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A Simulation Model for Integrating Multidisciplinary Knowledge in Natural Sciences

Heuristic and Application to Wild Rodent Studies

Keywords: Multidisciplinary Knowledge, Heuristic, Simulation Model, Agent-Based Model, Object-Oriented Design, Case Study, Robustness, Rodents.

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Objectives

- Aim: Explore means to formalize and simulate multidisciplinary knowledge about complex realities observed in the wild.
- Use case : scientific studies on rodents in Senegal (West Africa) and France.
- Heuristic: complete design from scratch did not appear practicable : we try to let the model 'grow ' using aggregration of successive case studies models upon a minimalist seed.
- Expected result : emergence of a robust model for integrating various past or forthcoming knowledge within the use case.

Method

Case studies models: We used eight contrasted case studies for model development and tests of the robustness of the approach.
Each case study was supported by a field scientist, each led to an agent-based model with particular scales, items and functions (ex. Figure 1).

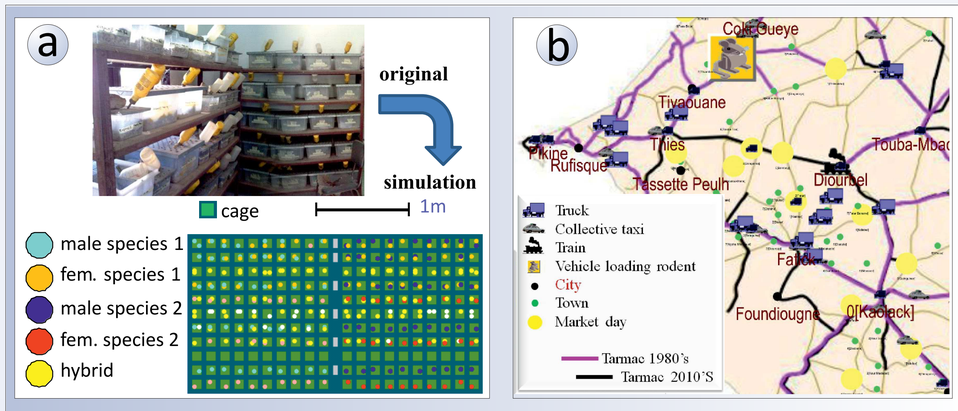

Figure 1: Simulation displays for two extreme case studies out of the eight considered in this work.
a) animal room protocol for the crossing of rodents from sibling species
b) invasive rodents ' colonisation of Senegal (West Africa) by means of commercial transportation

Syntheses: following each case study, the model is generalised by abstraction and interfacing. Shared methods are factorised, using polymorphism and inheritance, names are refactored, new interfaces created, time and space unit conversions are checked, ... while ensuring the back-compatibility of the code.

Result (fig.2)

- The resulting model makes it possible to represent contrasting simulations, addressing diverse aspects of dynamics, for several rodent species, over various spatial and temporal scales and within different simulation contexts.
- The class tree is partitioned into seven distinct successive functional domains.
- At the ends of the tree, three diversity realms can be extended: agents, species they can instantiate, and substrates.

Discussion

- The *a posteriori* evidence of the classifications obtained can be seen as a sign of robustness, an issue of prime importance for the proposed approach.
- Even the oldest case studies remain upgraded with new features allowing further investigation of their specific model
- The class diagram is always incomplete as it is supposed to continue improving with forthcoming models of case studies.

Conclusion

- The heuristic used and the proposed incremental approach proved effective for the development of this versatile model.
- The model could be adapted to other use cases, *e.g.*, simply by removing the unnecessary leaves of the class tree.

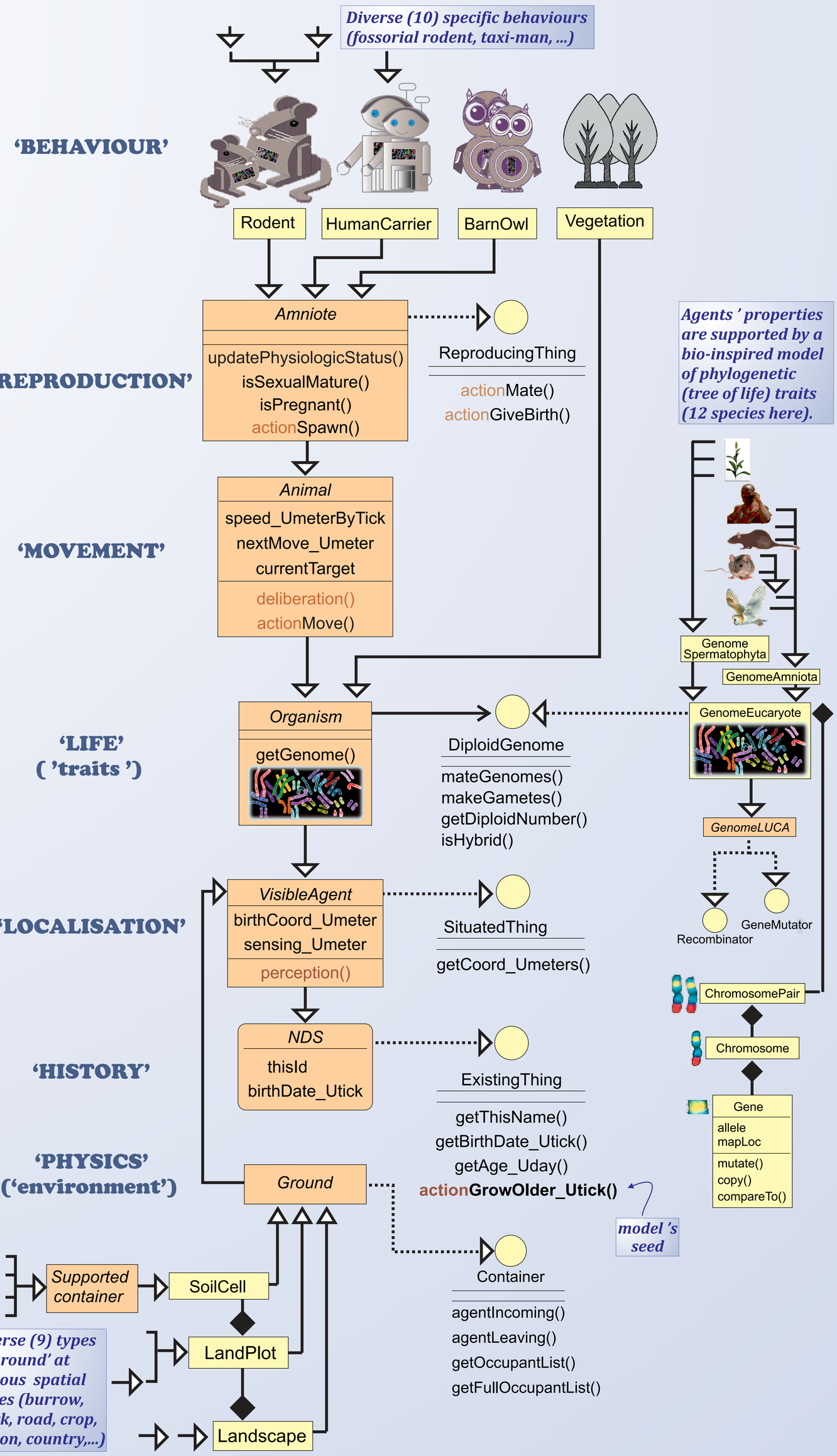

Figure 2: UML-based class diagram of the model's structure that emerged from the compilation of the eight case studies. Only the relevant methods, properties or relationships are presented

CAPTION:
interface | *abstract* | *class* | is a kind of | implements | owns | is composed of | action...: part of PDE decision scheme | *Comment* _Uxxx: unit

LUCA: last universal common ancestor, root of the species phylogeny

NDS: Nearly Decomposable System
(Simon, H.A., The Architecture of Complexity. Proc. Amer. Phil. Soc., 1962, 106(6):467-482)

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