Discovering Unique, Low-Energy Transition States Using Evolutionary Molecular Memetic Computing

In the last few decades, identification of transition states has experienced significant growth in research interests from various scientific communities. As per the transition states theory, reaction paths and landscape analysis as well as many thermodynamic properties of biochemical systems can be accurately identified through the transition states. Transition states describe the paths of molecular systems in transiting across stable states. In this article, we present the discovery of unique, low-energy transition states and showcase the efficacy of their identification using the memetic computing paradigm under a Molecular Memetic Computing (MMC) framework. In essence, the MMC is equipped with the tree-based representation of non-cyclic molecules and the covalent-bond-driven evolutionary operators, in addition to the typical backbone of memetic algorithms. Herein, we employ genetic algorithm for the global search, Berny algorithm for individual learning, and make use of the valley-adaptive clearing scheme as the niching strategy in the spirit of Lamarckian learning. Experiments with a number of small non-cyclic molecules demonstrated excellent efficacy of the MMC compared to recent advances of several state-of-the-art algorithms. Not only did the MMC uncover the largest number of transition states, but it also incurred the least amount of computational costs.