3D CARTOGRAPHY IN URBAN ENVIRONMENTS FOR MUNICIPAL ADMINISTRATIONS

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Abstract
Previously, the first GIS data that served the Municipalities' decisions were limited to a geodatabase containing thematic layers of street networks, building footprints, functional areas and some descriptive attributes for each feature. Today, most of the cities are in a continuous expansion as streets and buildings began to have complex heights, volumes and shapes. In this context, urban planners understood the importance and need for these elements to be analyzed from another perspective - 3D. This is also the direction in which the Geographic Information Systems domain is expanding, by developing software applications such as City Engine. This paper's purpose is to prove that existing 2D GIS data that describes features for an entire city, does not lose its value with time, but instead represents the base for instant generation of 3D urban content through procedural modelling. ComputerGeneratedArchitecture rules rely on attributes stored in the geodatabase (such as constructive and functional characteristics of buildings, number and width of lanes for streets, etc.) that are useful in setting the level of detail when extruding buildings, defining parcels, streets and details. Depending on the aimand analyzed elements, various application can be developed for use in urban planning: visibility and impact analysis in the case of new constructions, flood risk evaluation, simple 3D visualization etc. These are brouth to the public attention in the form of 3D web scenes that can be accessed from all kind of devices, anywhere, anytime.

Keywords: *urban environments, urban development, 3D modeling, procedural modeling, CityEngine, 3D GIS, UAVs, land survey*

INTRODUCTION

Cartography, in present days, represents a graphical method for revealing ground data and information displayed on multiple types of maps. Analyzing how the cartography evolved on multiple series of maps can help the readers to identify and to determine the evolution of landscape from the analyzed area and also how it has been changed.

The idea is to show how different types of data and different periods of data collection can be integrated for obtaining beautiful cartography represented by maps, videos or interactive cloud apps and 3D web scenes.

STUDY AREA AND DATA

The location used in the analysis is represented by an urbanized part of Mogoșoaia city, a place situated in the NE part of Bucharest.

Using modern GIS technologies which offers various types of maps as support for displaying collected GIS data represent the first method in identifying the changes that occurred. Also, it has been used several fragments from map sheets called "Planurile Directoare de Tragere" which were made after the first Word War and managed to display real information such as elevation contours, toponimy, hydrography, buildings, streets and other points of interests.

The fragments were display on top of current maps and successfully revealed the changes that occurred in the area; also, it pointed out how the city expanded and transformed itself in 100 years of evolution. The application used, a newly GIS software application named ArcGIS Pro from ESRI, was the necessary tool for displaying GIS data represented by historical map and up to date maps in a comparison method.

Figure 1. Historical map – Planurile Directoare de Tragere

Figure 2. Comparison mode between historical maps and up to date topography basemap

In the second map, the details are greater by it also reveals the changes in landscape and infrastructure by viewing both maps in comparison method.

DATA ANALYSIS

The GIS application called ArcGIS Pro is part of a larger GIS platform which has different components for desktop GIS, cloud and web GIS, online or offline GIS, 3D, remote sensing, spatial and urban planning or drones. The data collected can be used in all components with 100% interoperability in data transfer or utilization and with very fast and effective results.

3D Modelling

The next step in using modern GIS technologies for creating beautiful urban cartography and for analyzing urban evolution was to gather up to date data by using a drone; the used drone was effective in obtaining a DSM (digital surface model) an ortophotoplan and also point cloud for the area surveilled.

The data obtained was also displayed in ArcGIS Pro application which has the capability for viewing both a 2D map and a 3D scene. By using the high resolution imagery from the drone, the buildings were obtained and introduced in a 3D scene which enabled 3D capabilities such as z-extrusion or 3D analysis.

Also, the DSM (digital surface model) allowed for the height information to be transmitted to the buildings GIS data for a 3D representation.

Figure 3. 3D representation of buildings

Besides the buildings, vegetation data was obtained for a 3D representation that could bring the 3D scene closer to the reality and also that would enable future analysis regarding environmental challenges in the city. A strong capability is represented by using a link view from a 3D scene to a 2D map into the same project which enables the users to have different perspective towards the data.

The possibility to represent the present data and the historical map into the same view and the same project enabled various analysis which determined in which way the evolution of the city took place and also what were the factors which influenced urban expansion and planning.

Also, by having a 3D representation of the vegetation in the city can offer a different perspective toward the total amount of trees for each area and also if any modification could be made for a modern life style and modern environmental conditions.

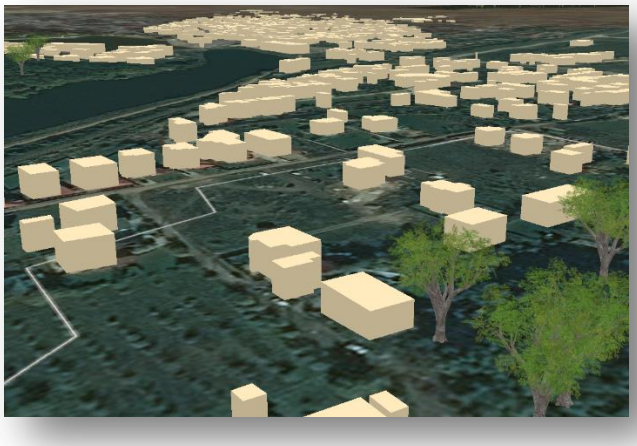

Figure 4. 3D representation of buildings and vegetation in analyzed area

The application which integrated the data from the drone to the GIS application is called Drone2Map and is 100% interoperable with ArcGIS Pro and also with ArcGIS Online which is the online component for uploading, storing, viewing and analyzing GIS data, but also the component which allows the creation of 2D maps and 3D scenes.

The data from the drone was used in Drone2Map application and the output from it were used in ArcGIS Pro. The elevation from the DSM was used to obtain the buildings, the heights and the vegetation and the imagery was draped over the DSM and used for a close up visualization over the area.

A closed view over the evolution of the area could be made by overlapping the present-day buildings and the historical map and the have a 3D scene which could allow future analysis.

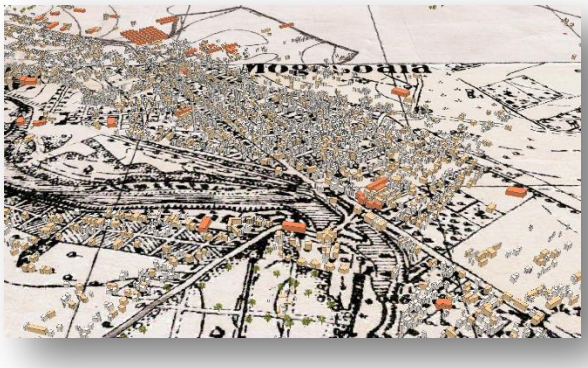

Figure 5. 3D buildings displayed over the historical map

Again, the comparison between different types of data allowed for advanced demographical analysis like the number of houses in the expended area, population or population per square meter or kilometer. The trend regarding the spatial representation of population by age could be made and also by religion or minorities.

A very important analysis was to identify the principal zoning areas from the city and the main sectors in which different activities are taking place and also to compare the present zoning to the one from 100 years ago obtained from the historical map.

By having a side-by-side cartographic representation of the historical map and the present-day imagery allowed the identification of areas, buildings and important elements from the city which appeared in the studied interval and also to determine their usage.

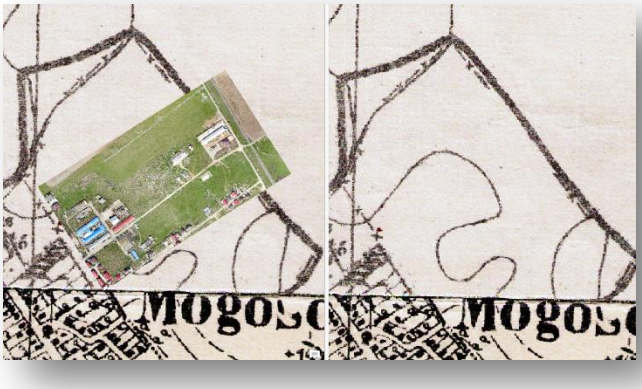

Figure 6. Drone imagery displayed over the historical map

Another important process was the rendering and the representation of the 3D point cloud for the area and it`s overlapping over another sources of information for a better cartographic analysis over the studied urban areas. The 3D data could be used in 3D analysis such as visibility, shadow, solar exposure, shadow analysis, noise or pollution.

Also, the data could be the base for future development or expansion and also for online scenes which could be used by the citizens for public debates regarding future projects in the area.

The point cloud has the capability to be visualized in different ways such as elevation, intensity, slope or natural RGB.

In elevation representation, the heights are easily viewed and the buildings or other objects such as street lamps or pools could be easily identified.

In natural RGB method, the point cloud represents the data in natural colors which offers a real representation of the area as it can be seen with the human eye.

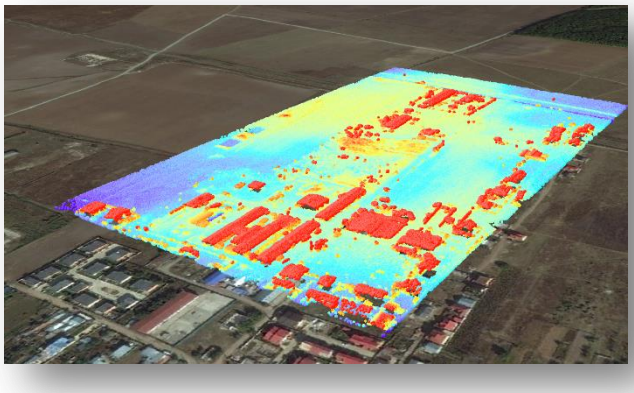

Figure 7. Point cloud elevation representation

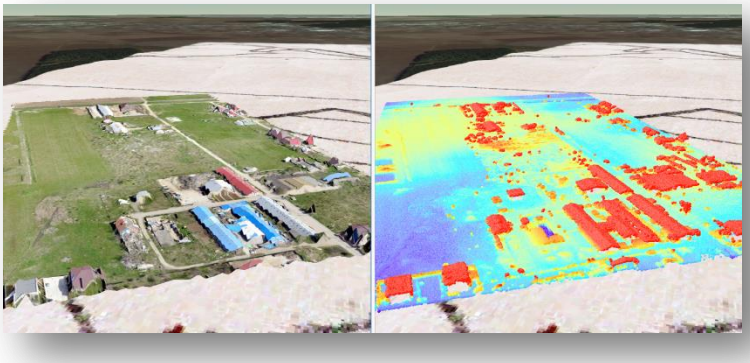

Figure 8. Natural color point cloud representation side-by-side with elevation point cloud representation

CONCLUSIONS

By having this type of modern information with cutting edge technologies is very helpful in managing, organizing and planning future developments in a certain city, not only for beautiful cartographic representation of urbanized areas but also for the various number of analyses that could be done in different GIS environments, online or offline, and also in different perspective or dimensions such as 2D maps, 3D scene or 4D time analysis of the past, the present and the prediction of the future.

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