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UFPR CampusMap: a laboratory for a Smart City developments

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Abstract:

A Smart City is based on intelligent exchanges of information that flow between its many different subsystems. This flow of information is analyzed and translated into citizen and commercial services. The city will act on this information flow to make its wider ecosystem more resource-efficient and sustainable. The information exchange is based on a smart governance operating framework designed to make cities sustainable.

The public administration needs updated and reliable geospatial data which depicts the urban environment. These data can be obtained through smart devices (smartphones, e.g.), human agents (collaborative mapping) and remote sensing technologies, such as UAV (Unnamed Aerial Vehicles). According to some authors, there are four dimensions in a Smart City. The first dimension concerns the application of a wide range of electronic and digital technologies to create a cyber, digital, wired, informational or knowledge-based city; the second is the use of information technology to transform life and work; the third is to embed ICT (Information and Communication Technology) in the city infrastructure; the fourth is to bring ICT and people together to enhance innovation, learning, and knowledge. Analyzing these dimensions, it is possible to say that in all of them the geospatial information is crucial, otherwise, none of them are possible. Considering these aspects, this research intends to use the Smart City concept as a methodological approach using the UFPR (Federal University of Parana) as a target to develop a case study.

The UFPR has 26 campus in different cities of the Paraná State, south of Brazil. Its structure has 14 institutes. It comprises 11 million square meters of area, 500,000 square meters of constructed area and 316 buildings. There are more than 6,300 employees (staff and administration), 50,000 undergraduate students and 10,000 graduate students. Besides these figures, there are external people who need access to the UFPR facilities, such as deliveries, service providers and the community in general.

The lack of knowledge about the space and its characteristics has a direct impact on issues such as resources management (human and material), campi infrastructure (outside and inside of the buildings), security and other activities which can be supported using an updated geospatial database. In 2014, the UFPR CampusMap project was started with the indoor mapping as the main goal. However, the base map of the campus was needed in order to support the indoor mapping, the available one was produced in 2000. Thereafter, the campus Centro Politécnico (located in the city of Curitiba) is being used as a case study to develop methodologies to create a geospatial database which will allows to different users the knowledge and management of the space.

According to Gruen (2013), a Smart City must have spatial intelligence. Moreover, it is necessary the establishment of a database, in particular, a geospatial database. The knowledge of the space where the events happen is a key element in this context. This author also states that to achieve this objective are necessary the following items:

- Automatic or semi-automated Digital Surface Models (DSM) generation from satellite, aerial and terrestrial images and/or LiDAR data;
- Further development of the semi-automated techniques onto a higher level of automation;
- Integrated automated and semi-automated processing of LiDAR point clouds and images, both from aerial and terrestrial platforms;
- Streamlining the processing pipeline for UAV image data projects;
- Set-up of GIS with 3D/4D capabilities;
- Change detection and databases updating;

- Handling of dynamic and semantic aspects of city modeling and simulation. This leads to 4D city models;
- LBS (Location Based Services) system investigations (PDAs, mobiles); and
- Establishment of a powerful visualization and interaction platform.

Some of these aspects are being addressed in this research. The first one is the integration of indoor/outdoor data to helps the space management and provides a tool for navigation between the spaces. The base map was updated through a stereo mapping compilation from images collected using a UAV Phantom 4 from DJI (https://www.dji.com/phantom-4). The use of this technology for data acquisition is not only faster but also cheaper compared to the traditional photogrammetric method. Besides the quality of the images (in this case a GSD – Ground Sample Distance – of 2,5 cm), it can be use in urban areas as a rapid response in emergency situations.

To georreferencing the image block, it was used 50 control points collected by GNSS (Global Navigation Satellite System) and the software Agisoft Photoscan (http://www.agisoft.com/) to perform the bundle block adjustment with self-calibration. After the processing, the exterior orientation parameters of image block and the tridimensional coordinates of each tie point were calculated simultaneously with the determination of the interior orientation parameters: focal length (f), principal point coordinates (x0, y0), radial symmetric (k1, k2, k3) and decentering distortion coefficients (p1, p2).

In the mapping production step, the features were extracted through stereo mapping compilation accordingly the standards defined by the Brazilian Mapping Agency. The several layers were edited in GIS software (QGIS) and then the topology was built. Afterward, it was created a spatial database using Postgre/PostGIS. Also, the dense point cloud was generated using SfM (Structure from Motion) algorithms to allow to generate the digital surface model and orthomosaics.

Meanwhile, a website using HTML5+CSS3® and JavaScript® technologies was developed to publish the results and the first applications. (www.campusmap.ufpr.br). The architecture of this application uses JavaScript®, LeafLet, PgRouting library (to calculate the routes between interest points), files in GeoJson format and custom applications. The indoor database comprises the data about the interior of the buildings and provides to the user some functionalities such as: search for rooms, laboratories, and buildings; routes between points (inside and outside the buildings), floor change. Also, some web applications were developed in order to demonstrate the capabilities of the use of geospatial information in an environment very similar to a city and its problems, e.g. parking management, security, logistics, resources inventory, among others. It was developed a mobile application to provide the indoor user positioning through Wi-Fi (Wireless Fidelity) networks. This, combined with the indoor mapping, will allow the users to navigate in real time inside the buildings. Using the data from the point cloud and the CityGML standard it was developed a 3D model of some buildings. An application to inform crime occurrences (such as robbery, assaults) was also developed so these occurrences can be mapped, and the administration can increase the security of the campus.

The next steps are:

a) Design an interface with functionalities to integrate all applications which are being presented in individual Webpages;

b) Develop a visualization tool for 3D models using CityGML;

c) Evaluate the potential of UAV images for different applications in urban scenarios;

d) Develop an interface for collaborative database update.

e) Expand the database to other campus of UFPR and develop new functionalities to different users;

The “smart city” concept allows to develop an optimized system that use geospatial data to understand the complexity of the urban environments. The use of the geospatial data can improve efficiency and security to manage urban aspects like infrastructure, building and public spaces, natural environment, urban services, health and education. Also, this concept can give a support to the city management agents during the design, realization and evaluation of the urban projects.

In the present project, we believe these are the first steps to build a connected environment and apply the “smart city” concept into the university administration to make the sustainable use of resources and could suit as an example to some existing problems in public administrations.