Space Technologies for Smart Cities

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ABSTRACT: *Satellite technologies have a huge potential to help design more sustainable cities. Combination of Earth observation imagery and crowdsourced data enables a creation of a series of data analyses and applications to support smart urban planning, climate change mitigation and to enhance the quality of life in smart cities and communities.*

SPACE-SI with its micro satellite for multispectral Earth observation, ground station, multidisciplinary laboratory, satellite data processing chain and a distribution system based on web and mobile applications ensure the whole chain from the space technologies to the end user friendly data and derived information. Timely geolocated information is crucial for well organized smart cities and communities. Our expertise is near real- time processing of space-borne data and the extraction of the needed information from this ever-growing data source.

Keywords: Satellite Technologies, Smart Cities, Micro Satellite, Mobile Applications

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1. Introduction

Increasing urbanization and ever-growing urban population are opening new challenges to be addressed to ensure sustainable development of the cities offering a good quality of life for the citizens. To effectively plan and manage the urban areas accurate and timely geolocated data is essential. Space-borne Earth observation provides up-to-date spatial information on various topics supporting smart urban planning and enabling sustainable development of the cities and the climate change mitigation.

2. Space-si in and for Smart Cities

The research and development strategy of the Centre of excellence for Space sciences and technologies (SPACE-SI) is based on two global breakthroughs in the aerospace industry in the field of small and large satellites that will provide new, extremely reach

data sources for the development of satellite applications needed to support the development of smart cities and communities.

Radical miniaturization of the micro and nano satellite subsystems has reduced the costs for developing, launching and operating satellites. Due to lower costs more satellites can be launched and consequently, the larger areas can be observed with better temporal resolution (images are acquired more often). Thanks to those radical changes space technologies are not anymore reserved only for large research and development institutions from economically strong countries. They have opened the door for the satellite development and operation also in new small countries and on fast growing markets. With its excellent staff and infrastructure network SPACE-SI is ready for the new wave of opportunities. SPACE-SI has developed the first Slovenian micro satellite for interactive remote sensing, built the ground station, equipped multidisciplinary laboratory for the integration and testing of satellite components and has prepared a wide range of mobile and web applications prototypes to be used by companies, government offices, and general public. With the current achievements SPACE-SI is planning active engagement in the very perspective international markets regionally and globally.

European Commission and European Space Agency (ESA) have developed a family of large satellites missions called Sentinels. These missions carry a range of technologies, such as radar and multi-spectral imaging instruments for land, ocean and atmospheric monitoring. Sentinels will provide massive amounts of global satellite high and medium resolution images which will be freely and openly accessible for the users. This will greatly increase the potential for development of new services based on satellite data and open new employment opportunities. Due to extremely large amount of data it will also pose a big data processing challenge.

SPACE-SI will integrate the new data sources into a single system for data processing and management and for web and mobile applications development for the end users. These data and applications have a huge potential to help design more sustainable and smart cities and communities.

Furthermore, to be able to make better use of fast growing amount of satellite data SPACE-SI has developed and implemented a complete fully automatic processing chain (called STORM) that includes all necessary processing steps from sensor corrected (Level 1) optical satellite image up to web-delivered map-ready products.

3. Current Smart Products

SPACE-SI's current activities related to the area of smart cities and communities can be divided in three main groups:

• Providing the **infrastructure** for data acquisition and transmission from the satellite to the ground (micro satellite, laboratory for satellite integration and testing, ground station), as well as providing the Sentinel data,

• Automatization of satellite **data processing** from sensor-corrected (Level 1) optical satellite image up to web-delivered map-ready products (automatic processing chain), and

• **Applications** using information derived from satellite data, combining Earth observation data with in-situ data (web and mobile applications).

The scheme of our activities is presented in the Figure 1.

3.1 Infrastructure

SPACE-SI has the key infrastructure to ensure the whole chain from the space technologies to the end user friendly data. The main infrastructure consists of the micro satellite for multispectral earth observation, multidisciplinary laboratory for satellite systems integration and testing, ground station for retrieving the data from satellites to the ground, automatic data processing chain and web GIS.

3.2 Data Processing

Space-SI has developed an automatic image processing chain that performs all processing steps from sensor-corrected (Level 1) optical satellite images to web-delivered map-ready products. It is a near-real-time processing workflow that operates fully automatic with no operator's intervention required. It performs several steps, starting with automatic geometric and radiometric

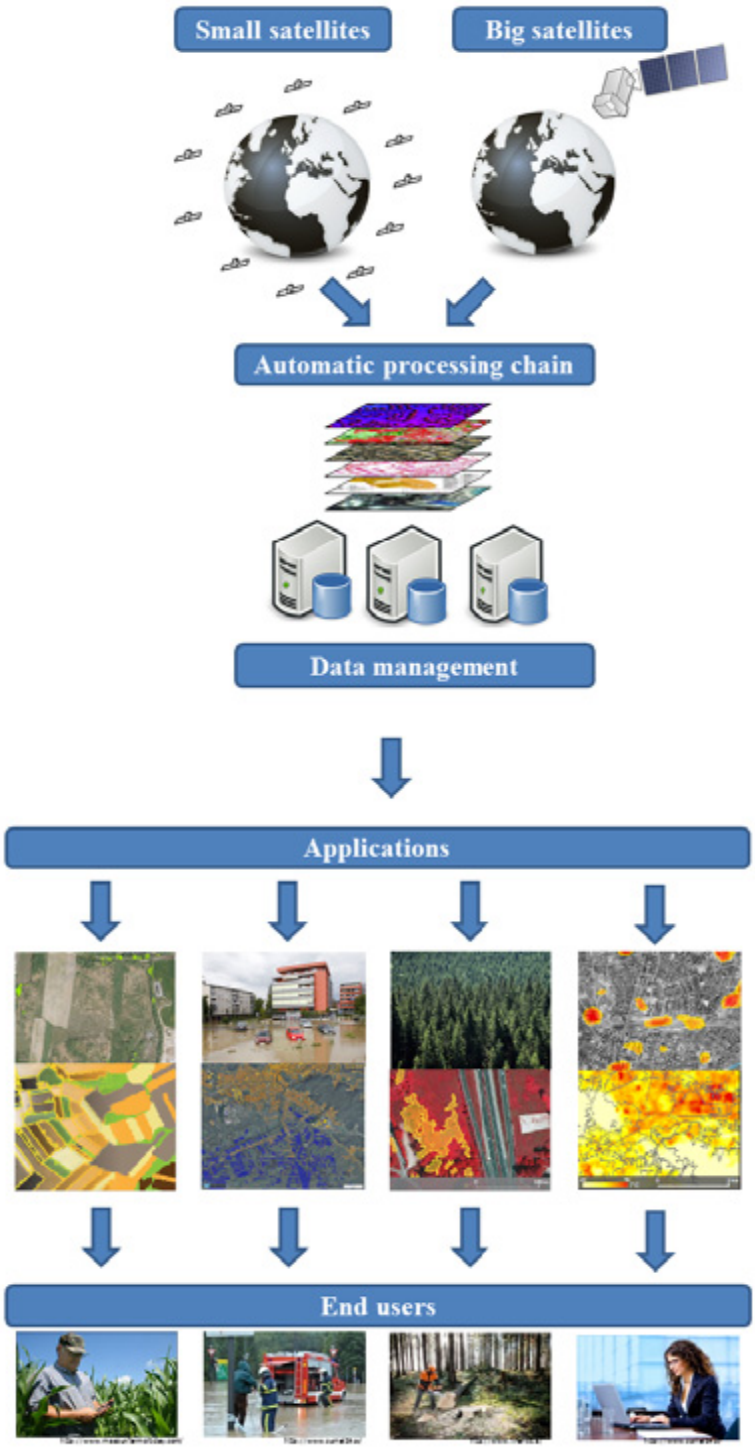

Figure 1. Schematic representation of SPACE-SI's activities - from technologies to end user services

pre-processing, followed by a variety of automatic interpretations and analyses. In the preparation for the processing of the Sentinel satellites data we are proposing a regional data archiving and processing center. Data processing chain makes use of cloud computing, which makes remarkable scientific results also supporting Earth observation.

To enhance the data processing chain our future scientific work will still be focused on the development of algorithms for

automatic processing of multi-spectral images from remote sensing satellites. A number of highly specialized algorithms will be developed for monitoring drought, mapping of invasive plant species and plant diseases as well as for mapping of natural resources and various indicators for analyzing natural disasters.

3.3 Web and Mobile Applications

To optimize the use of spatial data acquired with our satellite system or other data sources (partner satellites, governmental data, etc.) we have built a distribution system based on web and mobile applications. The system is based on Geopedia, a cloud based web GIS viewing and editing solution.

SPACE-SI has developed also a mobile application called Mo mnozic (the power of the masses) for data crowd sourcing with the help of general public. This mobile application allows any smart phone user to report data on unusual events, especially in the case of natural disasters. The web application allows users to enter the necessary data (which vary according to the type of the event) in real time and on the spot. All data is collected on a shared server where they are analyzed with the assistance of the operator and the final product is produced (e.g. identification of areas with hail, flooded areas, etc.).

Applications enable support in responding to the societal challenges, such as:

- Adaptation to climate change,
- Management of renewable energy sources,
- Improve food self-sufficiency, and
- Protection against natural disasters.

Current applications based on the spectral analysis of high resolution satellite images for the user cases related to smart cities and communities are:

- Change detection in urban areas,
- Determination of heat islands in cities,
- Insolation modeling,
- Continuous drought mapping and early warning,
- Natural disasters mapping (e.g. floods, landslides, fires),
- Mapping of agricultural areas (crop state, prediction, needs),
- Invasive plants mapping (e.g. Japanese knotweed),
- Detection of plant diseases,
- Advanced maritime surveillance, and
- crowd sourcing – Earth observation, modeling, mobile data input and output.

4. Suggestions for Joint Project Proposals

SPACE-SI can support the proposed joint projects with up-to-date satellite images in high spatial, spectral and temporal resolution. Our satellite will offer in addition to still high resolution images also the real time interactive high resolution HD video of the area of interest. All satellite images are processed for sensor, geometric, atmospheric and topographic correction and therefore ready to be used by the end users. There are enormous amounts of satellite data generated every day. Our expertise is to enable their near-real-time processing and to derive from them the needed information. Geolocated information is crucial for well-organized smart cities and communities.

We can offer a series of web and mobile applications (see chapter 3.3) to support the sustainable and green development of the cities and a GIS-based decision making support tool.

Mobile application Moc mnozic for the crowd sourcing of the data with the help of general public originally developed to observe the natural disasters can be adapted to any smart case study where the crowd sourcing is relevant enhancing the quality of life and human well-being within the smart city or community.

5. Conclusion

Earth observation data and the applications based on it offer a powerful tool for smart city planners and for citizens. They give accurate information on what and where is going on in near real time. Satellite images provide a comprehensive view of the subject matter for the whole area at the same time. Real time monitoring eliminates the need for regular inspections and therefore reducing costs. Costs are not only saved in the collection of data but also in the analysis of the satellite images as compared to other methods.

Advanced applications are combining Earth observation data with in-situ data and/or with crowd sourced data gathered by the general public users with their smart phones.

These data and applications have a huge potential to help design more sustainable and smart cities and communities. SPACE-SI can offer smart solutions for smart cities.

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