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SCENT - Smart Toolbox for Engaging Citizens into Monitoring Flood Phenomena

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KEY POINTS

- *Using crowdsourced data to monitor Land Cover/Land Use (LC/LU) changes*
- *Incorporating crowdsourced data into flood models*
- *Extract river measurements from multimedia*

1 INTRODUCTION

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. The climate change has made the monitoring of the flood events imperative and has raised the question of whether the development of flood models can be disengaged from the in-situ sensors. The Scent toolbox is based on smart collaborative and innovating technologies that augment costly in-situ infrastructure, enabling citizens to become the 'eyes' of the policy makers by monitoring Land Cover/ Land Use (LC/LU) changes in their everyday activities and environmental phenomena like floods by crowdsourcing relevant information.

Experts in the field of flood models define areas of interest through a specifically designed tool and ask volunteers to collect specific data needed at these areas using engaging gaming applications. These data may include images that are processed through an Intelligent engine and classified based on a LC/LU taxonomy, video of floating objects and images of water level indicators that allow the automated extraction of the water velocity and the water level and sensor measurements with low-cost portable environmental sensors. It will be described in detail how the volunteers are engaged to collect these data, how the data are validated, and how they are used to create improved LC/LU maps and contribute to the development of improved flood models reducing the cost and infrastructure needed.

2 SCENT TOOLBOX ARCHITECTURE

In order to achieve its goals the Scent toolbox is based on an innovative architectural design that is presented in Figure 1, where key components dedicated to specific tasks are connected in a way that allows the flow of information from local authorities, to volunteers, to environmental experts and back to the authorities that can now have improved monitoring of the phenomena of interest allowing them to make educated decisions that can help and support the areas. The key components of Figure 1 are briefly presented here.

A crowd-sourcing platform that provides a series of tools and applications that allow the flow of information between the components of the toolbox as well as the creation of information from policy makers and contributions from the volunteers. It includes a dedicated tool (Authoring tool) for policy makers that allows them to identify areas of interest, create campaigns and Points of Interest (PoIs) and access the collected and extracted information in a user-friendly way as map overlays. Part of the crowdsourcing platform is also a series of gaming applications that aim to engage volunteers to collect images and sensor measurements as defined in the Authoring tool and to contribute to environmental monitoring by providing, qualifying and interpreting information about LC/LU.

An intelligence engine, which uses innovative machine learning techniques to classify and annotate images from citizens and open platforms. The classification is done with respect to the Scent taxonomy, which is based on the CORINE taxonomy but is also enriched to include elements needed for the flood models. To fully utilize the collected and extracted information, the validated data are used to create improved LC/LU maps. In addition, in order to support the collection of river measurements in a uniform way, useful to the flood models and invariant of the experience of the volunteers to collect scientific data two tools have been developed. The tools use state of the art image recognition algorithms that extract from multimedia (video & image) water level and water surface velocity measurements.

A collection of environmental sensors that are going to support the collection of the data needed for the flood models. The sensors will range from in-situ sensors that are available in the areas of interest, portable sensors that the volunteers use to collect additional measurements as well as sensors mounted on drones flying over the areas of interest.

A Harmonisation platform that collects all the crowdsourced observations, transforms them to OGC compliant observations, stores them with respect to time and space as such and offers them to the Scent toolbox components as needed as well as to GEOSS as web services making the collected data findable and re-usable. Part of the Harmonisation platform is also the Data Quality Module that assigns a trust level to every registered user and sensor.

The Scent toolbox will be evaluated for a year during a series of campaigns starting the summer of 2018 in two large scale pilots of great environmental impact; the urban site of Attica Kifisos River and the rural site of Danube Delta. The two pilot areas have been chosen carefully for their specific characteristics as well as their different needs and topology.

Finally, the collected data along with the extracted information from the different components will be used to improve the flood models of the areas, quantify the impact of LC/LU changes to flood maps and spatio-temporal flooding patterns enabling more effective flood-related planning and management by policy makers.

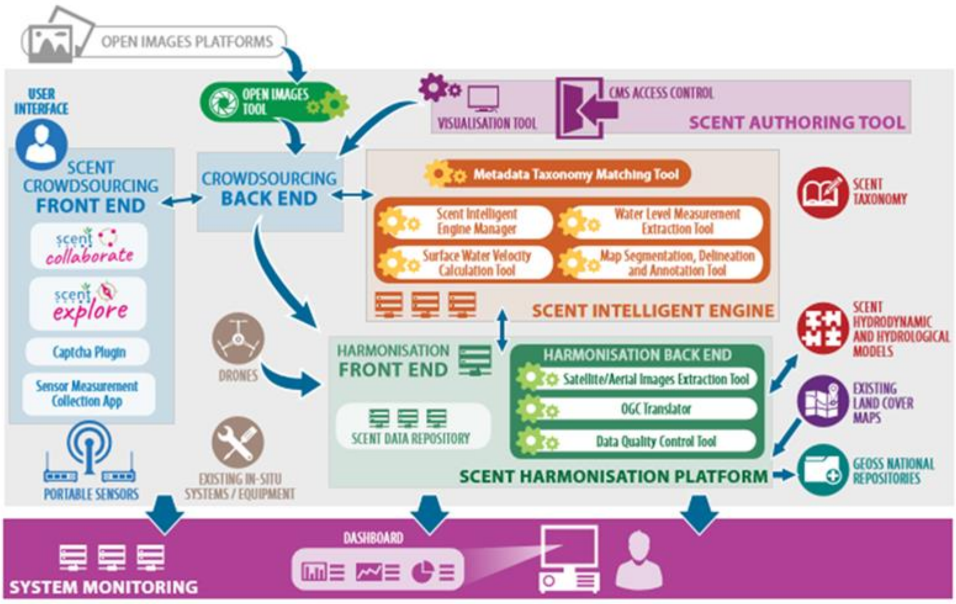

Figure 1. Architectural overview of Scent toolbox

3 EXTRACTION OF RIVER MEASUREMENTS FROM MULTIMEDIA

It has been recognized that in order for the Scent toolbox to be successful and achieve its goals the data provided to the experts and used to improve the flood models should be consistent, accurate and invariant of the expertise of the volunteers collecting them. In order to properly collect river measurements scientist use a variety of methods that require extended training and can be very time consuming. To avoid that the Scent volunteers are simply asked to take a picture of a water level indicator or a video of a predefined floating object and upload it through the gaming applications. The crowdsourced data are then forwarded to two tools have been specifically designed to automatically extract the water level and the water velocity in a consistent and accurate way.

3.1 Water Level

The Water Level Measurement tool uses state of the art image recognition techniques in order to extract the water level from images containing a water level indicator that is half-submerged into water. The initial goal of the tool is to "read" the indicator and extract the number that is closer to the water lever. In order to achieve that the tool extracts features of the input images and match them with pre-calculated models invariant of rotation, luminance variation, image noise or scale that are stored in a model database. If the quality of the image does not allow for the recognition of the numbers of the indicator, calibration techniques based on the patent of the indicator and tis bounding box are exploit resulting in a less trusted estimation of the water level.

3.2 Water Surface Velocity

The Water Velocity Calculation tool uses state of the art video processing algorithms in order to extract the water surface velocity from a video containing a pre-defined floating object moving on the surface of a water body. The Kalman filter is used for the object localisation, while the object displacement is estimated based on feature matching algorithms and calibrated using the known dimensions of the floating object. The tool is resistant to noise introduced to the video by intentional or unintentional movement of the camera as long as the floating object is included in the video frames. The more stable elements from the surrounding environment (such as trees and rocks) the video includes the more accurate calculation of the estimation of the displacement can be achieved.

3.3 Measurement Degree of Trust

Each measurement estimation extracted by the tools is accompanied by a degree of trust that highly depends on the quality of the input data. The tools have been designed so that a high degree of trust can be achieved from images and videos taken from regular smartphones.

4 Machine Learning Techniques for Improved LC/LU Maps

Scent introduces novel approaches for machine learning based image classification that combine categorical classification of scenes (field, forest, street, burnt field) with land-cover object type recognizers (e.g. types of grass, trees, flowers, pavements) to produce a superior scene description engine able to provide environmental data on the region observed in a given image.

There are many approaches and algorithmic tools that are adequate for effectively performing map segmentation regarding LC/LU; their applicability however is closely related to the classification problem and the characteristics of the study area. After a study of the available aerial images of the areas of interest and preliminary data exploration, it has been concluded that the preferable way of performing the map segmentation is to handle it as an aerial scene classification task. Accordingly, the map under consideration is split into overlapped tiles of predefined size, which are slid across both vertical and horizontal directions, aiming to build one or more classifiers that are capable of classifying all the tiles according to the Scent taxonomy.

5 Interoperability In Citizen-Generated Data

Considering the constantly increasing volume of citizen-generated data, it is of high importance to ensure that data of different origin and type are comparable and compatible, whilst facilitating their integration into models and the development of new applications. To this end, the data should be easily discoverable, accessible, re-usable and preserved for future use. Scent meets these aspects of data interoperability through the development of a Harmonisation platform that translates the collected measurements from citizens to OGC compliant resources.

In particular, a Sensor Observation Service (SOS)[1] is implemented in compliance with OGC Sensor Web Enablement (SWE) standards that facilitate the exchange of sensor data and sensor information. The offered sensor data comprise of descriptions of sensors themselves, which are encoded in the Sensor Model Language (SensorML)[2] and of the measured values in the Observations and Measurements (O&M) encoding[3]. In addition, the concept of a scalable approach to "citizen science application profiles" is evaluated, as it is described by the SWE4CItizenScience (SWE4CS) initiative[4] including also guidelines for migrating to the SWE4CS data model.

Session Organisation

Intervention	**Speaker**
Scent Overview and State of Play	Chrysovalantis Tsiakos
Extraction of river measurements from multimedia	Maria Krommyda
Crowdsourcing tools for environmental data collection	Stefano Tamascelli
Machine Learning Techniques for Improved LC/LU maps	Maria Krommyda
Interoperability in citizen-generated data	Chrysovalantis Tsiakos
Scent Toolbox Interactive Demonstration	Maria Krommyda, Chrysovalantis Tsiakos

[1] https://portal.opengeospatial.org/files/?artifact_id=47599
[2] http://www.opengeospatial.org/standards/sensorml
[3] http://www.opengeospatial.org/standards/om
[4] https://portal.opengeospatial.org/files/?artifact_id=70328