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## How Citizen Science and Artificial Intelligence can support Digital Earth

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# How Citizen Science and Artificial Intelligence can support Digital Earth

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**Abstract.** The Digital Earth vision stimulates thinking on how to benefit from new data sources and technologies. In this contribution, we particularly focus on the application of machine learning algorithms on data that has been collected with mobile devices. We present experiences from Copernicus and the identification of (alien) species in order to open a discussion about the possibilities and limits of using Citizen Science and Artificial Intelligence for Digital Earth.

## 1. Introduction

Today, Earth Observation embraces a rich set of diverse data sources, including – among other – satellite imagery, pictures and videos taken by drones, in-situ measurements from sensor systems, and observations from citizens. We are challenged to meaningfully combine these sources and to analyse them so that timely and useful knowledge is extracted. Whereas the Digital Earth vision [1] and concepts such as the Digital Earth Nervous System [2] do provide us with the frameworks and theory that is required to develop sensible solutions, we usually see only few specific applications that put high-level concepts into practice. Examples include the monitoring of seasonal and daytime population density, identification of migration flows, damage assessments after natural disasters.

In between the overall frameworks, and the concrete applications, we see a lack of a more structured investigation and reflection on how particular approaches can be applied. In our work we focus on two such approaches, which are both widely discussed in the past few years: Citizen Science and Artificial Intelligence.

## 2. Background

Citizen Science embraces a suite of tools and methodologies for public participation in scientific research, including – for example – the contribution of volunteers in data gathering, provision of computing power, human cognition, dissemination of scientific results, as well as, the framing of research questions, methodologies and tools [3].

Following earlier research of the European Commission, we understand Artificial Intelligence (AI) as ‘a generic term that refers to any machine or algorithm that is capable of observing its environment, learning, and based on the knowledge and experience gained, take intelligent actions or propose decisions. Autonomy of decision processes and interaction with other machines and humans are other dimensions that need to be considered’ [4].

Citizen Science and AI can be applied in many useful combinations. On the one hand, knowledge generated by citizen scientists can provide ground truth for AI algorithms, an additional data source to process, or support (crowd-based) semantic annotation of Earth Observation (EO) imagery. For example



– motivated through gamification – Citizen Science can help to gather additional knowledge about geographic areas that are not sufficiently covered by digital models from other sources. On the other hand, AI can help in EO imagery processing, identify data gaps, and data capturing requirements that can help to shape Citizen Science actions in a way that would benefit the optional combination of human intelligence and computational power.

Whereas the arising possibilities are manifold, it should not be forgotten that such an implementation of the Digital Earth vision also comes with its challenges. Among other, ethical considerations and matters of trust should be highlighted. People might not be particularly keen to be guided (or ‘controlled’) by AI algorithms. Furthermore, citizens might not support the vision that the data they produce is handled by systems that are basically black boxes. Overall, we see a strong need to address both the opportunities and challenges in combining Citizen Science with AI.

### 3. Two guiding examples

Motivated by the increasing availability of open and free EO data we assessed the practical and computational aspects of multi-class Sentinel-2 image segmentation with convolutional neural network (CNN) models, using an annotated learning set is derived from the INSPIRE knowledge base [5]. The CNN model proofed to produce relatively high quality data for the machine-driven mapping of geographical data gaps and for potential updating of the existing information. Except for data generation, the CNN model can automatically identify land use changes. In order to improve the original approach, on-site checks by citizen scientists could help to verify the detections from the CNN model. The combined use of the CNN model with citizens’ on-site check can improve land use monitoring.

In addition, we started to investigate self-learning recognition of invasive alien species based on geo-located photographs. We examined the possible use of already available machine learning approaches for two purposes. First, the images retrieved from the ‘Invasive Alien Species Europe’ mobile application were pre-validated automatically using well-established image recognition algorithms offered by Google and Microsoft. In this way, we could identify those images that are likely to include information about a plant or animal species, and filter out inappropriate contributions. Second, the remaining (approximately 400) images of our test data set were validated by experts (as a golden standard), and we applied a machine learning model that was trained to recognize approximately 8000 different species in the context of a competition that was launched by iNaturalist in 2018.

### 4. Conclusions

By presenting the results of our work at the 11th International Symposium on Digital Earth, we explore a novel area for Digital Earth research and hope to stimulate a constructive debate about the most urgent research questions. The discussions will inform our future research on the topic, and should especially help to explore a more general methodology to combine AI and Citizen Science.

### References

- [1] Goodchild M F, Guo H, Annoni A, et al. 2012 Next-generation Digital Earth *Proceedings of the National Academy of Sciences* Jul 2012 **109** (28) 11088-11094
- [2] De Longueville B, Annoni A, Schade S, et al. 2010 Digital Earth's Nervous System for crisis events: real-time Sensor Web Enablement of Volunteered Geographic Information *International Journal of Digital Earth* **3:3** 242-259
- [3] Shirk J L, Ballard H L, Wilderman C C, et al. 2012 Public participation in scientific research: a framework for deliberate design *Ecology and Society* **17**(2) 29
- [4] Craglia M, Annoni A, Benczur P, et al. 2018 *Artificial Intelligence - A European Perspective* EUR 29425 EN Publications Office Luxembourg ISBN 978-92-79-97217-1 DOI:10.2760/11251 JRC113826
- [5] Syrris V, Hasenohr P, Delipetrev B, Kotsev A, Kempeneers P, and Soille P 2019 Evaluation of the Potential of Convolutional Neural Networks and Random Forests for Multi-Class Segmentation of Sentinel-2 Imagery *Remote Sensing* **11**(8) 907