arXiv:2002.05651v1 [cs.CY] 31 Jan 2020

TOWARDS THE SYSTEMATIC REPORTING OF THE ENERGY AND CARBON FOOTPRINTS OF MACHINE LEARNING

A WORKING PAPER

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February 14, 2020

ABSTRACT

Accurate reporting of energy and carbon usage is essential for understanding the potential climate impacts of machine learning research. We introduce a framework that makes this easier by providing a simple interface for tracking realtime energy consumption and carbon emissions, as well as generating standardized online appendices. Utilizing this framework, we create a leaderboard for energy efficient reinforcement learning algorithms to incentivize responsible research in this area as an example for other areas of machine learning. Finally, based on case studies using our framework, we propose strategies for mitigation of carbon emissions and reduction of energy consumption. By making accounting easier, we hope to further the sustainable development of machine learning experiments and spur more research into energy efficient algorithms.

1 Introduction

Global climate change is a scientifically well-recognized phenomenon and appears to be accelerated due to greenhouse gas (GHG) emissions such as carbon dioxide or equivalents (CO_{2eq}) (Crowley, 2000; IPCC, 2018). The harmful health and safety impacts of global climate change are projected to "fall disproportionately on the poor and vulnerable" (IPCC, 2018). Energy production remains a large factor in GHG emissions, contributing about $\sim 25\%$ of GHG emissions in 2010 (IPCC, 2018). With the compute and energy demands of many modern machine learning (ML) methods growing exponentially (Amodei and Hernandez, 2018), ML systems have the potential to significantly contribute to carbon emissions. Recent work has demonstrated these potential impacts through case studies and suggested various mitigating strategies (Strubell et al., 2019; Schwartz et al., 2019).

Systematic and accurate measurements are needed to better estimate the broader energy and carbon footprints of ML – in both research and production settings. Accurate accounting of carbon and energy impacts aligns incentives with energy efficiency (Schwartz et al., 2019), raises awareness, and drives mitigation efforts (Sundar et al., 2018; LaRiviere et al., 2016), among other benefits.[1] Yet, most ML research papers do not regularly report energy or carbon emissions metrics.[2]

We hypothesize that part of the reason that much research does not report energy and carbon metrics is due to the complexities of collecting them. Collecting carbon emission metrics requires understanding emissions from energy grids, recording power outputs from GPUs and CPUs, and navigating among different tools to accomplish these tasks. To reduce this overhead, we present *experiment-impact-tracker* [3] – a lightweight framework for consistent, easy, and more accurate reporting of energy, compute, and carbon impacts of ML systems.

In Section 4, we introduce the design and capabilities of our framework and the issues with accounting we aim to solve with this new framework. Section 5 expands on the challenges of using existing accounting methods and discusses our

[1] See Section 4.1 for an extended discussion on the importance of accounting.
[2] See Section 3 and Appendix B for more information.
[3] https://github.com/Breakend/experiment-impact-tracker