LUCAS VISUAL BROWSER: A TOOL FOR LAND COVER VISUAL ANALYTICS

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ABSTRACT

In this paper we present the LUCAS Visual Browser system, a tool for land cover visual analytics. The system implements different web technologies in a multilayer server-client architecture in order to allow the user to visually analyse land cover heterogeneous information. The information manage is composed of EO multispectral and SAR products along with the multitemporal in situ LUCAS surveys. The fusion of these data provides a very useful information during the EO scene interpretation process. Furthermore, the system offers interactive tools for the detection of optimal datasets for EO multitemporal image change detection, providing at the same time ground truth points for both, human and machine analysis.

***Index Terms*—** Big Data, Data Fusion, GIS, LUCAS, SAR

1. INTRODUCTION

Earth Observation (EO) data is in a constant growing process since the last decades. The already operative missions generate a massive amount of data that already requires of Big Data approaches in order to exploit the information more efficiently. This tendency continues with an increasing number of scheduled heterogeneous EO missions. In this heterogeneous Big Data scenario it is a main challenge of the research community not only to provide better and more efficient algorithms, but also to design and implement tools that allow a greater exploitation of the available information by the experts, integrating and fusing EO and in situ information.

Regarding information fusion and integration, implementations with EO data have been presented for security and hazard decision makers like GEODec [1] or the systems introduced in [2] and [3]. Research projects like EOLib [4] or TELEIOS [5] have introduced the use of EO image metadata and linked data as query parameters in order to improve EO image retrieval results. The data fusion from third party sources has also been used in [6], where along EO image analysis data, an information layer extracted from OpenStreetMaps was used in the learning stage of the retrieval system.

In this paper we present a web based GIS that integrates in situ data measurements from the European LUCAS survey [7], which provides statistics on land cover and land use across the whole of the European Unions territory; with TerraSAR-X EO products, TerraSAR-X offers Synthetic Aperture Radar (SAR) images which are not very easily interpretable visually. Lucas Visual Browser represents a tool that will support the expert users through analytical processes to a better understanding of the EO data.

2. LUCAS VISUAL BROWSER

The architecture of the LUCAS Visual Browser tool as any Web based tool follows the server-client philosophy as shown in Fig. 1. The system is designed to rely all the computational complexity over the server making the client side lightweight and making it possible to operate from any electronic device capable of running a web browser with HTML-5 compatibility.

2.1. Server

The server side is responsible for most of the system functionalities. It provides all the connectivity assets between the system inner modules and the third party components. At the same time it manages the user queries and delivers the data to simultaneous different users. The LUCAS Visual Browser server is composed by three different modules: Ingestion Module, Database Management System and User Oriented Web Functionalities.

2.1.1. Ingestion Module

The Ingestion Module extracts the LUCAS survey metadata and ingest it into the System geographical database. From the European Commission's LUCAS surveys three types of information are obtained: 1) micro data of the land cover, land use and environmental parameters associated to the single surveyed points; 2) in situ photos of each point and landscape photos in the four cardinal directions; and 3) statistical tables with aggregated results by land cover, land use at geographical level. LUCAS 2009 includes 234.561 points visited in situ by 500 field surveyors on 23 countries, defining 77 different land cover classes. Moreover, LUCAS 2012 survey includes 270.389 points visited in situ by 594 field surveyors on 27 countries, defining 83 different land cover classes.

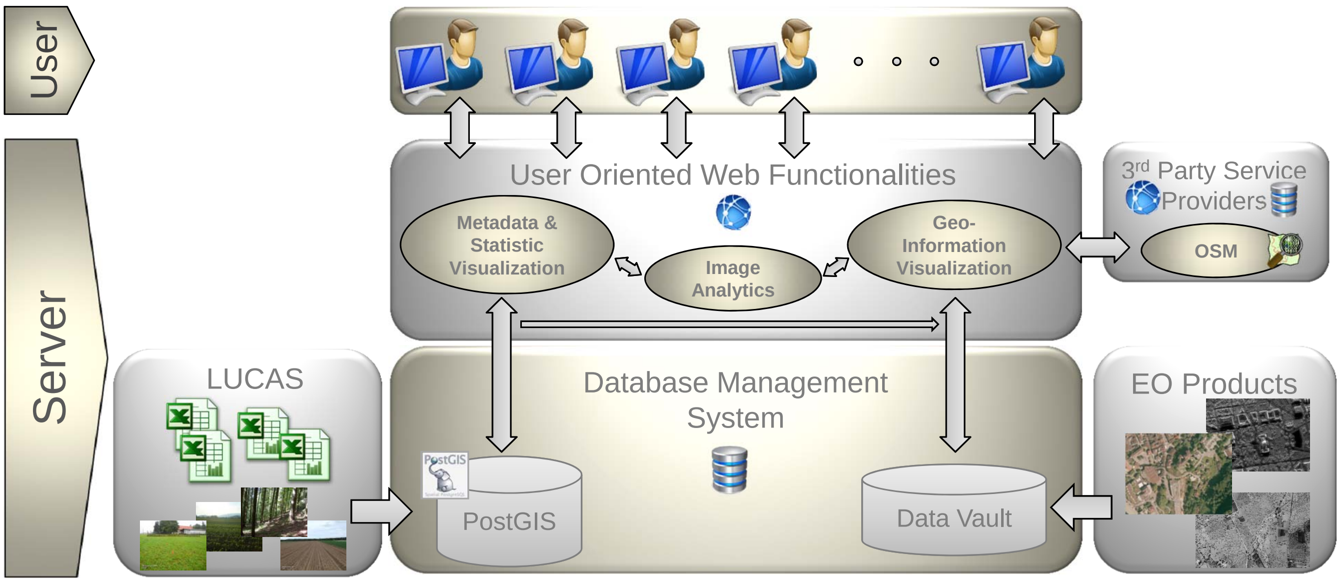


Fig. 1: LUCAS Visual Browser system architecture. The system is designed to rely all the computational complexity over the server making the client side lightweight.

Another functionality of the ingestion module is to produce tiles of the EO products at different zoom levels in order to make more efficient the visualization of those via Tile Map Services (TMS).

2.1.2. *Database Management System*

This module is composed by the main geographical database that uses PostGIS technology and a data repository in a system archive. The PostGIS database schema defines LUCAS survey content of different years with will allow data point comparison in time and geographically. The database also has URLs to each image in the Data Vault linking the survey metadata with the multimedia images showing the cardinal directions and a photo of the point itself. Additionally, the Data Vault also stores the tiles generated from the EO products.

2.1.3. *User Oriented Web Functionalities*

The User Oriented Web Functionalities module processes every user request. It implements the necessary communication protocols to connect with the third party service providers and/or the Database Management System. Geo-Information Visualization process retrieves the required visual and data content for the analytic process and for the user presentation. Metadata and Statistic Visualization process collects the data from the database to generate the required data visualization. The products generated by the previous processes are presented together to the user by the Image Analytic process. This process collects the interaction of the user with the data and sent the required instructions to Geo-Information and statistical visualization processes in case of an update is required.

2.2. Client

As mentioned before, the computational complexity rely over the server making the client lightweight and making it possible to operate from any electronic device capable of running a web browser with HTML-5. Through the user interface, shown in Fig. 2, the user interacts with the system. The user can select specific regions of interest to focus the analysis. Once the region is selected it is possible to: 1) query all the points inside the region, or 2) ask for the points with a specific land cover or even 3) get the survey points with land cover changes among the surveys. The system supports several different WMS layers to switch from OpenStreetMap to the EO SAR layer. Once the region points are retrieved interactive statistical charts with the point information are presented. It is also possible to click over each point and check the specific information of that specific point like location information land cover and in situ images and compare the data of different years.

3. CASE OF STUDY

In this section aiming to show the potential of the system we present a case of study located in the city of Munich, Germany. The system has been ingested with the LUCAS information of Germany, linked with an OpenStreetMap layer; and two EO products of Munich: 1) a multispectral image from WorldView-2 and 2) a SAR image from TerraSAR-X. Both

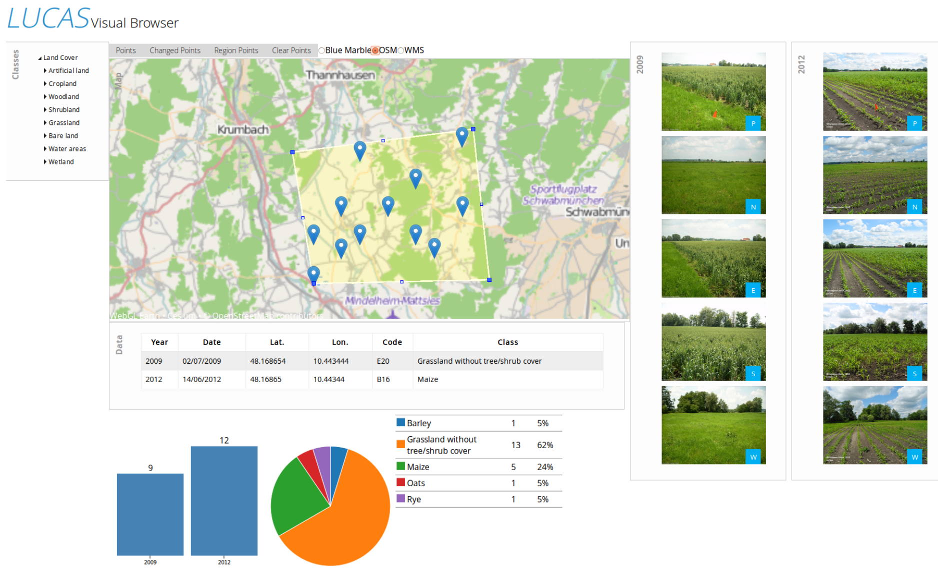


Fig. 2: LUCAS Visual Browser user interface.

EO images have pixel spacing of 1.25 meter, covering an area of 24 km^2. The size of the total scene is 4890x3202 pixels.

Firstly we present an scenario where the availability of heterogeneous data sources from a same location allow a better understanding of the EO scene by expert and non-expert users. The data used on the experiment are shown in Fig. 3. Analysing just the SAR image, Fig. 3a, it is possible for both users to deduce that the main vertical structures of the image correspond to a couple of bridges. Moreover, an expert user most probably would interpret, due the intensity of the surrounding pixels, that the bridges are over several lanes of railways.

For the second step of the experiment, the users have also available a multispectral image, shown in Fig. 2b, for the scene interpretation. In this case the railway assumption would be clear. With the multispectral image the initial assumption about the bridges can be modified. The right structure of the image corresponds clearly to a bridge, but a question rises concerning the element on the left. Due to its width the left structure can not be a bridge where the cars can transit, but it could still be a gangway for pedestrians.

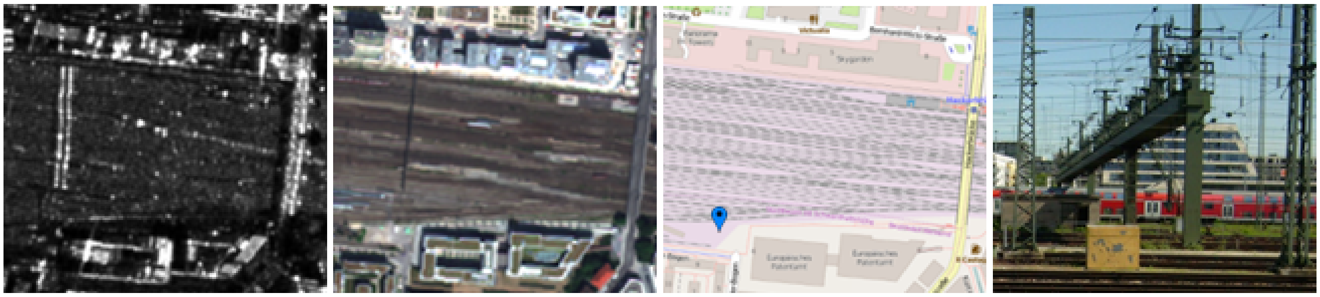
In the next step of this experiment we add one more data source to the scene interpretation process, the map layer with the OpenStreetMap information, Fig. 3c. The map clearly identifies the railways and the big bridge, providing at the same time more detailed information about the surrounding buildings, street names, etc. On the other hand, it does not help with the interpretation of the unidentified structure clearly visible in the SAR image.

The last step uses the last of the available sources that our system integrates, the LUCAS surveys. Going back to Fig. 3c it is visible a blue market pointing out the availability of information from the LUCAS survey. Retrieving this information and adding it to the scene interpretation, the users would know that the survey point is classified as *non built-up area* inside the *artificial land* land cover category. Moreover, analysing one of the available photos, see Fig. 3c, the users can finally get an interpretation of the unidentified structure. The structure correspond to a main overhead line supporting infrastructure for the trains.

Our second scenario intends to show the possibilities of LUCAS Visual Browser as a tool for the selection of optimal datasets and ground truth information for change detection on EO image time series. As mentioned in 2.2, Lucas Visual browser allows to query changes on user defined regions. Table 1 shows some land cover changes around Munich city. Using these query capabilities and the interactive statistical graphic representations it is possible to detect regions with generic land cover changes or even specific changes, e.g., crop changes. Some examples of specific crop changes are crops moving from *barley* to *potato* or from *common wheat* to *rape*. The land cover detectable changes are the combination of the classes registered in LUCAS. After locating a region with the desired change type, or a big change diversity, the user can easily get the region coordinates and acquisition dates. With them the user could contact the data suppliers in order to get the desired EO data and proceed with the change detection analysis using available LUCAS information as ground truth int he validation processes.

4. CONCLUSIONS

We have presented the Lucas Visual Browser web tool. Implementing a server-client architecture, which integrates several web technologies, the system manage the more complex processing tasks on the server offering lightweight clients for



(a) SAR (b) Multispectral (c) Map - OpenStreetMap (d) LUCAS

Fig. 3: Lucas Visual Browser EO scene understanding. From the (a) SAR image an user can recognize two different bridge structures. When adding (b) Multispectral image to the scene interpretation it is clear that the left structure, because of the small width, can be at most a gangway for pedestrians but the resolution of the image does not allow a correct identification. Adding the (c) Map layer the user realises that the structure is not appearing what practically discard the gangway. Including the in situ information from (d) LUCAS surveys the user can finally recognise the unidentified structure as a main overhead line supporting infrastructure for the trains.

2009		2012	
Class	Image	Class	Image
Barley		Potato	
Common Wheat		Rape	

Table 1: LUCAS survey data examples obtained after querying for specific changes outside Munich city.

different devices types. The presented case of study shows the system capabilities managing heterogeneous EO and in situ data sources. In the first proposed scenario the system has proved its utility helping to get a better understanding of EO scenes for expert and non-expert users. We also defined an scenario where the system, based on LUCAS survey data, can be used as a tool for the selection of optimal datasets and ground truth information for change detection on EO image time series. As future work we plan to implement different data mining learning tools based on LUCAS and EO imagery fusion.

5. ACKNOWLEDGMENT

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