

ARTIFICIAL INTELLIGENCE

DM 630/Fondazione ISI - Large Language and Multi-modal Models for human behavior understanding and outbreak analysis

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [Piva/CF:97429780584] FONDAZIONE DI PARTEC.PER L'INNOVAZ.E LO SVIL.IMPREDITORIALE [Piva/CF:02247870500] Politecnico di TORINO [Piva/CF:00518460019]
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Context of the research activity	This PhD research project focuses on the study of Large Language and Multi-modal Models for agent-based modeling simulation. The goal is to design innovative strategies to improve the existing models so that when introduced into simulation environments to mimic human agents, they allow to study macro-level phenomena providing robust predictions. Specifically, the focus will be on enhancing epidemic modeling and management. Progetto finanziato dal PNRR a valere sul DM 630/2024 - CUP: E14D24002330004
	The first part of the project will be dedicated to an in-depth study of existing Large Language and Multi-modal models to understand potentialities and limits, considering aspects related to their adaptability (e.g. via efficient fine-tuning strategies) as well as interpretability (e.g. both concept based and mechanistic). This will help to define the best setting for them to simulate human behavior. To refine generic large models we will consider extensive and diverse textual datasets, such as scientific literature, social media posts, and health reports, to extract relevant epidemiological insights. This will then help to guide the generation of intuitive text and video summaries and actionable recommendations for public health officials, improving communication and strategic planning during epidemics. Finally, the models will be used to support the simulation of agents capable of interacting naturally with others in complex environments, enabling more

Objectives	realistic and dynamic simulations of disease spread and control measures. This newly designed strategy will facilitate the creation of automated analytics pipelines, where continuous data updates enhance real-time situational awareness and decision-making processes. By combining Large Language and Multi-modal models with advanced agent-based modeling, this research aims to create a robust, data-driven framework for outbreak analytics. This framework will be adaptable to evolving scenarios and support effective epidemic containment strategies. The expected outcomes include enhanced outbreak forecasts, more dynamic and adaptive epidemic models, and improved public health response mechanisms, contributing to the theoretical and practical advancements in epidemic modeling and control. “Large Language Models Empowered Agent-based Modeling and Simulation: A Survey and Perspectives”, Chen Gao et al. Arxiv 2023 (arXiv:2312.11970) “Epidemic Modeling with Generative Agents Ross Williams”, Arxiv 2023, (arXiv:2307.04986) “Importance of investing time and money in integrating large language model-based agents into outbreak analytics pipelines”, the Lancet Microbe 2024 (https://doi.org/10.1016/S2666-5247(24)00104-6) “Using Large Language Models to Simulate Multiple Humans and Replicate Human Subject Studies”, Gati Aher et al, ICML 2023 This research is part of a collaboration with ISI Foundation and it will involve a 6-month internship with them. It is expected that the scientific results of the project will be reported at top biomedical, robotics, machine learning, natural language processing, and computer vision conferences. At least one journal publication is expected.
Skills and competencies for the development of the activity	Strong knowledge of linear algebra, calculus, and probability are prerequisites. The candidate is required to have a good understanding of machine learning, deep learning, and natural language processing concepts. The candidate is expected to have strong programming skills (Python) and familiarity with at least one recent deep learning framework (PyTorch or Tensorflow). The candidate is expected to be proactive and capable of autonomously studying and reading the most recent literature. English fluency, both oral and written, is required.