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Urban Green Space Monitoring Technique with Remote Sensing, its application and urban green space index

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Abstract: City is the important area of earth's surface material, energy, and information exchanging; also it is the centre in national, regional political, economic, scientific and cultural aspects. A mere 10% of the global population were urban dwellers in 1900, but that percentage exceeds 50% now (Grimm et al. 2008).With the rapid economic development, city is suffering from a series of serious problems such as air pollution, solid waste pollution, vegetation reduction, deterioration of water quality and living environment. According to latest predictions, 4.9 billion people, or 60% of the world's population, is expected to move in urban locations by 2030. The studies and analysis show significant differences in urban population (Herban et al. 2011). Those studies showed that there is a huge discrepancy between the changes in developed regions and the less developed regions.

Remote sensing imagery enables rapid and efficient quantification urban eco-environment and it gives a new insight for urban environmental research. A wide range of urban remote sensing applications is available.

With the availability of super high resolution remotely sensed imageries and multi-source remote sensing data, there is a great need to transform remote sensing data into useful information that we need for urban studies. High resolution remote sensing data make a clear potential to help humans to make a better understanding of their living places, to measure the biophysical parameters of urban vegetation, to model the environmental process in urban areas, to map the urban features quickly, to update the urban land covers. Romania has many areas with different environmental problems concerning: air quality, water quality, soil quality, forest health, accidental pollution caused by the chemical industry, thermal processes or oil refineries. They represent a serious threat to the environment and implicitly for the population. Disasters have also a negative impact on the environment as they are an obstacle to achieve sustainable development.

Romania has endured the most sizeable and rapid urban change during the last decade. At the same time, this is a territory of substantial importance due to its significant natural and economic resources, as well as to its sensitivity with respect to unfavourable ecological impacts. Some of urban areas have undergone a considerable change in the past ten years. Therefore, urban dynamics monitoring of Romania appears to be an essential factor to the integrated urban areas management. So, we can work on urban environment models in order to understand the mechanism of environmental issues better. With the study on these mechanisms of environmental issues, we can make a better urban environmental planning to achieve the best urban environmental benefits. The level of the living environment of humans, animals and plants is rising as a result of the improvement of the ecological environment. This is not only beneficial to human health but also to the protection of endangered plant and animal species. The study has great significance to human and nature.

Keywords: Remote Sensing, Vegetation Index, China, Romania

1. INTRODUCTION

There are few special studies on the urban green space monitoring based on modeling the proximity of buildings to green space with remote sensing using multi-source satellite images. The study achievement would provide reference for the measurements of green space, serving the urban eco-environment quality monitoring. At the same time, it was of great theory and practical significance to improve utility efficiency of satellite data and eco-environment monitoring precision.

The Institute of Remote Sensing and Digital Earth Chinese Academy of Sciences has immediate goals to carry research in urban green space modeling and assessment. Chinese organization is experienced in remote sensing data processing, analysis technology and applications, also has some achievements in the study to be conducted (Meng et al., 2012; Li et al., 2012; Zhang et al., 2011).

POLITEHNICA University of Timisoara, Civil Engineering Faculty, through Land Measurement and Cadastre Department (UPT) proposed and developed areas of interest regarding studies related to the impact of globalization over urban planning and environment. Some of these studies were developed in collaboration with Municipality of Timisoara.

With the availability of remote sensing technology, it is intended to support urban environment monitoring and meet the developing needs and promote the scientific understanding of the environment science.

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Optical remote measurement techniques are most typically designed and used to measure concentrations and, when paired with meteorological data, allow for calculation of mass fluxes of pollutants downwind of fugitive and non-point emission sources. Optical remote techniques provide opportunities to measure sources that are not conducive to measurement using more traditional stack testing or single point ambient techniques. Actual application, however, needs to be determined on a case-by-case basis.

Applications of ORS are relatively new, but maturing rapidly. For example, Differential Optical Absorption (DOAS) and Fourier Transform Infrared (FTIR) systems have been commercially available since the early 1990s. These earlier instruments, although designed for both background ambient and higher stationary source emission-related monitoring applications, have mostly been employed to measure stationary and fugitive source emissions or green space monitoring.

As applications and technologies expand and new technologies and applications are developed, it is foreseen that the ones presented here (Fig. 1) will expand as well.
<https://www3.epa.gov/ttnemc01/guidlnd/gd-052.pdf >

	Emission-Rate Estimation Methods						
Active ORS Technology	**Point Source**	**Area Source**	**Stationary and Mobile Tracer Correlation**	**Vertical Radial Plume (VRPM)**	**Solar Occultation Flux (SOF)**	**Plane Concentration Flux***	**Back Lagrangian Stochastic (bLS)**
Fourier Transform Infrared (FTIR)	✓	✓	✓	✓	✓	✓	✓
Ultraviolet (UV) and UV-DOAS	✓	✓	✓	✓	✓	✓	✓
Tunable Diode Laser (TDL)	✓	✓	✓	✓		✓	✓
Differential Lidar (DIAL)	✓	✓		✓		✓	✓
Cavity Ring down Spectroscopy (CRDS)	✓	✓	✓			✓	✓

Figure 1. Technology vs. Application Cross-Table

Comparing the range of each optical technologies, the following table is a general comparison between the different types of optical technologies (Fig. 2). The parameters listed are dependent upon factors such as the chemical properties of the analyte measured, path length and signal strength, and may be better or worse for each specific site specific application depending on these conditions.

TECHNOLOGY	TYPICAL RANGE OF APPLICATION	SENSITIVITY (DETECTION LIMITS)	ACCURACY	PRECISION (RSD)
FTIR[14]	0-50 ppm	< 1.0 ppmm	0-30%	< 1.0%
TDL[15,16]	0-800 ppm	< 15.0 ppmm	0-40%	< 5.0%
UV-DOAS[17,18]	0-1000 ppb	< 0.10 ppbm	0-20%	< 5.0%
LIDAR	0-120 ppb	low-ppb Range	0-15%	< 1.5%
IR Camera	N/A	N/A	Qualitative Only	Qualitative Only

Figure 2. Technology characteristics

2. OBJECTIVES, EXPECTED RESULTS, PLANNED UTILIZATION OF THE RESULTS

The paper primarily aims to study the techniques of monitoring urban green space using high resolution remote sensing data (Fig. 3) to support the application of high remote sensing in urban mapping and feature extractions, to build information model to convert spatial and spectral information from remote sensing data to useful information, to evaluate urban environment by the analysis of the spatial configuration of urban buildings and urban green space, to promote scientific understanding of the interaction among buildings, green space and human beings.

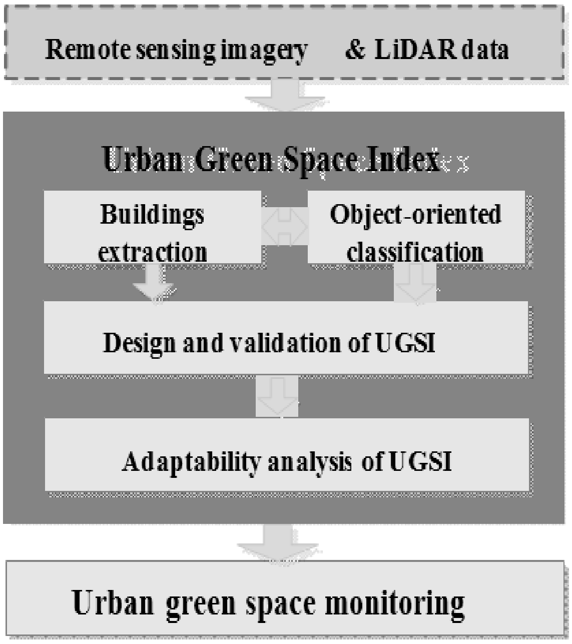

Figure 3. Technology route

1. Propose image classification method and urban features extraction algorithm.

A Generation of the Normalized Height Model (NHM)

(1) Collection of LiDAR data on urban areas.

(2) Collection of DEM (Digital Elevation Model) on urban areas.

(3) Generation of DSM (Digital Surface Model) from LiDAR data

(4) Generation of the Normalized Height Model by subtracting the DEM from the DSM

B Image segmentation algorithms

(1) Design of a robust segmentation algorithm for urban feature segmentation

(2) Segmentation accuracy assessment

C Extraction of Urban Buildings.

(1) Building mapping

(2) Generation of Building Height model

D 3D modeling of urban trees using LiDAR.

(1) Urban green mapping

(2) Tree detection and the 3D modeling of the urban trees.

D Urban green mapping using Multi-spectral images

(1) Machine learning techniques for classification of urban green

(2) Shadow detection and removal

(3) Accuracy assessment

3. DEVELOP URBAN GREEN SPACE INDEX TO OBSERVE THE URBAN GREEN SPACE AT BOTH HORIZONTAL AND VERTICAL DIMENSIONS

A) Inversion of biophysical parameters for urban green space from remotely sensed data.

The ecological benefits of urban vegetation depend on the ecological processes like photosynthesis, transpiration and metabolism. The biophysical parameters (such as LAI, net primary production) for urban vegetation are very effective indicators to indicate the ecological benefits for urban green space. So, how to inverse the biophysical parameters for urban vegetation from remotely sensed data is a valuable tool in modeling urban ecological process.

B) Develop several urban green space indexes

The model will give us a digital support to evaluate urban green space. This model will be enriched by the analysis of the spatial configuration of urban buildings and urban green space (Fig. 4). All input parameters can be inversed from remotely sensed imagery.

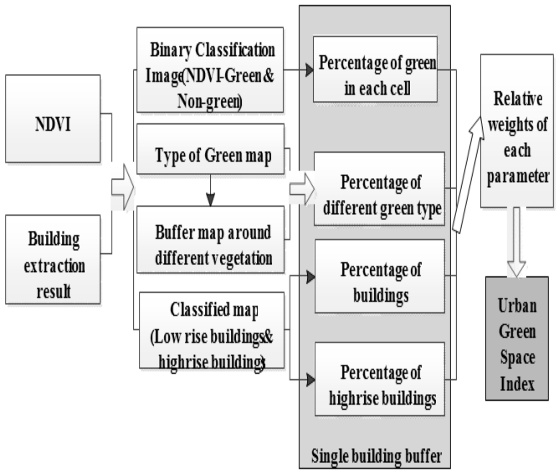

Figure 4. Urban green space index

C) Develop an evaluating system for measuring the quality of the urban environment using remote sensing technology.

D) Probe the relations between green space and other environmental elements based on the space-time multi-scale urban green space model.

E) Demonstrate the urban green space monitoring technology among different cities.

4. CASE STUDY

The aim of this study involves urban green spaces monitoring with a view to inventorying urban wooded areas and the trees inside the cities using LiDAR technology. As study area, a park near the “Dan Păltinişanu” stadium, Timişoara, Romania was chosen. The measurements have been realized using Trimble MX2, a mobile laser scanning system that combines high resolution laser scanning and precise positioning to collect georeferenced point cloud that is useful to projects with vast requirements. The platform used for data collection is composed of a Ford vehicle on which the Trimble MX2 scanner has been mounted. There were two sets of data collected at different speeds of approximately 10km/h, respectively 30km/h. For data processing, corrections are needed either given by a reference station either by a permanent GNSS station. In the second case, the correction are ordered and paid according to the number of hours requested to the Cadastre and Land Registration Office. For the present study, corrections from our own reference station have been used.

The measurements have been realized using Trimble MX2, a mobile laser scanning system that combines high resolution laser scanning and precise positioning to collect georeferenced point cloud that is useful to projects with vast requirements. Trimble MX2 is an integrated system which captures, processes, and analyses point clouds for mobile applications using spatial images. The system has three main elements: the sensor (Fig. 5), operator console and analysis software.

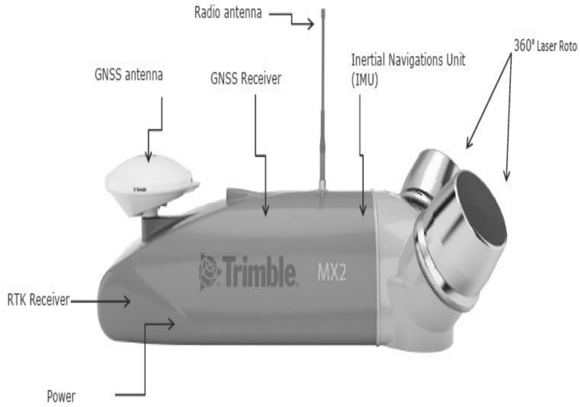

Figure 5. Trimble MXS with 2 sensors

As optional equipment, Trimble MX2 mobile scanning system can be equipped with a DMI-Distance Measurement Indicator which calculates the rotation of the wheels to help positioning the vehicle and with a G360 panoramic camera system (Fig. 6).

Figure 6. G360 camera system

The platform used for data collection is composed of a Ford vehicle (Fig. 7) on which the Trimble MX2 scanner has been mounted.

Figure 7. The complete monitoring system

As performance, the system (Fig. 8) has the following characteristics: operating temperature: –10°C to +50°C; laser type: dual SLM -250 Class 1 lasers; range up to 250m; accuracy ±1cm to 50m; field of view 360degrees, measuring rate 72.000points/second.

Figure 8. The Mobil Platform

The Trident software (Fig. 9) is used for data acquisition. Because it is a mobile platform, the system needs initialization to facilitate subsequent post-processing. This takes about 5 minutes after which the measurement itself is realized in about 30 minutes. There were two sets of data collected at different speeds of approximately 10km/h, respectively 30km/h. The resulting measurement consists of the files containing the entire trajectory of the car – POS, files containing the actual measurement – TRIDB along with the point cloud and images taken by the camera – CAM. The measurements have been carried out between 9:58-10:18 AM, 11/05/2017 and the corrections have been recorded for the whole day. The park chosen as study areas is located in plain area, the terrain height is between 86 and 91m.

Figure 9. Trident software

The Trident software assures the precision, accuracy, reliability and efficiency, to data capture and data processing and its enable to deliver imaging data rapidly.

As a result of data processing, the following resulted for the two sets of measurements:

- a point cloud consisting of 10 million points and a distance of 10cm between them for 10km/h speed,
- a point cloud consisting of 4.5 million points and a distance of 35cm between them for 30km/h speed.

5. CONCLUSIONS

It can be concluded that a higher speed of movement of the platform leads to reducing the number of points and their density.

Sustainable urban planning uses a conscious approach to energy and ecological conservation in the design of the built environment with a view of stimulating investments, attracting tourists and increasing the living standards of inhabitants. Green space monitoring is considered a key instrument for urban environmental management and will facilitate the development of local urban ecological environment policies by local authorities.

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