Editorial
Special Issue on *Artificial Intelligence for Sustainability*

Joaquín Salas *Member, IEEE*, Geneviève Patterson and Flavio de Barros Vidal

***Index Terms*—Artificial Intelligence, Sustainability, Biodiversity, Human Vulnerability.**

Sustainability is the challenge of our time. It is an exciting and necessary problem to be solved that requires an all-hands-on-deck attitude. Given the demonstrated capabilities developed in Artificial Intelligence (AI) during the last decades, the techniques it provides may ease the ancestral problems in Latin America and the Caribbeans (LAC) related to its development. Current climatological models predict that given its relatively little contribution to the emission of greenhouse gases, LAC will suffer a disproportionate effect of extreme weather events (EWEs) in the form of droughts, forest fires, and flooding. These events could significantly alter the life of about 660 million LAC's inhabitants, making it harder to thrive in societies that have historically demonstrated low fluidity, inequality, and gender and family-based violence. Furthermore, EWEs have the potential to be catastrophic for the biodiversity of LAC, which holds about 60% of the terrestrial life.

Despite the dangers of climate change, the current era could be a positive turning point for LAC, where economic growth can coincide with improved living standards for vulnerable populations. LAC can convert historical exploitation and neglect into efficiency, equity, and symbiotic stewardship of natural resources. LAC has many natural advantages that position it well for decarbonization of the energy sectors, electrification, and other sustainability-related areas of the economy, which can be sources of new jobs and valuable education. LAC is positioned in many ways for a bright, post-fossil-fuel future driven by a technology-focused, bottom-up, whole-of-society effort for socio-environmental sustainability. We must communicate to researchers, policymakers, and the public, how sustainability work will improve the future, not just lessen the destruction.

There is a profound opportunity to contribute to constructing more resilient societies in LAC. Besides proposing a roadmap defining the use of AI for sustainability in terms of biodiversity, human vulnerability, and climate change, this special issue (SI) unveils the degree to which LAC is currently under served in terms of research exploring the use of advanced analysis techniques to withstand its development. For its preparation, this SI welcomed an initial 32 submissions. Ultimately, the Guest Editorial Board accepted 12.

This SI is forwarded by an article by ourselves, the editors, Joaquín Salas, Genevieve Patterson, and Flavio de Barros Vidal. We present a systematic mapping of AI solutions to address the sustainability challenges in LAC. As the systematic mapping suggests, the rest of the articles could be organized by topics addressing human vulnerability, biodiversity, and climate change. More specifically, our accepted submissions fell into the following slightly narrower application areas of those three more prominent topics.

a) Energy & Transportation: In the article *Prediction of the Estimated Time of Arrival (ETA) of container ships on short-sea shipping: A pragmatical analysis*, Valero *et al.* present a proposal to make the maritime industry greener. Using automatic identification systems and meteorological data, their model is capable of predicting, in a data set collected under actual conditions, ETA for port management with low error tolerance.

In the meantime, in *A multi-objective swarm approach with pedestrians spotlight in urban traffic optimization*, Olivera and Vidal study the problem of traffic light synchronization to reduce the time it takes pedestrians to move between places. They demonstrate their approach by employing a large-scale urban area and obtain promising results compared to state-of-the-art alternatives.

Also, in *Hybridization of NSGA-II and MILP for optimization of the location of electric-scooter sharing-stations*, Baquela and Olivera research methods to optimally place electric scooters stations employing a blend of genetic and linear programming techniques. Their method results in solutions for the decision-maker to explore the tradeoffs between coverage and costs. The method finds parallelisms with the problem of placing bicycle stations and can be employed altogether.

Next, in, *The Role of Artificial Intelligence in Latin America's Energy Transition*, Meza Jimenez *et al.* contribute a detailed and well-cited survey of the current problems in decarbonizing and stabilizing Latin American power systems and how AI technologies may be able to help. This paper starts by giving an overview of the state and challenges of Latin America's energy transition and provides a primer on AI. AI researchers and readers from industry and policymaking will find an overview of applications of AI in the electric energy system and a maturity model to assess the state within system operators. This substantial work could be a key reading for anyone who wants to study energy in LAC.

Joaquín Salas is with the Instituto Politécnico Nacional, México.

Geneviève Patterson is an industrial researcher and member of the nonprofit organization Climate Change AI.

Flavio de Barros Vidal is with the University of Brasilia, Brazil.

Finally, in *Experimental Validation of State of Charge Estimation by Extended Kalman Filter and Modified Coulomb Counting*, Sylvestrin *et al.* present an implementation using the Extended version of the Kalman Filter to estimate the state of charge of battery management systems. The method presented is called *Modified Coulomb Counting*, which allows for a simple and low estimation error (less than 1%), allowing its application in lithium cells with greater efficiency and allowing its use with more excellent reliability in the powering devices such as electric vehicles, crucial in the process of implementing carbon and pollutant reductions.

b) Biodiversity Monitoring: Campos *et al.* contribute the article, *Simplifying VGG-16 for Plant Species Identification*, which proposes structural changes to the popular VGG network architecture to create smaller, easier to train, easier to deploy in the field models. This paper presents a new plant classification benchmark, the Mexico 120 dataset, which we as editors hope will draw attention to the wide variety of biodiversity deserving of attention in LAC.

Esquivel-Barboza *et al.* give a clever solution for hallucinating images of plants at different ages and states of decay in, *Senescence Reversion in Plant Images Using Perception and Unpaired Data.* This paper explores the use of CycleGAN for senescence inversion without using paired images, and compares to more commonly used approaches that require paired images. This solution obviates the need for paired training data, which opens up possibilities for experiments starting with fewer images.

In the process of elaborating and developing techniques for the conservation of biodiversity, it is vital to develop non-invasive methods to preserve the natural interaction of the monitored species with its ecosystem. In this line, the work created by Tavares, T. F. entitled *Open-set classification approaches to automatic bird song identification: towards non-invasive wildlife monitoring in Brazilian fauna* allows automatic monitoring to identify the song of Brazilian fauna birds using an Open-set approach. Despite being an early work, the author demonstrates the range of opportunities still open for improvements in this type of approach to wildlife monitoring.

c) GHG Emissions Mitigation: In the only paper in this special issue to directly address emissions, *A k-means-based-approach to analyze the emissions of GHG in the municipalities of MATOPIBA region, Brazil*, Ferreira Paiva *et al.* created a task-specific GHG emissions dataset for the Matopiba region in Brazil from an extensive database of emissions data for the whole country. Helpfully, the authors released a public GitHub repository with the emissions data points and python code for processing the dataset in the same fashion as in the paper. This article presents an interesting trade-off between the state of land use and agricultural development in a local area versus different types of GHG emissions.

d) Agriculture and Land Use: In a work by Silva, M. A. S. *et al.* entitled *Tracking the Connection Between Brazilian Agricultural Diversity and Native Vegetation Change by a Machine Learning Approach*, an approach is presented using artificial neural networks based on self-organizing maps to relate the high variability of agriculture and changes in native vegetation. The proposed method was applied in Brazil's Midwest and North regions, where the spatial relationship of the diversification patterns and the dynamics of native vegetation is more intense and contains the most critical and essential biomes (Cerrado and Amazon).

In summary, we believe the papers included in this SI are a fair sampling of the emerging field of AI for Sustainability. They offer a vision of a future where technology is put to work for responsible and well-considered change.

We take this opportunity to express our sincere thanks to all the authors who submitted their works to this SI and the anonymous referees who helped the authors improve their contributions by providing constructive feedback. We also thank the people on this journal's Steering Committee for accepting our proposal.

Finally, we extent our gratitude to the members of the Guest Editorial Board who generously participated providing useful feedback and revision for the papers submitted to this Special Issue. They include: Adolfo Bauchspiess (University of Brasilia), Agata Lapedriza Garcia (Universitat Oberta de Catalunya, Massachusetts Institute of Technology), Alcides X. Benicasa (IFSE), Álvaro Nogueira de Souza (University of Brasilia), Ana Carolina Lorena (Instituto Tecnológico de Aeronáutica), Ana Paula G. S. de Almeida (University of Brasilia), Andre Luis S. Braga (Audi), Anésio Leles Ferreira Filho (University of Brasilia), Antonio Fernández-García (Universidad de Extremadura), Benjamín Barán (Universidad Nacional de Asunción), Carla Maria Chagas C. Koike (University of Brasilia), Cauê Zaghetto (Samsung Research), Cecilia Sandoval-Ruiz (Universidad de Carabobo), Cristóbal de la Maza (Universidad San Sebastián), Daniel Mauricio Muñoz Arboleda (University of Brasilia), Daniel Robles Camarillo (Universidad Politécnica de Pachuca), Edgar Román-Rangel (Instituto Tecnológico Autónomo de México), Erik Zamora (Instituto Politécnico Nacional), Flávio Elias Gomes de Deus (University of Brasilia), Francisco Sánchez (Universidad de Jaen), Geraldo Pereira Rocha Filho (University of Brasilia), Hannah Quay-de la Vallee (Center for Democracy and Techonology), Hari Prasanna Das (University of California, Berkeley), Issabelle Tingzon (Technical University of Munich), Ivan Camargo (University of Brasilia), Ján Drgoňa (Pacific Northwest National Laboratory), Jesús Hernández (University of Jaén), John Oberlin (Avtiv Surgical), José Francisco Martinez Trinidad (Instituto Nacional de Astrofísica, Óptica y Electrónica), Juan Irving Vasquez-Gomez (Consejo Nacional de Ciencia y Tecnología), Juan Ramon Terven (AiFi), Kalai Ramea (Palo Alto Research Center), Lakshmi Babu Saheer (Anglia Ruskin University), Lucas Faria Porto (Rumina SA), Luiz Antonio Celiberto Jr. (UFABC), Marcelo García (Universidad Politecnica Salesiana), Marcus Voss (Technische Universität Berlin), Michael Barbehenn (Massachusetts Institute of Technology), Moacir Antonelli Ponti (USP), Nikola Milojevic-Dupont (Technische Universität Berlin), Omar Rodriguez Abreu (Universidad Politécnica de Querétaro), Othon Gonzalez Chávez (Centro de Investigación en Ciencias de Información Geoespacial), Pablo Martín Vera (Universidad Nacional de La Matanza), Pablo Vera Alfaro (Instituto Politécnico Nacional), Raphael Batista (IFMG), Reynaldo Iracheta Cortez

(Consejo Nacional de Ciencia y Tecnología), Rubén Ruelas (Universidad de Guadalajara), Sara Beery (Massachusetts Institute of Technology), Wilfrido Gómez Flores (Centro de Investigación y Estudios Avanzados).

ACKNOWLEDGEMENTS

This research received financial support from UCMexus-CONACYT, SECTEI under grant 201/2021, and SIP-IPN 20220583 for Joaquín Salas. Thanks to the anonymous reviewers for their insightful comments.

Joaquin Salas is a professor in the field of Computer Vision at Instituto Politécnico Nacional. Member of the Mexican National Research System, his research interests include monitoring natural systems using visual perception and aerial platforms. Salas received a Ph.D. in computer science from ITESM, México. He has been a visiting scholar at MIT, Stanford, Duke, Oregon State, Xerox PARC, the Computer Vision Center, and the ÉNST de Bretagne. He has served as co-chairperson of the Mexican Conference for Pattern Recognition three times. Salas was a Fulbright scholar for the US State Department. He has been invited editor for Elsevier Pattern Recognition and Pattern Recognition Letters. For his services at the Instituto Politécnico Nacional, he received the *Lázaro Cárdenas* medal from the President of Mexico.

Geneviève Patterson is a freelance researcher. Until July 2022, she was the Head of Applied Research at Visual Supply Company (VSCO), specializing in Computer Vision and Blockchain technologies and is a Core Team Volunteer at Climate Change AI. Previously, she was CTO of the TRASH app (acquired by VSCO). Before working on her start-up, she was a Postdoctoral Researcher at Microsoft Research New England. Her research focuses on human-in-the-loop AI methods. Her interests include AI for climate science, cinematic video understanding, and active learning. She received her Ph.D. from Brown University in 2016. Contact her at genevieve@climatechange.ai.

Flavio de Barros Vidal received a B.Sc. in Electrical Engineering from the Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil, in 2002. Then, in 2005, he received an M.Sc. in Electrical Engineering from the University of Brasilia (UnB), Brasília, Brazil. In 2009, he received a Ph.D. in Electrical Engineering from the University of Brasília, Brasília, Brazil. He is currently an Senior professor in the Department of Computer Science at the University of Brasilia, Brazil. His current research interests include forensics, biometrics, deep learning, and computer vision. He is the leader of the Biometric and Technologies Group (BiTGroup) and a member of the Image, Signal, and Acoustic research group (LISA), both at the University of Brasília, Brazil. Contact him at fbvidal@unb.br.