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Editorial — Special issue on multimedia in ecology

The recent advances in digital cameras and sensors, as well as in network bandwidth and information storage capacities, have revolutionized our ability to capture multimedia data (sounds, images, videos, etc.) for environmental monitoring and are also greatly improving our ability to effectively manage natural resources. Sensors are used increasingly in a range of monitoring or exploratory applications, in particular for biological surveys: for instance, the Xeno-canto project[1] has collected thousands of bird sounds over the world, while as part of the EcoGrid project[2] several Terabytes of data (videos, images and audio recordings) of monitoring forest animals in Taiwan were collected. The proliferation of ecological multimedia data has opened new frontiers in ecology, thus making it an interdisciplinary, collaborative and data-intensive science and shifting from passive analysis performed by expert ecologists to proactively provide analytical information on the environment.

Despite these advances in data collection technologies, the analysis of the acquired multimedia data usually requires very time-consuming and expensive input by human observers. This analytical "bottleneck" greatly restricts the use of these otherwise powerful technologies and demands for efficient organization, browsing and retrieval tools in order to effectively support investigators in monitoring and analyzing the natural environment, promoting its preservation, and understanding the behavior and interactions of the living organisms that are part of it.

This special issue specifically addresses the development of methods for the processing, interpretation, and visualization of multimedia data recorded for monitoring ecological systems, with particular attention to animal and plant identification and classification and pollution analysis.

Animal identification and behavior understanding. Boray et al. in "Robust localization and identification of African clawed frogs in digital images" propose a method for automatic identification of African clawed frogs (*Xenopus laevis* sp.) by processing images taken in a laboratory setting. The authors developed an approach for frog body localization and then tested several low-level feature extraction methods for skin pattern analysis. The results showed that raw pixel values perform the best against rotation, scale, and blurring modifications, whereas SIFT features allow for affine invariance, which might enable the method to operate in "real-life" environments.

Hsiao et al. in "Real-World Underwater Fish Recognition and Identification, using Sparse Representation" describe a distributed real-time underwater video observational system for environmental monitoring of a coral reef ecosystem. The system is provided with an automatic fish species recognition method for fish biodiversity investigation. The fish recognition approach exploits a maximum probability, partial ranking method operating on a sparse representation of low-level visual feature data extracted by means of Eigenfaces and Fisherfaces, and it is able to achieve recognition performance of about 82%.

Plant identification and phenotyping. In "Interactive plant identification based on social image data" Joly et al. present a system that promotes the engagement of both expert botanists and amateurs in the collection of botanical observation data. Taking advantage of a botany-oriented social network, the proposed system collects image data of plants and related metadata that are contributed by the users with the help of a semi-automatic collaborative tagging tool. The knowledge that is accumulated in this way is used for supporting the automatic content-based identification of plants. The use of the system is possible through both a web application and a mobile one. Covering already about half of the plant species living in France (2200 species), the developed system represents a valuable tool for making botanical knowledge accessible to the public and for assisting experts in discovering new knowledge.

Minervini et al. in "Image-based plant phenotyping with incremental learning and active contours" propose a semi-automatic segmentation method for the automated analysis of time-lapse plant images from phenotyping experiments. The method requires minimal user interaction to establish the statistical experiments. Then, it builds plant appearance models based on using color intensity, local texture, and prior knowledge modeled with Gaussian Mixture Models for automatic segmentation of plants in images containing several specimens of the same species. The proposed approach was tested on *Arabidopsis* plant images reporting an average accuracy of 96.7% (Dice Similarity Coefficient), outperforming state-of-the-art methods.

Almeida et al. in "Applying machine learning based on multiscale classifiers to detect remote phenology patterns in Cerrado savanna trees" describe a method for monitoring leaf-changing patterns of Cerrado savanna vegetation by processing still images. The authors first investigate whether temporal variation of color and texture cues allows for plant species categorization, and then apply multiscale classifier, based on Adaboost, to classify phenological patterns. Performance analysis shows good classification accuracy for several plant species.

Multimedia data processing for pollution monitoring. Graves and Newsam in "Camera-based visibility estimation: Incorporating multiple regions and unlabeled observations" investigate image processing and pattern recognition techniques to estimate atmospheric visibility based on the visual content of images from off-the-shelf cameras. The

[1] http://www.xeno-canto.org/.
[2] http://www.aiai.ed.ac.uk/project/ecogrid/.

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1574-9541/

authors implement a prediction model, based on regression trees and multivariate linear regression, that relates image contrast to the coefficient of light extinction. The model is then evaluated with a dataset of images and ground truth light extinction values from a visibility camera system in Phoenix, Arizona. Moumtzidou et al. in “A Model for Environmental Data Extraction from Multimedia and its Evaluation against various Chemical Weather Forecasting Datasets” propose a framework for semi-automatic extraction of pollution information by applying image and text processing techniques on air quality and pollen forecast images automatically retrieved from several free web-services. The results show a satisfactory performance in terms of data recovery and positional accuracy.

Frameworks for supporting environmental monitoring. In “A research tool for long-term and continuous analysis of fish assemblage in coral-reefs using underwater camera footage”, Boom et al. outline a novel and visionary research tool for collecting data related to fish in clear water ecosystems. The proposed system enables continuous monitoring and automated content analysis of the acquired visual data. This allows marine ecologists to explore and screen massive amounts of underwater video material for the presence of fish, providing valuable insight for further experimentation and better understanding of the underwater world.

In “Design and Implementation of a Wireless Video Camera Network for Coastal Erosion Monitoring” Yuting Zhang et al. describe their wireless camera network for monitoring short-term coastal erosion on Thompson Island in the Boston Harbor area. The paper provides practical insights in the cost-effective setup of the network in terms of equipment prices, maintenance costs, power consumption and long term remote access capabilities. It also discusses preliminary results documenting the effects of storm, frost and tide events on cliff erosion, while possibly refuting the claim that boat wakes were the main cause of observed damage.

Multimedia information retrieval on ecological data. The work of Priya and Domnic on “Shot based Keyframe Extraction for Ecological Video Indexing and Retrieval” proposes a three-step approach consisting of shot boundary detection, key-frame extraction and video retrieval. A new block-based feature combining color and edge information is proposed and used to cluster similar consecutive frames. The resulting shot-cluster and the associated keyframe obtained using Inter Cluster Similarity Analysis (ICSA) are evaluated on public datasets, demonstrating high performance compared with state of the art algorithms.

Smeaton et al. discuss the parallels and differences between two separate fields: multimedia information retrieval and heterogeneous sensor networks for environmental monitoring. In their position paper “Multimedia Information Retrieval and Environmental Monitoring: Shared Perspectives on Data Fusion” they focus on trust and reputation and claim that data fusion plays a prominent role in both fields, and that models in both areas need to deal with uncertainty, missing information and overall ranking strategies.

Classification and characterization of natural habitat. Torres and Qiu in "Automatic habitat classification using image analysis and random forest" present a dataset of over 1000 high-quality ground images manually annotated by experts. The authors also describe a method based on random forest for annotating automatically ground images according to the habitat categories they contain. The experimental results show how the proposed approach is able to annotate with good confidence four habitats: woodland and scrub, grassland and marsh, heathland and miscellaneous.

We would like to thank, first, the authors for their contribution to this special issue, then, all the reviewers for the effort and time spent to provide thorough reviews and valuable suggestions on the submitted manuscripts. Finally, we would also like to extend our thanks to the Editor in Chief, Professor Friedrich Recknagel and the entire editorial staff of Ecological Informatics for recognizing the importance that the subject of this special issue may have on future research on this ground-breaking research area, whose development will provide significant benefits for the society, allowing scientists to exploit technology advances in order to better understand the world we live in and how we can sustainably use its resources while preserving biodiversity.

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