Multi-agent simulations of climate negotiations

Master 2 internship topic (2023/2024)

Context.

The study of climate negotiations is highly complex, since they involve many players, interacting at different levels, according to complex modalities, which require the implementation of original deliberation and negotiation mechanisms in order to reach agreements whose outcome is sometimes difficult to assess (particularly with respect to long-term consequences).

The models aim, in particular, to help understanding the dynamics of these negotiations, and to design mechanisms facilitating the achievement of agreements to reduce global warming. Since the late 90s, the subject has been approached from a number of perspectives, in particular from the angle of economic analysis and game theory.

Models that integrate both economic and climate dynamics are known as **Integrated Assessment Models** (IAMs). Nordhaus's Dynamic Integrated model of Climate and Economy (DICE) [4] is one such example. These models can be used to simulate the effects of public policies on climate, and in particular to study equilibrium situations.

It is known, however, that current IAMs are limited in many aspects:

- the limited and highly simplified account of uncertainty, particularly in relation to the long-term effects of global warming, with the fear of significantly underestimating it;
- the inability to model negative feedback loops arising from actions taken by agents at the micro-individual level, and in general the difficulty in grasping the heterogeneity and multi-level aspect of these systems;
- finally, the lack of adaptability of the actors modeled (each agent being typically identified with a fixed policy, or following strong assumptions of rationality).

Thus, the use of **multi-agent simulations** (Agent-based Models, ABMs) can be seen as an alternative or complementary approach, enabling the inherent complexity of the problem to be better taken into account (see, for example, chapter 2 of [1] for a recent survey). Indeed, a number of agent-based models have been developed: for example, a multilateral negotiation model [7], with numerous agents equipped with simple learning mechanisms (of the *fictitious play* type), but which already allows us to see some interesting results (the importance of the number of players, and the interest in resorting to progressive agreements with the aim of reaching a situation of cooperative equilibrium).

While these works show the full potential of the approach, there are still a number of obstacles and avenues for improvement, such as taking into account the hierarchical aspect of interactions with a **multi-level modeling perspective** (Putnam's *two-level games* [5]). This kind of modeling allows us to articulate the behavior of both negotiating agents (level I) and agents representing national or regional public opinions ('*constituencies*', level II). Preference

update rules allow us to take into account the way in which these different groups can influence each other.

The study in [6] implements these notions in a multi-agent simulation framework and shows the relevance of this approach for a decision involving 3 alternatives. A more in-depth study of this multi-agent simulation identified certain limitations and various avenues for extending the model: richer modeling of preferences, greater diversity of voting procedures, models of influence between agents, forms of negotiation, etc.

Goal.

The aim of this internship is to investigate the relevance of multi-level models for multi-agent simulations of climate negotiations. In particular, we will seek to identify and study the most relevant models of influence or negotiation.
This internship is part of the MITI NegoClim project.

With the aim of developing multi-level models adapted to the framework of climate negotiations, the internship may follow one of the following directions:

➢ Coupling multi-level models to ABMs in order to develop negotiation protocols as part of the AI for Global Climate Cooperation challenge [2];
➢ Collect data on climate negotiations available on social networks such as Twitter and analyze this data to learn negotiation models used in practice between micro and macro levels of decision-making and the dynamics of opinion diffusion;
➢ Theoretically and empirically study models of climate influence and negotiation. These models will be implemented in the multi-agent simulation based on Earnest's model [6] that has already been developed in the NegoClim project.

Practical Info and Contacts.

- Internship start date and duration: 6 months, starting from February 2024
- Location: LIP6 (Sorbonne Université) and CES (Paris 1)
- Compensation: 614 euros / month
- Contacts: Aurélie Beynier (aurelie.beynier@lip6.fr), Arianna Novaro (Arianna.Novaro@univ-paris1.fr)
- Supervision: Beynier Aurélie, Mandel Antoine, Maudet Nicolas, Novaro Arianna, Rusinowska Agnieszka, Zuber Antoine

Applications will be considered as they are received.

Bibliography.

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2. AI4ClimateCooperation: https://www.ai4climatecoop.org/

3. Zhang, Tianyu and Williams, Andrew and Phade, Soham and Srinivasa, Sunil and Zhang, Yang and Gupta, Prateek and Bengio, Yoshua and Zheng, Stephan, AI for Global Climate Cooperation: Modeling Global Climate Negotiations, Agreements, and Long-Term Cooperation in RICE-N (August 14, 2022). Available at SSRN: https://ssrn.com/abstract=4189735 or [http://dx.doi.org/10.2139/ssrn.4189735]

4. Nordhaus, W. (2018) Evolution of Modeling of the Economics of Global Warming: Changes in the DICE Model, 1992–2017. *Climatic Change* 148(4): 623–640

5. Putnam, Robert D. (1988) Diplomacy and Domestic Politics: The Logic of Two-Level Games. *International Organization* 42(3): 427–60, http://www.jstor.org/stable/2706785.

6. David C. Earnest (2008) Coordination in Large Numbers: An Agent-Based Model of International Negotiations. *International Studies Quarterly* 52(2): 363–382

7. Smead, R., Sandler, R.L., Forber, P., Basl, J. (2014) A Bargaining Game Analysis of International Climate Negotiations. *Nat. Clim. Change* 4 (6): 442–445