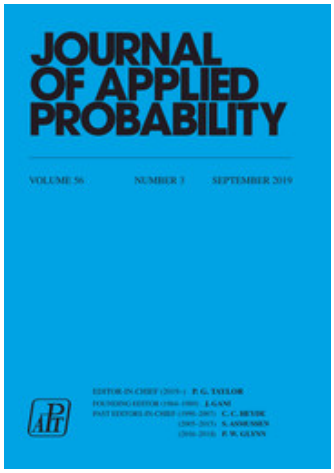


# Approximate lumpability for Markovian agent-based models using local symmetries

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WASIUR R. KHUDABUKHSH, ARNAB AUDDY, YANN DISSER, HEINZ KOEPPL

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## Abstract

We study a Markovian agent-based model (MABM) in this paper. Each agent is endowed with a local state that changes over time as the agent interacts with its neighbours. The neighbourhood structure is given by a graph. Recently, Simon, Taylor, and Kiss [40] used the automorphisms of the underlying graph to generate a lumpable partition of the joint state space, ensuring Markovianness of the lumped process for binary dynamics. However, many large random graphs tend to become asymmetric, rendering the automorphism-based lumping approach ineffective as a tool of model reduction. In order to mitigate this problem, we propose a lumping method based on a notion of local symmetry, which compares only local neighbourhoods of vertices. Since local symmetry only ensures approximate lumpability, we quantify the approximation error by means of the Kullback–Leibler divergence rate between the original Markov chain and a *lifted* Markov chain. We prove the approximation error decreases monotonically. The connections to fibrations of graphs are also discussed.