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Using BEN for the simulation of cognitive, affective and social agents

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Keywords

Social Simulation, cognition, emotions, personality, norms

Abstract

Social Simulations are used to study complex systems featuring hundreds of human actors. This means reproducing real-life situations involving people in order to explain an observed behavior. However, among the most popular platforms for agent-based simulation, none of them integrated agent architectures that could really easily model human actors. This situation led modelers to implement simple reactive behaviors while the EROS principle (Enhancing Realism Of Simulation) [2] fosters the use of psychological and social theories to improve the credibility of such agents.

To tackle this issue, we proposed the BEN architecture (Behavior with Emotions and Norms) that uses cognitive, affective and social dimensions for the behavior of social agents [1]. In details, BEN features cognition based on the BDI paradigm, emotions, personality, emotional contagion, social relations and norms to describe the behavior of an agent simulating a human actor. All these features are organised into a decision making architecture so an agent may choose an action according to its perception of the environment and its previous knowledge.

The main goal of BEN is to provide modelers with a tool to create agents with a believable behavior for social simulation. Each of these components relies on psychological or social theories, helping a modeler to improve the credibility of simulated humans and ensuring an explainable behavior with high level concepts. The architecture is modular so it may be adapted to different use cases, depending on what is necessary : every module may be activated or not easily and very few parts are mandatory.

BEN has been implemented in the GAMA platform so it may be used by a large audience to model agents with a high level explainable behavior. To do so, each module of the architecture is translated into GAML statements with multiple options. BEN is now used in many projects dealing with issues as varied as risk management, territorial evolution or resource management.

To illustrate the use of BEN, we propose to focus on two real case scenarios related to building evacuation.

The 27th of January 2013, the Kiss Nightclub in Santa Maria, Rio Grande do Sul state is Brazil, was set in fire, causing the death of 242 people. BEN was used to model the behavior of the people inside this nightclub - including cognition, emotions, personality, emotional contagion, social relations and norms - to obtain a credible behavior, reproducing the real case. This behavior, explainable with high level concepts, has been tested on the evacuation of the Station Nightclub, which caught fire the 20th of February 2003 in West Warwick, Rhode Island, USA. These experiments show that BEN allows to obtain believable simulation results in front of real case scenarios.

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Additional material

The use case models and videos of their execution may be found at this address : https://github.com/mathieuBourgais/ExempleThese

An agent-based model to simulate the impact of ewes' response variability to the male effect on a dairy sheep herd's performance.

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Keywords

agent based model, hormone-free reproduction, dairy sheep, male effect

Abstract

The management of hormone-free reproduction in dairy sheep farming is a lever to be explored in order to respond to the challenges of agro-ecology and the evolution of societal demands. The male effect is an effective technique to manage the reproduction of dairy ewes in sheep farming systems, without the use of hormonal treatments. The success of this technique is characterized by the resumption of the sexual cycle for ewes that were in seasonal anestrus, with an entry into heat of the ewes (estrus). However, this response to the male effect is relatively variable from ewe to ewe and from year to year. Indeed, there is variability in the male effect response due to the fact that several intrinsic biological factors such as ewe's age or body condition score (BCS) but also farmer's reproduction practices, influence the response to the male effect. In order to study the impact of this individual variability on herd performances and management, we developed an agent-based model using the GAMA open-source platform. The use of an agent-based simulation tool allows us to represent the interaction between the different agents involved in herd performances. Thus, the farmer, as a decision-making entity implementing a breeding strategy, and the herd, as a biotechnical entity made up of a set of animals, are represented. The herd is represented by a set of ewe agents and for each ewe agent the model simulates a biological reproductive process. Response's variability to the male effect is integrated via a probability which takes into account a set of physiological (age, BCS, milk production) and technical (date of introduction of the ram, breeding season) parameters which have been proven to influence that response. The farmer's practices motivated by his production objective (expected milk delivery period and therefore expected lambing period), is represented by a set of decision-making rules which determine a number of technical operations such as the date of mating, the constitution of mating batches or ewe's replacement. Different reproduction management strategies and different herd phenotypic compositions have been tested, in order to visualize the effects of individual response's variability to the male effect on the lambing distribution at the herd scale. Particular attention was paid to the impact on the distribution of lambing periods at the scale of a production cycle and at the scale of the ewe's career. Our main hypothesis being that the response's variability to the male effect will lead mostly to a change in the distribution of lambing periods which will lead to a change in the organization of reproductive management in the long term.

Multiagent Systems applied to Hydric Resources: A comparison between Gama and Google Earth

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Keywords

Gama, Google Earth, Multiagent System, Hydric Resources.

Abstract

Our main contribution in this research is to make a comparison between the functionalities of the tools GAMA and Google Earth. The main objective of this work is to identify and evaluate which of the tools would be more adequate in the context of data analysis in water resources. Furthermore, we evaluate the availability of data provided by each one, and we also analyze the possibility of integrating them.

This research also aims to evaluate the possibility of using Multiagent Based Simulation (MABS) in the participatory management of hydric resources, more specifically using as a base data from the state of Rio Grande do Sul, and focusing on the pilot application of the work in the Management Committee of the Hydrographic Basins of Lagoa Mirim and São Gonçalo Canal, which involve the cities of Rio Grande and Pelotas. According to our knowledge, this methodology has not yet been applied in the context of the state, seeking a more interactive and participatory way for decision making on water issues. In this approach, the participation of the agents involved is vital. Therefore, integration with the proposed region's basin committee members is essential.

GAMA (*GIS Agent-based Modeling Architecture*) is a development, modeling and simulation platform consisting of tools that assist in the design of complex models through the integration between agent-based programming, geographic data management, flexible visualization tools, multi -level representation and a complete modeling language called GAML (*GAma Modeling Language*).

Google Earth Engine combines a set of satellite imagery (petabytes of data) and geospatial data with analysis capabilities on a planetary scale. The tool makes it possible for scientists, researchers, and developers to detect changes, map trends and quantify differences on the Earth's surface. The programming language used in this tool is javascript, which facilitates the development of mobile applications, games, and machine learning applications.

For analysis of this comparison, we conducted a case study on both tools. Data from the region near Lagoa Mirim, Lagoa dos Patos and Canal São Gonçalo were used, which were made available by the State Environment Secretariat of RS, totaling 34 different layers of the area.

As a result of this study, we can see that multiagent simulation is inherent in the GAMA tool, while to build the same simulation in Google Earth, we need to develop a complex model through the integration between agent-based programming and georeferenced data.

Multi-level nutrient cycle model in agro-sylvo-pastoral systems of West Africa

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Keywords

Agent-based model; Crop-livestock integration; Multi-level; Nutrient spatial transfer; West Africa.

Abstract

Nutrient recycling plays a key role in the functioning of agro-sylvo-pastoral systems (ASPS). In West African ASPS, livestock-driven nutrient flows are the main sources of soil and crop fertilization. Livestock mobility organizes spatial transfer of nutrients within the landscape. During daytime, livestock eats natural resources in rangelands while at night, it is paddocked in harvested fields. Livestock effluent are thus concentrated on the cultivated fields. However, farming systems transitions tend toward an expansion of croplands onto rangelands and a shift from these traditional "extensive" systems to more “intensive” systems based on in-barn livestock fattening. In these new systems, farmers use an increased quantity of feed concentrates and crop residues and livestock effluent are stored in barns and manually spread on fields. In order to study the consequences of such changes on nutrient transfers and, thus, on soil fertility, we built a spatially-explicit agent-based model, the TERROIR model — TERRoir level Organic matter Interactions and Recycling model.

The purpose of the model is to provide realistic estimations of the nutrient flows structure of a typical West African ASPS at different levels: land plot, herd, household and village. It is built to compare different agro-ecosystems, depending on input parameters concerning i) the structure of the landscape such as proportion of land units, i.e. homogeneous part of the landscape in terms of land use and management practices; and ii) crop-livestock systems diversity, linked to a typology of households. The model simulates the exchanges of biomasses between dozens of households with different strategies and practices, on a daily and weekly basis. It includes spatial transfers of biomasses between several hundred plots orchestrated by dozens of herds moving independently. These flows are analyzed through a set of indicators from two methods of analysis (Ecological Network Analysis and System Gate Balance) to describe the structure, functioning and sustainability of the agroecosystem, in terms of productivity, efficiency, autonomy, recycling, spatial transfers and nutrient balance.

The model was designed and configured with available data on savannah agroecosystems in West Africa. It focuses on processes related to nitrogen (N), a key limiting resource for both plant and animal production. It was implemented with Gama (v1.8). Model evaluation was based on field-data from two villages of the Groundnut Basin in Senegal, where agro-pastoralists have contrasted farming practices. It showed that the model reproduces the differences between an “extensive” and an “intensive” system.

In a context where historical quantitative data on nutrient flows are lacking, the model was used to explore past agro-ecosystems functioning and performances regarding N flows. Simulations highlighted bottlenecks along the N cycle like accumulation of N in manure heaps and housing areas, reducing N recycling efficiency, especially in “intensive” systems. Two major properties appeared to be outlasting the transition: i) independence towards external inputs, based on crop-livestock integration; ii) spatial heterogeneity due to nutrient transfers from peripheral land units to core land units, mainly through livestock. This model can be further used to explore improved agro-sylvo-pastoral landscapes. Processes related to carbon sequestration can also be implemented.

Additional material

- Repositories: https://github.com/MyriamGrillot/TerroirModel ; https://www.comses.net/codebases/5608/releases/2.0.0/
- Full model description: Grillot M., Guerrin F., Gaudou B., Masse D., Vayssières J., 2018. Multi-level analysis of nutrient cycling within agro-sylvo-pastoral landscapes in West Africa using an agent-based model. Environmental Modelling & Software 107, 267-280. https://doi.org/10.1016/j.envsoft.2018.05.003

OPALE: a Framework for Assessing the Eco-functionalities of Landscapes

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Keywords

agricultural systems, decision rules, agricultural landscapes, crop management, hydrological processes

Abstract

Ecohydrological processes are of primary importance in agricultural landscapes where fluxes of water are driven by vegetation, whether cultivated in fields or grasslands or present in semi-natural habitats and interstitial areas (open channels, riparian borders, inter-ranks of perennial crops) surrounding the cultivated parcels. Human practices are a key lever of the composition and properties of vegetation in landscape agroecosystems.

In order to better understand their impact, we propose a suite of Gama and Matlab programs coupled in a single OPALE-gui (OPerational Assessment of Landscapes Eco-functionalities) that aims at (i) representing landscape organization in relation with the functioning and decision rules of annual crops or breeding systems, (ii) evaluating water movements and trajectories from biomass and hydrological exchanges, and (iii) analyzing the transfer dynamics of nutrients, suspended matter or fecal bacteria based on particle tracking methods. More precisely, the tool includes a set of libraries about:

- the distribution of the farmland part of the landscape, allowing to spatially allocate crops into farm fields and the related farming practices (inputs, soil tillage, fodder management...) following time schedules (Land Use and Land Cover Change model, LULCC);
- the modeling of water movements within previous simulated landscapes, considering surface, sub-surface and deep flows (Water Movements Within Landscapes model, WMWL);
- the evaluation of –inert and living– solute and suspended matter transfers related to water movements, including N, P, *E. Coli* (EC) and Suspended Matter (SM);
- the construction of output normalized indicators of landscape function in order to assess its regulation service.

OPALE allows to better understand the underlying processes that drive exchanges and sink-source effects operating at the landscape scale, including a landscape transfer function and a delivery ratio for the global assessment of landscapes. It was tested in three agricultural contexts and biophysical situations. Water flows and flows of associated matters were compared to data recorded at the catchment outlet, and showed the efficiency of the algorithms developed in the generic OPALE libraries.

Anticipation of the evolution of the criminality at the city scale through agent-based simulation

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Keywords

Agent-based simulation, Social simulation, criminality

Abstract

The evolution of criminality is a crucial question to design security policies at the city scale but is often left unexplored in main smart-city scenarios or simulators. Together with the ENSP[1] and the DCSP[2] in the context of the project MEGA, we built an agent-based simulation of the evolution of the criminality of the French city of Montpellier. Such simulation implemented on the Gama platform enables to demonstrate the interest of such a tool in order to explore potential scenarios and help design adapted policies. The simulation was built using existing police data concerning crimes, victims and criminals, that we used to generate an artificial synthetic population of 50 000 potential criminals distributed on the city of Montpellier at the IRIS[3] scale. Such synthetic population corresponds to the statistics available from the police and enables as well to limit the population size in focusing on the potentially active part of the population in the simulation. We generated a synthetic social network among agents taking into account rough statistics concerning their location and age. From this population, the behavioral model of the agents leading them to commit crimes in the simulation is structured through three main components. The first one concerns the moral values and the opinion of the agent, influenced through his social network and that corresponds to his own moral position concerning crime (i.e., whether it is totally unacceptable or could be envisaged depending on the circumstances). The second component corresponds to a risk evaluation and captures roughly the risk of being caught and the consequences. The third component corresponds to the crime modalities: if the first two components are positive (pro-crime and low risk), then the agent elaborates a strategy in order to determine where and when to commit crime. Such modular architecture for the criminal behavior can be seen as oversimplistic, however it presents the advantage of capturing a large spectrum of behaviors (from social influence only, to pure risk evaluation or opportunistic behavior). It has also the advantage to enable and test quite different scenarios of actions from the police (from accompanying the criminals (therefore playing on moral/opinion dynamics), to playing on the consequences if found guilty, but also on more spatial strategies of distributing the police resources). Another main advantage of such model is that it is potentially quite easy to calibrate, as we can use different sources of data to calibrate independently each component. Finally using this model on Gama, we tested different scenarios in order to explore the potential of the proposed architecture. The designed scenarios were encouraging concerning the expressivity of the proposed model to envisage very diverse situations. To name a few, we explored scenarios concerning: the police resources and their spatial distribution, the impact of building a new stadium (that created crime opportunities), the support for juvenile offenders… In any case the aim of such scenarios is not to predict the evolution of criminality but rather by comparison with a base scenario to anticipate potential evolutions and help and test corresponding policies.

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Three GAMA plugins to define agent behavior: Argumentation framework, Bayesian network and Machine learning

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Keywords

Agent-based simulation, Argumentation framework, Bayesian network, Machine learning, GAMA platform

Abstract

GAMA provides several tools to model the behavior of agents: reflexes, BDI architecture, systems of differential equations, etc. Nevertheless, in the last few years different plug-ins have been developed to enrich these possibilities. We present here 3 plug-ins: the argumentation plugin, the Bayesian network plugin and the artificial learning plugin.

The first one allows modellers to use the Dung's argumentation system to simulate opinion dynamics [1, 2]. More precisely, this plug-in allows to explicitly represent agents' own mental deliberation process from arguments towards an opinion, through the use of the argumentation system of Dung. This plugin was already used to study the adoption of vegetarian diets and digital tools in agriculture.

The second plugin allows modelers to build a bayesian network, i.e. a probabilistic graphical model that represents a set of variables and their conditional dependencies via a directed acyclic graph, and make decisions based on them: typically, knowing the probability of a variable from a set of other variables.

The last plugin based on the open-source library Weka [3] allows the modeler to use a large number of supervised (CHAID, JRip, Multi-layer perceptrons, SMO, J48, Random Forest...) and unsupervised (K-means, EM,DB-scan, Cobweb...) learning algorithms. In particular, this plugin allows to build a classifier from a set of instances and to use the classifier to classify new instances.

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Additional material

Github (plug-ins code): https://github.com/gama-platform/gama.experimental

The traffic plugin of GAMA

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Keywords

Agent-based Modeling, Traffic Simulation, GAMA Platform

Abstract

Modeling traffic is about as old as car traffic itself. Among the existing modeling approaches, one of the most popular for traffic simulation is agent-based modeling. Agent-based models enable to describe each driver as an autonomous agent, making decisions based on its own aptitudes and local environment. With these models, each vehicle moves according to surrounding infrastructure and vehicles, accelerates and slows down according to its environment while maintaining a safe distance with other cars. These last few years have seen the number of traffic agent-based frameworks (MATSim, SUMO...) increase significantly. While these frameworks are appropriate for the study of normal traffic conditions, it is often complex to adapt them, in particular for non-computer scientists, to more specific application contexts such as the study of the impact of uncommon events (e.g. car accidents, evacuation following a technological disaster). In this context, we present the traffic plugin of the GAMA modeling and simulation platform, allowing the modeler to easily define new easily-tunable microscopic traffic simulations with a detailed representation of the driver's operational behaviors. In particular, it allows the integration of road infrastructures and traffic signals, change of lanes by driver agents and their tendency to follow norms [2]. Moreover, the tool allows for city-level simulations with tens of thousands of driver agents. In addition, its latest version offers the possibility to define vehicles occupying different numbers of lanes allowing to simulate mixed traffic with cars, motorbikes, bus, etc. In addition, this version improves the speed management of vehicles by using the classic IDM (intelligent driver model) model. The plugin was validated and uses in many applications cases in France and in Vietnam, in particular to simulate city evacuation in disaster contexts [1].

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Acknowledgment

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GAMA: 14 years and counting

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Keywords

Platform, modeling language, IDE

Abstract

GAMA in 2021 is more or less 13 years old, depending on where we place the starting point of this great adventure. Heir of a series of modeling "platforms" (MANTA, EMF, …), first born as an extension of RePast to facilitate the handling of geographical data within agent-based models, influenced by great ancestors such as NetLogo, RePast, SWARM or CORMAS, made possible by the advent of IDEs such as Eclipse, the popularity of meta-modeling or the progresses in open-source code sharing, progressively provided with capabilities going well beyond the strict implementation of agents in agent-based models, used for applications that no one had foreseen ten years ago, GAMA does not have an exactly linear history ! While this (apparent) lack of roadmap has probably prevented a wider adoption of GAMA in the industrial (and even academic) world, it has allowed it to evolve with an amazing agility, and to be in particular flexible when incorporating other modeling approaches, open to new technologies and concepts, while remaining accessible to users and modelers.

This presentation, hopefully avoiding making a boring summary, will go through some of the main stages of the short history of GAMA with the aim of triggering discussions and providing insights on how the platform can – and should -- evolve in the future: i.e, what mistakes not to make again? Which lessons can we draw from these 13 years in terms of agility and organization of the development of GAMA? Which forgotten development path could or should be promoted again?

Simulating innovation diffusion using agent based modeling, argumentation and the theory of planned behavior

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Keywords

Agent-based simulation, Diffusion of innovation, Argumentation, Theory of planned behavior

Abstract

Agent-based simulation has long been used to study the dynamics of innovation adoption and diffusion. However, the vast majority of this work is limited to a simplified representation of this process, which does not make it possible to explain the reasons for an agent's change of opinion, an element that is nonetheless fundamental to understanding the dynamics of innovation diffusion. In order to overcome this limitation, we propose a generic agent-based model in which the knowledge of each agent is explicitly represented in the form of arguments, which carry information about the innovation. These arguments are the objects that the agents will exchange during their interactions. The advantage of this approach is that it allows to trace the state of knowledge of an agent in order to understand the evolution of its behavior in front of an innovation. We also propose to represent the decisional model of the agents with the Theory of Planned Behaviour (TPB). This theory, very classical in psychology, offers an integrative framework to formalize the behavior of agents. In TPB, the intention to behave is derived from three variables: the attitude, the subjective social norm and the perceived control of the behavior (PBC). The attitude represents the knowledge and opinion that an individual has about a behavior - in our case the adoption of the innovation. The subjective social norm is the individual's perception of the adoption intention of his/her social network. Our proposal is to compute the attitude of the agents from their knowledge about the innovation, modeled as an argument graph, using the same approach as the one proposed by [2]. Concerning the social norm, we propose to be inspired by the work of [1], who suggests that during an interaction between two individuals the influence of one on the other depends on the opinions and the certainties that they have on the subject. At last, concerning PBC, which is specific to the type of innovation studied and to the individual concerned, we propose to transcribe it in the form of a variable specific to each individual, which may or may not be constant depending on the case of application. An application of this model is proposed to study the diffusion of communicating water meters by farmers on the Louts River (South-West of France).

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Additional material

GitHub repository for GAMA implementation: https://github.com/LSADOU/Innovation-Argumentation-Diffusion/tree/ms_dialog-implementation

Acknowledgements

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ABM for a better understanding of complex byproduct economic system

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Keywords

Bioeconomy, value chain, complex system, evolutionary economic, agent-based modelling

Abstract

The valorization of by-products from all productive activities is a major strategy to support the ecological transition. Regarding the agricultural and food sectors, the majority of by-products are nowadays valorized. There are four ways of valorization: (i) agronomic (spreading, compost), (ii) animal feeding, (iii) energy (biogas production, etc.) and (iv) as raw material for industries (cosmetic, pharmaceutical, textile, etc.). In fact, currently, biomass mainly uses the first three routes. The use of the fourth route remains limited, in spite of the fact that, unlike others, it would allow (i) a cascading valorization and (ii) the production of medium to high economic and environmental value raw materials for the industry (extraction of high value molecules). This entire system brings together multiple stakeholders from different economic sectors with contrasting technical and economic backgrounds. Together they construct byproduct valorization value chains. The problem we are facing is to understand how to combine the fourth way of valorization with the others into one viable value chain. Doing so raises organizational, regulatory, logistic and technical issues. To address this complex issue a computational approach has been chosen. Facing the diversity of computational model, agent-based model appears to be the best option for having a dynamic glimpse of a system emerging from the interaction of heterogeneous players.

We propose thus a agent-based model to simulate the emergence of a by-product value chain consisting of one, several or all of the valorization ways. Based on evolutionary theory (Dosi et al, 1990), we aim to simulate interactions among six types of economic agents : farmer, primary processor, extractor of molecules of high interest, composter, biogas plant, animal feed industry. Each of them can realize three types of action: (i) produce/store/transform, (ii) sell/buy, (iii) invest/disinvest. The decision-making process is based on individual characteristics (risk aversion, production capacity and location, past performance) but also on those of other agents. Whether or not the other agents information are taken into account for decision making depends on the existence of a bond of "trust" between the two agents. This link is bound to evolve as agents interact with each other. The outputs of the model are the dynamic of the bond of trust and commercial link between agents, the benefit of each actor, the investment they have realized. These results will give us information on whether or not a value chain has emerged (i.e. arising of a vertical organization from the interactions of the units), its characteristics and performances. A first version is currently implemented on the case of pomegranate by-product value chain. This model uses data collected from interviews with farmers, industrials and public institutes.

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PaSyMo + SmartUpLab: Developing and Testing a Participatory Modelling Toolbox for Urban Systems

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Keywords

Participatory modelling, Urban Development, ABM, Urban Planning Toolbox

Abstract

In order to provide small and mid-sized municipalities with a collaborative decision support system to engage local stakeholders in the planning process, we are developing a participatory modelling toolbox for urban systems across multiple research projects at the University of applied sciences Potsdam.
Our contribution presents a brief overview of the development of the toolbox comprising hardware and software tools in the project *PaSyMo* (Participatory Systems Modelling) as well as an insight on the user-centric approach for urban mobility challenges focused on co-modelling for comparative scenario analysis in the project *SmartUpLab*. We describe the challenges of using GAMA-Platform in our participatory modelling approach within different contexts, levels of analysis and with project partners and stakeholders. Finally, we identify GAMA features that can be relevant for our future work in the mentioned areas.

PaSyMo represents a frugal approach to participatory modelling, and features a growing library of simulation models, a mobile interactive modelling lab, (georeferenced) survey tools as well as serious games. Focusing on challenges of mid-sized German towns in the state of Brandenburg, we conducted iterative testing. During testing, researchers, experts, and stakeholders co-create models of specific urban contexts and phenomena, integrating implicit knowledge as well as geo-referenced datasets and survey results. Participants interact with the models in workshops and adapt them continuously to support decision-making processes. The first field applications addressed residential mobility and population dynamics in a late-GDR social housing district in the city of Potsdam and scenarios for future population development of the town of Luckenwalde. The stakeholders engaged in these processes are experts of the municipal housing company, the municipal urban planning authority, local enterprises as well as civil society.

The ongoing research project *SmartUpLab* aims to expand the *PaSyMo*-toolbox by designing a platform that integrates urban mobility stakeholders, gathers and processes data and simulates scenarios. Rather than providing estimations of traffic flows, the tool facilitates the envisioning and communication process among different mobility stakeholders by including demographic and land-use variables. For this purpose, we build on a user-centric approach based on co-creation methods for translating stakeholders' needs and ideas into formal model requirements and features. Over several meetings we identified and developed together with the stakeholders mobility concepts, scenarios and key performance indicators (KPI) relevant to them, which will be compared.

Conceived as a modelling platform that facilitates GIS data integration into agent-based models and allows spatially-explicit ABM with a relatively low level of coding knowledge, GAMA's range of possibilities continues growing. In our research, GAMA has a central role as a rapid prototyping platform for agent-based modelling, integration of data, visualisation of dynamic scenarios and stakeholder interaction with co-created models. Considering different user roles, levels of analysis and purposes of use, we will illustrate our next steps and discuss how they can be matched with the development of future GAMA features.

Agent-based modelling of habits in urban mobility

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Keywords

Agent-based simulation, decision model, urban mobility, habits.

Abstract

Means of mobility have changed a lot recently and will continue to evolve, in order to meet new environmental challenges. For instance, self service electric scooter or VTC are new ways of moving within the city. The SwITCh project aims to create a tool to help urban planners designing smart and sustainable cities that integrate these new mobility modes. This tool will let them explore scenarios to find out tendencies in human behaviour. It is therefore important that this tool can explain the reasons of the population's mobility choices, so as to help deciders change their decisions if needed, to mitigate unwanted behaviours.

Our approach is therefore to provide an agent-based model of the population. This model must recreate and explain the cognitive process of decision. Thus we will not use machine learning models that recreate only the final decision without explaining the reasons leading to it. Many cognitive models of decision making already exist, but most are purely rational. Nevertheless, it has been shown that habits highly impact everyday mobility choices [1]. Therefore we aim at designing a more realistic model of human decision that integrates habits.

Our first model takes into account six rational criteria (time, price, safety, comfort, simplicity and ecology) to calculate a score for each mode of transport. The score is then weighed by a habit coefficient that favors the usual mode of transport. Each agent then makes a decision to choose its favorite mode of transportation depending on its characteristics and the environment.

Our simulator is a GAMA implementation of this agent-based model of how the population of a town chooses their mode of transportation from home to work. With this first version, our results show that better cycling infrastructures result in an increase in the number of cyclists; but that a simple petrol price rise is not enough to discourage car users, who still stick to their habit.

In later work, we propose to enhance the BDI architecture in order to directly integrate habits in the reasoning. Concretely, habits are created when an action is performed multiple times in a stable context. Using this information, we will create a database of habits for each agent, from which the agent can use an habit anchor coefficient to prioritize one plan over another. This will allow to investigate other urban planning strategies, such as making interventions at specific rupture points in an agent's routine: changing job, moving home, etc. Such rupture points have been shown to be particularly favorable to introduce new, better habits. The simulator will also be turned into a serious game where players take on the role of urban planners to better understand the impact of their mobility choices on various indicators (well-being, pollution, traffic jams, etc).

Acknowledgements

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GAMA tools for multi-level traffic simulation

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Keywords

Traffic simulation, event-driven simulation, simulation tools, multi-level model

Abstract

Simulation is one of the most widely used tools in the context of mobility and traffic studies. However, there are a large number of models based on different types of premises and also running at different spatial and temporal scales. Each model can provide a different point of view of the system and we would like to combine them in order to have more pieces of information about this system.

Agent-based simulation, in particular, is widely used in this context. Indeed, each vehicle representing an agent is a relatively intuitive approach, moreover, the interaction of agents allows the emergence of some phenomena such as congestion. The GAMA platform, in addition to being a multi-agent simulation platform, natively provides tools for reading and agentifying GIS data, and is it also possible to create coupled or multi-level model be design, which makes it a very good tool in the context of traffic and mobility studies. However, there is a lack of ready-to-use tools to do this kind of simulation, such as ready-to-use models or some mechanics. For instance, the absence of the widely used IDM microscopic model, and also, some models are event-based rather than time-based, and that the platform does not provide a way to natively schedule agent actions (although this problem is more generally related to event-based models). These tools and models must therefore be reimplemented or readapted for each model and this can be a source of bugs.

So, here we present some of these tools directly accessible in GAML as a plugin: (I) an event manager able to execute agent actions at a given time, combined with a new skill to allow agents to schedule some of their actions or those of other agents. (II) A new skill to instantiate agents in a mesoscopic traffic model based on events and queues (the latter requiring, of course, an event manager to be properly instantiated). (III) As well as a skill to instantiate agents for the IDM microscopic model. All these skills aimed to instantiate a multi-level traffic model, where the traffic network is divided into 1km sections, and each section can be set as using the IDM model or the event and queue model. These choices can be used to find a balance between computation time and the variety of observed behavior. In this first iteration, each section is not able to change its model during the execution, further work will tackle this issue.

This work is part of a process of capitalizing on tools whenever possible, or even necessary, in order to have a library of the most used models and tools ready to use. This kind of library could be useful in further work where we could provide a coupling engine fed by many model ready-to-use and mechanisms to do coupling or multi-level models.

Additional material

https://github.com/gama-platform/gama.experimental/tree/master/irit.gama.feature.switchproject
https://github.com/ANR-Switch

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Combining SIR and agent-based models of the COVID-19 epidemics

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Keywords

Compartmental models, agent-based models, SARS-COV-2, Spread prediction

Abstract

Today, over a year after the start of the COVID-19 epidemic, we still have to deal with the virus. It is also difficult to accurately predict the impacts that political measures may have, or how the number of cases will evolve in the future.

To study the propagation of a virus, the most frequently used models are so-called compartmental models, that separate the population into several distinctive classes. For instance, the basic SIR model distinguishes 3 such classes: Susceptible, Infectious and Recovered people. These models make it possible in particular to study the spread of a virus at the scale of a city or even whole country, and they are currently used to study the spread of SARS-COV-2. However, these models only give a **macroscopic** view of the propagation, which is mainly done *a posteriori*. It is also difficult to accurately predict the number of future cases beyond a certain number of days, due to the lack of knowledge about the actual number of infected and recovered people (in particular due to asymptomatic cases), and to the propagation and multiplication of this uncertainty.

Multi-agent systems are computer models that give a **microscopic** view of the problem. They make it possible to model each human being as an autonomous agent, and thus to study the propagation of the virus according to the behavior of the agents. They also account for a heterogeneous population, each agent having different individual attributes.

The aim of our work is to be able to combine these two approaches, in order to take advantage of their strengths and overcome their weaknesses. In particular, SIR models rely on various coefficients that are difficult to evaluate accurately. By simulating the restrictions currently imposed on the population (physical distancing, curfew...) in an agent-based model, and comparing the simulated contagion force with real observed data, we could calibrate the compartmental model. The microscopic agent-based approach could thus make it possible to anticipate and refine the new values of the parameters of a compartmental model, with respect to various sanitary restrictions enforced at the moment.

Our work is applied to the city of Lumbin, in Isère, which has about 2500 residents. We simulated the spread of the virus in this town. Our model is implemented in GAMA, and based on the Luneray's flu model, which was adapted by importing the Lumbin shapefile. The model was then made more complex and realistic: different types of buildings were created (houses, work places, schools), for the moment randomly, and we added different human habits, such as shopping, going to work or to school, depending on the agents' age, to be closer to reality. The goal of this simulator is then to study the impact of the different government strategies on the propagation of the virus in this town.

Acknowledgements

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A Land Use Agent Based Model Incorporating Procedural Utility

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Keywords

Procedural Utility, Land Use Change, Land Markets, Agent Based Model

Abstract

The process-consequence dichotomy has been an ongoing discussion in economic decision making. This extends to utility theories in land use analyses. The consequence approach is concerned with the materialistic benefit gained from the land plot (Output Utility). The process approach focuses on the benefit gained from undergoing a land market exchange process (Procedural Utility) (Frey, 2008). Land use analyses – particularly simulation methods – only use output utility.

Accordingly, this paper introduces a land use Agent Based Model (ABM) that incorporates both procedural and output utility. We reinterpret procedural utility in land use analyses and quantify it using motivations to be involved in land markets. These motivational parameters facilitate the implementation of the ABM in both Netlogo and Gama. We subsequently aim to compare both models in terms of implementation (on GIS contexts) and different initialisation results (due to random parameters).

Procedural utility is defined as the value of the process of reaching an end goal – the valued processes in land use simulation methods are land markets. Processes are valued due to the satisfaction of the three psychological innate needs: autonomy; relatedness; and competence (Frey, 2008).

Originally introduced in the Self Determination Theory (SDT) (Deci & Ryan, 1985), these three innate needs act as mediators between the external factors and the motivations of undergoing a certain process (Vallerand & Ratelle, 2004). Land markets as external factors can lead to different satisfaction of innate needs due to different individual motivations. To measure the satisfaction of the innate needs, SDT introduced four motivational categories: external (material benefit), introjected (avoid guilt), identified (align with moral values) and integrated motivation (enjoy the process) (Ryan & Connell, 1989). Accordingly, SDT observes motivations quantitatively by questioning why individuals undergo specific processes and scaling the answers from 0 to 4 – each answer correlates to one of the four aforementioned motivational categories.

We use these motivations as an indicator of procedural utility as both are tied to the satisfaction of the innate needs. We aggregate the four motivational values to describe procedural utility. In the ABM, this allows agents to consider procedural utility during residential relocation and compare it to the traditional output utility.

In summary, the paper shows the mathematical formulation of procedural. It applies a procedural utility ABM in Netlogo and Gama on both a square cell grid and a sample GIS shape file with land geometries describing land plots. It compares the Gama model with the Netlogo one, especially the GIS shape file version where Gama is more flexible with using vector GIS files. Further, the paper also showcases some insights on observed results regarding segregation in mono-centric cities due to land market preferences using the pixel based version.

Additional material

Video of a sample run from the ABM in Gama on a pixel context is shown in the link below (Development is still in progress; the final model may vary from the provided sample)
https://drive.google.com/file/d/1iKHN3u1quho1SjorNhwg5m4MDK9RD2_I/view?usp=sharing

A spatially explicit model to simulate soil microbial communities' dynamics at an agricultural landscape scale

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Keywords

Agent-based model, Soil microbial communities, Agricultural landscape, Participatory

Abstract

Soil microorganisms play a major role in soil functions and are an efficient indicator to evaluate the impact of agricultural practices on soil quality. Biogeographical studies over wide scales ranging from landscape to countries have concluded that soil microbial abundance and soil prokaryotic richness is following a heterogeneous distribution in space under the dependence of soil properties (e.g. pH, soil texture, organic matter content) and agricultural practices. The goal of this study is the creation of a model that can predict dynamics of soil microbial communities depending on the agricultural management over time. For this, we focus on a monitored landscape (Fénay landscape, 1.200 ha, Burgundy, France) where agricultural practices are recorded since 2004. A regular grid of 267 sites is set up over this landscape and soil samples are characterized for their soil microbial biomass and prokaryotic richness in 2011, 2016 and 2019. We propose a coupling agent-based model (ABM) with experimental data, ecological concepts and mathematics models. As we work on spatial and temporal dynamics of populations, GAMA Platform seems to be a relevant software. We consider several agents "farmers" that can own one or more agricultural "plots" and have activities on it (panel of agricultural practices). Each cropland plot owned by a farmer is divided into small entities called "microplots" of, at most 30m per 30m, which contain different information about soil properties and microbial communities. The dataset is divided into a learning dataset (70% of data) and a validation dataset (30% of data). We calibrate our methodology first on soil microbial biomass dynamics and we will apply the same modeling protocol on prokaryotic richness. First, the dynamics of soil microbial biomass is evolving at each iteration (daily) and is compared to a theoretical value obtained based on the RMQS (french soil quality monitoring network) repository. The impacts of each farming practice and flow level of microorganisms are evaluated with R software based on the learning dataset. Daily microbial growth and carrying capacity of the habitat in zero impact conditions were calibrated with numerical simulation method (based on equation system). In order to evaluate the model, we initialize data in 2011 and we run the model until September 2016 and then until September 2019, date of the second and third sampling campaign. Then, we compare the outputs of the model with the values obtained in 2016 and 2019 on the validation dataset. A sensitivity analysis is also under way and will allow identifying redundant parameters. A serious game has been constructed upon this ABM where users can manage agricultural plots and observe evolution of soil microbial biomass due to their practices and their neighborhood's actions. These participatory workshops permit to explore the model in a different way by providing various realistic agricultural management and add knowledge valued by expert opinion. To go further, the next steps are the validation of this modelling protocol and the use of it in order to evaluate prokaryotic richness dynamics and predict the interactions between bacterial phyla in space and time.

Additional material

An Agent-Based Model of a Sustainable Forest Operation: A case of a Low Mountain Dipterocarp Forest in the Philippines

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Keywords

Forest Operation Modeling, Economic Valuation, Sustainable Forestry, GIS, ABM

Abstract

Historically, the forest of the Philippines was drastically reduced from 97% in the 1500s to 23% in 2015. And for the country, forests are undeniably vital for economic growth and social development. Thus, a sustainably managed forest ensures these benefits and services for the present and future generations. Unfortunately, despite a seemingly superior selective harvesting system called Philippines Selective Logging System (PSLS) once employed in the country, the Philippine forests were overexploited prompting a ban in 2011 on harvesting of natural forests (Executive Order No. 23) that is in place up to the present date. Before the moratorium, the implementation of the PSLS lacked an efficient and effective logging system that eventually decimated the natural forests of the country. The wanton degradation of the forests naturally led to concomitant natural disasters like floods and landslides.

In this regard, identification of sustainable forest operation is imperative. This paper presents a model of sustainable forest operations with the use of GIS and GAMA. The objective of the model is to simulate a sustainable forest where at least one rotation of harvest is achieved under certain assumptions of growth rates of two groups of tree species, volume equations, environmental constraints, cost of harvest, and net income. The main sustainable forest operation explored revolves around the simulation of assisted natural regeneration. The model is developed using a theoretical forest based on actual data of low mountain Dipterocarp forest in the Philippines. An arbitrary piece of land with real terrain is used as the forest substrate with actual tree inventory data. The forest spans 1,024 hectares and encloses road and river features. The study site is subdivided into 4-hectare parcels. Each parcel represents an area to be either harvested or replanted.

With integration of real data on tree inventory plus the actual forest growth and economics of forest utilization and management, the paper aims to present a model that can be used as a tool for evaluating existing forest, the results of which can be used to determine spatially-explicit harvestable volume and/or requirements for assisted natural regeneration - that is, evaluate whether the forest is productive or degraded.

Additional material

Repository: https://gitlab.com/zoarnejo/gama-project

Simulating pedestrian flow in new neighborhoods: Grasbrook district in Hamburg

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Keywords

Pedestrian flow, Pedestrian simulation, Integrated Urban Development, Grasbrook, Digital City Science

Abstract

Using methods and tools for digital urban research, our team creates an interactive city model interface for the design and development of the new district Grasbrook in Hamburg. The model is used to support integrated planning and decision-making via the visualization of complex spatial and social contexts. It simulates different development scenarios based on several user inputs and performs computations in the fields of pedestrian walkability, noise comfort, solar and wind exposure, and stormwater. The results of the simulations help designers, developers, and other stakeholders to make decisions about sustainable urban-morphological characteristics as well as determine the location of specific functions and land uses. The tool is hosted in an online interface, and it is implemented in an integrated process of urban and landscape design, mobility and infrastructure planning.

More in detail, the "Pedestrian flow simulation" module operates in a workflow in which the urban planner's original designs are inputted for the new development area, and merged with the surrounding urban context. On a later step, streets, buildings, and target demographic data are loaded into the GAMA Platform and several scenarios are modeled. GAMA models simulate daily routines of residents, workers, and visitors. These scenarios are intended to help address questions about connectivity, such as where to place bridges across canals, and questions about the strategic placement of services and amenities, aiming at a compact mixed-use district. The outputs of the scenarios are loaded into an interactive web interface, where they are compared against the results of other simulation modules (i.e. noise, stormwater, wind, and solar exposure) in order to detect areas of high value and areas of low performance. Decision makers and designer use this information as an assessment within the design process (1) detecting areas of design interest, and (2) exploring options to address specific issues.

Additional material

Project repository: https://github.com/grasbrook-cityscope

Synthetic population generation: the hidden model in agent based models

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Keywords

multi-layer synthetic population, Gama library, Gen*

Abstract

Almost 20 years after the creation of the KIDS acronyme [Edmonds and Hamilton, 2004] and after decades of descriptive ABM, the effort modelers put into the generation of a realistic population of agents remain limited [Chapuis and Taillandier, 2019]. If we consider it as a mandatory piece of expertise required to initialize a data-driven agent based social simulation, the generation of a synthetic population is in a strange methodological position, to say the least: many publications have proposed algorithms and libraries, discussing *in extenso* about a variety of methods and tools, but synthetic population generation is still a modeling blind spot for most ABM researchers. In fact, principles and challenges are often misunderstood [Chapuis et al. 2019], the tools are merely used, resulting in a start-from-scratch syndrome [Lovelace et al. 2015] and the synthetic population characteristics are rarely discussed when reporting ABMs (e.g. there is only one occurrence of "agent population" in the supplementary materials related to the initialization part of the latest updated ODD version publish in JASSS - Grimm et al. 2020). In this proposal, we try to illustrate the main difficulties a modeler can face when dealing with synthetic population generation using the creation of individuals into household agents in the Gama platform, as an example. Based on french demographic data, we detail a simple (yet complicated) process using a minimal synthetic reconstruction algorithm from the Gen* library, to build the population of individual agents, combined with a hierarchical sampling algorithm, written in gaml, to construct households. After a brief description of the approach, we identify three main limitations: the algorithm needs for new developments when new data are added or when data changes, the process requirement in terms of modeling effort to fill the gaps left by missing data, and the global approach complexity, including the necessity to conduct parameters sensitivity analysis and to build population quality assessment indicators. Based on this feedback from experience, we advocate for the use of generic platform extension tools to support the development of dedicated models to generate synthetic population, hence discovering the hidden model in models.

Additional material

https://github.com/ANRGenstar

Gen*: realistic synthetic population generation plugin for Gama

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Keywords

Synthetic population, agent based model initialization, data integration

Abstract

Context: The increasing complexity of agent-based socio-environmental models raises the issue of data integration. In fact, descriptive ABM (Edmonds & Moss, 2005) heavily rely on input data: in order to setup initial model state to mimic the targeted system, modelers have to collect, harmonize and integrate data that comes in various shape, quality and quantity. This is usually done following rules-of-thumbs and case by case methodology that limit model's reproducibility, modularity and re-usability (Kehoe, 2017).

Problematic: One key dimension of such realistic initialization is the synthetic population generation process: it aims at creating the attributes of agents, asses their localization and connect them to one another based on empirical, statistical or spatial data about the actual targeted population. It exists many methodologies and algorithms to generate agent attributes using statistical approaches (Müller & Axhausen, 2010), to localize synthetic entities using spatial statistics (Chapuis et al., 2018), and to build an interaction network between synthetic entities. However, except for the generation of networks, very little has been done for those tools to be readily used in generic agent-based modeling platform: in fact, most of the procedure for synthetic population generation have been developed and used in the context of a specific case study without any consideration to accessibility and usability of the proposed methodology (Chapuis & Taillandier, 2019). In other words, there is a need for consistent and re-usable guidelines, methods and tools to integrate demographic, GIS and survey data to build realistic synthetic population of agents.

Proposal: In this proposal, we introduce Gen*, a dedicated tool that makes it possible to generate, localize and connect a set of synthetic entities that can be directly used within the Gama Platform. The plugin is scattered into three main components for the generation of agents based on demographic data, their localization using generated attributes as well as explicit spatial objects from any GIS files, and lastly many algorithms to connect them using all previously generated socio-spatial features. In this communication we present the generation and localization procedure enabled by the Gama plugin using sample code from other projects to illustrate the capabilities as well as the re-usability of the proposed tool.

Additional material

Main API repository : https://github.com/ANRGenstar/genstar
Plugin repository : https://github.com/ANRGenstar/genstar.gamaplugin

Landscape generation for a Land Use and Land Cover Change Agent-Based Model, with GAMA platform

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Keywords

Agent-based modelling ; LUCC modelling ; landscape generation ; Northern Ecuadorian Amazon

Abstract

The earth's surface is increasingly altered due to human activities, such as agricultural expansion or urban sprawl. Land change models have emerged over the past few decades to explore the causes and consequences of land use and land cover changes (LUCC) and to better forecast them in order to guide public policies. Agent-based models of LUCC (LUCC-ABMs) allows formalizing the interactions between society and environment through the modelling of heterogeneous stakeholders involved in land change and their individual decision-making process regarding to the land use, which has an impact on regional land cover. We introduce a LUCC-ABM of deforestation dynamics in Northern Ecuadorian Amazon, built with GAMA platform. The purpose of the model is to reproduce LUCC patterns due to human activities over eight years as they appeared between two land cover maps. To this end, we have developed a workflow based on i) a strong input of both qualitative and quantitative data at initialization step by a landscape generator based on census and survey data ii) livelihood strategies to typologize land use behaviours. Our model workflow can be described as following: after the data processing, we generate a spatially and socially structured population with a synthetic population generation library (GENSTAR) on the basis of census, cadastral and land cover data. Then, we assign a livelihood strategy to each household through a multi-criteria evaluation according to qualitative and spatial criteria from field surveys. Next, once again with GENSTAR, we generate an agricultural landscape for the entire study area by specifying a patchwork of farming activities in each plot assigned to these agents according to their livelihood strategy, on the basis of field survey data in a sparse remote sensing data context. Lastly, we calibrate parameters related to agent decision-making processes in order to better reproduce environmental dynamics. In addition to a contribution on the integration of data in LUCC-ABMs, this work aims to investigate the connection between pattern-based and process-based modelling of LUCC.

Additional material

Link to the repository : https://github.com/rmejean/nea-lucc-abm

Multi-Agent Simulation and Analysis of Surveillance Systems

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Keywords

design of experiment, multi-attribute decision making, R shiny application, parametric analysis

Abstract

The Army is looking for ways to reduce the number of Soldiers exposed to the hostile war environment by using advanced technologies. These technologies will modernize the equipment the Army is using to conduct varying missions such as reconnaissance operations. The Combat Capabilities Development Command's (CCDC) Army Research Laboratory (ARL) has been researching and developing multi-agent simulations of humans and UAVs for this purpose. The multi-agent simulation is a 3km x 3km field with 100 points of interest. The simulation's standard agents are an operator and three distinct UAVs: fixed-wings, flapping wings, and quadcopters. The performance metrics measured in the simulation are duration, the time it takes the UAVs to photograph and classify the imagery; noise, duration and decibel level of exposure at evenly spaced points throughout the field; and accuracy, the proportion of images the operators identify correctly. Within the simulation, varying the number of agents will have a measurable effect upon these performance metrics. To understand this effect, the team developed a full-factorial design of experiments (DOE). The human operators and fixed-wing unmanned aerial vehicles ranged between one to ten and the quadcopters and flapping wing ranged from zero to ten. Using the results of the DOE, we conducted a parametric analysis to determine the breakpoint for the metrics and developed an interactive R shiny application.

The team conducted the parametric analysis by holding two of the factors constant and varying the other two. We determined that, after seven operators, accuracy did not have significant improvement, and in order to achieve an optimal accuracy rating, the number of UAVs should be less than 13. In terms of duration and noise, we determined that six quadcopters were the optimum number. After six quadcopters, there was no improvement in duration and the noise in the simulation reached possible detection levels.

The team developed the interactive R shiny multi-attribute decision-making (MADM) optimization tool using Simple Additive Weighting (SAW). The purpose of the tool is to output the optimal combinations of human operators and UAVs based on how the user weighs these system-level attributes: of number operators, total number of UAVs, accuracy, noise, and duration. The project will facilitate answering the following issues for analysis: 1) Which of the four factors has the most significant impact on the performance metrics?, 2) How does the interaction between the factors affect the performance metrics?, and 3) What is the optimal mixture of human operators and UAV platforms?.

BDI model for simulating urban negotiations: the case of developer obligations in England

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Keywords

Urban negotiations, developer obligations, Belief-Desire-Intention (BDI), automated negotiation

Abstract

Agent-based modelling has been widely used in urban planning mainly to simulate the emergence of spatial patterns like urban growth, transportation, spread of disease…etc. Models have been producing data related to actors, activities, infrastructure, and land. However, there has not been much attention in developing models whose outputs are urban policies rather than urban patterns. In urban planning, policies are usually decided by a group of stakeholders after a process of negotiation to reach a consensus. Therefore, for a model to produce data on policies, it needs to simulate the negotiation between stakeholders that led to those policies. Simulating negotiation has been studied by researchers in artificial intelligence, management, engineering…etc. but only few in urban planning. Besides having few urban negotiation models in the first place, even the existing models in the literature did not have a generic simulation framework that can be reproduced. They have also ignored much of the complexities explained in negotiation theories like the uncertainty of negotiators' reactions or their discussions of other solutions when reaching a deadlock.

This article presents an agent-based model which simulates the exchange of offers in urban negotiation with a degree of complexity that has not been approached in previous models in the literature. The model is designed in Gama platform using the Belief-Desire-Intention (BDI) as the model architecture and FIPA-ACL as the language for exchanging offers between agents. The model is applied on the case of developer obligations negotiations, particularly Section 106 negotiations on affordable housing in England. Section 106 negotiation was simulated in a previous simple model by the same authors using the Finite-State-Machine (FSM) architecture in Gama. That model produced probability charts showing the likelihood of stakeholders to achieve their goals when they negotiated on a certain site. Although it did not capture much complexity, the output was useful in giving stakeholders a prior expectation of the negotiation. Therefore, when designing the BDI model, it was decided to take advantage of the previous model by integrating it through co-modelling and allowing each BDI agent to run it and understand the expected utility before negotiating. Then, this expectation as well as other factors will influence the agent's choice of strategies and tactics which they can easily change thanks to the modularity of the BDI architecture. Agents can also suggest other solutions for fulfilling obligations, e.g. providing the affordable housing in another site, or offering money to the authority in compensation.

With these capabilities, the BDI model shows how changing the agenda or the expectation of stakeholders can influence the path of negotiation, and hence the outcome. It produces series charts showing the history of offers exchanged between each pair of negotiators, and a chart showing the decision that they finally agreed on if any. The output is not a prediction of the actual negotiation, but an indicator for understanding the influence of negotiators' agenda on the outcome. Thus, it can be used for training or preparation before actual negotiation.

An Agent-Based Model for Preemptive Evacuation Decisions During Typhoon

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Keywords

Typhoon, Preemptive Evacuation Decision, Agent-Based Model

Abstract

Natural disasters continue to cause tremendous damage to humans' lives and properties. The Philippines, due to its geographic location, is considered a natural disaster-prone country experiencing an average of 20 tropical cyclones annually. This condition necessitates the need to study what can be done to mitigate the effects of weather-related disaster. Understanding what factors significantly affects decision making during crucial evacuation stages could help in making decisions on how to prepare for disasters, how to act appropriately and strategically respond during and after a calamity. In this work, an agent-based model of human behavior during typhoon evacuation is presented. In the model, civilians are represented by households and their evacuation decisions were based from their calculated perceived risk. Also, rescuer and shelter manager agents were included as facilitators during the preemptive evacuation process. National and municipal census data was employed for the model, particularly for the characteristics of household agents. Further, geospatial data of a village in a typhoon-susceptible municipality was used to represent the environment. In the model, household agents are placed randomly on buildings while rescuers roam the area. Shelter managers are in designated evacuation shelters and are stationary. Additionally, conceptualized formulas are provided to attain the individual evacuation decision of household agents. The decision to evacuate or not to evacuate depends on the agent's perceived risk which also depends on three decision factors: characteristics of the decision maker (CDM); capacity related factors (CRF); and hazard related factors (HRF). Weights are assigned to each decision factor to assess their impact on the model outcome. Finally, the number of households who decided to evacuate or opted to stay as influenced by the model's decision factors were determined during simulations. Linear regression was used to determine significant predictors to determine evacuation decision. Sensitivity analysis shows that all parameters used in the model are significant in the evacuation decision of household agents. Findings also show that total evacuation decision is more sensitive to weights assigned in capacity related factors, specifically type of house, floor level and past typhoon experience.

Additional material

https://drive.google.com/drive/folders/1lt7s87y8UCw6tzX3_RPQGURfhs5F7vw5?usp=sharing

Floodaware - Near Realtime Granular Flood Forecast and Modelling using IoT

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Keywords

Hydrology, Flash Flooding, Internet of Things, Live Data

Abstract

Flash flooding is one of the most frequent natural disasters of the modern world, forming a major threat to life and property. Floodaware is a system designed to give early warnings in flood prone areas, giving people the extra few minutes needed to save lives. The Floodaware system connects live sensors and rainfall data to provide a near realtime prediction forecast of flooding to residents, as well as enhanced modelling capabilities using the GAMA platform. Floodaware uses network of ultrasound based water level sensors connected to The Things Network (TTN) to record levels at sections of the streams in the catchment. The water levels are used to calibrate the model of the catchment to best reflect catchment dynamics and provide large amounts of empirical data for further modelling. Live rainfall data is then used within the model and to provide early warnings and forecasts of floods to local authorities. The model of the catchment features a number of interconnected layers which interact with each other. The layered approach allows to exploit certain features of geometry to accelerate computation and give an understandable conceptual model. The first layer is the rainfall or cloud layer which is comprised of agents given particular rainfall payloads and geometries. At the time of each agent's precipitation the intersection of the agent and underlying sub catchments is calculated to convert the level of rain (in mm) to a volume. Once calculated the payload is transmitted to the underlying sub catchment to allow for flow within the sub catchment, and overall flow through the whole network. The flow within the network is based upon the Watershed Bounded Network Model (WBNM). WBNM is a commonly used hydrological model for modelling floods in catchments. In Floodaware the WBNM equations have been used to govern the flow within sub catchments, and the flow downstream towards the outlet. Floodaware uses GAMA to create a more accessible instance of the WBNM logic, and connect it with richer data. The modelling harnesses GAMA's GIS capabilities by accessing a PostGIS enabled PostgreSQL database. The database allows for simple execution and setup of different modelling scenarios, and an excellent way to store, maintain and access relevant data. Initialisation, runtime, and final results are all stored within the database to log results and keep a record of experiments performed outside Floodaware's live operation. GAMA's GIS features and database access have made it a useful and accessible platform for the purpose. More development and support for newer data storage methods will help enrich GAMA's future in the modelling world. Object based data formats would be especially useful as they closely parallel the descriptions of agents in GAMA. The integration of data storage and presentation within Floodaware are greatly enabled by GAMA and allow for greater interactivity and understanding of the workings of the model.

Additional material

https://cloudstor.aarnet.edu.au/plus/s/Ou7UpVsVEFRu4Zj

Hybrid Model (Cellular Automata + Agents) for Simulating Urban Growth, Real Estate Market Dynamics and Sea Level Rise

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Keywords

Urban Modelling, Cellular Automata, Agents, Complex Systems

Abstract

This contribution aims to presents the model that is being developed on Gama platform with the objective of representing urban growth and land use dynamics for a city considering: i) the locational preferences of its population groups; ii) land value variation dynamics; and iii) the impact of sea level rise on urban environment.

The development of such model has the goal of contributing to the discussions on urban planning policies for the north coast of Rio Grande do Sul - a state located in south Brazil - which has been showing significant demographic growth coupled with a seasonal increase in its population due to the tourist attractiveness of its beaches. Such dynamics lead to the existence of an intense local real estate market that presses for more urban growth to the detriment of the surrounding natural environment. The suppression of natural elements, such as dunes and coastal vegetation, makes the urban environment more susceptible to disasters such as storms, gales and, in the long run, the sea level rise due to global climate change, which should impact Rio Grande do Sul by the end of this century. Therefore, the use of modelling and simulation techniques can be useful to represent possible development scenarios for the region, seeking to identify future urban trends whose anticipation can contribute to make the region's management and planning more efficient.

The proposed model is based on the theory of complexity applied to cities - which emphasizes the bottom-up nature of urban growth - and uses cellular automata (CA) to represent the dynamics of the territory and agents to represent the behavior of the population. In this way, the model seeks to reproduce urban growth dynamics by simulating the process in which: i) agents define a place to establish themselves to execute residential or commercial activities; ii) the value and attractiveness of each point in the territory changes as the agents settle in; and iii) these changes in the urban environment affect the decision of each agent of staying in the same place or move to a more advantageous one. This main simulation process is complemented by three auxiliary modules: i) the representation of the CA cells and their connections as a graph, enabling the computation of metrics that indicate the attractiveness of each cell for the agents that inhabit the study area; ii) the definition of land value based on the demand of the agents for each cell of the CA; and iii) the simulation of sea level rise, which restricts the cells in which the agents can settle in.

The municipalities of Imbé and Tramandaí – located in the north coast of Rio Grande do Sul - were chosen as the study area and were the object of experimental simulations that indicated the feasibility of the proposal. However, the utility of the model for practical applications still depends on its connection to real databases, which is being developed in the current stage of the research.

Additional material

A website is being developed in order to present the partial results of the research: www.urban-simulations.com

Modeling citizens' behavioural patterns towards housing and mobility mode for algorithmic urban policy design

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Keywords

Housing choice. Mobility choice. Urban Policies. Algorithmic Zoning. City performance.

Abstract

As cities become increasingly populated, urban design and policies play a key role in ensuring the resilient, sustainable, safe, and inclusive development of metropolitan areas. CityScope is a data-driven tangible platform that aims at bringing different stakeholders together to collaboratively decide which are the most adequate urban actions to be taken. The algorithmic zoning project described in this document constitutes a new module of CityScope. The idea behind this module lies on the exploration of dynamically reconfigurable set of urban policies that will contribute to an open, cross-sectoral, and informed decision making, while promoting greener, more walkable, and diverse urban areas.

This abstract summarizes the first step towards the aforementioned dynamic urban policy system based on incentives. Among the numerous aspects that the policy system could address, we will focus on the deficiency of affordable housing in city centres. In order to foresee citizens' reactions to a wide range of housing-related financial stimuli, it is necessary to unveil the dynamics that take place among the agents constituting the system. This includes characterizing citizens' criteria when choosing their housing option –and, thus, their residential mobility mode–. CityScope will then be able to interactively suggest those policies based on incentives that boost the urban indicators that best reflect citizens' aspirations regarding the built environment.

The present methodology suggests the development of an Agent-Based Model where housing- and mobility-mode-related preferences are described based on eight different income profiles. The housing-related criteria include (1) housing price, (2) diversity acceptance, (3) zone preference, and (4) commuting time. As this last parameter depends on the availability of transportation and users' preferences, this joint model considers the interconnection between housing and residential mobility. Apart from the (1) resulting commuting time, mobility-related criteria consist of (2) commuting price, (3) social pattern, and (4) difficulty of usage.

The simulation process is inspired by the well-known Schelling segregation model. An iterative process has been designed, so that in iteration i+1 citizen agents are given an alternative housing option to the one they had chosen in iteration i. After evaluating the most convenient available transportation mode for this alternative housing option, and the resulting commuting time, they will decide whether this option maximizes their preference score. The simulation converges whenever the amount of agents willing to move to an alternative housing option asymptotically approaches zero.

In order to represent the influence of external regions surrounding our area of interest, while working with a reasonable amount of environmental variables, two levels of granularity have been defined: (1) the census block group level and (2) the building level. The geographic data used for the simulation comprises Kendall Square and the Greater Boston Area, in Massachusetts, US. The criteria have also been calibrated for this particular zone, using census data and transportation data. The identification and tuning of these parameters, therefore, enables the prediction of citizens' reactions to urban disruptions and potential financial incentives tested on the CityScope platform. The algorithmic proposal of the most beneficial actions is, then, possible.

Additional material

https://github.com/CityScope/CS_Dynamic_Urban_Planning

GAMA/Unity: an interactive end-user interface for participatory modelling with GAMA

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Keywords

Agent-based simulation, Participatory modelling, Participatory simulation.

Abstract

In recent years, several agent-based simulation models have been produced to study complex systems in a wide range of domains. Three main stages are conducted: modelling, simulation and analysis of results, which represent the main focus of the majority of proposed agent-based simulation tools [1]. Participatory modelling aims at using modelling in support of a decision-making process involving stakeholders in one or several stages of the modelling process [2]. Participatory simulation aims at allowing stakeholders to interact with a simulated model at runtime, often through a serious game [1].
However, most of the existing agent-based simulation tools do not support the involvement of the stakeholders in the modelling and simulation process. In fact, this makes them unsuitable for situations that require real-time interaction with the stakeholders. For instance, for building serious games as a support for decision-making processes. In such situations, it is necessary to simplify interactions and integrate relevant feedbacks among complex systems into the model. So, the stakeholders can make direct changes within the simulation process, as well as see the results of their changes almost instantly.
In light of the voids identified above, we aim to evolve GAMA to support participatory modelling. So, we developed a new tool, called GAMA Unity Client, that allows the visualization of simulations on different devices without having to install GAMA (e.g. devices running under android), and more importantly, allows stockholders to set up simulations and interact with the model during the simulation process.
GAMA Unity Client consists of two parts: a GAMA plugin that implement a new agent's skill (called unity) and a Unity Client, as a Unity generic scene that can be installed in different devices, with different operating systems. So, it relies on the GAMA platform; which offers several multi-agent modelling and simulation tools and ii) Unity; which is a cross-platform game engine.
GAMA Unity Client relies on two existing tools in GAMA: i) The network skill, to manage network connections and messages exchanges and ii) The remote plugin which provides a reliable mechanism to publish (expose) data values to distant clients when changes occur during simulation. Here, the model is run on a distant GAMA platform, and the stockholders can interact with the model using the Unity Client on different devices connected to the network. The communication between the Unity Client and the GAMA Platform is made using the MQTT protocol.

Additional material

[1] Patrick Taillandier, Arnaud Grignard, Nicolas Marilleau, Damien Philippon, Nghi Quang Huynh, Benoit Gaudou, Alexis Drogoul: Participatory Modeling and Simulation with the GAMA Platform. J. Artificial Societies and Social Simulation 22(2) (2019)
[2] Barreteau, O., Bousquet, F., Etienne, M., Souchère, V. & d'Aquino, P. (2014). Companion modelling: A method of adaptive and participatory research. In Companion Modelling, (pp. 13–40). Berlin/Heidelberg: Springer.
Git: https://github.com/YoucefSklab/GamaUnityProject.

Individual-level Modeling of COVID-19 Epidemic Risk Using GAMA simulation data

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Keywords

COVID-19, COMOKIT, risk prediction, individual-level models

Abstract

The COVID-19 pandemic highlights the need for a multi-faceted response comprising a range of public health interventions including quarantining and targeted lockdowns, in conjunction other measures such as vaccination campaigns and genomic disease surveillance. Many of these interventions need to be informed by epidemic risk predictions given the available data, including clinical symptoms, contact patterns, and environmental factors. Here we propose a novel probabilistic formalism based on Individual-Level Models (ILMs) that offers rigorous formulas for the probability of infection of individuals, which can be parameterized via Maximum Likelihood Estimation (MLE) applied on compartmental models defined at the population level. We integrate individual data collected in real-time with overall case counts to update a predictor of the susceptibility of infection of a single person as a function of their individual risk factors (e.g.: age, immune status, etc.) In order to generate realistic synthetic data for the purpose validating models that depend on such individual-level covariates, we used an agent-based model (ABM) in the GAMA simulation platform using the COMOKIT parameters for COVID-19. The initial simulation experiments are promising and suggest that is possible to: (1) obtain good estimates for the individual-level parameters by applying MLE on the population level data, (2) predict what individuals in the population are at higher risk of infection, and (3) inform effective public health interventions, such as quarantine, based on the predicted individual risks.

Additional material

ArXiv preprint: https://arxiv.org/abs/2006.16761
Source code repository: https://github.com/colabobio/ILM-COVID19-risk

ChargEVal - a multi-user framework for simulating and analysing charging station deployment scenarios using agent-based modelling

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Keywords

electric vehicles; fast-charging; electric vehicle supply equipment;

Abstract

ChargEVal is a framework for simulating charging station deployment scenarios using agent-based modelling (ABM). The ABM utilizes behavioural models for simulating vehicle choice for the trip and charging choice during a trip. ChargEVal supports several users to submit multiple simulations simultaneously, using the graphical user interface or programmatically. ChargEVal also has a dedicated results viewer for viewing the simulation summary statistics and agent state values facilitating detailed insight and simulation comparison. While the current implementation of ChargEVal is specific to the State of Washington, USA; the underlying framework is generic enough to be applied to any geography at any scale.

GAMA-Brix; Coupling GAMA models with CityScope tables

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Keywords

urban planning | simulation | web application

Abstract

As a spatially explicit agent-based simulation software, GAMA-platform is especially suited for simulating complex urban environments [1, 2]. Models built for these environments typically rely on a large number of parameters, with specific constraints due to idiosyncratic preferences of local stakeholders. A recent trend in urbanism has shown that the power of simulations is not in optimizing planning needs but in supporting decision making by motivating professionals and non-professionals to engage in a discussion through collective exploration of urban models [3, 4, 5, 6]. This process usually involves multiple users changing model parameters and discussing the results in real-time. Yet, collective exploration of GAMA models of urban environments has been challenging due to the lack of a framework that allows users to share not just their models but also the configuration of the parameters. Here we introduce GAMA-Brix, a GAMA library that couples GAMA models with CityScope [7] to allow multiple stakeholders to collectively explore urban models. To achieve this, GAMA-Brix defines a set of species that act as 'observers,' which report simulation results to the 'City I/O' server [8]. Information from the 'City I/O' server can then be accesses through the CityScopeJS front end [9] or through any of the API's endpoints.

Additional material

- Documentation can be found here: `https://cityscope.media.mit.edu/modules/GAMA`.
- Source code can be found here: `https://github.com/CityScope/CS_Simulation_GAMA/blob/master/CS_CityScope_GAMA/models/cityIO/models/GAMABrix.gaml`.

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[9] MIT CityScope Project. *CityScopeJS*. `https://github.com/CityScope/CS_cityscopeJS`. 2021.

The relationship between the cultural orientation of a population and the evolution of an epidemic: an agent-based approach

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Keywords

Cultural orientation, agent-based modeling, theory of planned behavior, Bayesian inference, decision making

Abstract

The evolution of a contagious disease is strongly related to the behavior of individuals. People make decisions based in part on their knowledge of the environment in which they live and this, at the collective level, represents the possibility that an epidemic will grow or be mitigated. Some of these decisions are related to the commitment of the person to comply with the measures recommended by the authorities to reduce the risk of contracting the disease: wash hands, use face masks, avoid crowds, maintain physical distance, etc.

Social psychology explains the way in which a person makes these types of decisions, depending on the level of individualism, which is known as cultural orientation (CO). CO also helps to explain the behavior of societies during vaccination processes, in which collective behaviors of rejection of the vaccine could emerge due to conspiracy theories. In this work we address cultural orientation and how it affects people's decision-making in an epidemic situation. We consider that people can have an individualistic or collectivist orientation. For this we use agent-based modeling (ABM). The behavior of the agents is approached using the theory of planned behavior (TPB) through an implementation of Bayesian inference (BI). BI allows managing agents' decisions through the probability of making a decision, based on external information and their own cultural orientation. The decisions we focus on are those in which the agent determines whether to follow the recommended prevention measures, as well as whether to accept the vaccine. As a result of the simulations, we measure the indicators of an epidemic to determine the impact that people's behavior has on the control of the epidemic in societies with different CO profiles. The model we propose is based on theories from the social sciences, and can be used in the planning stages of strategies to combat any epidemic in the future, designing measures that are successfully adopted by the population of each community of interest.

Proxymix: Influence of Spatial Configuration on Human Collaboration through Agent-based Visualization

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Keywords

Scientific collaboration, architectural design

Abstract

This study proposes the use of agent-based simulation as an alternative to space syntax, a common technique in architecture, to reveal how architectural design can influence scientific collaboration. Using the MIT Media Lab building as a case study, we use Gama-platform to implement a parsimonious agent-based model of researchers' daily routine as they move inside the space. We found that the simulated collaboration network predicts the ground truth collaboration inferred from the Media Lab project database, even after controlling for institutional barriers such as the research lab researchers belong to. Our results highlight that agent-based simulation can be used to construct flexible indicators from architectural blue-prints that reveal important characteristics of people's interaction inside the space.

Empowering a model for improved multi-actor discussions: case study from Dairy production in Sahelian agro-pastoral systems

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Keywords

Model Empowering, Multi-actor discussion, Agro-pastoralism

Abstract

This work is part of a long-term partnership between CIRAD and Laiterie du Berger (LDB) ; a dairy specialized in collecting milk from pastoral system environment around Richard-Toll, Senegal. The Richard Toll milkshed (area geographically demarcated for the collection of milk or milk products) serves as exemple for a computer simulation to support ecological intensification of milk production and collection in a space mainly dedicated to pastoral cattle farming. This transition need the commitment of various actors for viable solutions.

Our Gama simulation is a co-constructed model with stakeholders involved in the Global Agenda for Sustainable Livestock (GASL). This co-design modeling process took place from 2017 to 2019. Following a first beta-test with local partners in November 2019, the model evolves in a finalized version in april 2021. The objective is to use the model as a discussion support to go beyond the issue of dairy production and explore four dimensions of "multifonctionnality": economic, social, environmental and territorial development.

In this work, we propose to follow the process of empowerment/autonomization of the model through the Actor Network Theory (Callon 2013). By documenting the process of evaluating the reliability of the results and the validity of the model (Sim and Arnell, 1993) as we conducted them with the actors, we propose to highlight the transformation of the model from an artifact in favor of a real actor (Latour 2007).

The validation of the internal mechanisms of the model led the participants to formulate questions about the functioning of the model following the abduction process (Peerse), i.e. the ability to generate temporary hypotheses and to test them. This abductive validation phase is intended to empower the model as an actor. The inter-actor validation allowed to go beyond the model. The model having acquired its autonomy (Latour 2007) in the internal validation, the participants summoned the model as an actor in the meeting by summoning simulation results to discuss livestock feeding options with the objective of identifying the margins of maneuvers for agro-ecological intensification.

This work of autonomization of the model is a necessary step in the process of accompanying the exploration (ComExp) of simulation results (Delay et al. 2020). The ComExp process aims to explore the model with robust methods to overcome the problems of storage and understand the diversity of results that are accessible to the model. This diversity of results allows the actors to consider situations that are difficult to envisage for the actors and aims to accompany them in a process of anticipation.

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An ABM to support collective reflection on the evolution of mobility

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Keywords

Urban mobility, Traffic simulation, Collective reflection support, Prospective simulation

Abstract

Transport infrastructures play a large part in defining a smart, sustainable and resilient city. Planning transportation systems traditionally rely on well-known evolutions of roads or public transportation (roundabouts for security, etc.). Yet, infrastructures might also benefit from, or may have to adapt to, recent disruptive innovations concerning modalities, technologies and societal organization (autonomous cars, smart infrastructure, homeworking, etc.). However, innovative urban policies might either facilitate mobility and increase citizen well-being, or create negative side effects. Urban planning therefore requires the city to assess the impact of these disruptive innovations by using "what if?" prospective studies. However, cities are complex sociotechnical systems: dynamics of transportation are nonlinear, and even wise choices might lead to negative side effects (*e.g.* the improvements in road layout might decrease the number of accidents, but increase road use and therefore increase pollution). Unfortunately, even if urban planning models and methodologies are available for traditional modalities (car, bus, etc.), no tool, nor methodology, exists today to assess the potential impact of disruptive innovations, and how they can be progressively integrated into planning infrastructures.

The SwITCh project aims at providing a tool for a participative reflection on the evolution of urban mobility in the next 30 years (horizon 2050). It aims to support decision-making for urban planning related to transport issues, by providing a participative simulation tool. The ambition of the project is not to produce a simulator that can predict what will happen from now to 2050 and to solve all the problems, but to help stakeholders (urban planners, citizens, etc.) enrich their reflections and build a shared project to improve transport infrastructures. The tool is based on an agent-based model (ABM) of citizens' mobility, implemented on the GAMA platform, which simulates different scenarios of city/environment evolution (based on a combination of literature review and interviews with experts and stakeholders) and tests different strategies to face them.

In this presentation, we will introduce the approach in order to illustrate four different scientific challenges: (I) the modeling of individual mobility choices by the agents, (II) the multi-level modeling of the city, (III) the design and exploration of different scenarios of mobility evolution, and (IV) the design of a methodology based on the proposed tool to support collective reflection.

Additional material

The website describing the project is at the address: https://www6.inrae.fr/switch_eng/. All the models code is publicly available on the project GitHub organization: https://github.com/ANR-Switch.

Acknowledgments

This work is part of the SwITCh (Simulating the transition of transport Infrastructures Toward smart and sustainable Cities, ANR-19-CE22-0003) research project funded by the French Research Agency (ANR).

comokit4py : a python package to ease GAMA model's simulation integration into a high performance computing workflow

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Keywords

Model exploration, high-performance computing, software engineering, covid-19

Abstract

Agent-based model (ABM) are a kind of computer model that makes it possible to simulate a set of autonomous interacting programs called agents in a shared virtual environment. Among other application field, it has been commonly used to simulate social phenomena such as urban segregation, opinion dynamic or epidemiological crisis. Recently, a research emphasis has been put on ABM to study *in silico* the impact of non-pharmaceutical interventions to mitigate the SARS-CoV-2 outbreak of 2020, with few of them that had a great impact on global political responses. Among the model used COMOKIT has been design to simulate the every-day-life of inhabitant of various cities in Vietnam and test policy interventions for various COVID-19 spread scenarios. Such endeavor required huge computational power to handle a huge number of simulation replication over a large set of parameters. In this proposal we present a python package that enables to easily generate, explore and build reports for any COMOKIT experiment to be launched over High-Performance Computing (HPC) infrastructure.

Additional material

Multi-agent system for spatial modeling of forest dynamics: Case of the forest-savannah in Adamawa Cameroon.

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Keywords

Complex systems, Forest, Modeling, Simulation, GIS, MAS

Abstract

For several years, significant modifications have appeared in many so-called natural forest areas, either because of the emergence of new functions in relation to the development of new activities, or as a result of the emergence of new practices competing with traditional practices. The mastery of these multiple activities leads to imagine forms of aid and concerted assistance capable of making forest users aware of the consequences of their actions on the resources they use to destabilize the environment. This article presents an intelligent solution based on a Multi-Agent System (MAS), a particularly powerful tool for representing such complex systems and for accounting for the different components of the environment, the relationships between social groups and the interactions between the practices of the actors of the system and the main geographic dynamics. The modeling and the spatial dynamic simulation over time of any forest recovery proposes to mobilize computer models of the multi-agent system type integrating Geographic Information Systems (GIS) to represent the interactions between natural dynamics and social dynamics. It is a question of confronting the actors acting on natural forest areas with probable dynamics of evolution of their environment, using the GAMA modeling language (GAML). The proposed SMA is applied to a grove, the starting point for any reforestation, located in the town of Ngaoundéré in northern Cameroon. A comparison between two scenarios (with and without the proposed system), Multi-agent solution for controlled forest management (ADFMS, Agent Dynamic Forest Modelling with SIG) revealed the effectiveness of the proposed solution. The results obtained show a significant forest cover of…%.

Additional material

SYNERTA: An interactive tool for visualization and simulation of the business process

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Keywords

Agent-Based Simulation, GAMA platform, Interactive Decision-making, Tangible Interface, Visualization

Abstract

SYNERTA, or, the Synergy Table, the technology developed by Schuberg Philis. It is inspired by the MIT city planning technique (CityScope), but completely redesigned and adapted for the purpose of visualization and simulation of the business processes.

It all started with a dream, to create a conversation piece to talk about business challenges within the vital infrastructure in an interactive and attractive way. To involve stakeholders in the modeling and simulation processes for decision-making support. While agent-based simulation of the complex systems is extremely useful in this case, it was desirable to enrich it with highly intuitive and fully interactive tangible interface.

We present the new interactive tool integrated within the GAMA modeling and simulation platform that uses a real-time feedback loop of multi-agent simulations to help stakeholders to evaluate their business processes. For example, “what-if-scenarios”. With tangible interface, stakeholders can acquire faster, deeper understanding of the problem. “How can I talk about my business process?” “What position do I have in the logical chain?” “How will I impact the chain?” “What consequences should I expect?”

SYNERTA allows to support decision making by visualizing and providing insights into total business process, sub processes, value streams, information streams, dataflows and telematics of individual agents.

Additional material

Schuberg Philis (website): https://schubergphilis.com
Schuberg Philis (linkedin): https://www.linkedin.com/company/schuberg-philis/

An Agent-Based Model for a participatory network of air quality sensors on bicycles

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Keywords
Bicycle traffic, Urban mobility, Air quality, Urban pollution, Agent based simulation, Synthetic population

Abstract
Excessive concentrations of pollutants in the urban air are regularly observed, posing a long-term danger to the health of inhabitants. Monitoring the quality of urban air is therefore a very important issue to help stakeholders to take appropriate measures (reduction of road traffic...). The urban spatial distribution of air pollution is very heterogeneous and evolves rapidly over time. It is therefore important to develop reliable, fast, and spatially spread measurement methods. This last criterion is often hard to implement. For example, air quality measuring stations are very accurate, but their measurements are too local to obtain information on areas with no station.

In this work, we propose to study the usage of residents' daily bicycle traffic as a participatory network of air quality sensors, providing volunteer cyclists with an air quality sensor to use during their daily commute. To evaluate the effectiveness of such a network, we choose to build a multi-agent simulation based on the GAMA development environment that models a group of bicycle-mounted sensors mapping urban air quality. Traces of urban air quality collected by the sensors are then used to infer air quality at the city level. Results are compared with actual data from public air administration.

The model simulates the daily mobility of a synthetic population of cyclists in the city. The population (with age, activity, location) is created from census data provided by the INSEE French institute, trips data coming from House trip surveys of Mobiliscope (https://mobiliscope.cnrs.fr), and from geolocalized, time-stamped and anonymized travel data from private companies. The simulated daily routes of the bicycles are associated with pollution levels (NO2 and particulate matter PM10) provided by a state-of-the art urban air quality model. The synthetic observations recorded along the bike trips are complemented by geographical information (height of buildings, natural areas, distance to highway, …) that are obtained through Geographical information systems (GIS) and further used as predictor variables in a land use regression (LUR) model.

The dataset of synthetic information is used to infer a critical number of bicycles that would be required for an optimal assessment of the intra-urban air quality. To this end, we process the collected pollution data, for each time step, with extrapolation algorithms (eg. LUR) of the measured pollution concentrations and the city environment. For example, the distance of a point to primary roads is a relevant indicator for determining NO2 concentration. Thus, by performing a regression to estimate the relationship between the distance to the main roads and NO2 concentration, we can predict the NO2 concentration at unmeasured points. Moreover, the impact of the cyclists' circadian rhythm on the monitoring of the daily cycle of pollutants is investigated. We also evaluate the opportunity for cross-calibrating the mobile sensors during the biker's Rendez-vous based on the daily agenda of the different biker categories.

Additional material
All the models code is publicly available on : https://github.com/Nathancoisne/participatory-bicycle-network

Acknowledgments
This work has been partially funded by the University Paul Sabatier in the frame of the neOCampus program.

Coupling GAMA with OpenMole to easily explore agent-based models in HPC environment

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Keywords

Model exploration, high-performance computing, software engineering, software coupling

Abstract

The evolution of agent-based models makes them be more and more complex. This complexity makes them heavier and more complicated to calibrate and explore. The first point leads to use *high-performance computers* (HPC) and *computing grids*, the second one require new tools to easily handle a huge amount of model parameters to calibrate it over a huge number of simulations. This paper aims to show the integration of the GAMA Platform with one of these tools called *OpenMole*.

Additional material

- https://openmole.org/
- https://openmole.org/GAMA.html

COMOKIT advanced user interface: Dashboard

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Keywords

GAMA, COMOKIT, user-interface, user interaction, dashboard

Abstract

GAMA is a modeling and simulation platform for creating simulations following a multi-agent approach. COMOKIT is a modeling kit written by GAMA for the purpose of analyzing and comparing the policies against the spread of the Covid 19 pandemic at the scale of a city. As a member of the COMOKIT project, with the mission of researching and developing to improve the user interaction and user interface on both GAMA and COMOKIT, we propose to develop a necessary feature for GAMA. That's dashboard feature, a good means of communicating and analyzing information for the most fields today.

Currently, GAMA platform provides users display chart types to support the analysis and visualization of data in the simulation, some of which have not yet available to put on a dashboard, for example: gauge type, metric type, data table type. However, the layout and the way to interact with the chart are limited, the output of simulation is not really user-friendly. This research will focus on creating a new syntax (GAML) in GAMA to use for displaying a dashboard in simulation. The generated syntax should be really easy to use, easy to understand and easy to edit. The dashboard is created allow users to arrange the charts depending on the research purpose.

With the creation of a dashboard feature, it can be applied to specific research models such as COMOKIT, helping modelers to synthesize analytical data on the dashboard. From which to evaluate the results and effectivenesss of the research model correctly.

Additional material

https://drive.google.com/file/d/1O7sRZagLkzGIeOxieAc3uyMON_Mp8OxV/view?usp=sharing

Re-implementing an agent-based model of urban systems in GAMA

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Keywords

Urban system, transport, Repast, NetLogo, GAMA

Abstract

Simulation models of city infrastructure systems, including transport, energy, water and waste, can provide valuable decision-support on their design and operation by testing different "what-if" scenarios and evaluating different plans and changes to the wider environment. Agent-based models in particular are of interest here because they can capture the heterogeneous nature of the infrastructure users and can incorporate the behaviour of individuals as they interact with each other and with the urban system. Previously we have used simulation models implemented in Repast Simphony as well as NetLogo for this purpose, but in this presentation we would like to share our motivation to change the simulation platform to GAMA and our initial experience making this translation from existing models. Our aim is to provide an example agent-based urban model of transport networks that can inspire modellers and users at different levels of experience, much like Nick Malleson's RepastCity model (https://github.com/nickmalleson/repastcity). Such a model could be used in education and student projects as well as serve as a foundation for larger scale research projects, by providing an easy to understand and modify example of a system which: 1) loads land-use/building/point of interest maps which act as possible origins and destinations; 2) loads a road network (nodes and links) along which agents can move; 3) generates a synthetic heterogeneous population based on distributions on some key characteristics; and 4) simulates simple activity-based behaviour rules which results into journeys from an origin to a destination along the provided transport network. The model could then capture metrics around the use of the links in the transport network and occupancy of the defined physical spaces (see Fig 1). The main idea is that the model can be configured from spatial data so it is accessible to non-modellers (e.g. urban planners) to test different layouts and population configurations. To this end, input to the model (for points 1-3) is provided through GIS shapefiles. Our main reasons for re-implementing the existing models are as follows: 1) a desire to simplify the code to make it more accessible; 2) using a more intuitive programming language to aid in teaching; 3) improved computational performance to run larger number of agents or larger areas; and 4) higher quality visualisations to engage with external stakeholders. While this is currently ongoing work, at GAMA Days 2021 we are keen to share our first impressions, get input on this project, and build connections with other users.

Additional material

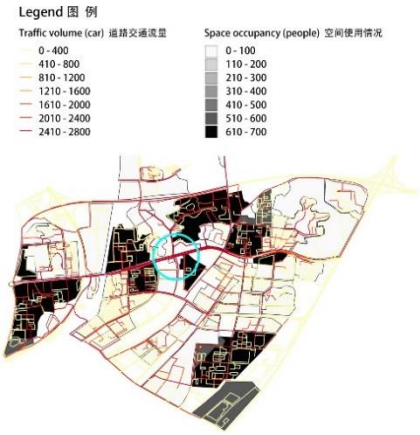

Fig 1—Illustrative output of the Gama model showing traffic volumes and occupancy as result of simulated activities (from: Liu Yang, Koen H van Dam, Yuan Zhu, Jianguo Wang, submitted to Social Simulation Conference 2021)

Probabilistic swarms guidance within the Gama-platform

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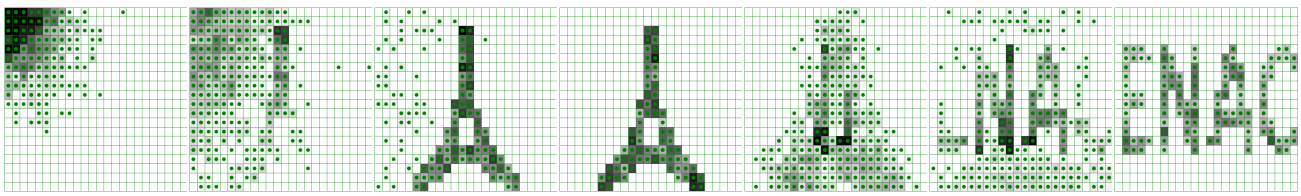
Keywords

Probabilistic swarm guidance - Density control - Multi-agent systems - Markov chain

Abstract

Providing means to address the controlling of a large-scale swarm as a whole is a challenging problem. In this context, B. Açikmeşe et al. [1] introduced a probabilistic guidance approach, to guide a large-scale swarm of autonomous agents into a desired formation shape. The mission is accomplished in a decentralized manner. Thus, the swarm asymptotically achieves the desired distribution without any communication between agents. A variety of swarm coordination and control methods appeared in the literature, but there is not a multitude of solutions to visualize and control the swarm in real-time.
Therefore we proposed to interface probabilistic swarms guidance into the Gama platform, since it supports great number of agents and offers a flexible interface. For now, we focused on the Markov-chain swarm guidance approach, presented in [1]. The method can be divided in three main steps. First, the desired physical space is divided into m bins (subregions), and the desired probability density is prescribed for each bin in $v \in R^m$. Note that the number of bin is directly determined by the spatial resolution of the desired formation shape. In order to restrict allowable agent motion, an adjacency matrix A is build, such that $A[i,j] = 1$ when the transition from bin i to bin j is authorized, and is zero otherwise. Given adjacency matrix A and desired density v, the Markov matrix $M \in R^{m \times m}$ is constructed. The entries of matrix M are defined as transition probabilities. In practice, an agent in bin j transitions to bin i between two consecutive stages with probability $M[i,j]$.
In order to set up the simulation environment in Gama, we have developed a plugin which add the required functionalities to Gama-platform and a gaml model to build the Graphical User Interface (GUI). The GUI allows the user to select the resolution of the grid or volume as a set of bins, then to choose the desired shape. The shape are computed from images which are rasterized to generate the desired distribution. Adjacency matrix is also specified as the distance between bins that can be reached within one transition. Once this step is done, the user can choose the initial number of agents and run the simulation. During the simulation, the user can interact with the swarm (kill or add agents). Most importantly, one can change the target distribution, updating the Markov matrix to all agents, and guiding the transition to the selected shape.
Given the encouraging results, future work will focus on implementing: motion characteristics for agents, conflict avoidance techniques [2] and three dimensional simulations.

Additional material



(a) t=15 (b) t=50 (c) t=300 (d) t=730 (e) t=765 (f) t=780 (g) t=920

Figure 1: A swarm of 1000 agents evolving during the simulation at different time instances. At t=740, the target shape is changed. (the darker the cell is, the more agents there are)

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LittoSIM-GEN: exploiting GAMA features to simulate a serious game of flooding risk management

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Keywords

LittoSIM-GEN, participatory simulation, serious game, coastal flooding, risk management

Abstract

LittoSIM-GEN is a generic participatory simulation model composed of three agent-based models that allow playing a multirole serious game of flooding risk management. The central component of LittoSIM-GEN is the *manager* model where submersion events are calculated and displayed on a multidistrict study area. The *player* model offers a set of land use and coastal defense actions to distant playing teams (usually four) to manage their districts and mitigate the unpredictable flooding damage. The last model is the *leader*, which represents a state risk agency that supervises the game and pushes players towards collaborative and alternative strategies.

The model creates a virtual environment for decision makers, urban planners, and risk managers to deal with different scenarios that they may confront in real world situations. Such experiences promote risk culture and raise awareness of the workshop participants who share their feedback and discuss their learning during the debriefing debate. Game animators use automatic and manual data collection, pre- and post-surveys, and a set of graphical indicators to report and assess the results of workshops.

To implement such a realistic ludic game with relevant outcomes, LittoSIM-GEN makes use of multiple features of the GAMA platform, a modeling environment for developing agent-based simulations:

- *Reading and writing text files*: besides exporting results as textual data for further analysis, the model reads multiple hierarchical configuration files during the initialization phase. This allows loading diverse territorial archetypes with different parameters, which makes LittoSIM-GEN a generic and dynamic model.
- *Processing geospatial data*: loading and accessing vector and raster files is a simple task in GAMA. LittoSIM-GEN uses this feature to create a realistic environment by using empirical data, such as administrative boundaries, elevation models, and land cover databases.
- *Using ergonomic interfaces*: GAMA allows developing user-friendly graphical interfaces to handle player actions. LittoSIM-GEN players can use tablets to make the game more playful.
- *Implementing large-scale models*: agent-based models developed with GAMA can go up to millions of agents with the possibility of executing parallel processes to speed up calculus. LittoSIM-GEN uses large spatial grids to represent the territories and simulate inundations gradually.
- *Connecting to the network*: participants can play LittoSIM-GEN as a remote game through GAMA primitives that allow serializing data and communicating over the network using shared messaging brokers such as Apache ActiveMQ.
- *Accessing the system command*: GAMA can access the system prompt to execute any command or external program. This feature allows LittoSIM-GEN to use LISFLOOD-FP model to calculate the real extent of a submersion based on data of the study area.
- *Displaying graphical outputs*: during the game, multiple real-time indicators and dynamic graphs show the current state of the territory. GAMA can visualize any relevant information on graphical displays, as well as saving these data to different output files (textual, vector, raster).

Improving LittoSIM-GEN depends highly on future enhancements of the GAMA platform, particularly:

- Portability of GAMA applications to allow the execution of models out of the platform.
- Dynamic graphical components to handle more user interactions, such as built-in buttons and text boxes.

Additional material

GitHub repository: https://github.com/LittoSim/LittoSim_model

Extending BEN architecture for modeling MBTI agents

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Keywords

Multiagent systems, BEN, MBTI, Human Behavior, BDI.

Abstract

The Myers-Briggs Type Indicator (MBTI) [3] is an instrument developed by Isabel Myers and Katherine Briggs that groups individuals through distinct personality types. Inspired by the work of Carl Jung, it proposes four categories to discriminate the individuals: extraversion-introversion, sensing-intuition, thinking-feeling, and judging-perceiving. By combining these categories, sixteen distinct personality types may arise. The instrument can be applied in different contexts, such as in career counseling, in the development of educational actions considering different learning styles, and in organizational support aiming at a better understanding of the influence of human behavior in organizations, among others. Concerning this last issue, multiagent-based simulation (MABS) has proved to be a powerful tool to observe the behavior of artificial agents' organizations. In this work, we investigate the use of the Gama platform to develop artificial agents' personalities based on the MBTI; in particular, we propose to extend the BEN (Behavior with Emotions and Norms) [1] architecture to accomplish this task. The BEN architecture enables the implementation of BDI agents [4], in which agents have beliefs, plans, and intentions. BEN helps to provide agents with cognitive skills, representation of emotions, personalities, social relations, and norms. The agents' personalities in the BEN architecture are based on the OCEAN model [2], also known as the Big Five. This model considers five behavioral characteristics of people: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. Although both models deal with human behavior, it can be seen the OCEAN theory contrasts at significant points with the MBTI theory, and is important to adapt the architecture so that new studies can be applied using different personality models. Despite the necessary adaptations, BEN's current architecture already allows several functions to be reused independently of the personality model; as an example, perception functions enabling agents to perceive others in a certain vision radius, and thus adding beliefs related to these perceptions, are extremely important in agents' simulations using the BDI model. In addition, the definition of agents' action plans allows a simple way to manage the intentions, desires, and beliefs of agents in different situations, helping to successfully implement BDI agents in a simple way and with multiple capacities. Our approach seeks to extend the BEN's capabilities so that other instruments, such as MBTI, could be used together with BEN, thus aiming that different personality theories of human behavior can be tested within the described architecture. In our work, a customized algorithm will be implemented using some BEN native features, but expanding the decision-making agents' capabilities through the algorithm by adding components that better represent the agents' personality modeled after MBTI.

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Exploring the viability of walk-sharing in outdoor urban spaces

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Keywords

pedestrian safety, fear of crime, walk-sharing, agent-based modelling

Abstract

Walking is the most common mode of travel, given its higher levels of accessibility, especially for short trips. Researchers have suggested that walking has significant health benefits as well as community benefits, and more walkable urban spaces leads to sustainable and liveable communities. However, challenging walking environments discourage people from walking. Pedestrians, while walking alone, feel unsafe and vulnerable in certain outdoor spaces at certain times of the day. Fear of crime has been cited as the most important barrier for which walking becomes unattractive at critical times of the day, even though walking might be convenient otherwise. Pedestrian route and travel mode choice is often influenced by fear of crime and it forces- pedestrians to avail costlier alternatives, such as taking viable detours or abandoning walking altogether and switching to alternative forms of transport. Fear of crime reduces the overall walkability of an urban area, reduces the time spent on walking, and thereby disrupts the benefits that are offered by walking.

Traditional approaches aimed at reducing the fear of crime amongst pedestrians are usually not cost-effective, never holistic and take significant time before coming into effect. Existing research suggests that the absence of people is the major reason for pedestrians feeling fearful while walking through urban spaces at critical times of the day, even when infrastructural elements are conducive for walking. Pedestrians feel safer when they walk with a companion as compared to walking alone in environments which they perceive as unsafe. The presence of just another pedestrian nearby boosts natural vigilance, increases sense of security, reduces perceived risk and fear of crime. People would walk more if they had a walking companion, such as a friend, a colleague, or a family member under critical circumstances. But, a pedestrian is not guaranteed a walking companion under all critical circumstances. To overcome this challenge, we have introduced *walk-sharing*, a hypothetical buddy-service, which is aimed at encouraging people to choose walking when it is viable, and not pursue alternative modes. In walk-sharing, a potential pedestrian will get matched to another (assumed to be unknown to each other) so that they are able to walk together, instead of walking alone, and thus overcome any potential fear that arises out of seemingly unsafe walking environments. We used an agent-based modelling platform GAMA (tailored for building spatially explicit agent-based simulations) to model walk-sharing, established proof of concept using synthetic data, and tested its technical viability under under real-world data-driven scenarios to understand the conditions in which walk-sharing will produce acceptable outcomes.

Additional material

Relevant input and code files are available at `https://github.com/bitmixes/Walk-sharing-model`.

Social influences on consumption choices in university catering: a multi-agent modelling approach using GAMA

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Keywords

nutrition and eating behaviours, social influences, decision, collective catering

Abstract

At first sight, composing a meal from dishes offered in a buffet menu is an ordinary and trivial task. However, this apparent simplicity hides a complex decision-making problem (taking into account preferences, trade-offs related to price, pleasure, variety, nutritional quality, etc.). This difficulty increases if we take into account the possible interactions between eaters. Indeed, food choices made in the presence of other eaters, such as in collective catering facilities, are the result of taking into account individual preferences as well as numerous social influences. Monitoring the evolution of choices in such contexts can be seen as studying the evolution of a complex system (many agents establishing multiple interactions with each other, thus producing a system whose evolution is difficult to predict). The objective of this project was to design and test a multi-agent system to simulate the choices of individuals choosing their dish in a university restaurant in accordance with their preferences but also under the influence of the other eaters they were brought to bump into while choosing their foods. For this simulation, we used the architecture and menus of a real university restaurant. In this model, implemented with the GAMA platform, each individual was arbitrarily assigned a preference for a certain nutritional profile for his or her own meal (ranging from poor to very high nutritional quality), this preference could be influenced by seeing other's choices. Each individual tended to conform to the choices of the other eaters they encountered. The perceived influence of an individual seen in the restaurant was variable across individuals (from poorly influential to highly influential). First experimental simulations validated that this model proposed plausible choice configurations. This represents an original approach to study the effect of social influences on the choices of individuals in a crowd situation. Future work will attempt to describe real-life situations in order to test hypotheses on how individuals integrate social influences into their food decision-making process.

Traffic model adaptive self-calibration using multi-agent systems

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Keywords

Multi-agent systems, adaptive multi-agent systems, traffic simulation, model calibration

Abstract

Simulation is a useful analysis and forecasting tool, often used to study and understand complex phenomena. It is based on simulation models that reproduce the behavior of an entity/system at different levels and scales. These models are in particular composed of input parameters on which depends the outcomes of the simulation. In order to obtain a model simulating real phenomena, a calibration step using real data is required to identify the corresponding values of the input parameters. In addition to this, by using real data obtained from observation points, microscopic entities can in real time adapt their behavior in order to make the simulation mimick the real system. The dynamics at the macroscopic level implies a continuous calibration of the microscopic level.

There are two main types of calibration approaches in the literature: iterative (optimization-based) methods and data assimilation methods. The first ones rely on traditional optimization methods like genetic algorithms [1, 2]. These algorithms are run only once prior to any simulation exploitation. Therefore, models calibrated this way are not able to adapt to events occuring in the reference system and user interaction is limited. In this case, the simulation has to be interrupted and calibration redone completely to adapt the model to new data. The second type of calibration methods are based on data assimilation. Contrary to the previous ones, they are executed while the simulation is running. Most widely used methods are the Particle Filter [4], the Kalman Filter and its derivatives like the Ensemble Kalman Filter [5] and the Unscented Kalman Filter. The main limitation of the Kalman Filter is the fact that it assumes that the uncertainties follow a Gaussian distribution and that the system is linear.

We propose a novel approach to model real time calibration based on self-adaptive multi-agent systems [3] called **CALICOBA** (*CALIbration COopérative à Base d'Agents* or *agent-based cooperative calibration*). This approach proposes to explore how the input parameters self-organize and self-adapt in real time their values in order to satisfy macro-level constraints (such as observation of a traffic jam or daily traffic density variations, etc.) to reach a specified collective behavior. This approach is evaluated in the context of the simulation of traffic on a campus. To calibrate this simulation, we run traffic simulation models used in Gama and record observations on some points of interest of the campus. Then, the observations are given as objectives to CALICOBA where the input parameters of the studied models self-adapt in real time their values in order to reach the desired objectives. This simulation should also let users interact with it by modifying these objectives and adapt to events that may occur in the virtual environment (e.g.: adding new constraints, closing a road, etc.).

Additional material

Code repository: `https://github.com/Darmo117/CALICOBA`

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Agent-based evacuation model of the mountainous massif of La Soufrière users under volcanic crisis: an application of the ESCAPE extension

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Keywords

agent-based model, evacuation model, synthetic population, volcano

Abstract

The eruption of Mount Pelée in 1902, the Montserrat Soufriere hill's since 1995 and the recent Soufriere hill of Saint-Vincent-and-the-Grenadine clearly illustrate the plurality of a volcanic eruption. The risk from a volcanic eruption depends on various factors (the type volcano, the geographical location or the perception of population, ...). Against the difficulty to forecast a volcanic activity, the only individual protection is to move forward from the threatened areas, which can be a big issue at a population scale. Mass evacuation and other protective measures are more effective if they are planned and organized before an emergency arises. A mass evacuation of a territory is a complex process, involving many different actors who have to make decisions with limited information and high uncertainty, on short time scales. In french overseas departments, despite the presence of several volcanoes, volcanic emergency management suffers a lack of experience feedback, especially for the volcanoes of the west indies. Numerous risk management and crisis documents exist, they marginally integrate the volcanic crises response, for which evacuation does remain the most appropriate solution. The success of a mass evacuation strategy will be dependent on the entire public authorities' strategy (general awareness of the hazard, legislative framework, scientific knowledge, warning system, ...) and the public perception of volcanic risk. Crisis exercises can be planned to prepare authorities and population on crisis, but evacuation order is rarely played due to human and resources costs. Simulation can be then a good compromise to this issue. Based on GAMA software and ESCAPE extension, a series of evacuation scenarios is tested, combining staged or simultaneous evacuation, whether or not the rapid deployment of local responses. The main objective of this research is to provide, by the development of a calibrated and validated model and its exploration (by OpenMOLE), some pertinent information for the stakeholder like road itineraries or optimal staged evacuation. This presentation describes therefore an agent-based model (ABM) of mass evacuation, focusing on deployment of local responses and using stratovolcano on the French island of Basse-Terre, in Guadeloupe (La Soufrière). This ABM is calibrated with a synthetic population from census microdata (Iterative Proportional Fitting) in which each agent belongs to a private household and is characterised by some decision rules. The individual evacuation decision model is complex and influenced by several factors. We use here a BDI approach to simulate evacuation decisions into two opposing predicates, namely, routine versus crisis. Beyond the evacuation decision, we test various local responses and assess the impact of ballistic projectiles on the evacuation time. We focus on the fear diffusion between interacting agents and its impact on the evacuation time.

COMOKIT-Region: A simple agent-based method for understanding large-scale Covid-19 transmission risk between regions

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Keywords

Epidemic Model, Pandemic Risk Model, Agent-Based Model, Dynamic Bayesian Network

Abstract

In many scenarios of epidemic model where researchers have access to limited data, one of the major paradigm in understanding the spread of the epidemic is agent-based model [1], with flexibility and explain-ability being some of its major advantages. Nevertheless, recent works have pointed out many of individual agent-based model shortcomings, namely robustness [2], computationally demanding and oversimplifying assumptions [4]. These problems have prevented researchers around the world to effectively utilize individual agent-based model to understand the macro-effect from long-distance travel in epidemic spreading. To address this issue, as a part of the COMOKIT project [3], we propose a new agent-based framework representing macro-interactions between regions, where agents are local regions characterized by their risk factors (ideally, we define a region to be a combinations all individuals in a high population-density areas + the maximum perimeter of their average travel routine, which can be approximated by major cities in case of limited data). In modeling the risk properties of a region, we take three main factors into account: transportation rate to/ from that region, the state of the epidemic at connected regions, and the population density of the region.
In this presentation, using the GAMA simulation platform, we demonstrate our framework through a toy example by a simulation of the time period between the first reported case of Covid-19 in Ho Chi Minh city, Vietnam and the first major outbreak in Da Nang 325 days later.

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Additional material

Presentation link (To be updated before GAMA Day)

From BPMN to GAML: application to crisis management

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Keywords

Multi-agent simulation, Crisis management, GAMA, BPMN, Model transformation

Abstract

Crisis management is by nature a complex situation involving a dynamic alea and various kinds of actors attempting to rescue people and fight this alea. Agent-based models and simulations are particularly useful to model these kinds of complex systems, as the complexity results from the interactions between agents and their environment. In addition, simulation can be a powerful tool to test alternatives, as it can be used during various stages of the crisis management life-cycle, notably pre-crisis stage (more particularly the warning step), and crisis stage (more specifically response definition and evaluation steps). For instance, a situation could be simulated to determine whether it could evolve into a crisis, or the various possible responses can be tested and assessed on the current available data. The GAMA platform is particularly adapted to model this kind of situation, as it is a multi-agent platform that has been designed to build models integrating spatial data. However, modelling specific behaviours relevant to a crisis, like evacuation dynamics or how (first) responders operate, and more specifically the coordination of the actors, can be difficult without a strong relevant background. Thus we need to provide a more abstract representation of the different actors involved in the crisis resolution to ease the modelling of responders' behaviours.

BPMN (Business Process Model Notation) is an appropriate notation for representing the behaviour of actors involved in crisis resolution. It is understandable by crisis cell members responsible for crisis resolution. It allows for the description of abilities and skills of responders as tasks along with the coordination of those tasks using gateways and sequence flows. This notation gives a macro-view on a crisis management process.

The goal of this work is to fill the gap between BPMN, convenient for crisis cell stakeholders, and GAMA, which supports the simulation of the crisis response and gives a micro-view of crisis resolution. We adopt a Model Driven Engineering (MDE) approach aiming at producing GAML (GAMA Modelling Language) code from BPMN diagrams. We choose to rely on a pivotal metamodel, named BPMN4GAMA that is a simplified version of the BPMN metamodel, as an intermediate between BPMN2.0 and GAML. Since we do not need every BPMN concept, having a pivotal model allows us to select the elements that are relevant to our problem, and to add new ones as needed. Furthermore, having a dedicated metamodel gives us the ability to adapt to the technical constraints of the tools used. From this metamodel, we then mapped each BPMN element to a concept in GAML: each BPMN process was encoded as a single GAML reflex embedding the tasks' sequences and parallelisms. From a technical point of view, our starting point is the BPMN2.0 Modeler, an Eclipse-based diagram editor. A model to model transformation using ATL (ATLAS Transformation Language) was used to get a BPMN4GAMA model from a BPMN2.0 diagram. Finally, this model is used to generate a GAML file using Acceleo (an Eclipse-based implementation of the OMG's Model-to-text specification).

Preliminary results show, first, the technical feasibility and the modelling benefits of this model to model transformation. Secondly, the generated GAML model has been shown to be coherent with the BPMN specification: only allowed execution traces are possible.

Acknowledgments

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BRAV-ABM: Agent-based integrated approach to study fishery practices environmental impact from the buttom-up

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Keywords: Socio-environmental modeling, Companion modeling approach, multi-objectives agent-based simulation model

Abstract

Context: Amazonian floodplains are the most populated rural areas in central Amazonia. There are one of the richest biodiversity hosts on earth, while being historically associated with human settlements practicing subsistence agriculture supplemented by fishing and hunting. Over the past several decades, commercial jute cultivation, commercial fisheries, and the expansion of cattle ranching have disrupted traditional patterns of resource use. In coming years, they will be increasingly threatened by development projects and agricultural expansion, as well as by climate changes.

Problematic: One of the main goals of the BONDS project is to provide insight on floodplains management to design development strategies that consider biodiversity issues and socio-ecological dynamics together. Our primary objective is to engage stakeholders at looking for solutions in fisheries management and land use strategies, enabling preservation of biodiversity and fundamental ecosystem services, such as food security, water quality or carbon storage in Amazon floodplain environments under different hydroclimatic scenarios.

Methods: Participatory role-playing game sessions will be implemented to reinforce social learning and capacity building as well as forging a mutual understanding of stakeholders' strategies and points of view on the resource. This will enable the design from the bottom-up of an agent-based model of broader scope and scale to study prospective floodplain biodiversity and ecosystemic services.

Proposal: Knowledge about social and natural dynamics of the floodplain will be shared among researchers and local actors through participatory agent-based. Produced qualitative and quantitative data will be used to feed an autonomous, data intensive, large scale agent-based model of the overall floodplain dynamic, including stakeholders, policy makers, hydrological processes and fish population dynamic. In this communication we will describe first the material, protocol and software involved in the participatory modeling phase; detail the data processing step to feed the autonomous version of the agent-based simulation model. Lastly, we report on the validation and calibration perspectives we engage in using land use/cover changes of the Varzea de Curuai floodplain on the past 30 years.

Additional material

bonds-amazonia.org

Perception-Based Maps as input data for Agent-Based Modeling: application to the colonization of the Ecuadorian Amazonia

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Keywords

Ecuadorian Amazon, Agent-Based Modeling, PBRM, qualitative data, GAMA platform

Abstract

The PASHAMAMA project aims at modeling the installation of settlers in the northern part of the Amazonian region of Ecuador under pressure from oil exploration and agrarian ressources from 1960 to 2016. Particularly, the model takes into consideration the intensive oil extraction touching the zone which has induced a high rise of population, pollution, agricultural work and deforestation and aims at reproducing these phenomena. One of the main difficulties in the construction of such a model is the complexity to model the agents representing human beings, and in particular their behaviors, their representation of the world of themselves, and of the other agents, as well as their decision making process.

The traditional approach in Artificial Intelligence is to look at psychological or sociological theories to build formal models of human behaviors rather than directly considering real data. But this approach often proves unsatisfactory in interdisciplinary work where it appears too disconnected from the real system to be accepted. We therefore adopt in this work the opposite approach: our starting point is real field data, quantitative (territory, practices) but also qualitative data from PBRM (Perception-Based Regional Mapping), that are semi-directed surveys letting local inhabitants produce subjective maps of the environment they know. One of the principal advantages of the use of quali-quantitative tools is the possibility to highlight the subjective and biased representation of the questioned person in its agro-ecological and socio-economic environment.
To this purpose, we rely on data collected during field studies organized between 2013 and 2016 to collect perception-based maps on the three modeled provinces in the PASHAMAMA model: Dayuma, Pacayacu and Sacha provinces of the Amazonian area of Ecuador. A key component of the model is the installation of new colons in the studied area over time and in particular their choice of *finca* (i.e. parcel). This process is particularly important because it has a strong impact on the simulation results and it is particularly relevant for our study because we assume that its result comes from a settlers decision-making process. In the current version of the model, the finca is chosen thanks to the minimization of a function of the distance and the type of roads.

The key idea of this work is to introduce subjective data in this decision-making process: we thus extend the previous function by introducing the settlers' desire to maximize the quality of the soil in their choice. We run experiments to compare results without the use of soil quality in the choice (original model), with the use of the real soil quality map (fully-informed model), and with the use of the subjective soil quality data coming from PBRM (subjective model). We assess simulation results given actual deforestation data.

Preliminary results show that the introduction of PBRM data improves the model results in terms of settlement areas of the colons. Another interesting result is this result is confirmed on the three studied provinces, in the limit of a well-differentiated area: improvements on a province with a uniform soil quality are not significant.

Acknowledgments

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Mixed-traffic agent-based simulation based on Bezier curve

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Keywords

Agent-Based Model, Mixed-Traffic, Traffic Modeling, Microscopic Simulation, Bezier curve

Abstract

In recent years, the rapid development of infrastructure and means of transportation has required scientists to provide a systematic framework to analyze their impacts. Various works have been dedicated to the understand of vehicles movement patterns through cellular automaton models, with some notable works includes car-following model[3], lane-changing model [4], and gap acceptance model [1]. However, while many agent-based models have been developed for cities' structured traffic patterns, many challenges still exist in modeling practical situations where different vehicle types do not always follow by lanes. Following the previous agent-based model for mixed-traffic [2], we extend the framework with three novel developments: (1) naturalistic representation of stochastic collision at junctions, which could potentially be used to study the rate of traffic accidents in the mixed-lane traffic setting. (2) integration of Bezier curve model for autonomous vehicles trajectories [5] in GAMA [6] agent-based platform (3) a pipeline to integrate our model with GIS data and real-time traffic information, which could be combined with other combinatoric optimization frameworks for logistics applications. Finally, we prove this model's capability by applying it for mixed-traffic simulation in a real simple road network in Hanoi city, Vietnam.

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Additional material

Presentation link (To be updated before GAMA Day)

Frugivore identity and landscape configuration affect seed rain during restoration

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Keywords

Spatially-explicit, individual-based model, seed dispersal, landscape structure

Abstract

Seed dispersal is an essential ecological function provided largely by vertebrate frugivores in tropical forests. The quality of seed dispersal provided by a species vary based on the interaction between the species' traits and the surrounding landscape structure. Managers willing to restore seed dispersal to degraded areas to facilitate passive regeneration need consider these landscape-frugivore interactions. Our aim is to explore how the relationship between landscape configuration and disperser traits affects seed rain patterns by assessing two restoration goals: (i) low non-native seed dispersal into intact areas combined with (ii) high native seed dispersal into degraded areas. We developed an individual-based, spatially-explicit model, "Estimating Seed-Animal-Landscape Interactions" (eSALI), and applied it to the case study of Guam, a tropical island that has faced near-total loss of animal-mediated seed dispersal after the extirpation of its vertebrate frugivores. We focus on two frugivorous bird species, Totot (*Ptilinopus roseicapilla*) and Såli (*Aplonis opaca*), both candidates for rewilding on Guam but differ in their gut passage times, movement distances, and habitat use. We simulated populations of both species in seven theoretical landscapes. These landscapes varied in the spatial configuration of degraded and intact forest patches, hosting non-native and native plant species, respectively. Our results highlighted that the seed rain pattern of both species differed across all scenarios. A clear tradeoff appeared between both restoration goals in all scenarios: Totot minimized non-native seed rain into intact areas at the expense of moving overall fewer native seeds in degraded areas. On the contrary, Såli moved overall more native seeds into degraded areas, while also moving more non-native seeds into intact areas. Land managers should explore the interactions between landscape configuration and dispersers to identify ideal candidates for restoring ecological functions.

Additional material

https://github.com/hthierryp/eSALI

Simulating bicycle traffic flows in a geospatial agent-based model

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Keywords

Bicycle traffic, agent-based modeling, transport model

Abstract

In order to minimize the negative consequences of motorized traffic, such as problems with space, congestion, and pollution, transport planning strategies promote the bicycle as sustainable mobility option. For efficient planning and monitoring purposes, vast amounts of mobility data are required. However, although sensor technology is advancing at high pace and IoT systems generate extensive data streams, suitable data on cycling mobility at a high temporal and spatial resolution is still sparse. Transport simulation models have become powerful frameworks, which facilitate linking various data sources and bridging existing data gaps. Against this backdrop, our research aims at the development of an agent-based model that simulates bicycle traffic flows at a regional scale level, at very high resolution for an entire day. The testbed for our proof-of-concept is the greater region of Salzburg city in Austria.

The bicycle simulation model is implemented in the GAMA RC1.8 platform. The platform's geospatial capabilities allow for and adequate representation of the environment and processes. We therefore implemented a complex transportation system, which includes spatial reasoning and determinants in human mobility behavior.

In general, the bicycle model generates a heterogeneous population of around 185,000 persons who are actively engaged in selecting activities and traveling to destinations. Their decision-making process is governed by probabilistic rules derived from mobility survey data. Choices include the selection of the next activity type, its location, the time of departure, duration, transportation mode, route, speed, and reasonable distances reachable by a selected mode. The routing of cyclists uses a bikeability index, instead of shortest distance or minimum travel time, as impedance (cost function).

The results of a simulation include spatio-temporal bicycle patterns at high spatial (road segment) and temporal (minute) resolution, mapped on a topologically correct graph. Scenario analysis justifies the model's complexity and demonstrates that models with implemented context-dependent behavior outperform null models. Empirical validation shows different correlations between simulated and observed data, which are GPS trajectories and stationary counting data. Relative frequencies, such as ratios of morning vs. afternoon peaks, city center vs. outskirts, and west vs. east sides of the city are well imitated. The temporal distributions of cyclists at counting stations are strongly correlated with observed data, while the spatial distributions over a network have moderate to weak significant correlations.

These findings may help us understand the importance of the quality of input and validation data. Data bias hugely influences the model's predictive power and accuracy. Further improvement in the design of mobility behavior is possible. The routing choice would benefit from the consideration of traffic lights, visibility index, number of turns, and current volumes of other traffic participants. Commuters' navigational rationalism can be modeled differently from city residents. Another important step for further research is to examine the model's transferability, decide which components are to be re-parametrized or generalized for similar city regions.

In conclusion, we have developed the bicycle agent-based model where spatio-temporal traffic patterns emerge from individual mobility behavior. The findings of our research provide a methodology to investigate different traffic scenarios and to assist transport planning in decisions regarding the promotion of bicycle mobility.

Additional material

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Development of Multi-Agent City Simulator on GAMA (MACiMA)

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Keywords

Traffic Simulation, Traffic Flow Optimization, Data Assimilation

Abstract

Traffic is one of the popular application domains for Multi-Agent Social Simulation (MASS). There are many studies to apply MASS to predict or assess traffic flows under some kinds of traffic rules, environments, policies, etc. It is expected that MASS can greatly enhance the design of traffic systems, environments, policies, and services, as it takes a different approach from existing ways based on a macroscopic viewpoint. A typical issue of MASS is how to secure the quality of the reproduced traffic flow in multi-agent traffic simulations. There are several elements to be considered to achieve that; 1) traffic simulation should be conducted with high-precision GIS data to produce realistic travel distance, travel time, etc., 2) vehicles included in traffic flows should drive on a reasonably loose driving route, 3) vehicles should be assigned appropriate OD (Origin-Destination) to achieve reasonable distribution of vehicles over simulated area. The authors, for conducting multi-agent traffic simulations for practical use by considering the elements presented above, have developed their original simulation environment, called MACiMA (Multi-Agent City Simulator on GAMA).

Core features of MACiMA can work well to achieve the quality of simulated traffic flows. Firstly, thanks to the empowerment of GAMA's main feature, MACiMA is familiar with GIS data. The movie (URL is shown below) shows the traffic simulation of Kusatsu City (Shiga Pref., Japan) and Gotenba City (Shizuoka Pref., Japan) on MACiMA. We constructed a road network for traffic simulations by extracting data of road sections and connection information of those road sections from the high-precision digital map. Thus, from the simulation results, we can obtain realistic travel distance, travel time, and so on. And, visually striking results can enable users to sense the reality of simulations. Secondly, through simulations, vehicle agents can find reasonably distributed driving paths. In the process of traffic simulations, it is natural that vehicle agents try to find a path that can minimize the driving distance. But, in the consequences of such behaviors of all vehicles, unnatural congestion tends to happen since vehicle agents assigned alike OD (Origin-Destination) find the same shortest path. In MACiMA, vehicle agents try to find better paths in terms of the time distance through iterations of simulations with the rerouting of some agents at each iteration. As shown in the movie, the volume of vehicles is not biased toward the main lines and some of the vehicles drive a narrow or winding detour after 50 iterations of traffic simulations consisting of 10,000 vehicle agents for 4 hours. Thirdly, vehicle agents should be reasonably distributed over the area for simulations. Thus, OD assigned to each agent is an important parameter for achieving realistic traffic flow although there are other important simulation parameters. If we can set appropriate ODs to vehicle agents, the generated traffic flow can achieve the approximation of the traffic flow to that in the real world. One approach for finding appropriate ODs is to apply iterative process consisting of simulations and comparisons between traffic volume in simulations and real-life traffic volume. This time, we are going to present the results of our trials at an early stage for exploring appropriate ODs (simulation parameters).

Additional material

Demo Movie:

http://collabodesign.org/wp-content/uploads/2019/07/mass_demo_20190627.mp4

http://collabodesign.org/wp-content/uploads/2021/07/macima_gotenba_mix.mp4

MACiMA's System Diagram:

http://collabodesign.org/wp-content/uploads/2020/02/MACiMA_diagram.pdf

Does memory help optimise fruit fly foraging in a local heterogeneous landscape?

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Keywords

Ecology, population dynamics, memory

Abstract

Learning and remembering hosts is a mechanism which is thought to help optimise individual foraging. However, there are perhaps conditions of host distribution where individual memory of, and thus an affiliation with, poor hosts may be detrimental to population survival at the landscape scale. For Queensland fruit fly, the major Australian horticultural pest, I have developed a mechanistic individual-based model. This model is parameterised with data from multiple laboratory and field studies, to explore population dynamics and survival in heterogeneous host landscape scenarios. The model incorporates population dynamics based on larval survival and adult survival and fecundity depending on fruit host quality. Movement behaviours are simulated depending on host quality and prior oviposition experience in fruit hosts. I present an analysis of scenarios where local host environments vary in aggregation and proportion using three host tree types (poor, average and good) with either a synchronous fruiting season or asynchronous fruiting seasons over 10 years. Optimal foraging with and without memory is simulated over various landscapes. It is hypothesised that fly populations do best with optimal foraging plus memory in landscapes with low aggregation but will be driven to extinction in modified landscapes with high aggregation if they experience a poor host. The simulation model also enables further exploration of complex interactions and emergent behaviours.

Landscape, vegetation and resources' modeling: reconstituting the pre-Neolithic Roussillon territory (France) and its vegetation by implementing Plant Functional Types, hydrosystems and climate into a cellular automaton.

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Keywords
Cellular Automata; LUCC modeling; Plant Functional Types; Roussillon; Water dynamics; GAMA platform

Abstract
Vegetation covers did dramatically change since the beginning of the Neolithic era, especially in anthropized areas such as the Mediterranean shores. The Pyrénées-Orientales French Department, also named Roussillon, the meridional district of continental France, has been cropped since the 5th millennium BC. Along with climate progressive aridification, this land use has deeply transformed the local vegetation cover, both in terms of biomass and vegetation type distribution, but not evenly on the territory according to the local combination of human activities. We here present the first step of the dynamic reconstitution we plan for this territory by settling the land cover before this colonization:

1) In order to be able to compare simulation results with archaeological data, we reconstitute the potential vegetation biocenosis by discriminating the 94 trees and bushes present at that time according to archaeological records into 10 Plant Functional Types (PFTs) according to their behavior facing the three most cited variables affecting them, i.e. soil water availability, mean annual temperature and soil pH;
2) In order to provide the spatial characterization of the territory according to the three above cited variables, the Roussillon has been simulated with its biotope, i.e. climate (Rainfall and temperature thanks to the WorldClim data), its elevation and pedology (pH and fertility), and by then, its water dynamics (run-off, river fluxes, water table balance) with a resolution of 90m*90m raster pixels and with a seasonal time resolution. Extreme events are implemented with their probability according to local temperature and water availability: frosts, fires, tempests, floods all affecting glade appearance probabilities and by then renewing the vegetation cover and PFTs;
3) Finally, we settle the 10 PFTS for all the pixels of the territory. Initialization goes through the succession of average seasons, including extreme events. Such a succession over an artificial calibration period of 500 years discriminate the various PFTs for each pixel reconstituting by then a locally adapted vegetation;

As a result, we plan to get a vegetation and biotope dynamic reconstitution that: (i) can be tested facing palynological archaeological data, avoiding therefore the main flaw of pollen-based landscape reconstitution methodologies using pollen as inputs and having no data for refutation tests as a consequence; (ii) can be used for the following step, i.e. implementing Neolithic farmers and livestock keepers, including their fishing, gathering, pruning and hunting activities, onto this reconstituted Roussillon territory.

Acknowledgements
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Challenges for integrated assessment modeling of socio-agro-ecological systems

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Keywords

social-ecological systems, spatial simulation, agent-based modeling

Abstract

MAELIA is a simulation platform for integrated assessment modeling of socio-agro-ecological systems. It has been designed to assess environmental, economic and social impacts of combined changes in agricultural activities, biomass transformation and recycling chains, natural resource management strategies (e.g. water) and external drivers (e.g. demography, climate changes). This platform enables users to simulate the dynamics and the interactions of the four main sub-systems of social-ecological systems: 1) resource systems (e.g. hydrological systems), 2) resource units (e.g. water volume and flow), 3) governance systems (e.g. which manage water resources) and 4) users (e.g. individuals and collectives who use water). MAELIA is a spatially explicit fine scale platform in which the interacting behaviors of plots, farmers, farms, agro-chain agents and governance agents are represented on an individual level. Hence, users can define and use outputs from field to local scale (e.g. watershed scale). This makes MAELIA a powerful and detailed tool used to simulate agricultural landscape dynamics from a few isolated farms to a thousand sq. km.

MAELIA is an ambitious platform that aims to offer an integrated perspective on socio-agro-ecological systems. For this purpose, the platform has a modular structure that enables users to activate/deactivate sub-models according to their research objectives. Modules are articulated around a core set of sub-models that is the simulation of farmer agent behavior based on Belief-Desire-Intention (BDI) architecture and decision rules. Four sub-models are actually organized around this agricultural core and interact with each other:

- The crop sub-model that simulates interactions between water, nitrogen and carbon-cycles and crop growth, at the field level;
- The agroforestry sub-model that simulates interactions between crop and tree growth (competition for water and light);
- The hydrological sub-model that simulates water flows and volumes in rivers, lakes, groundwater and dams;
- The organic resource chain sub-system in which exchanges and transformation processes of organic resources are represented (e.g. anaerobic digestion).

Each of them is based on external models that have been implemented and adapted in MAELIA platform (respectively AqYield, Yield-Safe, SWAT and UPUTUC). These models have been chosen based on their robustness as well as their simple handling (ease of use, parsimoniousness). The combination of these models results in a very large model that pushes GAMA to its limits. This situation has led the MAELIA development team to adapt implementation strategies.

Besides these technical challenges, MAELIA faces other challenges due to its fine-scale, integrative and generic modeling ambitions and its maintenance requirements. The use of such a platform in a new study area requires a huge amount of work regarding data integration. It usually implies fieldwork campaigns usually conducted along with local partners involved in research projects that aim using MAELIA. In addition, the integrative approach implies a wide range of scientific skills and knowledge to deal with specific research questions and to implement new modules.

Our communication aims to address the challenges that faces the development and utilization of such a platform and to discuss the work strategies selected throughout the twelve years history of MAELIA.

MAELIA-OWM : an integrated assessment and modelling tool for territorial management of organic resources

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Keywords

social-agro-ecological systems, spatial simulation, ecosystem services

Abstract

The use of organic wastes as fertilizers has various positive effects on ecosystem services such as soil fertility (e.g. nutriments provision, water storage, erosion control), climate regulation and soil biodiversity. Organic wastes use can also have negative effects such as increased nitrogen leaching and heavy metals accumulation. Moreover, organic wastes can affect different aspects of a farming system (workload, yields, fertilizing costs). Optimizing organic wastes management at local level requires an approach that would consider their characteristics (e.g. organic matter stability, fertilizing value), climate, soil and cropping systems heterogeneities (differences in rotations and crop management) as well as the multiple feedback relationships that link the system components. Organic wastes territorial management could benefit from an Integrated Assessment and Modelling (IAM) tool allowing stakeholders to consider biophysical and socio-economic processes from field to territorial level.

To reach this objective, we adapted the IAM MAELIA platform developed for modelling and simulating social-agro-ecosystems at local/regional level and implemented with the GAMA platform. MAELIA-OWM (Organic Wastes Management) provides solutions for assessing ecosystem services, economic and social impacts of scenarios regarding territorial OWM, agricultural activities, agro-environmental policies and climate changes. MAELIA is based on a set of models that for which parameters can be set for different biophysical contexts (e.g. AqYield cropping system model).

MAELIA-OWM is applied on the Versailles Plain, France (240 sq.km). This territory is dominated by rapeseed and wheat cultivation and is characterized by a high availability but low usage of urban organic wastes. We compare three different scenarios (greater use of available organic wastes and mineral fertilization only) to a baseline scenario (little use of organic wastes, current practices). These scenarios are assessed through a set of agro-environmental and socio-economic criteria (GHG emissions, carbon storage, nitrogen leaching, gross margins and workload). Actual developments of the model are dedicated to the implementation of an organic wastes chain model that will consider organic wastes production, transformation and transport.

Decisions and Behavioral Responses for Impact Estimation in Flash Floods

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Keywords

Social response, flash floods, Agent-Based Model, GAMA Platform, coping behavior, individual vulnerability

Abstract

Over the past years, flash flood forecasting has been significantly improved. However, it remains one of the most deadly natural disasters. Indeed, advanced forecasting still does not link natural hazards to exposition and vulnerability. Those elements are key to understand and prevent the emergence of dangerous situations and behaviors during flash flood events.

In the past, static modeling has been widely used to analyse natural hazard consequences. Nevertheless it fails to address complex interactions between individuals' behaviors and the social and environmental dynamics during the crisis. Conversely, Agent-Based Modeling (ABM) are well fitted to simulate complex coupled human-natural system dynamics.

Here we present the DeBRIEFF model (Decisions and Behavioral Responses for Impact Estimation in Flash Floods) which is part of the PICS project (Toward integrated nowcasting of flash flood impacts). The overall goal of the project is to enhance human, social and economical impact forecasting in the context of flash floods. DeBRIEFF aims at simulating the transition from individuals' routine activities (daily schedules) to self protective behaviors based on the reception and interpretation of environmental cues, alert messages and interpersonal interactions in the context of sudden flooding. This tool would allow testing hypotheses on the influence of warning message contents, spatial accuracy and lead times on the speed and adequacy of the social response with respect to the flooding dynamics. These questions are particularly relevant for the development of the improved weather warning system of the french Met office (carte de vigilance de Météo-France). In fact the system is currently being enriched with probabilistic information concerning the risks of dangerous phenomena in the longer term (from D+1 to D+7). Progressively it should also account for elements of territorial vulnerabilities to assess the risk at the "infra-departmental" scale, an information that may indeed change the perception and interpretation of end-users.

The model is implemented using the GAMA Platform, as it is particularly suitable to develop agent-based models integrating GIS data and complex human behaviors. For now, we are focusing on the case of Draguignan (36 000 inhabitants) having faced flash flood events in June 2010. The model combines the replay of the flash floods produced by external flash flood simulations with human beings' daily mobility and their adaptation to the hazard. The synthetic population, used to initialize the agents' population, has been produced by the Genstar library based on aggregated data from the INSEE in which individuals are defined by standard characteristics such as age and gender which allow us to define different profiles. The daily schedule of the people will be based on those profiles and so will be the alert threshold needed to trigger a reaction and the coping behavior.

As expected results, we plan to map both the human exposition and casualties due to the hazard depending on several scenarios of profile distribution and warning messages and signals.

Acknowledgements

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COMOKIT-Albatross: An agent-based, activity-based model on COVID-19 simulation

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Keywords

COMOKIT, Albatross, Activity-based model

Abstract

COVID-19 may become a norm in our day-to-day life the way flu did. However, given the unique characteristics of COVID-19 pandemic, our societies are not ready to effectively respond to extensive changes such as expensive lockdowns or teleworking. Society cannot afford operating, in the long run, under lockdown restrictions. Therefore, policies so far adopted by many politicians is to impose and relax restriction measures on periodic basis to assure the economy and wellbeing of the society are guaranteed while being able to manage the influx of hospitalized citizens. Nonetheless, the effectiveness of these restrictive policies, which are typically hypothetical, is to large extent unknown to us. Most of the already implemented policies are defined around quarantining people (including infected and uninfected). The main goal of these quarantine-based policies is to reduce the exposure of the susceptible population to the disease. However, several activities remain vital for the society, e.g., grocery shopping, and medical work trips. Thus, modeling human activities and their mobility patterns is critical for studying the spatial transmission of infectious diseases in large-scale urban areas.

Activity-based models (ABMs) have been developed by transport modelers in the past decades replicating the mobility of people with high temporal and spatial resolution. We are working with such model (i.e., Albatross) which can simulate data-driven activity pattern and travel of all people in the Netherlands which such fine granularity. Albatross mimics the decision-making process of the agent based on decision-trees derived from activity diary data. We understand from this model who interacts with who, where, for how long, how is using which transport mode and so on. In addition to location and modes of transportation of activities, detailed information about demographic attributes of people can be provided by Albatross. In epidemiology, it is essential to know age, gender, and any health background of individuals. Nonetheless, the existing SEIR (Susceptible – Exposed – Infectious – Recovered) models are completely blind to these attributes of people because of their intrinsic crude aggregation in time, space and demographics.

Against this background, we plan to combine the activity-based model (Albatross) with an epidemiology agent-based model (COMOKIT). COMOKIT-Albatross is a dedicated custom adaptation of COMOKIT. It simulates the spread of COVID-19 at the scale of the Netherlands. A large-scale (multi-million agents) simulation with the aid of Dutch supercomputer Cartesius. The activity diary for COMOKIT comes from the pre-generated mobility agenda in Albatross. The daily activities in Albatross are modelled at the precision of a minute, while the default COMOKIT behavior is modelled at the precision of one hour. The atomic spatial unit of this extension is at a Dutch 6-digit Postal Block level compared to the building level in COMOKIT. Epidemiological dynamics for COMOKIT-Albatross has also been modified to take into account this larger atomic spatial unit. The larger spatial resolution makes it possible to simulate a wider region, and fits the required spatial distribution of activities as modelled in Albatross agenda generator.

Additional material

Website: https://comokit.org/docs/officialExtensions/C-Albatross

ESCAPE: a city-scale evacuation agent-based simulation framework

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Keywords

Agent-based Modeling, Traffic Simulation, Population Evacuation modeling

Abstract

Partial or total horizontal evacuation of populations in urban areas is an important protection measure against a natural or technological risk. However, casualties during massive displacement in a context of stress and in a potentially degraded environment may be high due to non-compliance with instructions, accidents, traffic jams, incivilities, lack of preparation of civil security or increased exposure to hazards. Working on evacuation plans is therefore fundamental in avoiding casualties caused by improvisation and in promoting self-evacuation whenever possible. Since it is impossible to re-create the conditions of a crisis on the ground to assess such evacuation plans, there is a need for realistic models in order to evaluate them using simulations.

In this paper, we present the ESCAPE software framework that helps in the development of such plans and testing them. In particular, ESCAPE, which uses the GAMA open-source platform as a core component, provides an agent-based simulation tool that supports simulation of the evacuation of a city's population at fine temporal and geographical scales. The framework was developed such that it works for a wide range of scenarios, both in terms of hazards, geographical configurations, individual behaviors and crisis management.

The ESCAPE project gave birth to improved mobility modeling (car, bus, bikes, pedestrians), connection to census and mobility surveys to generate realistic population generation, individualized perception of space for thousands of agents and an improved connection to OpenMole for exploration and optimization, many of which have been integrated into GAMA. In order to show its adaptability, two applications are presented, one concerning the evacuation of the city of Rouen (France) in the context of a technological hazard and the other pertaining to the evacuation of the city of Saumur during a flash flood event [1].

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COMOKIT: a brief synthesis of the Gama supported agent-based framework to study NPI against Covid-19

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Keywords

Covid-19, NPI, agent-based epidemiological model, SEIR

Abstract

Since its emergence in China late 2019, the COVID-19 pandemic has spread rapidly around the world. Faced with this unknown disease, public health authorities were forced to experiment, in a short period of time, with various combinations of interventions at different scales. The scientific community has quickly emerged as a centerpiece to resolve the various puzzles the virus was the origin of, including how to flatten the curve of infection, limit the spread of the pandemic, create and dispatch the vaccines, and what could be the treatments. One of the main expectations from policy makers was to be able to help them build an appropriate response and forecast the consequences: this has put lights upon epidemiological models like never before. To meet this demand, we have developed an agent-based modeling framework called COVID-19 Modeling Kit (COMOKIT), designed to be generic, scalable and thus portable in a variety of social and geographical contexts. COMOKIT combines models of person-to-person and environmental transmission, a model of individual epidemiological status evolution, an agenda-based 1-h time step model of human mobility, and an intervention model. It is designed to be modular and flexible enough to allow modelers and users to represent different strategies and study their impacts in multiple social, epidemiological or economic scenarios. Since its first version (COMOKIT 1.0 - presented in (Gaudou et al., 2020)), COMOKIT has deeply evolved, through different related projects such as the ANRS COMOKIT project, COMOKIT Camps on the transmission of covid in refugee camps, COMOKIT Azur on the impact of morpho-functional characteristics of cities or neighborhoods on the spread of the disease, COMOKIT Albatross on a large-scale application of COMOKIT in the Netherlands using data for the construction of individuals' agendas: enrichment of the population generation process, better consideration of the link between the simulated territory and the outside area, accounting of variants and new types of interventions (e.g. vaccination), dashboard to better visualize data, multilevel modeling, etc.

In this presentation, we propose to go back over COMOKIT, its evolutions, but also to look at the impact of COMOKIT on the development of the GAMA platform. Indeed, all the efforts put in COMOKIT have greatly shaped ideas for the future development of GAMA, mostly questioning the link between the platform, data and decision-making process.

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Additional material

COMOKIT project website: https://comokit.org

An Agent-Based Modeling Approach for Understanding Land-use Adaptation in the Mekong Delta under the Context of Climate Change

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Keywords

Agent-Based Modeling, farmer decision, GAMA platform, land-use change, climate change.

Abstract

In recent years, the combined effects of fluctuations in the benefit of agricultural and seafood production, management policies and environmental changes (increase of saltwater intrusion due to subsidence and sea level rise, increase of the length of drought periods because of the elevation of temperatures and the decrease of freshwater availability) have seriously affected the agricultural production of the coastal provinces in the Mekong Delta. Adaptation of farmers take many forms, including deep changes in their agricultural practices and land-use in order to maintain their income. However, the somewhat uncontrolled conversion of farming systems to follow market demand and get immediate profits will in some cases negatively impact the environment (degradation of soils, increase of salinization) and locally disrupt the long-term land-use plans established by provinces, normally designed to be sustainable at the global scale.

In this work, we focus on land-use decision in the Mekong Delta. This region is planned to be a sustainable land-use types, but farmers tend to shift from rice to shrimp farming systems due to economic reasons. These decisions endanger the planned sustainable development of the area and the effects of infrastructures built to reach the plan. It is thus necessary to study and forecast this conversion to support the land-use planning and recommend the best suitable strategy to farmers. However, this forecasting work is currently lacking tools. It is mainly based on the human-made land inventory carried out every 5 years, which is obviously made under times and human resources limitations.

This work aims to apply an Agent-based model to support managers' decision-making and to provide a picture of the future to encourage people to choose land-use types. The model is designed by agent-based approach where farmers are represented as the cell from the land-use map and the description of their states and behaviors. The simulation will let them interact and from these interactions, the dynamics of the system is expected to emerge. Decision making process is based on the multicriteria analysis in which farmers will thus have to make their decisions given environmental, climate and socio-economic changes. The input data for verification and calibration of the model have been collected from the existed land-use map in 2015 and interpreted from Sentinel 2 satellite images in 2020 for the land-use. The climate change scenarios are forecasting to 2030. The results of the experiments showed evolutions of land-use in 2030 with climate change scenarios to analyze farming risks when the environment (including temperature, rainfall, water volume) and prices change in a harsher direction.

Additional material

Code of the model: https://github.com/tcquang/MK_landuse

COMOKIT BUILDING: simulating the impact of NPI against Covid-19 at building scale

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Keywords

Covid-19, NPI, agent-based epidemiological model, SEIR

Abstract

Since the appearance of Covid-19, many models have been developed to answer the question of what policies to implement to minimize its spread. Among these models, some are interested in the propagation inside buildings. Many works have indeed highlighted the impact of propagation in closed environments. It is in this context that we have developed the COMOKIT BUILDING model. This model is part of the COMOKIT framework (COVID-19 Modeling Kit) [1]. COMOKIT BUILDING is based on the model proposed by [2]. As in this model, the agents represent individuals who will come to do activities in the building. For that, each agent has an agenda that defines the activity it has to perform according to the time. They will then move in the building to go to their activity place and realize it. However, contrary to the model [2], which is primarily interested in the risk taken by individuals over a day, we are interested impact of the preventive measure over a longer period. Thus, we use the epidemiological model of COMOKIT (SEIR) to describe the evolution of the disease for individuals. In addition, taking inspiration from [2], we defined three types of transmission vectors (direct, airborne and via surfaces). Several types of interventions are taking into account: masks, physical distancing, room ventilation, physical barrier, etc.
The model was implemented using GAMA 1.8.2 and takes advantage of some new features of this version, in particular the use the newly integrated pedestrian plugin for the agent movement.
An application of the model to study the impact of prevention measures on the spread of the virus in a Hospital in the city of Danang in Vietnam will be presented. This hospital was at the origin of the formation of a cluster. Since then, several clusters have appeared in hospitals in Vietnam, making the issue of preventive measures in hospitals a major challenge for the Vietnamese government.

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Additional material

Github (model code): https://github.com/COMOKIT/COMOKIT-Model