Abstract: Stochastic Gradient Descent (SGD) is a widely deployed algorithm for solving estimation problems that arise in statistics and learning. Accordingly, SGD has been analyzed from many perspectives to understand its behavior and to ensure its reliability, especially from a global convergence/consistency perspective. Unfortunately, we will show through simple examples that existing global convergence analyses make unrealistic deterministic assumptions, which result in incorrect conclusions or the utilization of inappropriate techniques. To be specific, counter to existing results, we will construct a deterministic example under realistic assumptions for which Gradient Descent (GD) will diverge catastrophically. Then, counter to a popular technique, we will provide a deterministic example for which approximating GD with continuous GD leads to incorrect conclusions about GD. Turning to stochastic assumptions, we show that existing stochastic assumptions are unrealistic for simple machine learning and statistics problems. Thus, we highlight that GD and SGD do not have an appropriate theory for learning problems. Finally, we provide a result for the global convergence of GD and SGD that addresses this gap.

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