Machine learning techniques and Big Data analysis for flood risk management, assessment of droughts and other extreme climate events: different approaches

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Considering the challenges presented by the climate and global changes, the Basin District Authority of the Oriental Alpes River District (AAWA), as the competent authority appointed for implementing The EU Directives 2007/60/EC and 2000/60/EC, is exploring innovative methodologies for water management, assessing the flood risk, droughts and the status of water bodies.

Past experiences (Ferri et al. 2018) prove that particular effective approaches for an integrate water and extreme climate event management rely in the aggregation of hybrid datasets from various sources, including both 'artificial sensors' (e.g., traditional environmental monitoring and detection sensors, remote sensing, surveillance cameras etc.) and 'social sensors'.

Examples of such technologies are the one being developed inside various Horizon 2020 European projects followed by AAWA, such as: WQeMS project (Copernicus Assisted Lake Water Quality Emergency Monitoring Service - Call: H2020-SPACE-2020, G.A. 101004157, https://wqems.eu/); XR4DRAMA (Extended Reality For DisasteR management And Media planning - Call: H2020-ICT-2018-20, G.A. 952133, https://xr4drama.eu/); aqua3S project (Enhancing Standardisation strategies to integrate innovative technologies for Safety and Security in existing water networks – call: H2020-SU-SEC-2018, G.A. 832876, https://aqua3s.eu/).

WQeMS approach aims to provide an operational water emergency monitoring service in order to support and complement existing decision support systems, including also qualitative aspects in alignment to 2000/60/EC. The target is the optimization of the use of resources by gaining access to frequently acquired, wide covering and locally accurate water-status information. WQeMS starts from the latest developments and advances in the Copernicus EMS, identifying the adaptation needs of existing products and services, as well as suggesting new ones to be added in the existing portfolio.

The XR4DRAMA approach is about facilitating the sourcing of all relevant (digital) information (satellite images, AV content from social media and drones, sensor data) needed to deal with a specific, potentially dangerous or challenging scenario faced by natural disaster managers, creating immersive representations of the environment via XR technology to anticipate the event as accurate as possible and to understand and re-assess consequences of specific actions/decisions.

The aqua3S approach aims to reach an integrate water and extreme climate event management, with a focus also on water distribution and supply networks, through incorporation of existing sensor networks with videos from UAVs satellite images and social media observations. Dedicated components are developed for heterogeneous data collection, harmonization trough a dedicate ontology (Karakostas et al. 2020) and storage. Semantic representation and data fusion provides intelligent decision support systems, alerts and messages to the public. Finally, the user interface offers the most suitable visualization for each type of data.

Examples of the algorithms deployed specifically for hydrologic and hydraulic applications in the aforementioned projects include:

i) monitoring the extension of water bodies and identification of flooded areas from Satellite (Sentinel-1) images, with an estimation of water depth and flow velocity. The approach for the extension detection consists in pixel-based classification on thresholds over the processed VH band (Antzoulatos et. al. 2022). The algorithm is being validated by AAWA annotating the data processed by a set of satellite images from 2019. Estimation of depth and velocity requires the elaboration of data from the DEM and from the Corine landcover;

ii) automatic flood risk and hazard mapping for the flooded areas detected by the previous procedure, using the same algorithm used in the update of the Flood risk management plan of the Oriental Alpes River district-II Cycle (AAWA 2021). Hazard classification relies on estimation of water depth and velocity; Risk classification requires also a set of socio - economic and demographic datasets for assessing vulnerability and exposure;

iii) social Media Monitoring to collect and analyze social media data from Twitter and dedicated mobile app. A specific crawler tool receives in almost real-time tweets that satisfy a query, based onto a set of keywords; the procedure includes the identification of eventual fake news; the automatic geotagging and the classification of a tweet as relevant or not, which is a supervised machine learning technique that requires to be trained with manual annotation (Moumtzidou et al. 2018);

iv) anomaly detection based on real time data acquisition from monitoring sensors and numeric simulation models. The measure of hydrological and hydraulic variables are compared with a set of thresholds, defined as representative of an anomaly situation (i.e. drought, a flood etc.). In case of threshold overtopping, automatic warning and possible operational scenarios are provided.

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