Chapter 10
Green Artificial Intelligence (AI) and Machine Learning (ML)

D. Pavunraj
https://orcid.org/0000-0001-5651-6565
Vel Tech Multi Tech Dr. Rangarajan Dr. Sakunthala Engineering College, India

A. Mathankumar
Vel Tech Multi Tech Dr. Rangarajan Dr. Sakunthala Engineering College, India

K. Anbumaheshwari
Sethu Institute of Technology, India

R. Daisy Merina
Vel Tech Multi Tech Dr. Rangarajan Dr. Sakunthala Engineering College, India

ABSTRACT

Artificial Intelligence (AI) and Machine Learning (ML) are at the forefront of technological progress, revolutionizing fields such as healthcare, finance, and transportation. However, the energy-intensive processes involved in training and deploying complex AI models have raised significant environmental concerns. Green AI and ML represent a shift toward sustainable practices by emphasizing energy efficiency, reducing carbon footprints, and minimizing resource usage. This approach encompasses the development of optimized algorithms, efficient hardware solutions, and the use of renewable energy during computation. Green AI advocates for training smaller models with reduced computational complexity, thereby ensuring performance with lower environmental costs. Techniques such as model distillation, pruning, and quantization are increasingly being adopted to achieve

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this balance. Furthermore, Green AI encourages collaboration among researchers, policymakers, and industries paradigm is essential for advancing AI responsibly in an era of growing environmental challenges.

INTRODUCTION

Modern technology has been transformed by artificial intelligence (AI) and machine learning (ML), which has fueled developments in sustainability, healthcare, finance, and transportation. However, growing worries about energy usage and its effects on the environment have resulted from the high computational demands of training and implementing large-scale models (Garg et al., 2022). According to research, for example, training cutting-edge models can produce carbon emissions that are on par with those generated by the lifecycle of a number of automobiles (Henderson et al., 2020; Strubell et al., 2019). This emphasizes how vital it is to incorporate sustainability into AI development methodologies.

By optimizing algorithms, increasing hardware efficiency, and leveraging renewable energy sources, green AI is a new research paradigm that aims to lessen the environmental effect of AI systems (Schwartz et al., 2020; Amodei et al., 2018). In order to minimize energy consumption without sacrificing performance, methods including model pruning, quantization, and distillation have been proposed to reduce the size and complexity of AI models (Cheng et al., 2022; Tan et al., 2019; Wang et al., 2021). To improve computational efficiency, novel techniques in distributed computing and federated learning have also been investigated (Smith et al., 2020; Kairouz et al., 2019).

The Green AI movement has also benefited from the creation of energy-efficient AI hardware, such as neuromorphic circuits and tensor processing units (TPUs) (Jouppi et al., 2017; Chen et al., 2021). These technologies enable faster computations while consuming less power, addressing the scalability challenges associated with large AI systems (Patterson et al., 2022; Lorenz et al., 2021). Additionally, renewable energy integration into data centers and the adoption of carbon offset strategies are becoming central to sustainable AI development (Shao et al., 2021; Zhao et al., 2022).

Research on life-cycle assessments has emphasized the importance of measuring the environmental impact of AI systems across their entire lifecycle, from development to deployment (Gupta et al., 2020; Feng et al., 2021). Frameworks such as these provide actionable insights for reducing energy usage and emissions while maintaining technological progress (Kumar et al., 2021; Bajaj et al., 2021). Moreover, policies aimed at promoting Green AI practices, such as carbon-conscious research