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NERC SCIENCE OF THE ENVIRONMENT

Agent Based Modelling for Wildlife Applications (Ref IAP-17-124)

University of Stirling, Biological & Environmental Sciences
In partnership with: Centre for Ecology & Hydrology

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Overview

Agent based models (ABM) enable researchers to gain a better understanding of the interactions between animal populations and the environment. They are simulated environments where entities are modelled and controlled by a set of rules, which through interactions can lead to complex dynamics. Despite the simplifications an ABM facilitates the understanding of complex interplay between multiple agents, including the environment.

This project will focus on building a web based ABM tool which can be used to model wildlife and their environment. The main case study will be based on simulating the movement of wildlife in and around the Chernobyl Exclusion Zone (CEZ), estimating the radiation exposure that each animal species would receive, summarising the population estimates and variation within population, and comparing the model runs to known data. However, the web based ABM would allow other researchers from around the world to devise their own agents, rules, and environments and to share those models, enabling collaborations in exploring a range of wildlife issues and domains. By generating web based simulations the knowledge from expert groups can be better shared and explored by others.

Some work on ABM has been conducted for Swedish moose under the auspices of the International Atomic Energy Agency (IAEA) MODARIA I and II programmes (www-ns.iaea.org/projects/modaria/modaria2.asp) and it is anticipated that this studentship will expand this work into the CEZ studies.

The ideal student would be interested in environmental issues with strong programming skills (e.g. Python, C#, R), GIS skills (e.g. QGIS, PostGIS, ArcGIS), web development skills (e.g. PHP, NodeJS, Leaflet). They would work with a team of experts on radioecology carrying out research in the Chernobyl region.

Figure 1: Elk taken by a Camera Trap in the CEZ
Source: TREE website http://tree.ceh.ac.uk/

Research objectives:

This studentship will focus on the development of simulations (ABMs) based on field data, to further our understanding of the uptake of, and exposure to, radioactivity by wildlife in the exclusion zone around Chernobyl. The overall aim is to provide critical advances in analysis of field data to build better informed modelling of radiation exposure of animals based on their home ranges, food availability, and species type.

An additional objective would be to design and develop a web based simulation environment that allows researchers to setup their own simulations that run in

the cloud, and enable collaboration between different research groups.

The student will address the following research objectives:

1. Develop machine learning tools to process field data on wildlife radiation uptake based on season and species to assist in agent rule generation
2. Develop a web hosted agent based modelling tool that will allow researchers from around the world to collaborate
3. Test (and improve) existing exposure assessment modelling approaches for wildlife in complex contaminated environments.

The field site

Field work and data collection has been carried out in the CEZ by a team of researchers as part of the NERC-funded TREE project (http://tree.ceh.ac.uk/). These data include detailed maps of the radioactive contamination across the zone and camera trap images (see Figure1) of large mammals at locations across the zone to help inform the modelling of animal movement and their exposure to radiation. Further studies by the student in the CEZ can be performed to test the ABM outputs.

Methodology

Data already collected from the field sites will be used to inform rule generation and test the ABM. The student will use statistical and machine learning packages (e.g. using R, Python, Rapidminer) to explore the training data and the knowledge gained from this would facilitate the generation of rules that control animal movements, interactions, and determine radiation exposure.

The student would develop a web based agent modelling framework hosted in the University of Stirling's private cloud. This tool would allow users to sign up online and then set up an environment with agents, including supplying their own basemap environmental data and species distribution maps. They would then be able to define rules for each agent and run simulations. Each agent would have a user defined set of parameters that control its abilities, goals, and interactions. For example an owl may move in straight lines (Euclidean distance) while a wolf would be restricted by barriers (e.g. deep fast flowing rivers). In addition, the system would be able to model group dynamics (e.g. pack animals) and resources (e.g. food availability). Other modelled variables would include species, gender, age, environment, and temporal factors (e.g. winter versus summer flow rates and river depths), as well as other agents (e.g. prey / predator).

The online tool would need to support a range of spatial coordinate systems, and be able to handle large datasets. The outputs from various simulations would be statistically compared against field data to ensure alignment.

Timeline

The development and field components of the studentship will take 36 months to complete, with the remaining time being allocated to writing the thesis & papers for publication, attending conferences & networking. An anticipated timetable might look like:

0-5 months: Literature review; data familiarisation field site visit;
5-8: Development of tools for data analysis
8-30: Development of web based agent based modelling tools
20-36: Model evaluation
37-42 months: Finalise thesis.

Training & Skills

This studentship will provide a platform to build an interdisciplinary research career in applied geospatial technologies in the context of environmental monitoring. The student will also be exposed to GIS modelling methodologies including computer coding and risk & uncertainty analysis, with a focus on web based technologies, such as cloud computing and web services, for effective scientific research.
The student will also benefit from a range of specialist and generic training skills that will be provided during placements within the Centre of Ecology and Hydrology and through membership of the NERC IAPETUS DTP consortia including research skills, project management, statistics, scientific writing and employability skills. The student will be expected to present the results of their research annually at the BES student symposium and at least one national and one international conference.

References & Further Reading

Grimm, V., Berger, U., Bastiansen, F., Eliassen, S., et al. (2006) A standard protocol for describing individual-based and agent-based models. Ecological Modelling, 198 (1-2), pp. 115-126.

Thiele, J.C., Kurth, W. and Grimm, V. (2012) RNetLogo: An R package for running and exploring individual-based models implemented in NetLogo. Methods in Ecology and Evolution, 3 (3), pp. 480-483.

https://netlogoweb.org

Further Information

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