How to generate micro-agents? A deep generative modeling approach to population synthesis

Population synthesis is concerned with the generation of synthetic yet realistic representations of populations. It is a fundamental problem in the modeling of transportation where the synthetic populations of micro-agents represent a key input to most agent-based models. In this paper, a new methodological framework for how to 'grow' pools of micro-agents is presented. The model framework adopts a deep generative modeling approach from machine learning based on a Variational Autoencoder (VAE). Compared to the previous population synthesis approaches, including Iterative Proportional Fitting (IPF), Gibbs sampling and traditional generative models such as Bayesian Networks or Hidden Markov Models, the proposed method allows fitting the full joint distribution for high dimensions. The proposed methodology is compared with a conventional Gibbs sampler and a Bayesian Network by using a large-scale Danish trip diary. It is shown that, while these two methods outperform the VAE in the low-dimensional case, they both suffer from scalability issues when the number of modeled attributes increases. It is also shown that the Gibbs sampler essentially replicates the agents from the original sample when the required conditional distributions are estimated as frequency tables. In contrast, the VAE allows addressing the problem of sampling zeros by generating agents that are virtually different from those in the original data but have similar statistical properties. The presented approach can support agent-based modeling at all levels by enabling richer synthetic populations with smaller zones and more detailed individual characteristics.