Towards an LLM-enhanced Agent-based modeling

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This study investigates the integration of Large Language Models (LLMs) as cognitive engines in Agent-Based Models (ABMs). LLMs enhance agents' decision-making capabilities by providing sophisticated language understanding, enabling more realistic simulations of human behavior. This would have been possible had there been the possibility of including a sophisticated production and understanding of text messages, which are crucial in every human society. However, this was never implementable into an ABM before, if not in a very primitive form.

This advancement has the potential to improve accuracy in various applications, such as predicting social dynamics, optimizing market analysis, enhancing crowd behavior studies, understanding opinion dynamics, and refining urban planning models.

Also, theoretically, the incorporation of LLMs could lead to the observation of new emergent properties resulting from more sophisticated interactions, thereby advancing computational social science research.

However, there are notable downsides to using LLMs as agents' cognitive engines. The first is computational inefficiency. Typically, an agent-based model relies on multiple simulations of populations composed of at least hundreds of individuals, which is feasible because the decisions taken by each of them are relatively simple.

Another significant issue is the propagation of biases inherent in the training data. For LLMs, these biases are often subtle and not easily recognizable. While every model has biases, they are typically explicit and considered a modeling hypothesis in ABMs.

Additionally, the question of replicability arises. Agent-based modeling already faces challenges in replicability due to code complexities and the lack of a shared implementation framework. Including LLMs in the process exacerbates this issue, as their results are inherently not explainable and thus not replicable. Even if a local LLM, fine-tuned for a specific purpose, were used, replicating the exact training needed to obtain it would be challenging.

Ensuring ethical considerations and robust validation frameworks is crucial to mitigate these challenges. This work aims to balance innovation leveraging LLMs to enhance ABM while addressing inherent limitations.