

Traffic model adaptive self-calibration using multi-agent systems

D. Vergnet¹, F. Amblard¹, E. Kaddoum², N. Verstaevel¹

¹ Université Toulouse 1 Capitole, IRIT

² Université Toulouse 2 Jean Jaurès, IRIT

damien.vergnet@irit.fr

Keywords

Multi-agent systems, adaptive multi-agent systems, traffic simulation, model calibration

Abstract

Simulation is a useful analysis and forecasting tool, often used to study and understand complex phenomena. It is based on simulation models that reproduce the behavior of an entity/system at different levels and scales. These models are in particular composed of input parameters on which depends the outcomes of the simulation. In order to obtain a model simulating real phenomena, a calibration step using real data is required to identify the corresponding values of the input parameters. In addition to this, by using real data obtained from observation points, microscopic entities can in real time adapt their behavior in order to make the simulation mimick the real system. The dynamics at the macroscopic level implies a continuous calibration of the microscopic level.

There are two main types of calibration approaches in the literature: iterative (optimization-based) methods and data assimilation methods. The first ones rely on traditional optimization methods like genetic algorithms [1, 2]. These algorithms are run only once prior to any simulation exploitation. Therefore, models calibrated this way are not able to adapt to events occurring in the reference system and user interaction is limited. In this case, the simulation has to be interrupted and calibration redone completely to adapt the model to new data. The second type of calibration methods are based on data assimilation. Contrary to the previous ones, they are executed while the simulation is running. Most widely used methods are the Particle Filter [4], the Kalman Filter and its derivatives like the Ensemble Kalman Filter [5] and the Unscented Kalman Filter. The main limitation of the Kalman Filter is the fact that it assumes that the uncertainties follow a Gaussian distribution and that the system is linear.

We propose a novel approach to model real time calibration based on self-adaptive multi-agent systems [3] called **CALICOBA** (*CALibration COopérative à Base d'Agents* or *agent-based cooperative calibration*). This approach proposes to explore how the input parameters self-organize and self-adapt in real time their values in order to satisfy macro-level constraints (such as observation of a traffic jam or daily traffic density variations, etc.) to reach a specified collective behavior. This approach is evaluated in the context of the simulation of traffic on a campus. To calibrate this simulation, we run traffic simulation models used in Gama and record observations on some points of interest of the campus. Then, the observations are given as objectives to CALICOBA where the input parameters of the studied models self-adapt in real time their values in order to reach the desired objectives. This simulation should also let users interact with it by modifying these objectives and adapt to events that may occur in the virtual environment (e.g.: adding new constraints, closing a road, etc.).

Additional material

Code repository: <https://github.com/Darmol17/CALICOBA>

References

- [1] Glareh Amirjamshidi and Matthew J. Roorda. Multi-objective calibration of traffic microsimulation models. *Transportation Letters*, 11(6):311–319, July 2019.
- [2] Sandro Chiappone, Orazio Giuffrè, Anna Granà, Raffaele Mauro, and Antonino Sferlazza. Traffic simulation models calibration using speed–density relationship: An automated procedure based on genetic algorithm. *Expert Systems with Applications*, 44:147–155, February 2016.
- [3] Jean-Pierre Georgé, Marie Pierre Gleizes, and Pierre Glize. Conception de systèmes adaptatifs à fonctionnalité émergente: la théorie amas. *Revue d'intelligence artificielle*, 17(4):591–626, 2003.
- [4] Nick Malleson, Kevin Minors, Le-Minh Kieu, Jonathan A. Ward, Andrew A. West, and Alison Heppenstall. Simulating Crowds in Real Time with Agent-Based Modelling and a Particle Filter. *arXiv:1909.09397 [cs]*, September 2019. arXiv: 1909.09397.
- [5] Jonathan A. Ward, Andrew J. Evans, and Nicolas S. Malleson. Dynamic calibration of agent-based models using data assimilation. *Royal Society Open Science*, 3(4), April 2016.