A Scalable Hybrid SD/AB/SD Modelling Approach to Climate Assessment Modelling

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Modelling and simulation plays an increasingly significant role in exploratory studies for informing policy makers on climate change mitigation strategies. The growth in computing power allows more comprehensive and sophisticated models to be produced and to be put into use. In fact, the existing literature in the discipline is considerably mature, with robust climate models capable of forecasting the weather down to the granularity of hours. There is also considerable research being done in creating more accurate Integrated Assessment Models (IAMs) which focus on examining the human impacts on climate change. Many popular IAMs as for example DICE (Nordhaus 2006) and C-ROADS (Climate Interactive 2016) are built using a System Dynamics Modelling (SDM) approach. Such models are made up of stock variables and complex feedback loops which, as a whole, give rise to the behaviour of the system. SDMs hold aggregate views on variables and hence are unable to capture a finer level of details of the underlying system components. Humans, the major contributors to global warming, in SDMs are therefore viewed through a universal lens. In reality, however, humans are independent and discrete beings with diverse behaviours. The SDMs also neglect the non-linear relationships between humans, which could bring about unpredictable patterns. In addition, the tightly-coupled internal components of the models prevent or discourage dynamic modification to their structure. As such, these models lack flexibility in modelling different levels of aggregation and scalability, which constitute their major limitations, considering that the risks and impacts associated with climate change are unevenly distributed, geographically and demographically. An alternative approach that allows modelling populations as a collection of individual and unevenly distributed entities is Agent Based Modelling (ABM), often used in the field of Social Simulation. But simulating huge numbers of individual entities can quickly become an issue, as it requires large amounts of computer memory and slows down simulation model execution.

Our research seeks a novel approach in integrated assessment modelling by combining the top-down approach used in SDM, where the overall system behaviour is captured through complex feedback loops, with the bottom-up approach used in Agent-Based Modelling (ABM), where a system is modelled as a collection of autonomous decision making entities. We use SDM to represent the environment in general as well as a conception of the environment inside an individual's conscience and ABM to represent collections of individuals that can interact with other collections of individuals and the environment. In our current work we address the feasibility of such a scalable hybrid IAM as a proof-of-concept. Our test case takes the settings of the USA, as this country contributes to the majority of the global carbon footprints and is the largest economic power in the world. This creates a good opportunity to investigate the carbon emissions and its relevant economic impacts on the nation. Our experiment produced useful insights through the projections of CO2 emissions. The patterns of these projections suggest that policy makers should not only focus on policies which produce quick results but also invest more resources in long-term but less obvious solutions, like educating people's mindsets.

References:

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