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Encounter times of random walkers with simultaneous resetting on networks

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In this work, we study the dynamics of multiple random walkers on networks subject to a simultaneous resetting protocol, whereby all walkers are synchronously returned to their respective initial nodes. For this collective Markovian process, we derive exact analytical expressions for the mean first-encounter time, defined as the average time required for all walkers to meet for the first time at a given node. These results are formulated in terms of the eigenvalues and eigenvectors of the transition matrices governing the dynamics without resetting, providing a clear spectral interpretation of the impact of resetting on encounter processes. We further establish a general criterion for finite networks that determines when the introduction of a nonzero resetting probability reduces the mean first-encounter time and leads to an optimal resetting strategy. The theoretical predictions are illustrated through numerical results on regular and heterogeneous networks, for encounters involving two or more walkers, and for combinations of local and nonlocal dynamics. Our findings demonstrate that simultaneous resetting can significantly reduce encounter times for specific targets and initial conditions, while becoming ineffective for highly exploratory dynamics or distant targets. The framework provides a unified approach to collective search and encounter problems on networks with resetting.

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