following this, a summary evaluation was done for each object class, and the results are displayed by using visualizations in form of maps and diagrams. Therefore the students used ArcGIS and Excel, in most cases by terminal server at their student apartment.

In addition each student had to solve an individual research question given by the above mentioned research disciplines. For instance students dealing with kettle holes had to investigate the place of the kettle hole in relation to the digital terrain model (DTM). Attributes such as slope and aspect had to be generated from DTM and appended to the attribute table for the kettle holes. Thus the student could analyse whether the kettle hole lies in the slope or in the plane, in the sink or on a summit.

Other students used different landscape metrics measures (such as nearest neigbor, shape index, proximity index) to derive information on the functioning and the interaction of the individual digitized objects.

Beside a lot of problems caused by the parallelism of developing the platform while students digitized and different versions of ArcGIS in the computer laboratory and via terminal server the students evaluated the use of the Internet platform in general as positive.
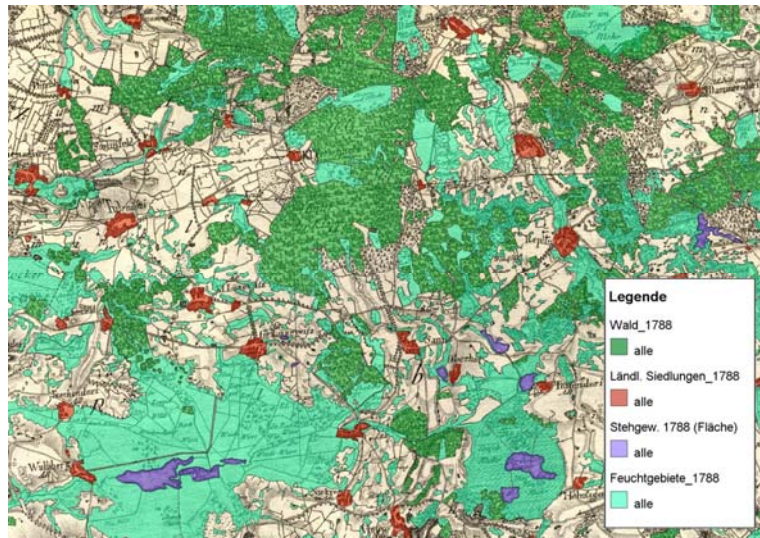

Fig. 5: Captured forests, settlement and water areas within the time slice 1788.

Fig. 6: Captured features within the feature class „Kettle holes".

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