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Accelerating Evolutionary Algorithms to Solve High-dimensional Expensive Problems via Autoencoders

Abstract:
High-dimensional computationally expensive problems (HEPs) in which a single fitness evaluation consumes hours or even days have attracted much attention from both academia and industry. Exponentially expanding search space and complex landscape brought by numerous decision variables make HEPs extremely challenging to be solved by traditional algorithms with limited physical/computational resources. Therefore, an Autoencoder-embedded Evolutionary Optimization (AEO) framework is invented to deal with them. To be specific, high-dimensional search space can be compressed to informative low-dimensional space by using an autoencoder as an effective dimension reduction tool. The search operation conducted in this low-dimensional space facilitates the population in convergence towards the optima. To balance the exploration and exploitation ability during optimization, two sub-populations are adopted to coevolve in a distributed/parallel fashion, wherein one is assisted by an autoencoder and the other undergoes a regular evolutionary process. Dynamic information exchange is conducted between them after each cycle to promote population diversity. Moreover, surrogate models can be incorporated into AEO (SAEO) to further boost its performance by reducing unnecessary fitness evaluation. Compared with the state-of-the-art algorithms for HEPs, AEO shows extraordinarily high efficiency for these challenging problems while SAEO can greatly improve the performance of AEO in most cases, thus opening new directions for various swarm optimization and evolutionary algorithms under both AEO and SAEO to tackle HEPs and greatly advancing the field of high-dimensional computationally expensive optimization.