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Assessment of “mobile mapping system”: A GIS-based support methodology

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Abstract
In this article, the authors examine the current status of different elements that integrate the landscape of the municipality of Olias del Rey in Toledo (Spain). A methodology for the study of rural roads, activity farming and local hunting management. We used Geographic Information Technologies (GIT) in order to optimize spatial information including the design of a Geographic Information System (GIS). In the acquisition of field data we have used vehicle "mobile mapping" instrumentation equipped with GNSS, LiDAR, digital cameras and odometer. The main objective is the integration of geoinformation and geovisualization of the information to provide a fundamental tool for rural planning and management.

1. Introduction

Over the last decade there have been numerous investigations to identify landscape values using GIS methods. The rapid suburban enclaves rural planning has led in recent years to a profound change in the perception of the landscape next. Along these lines assessment studies of regional landscape have been carried out (Brown, 2012; Mallinis, 2011; Tavares, 2012).

There are numerous definitions of GIS. A widely accepted definition is that given by Burrough and McDonnell (1998), which defines a GIS as a powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data from the real world for a particular set of purposes.

Technologies used for geolocation and geovisualization in urban landscape, have been used in rural areas. Three-dimensional survey (3D) was carried out from the rural road and surrounding areas (+ / - 30 m). The study includes an analysis of the evolution of land use mapping and farming activity. Finally, we have geolocated place and barracks reserves. Our aim is to approach the problems in these rural areas, caused by the lack of correlated, sorted and updated information, both graphic and cartographic, as documented.

The main objective of this study is the creation and design of a GIS accessible to all agents involved in socio-economic activities that take place in the town of Olias del Rey (Toledo), own known for its agricultural component and its relationship with hunting management. This objectives are being achieved through the use of TIG, such as "mobile mapping" GNSS (GPS), LIDAR, aerial photography, digital cameras and digital mapping.

1.1 Area of study

Olias del Rey is one of the 205 municipalities in the province of Toledo (Spain) (Fig. 1). Its location between Madrid and Toledo has been decisive in the evolution of the landscape elements. Located on maps nº 629 (Toledo) and nº 604 (Cabañas de la Sagra) from National Topographic Map (MTN) (1:50000).

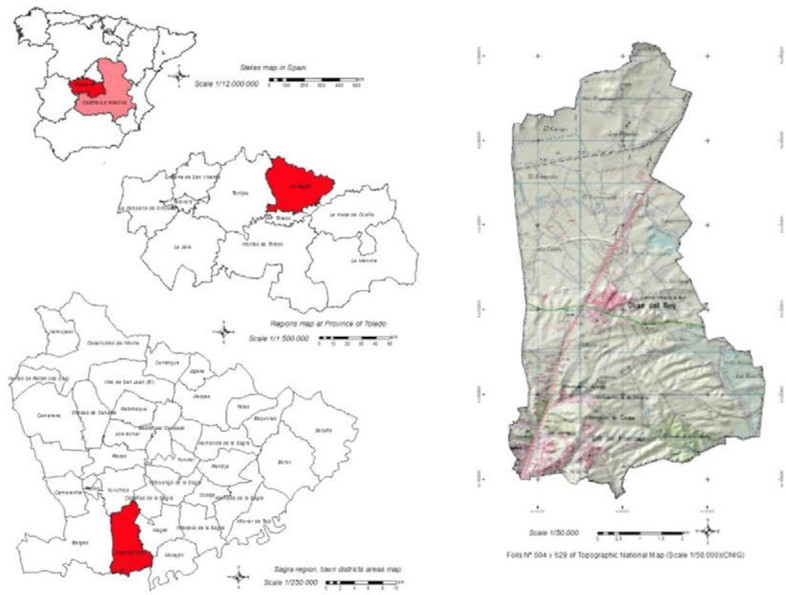

Figure 1. Location maps at different scales of Olias del Rey

The surface studied was 4032.15 ha. as per cadastral data. It has two urban areas, the oldest town is in the center of the municipality (Fig. 2). Another south consists of industries and neighborhoods built since the 80's, known officially by the City Council as "South Zone Olias del Rey". The observation of this territory shows a strong anthropization, whose main landscape resource is the geomorphology, formed by flat terrain, with slight ripples around 600 meters mid-altitude, such as the Guadarrama river valley. The landscape of the municipality can be divided into four units, corresponding to herbaceous and woody crops, the olive tree, the Mediterranean scrub present in the south of the municipality, and the coniferous forest.

2. Methods

In recent years the use of digital mapping as a resource for territorial planning and management (Aguilar, 2007) entails having updated the geographical databases and other digital applications to ensure a rapid and effective response (Mallinis, 2011).

There have been previous studies on the use of digital mapping, as a support tool in decision making in the area of rural planning (Brown, 2012; Arciniegas, 2012), groundwater (Lee, 2012). The study was conducted in two phases. The initial phase was carried out using GIS techniques and field work. Secondly, we used the "mobile mapping" methodology, to perform a three-dimensional survey of the rural road.

A research work has been done to collect all cartographic information of the municipality: since the Catastro de Ensenada (1752), the cadastral map of 1908, the American flight 1958 to existing digital mapping in the Instituto Geográfico Nacional. The study and analysis of the historical evolution of the landscape is essential in rural planning (Skalos, 2010). Land reforms are reflected in the agricultural landscape (Skaloš, 2012). Upgrade of cartographic information has been done using data supplied by fieldwork. Field data refer to the study of rural roads, crop map upgrading and the location of the points of interest in the hunting reserve.

We have used existing maps for the geolocation updated through GNSS techniques. Corrections have been checked and included in the GIS. A three-dimensional survey has been done with second generation "mobile mapping" technology. Graphical analysis of the survey has been done. The procedure for data collection and GIS update is reflected on the diagrams in Fig 2:

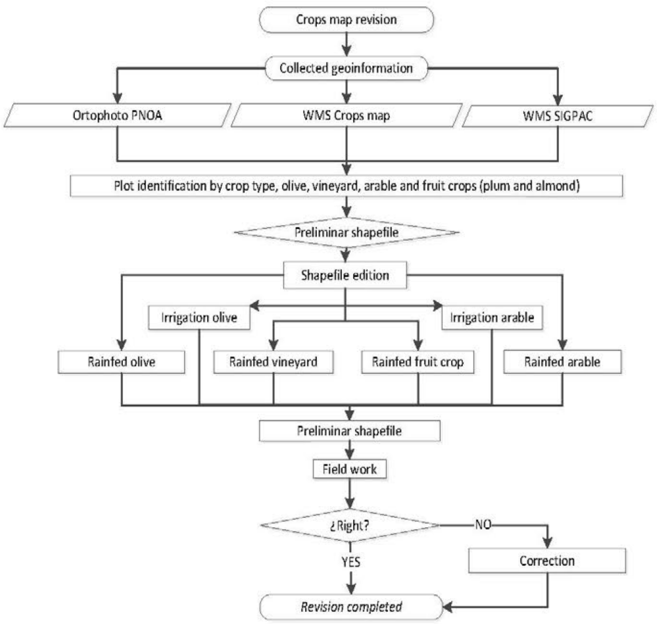

Figure 2. Procedure for field data collection and update of the information system

Over the last two or three years, some very big companies such as Google, Tele Atlas and NAVTEQ have adopted the technology on a large scale, introducing substantial fleets of mobile mapping vehicles for their imaging and mapping operations. Topcon´s IP-S2 Mobile Mapping System is a technology that is being used in studies of information systems because of its speed and accuracy in acquiring massive data (Li, 2011).

There are different integrated systems (GNSS, IMU, video camera) that allow accurate and quick mapping (Kukko, 2012; Madeira, 2012). Topcon´s IP-S2 has three high-resolution LÍDAR scanners, performing a scan of 100000 dots/s, located one on each side of the vehicle and one at the rear (Fig. 3). The unobstructed distance for measuring data capture is 30 m. on each side of the vehicle axle. The system is also equipped with a GPS receiver which allows the vehicle to accurately geo-locate through postprocessing differential correction, ensuring precision between 1 and 3 cm point. Image has been used in other studies as fundamental datum for GIS (Mills, 2010). The equipment includes a 360 degree spherical camera that captures images during the survey. The imaging was performed every 4 m. This allows to obtain a photogrammetric model of the study area. The geovisualization of rural heritage features and knowledge contribute to the rural landscape evaluation (Perez-Martin, 2011).

The combination of GPS and IMU (Inertial Measurement Unit) sensors allows continued accurate position updates in GPS outage áreas. The odometer in conjunction with the IMU, can help establish position wherever GPS coverage is poor or has been lost in tunnels or within high-rise urban areas. This system must be calibrated by performing eight-shaped displacement before proceeding to data collection.

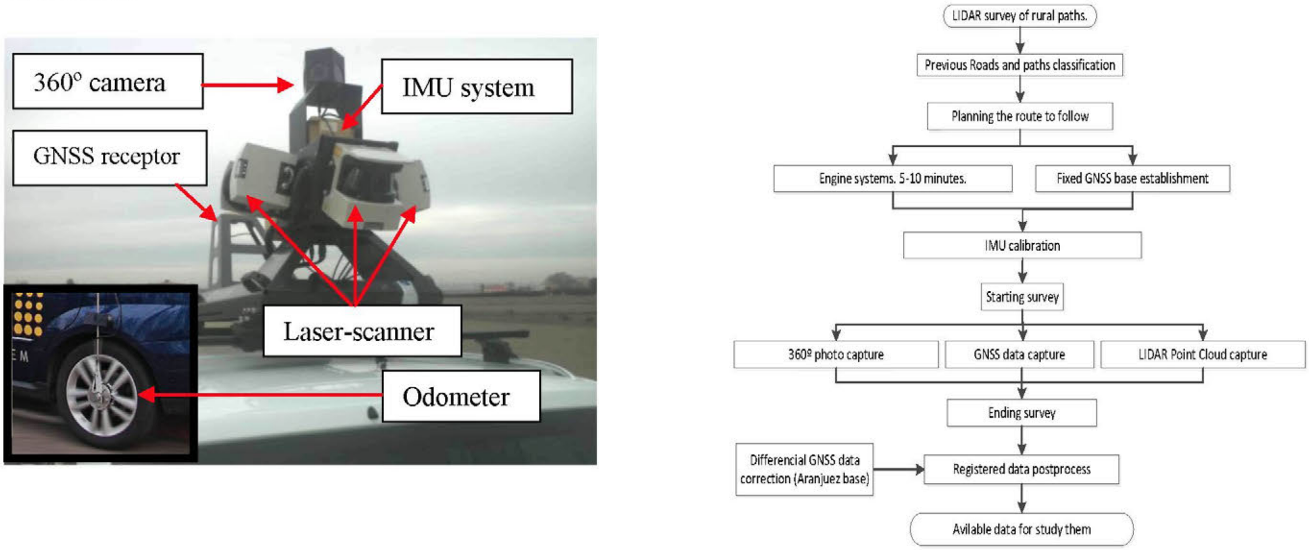

Figure 3. Detail of laser scanner and methodology

3. Results

A complete municipal GIS was performed. Also there was a 3D digital model within centimeters accuracy of some rural roads.The obtained GIS is a very useful tool for the government or a private company. The divulgation of geoinformation was performed using KML/KMZ to allow its use in current mobile devices. The GIS provides the user with complete information about the landscape of Olias del Rey. As seen in Fig. 4, a single click unfolds a dialog box with all the information.

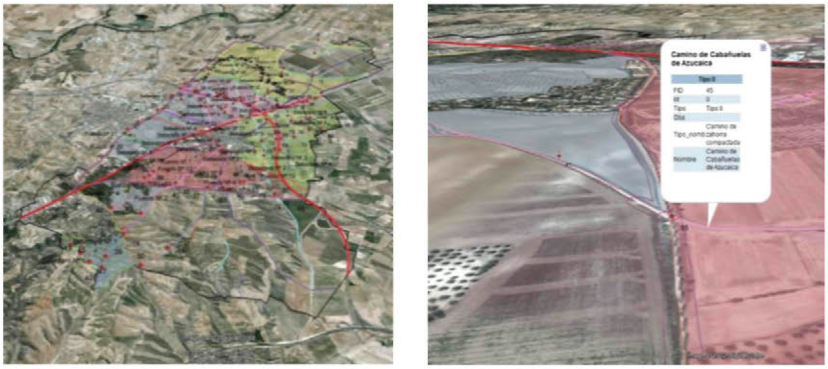

Figure 4. GIS of Olias del Rey

During the fieldwork there were located 57 points of interest of the hunting reserve, twenty one drinking troughs in the hunting reserve and we identified a total of 87 incidents on the rural road network previously unidentified. Concerning the crop map of the municipality, the results show that the official crop map does not correspond to reality.

The point cloud of a part of the rural road was obtained from the 3D survey. It consists of a 3D photogrammetric road model. As shown in Fig. 5, the model allows accurate measurement directly on the point cloud model as well as on the photogrammetric model. Additionally, vectors, points, lines and polygons can be drawn.

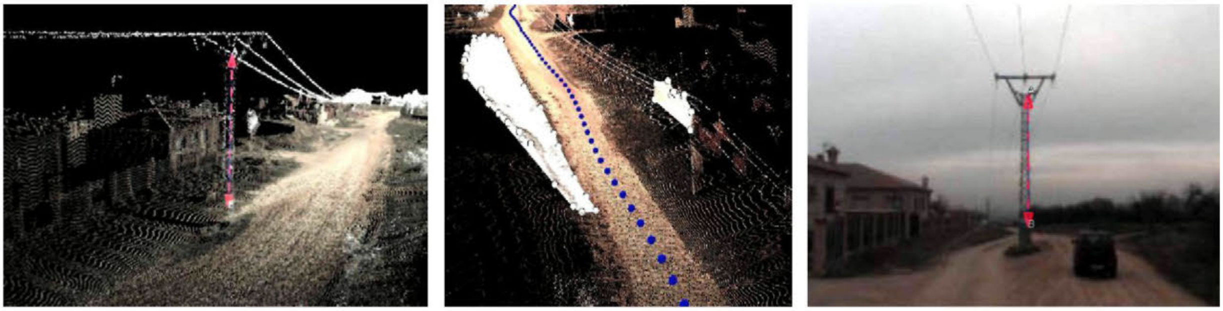

Figure 5. Features of 3D point cloud.

Time consumed was registered in the three-dimensional survey. The total time was 72.26 minutes, considering the time used in displacements, calibration and establishment of a fixed base for post-processing differential correction of GPS observations. The total distance of the survey was 10.7 km.

Data show short time considering the dimensions of the survey, hardly achievable with static methods such as the total station or the 3D scanner (terrestrial LiDAR).

4. Discussion

The proposed methodology has proved to be valid and suitable for extending these studies to areas with similar characteristics. It has obtained a digital map that serves as a basis for implementing an accessible GIS.

This methodology allows modifications to adapt it to areas with specific characteristics such as accessibility, terrain insufficient or not accurate geographic information. The possibility of access to digital map base optimizes planning in rural areas. The option to download files kml/kmz, from the online environment, allows the user to have a GIS of rural area and hunting information sources. The query in the last generation mobile devices enables decision making in real time.

There is a difference between the data of cultivated areas offered by the Censo Agrícola of 2009 (Instituto Nacional de Estadística) and data areas used to grow in the MCA 2002-2010 (Map of Crops and Utilisation). The MCA is outdated, showing areas used for a type of crop that are not in accordance to reality.

The 3D survey of rural roads carried out by Topcon's IP-S2 Mobile Mapping System has allowed to obtain accurate models and get an integrated visualization of reality. Mobile Mapping System technology used successfully in urban environments, offers the possibility of different applications in rural areas, from the integral study of rural road network, re-designation of areas, hunting preservation, public forest, paved surface inspection, photo logs, etc.

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