Improved LC/LU maps and flood models through crowdsourced information

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Abstract

Flood risk prediction has been traditionally based on models that are developed from time-series of data collected over long periods of time from expensive and hard to maintain in situ sensors available only in specific areas. SCENT is a H2020 project which provides an integrated toolbox of smart collaborative and innovating technologies that augment costly in situ infrastructure, enabling citizens to become the 'eyes' of the policy makers by monitoring LC/LU changes in their everyday activities and related environmental phenomena like floods by crowdsourcing relevant information.

Policy makers and relevant stakeholders are able to set-up citizen science campaigns in areas where specific environmental information is needed. These data may include images that are processed through an intelligent engine and classified based on a LC/LU taxonomy, sensor measurements with low-cost portable environmental sensor or river measurements. The crowdsourced LC/LU information is used to created improved and more detailed maps of the area of interest where taxonomy elements such as river banks are identified and categorized base on their coverage, such as low grass and stone.

The produced LC/LU maps along with the sensor and river measurements are used to create flood models, used by public authorities and stakeholders to better understand the area of interest, its needs and the steps needed to support its sustainability.

Keywords: LC/LU maps, citizen science, flood models

1. The SCENT Approach

Scent is a Horizon 2020 funded project that has created a toolbox of smart technologies and applications that aims to enable citizens to monitor Land Cover/Use (LC/LU) changes and how these affect flood phenomena in their urban or rural areas. Citizens simply use low-cost equipment to collect various environmental information, that are consolidated to improve flood modelling and will be offered to several national repositories and GEOSS as OGC-compliant observations.

An important element of the SCENT toolbox lies on the development of a machine learning-based automated engine aiming at creating maps that have well defined regions characterized and annotated with a predefined subset of the SCENT land-cover descriptor taxonomy (e.g. river bank, coniferous trees, etc), which is based on the CORINE taxonomy but is also enriched to include elements needed for flood management.

2. Leveraging Citizen Science for improved Land Cover / Use mapping

To automatically characterise land cover/ land use of level 2 and 3 of CORINE and/or SCENT taxonomy is a challenging task. When comes to 'micro structures' that occupy lower than 100m width or length, such as buildings and canals, then high-resolution satellite imaging is a necessity. Machine learning is the framework of choice for automatic aerial scene classification and/or for pixel-wise LC/LU segmentation of satellite images. The advent of Deep Neural Networks (DNN) dominated the field leading to enhanced segmentation performance. However, only recently DNN learning technologies found their path in LC/LU field leading to significant improvements in performance. The vast majority of the relative works so far concern satellite map tiles classification, meaning that small tiles from the satellite images are classified according to certain LC/LU classes in isolation from the whole map. These developments were propelled by the a large collection of relevant tile-based annotated datasets of 0.3-0.5 square meter resolution satellite data, such as the Aerial Image Dataset (AID) consisting of 30 classes with 200 to 400 images per class, (forest, river, pond, stadium, port, baseball field, etc) and the WHU-RS19 dataset, (50 images per classes, up to 0.5m resolution, airport, beach, farmland, forest, industrial area, meadow, pond, residential area, river).

In SCENT, state-of-the-art Deep Neural Network technologies have been employed and properly adjusted to the satellite imaging peculiarities in order to build an effective satellite map segmentation tool, appropriate for certain SCENT land cover/land use taxonomy items of the project, that aims (i) to assign a semantic class (SCENT taxonomy) to each pixel, (i.e. convert the raw data to a semantically meaningful raster map), (ii) to convert SCENT taxonomy annotated points into annotated areas on the satellite/aerial maps and, (iii) to characterize whole areas for which a land-cover/use description is not available.

Crowd-sourced data, consisting of images of LC/LU and other important environmental parameters that are being collected and annotated by volunteers through a dedicated application, constitute an important source of training data for the development of the DNNs in the project. These data have been collected and validated (through different components of the SCENT toolbox) in the context of two large scale pilot demonstrations that have been conducted so as to showcase the usefulness of the toolbox in real conditions; the urban case of the Kifisos river in Attica, Greece and the rural case of the Danube Delta in Romania. In addition, satellite imagery of very high spatial resolution from the Copernicus Contributing Missions are utilised, so as to allow the identification and segmentation of the SCENT taxonomy elements and the production of improved land cover/ land use maps.

3. Results

The output of the tool is a semantically meaningful raster map represented as a taxonomy layer on top of the acquired satellite maps (Figure 1). The later would be obtained automatically covering not only the areas were crowdsourced notations would be available but the whole available map. The automatic map segmentation tool is embedded in the SCENT platform and it will be capable to get appropriately re-trained and operate with LC/LU taxonomy classes 'different than those trained for the SCENT piloting program as well as for satellite maps different than those used. In terms of the flood modelling, in Danube Delta, the LC/LU data are used to provide improved roughness parameter, and other data are used to validate the model in terms of spatial distribution of flood extent, flood levels and flood velocities and discharges, calculated by a 1D-2D HEC-RAS model. In Kifisos the LC/LU information is used for updating infiltration and runoff parameters of the rainfall runoff model built by HEC-HMS, and improved cross section data and updated measurements of water levels and velocities / discharges in the river are used to better calibrate and validate the HEC-RAS hydraulic model of the downstream part of the catchment.

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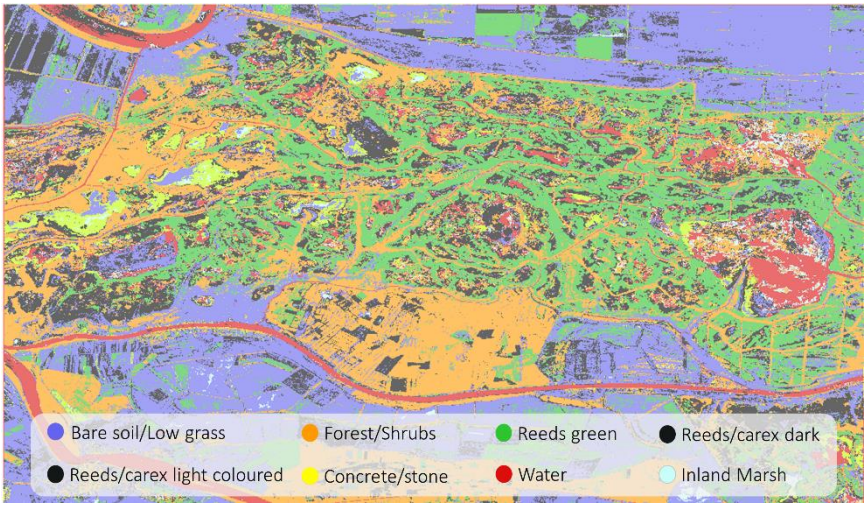

Figure 1. Results of the map segmentation tool in Danube Delta pilot area

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