Computational Sustainability and Technology (CST)

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EXTENDED ABSTRACT

Computational sustainability (CS) is the scientific field that aims to balance societal, economic, and environmental resources using methods from computer science and artificial intelligence (AI). AI models, e.g., machine learning models, enrich models of computational sustainability. Research in interactive machine learning can make important contributions to help address key challenges of sustainability (AI for CS). Computational sustainability questions enrich AI research, not only by providing problems that involve uncertainty or vagueness, thus generating compelling new AI challenges, but also by providing a requirement framework for resource-bounded computation (CS for AI).

The research department Interactive machine learning of the German Research Center for Artificial Intelligence hosts "Computational Sustainability & Technology"; we use applied artificial intelligence methods in the areas of machine learning, knowledge representation, and intelligent user interfaces to help achieve more sustainable systems (AI for CS) or to build more sustainable AI systems (CS for AI).

Using the power of, for example, deep learning computers, we can process large quantities of information and allocate resources based on real-time information. On the other hand, we have to decide when to regulate the power consumption of such AI systems. Applications are widespread. For example, smart grids implement renewable resources and storage capabilities to control the production and expenditure of energy. In the project Seadash, we work on integrating machine learning methods for event detection and classification of underwater signals to preserve marine fauna. Further, together with edge computing (the new distributed computing paradigm that brings computation and data storage closer to the location where it is needed) we do not only improve response times and save bandwidth, but also reduce energy consumption (Mobile AI Lab).

The theory of computational sustainability includes aspects from game theory, machine learning theory and human computer interaction theory. For example, climate change, pollution, and other environmental crises can be explained by theories of human psychology (e.g., the individual in a social world) and can hence be computed by (machine learning) models with computational models of the Prisoner's Dilemma. More is More? More computation is not always more, as unsustainable consumption of energy should be avoided. There are already interesting approaches in the machine learning community, e.g., towards the systematic reporting of the energy and carbon footprints of machine learning or looking at methodological issues related to training on big data and large web corpora where billions or even trillions of parameters are tuned. Humans, on the contrary, can do such "training" with only a few examples or from simple instructions (cf. interactive machine learning, https://www.dfki.de/iml/).

AI for CS and CS for AI and the application domains bring us back to the main challenges of artificial intelligence research and applied research in the area of CS technology: (1) Incompleteness, (2) vagueness, (3) uncertainty and reasoning (in deep learning), and (4) resource-bounded computation and learning. In our projects, we tackle these theoretical challenges and focus on imitation learning, learning with small datasets, transfer learning, long term autonomy of sustainable AI systems, never ending learning, hybrid teams, IoT, multi-sensor streams for small interaction

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devices, mobile computing platforms (Mobile AI Lab), and the efficient use of big deep learning clusters. References: [Zacharias et al. 2018] [Fry and Henry 2018] [Milgram et al. 1992] [Henderson et al. 2020] [Rahwan et al. 2019] [Gomes et al. 2019]

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