Delft Al Labs & Talent Programme Spring Event - Sustainable Al Futures 15/06/2023

Green AI: Thinking first before using Artificial Intelligence

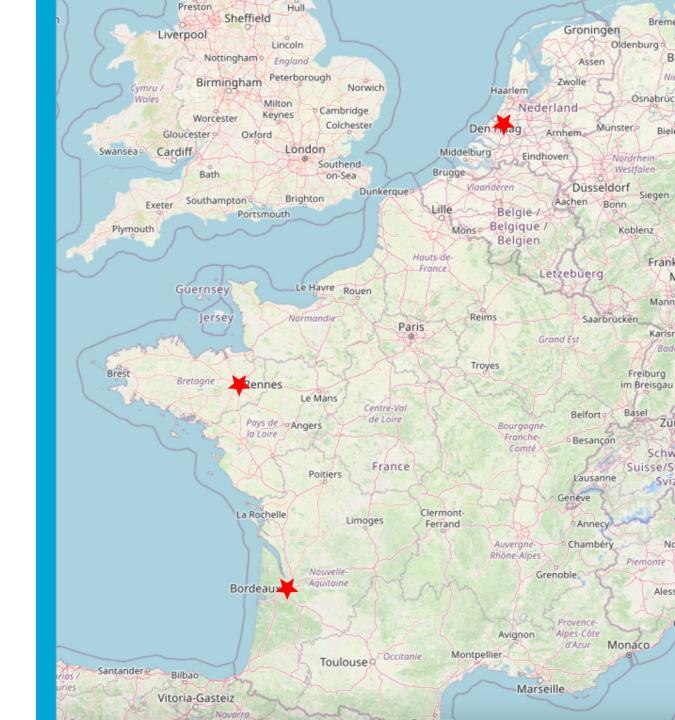
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My Background

- MEng in Agronomy / Environmental Science
- MSc in Software Engineering
- PhD in Software Engineering
- Postdoc in (Sustainable) Software Engineering
 - TU Delft, SERG





AI: A key enabler of new possibilities





https://www.forbes.com/sites/alanohnsman/2020/03/17/is-your-company-using-artificial-intelligence-to-transform-an-industry-nominations-for-the-forbes-2020-ai-50-list-are-now-open/
https://innovationatwork.ieee.org/the-smart-grid-could-hold-the-keys-to-electric-vehicles/
https://autoversed.com/15-amazing-car-features-were-likely-to-see-in-the-near-future/
https://www.openpr.com/news/2285053/artificial-intelligence-ai-in-medical-diagnostics-market

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No limits?

Training compute (FLOPs) of milestone Machine Learning systems over time

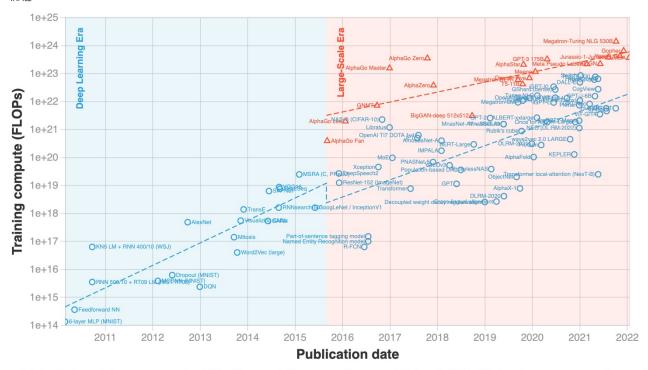


Figure 3: Trends in training compute of n102 milestone ML systems between 2010 and 2022. Notice the emergence of a possible new trend of large-scale models around 2016. The trend in the remaining models stays the same before and after 2016.

[Hoffmann et al 2022]

Parameters	FLOPs	FLOPs (in Gopher unit)	Tokens
400 Million	1.92e+19	1/29, 968	8.0 Billion
1 Billion	1.21e+20	1/4, 761	20.2 Billion
10 Billion	1.23e + 22	1/46	205.1 Billion
67 Billion	5.76e + 23	1	1.5 Trillion
175 Billion	3.85e + 24	6.7	3.7 Trillion
280 Billion	9.90e+24	17.2	5.9 Trillion
520 Billion	3.43e + 25	59.5	11.0 Trillion
1 Trillion	1.27e+26	221.3	21.2 Trillion
10 Trillion	1.30e+28	22515.9	216.2 Trillion

Table: Optimum number of tokens from training megamodels, and the corresponding compute power. [Duranton 2023]



At what cost?

- 284,019 kg of CO2e for training 1 NLP model [Strubell et al. 2019]
 - 5x lifetime emissions of a car
- Al training computations: up by 300000x for 2012-2018 [Amodei and Hernandez 2019]

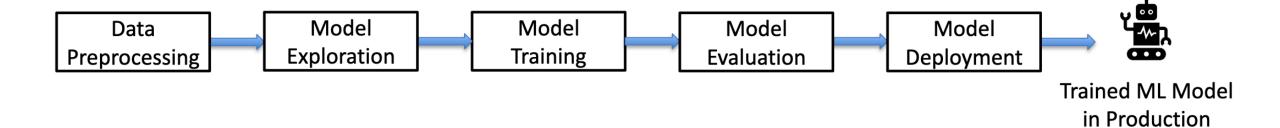




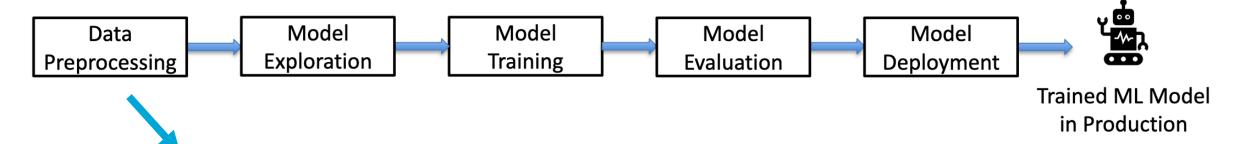
 energy efficiencies in ICT can reduce ICT's carbon footprint [Malmodin et al. 2018, Masanet et al. 2020, Freitag et al. 2021]

- Green AI [Schwartz et al. 2019]
 - increasing efficiencies of AI computations > accurate AI computations without consideration of resource costs or efficiencies
- "Green AI regards practices aimed at utilizing AI to mitigate the impact that humans have on the natural environment in terms of natural resources utilized, and/or mitigating the impact that AI itself can have on the natural environment." [Verdecchia et al 2023]









Data-Centric Green Al An Exploratory Empirical Study

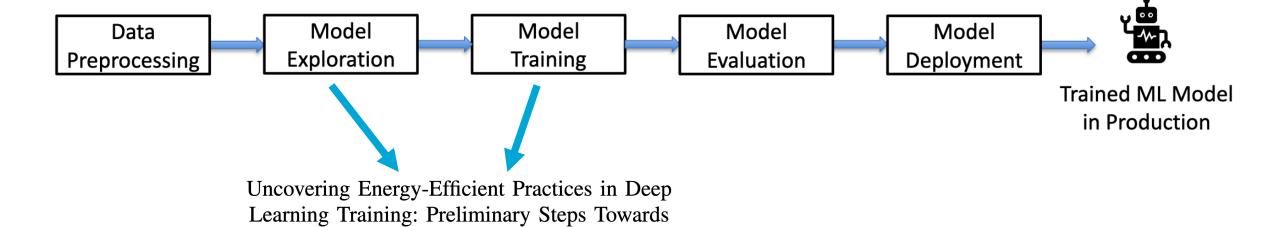
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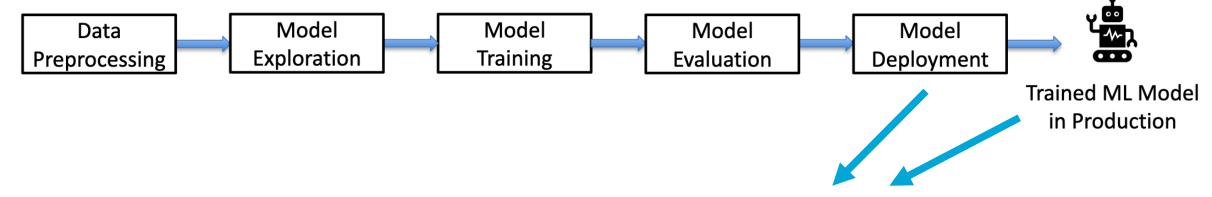
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Green AI





Retrain AI Systems Responsibly! Use Sustainable Concept Drift Adaptation Techniques

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Is it enough?

Rebound Effect!!!

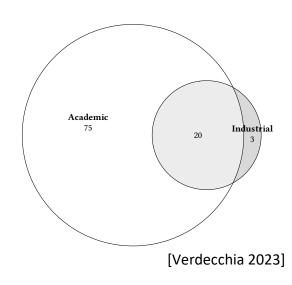


Decreasing the energy consumption can lead to increasing the overall usage



Is it enough?

 Transfer research knowledge and findings to practices in industry



- Regulations ?
 - Can we forbid some Al applications?



Conclusion

- Reducing the environmental impact of AI is possible
 - Can be quite simple and with great results!
 - Across the AI pipeline
- Ensuring to tackle rebound effects
- Regulating the use cases of AI?
 - Other dimensions of sustainability
- Smart usage of (Green) AI: Thinking first before using it!



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Thank you for your attention

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