The AI Carbon Footprint and Responsibilities of AI Scientists

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Overview

AI Carbon Footprint

Responsibilities of AI researchers

Innovative Solutions to mitigate this issue

AI-powered Cyberweapons

AI Carbon Footprint

AI Carbon Footprint - Strubell Estimates

- A carbon footprint analysis on AI models used for Natural Language Processing (NLP) was performed by Strubell and co-workers.
  - Strubell, E.; Ganesh, A.; McCallum, A. Energy and Policy Considerations for Deep Learning in NLP. 2019.
- Electricity consumption and Greenhouse Gas (GHG) emissions were extrapolated from an estimate of computational training costs.
- An NLP Transformer model, based on a Deep Neural Network (DNN) architecture, was estimated to produce GHG emissions equivalent to that of five automobiles throughout their lifecycle.
- A BERT large model, trained using Graphic Processing Units (GPU), was estimated to produce GHG emissions equal to that of a flight from San Francisco to New York.

AI Carbon Footprint - A Call for Action

- The public release of these estimates resulted in the European Commission (EC) issuing a call for action to be taken in evaluating the environmental impact of:
  - AI systems throughout their lifecycle.
  - The various actors involved in the development of AI.

"Given the increasing importance of AI, the environmental impact of AI systems needs to be duly considered throughout their lifecycle and across the entire supply chain, e.g., as regards resource usage for the training of algorithms and the storage of data."

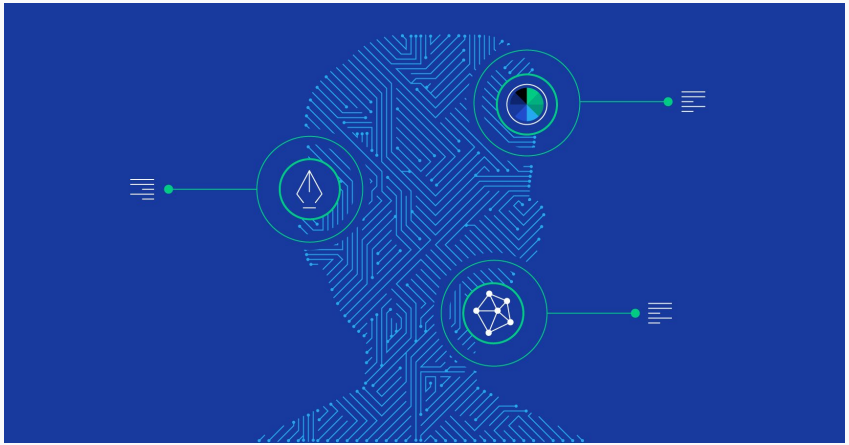
- European Commission. White Paper on AI. A European Approach to Excellence and Trust. 2020.

AI Carbon Footprint - A Call for Action

- The knowledge gathered as a result of the EC inquiry will help in:
  - Understanding how big the AI carbon footprint is and the amount that each industry segment contributes to it.
  - Holding the respective actors involved in the AI industry accountable and responsible for minimizing the impact of their actions.
  - Identifying actions, policies, and metrics that can be used to analyze and help curb the carbon footprint.

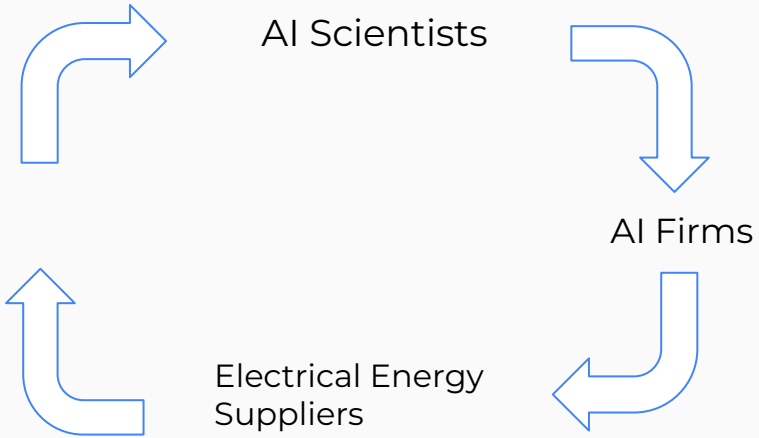
AI Carbon Footprint - Emission Sources

- During training, as the AI model grows in size, so does the impact it has on the amount of GHG emissions it generates.
- The size of the training sets and the number of hyperparameters also have an impact.
- Post-training, the companies' uses of the AI is another major source of energy consumption, comprising up to 90% of a company's energy costs.



Responsibilities

Who is responsible?



- Policymakers
- Educators
- Universities
- Infrastructure Providers
- Research Facilities

Detach Responsibilities

- AI researchers vs. other actors
- Every group must be responsible for specific things
- Type of electricity mix used

Identify Computational Efficiency

- Better to focus on Floating Point Operations than simply calculating GHG emissions
- FPO calculation can help understand the work done by a process
- AI researchers can also focus on what data centers, cloud providers and other actors involved in AI do
- Choosing efficient hardware
- Designing efficient datacenter as well as when and where the training of AI is done

AI Training and Application Considerations

Practical:

- Preference to finding energy mix resources using clean energy to power hardware
- Actively choosing datacenters with more efficient hardware available
- Performing intensive training and application during low use times (ie. night time)

Mindset:

- Become cognizant of energy usage, can utilize software that identifies computational efficiency of AI models
- Shift primary focus from just high accuracy to balance of high accuracy and efficiency

What is a “good” result in AI?

- Good results only focus on accuracy right now
- Need a shift of mindset
- Prizing and awards should also focus on computational and energy efficiency in competitions and AI research

Policy and Education

- Similar to other energy related industries, the AI industry may eventually need to be regulated on carbon emissions and throughput
- AI scientists and researchers have an responsibility to properly educate policymakers on the subject
- Considerations must be made for AI that directly contributes to the betterment of environment, while having its own environmental cost

Solutions

The role of research

- AI researchers hold the most power in mitigating AI carbon footprints.

- Current goals for ML research:
  - Optimize metrics/KPIs intrinsic to model performance.
  - Accuracy, F1 score, recall, etc.

- Computational efficiency is **not** a current goal of most researchers.

- E.g. in a random sample of the top 60 papers presented at recent top-level AI conferences, an overwhelming majority had no mention on energy usage, and focused on performance metrics instead.

How can we incentivize and encourage computionational efficiency?

- A potential solution is to change the scoring mechanism– focus on carbon mitigation and energy efficiency **as well as** performance.
- Rework the current benchmarks so that it becomes a “best practice” to include energy efficiency
- AI research within the research field is often heavily focused on innovation, and environmental issues are often second-place to “new ideas” (if even thought of at all).
- Outside of the pure research fields, it may be beneficial to introduce this idea in competitive games/competitions to further reinforce the value and make it commonplace.

Are these “nudges” the silver bullet?

- The primary goal of increasing computational efficiency is to reduce carbon emissions to protect the environment.
- One criticism of this proposed plan is the idea that these “nudges” will decrease overall research freedom.
- There is the conflicting belief that completely unrestrained research and innovation in the AI space will ultimately yield solutions that provide much more environmental benefit vs. reducing the energy usage used to train and develop these models.
- In the end, it will likely take a hybrid approach of both innovative solutions applied to environmental problems + increased computational efficiency of AI models.

AI Cyberweapons

Cyberweapons and Ethical issues (AWS)

- AI have been used by the military to develop very sophisticated autonomous weapon systems (AWS).
- These systems are able to plan, target, and attack all autonomously.
- Localized ethical issues are debated regarding AWS's breaching just war theory, and international humanitarian law.
- There are concerns that any targeting choices made with AWS take away the human dignity of its victims.
- There are a growing number of tasks AI weapon systems are performing, increasing the concerns of a worldwide nuclear conflict, and the associated ethical issues.

Cyberweapons and Ethical issues (ACW)

- Its been found that groups that are a part of armed conflict use cyber weapons frequently.
- These autonomous cyber weapons (ACW) can exploit software vulnerabilities in digital military systems.
- This results in ethical issues that are no longer localized.
- It can be concluded that ACW are a form of AWS, even if they are not physical devices such as armed drones.
- The rise of ACW raises concerns of cyber threats to nuclear weapons systems and nuclear command, control and communication (NC3).
- The advancement of these systems clearly has far-reaching ethical concerns.
- It is imperative AI scientists, bring these concern to the public's, and policy makers attention.

Thanks!