

# Combining SIR and agent-based models of the COVID-19 epidemics

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## Abstract

Today, over a year after the start of the COVID-19 epidemic, we still have to deal with the virus. It is also difficult to accurately predict the impacts that political measures may have, or how the number of cases will evolve in the future.

To study the propagation of a virus, the most frequently used models are so-called compartmental models, that separate the population into several distinctive classes. For instance, the basic SIR model distinguishes 3 such classes: Susceptible, Infectious and Recovered people. These models make it possible in particular to study the spread of a virus at the scale of a city or even whole country, and they are currently used to study the spread of SARS-COV-2. However, these models only give a **macroscopic** view of the propagation, which is mainly done *a posteriori*. It is also difficult to accurately predict the number of future cases beyond a certain number of days, due to the lack of knowledge about the actual number of infected and recovered people (in particular due to asymptomatic cases), and to the propagation and multiplication of this uncertainty.

Multi-agent systems are computer models that give a **microscopic** view of the problem. They make it possible to model each human being as an autonomous agent, and thus to study the propagation of the virus according to the behavior of the agents. They also account for a heterogeneous population, each agent having different individual attributes.

The aim of our work is to be able to combine these two approaches, in order to take advantage of their strengths and overcome their weaknesses. In particular, SIR models rely on various coefficients that are difficult to evaluate accurately. By simulating the restrictions currently imposed on the population (physical distancing, curfew...) in an agent-based model, and comparing the simulated contagion force with real observed data, we could calibrate the compartmental model. The microscopic agent-based approach could thus make it possible to anticipate and refine the new values of the parameters of a compartmental model, with respect to various sanitary restrictions enforced at the moment.

Our work is applied to the city of Lumbin, in Isère, which has about 2500 residents. We simulated the spread of the virus in this town. Our model is implemented in GAMA, and based on the Luneray's flu model, which was adapted by importing the Lumbin shapefile. The model was then made more complex and realistic: different types of buildings were created (houses, work places, schools), for the moment randomly, and we added different human habits, such as shopping, going to work or to school, depending on the agents' age, to be closer to reality. The goal of this simulator is then to study the impact of the different government strategies on the propagation of the virus in this town.

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