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SMART Global Ecosystems an academic-industrial partnership to integrate artificial intelligence in forestry

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Abstract

SMART Global Ecosystems is an alliance between the University of Valladolid and the technological company SNGULAR to promote research and training in the area of artificial intelligence and sustainable environmental data science through information and communication technologies (ICTs) and big data analysis. ICTs, together with massive data analysis, open a world of opportunities to implement training, research, and social awareness actions to develop data science and artificial intelligence methods and products that facilitate sustainable ecosystem management. Through the development of ecosystem monitoring, analysis, and management methods based on data science and artificial intelligence, the aim is to ensure Sustainability, Mitigation, Adaptation, Resilience to Global Change, and Trade-offs of Ecosystem Services (SMART) globally. Promoters, professors and researchers at the University of Valladolid (campus at Palencia) and the data and artificial intelligence team from SNGULAR, have been collaborating for twenty years in the development of programs and algorithms for ecosystem management. Through different collaborative projects developed with students from master DATAFOREST (University of Valladolid) and from Vietnam National University-University of Science (VNU University of Science), we have generated a set of lessons learned on the detection of singular trees by using ground and remote sensing data and artificial intelligence.

Keywords: Innovation, Partnerships, Monitoring and data collection, Research, Learning by doing.

Introduction, scope and main objectives

Artificial Intelligence (AI) is formerly known as the ability of computer systems to simulate human intelligence processes such as natural language processing, decision-making or visual perception. This technology is one of the most popular topics nowadays and it's becoming a very important part of most industries. For instance, forestry is one of the fields where AI, and specifically Computer Vision, is gaining popularity. It is due to the progress in image acquisition, the access to satellite data and the huge amount of information we can extract from these images. Remote sensing is a crucial tool in forest monitoring and represents a landmark in monitoring

for different important issues as CO2 emissions reduction from deforestation and forest degradation and versification of the impact of silvicultural activities. The combination of remote sensing imagery and computer vision in operational forestry allows managers and decision makers to implement sound policies. Computer Vision enables computers to understand the content of images and videos. Driven by the latest advances in Deep Learning, it is key both in the process of acquiring and improving the quality of images and in the detection of objects in real-time. Computer Vision is present in many solutions, like tracking animals (Chen et al., 2019), detecting fires (Dios et al., 2008), timber classification (Ravindran et al., 2021) or plant pathology detection (Zhou et al., 2020) in an automated way. Thanks to this automation, we can carry out safer inspection and maintenance tasks "at a distance", by using cameras, robots and drones.

The main objectives of this alliance are to provide new skills in AI and leading-edge technologies that enhance students and further exploration of the AI methods to develop new ecosystem management tools. To accomplish these objectives, a dynamic challenge has been proposed to students from master DATAFOREST (University of Valladolid) and students from Faculty of Environmental Sciences and Faculty of Geography (Vietnam National University-University of Science). In this way, students have been exploring the new AI methods in a practical way. The study and practice of AI methods during the tertiary stage of education bring the students the opportunity to come closer to leading-edge technologies that can be not well-known during their degrees on forestry or natural resources. The knowledge of AI algorithms and tools complete their training and prepare them for their future career. Moreover, this experience enriches their expertise in dealing with actual problems, using real data and could be a great first contact making research and industry applications.

Approach

Integration of different actors (students, professors, researchers and developers) on a focused project has been facilitated by the challenge of locating Global Singular Trees by using AI, developing a procedure upscalable from regional to global scale. Students from the University of Valladolid (master on DATAFOREST, https://dataforest.uva.es/), Spain and Vietnam National University-University of Science, Hanoi were selected to participate in the project due their interest on the topic and their skills to develop the envisaged tasks. nvolved students have been confronted with the challenge of locating and identifying singular trees in the forest through the use of remote sensing and artificial intelligence techniques. Different questions were first addressed by the students assisted by the supporting team from universities and company. Follows the main questions and how were addressed during the collaboration.

What is a Global Singular Tree? Trees are the largest singular living entities on Earth, but among them there are exceptionally large ones, both from the point of view of their enormous size and because they are very large in comparison with the rest of the trees in their environment or of their species. This exceptional size is usually linked to advanced age, but singular trees are not always very old. They can also be found isolated or in the middle of a forest. Many inventories of singular trees include specimens that may be exceptional for various reasons, not only size but also age, shape, beauty or historical-cultural value. The definition at operational level has been shaped in successive stages, as progress is made in managing the databases and available tools. Just to launch an avenue of research, we took as first approach the methodology used for the superior-tree selection in the wild for breeding programs:

- In even-aged and monospecific forests, the comparison-tree selection techniques are applied (comparing the candidate tree with the best 5-6 in the stand and defining a minimum percentage of superiority in the targeted trait, such as size).
- In uneven-aged stands or mixed forests, the comparison with neighbor trees is not suitable, being the baseline method an alternative (after an inventory, the highest percentile of interest is defined based on a broad picture of the variation of sizes with age, for example).

Why the Global Singular Trees matter? Trees of exceptional size are important from several points of view: they are important carbon stores and have a great effect on the microclimatic conditions of the site where they are found; They are home to great amount of biodiversity, including vertebrate and invertebrate animals, plants, fungi, and microorganisms, providing a large number and diversity of microhabitats. They play an important role in the dynamics of the ecosystem and particularly in the population genetics due to their production of pollen and seeds. They can be of great value for genetic improvement programs and of great interest for research because they are historical archives of remote climatic events, disturbances from the past (fires, pests, diseases ...). They are also a treasure from the socio-cultural point of view: legacy of ancestral uses and uses, traditions and customs, spiritual values, together with their great aesthetic value and their imprint on the landscape, which in many places has encouraged cultural and tourist developments, and of course human welfare.

Why this challenge? Knowing the location of unique trees is, in itself, an important step in helping to ensure their protection and conservation. It could also give rise to addressing environmental education and outreach actions. The procedure could perhaps be applied to phenotypic selection for breeding programs.

Until now there have been different approaches to locating singular trees, following different methods depending on the objectives. Traditional methods are supported by the knowledge of the local population about their environment, a review of various publications, and field inventories. These methods are time consuming and costly. Additionally, random sampling can lead to singular tree no detection so the integration of wall-to-wall information is needed to a comprehensive information. AI localization from remote sensing data and images of candidate trees to have these qualities could speed up their localization and reduce costs. It would also be of great help in areas of difficult access, large areas of forest with little population or little forest management. For this, the procedure should be applicable to different types of ecosystems and scalable.

Once these basic questions were addressed in the first stage our team started to develop the complete methodology that enabled find singular trees but also served as a learning by doing project for the involved students. The learning process included different questions that also were addressed by our team.

What IT tools has been learned by students? Students have had the opportunity to apply learned skills in collaborative programming. To achieve their goals, they followed this itinerary:

- Selection of target trees from a database, half considered as singular trees and the other considered as regular ones
- Developing scripts within *Google Colab* environment (https://colab.research.google.com/) to gather satellite images focused on the places previously described.
- Using AI technology, training models to evaluate whether an image includes singular trees or not, based on the capabilities of *Google Earth Engine* (GEE https://earthengine.google.com/)
- And finally, they tested the location of new Singular Trees outside the original database.

Open-source Learning Management System (LMS) based on Moodle framework and deployed on University of Valladolid (Spain) servers has been used to facilitate interaction between learners and knowledge facilitators (fig. 1) where different activities have been developed (see result section for details)

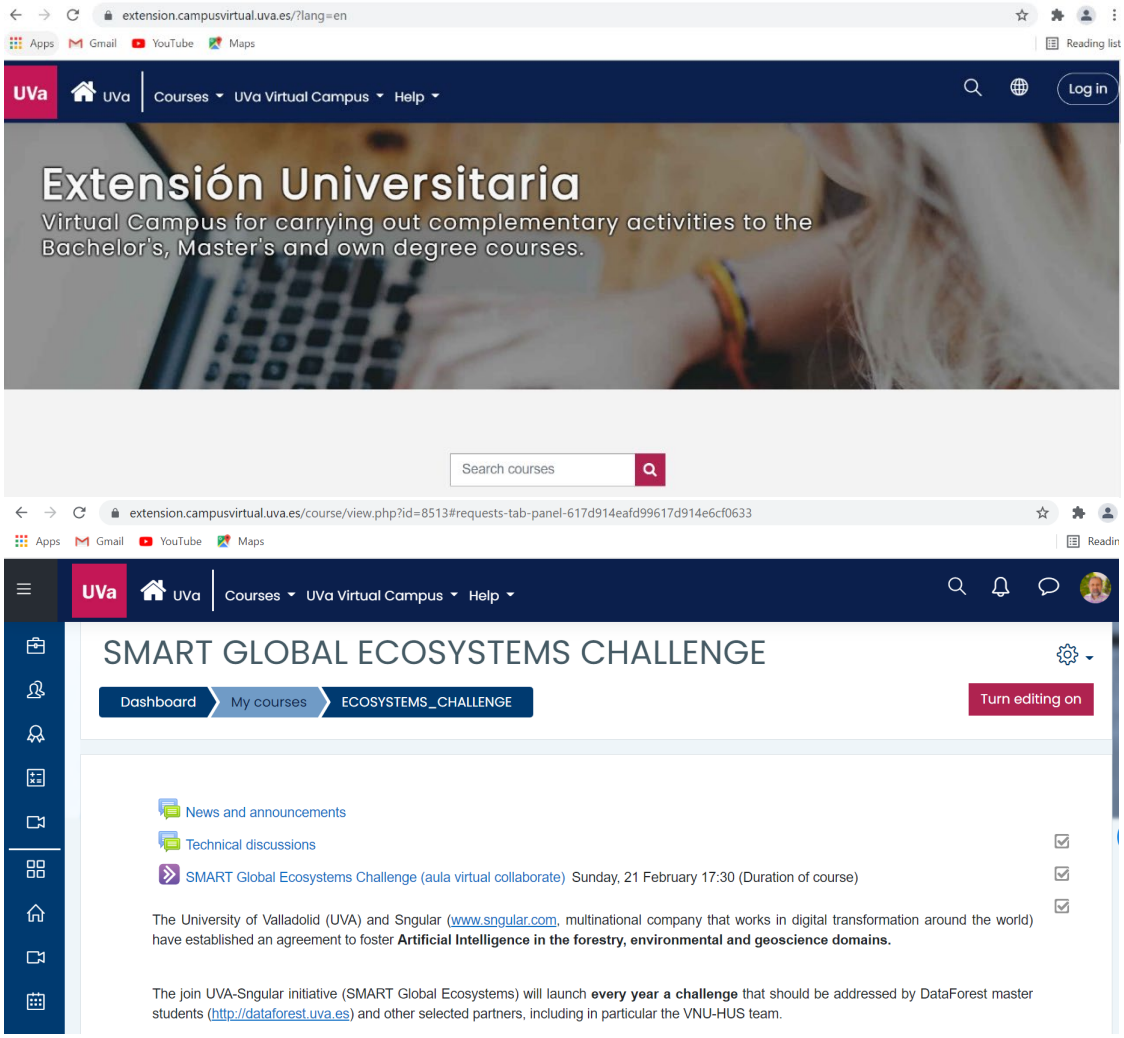

Fig. 1: University of Valladolid extension e-campus where SMART Global Ecosystems challenges are deployed

Results

Participation in the singular trees challenge equipped a new cohort of forest and natural resources students with:

- Insight on artificial intelligence techniques
- Multicultural experience working with students, professors, and professionals from Europe, America and Asia
- First-hand experience on project management and solving problems
- Credits on the final product that can be included in their CV.

A set of resources on the use of remote sensing and artificial intelligence in the forest and natural resources management has been created, collected and adapted (fig. 2 and table 1) These resources have been used in the project and will be used to train new students in the regular bachelor and master degrees both at University of Valladolid and Vietnam National University.

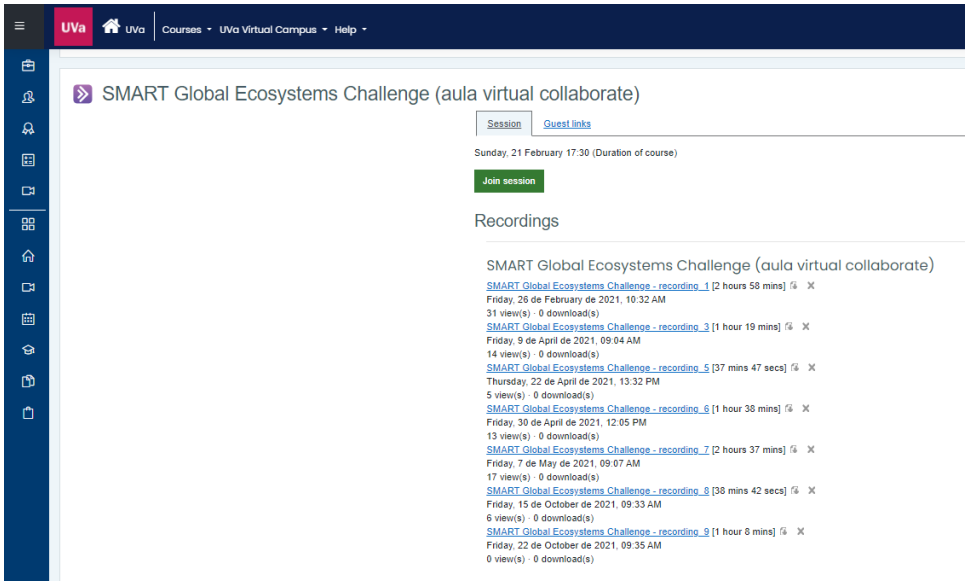

Fig. 2: Video meeting area in the University of Valladolid Learning Management System.

Soon students learned that generating an AI learning model is only a small piece of the whole project. It is necessary to put in place processes around it to make it work properly. Students also realized soon that different profiles (domain experts, data engineers, data scientists and data analysts) must work together and aligned to do properly the project.

Table 1: Resources created, collected and adapted during the singular trees project

Introductory seminars	• Data Science of Natural Environmental • What is a Global Singular Tree? • Artificial Intelligence: A look into future • From data to Artificial Intelligence • Artificial Intelligence at a Glance • How get the most from Google cloud: tools and resources • Introduction to REST APIs - A showcase in natural resources
How to do an AI Project?	• Five steps to help you scope AI projects effectively • DeepWind: Weakly Supervised Localization of Wind Turbines in Satellite Imagery • IDTReeS: Integrating Data science with Trees and Remote Sensing • Artificial Intelligence and the Forestry Sector • Singular trees ML Pipeline: Proposal & ideas for the project • Computer Vision 101 The machine Learning approach • How to do Region based Convolutional Neural Networks (R-CNN) in brief • What's growing there? Using eo-learn and fastai to identify crops from multi-spectral remote sensing data • Land cover classification with eo-learn • Get started with Google Colaboratory • Starting with Tensorflow
Data sources	• Ground (https://github.com/SMARTGlobalEcosystem-SingularTree/) • Remote sensing (Google Earth Engine)

Discussion

It is undeniable that international partnerships between universities and industrial partnerships are beneficial to all, from the professors and students to the world as a whole. This cooperation between the University of Valladolid, Vietnam National University of Science, and SNGULAR has brought benefits to the involved individuals and parties.

The collaborative activities under the framework of the projects led to a variety of outcomes, both tangible and intangible. Students, Professors, Staffs, and their institutions benefited in significant ways. Tangible outcomes included publication, learning resources and new interactions as ongoing master and doctoral thesis. Furthermore, the opportunity to meet virtually and work with people across disciplines and at other institutions helped participants, especially the students, to build relationships and professional networks that often continue beyond the life of the project.

The intangible benefits of collaborative project activities are less visible and certainly more difficult to measure. However, they are equally important to individual students, professors, staff involved in the project. For the students from Vietnam National University, enhanced community and collegiality were outcomes of being a part of the SMART Global Ecosystem project. As we learned from this project, various forms of collaboration activities, seminars, and joint programming work has promoted student proactive behavior, commitment to joint work, improved teamwork skills, knowledge gained in technologies, and application of theoretical knowledge into practice. Moreover, the project result also witnesses the learned of renewed and reenergized young lecturers as being part of an international project. The learning, increased productivity, and enhanced collegial relationships that resulted from the varied collaborations activities contributed substantially to these intangibles, but very beneficial, outcomes.

Additionally, the project helps to eliminate barriers due the silo effect (each person working on her/his topics with his/her tools and objectives) promoting new approaches to solve problems integrating views (tools, vocabularies, …) from different disciplines to generate meaningful and useful outcomes. Traditionally, forestry and forest science tend to be local but locals are the parameters not the scientific laws beneath the local conditions. Our challenge helps participant to focus on the things we share and not in the thing we differ in terms of ecosystems and forest management approaches. The collaborative and innovative methods allow the cross-fertilization with other disciplines and the adoption of integrative approaches.

Conclusions

The main outcome of this collaboration has been the integration of different approaches to generate a new framework to train new generations of foresters and natural resources managers on artificial intelligence including different dimensions as (1) insight and analysis of emerging methodologies, (2) data engineering (gathering, storage, processing, ...) and (3) upscaling from data science to decision making. Students learn by doing the basic approach for an artificial intelligence project (understand the domain, make the right questions, look for the valuable data, select the right modeling approach, build the model with different algorithms and, finally, deploy the solution in an operational environment) that they used to detect singular trees in the forests.

In the long term this industry-university partnership is fostering the integration of cutting-edge methodologies both in the academia and the company. While this partnership provided additional funding and new ideas to university, for the industry, always hungry of fresh ideas, provide new opportunities for networking with students and professors and access to lead scientists. New potential cooperation pathways with other

companies and universities (as the collaboration with VNU showed) are arising after the SMART Global Ecosystems partnership were launched by SNGULAR and University of Valladolid.

Acknowledgements

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References

Chen, R., Little, R., Mihaylova, L., Delahay, R., & Cox, R. (2019). Wildlife surveillance using deep learning methods. Ecology and Evolution, 9(17), 9453–9466.

Dios, J. R. M., Martinez-de Dios, J. R., Arrue, B. C., Ollero, A., Merino, L., & Gómez-Rodríguez, F. (2008). Computer vision techniques for forest fire perception. In Image and Vision Computing (Vol. 26, Issue 4, pp. 550–562). https://doi.org/10.1016/j.imavis.2007.07.002

Ravindran, P., Owens, F. C., Wade, A. C., Vega, P., Montenegro, R., Shmulsky, R., & Wiedenhoeft, A. C. (2021). Field-Deployable Computer Vision Wood Identification of Peruvian Timbers. Frontiers in Plant Science, 12, 647515.

Zhou, H., Zhuang, Z., Liu, Y., Liu, Y., & Zhang, X. (2020). Defect Classification of Green Plums Based on Deep Learning. Sensors, 20(23). https://doi.org/10.3390/s20236993