

Luís Correia
Luís Paulo Reis
José Cascalho
Luís Mendes Gomes
Hélia Guerra
Pedro Cardoso (Eds.)

ADVANCES IN ARTIFICIAL INTELLIGENCE _ LOCAL PROCEEDINGS

EPIA 2013 _ XVI Portuguese Conference on Artificial Intelligence
Angra do Heroísmo, Azores, Portugal, 9 -12 September



Luís Correia
Luís Paulo Reis
José Cascalho
Luís Mendes Gomes
Hélia Guerra
Pedro Cardoso (Eds.)

Advances in Artificial Intelligence Local Proceedings

EPIA 2013 - XVI Portuguese Conference on Artificial Intelligence
Angra do Heroísmo, Azores, Portugal, 9 – 12 September



Centre for Applied Mathematics and Information Technology
Department of Mathematics
University of Azores



Title: Advances in Artificial Intelligence, 16th Portuguese Conference on Artificial Intelligence. EPIA 2013. Angra do Heroísmo, September 9 – 12. Local Proceedings

Volume editors: Luís Correia, Luís Paulo Reis, Luís Mendes Gomes, Hélia Guerra, Pedro Cardoso

Cover: Carolina Furtado

Printing and binding: Coingra

ISBN: 978-989-95489-1-6

Depósito legal: 363242/13

©2013 CMATI, Universidade dos Açores, Portugal

Table of Contents

Invited Speakers Abstracts

Exploring complex MAS systems: Applications & Challenges	2
<i>Maria Faslì</i>	
Challenges for AI in Computational Sustainability	4
<i>Carla P. Gomes</i>	
Empathy in agents and robots	5
<i>Ana Paiva</i>	
When Algorithms Inform Real Life: Novelty Search and the Myth of the Objective	6
<i>Kenneth Stanley</i>	

Challenges Invited Contributions

Open Space of Opportunities in AI: the challenges now	8
<i>Helder Coelho</i>	
Perspectives and progress of ecology and conservation science in the Azores: the possible contribution of Artificial Intelligence.	11
<i>Paulo A. V. Borges, Pedro Cardoso, Orlando Guerreiro, François Ri- gal, Margarida Florencio, Isabel R. Amorim, Luís Borda-de-Agua, José Cascalho, Miguel Ferreira</i>	
The role of Machine Learning in understanding volcanoes behaviour for risk mitigation	15
<i>João Luís Gaspar, Luís Mendes Gomes, Gabriela Queiroz, Teresa Fer- reira</i>	
Optimal Transportation Networks under Low Demand and Public Service Obligations: An Operational Research Approach with an Application to the Azores	21
<i>João Pedro Pita, António Pais Antunes, António Gomes de Menezes</i>	
New technique for sampling the commercial fish sizes to be applied in landing ports and fishing vessels	29
<i>Gui M. Menezes</i>	

Perspectives and progress of ecology and conservation science in the Azores: the possible contribution of Artificial Intelligence

Paulo A.V. Borges¹, Pedro Cardoso^{1,2}, Orlando Guerreiro¹, François Rigal¹, Margarita Florencio¹, Isabel R. Amorim¹, Luís Borda-de-Água³, José Cascalho⁴, Miguel Ferreira⁵

¹Azorean Biodiversity Group (CITA-A) and Portuguese Platform for Enhancing Ecological Research & Sustainability (PEERS), University of the Azores, Angra do Heroísmo, Portugal

²Finnish Museum of Natural History, University of Helsinki, Finland

³Centro de Biologia Ambiental, Faculdade de Ciências, Universidade de Lisboa, Portugal

⁴CMATI – Centre of Applied Mathematics and Information Technologies, Department of Mathematics, University of the Azores

⁵Centro de Astrofísica, Universidade do Porto

pborges@uac.pt, pedro.cardoso@helsinki.fi, orlandogue@gmail.com, rigal@uac.pt, trakemi@hotmail.com, lbagua@gmail.com, jmc@uac.pt, miguel@uac.pt,

Abstract. There is an urgent need of new methodologies in ecological and conservation science to deal with increasingly complex problems. We introduce four emerging research areas in ecology in which Artificial Intelligence may be explored as a tool to tackle unsolved issues in island ecosystems: (1) modeling abundance of plant and animal species in space and time; (2) modeling spread of invasive species; (3) estimating species richness based on incomplete sampling and (4) modeling speciation and diversification in insular habitats.

Keywords: Abundance, Distribution, Species Richness, Speciation, Modeling.

1 Introduction

Oceanic islands have long been of special scientific interest, especially in respect to the geological mechanisms of formation and development, the means of biotic colonization, the development of unique biotas and ecosystems, and more recently, due to the extensive loss of endemic species [1]. In the Azores, several pressing issues in the conservation of native ecosystems need to be highlighted, namely the impact of land-use changes and the spread of invasive species in all habitats, including native forests [2,3]. The artificial intelligence field has seen tremendous advances during the latter years, up to a point where computers are able to partly substitute humans in creating and performing experiments, the so called "automation of science" [4]. Here we introduce four emerging research areas in ecology and conservation biology and

suggest the potential of Artificial Intelligence as a tool to tackle unsolved issues in the field of island ecology and evolution.

2 Modeling the abundance of plant and animal species in space and time

Species spatial distribution and abundances are key variables in ecological and conservation sciences [5]. Predicting population and species distributions and abundances across their ranges and over time is of great value for conservation and management purposes, in order to assess the impact of global changes on biodiversity. Distribution data is usually available for many species, but the same is not true for abundance data. In fact, particularly for arthropods, there are many logistical difficulties for obtaining abundance data in many locations.

It would be particularly advantageous if the relationship between local probability of occurrence of a species and its abundance were universal. In the Azores we have already tested this hypothesis, evaluating the degree to which environmental suitability assessed with presence/absence models accounts for abundance estimates [6]. Presence/absence data were modelled using artificial neural networks (ANN), a machine-learning method able to deal with non-linear relationships between the dependent variable and the predictors, therefore accounting for complex data. The results obtained so far were not particularly successful (see [6]), but other solutions based on Artificial Intelligence methodologies are yet to be explored.

3 Modeling the spread of invasive species

Scientists dealing with biological invasions have not been able to effectively persuade society at large nor the political power of the seriousness of the risks associated with biodiversity loss, namely when compared with other environmental risks, such as, climate change. For the Azores the data clearly shows that the widespread and continuous vegetation changes of the last 600 years, through the intensification of land-use management and species introductions, surpasses the effects of past Pleistocene climatic fluctuations [7]. Habitat loss and exotic invasive species are probably the main drivers of biodiversity decline in islands, including the Azores [2].

The artificial intelligence algorithm *Genetic Algorithm for Rule-set Prediction* (GARP) may be used to model the ecological niche of invasive plant species in the archipelago (e.g. *Hedychium* spp.). Using both distribution and environmental data we aim to predict distribution of *Hedychium*, which will improve the management of *Hedychium* dominated habitats for the benefit of Azorean native biodiversity.

The study of distribution patterns of insect pests, like urban termites, is also of high relevance for the Azores. One possibility will be to model the spread of several Azorean termite pests in the main towns, using an agent based modeling approach (see [8]).

4 Estimate species richness based on incomplete sampling

To know how many species live in any particular place at a given time is an overwhelming task. From scales as small as a single tree, which can house thousands of species, to the entire planet, which is home to millions [9], it is impossible to count every single taxon from bacteria to mammals. Thus, one key question in many studies is how to estimate species richness from incomplete samples?

Different approaches have been used to accomplish such goal, including species-area curves, species accumulation curves, parametric distributions of abundances and non-parametric estimators [10]. However, the proposed options are far from being optimal for most datasets. New ways of estimating species richness are in urgent need. Genetic programming, given adequate data, may provide an answer to this challenge. Current algorithms are in fact non-linear and often rather complex equations, obtained through theoretical reasoning. One possibility is to "distill" free-form formulas from complete, or close to complete, datasets including a range of taxa, area sizes and sampling methods in order to find candidate algorithms that are simultaneously efficient, not overly complicated, parsimonious and free from any assumptions.

5 Modeling speciation and diversification in insular habitats

A General Dynamic Model (GDM) of Oceanic Island Biogeography [11] has been recently proposed, which aims to unify ecological and evolutionary biogeography. The GDM is based on three main premises. The first two largely derive from MacArthur & Wilson's theory [12], and include both (1) their immigration/speciation-extinction dynamics, and (2) the argument that speciation and diversification on islands are "encouraged" by the ecological opportunity expressed by the concept of 'empty niche space', intertwined with the geographical opportunity provided by isolation. The final premise recognizes that (3) oceanic islands have a typical developmental life cycle from youth, to maturity, to old age and eventual loss; this cycle plays itself out at a temporal scale resonant with and strongly influencing the evolutionary dynamics of oceanic island archipelagos and basins. We are currently carrying out numerical simulations in order to determine how, in a geologically evolving island, the species richness, the proportion of endemic species and the species abundance distribution change in time. We will then compare our results with the GDM qualitative predictions. However, these simulations are at the same time very simplistic, in the way key ingredients such as speciation are included, but require a significant amount of computing time. The future will tell whether progress towards more realistic models requires completely new tools or importing methodologies from other fields such as Artificial Intelligence.

6 References

1. Whittaker R.J., Fernández-Palacios J.M.: *Island biogeography: ecology, evolution, and conservation*, 2nd edn. Oxford University Press, Oxford, UK (2007).

2. Borges, P.A.V., Azevedo, E.B., Borba, A., Dinis, F.O., Gabriel, R., Silva, E.: Ilhas Oceânicas. In: H.M. Pereira, T. Domingos & L. Vicente (Eds.), *Portugal Millenium Ecosystem Assessment*. pp. 461-508. Escolar Editora, Lisboa, (2009).
3. Borges, P.A.V., Myles, T.G. (Eds.): *Térmitas dos Açores*. Princípiã, Lisboa, (2007).
4. King, R.D., Rowland, J., Oliver, S.G., Young, M., Aubrey, W., Byrne, E., Liakata, M., Markham, M., Pir, P., Soldatova, L.N., Sparkes, A., Whelan, K.E., Clare, A.: The automation of science. *Science*, 324, 85-89 (2009).
5. Solow, A. R., Smith, W. K. On predicting abundance from occupancy. *The American Naturalist*, 176, 96-98 (2010).
6. Jiménez-Valverde, A., Diniz, F. Azevedo, E.B., Borges, P.A.V.: Species distribution models do not account for abundance: the case of arthropods in Terceira Island. *Annales Zoologici Fennici*, 46, 451-464 (2009).
7. Connor, S.E., van Leeuwen, J.F.N., Rittenour, T.M., van der Knaap, W.O., Ammann, B., Björck, S.: The ecological impact of oceanic island colonization – a palaeoecological perspective from the Azores. *Journal of Biogeography*, 39, 1007-1023 (2012).
8. Guerreiro, O., Ferreira, M., Cascalho, J., Borges, P.A.V.: Towards an Agent Based Modeling: The prediction and prevention of the spread of the drywood termite *Cryptotermes brevis*. In: Luis Correia, Luis Paulo Reis, José Cascalho (Eds.) *Progress in Artificial Intelligence EPIA2013 Springer Proceedings* (2013).
9. Mora, C., Tittensor, D.P., Adl, S., Simpson, A.G.B., Worm, B.: How Many Species Are There on Earth and in the Ocean? *PLoS Biology*, 9, e1001127 (2011).
10. Colwell, R.K. & Coddington, J.A. (1994) Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society of London - Biological Sciences*, 345: 101-118.
11. Whittaker, R.J., Kostas A.T., Ladle R. J.: A general dynamic theory of oceanic island biogeography. *Journal of Biogeography*, 35, 977-994 (2008).
12. MacArthur, R.H., Wilson, E.O.: *The theory of island biogeography*. Princeton University Press, Princeton (1967).