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Survey, rendering and management of Pisa Municipality roads

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ABSTRACT: The Pisa Municipality is working on the geographic information system of its roads. The A.S.T.R.O. Laboratory of Civil Engineering Department of Pisa University has performed the survey of these roads by mobile mapping system. The aim of this paper is to highlight the differences between the survey of suburban roads and the survey of urban roads. These differences are discussed both during survey step and during elaboration and visualization step. Moreover, this paper briefly describes the update of road graph and the standards for this updating procedure given by "Iter.net" project of Tuscany Region.

1 INTRODUCTION

The Pisa municipality is currently working on the geographic information system of its roads, which it also manages. The survey of the whole road network of the Municipality has been carried out as a collaboration between the ASTRO Laboratory (Seat of Topography and Photogrammetry, Department of Civil Engineering—University of Pisa) and the service in charge on account of the Pisa Municipality.

ASTRO has carried out the survey by means of the GIGIOne Mobile Mapping System (courtesy of the Geonetlab Research Centre—University of Trieste). This vehicle, designed for and operating in surveys for the set up of the road cadastre—following MD 01/06/2001—has also been successfully used for urban area surveys.

MD 01/06/2001, which defines the rules for set up and updating of road cadastre in Italy, does not sort out the different road levels (e.g. National, provincial and municipal roads) according to their geometric and descriptive features. Field surveys, however, clearly highlights the differences between operation in provincial roads external to built-up areas, and operation in local roads winding along built-up contexts. These differences are obvious both in the survey and in the processing and graphical rendering steps. Suburban roads typically feature longer, usually curved arcs and sparser crossings; besides, features as restraint systems, longitudinal traffic signs and clearance are particularly relevant for this kind of roads. On the other hand, in built-up areas roads are repeatedly interrupted by crossings, with much shorter, straight arcs. Besides, there are many one-way and closed end roads. Main features for a survey include side walks and preferential lanes, transverse traffic signs and the presence of drains and drain covers. The creation of the reference road graph is also substantially different. Whereas in extra-urban roads, usually with more regular, obstacle-free tracks, it can be reasonably assumed that the road axis can be detected from the paths in both ways of a surveying vehicle, this is not the case in built-up areas, where the surveying vehicle is forced to continuous deviations from its path and in many cases the same road can't be covered in two ways. Besides, the presence of areas with unstructured traffic makes it difficult to pick a survey path. In such ambit the graph must be therefore derived from existing Technical Cartography or by new aerial images.

2 MOBILE MAPPING SYSTEM GIGI ONE

The survey, as it has been carried out, is based on the precision vehicle positioning and the analysis of the photograms shot along the path and synchronised with position data.

```
<?xml version="1.0" ?>
<misure>
- <misura id="20080114181052_1067_1_101" operatore="g" timestamp="20080114181052">
    <fotogramma id="1" sessione="0_199990_AND" />
    <attributo codice="101" descrizione="Larghezza della carreggiata" />
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  </misura>
```


Figure 1. XML raw data format.

Vehicle positioning is defined with sub-decimetric precision and is covered by a couple of satellite receivers fitted on the vehicle itself and working in phase differential mode.

Therefore, precision vehicle positioning in the global reference system allows for the determination of the position, for the same reference time, of every hardware component of the MMS, among which particular relevance is held by the digital photo cameras fitted on the front end of the vehicle's roof. These are two Basler A101f, each with a 1300 × 1030 pixel CCD sensor, of which one works in full colour and is installed, parallel to the vehicle's axis, on the left-hand side, while the other, fitted on the right-hand side, works in B/W and is oriented 45 degrees towards the right.

While performing the surveys, the cameras shoot one photo every second, which, assuming an average speed of 40 km/h, result in one photogram every little more than ten meters, which enables the operators to extract all the characteristics of the roadway from the set of pictures. Besides, since the time of each shoot is recorded in the global reference system, each photogram is georeferenced.

The software which enables operators to determine all the required image coordinates has been developed by the Geonetlab Research Centre, owner of the surveying vehicle. Its interface is fine-tuned on the specific requirements of the road cadastre, and input/output data comply with the XML standard.

It allows for the observation of objects on the photogram, storage of their coordinates and association of the classification information provided by MD 1/6/2001 (Fig. 1).

Output data are then batch processed to set up the final data base in compliance to the road cadastre standards. These data are stored in a relational data base where one of the most important tables is the one that collect the entire set of roads segmented attributes.

3 ROAD SURVEY IN PISA MUNICIPALITY

The survey of the whole road network of the Municipality of Pisa has been carried out in the ambit of a collaboration between the ASTRO laboratory (Topography and Photogrammetry seat, Department of Civil Engineering—University of Pisa) and the Global Service representatives of Pisa municipality.

The main aim was the creation of a database of the vertical traffic sign system and some geometric and descriptive features of roads, and its rendering on an information system.

3.1 *Vertical sign system survey*

As regards the vertical sign system, there is no high productivity system enabling to survey position and other descriptive information, such as material, installation date and agent and refraction class. In fact, while it is possible to determine the position of any pole and the kind of the signs installed via the pictures taken by an MMS, accessory information present on the back side of the sign or detectable only by direct contact (e.g. material) can not be retrieved via the same method. For these reasons, an 'on-foot' survey campaign has been set up to fill up the database of the vertical sign system. This way, with the 1:2000 Regional Technical Cartography as a basis, operators have been able to mark up the position of the pole (Fig. 2) and collect any information for a full description of the sign, also taking detail pictures of the instalment (Fig. 3).

Figure 2. Poles of the vertical sign system in the information system.

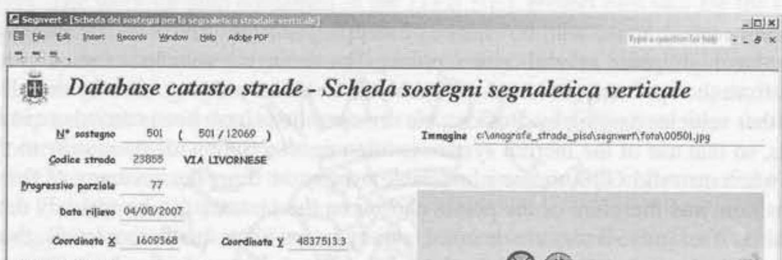

Figure 3. Vertical sign system database application.

3.2 *Road cadastre survey*

The survey of other road features (width, side walks, horizontal traffic signs, preferential lanes etc.) has been carried out at ASTRO by means of the GIGIOne MMS (courtesy of the Geonetlab Research Centre—University of Trieste). This vehicle, designed for and operating in surveys aimed at the set up of the road cadastre—following MD 01/06/2001—has also been successfully used for urban area surveys.

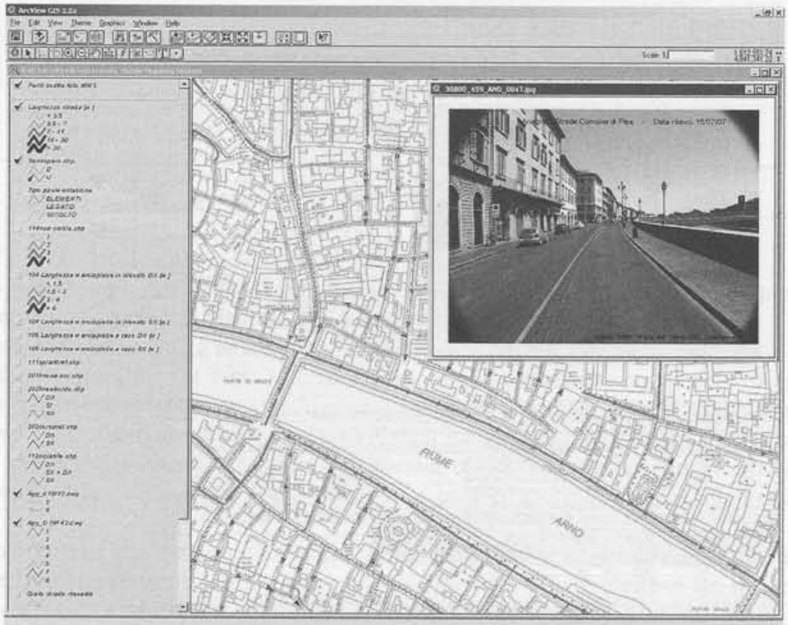

Figure 4. Information system of geometrical and descriptive features of roads.

Operation in urban areas, with no chance of stopping normal vehicle traffic or removing any parked car, has highlighted several critical points. The surveying vehicle is forced to continuous deviations from the optimum path, and road analysis based on pictures taken by the MMS is hindered by other vehicles passing by. Besides, survey operations have been carried out in buildings-lined roads, so that use of the inertial system is often needed to provide continuity to the survey. However, when no valid GPS update is available over some time, the accuracy of the fix of the vehicle position, and therefore of the points chosen on the pictures can be severely deteriorated. In these cases, if no gross errors are detected, survey keeps a fair qualitative levels, thanks to the Applanix system fit on the MMS used for this job, but may not comply, for short stints, to the very restrictive requirements of the law.

It must also be highlighted that the vehicle is subject to the general rules of circulation, which often results in having to cover one road in several stints, also dealing with conflicting one-ways, rather than cover it in a single pass from its start to its end.

Survey fragmentation also poses big issues in the rendering step. In fact, particularly near crossings, some sections can be surveyed more than once, or, on the contrary, can lay in shade zones. Besides, every time the vehicle turns to enter a road, there is a transitory section, in which the vehicle is not parallel to the longitudinal axis of the road: these sections, though very short and covered at very low speed, can cause loss of information for the objects framed in the picture. As regards this last issue, it must be noted that the GIGIOne MMS has been used in standard mode, i.e. with just two front facing cameras. Having more viewpoints, with different orientation could contain this loss of information.

Generally speaking, however, survey with a moving vehicle has always brought problems for a comprehensive and exact description for the crossings areas, which need additional survey methods (airborne laser/photogrammetry, manual surveys, etc) to integrate relevant information.

Besides, urban areas pose the problem of survey of squares and places, particularly so if these are open to traffic but lack structured circulation. The selection of the paths to be followed by any MMS is quite arbitrary, and the rendering of the survey in an information system is not unique.

Pisa Municipality already maintained a graph of its roads, on which every database of the GIS office was linked. This graph, resulting from digitalisation of Technical Cartography and aimed primarily at toponymy and urbanistic purposes, wasn't really fit for automatic rendering of MMS-based surveys (Fig. 4).

An update of the graph, based on the specifications of a project backed by Tuscany Region, has been attempted in order to maintain its acceptability in competent municipal bureaux and, at the same time, to enable its use for the rendering step of the surveyed areas.

4 ITER.NET PROJECT

The need for Tuscany Region to set up a Geographic Information System aimed at the production of standard and traffic-oriented topographic archives to be used with land management purposes, as led to the ITER.NET project (regional law DGR 44/2006). This provides for the establishment and update of regional archives, with consistent topographic content and information format and following well-defined technical specifications, including data coming from toponymy offices of each Municipality.

Starting from the topographic contents of Technical Regional Cartography, Tuscany Region has already created, via automated procedures, a specific archive for road network management made up by different 'datapacks': one 'street map' datapack filled up by thorough consultation of municipal toponymy archives, and one 'graph' datapack including geometrical and geographic information useful for managing the road network, which includes the entities 'road element', 'road junction' and 'road toponym'. Due to its incompleteness, Tuscany Region has asked the Municipalities taking part in the project to finish, adjust and manage this archive as well as to keep it up to date through time, thus providing a distributed support for operations of economic, social and environmental programming. Processing of these archives is consequential to the need for the creation of a collaborative network spread all over the territory, which ensures the consistency required for preserving the quality and the very nature of the whole information present in the archives. The working plan contained in the ITER.NET project provides for the finishing of the topographic database via information drawn from 1:2000 Technical Regional Cartography, and the development and creation of managing and sharing tools for information contained in the relevant layers of the topographic database. Besides, the project aims at the set up and activation of a partnership network among local authorities in charge for the information, for a shared management of information contained in the regional database.

Following the specifications of this project, standard analysis and updating of the road graph used by the Pisa Municipality have been started.

Following is an example of modifications of the graph relevant to Piazza San Sepolcro e Piazza Carlo Maria Clari.

Prior to the modification (Fig. 5 left) this square, lacking structured circulation, is rendered by arcs running along its outline. These arcs, however, do not represent actual traffic flows, and besides there is no 'non-structured circulation square' node as prescribed by the ITER.NET

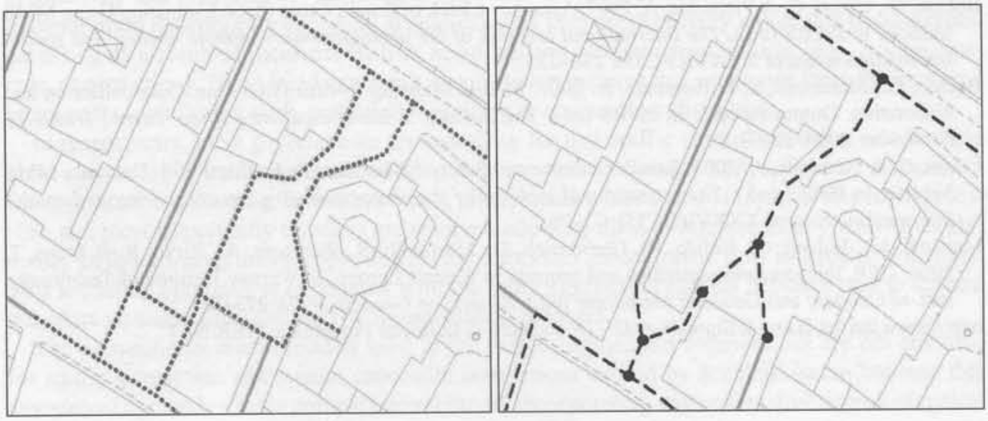

Figure 5. Piazza San Sepolcro and Piazza Carlo Maria Clari prior to and after modifications.

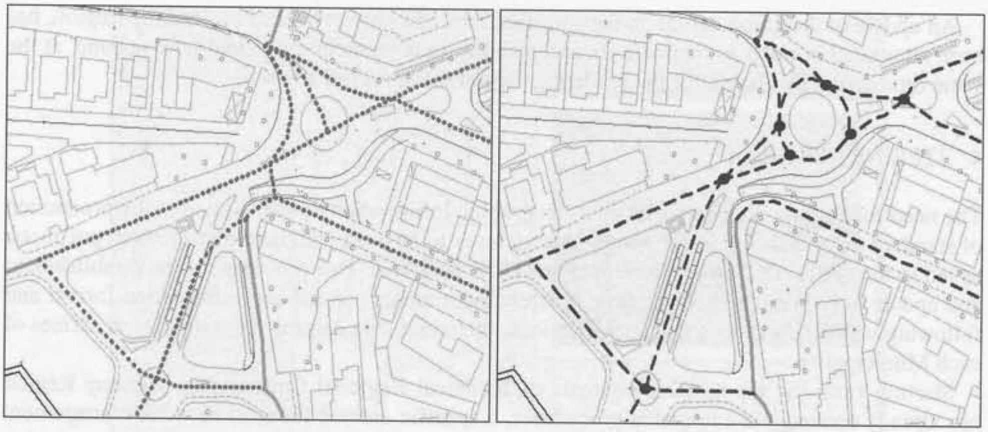

Figure 6. Via del Brennero, Via Lucchese, Largo San Zeno—Graph before and after corrections.

standards. The modified graph (Fig. 5 right) keeps some nodes as possible access points to the square, but also adds a node representing the square and the virtual 'square' nodes, representing accessibility to the square from the joining roads. Such renderings, besides from standards compliance, allow for more rigorous rendering of data surveyed by the MMS, assigning to the node and virtual arcs the features of the square itself (toponym, typology, paving, etc).

Figure 6 shows the corrections of crossings of via del Brennero, via Lucchese and Largo San Zeno. In the old rendering (Fig. 6 left) the graph didn't keep track of actual vehicle flows, particularly for the roundabout, offering just a schematic rendering. Automated rendering of MMS-based surveys, on the other hand, is possible only with actually covered arcs; ITER.NET standards meet these requirements.

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Natural and human activities change the environment, and impact on the quality of life. Analysing these dynamics leads to a better understanding of urban change and facilitates urban development. Research related to the management of urban data has a long tradition. Through the years a variety of challenging research questions has been investigated related to the collection, storage, use and visualisation of data representing the urban phenomena in a computer-based environment.

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