Advanced Agent-Based Modeling HW1

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Assignment Description:

Required for-discussion readings:

Epstein, J.M., 2008. Why model? *Journal of artificial societies and social simulation*, *11*(4), p.12.

DUE TO Professor Epstein AND Katie Feng: Wednesday February 5, 2025. 5:00 PM

Part A. In no more than a page (1/2 is fine), write up your review of the random article you chose. From the *Why Model* list or beyond, what were its goals, and were they achieved?

1. The ASIMOV model (Algorithm of Selectivity by Incentive, Motivation, and Optimized Valuation) is an agent-based model of a certain type of Sea Slug (Pleurobranchaea) that includes cognitive elements in a foraging environment in an attempt to understand the mechanisms through which addiction forms. The model clearly details the homeostatic reward circuit and nociceptor mechanism through which the agent "feels good" or "feels pain" through what they consume. In the proposed foraging environment, there are Hermi, Flab, and Drugs, which are healthy and rewarding, neutral, and harmful but rewarding respectively. The model also implements an Approach-Avoidance decision system, which effectively is chemotaxic in nature, as it allows the agent to identify what it can consume, and so that it may learn what it is most rewarding at the time. Finally, the model implements the "Cycle of Addiction", which models withdrawal, tolerance, and prolonged cravings.

   In terms of being an effective model, ASIMOV clearly states the explicit assumptions and mechanisms that are being used to model addiction. Furthermore, it produces widely reproducible results that allow us to recognize the importance of homeostatic plasticity and aesthetic preferences that drive compulsive behaviors in general (eg. gambling, shopping, self-harm, internet use, etc.). *Gribkova et al.* also chose to study an organism that is modeled in a simple social environment with no other agents and a steady stream of food and drugs, and make no claims or judgments about addiction/compulsive behaviors in humans. It purely focuses on understanding some of the cognitive elements of addiction, and so, it leads to a deeper understanding of Prey & Drug selectivity based on satiation and current "reward" levels, as well as the time-course of addiction.

   Gribkova et al. also compares their ASIMOV model with other models and theories of addiction and aesthetics to address the weaknesses and strengths of their model. The primary issues mentioned include homeostatic dysregulation, overvaluation, and boredom/curiosity. The authors also recognize that the physical neurocircuitry of Sea Slugs does not mirror mammals, thus it is not exactly representative of the reward-seeking, learning, and decision capacities beyond Sea Slugs.

Part B. Please address the following six essay questions. Try to limit your essay responses to a few clear polished sentences, three being the goal.

1. **What is meant by the motto, "If you didn't grow it, you didn't explain it," and what does this have to do with Agent-Based Modeling?**

   (a) The given motto essentially recognizes that, unless we can fully reproduce a phenomenon in a vacuum, we have only observed it and not yet understood the causal mechanisms responsible for that outcome. Agent-based modeling is particularly useful in this case, as modeling interactions and behavior is particularly difficult because of the randomness, irrationality, and unexpectedness of the real world and its "agents". Since we can choose the spatial dimension, set the behavioral complexity of these agents, and adjust arbitrary parameters, we can recognize that ABMs address the idea of existence in a vacuum, while also being reproducible so that we may observe different outcomes just based on randomness or parameter sweeps/sensitivity analyses.

2. **Models must be highly detailed and realistic to be useful. Discuss**

   (a) Models are not meant to be full-scale reconstructions of reality or the absolute truth, and we must be aware of those limitations. However, even simple models are valuable, as they can advance our understanding of existing phenomena by enabling new lines of questioning, better resource management (eg. data collection), and/or bounding outcomes by understanding some of their determinants. Thus, a model does not need to be perfect, but it must be clear in its assumptions, mechanisms, and what it is trying to model, so that it may help advance scientific discourse as a whole.

3. **Prediction is the only legitimate goal of modeling. Discuss**

   (a) While prediction is important, modeling is not limited to just that. Models can also be used to illuminate new critical questions, certain core determinants of an outcome(s), and to expose faulty sentiments in scientific and political communities. In fact, toy models can even be used to inform decision-making, especially when stakes are high, and there is little time to make a decision- in these cases, both political leaders and the public both stand to benefit from at least understanding the worst-case scenario of certain events, like war and epidemics.

4. **In science, data collection always precedes Theory. Discuss**

   (a) Perhaps in certain empirical fields, data collection always precedes theory, but when dealing with human lives, data collection means waiting for outcomes. At that point, the casualties have already occurred, and we will have missed the opportunity to save countless lives. Data collection is important because it allows us to calibrate models and make more informed models, and can even lead to developing novel theories, but it does not always precede theory itself.

5. **Anything you can do with an ABM you can do with an aggregate Regression. Discuss**

   (a) While you may be able to reproduce the results of an aggregate regression with an ABM, aggregate regression focuses on the macroscopic behavior of the collective, rather than informing us about the microscopic behavior at an individual level. Regression also requires data, some of which may not be feasible to collect (eg. animal and human trials), may not be clean/accurate (methodological/systemic error), or may not even exist in the first place. Thus, an ABM is much more capable of understanding/analyzing/capturing real-world phenomena than standard aggregate regression models.

6. **Policy choices should not me made until all the data are in. Discuss.**

   (a) Policy choices should not be made by any specific individual, especially when the stakes involve countless lives, since everyone intrinsically has their own personal biases and misconceptions from their own subjective experiences. Policy choices also cannot always wait for data, as is the case with trying to predict casualties, and so models help inform scientists and political leaders of the potential consequences of their decisions.

References:

1. Gribkova, E.D., Catanho, M. Gillette, R. Simple Aesthetic Sense and Addiction Emerge in Neural Relations of Cost-Benefit Decision in Foraging. Sci Rep 10, 9627 (2020). https://doi.org/10.1038/s41598-020-664650
