Innovations in the Geospatial Data Technologies

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Key words: geospatial tools; geospatial data collection; geospatial data integration; geospatial data processing

SUMMARY

Rapid technological advances in all areas of modern life such as - aerospace technology, robotics (and robotics in medicine in particular), computer science, Nano-scale electronic engineering, web and wireless technology, laser and the infrared systems - to name a few, mainly since the second half of the 20th century, affect mankind and its life. These major technological developments affect, inter alia, the surveying, mapping and geographic information communities and their implications are extremely significant. During the past 1-2 decades new advanced hardware systems and sophisticated geospatial processing algorithms have been developed, thus affecting dramatically the traditional methods for geospatial data collection and geospatial data processing.

Major technological developments in geospatial data collection (such as the LiDAR technology, the Hyper-spectral imagery, Crowdsourcing technology – to name a few) as well as 2D, 3D and even 4D geospatial data integration and analysis have been introduced - all that - as part of the ICT revolution. These new data acquisition technologies as well as methods, algorithms and software packages, have allowed surveyors, computer experts and the mapping community to provide rapid and frequent updating, integration and analysis of existing geospatial databases, and moreover, deal with data volumes, resolution levels, and accuracies that were unknown until recently.

These new spatial and geospatial tools and techniques enable to integrate the social, economic and environmental factors into the geospatial information – all within shorter timeframes than previously were possible or known. Data collection and maintenance of high resolution airborne and satellite imagery which is now available at an affordable rate, together with LiDAR data, and crowdsourcing geospatial data acquisition, opens up the possibility to efficiently generate topographic, planimetric and thematic mapping at very detailed scales and to better understand changes across our globe. Data integration and access techniques together with interoperable algorithms enable real-time merging of data and services from a variety of sources and leads to an innovative re-use of geospatial information.

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1. INTRODUCTION

Rapid technological advances in all areas of modern life (e.g., aerospace technology, robotics Nano-scale electronic engineering, web and wireless technology, laser and the infrared systems, and may others) mainly since the second half of the 20th century, affect mankind and its life. These major technological developments affect, inter alia, the surveying, mapping and geographic information communities and their implications are extremely significant. During the past 1-2 decades new advanced hardware systems and sophisticated geospatial processing algorithms have been developed, thus affecting dramatically the traditional methods for geospatial data collection and geospatial data processing.

In parallel to this continuous process of technological advances, the human civilization tends more and more to live in an urban environment. At the beginning of the 20^{th} century only 13% of the world's population was urban. During the next years, based on the technological advances (mainly improvements in medicine and science) allowed larger city densities. According to UN reports, the urban population increased from 220 million in 1900 to 732 million in 1950 (29% of the world's population). By 2007 50% of the world population live in the cities; further improvements in technology, medicine and prevention of disease allowed even larger urban densities; according to latest predictions, 4.9 billion people, or 60% of the world's population, are expected to be urban dwellers in 2030

Following these rapid urbanization processes, the need for updated, precise and continuous representation of our natural environment in general and urban areas in particular, is nowadays one of the more urgent and major tasks the surveying and mapping community has to answer and provide adequate solutions. These challenges have led the mapping and the computer science communities to develop new, significant and innovative algorithms, methods and techniques in geospatial data collection, geospatial data integration and geospatial data analysis. These new geospatial data technologies have allowed surveyors, computer experts and the mapping community to provide repeated updating, integration and analysis of existing geospatial databases. Moreover, the ICT revolution in software and in hardware, enable to deal with data volumes, resolution levels, and accuracies that were unknown in the past.

Within these new innovations can be mentioned: Data Collection Technologies (Photogrammetry, Field surveying and Global Positioning Systems, Cartographic digitization and scanning, Radar based systems and IfSAR imaging, LiDAR technology); Data integration (post processing and near real time map conflation and data fusion methods of geospatial and semantic heterogeneous diverse information sources); 2D and 3D DTM/raster data integration of digital terrain models, and rectified and non-rectified aerial and satellite imagery);

Construction of a seamless geospatial database (based on separate adjacent planimetric, topographic and cadastral separate maps); 3D City Modeling (buildings extraction from aerial images as well as from LiDAR data); Change Detection (automatic change detection algorithms for monitoring manmade structures and map updating); Urban Sensing (citizen activated sensors in the urban environment - such as cellular phones and RFID tagged items - enables to collecting and managing a wide range of urban information); and others.

The paper describes the geospatial innovations and their implementations as to efficient handling of urban areas. It is focused on the advantages of these geospatial technological improvements for a professional urban and environmental management by the governmental and municipal administrations as well as for the benefits for urban inhabitants.

2. DATA COLLECTION TECHNOLOGIES

As to data collection, until recently it was basically acquired and measured by one of the following three different techniques (Zhilin et al., 2005):

- Photogrammetry, which utilizes stereo pairs of aerial or space imagery covering approximately the same area;
- Field surveying that utilizes total station and Global Positioning System (GPS) receivers for a direct field measurements;
- Cartographic digitization and scanning, which utilizes raster vectorization techniques to convert existing maps.

Recent technological developments feature two new techniques in addition to the existing ones:

- Radar based systems, utilizing radargrammetry techniques as well as Interferometric Synthetic Aperture Radar (IfSAR) imaging;
- LiDAR (Light Detection and Ranging) that produces 3D point cloud representing the scanned region.

2.1 Photogrammetry

Photogrammetry utilizes a pair of stereo images (covering approximately the same area from two different directions and positions), i.e., stereoscopic model. The geometric properties of objects are determined from the acquired images by a metric measurement of 3D coordinates. Usually, large regions are covered by an aerial strip or a block containing a large number of photographs (and stereoscopic models). As a result, aerial imagery is probably the most common and most effective source to map a region (usually acquiring a digital geospatial dataset or database of the region), as well as to update existing maps (or GI databases).

Similar to aerial imagery, satellite imagery are common today and is being used in photogrammetry, usually only for production of maps at smaller scales. Though satellite imagery resolution is becoming denser, aerial images still present higher resolution - and are relatively more accurate. The horizontal and vertical accuracy is a variable figure that is a function of the sources and photogrammetric equipment utilized to collect the data. It is worth noting that with the development of digital aerial cameras since the 1990s and small digital metric (aerial) cameras in last few years, high quality digital imagery is increasingly available. Additionally, with the progress in high performance computer hardware and software, automation of part of the photogrammetric processes becomes feasible and techniques from image processing and computer vision have successfully been employed (Habib, 2009).

Figure 1: Operational Photogrammetric Systems (Habib, 2009)

2.2 Field Surveying

Traditional field surveying techniques acquire the precise location (position) of certain points on earth, i.e., coordinates, by direct measurement. This can be done by measuring distances and angles while utilizing total-station, or GPS receiver for the task. Though the accuracy of a position acquired here is very high (in respect to other techniques), this type of equipment deliver much fewer data and is usually used to measure and map only small areas (especially when high level of accuracy is required, i.e., in dense urban areas). Field surveying is usually being used to measure ground control points as a basis for the photogrammetric process.

2.3 Cartographic Digitization and Scanning

Digitization and scanning can be performed on maps in order to "transform" existing graphical paper maps to a digital dataset (probably as input to a digital geospatial database). This can be achieved by: i) vector-based line following, and; ii) raster-based scanning.

Though manual digitization is still performed, semi-automated and automated algorithms are becoming more available nowadays, and many off-the-shelf GIS (Geographic Information System) software packages are equipped with tools delivering these tasks. Manual quality assurance was widespread when applying theses tasks, though with new automated developments it is becoming less common - and eventually will disappear soon. Until recently, producing a digital database via these techniques while using medium-scale to small-scale maps was very common. Nowadays, these techniques are being used mainly to "digitize" graphical map of underground infrastructure networks (i.e., water and sewage networks) where direct field surveying might be non-possible or too expensive.

2.4 Radar Based Systems

SAR technology (based on Doppler frequency shifts principle) is utilized mainly to acquire images, and it was proved that these images are very sensitive to terrain variation. Until recently, SAR images were utilized mainly to produce DTMs (describing the terrain) either by radargrammetry algorithms based on parallax measurement (principally similar to traditional photogrammetry only here it utilizes intensity data for measurement), or by inteferometery algorithms by phase shifts extracted from two acquired epochs.

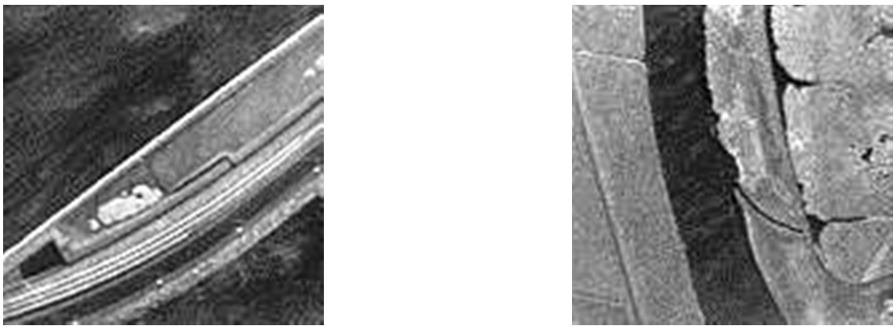

Figure 2: Samples of radar images: dike (left) and agricultural crop map (right). (source: MetaSensing Inc.)

In the last few years, based on the remote-sensing satellite technology, small and compact high-resolution radar systems have been developed, systems that can monitor land and buildings from air as well as from space. These radar systems monitor structures such as dams, harbors, canals and buildings, leading to mapping of urban areas, for planning, cadastral updating, etc. Several flights over the same location enable us to discover changes between pictures, revealing ground movements that could affect structures. This technology can be used for accurate mapping, deformation monitoring (at the range of millimeters), change detection and many more.

2.5 LiDAR

Since the mid-1990s, LiDAR technology has been becoming an applicable and available tool for surveying and processing of geospatial data. This system provides a dense and accurate 3D points cloud of the scanned area. The LiDAR system integrates three sub-systems: laser scanner, Global Positioning System (GPS) and the Inertial Navigation System (INS). The general concept of this system is precise measurement of the time that the pulse generated by the scanner travels to and from an object it hits on the scanned area (i.e., from the launch epoch to the receive epoch). Combined with the GPS and INS sub-systems, accurate calculation of the spatial location of the object becomes feasible.

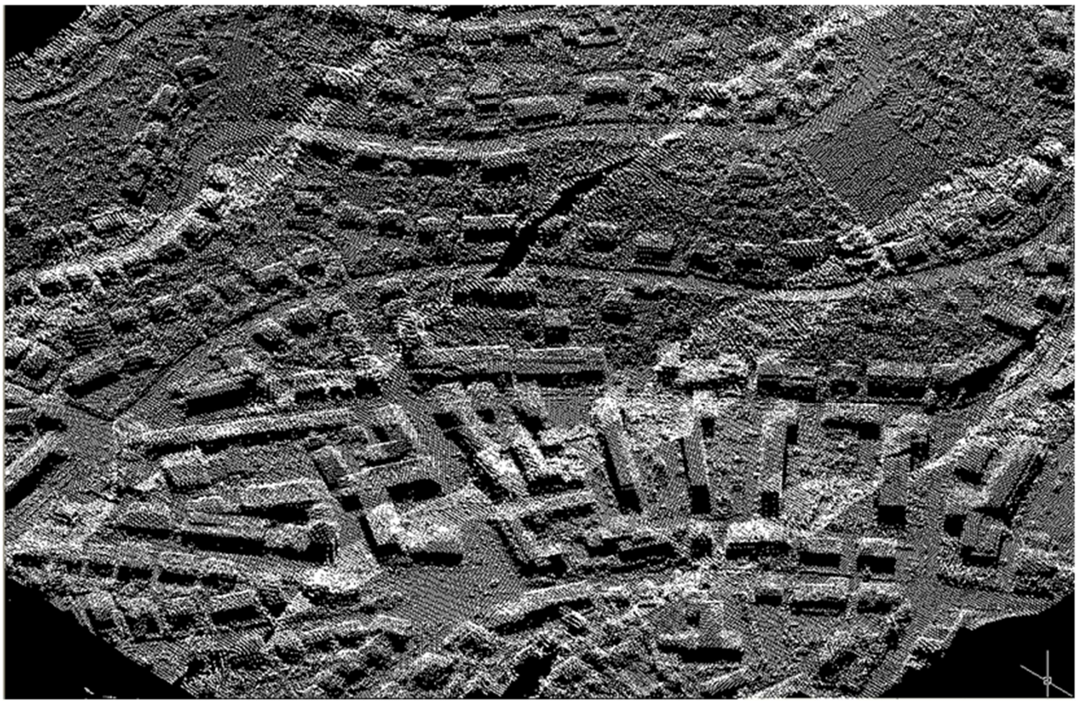

Figure 3: Sample of LiDAR data: A 3D view of urban neighborhood

Although the LiDAR system provides a dense 3D points cloud that describes accurately objects within the scanned area, it is not an explicit representation. This is due to the fact that points can not be classified automatically and semantically as terrain, trees, vegetation, objects (such as buildings), etc. Moreover, the amount of data is relatively large, and in respect to file size can reach up to several gigabytes. Therefore, an automatic or semiautomatic technique is required to analyze the acquired data. Different strategies to differentiate between the ground point and the non-ground points (i.e., buildings) have been developed in the last few years (Vosselman and Dijkaman ,2001; Morgen and Habib, 2002; Filin and Pfeifer, 2006; Abo Akel et al., 2009). These approaches enable to automatically (or semi-automatically) reconstruct the buildings and other natural as well as man-made objects and receives a 3D map of the measured urban area.

3. DATA INTEGRATION, PROCESSING AND ANALYSIS

During the last decades the digital mapping community is facing major and significant developments of algorithms, methods and software packages dealing with data integration, data processing and data analysis. These developments have improved our abilities to handle and process geospatial information. In the following sub-chapters a few of these abilities will be presented.

3.1 Data Integration

3.1.1 Vector Data

Digital vector maps are collected by various institutions and different means, representing different disciplines, kept in different databases, and maintained separately. Urban areas are in particular covered by diverse geographic information sources. These facts lead to partial different representations of the same world reality. In order for one to efficiently using the information, it should be obtained from the different sources and merged together (by applying an integration process).

Mechanisms for overcoming geospatial and semantic heterogeneity in diverse information sources are critical components of any interoperable system. In the case of diverse geographic information sources, such mechanisms present particular difficulties since the semantic structure of geographic information cannot be considered independently of its spatial structure. The issue of integration is even more complicated due to the fact that the different digital datasets (or databases) can contain data in vector format (a discrete data structure, where entities in the world are represented by objects) as well as raster format (a continues data structure, build of a two dimensional array of pixels, where each pixel represents a characteristic of an equal area rectangular of the world). Moreover, a simple solution of overlaying the different digital datasets (by using the straightforward "cut and paste" algorithm) is not applicable due to different geodetic projections and datum.

Integration of heterogeneous datasets has received a lot of attention in the past 1-2 decades. Diffrent approaches to the issue have been proposed by many reserachers. Wiederhold (1999), Neiling and Lenz (2000) and Boucelma et al. (2002) suggested an architecture of wrappers and mediators for integration systems. According to this approach, wrappers extract data from heterogeneous sources and transform the extracted data to a uniform format. A mediator receives data from the wrappers and integrates it. Integration of geospatial datasets by finding correspondences between schema elements was proposed by Devogele et al. (1998). It was shown that interoperability can be achieved in applications that manage geospatial data. This aspect of integration - how to provide interoperability - was also suggested by Parent and Spaccapietra (2000) and Laurini et al. (2002).

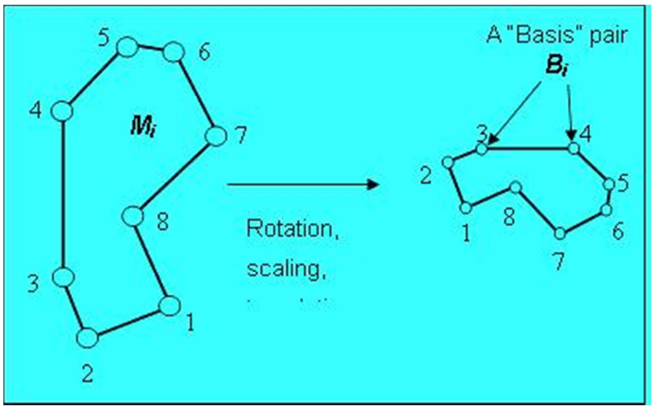

Figure 4: Conflation is depicted by the necessity to use "rotation", "scaling" and "translation" operations on homologous objects

Generally, there are two different types of applications for integration of geo-spatial datasets, namely, map conflation and data fusion. Map Conflation is the process of producing a new map (digital dataset) by integrating two existing digital maps (Saalfeld (1988); Cobb et al. (1998); Doytsher et al. (2001); Samal et al. (2004)). Map conflation of two geospatial datasets starts by choosing some anchors (see Figure 4). The anchors are pairs of points, from the two datasets, that represent the same position in the real-world. A triangular planar subdivision of the datasets with respect to the anchors (for example by using Delaunay triangulation) is performed and a rubber-sheet transformation is applied to each subdivision. In Figure 5 a conflated map based on two different road layers from two sources is depicted.

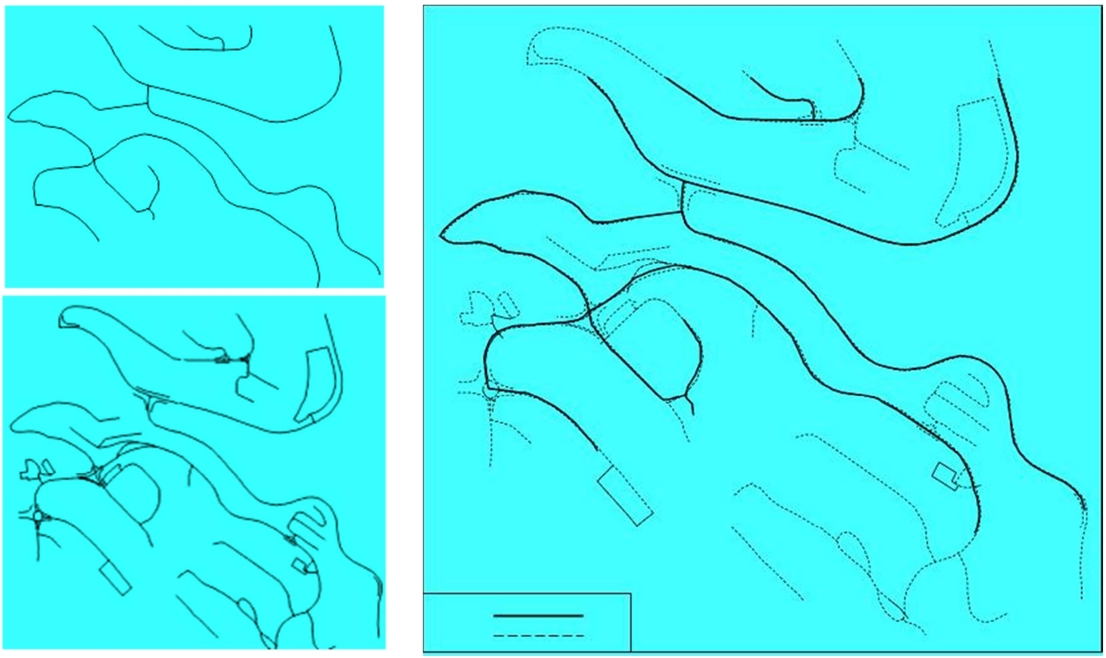

Figure 5: Two digital road maps of hilly urban area on the left (top and bottom) and the conflated (integrated) map on the right

Whilst map conflation deals with integration of vector datasets, data fusion refers more to the process of integrating raster data from multiple sources. In the first step of a fusion, objects or points of interest are extracted from the raster sources using image-processing algorithms (e.g. Mayer (1999), Mena (2003)). In the second step, matching algorithms are applied in order to join the extracted information. The corresponding objects which are discovered in the second step can be used as geo-references for matching and fusing the raster datasets.

3.1.2 3D DTM/Raster Data

Digital terrain models that cover very large regions are usually stored as grid (raster) datasets, in which for each grid-point (cell) a height value is given. The main advantages of this method are data handling simplicity and fast data access (needed for various analyses procedures - mostly real-time ones). Usually, datasets that were sampled with high accuracy (and hence are usually dense) will cover smaller regions than the ones sampled with lower accuracy. Simple overlay integration of these separate datasets - can produce model errors, discontinuity and incompleteness. For applications, such as visibility maps, terrain analysis and others, utilizing models that are incomplete and discontinuous will eventually lead to wrong outcome. Direct comparison of different datasets representing the same area can be utilized for morphologic tasks, such as change detection. By super-imposing the two models the height difference value of the two models will give a qualitative analysis of topographic changes occurred between the two epochs of collecting the data. In the past, common techniques such as "Cut & Paste" and "Height Smoothing" were in use. These techniques are characterized by not preserving the geospatial morphology and topography of the terrain (Laurini, 1998).

In the last few years, in order to avoid these complications when integrating terrain relief models, new approaches and new algorithms were suggested. These algorithms serve as the basis of establishing reliable and qualitative environmental control processes. As opposed to the previous common techniques, which did not or only globally analyzed the corresponding topography of both datasets, in the new algorithms a local thorough investigation of the relative geospatial correlations that exist between the datasets is achieved, and consequently, preventing distortions as well as an ambiguous and ill-defined modeling analysis. These algorithms are aimed at achieving a continuous topological representation and correct structures of the terrain as represented in the merged DTM, while taking into account the differences in both height field and planar location of terrain entities (see Figure 6).

It is worth noting that similar approaches are being implemented when raster datasets (images) are to be merged. A more detailed description regarding raster integration can be found in (Shragai et al., 2005). Figure 7 depicts an integration process of two datasets with different level of detailing into a hybrid unified dataset.

 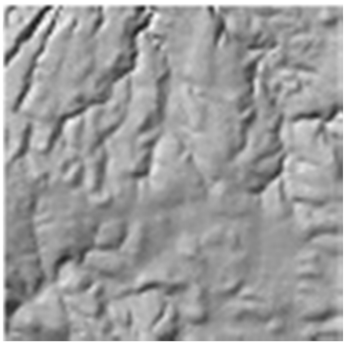

Figure 6: Integrated DTM: a non-continuous dataset based on the common Copy & Paste mechanism (left), and an improved continuous dataset (right) (source: Doytsher et al. 2009)

3.2 Constructing a Seamless Geospatial Database

One of the common procedures in establishing geographic databases is constructing a seamless database based on separate adjacent separate maps. The conversion of paper maps, i.e., cadastral blocks, into digital data (through processes of digitizing or scanning and vectorization) is usually performed separately, map by map, and only at a second stage all the separate maps are combined into one continuous database. Between adjacent digital maps, gaps and overlaps can be found due to various factors. Among those may be included the accuracy of digitizing or scanning processes; inaccuracies inherent in the original drawings; non-homogeneous interpretations by different operators during the input process of boundary lines of adjacent maps, etc.

Edge matching process means the determination of common boundaries of the adjacent maps, thus annulling the gaps and overlaps, and achieving continuity of details passing from one map into another (such as roads, power lines etc.). During this process only points lying on the external boundaries of the maps are corrected, thus obtaining a unique definition of those boundaries. During this process we do not normally correct or change features or points that fall within the map itself, and therefore relative distortions and discrepancies occur between the contents of the map and its boundaries.

It is possible to ignore this phenomenon of relative "disorders" between the boundaries of the maps and their content in cases of low accuracy data and/or maps at a small scale. Nevertheless, when handling geospatial data of urban areas in general and cadastral information in particular, these disorders and distortions cannot and should not be ignored. In these cases, edge matching is insufficient and it is recommended to apply non-linear transformations to solve existing disorders and distortions. Non-linear transformation or rubber-sheeting refers to a process by which a digital map or a layer is "distorted" to allow it to be seamlessly connected to adjacent maps or layers, and/or to be precisely super-imposed to other maps or layers covering the same area.

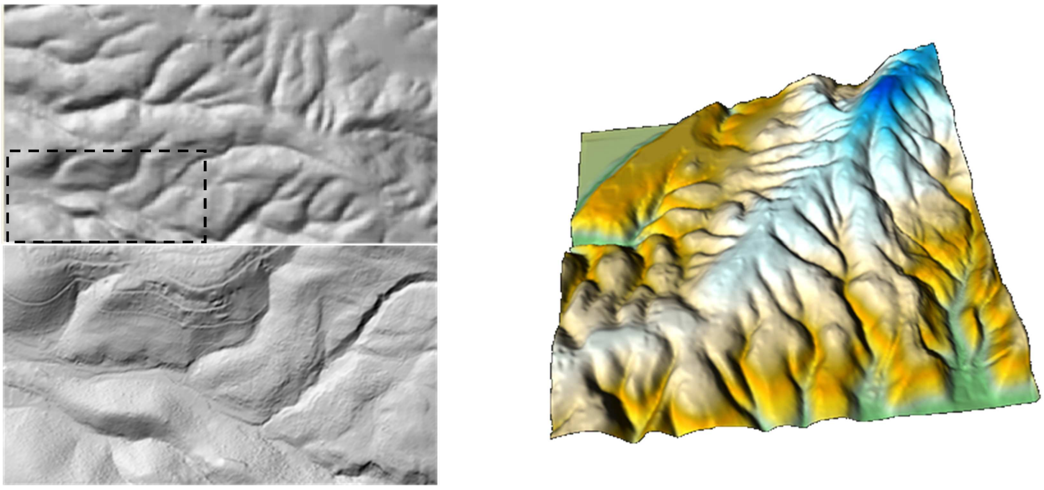

Figure 7: DTM (top-left) and LiDAR (bottom-left) datasets showing distinctive differences in level of detailing and accuracy (mutual coverage area is denoted by a dashed rectangle); hybrid dataset (right, rotated 90^0 counterclockwise) produced by integrating these datasets (mutual coverage region on lower-right area) (source: Doytsher et al., 2009)

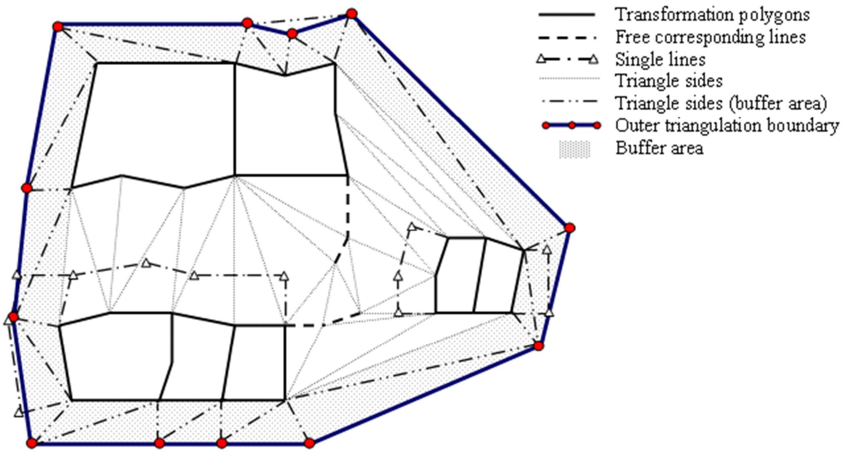

Figure 8: A triangulated rubber-sheeting map sub-division

In the last few years various approaches to rubber sheeting have been developed with various proposed solutions, inter alia, a polygon morphing technique associated with a Delaunay triangulation (Cho et al., 1996), a non-rectangular bilinear interpolation (Doytsher, 2000), a triangulation and rubber-sheet transformation for correcting orthoimagery (Chen et al., 2006), and others. Figure 8 depicts a typical triangulated rubber-sheeting sub-division. In Figure 9 a group of cadastral maps are depicted in their original situation (pre-processing) and in their final seamless cadastral definition (post-processing).

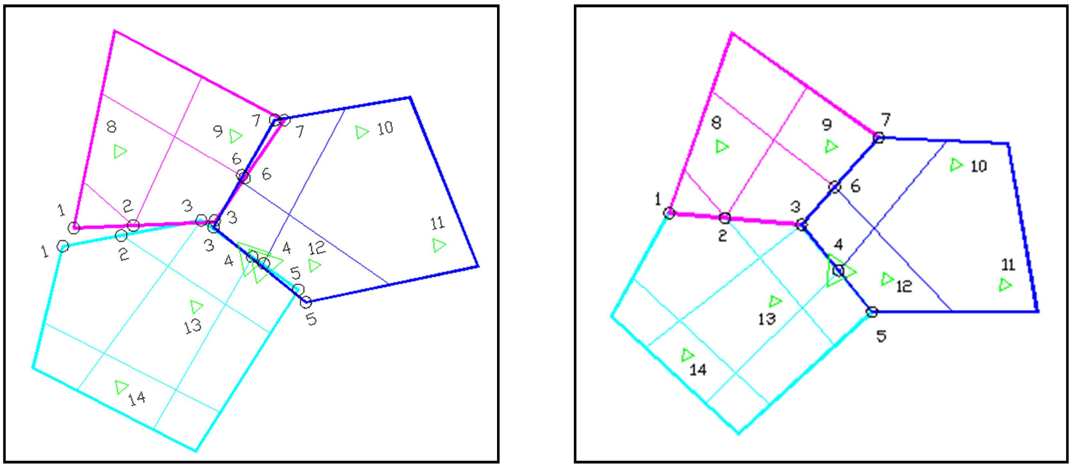

Figure 9: Original separate pre-processing cadastral blocks (left); Post-processing homogeneous seamless cadastral continuity (right)

3.3 3D City Modeling

Generating 3D city models is a relevant and challenging task, both from a practical and a scientific point of view (Gruen and Wang, 1998). This type of data is extremely important in many areas of the urban environment such as municipal management, planning, communications, security and defence, tourism, etc. Most of the input data for these systems was until recently collected manually ("point by point") on Digital Photogrammetric Workstations (DPW) or analytical streoplotters. In the last two decades, extensive research dealing with 3D building extraction from aerial images on the one hand and from LiDAR points cloud on the other hand has been carried out by the photogrammetric and computer vision communities. However, full automation of object space extraction by "autonomous" systems is still far from being implementable.

There is a great variety of algorithms for automation in building extraction both from aerial images as well as from LiDAR data, algorithms depending on the type of building, level of required detail, usage of external and a priori information, and level of automation and operator interference (Gruen, 1997).

As to aerial images, most of the 3-dimensional algorithms are based on processing at least two solved images (a photogrammetric model) and the assumption that roofs are composed of several geospatial polygons, and that they can be obtained by extracting all or even only some of them (when the model is known). The algorithms can be divided into two types: those that extract a contour and height (2½D) of flat roof buildings (e.g.: Gerke et al., 2001; Ruther et al., 2002; Oriot and Michel, 2004) and those that extract the detailed roof (3D) of the buildings (e.g.: Gulch et al., 1999; Gruen and Wang, 2001; Rau and Chen, 2003, Avrahami et al., 2009). In Figure 10 the steps of automatic extracting 3D buildings are depicted.

Since the LiDAR technology provides a dense and accurate 3D points cloud of the scanned area only as an explicit representation of the ground surface (terrain together with all connected man-made objects), algorithms has to be developed in order to extract 3-dimensionally the buildings. The extraction of buildings from LiDAR data is usually divided into two parts where the first involves their detection within the points cloud, and the second the reconstruction of their 3D shape. For their detection, different approaches have been suggested. Within these approaches can be mentioned: edge operators to localize buildings (Wang, 1998); morphological opening filters to identify the non-buildings (Oda et al., 2004); local segmentation to identify detached solid objects (Alharthy and Bethel, 2004); using of external data in the form of ground plans to localize the buildings (Schwalbe, 2004) and many others.

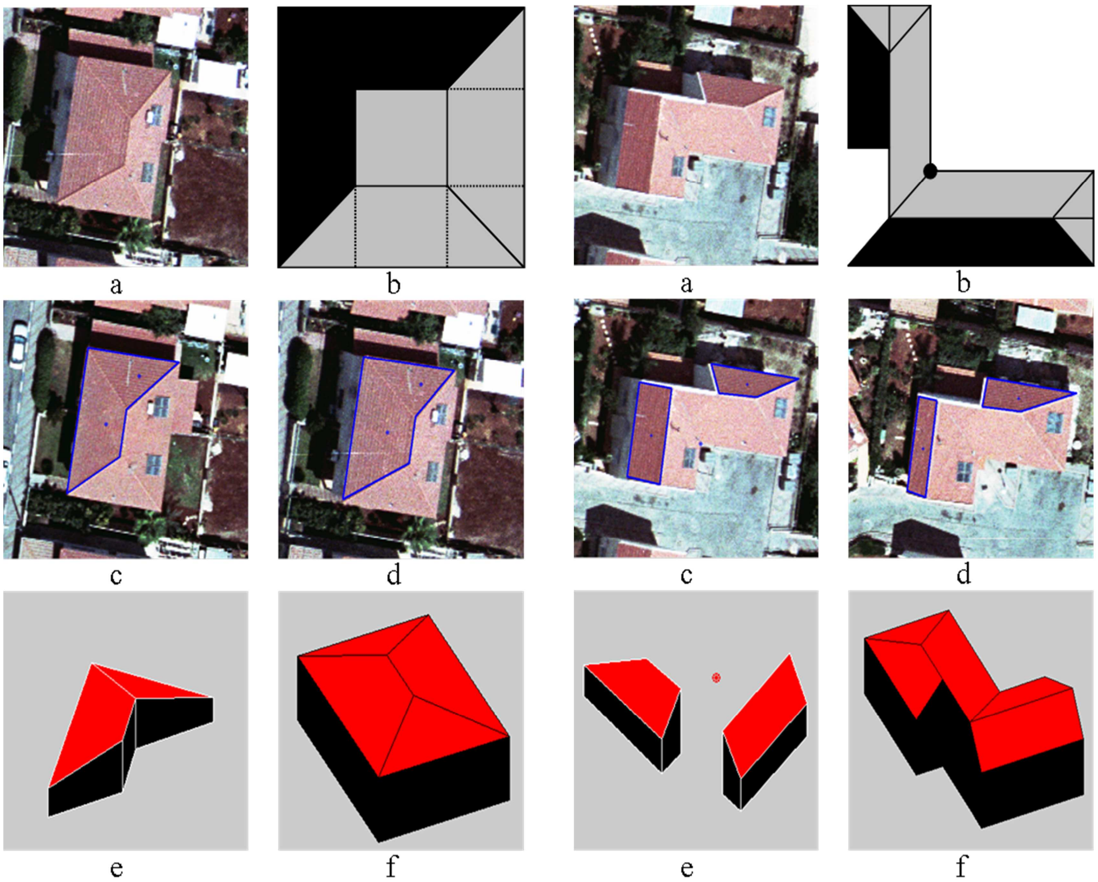

Figure 10: Steps in automatic extraction process of 3D building from aerial photographs (G-Model roof – left; L-Model roof – right)

As for the reconstruction of the 3D shapes of buildings, the extraction of the roof primitives, in almost all cases, is based on segmentation of the points cloud that will seek partition into a set of planar faces (Voegtle et al., 2005; Rottensteiner et al., 2005; Rottensteiner 2006, Abo Akel et al., 2009). While a large body of research has been devoted into building reconstruction, many challenges still remain unanswered. One such challenge concerns the general planar roof-face assumption that is common to almost all reconstruction models. While planar roof-face buildings are still the majority, buildings with general roof shape can be found in almost every scene. In Figures 11 and 12 the reconstruction results of buildings are depicted. In Figure 11 it is a complex building with a free-form roof surface that is constructed, while in Figure 12 three complex buildings with flat faces are constructed.

A sample of extracting the buildings of an urban neighborhood from LiDAR data is depicted in Figure 13. Even though the LiDAR information in this scene is a non-dense points cloud (only 0.6 points per square-meter), the results of extracting the complex buildings, as depicted in the figure, is impressive. It is noteworthy mentioning that new LiDAR systems are capable to measure nowadays up to 18-20 points per square-meter, and the potential for extracting very detailed urban scenes and build accurate and precise 3D city models is very high.

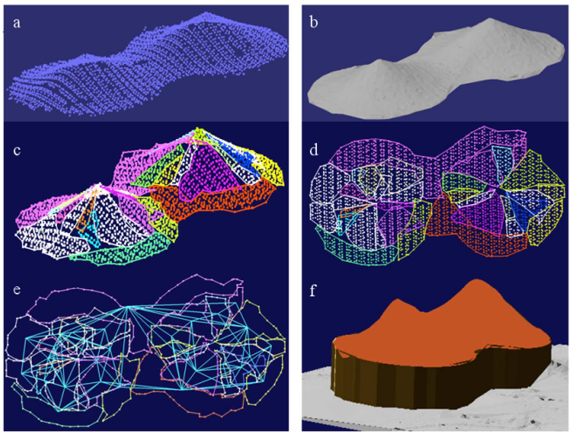

Figure 11: Reconstruction of a building with a free-form roof surface: (a) point cloud; (c) segmented point cloud; (d) segmented point cloud in down-looking view; (e) connectivity graph ; (f) reconstruction results

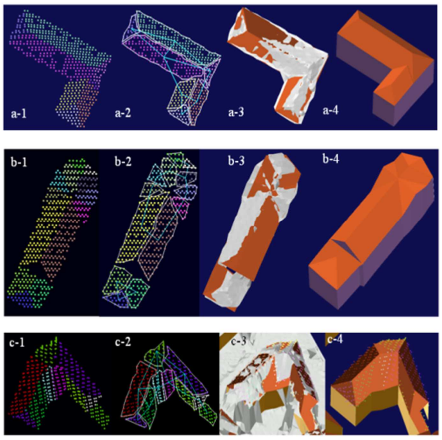

Figure 12: Reconstruction results of three complex buildings. Left to right: segmented point cloud; segments boundaries; roof topology; final reconstruction results

There are two types of laser scanners, namely, airborne and terrestrial. Even though the characteristics of the two types are similar, they are dissimilar in terms of the measuring range; density of the measured points cloud, precision, etc. Using terrestrial laser scanners are being used to construct realistic 3D building facade models of urban scenes. These models are beneficial to various fields such as urban planning, heritage documentation and better decision-making and organization of the urban environment. Laser data and optical data have a complementary nature when extraction of 3-dimensional feature is required. As efficient integration of these two data sources will lead to a more reliable and automated extraction of 3D features. Automatic and semiautomatic building facade reconstruction approaches and algorithms have been developed in last few years, approaches which efficiently combine information from terrestrial laser point clouds and close range images (Sester, 2009; Pu and Vosselman, 2009). The result of a terrestrial laser scanning (a points cloud containing several hundred thousand points) presented in Figure 14 depicts the inherent potential of this technology to construct realistic 3D building facade models of urban scenes.

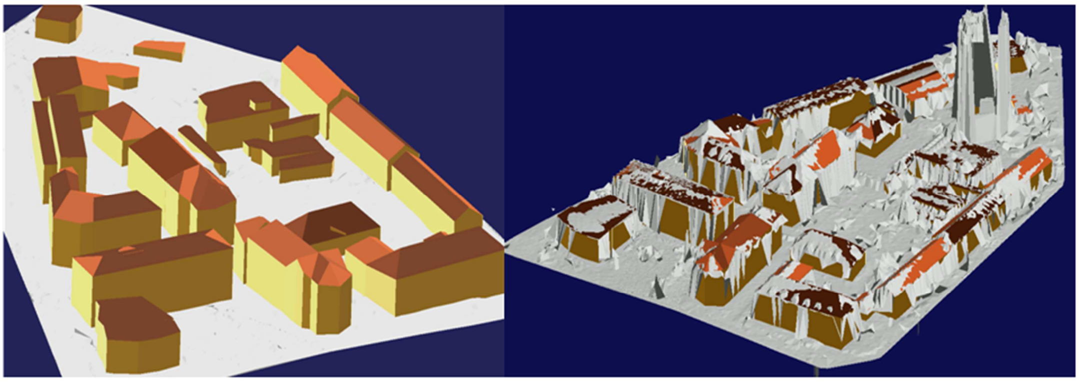

Figure 13. A 3D view of an urban neighborhood showing the original LiDAR data (right) and the complete reconstruction results (left)

3.4 Change Detection

Automatic change detection while using photogrammetric means can be used to monitor manmade objects (structures) like roads and buildings. This process is necessary for map updating, particular in urban areas (and megacities), a process which is an otherwise expensive and time consuming task if done manually. Although in its general form the problem of automatic change detection is complex and difficult to solve, on well-defined applications it is possible to achieve good results (see Figure 15) by imposing certain constraints. The available change detection methods are many and diverse. The following are some of the most distinctive attributes:

- Scale of the changes to be detected and consequently the scale of imagery to be used.
- The type of the basic comparison unit - the geospatial feature.
- The number of steps - one or two - in which the process is completed. The two-step approach is based on the extraction of objects in both time periods and only then the comparison between them to define the changes. A one-step approach on the other hand can be done by layering the two time periods into a single new product of differences and then deciding where the changes are.
- The path to change detection and incorporation of a priori knowledge, namely bottom-up or top-down approaches. In bottom-up methods by dealing initially with raw data, the changes can be defined. The opposite is the top-down approaches where certain models of change are searched and matched to the raw data.
- Deterministic or stochastic approach of the change detection problem, where in a deterministic approach there is a decisive answer as to what the change is, whereas in a stochastic approach there is a measure of how possible the change is.
- Differentiating between autonomous, automatic and semi-automatic methods is based on the level of automation versus level of manual intervention.
- Type of data used that can be divided into two major categories: raster and vector. Raster data means airborne or spaceborne imagery, whereas vector data mainly means digital maps (planimetric, cadastral, etc.).

Figure 14: Results of a terrestrial scanning of a complex facade

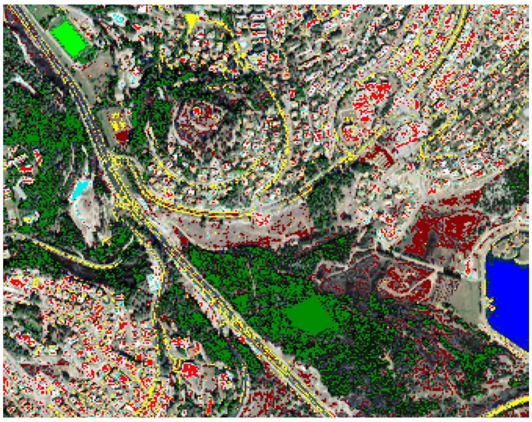

Figure 15: Change detection results – a comparison of satellite imagery and aerial photograph (Beit-Yaakov et al., 2003)

3.5 Urban Sensing

A new generation of citizen-activated sensors in the urban environment is creating opportunities for collecting and managing a wide range of urban information. This is termed 'urban sensing' and uses a wide variety of sources including cellular phones, Radio Frequency Identification (RFID) tagged items, GIS related technologies, Web 2.0 and crowdsourcing (mass collaboration using Web 2.0) to support the creation of a public infrastructure, a 'data commons,' that will enable the citizen to participate more effectively in politics, civics (including land administration and management), aesthetics and science (McLaren, 2009).

RFID tags are like barcodes that broadcast their information. They are now embedded in an increasing number of personal items and identity documents, including transport and toll passes, office key cards, school identity cards, "contactless" credit cards, clothing, phones and even groceries. However RFID tags were designed to be powerful tracking devices and typically incorporate little security. People wearing or carrying them are therefore vulnerable to surreptitious surveillance, tracking and profiling.

Thus we can say that the landscape of Internet mapping technologies has changed dramatically since mid-2000. New techniques are being used and new terms have been invented and entered the lexicon – mainly – crowdsourcing and neogeography. A whole range of websites and communities from the commercial Google Maps to the grassroots OpenStreetMap, and applications such as Platial, also have emerged. In their totality, these new applications represent a step change in the evolution of the area of Internet geographic applications (which some have termed the GeoWeb). The nature of this change warrants an explanation and an overview, as it has implications both for geographers and surveyors as well as the public notion of Geography and Geomatics. The implications of these new techniques and the challenges they pose to mapping and Geo-Information technology, science, and society at large have a real and significant impact on the continuation activity of our profession (Haklay et al., 2008)

4. SUMMARY

Urbanization is a major change that is taking place globally. Due to these rapid urbanization processes, in 2007 over half of the world's population was living in urban areas - around 3.3 billion people. This sets the greatest challenge for Land Professionals in the application of land governance to support and achieve the development goals of mankind in general and those who live in urban areas in particular. Administrations in the non-rural areas are often confronted with a multitude of key problems, like high urban densities, transport, traffic congestion, energy inadequacy, unplanned development and lack of basic services, illegal construction both within the city and in the periphery, informal real estate markets, creation of slums, and poor natural hazards management in overpopulated areas.

Geospatial information has become crucial for numerous aspects of urban development, planning and management. The increasing importance of geospatial information has been due to recent innovations in geospatial information capture, management and access, as well as the development of analytical techniques such as high resolution mapping of urban environments.

The new geospatial tools and techniques are required in order to integrate the social, economic and environmental factors associated with urban regions – all within shorter timeframes than previously accepted. Data collection and maintenance of high resolution airborne and satellite imagery which is now available at an affordable rate, together with LiDAR data, opens up the possibility to efficiently generate topographic and thematic mapping at detailed scales and to better understand changes across the urban areas. Data integration and access techniques together with interoperable algorithms enable real-time merging of data and services from a variety of sources across the city and will lead to the innovative re-use of geospatial information. Data mining and knowledge discovery techniques allow the integration of a wide range of geospatial information and associated attribute information. This creates the opportunity to perform more effective forms of analysis and decision making, thus leading to more cost effective solutions. 3-D city modelling enables visualisation of planning development proposals, flood predictions, modelling population growth, tourist visit simulations and the design of transportation network.

The presented geospatial innovations and their implementations as to efficient handling of urban areas in general and dense urban areas in particular, focus our awareness on the advantages of these geospatial technological improvements for a professional urban and environmental management by the governmental and municipal administrations as well as for the benefits for urban inhabitants.

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BIOGRAPHICAL NOTES

Prof. Yerach Doytsher graduated from the Technion – Israel Institute of Technology in Civil Engineering in 1967. He received a M.Sc. (1972) and D.Sc. (1979) in Geodetic Engineering also from Technion. Until 1995 he was involved in geodetic and mapping projects and consultations within the private and public sectors in Israel and abroad. Since 1996 he is a faculty staff member in Civil Engineering and Environmental at the Technion, and heads the Geodesy and Mapping Research Center at the Technion. He is the Chair of FIG Commission 3 on Spatial Information Management for the term 2011-2014, and is the President of the Association of Licensed Surveyors in Israel.

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