

THE SOCIAL COSTS OF AI

ETHICS, AI & ECONOMICS

23. MARCH 2022

1. WHO AM I?

2. THE RESEARCH QUESTION

3. WHAT IS BERT AND WHY DO WE NEED IT?

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WHO AM I?

WHO AM I?

- From 2020: PhD Student in Economics, BGSE
- Until 2020: Economics, Computer Science & Math
- Projects: Machine Learning in Economics
 - Modeling human decision making
 - Predicting the effects of programs
- Research: Computational Econometrics

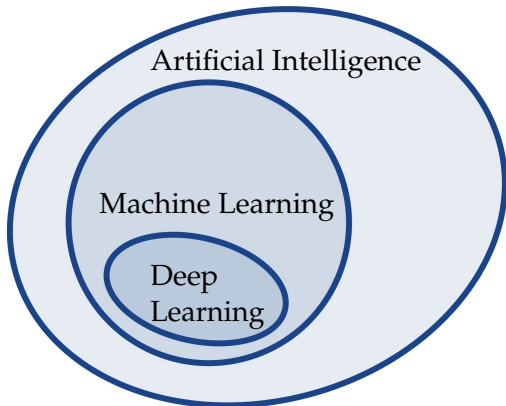
THE RESEARCH QUESTION

AI: AN EXAMPLE

Let's fix an example for this presentation

- Language modeling (NLP)
- Autocorrection on phones and computers
- Amazon Alexa etc.
- Google Translate etc.

EXAMPLE CONTD.



- AI: Teaching computers languages
- ML: Using specific models to do the above task
- DL: Using ML models but with **many parameters**

WHAT ARE PARAMETERS?

- Task: Write about your day
- Catch: You can only use max. 10, 100, or 1000 words
- Here: Number of words \equiv Number of parameters

THE PROBLEM

- **Many parameters** \implies large computational costs
- Large computational costs \implies large energy consumption
- Large energy consumption \implies **large CO₂ emissions**

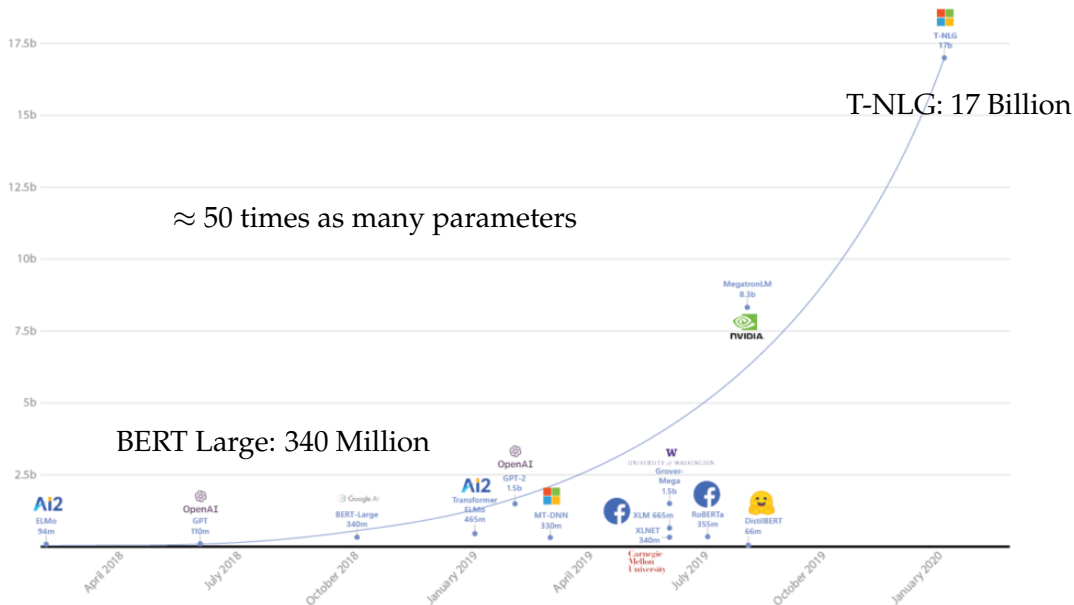
ARE THE EMISSION REALLY THAT LARGE?

ARE THE EMISSION REALLY THAT LARGE?

Yes!

Training a large NLP model \approx 125 round-trip flights New York - Beijing

—[Strubell et al. \(2020\)](#)



BUT WHAT CAUSES THE EMISSION?

For state-of-the-art large models:

- **(Pre-) Training**
 \approx 1 month on 1,000 computers; [Narayanan et al. \(2021\)](#)
- **Fine-Tuning**
 \approx few days on several computers; [Devlin et al. \(2018\)](#)
- **Deployment**
 \approx millisecond

HOW OFTEN DO THESE STAGES HAPPEN?

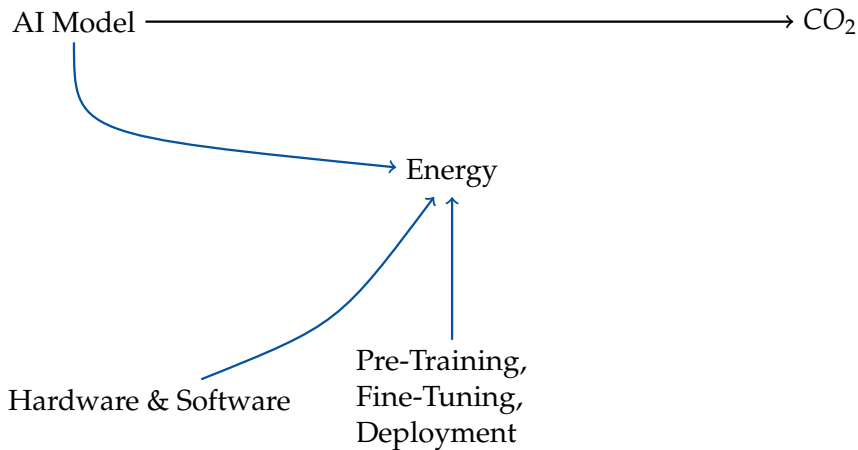
Let's consider a language model used by Google:

- **(Pre-) Training and Model Development**
 ≈ 100 times (*further resources needed*)
- **Fine-Tuning and Model Development**
 $\approx 1,000$ times (*further resources needed*)
- **Deployment**
 ≈ 5 billion Google searches every day

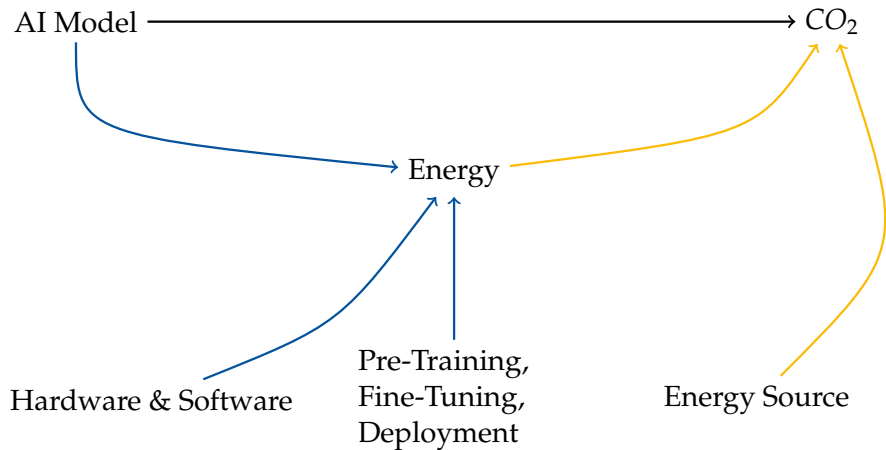
THE PROBLEM CONTD.

AI Model \longrightarrow CO₂

THE PROBLEM CONTD.



THE PROBLEM CONTD.



RESEARCH QUESTIONS

- How do we quantify emissions of AI models?
- Can we nudge the AI community towards sustainability?

— **WHAT IS BERT AND WHY DO WE NEED IT?** —

BERT

- Language model developed at Google by [Devlin et al. \(2018\)](#)
- Is used e.g. for Google search queries
- Main example in [Strubell et al. \(2020\)](#) and [Schwartz et al. \(2020\)](#)
- We use it, because
 - Perfect model size for our resources
 - The literature is already familiar with the model
 - We can compare our results to the literature

PROJECT STATUS

PROJECT STATUS

- Build test computing infrastructure ✓
 - Setup energy measurement architecture ✓
 - Setup computing environment ✓
 - Run BERT model 🔄
- Build real computing infrastructure ✗
 - Get new computing hardware ✗
- Analyze energy data ✗

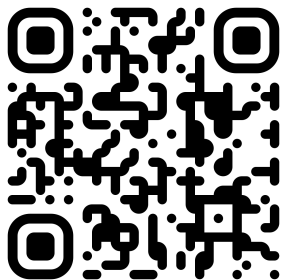
REFERENCES I

- Devlin, J., Chang, M., Lee, K., & Toutanova, K. (2018). BERT: pre-training of deep bidirectional transformers for language understanding. *CoRR*.
- Henderson, P., Hu, J., Romoff, J., Brunskill, E., Jurafsky, D., & Pineau, J. (2020). Towards the systematic reporting of the energy and carbon footprints of machine learning. *Journal of Machine Learning Research*.
- Kaack, L. H., Donti, P., Strubell, E., & Rolnick, D. (2020). Artificial intelligence and climate change: Opportunities, considerations, and policy levers to align ai with climate change goals. *Invited policy brief, Heinrich Böll Foundation*.
- Kaack, L. H., Donti, P. L., Strubell, E., Kamiya, G., Creutzig, F., & Rolnick, D. (2021). Aligning artificial intelligence with climate change mitigation. *Working paper*.
- Lacoste, A., Luccioni, A., Schmidt, V., & Dandres, T. (2019). Quantifying the carbon emissions of machine learning.
- Narayanan, D., Shoeybi, M., Casper, J., LeGresley, P., Patwary, M., Korthikanti, V., Vainbrand, D., Kashinkunti, P., Bernauer, J., Catanzaro, B., Phanishayee, A., & Zaharia, M. (2021). Efficient large-scale language model training on GPU clusters. *CoRR*.

REFERENCES II

- Schwartz, R., Dodge, J., Smith, N. A., & Etzioni, O. (2020). Green AI. *Communications of the ACM*.
- Strubell, E., Ganesh, A., & McCallum, A. (2020). Energy and policy considerations for modern deep learning research. *Proceedings of the AAAI Conference on Artificial Intelligence*.

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`github.com/timmens/social-cost-ai`