Karlsruhe Institute of Technology

Michael Färber
michael.faerber@kit.edu

David Lamprecht
david.lamprecht@student.kit.edu

aifb

The *Green AI Ontology*: An Ontology for Modeling the Energy Consumption of AI Models

Summary

1. We propose an ontology for modeling the energy consumption and other environmental aspects of AI models.
2. We constructed a Knowledge Graph and evaluated the ontology based on the competency questions.
3. The ontology can be used in various scenarios, ranging from comprehensive research data management to strategic controlling of institutions and environmental efforts in politics.

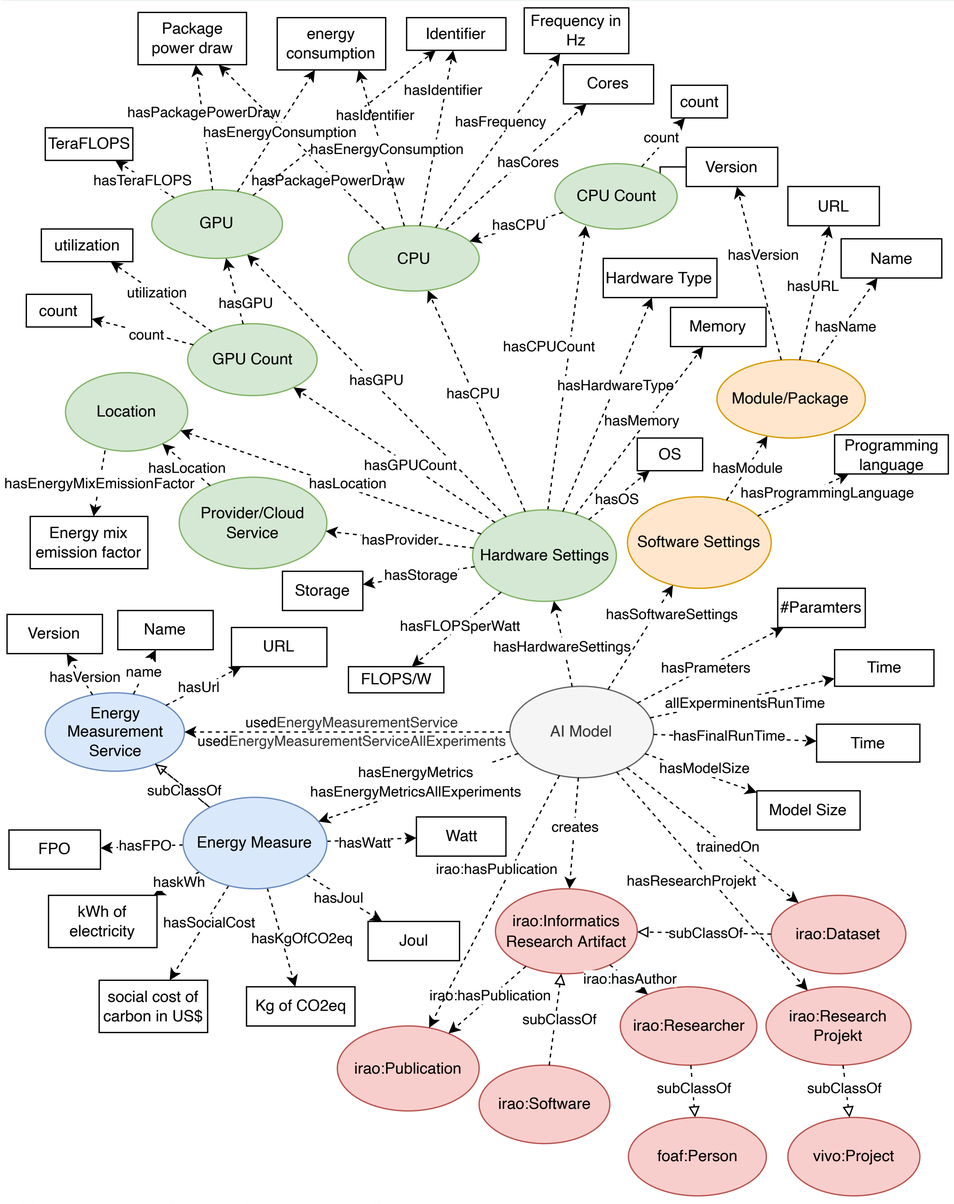
AlexNet to AlphaGo Zero: A 300,000x Increase in Compute	
AI Model	**Computation Amount in Petaflop/s-days**
AlexNet (2012)	0.0058 pfs-days
Seq2Seq (2014)	0.085 pfs-days
Xception (2016)	5.0 pfs-days
AlphaGo Zero (2017)	1860 pfs-days

The Amount of compute used in AI training runs has been increasing exponential with a 3.4-month doubling time. Source: https://openai.com/blog/ai-and-compute/

AI Models
- **Energy consumption**
- **Energy Metrics**

Environmental studies
Green AI
- **Comprehensive research data management**

Ontology Design



Overview of the Green AI Ontology.

Green AI Ontology: Overview

https://w3id.org/Green-AI-Ontology/ontology/ **Ontology OWL file**

The Ontology is designed to model the following aspects:

- Metrics and tools — **Energy Metrics to measure the energy consumption of AI models and Energy Measurement Services**
- Hardware settings — **Private Infrastructure, Cloud Provider, Location of the Hardware**
- Software settings — **Software Packages and Modules**
- Linking to scholarly linked data — **Integration of the modelled energy consumption information into the scientific landscape**

Example RDF Triples (in Turtle):

```
@prefix gai : <https://w3id.org/Green-AI-Ontology/ontology/>.
@prefix greenai-kg-entity : <https://greenai-kg.org/entity/>.
@prefix irao: <http://ontology.ethereal.cz/irao/>.

greenai-kg-entity:aimodel/1000001
      a gai:AIModel;
      dcterms:title "GPT-NeoX-20B";
      gai:hasFinalRunTime "1830.0";
      gai:allExperminentsRunTime> "2750.0”;
      gai:hasParameters> "20000000000.0";
      irao:hasPublication greenai-kg-entity:publication/1000001.

greenai-kg-entity:publication/1000001
      a irao:Publication;
      dcterms:title "GPT-NeoX-20B: An Open-Source Autoregressive Language Model".
```

Knowledge Graph Construction and Ontology Evaluation

SPARQL Query

```
PREFIX gai: <https://w3id.org/Green-AI-Ontology/ontology/>
PREFIX dcterms: <http://purl.org/dc/terms/>

SELECT ?aiModel ?aiModelName ?floatingPointOperations
WHERE {
      ?aiModel a gai:AIModel .
      ?aiModel dcterms:title ?aiModelName .
      ?aiModel gai:hasEnergyMetrics ?energyMetrics .
      ?energyMetrics gai:hasFPO ?floatingPointOperations .
}
```

	aiModel	aiModelName	floatingPointOperations
1.	https://greenai-kg.org/entity/aimodel/1000006	GPT-3 Small	225000000000000000000
2.	https://greenai-kg.org/entity/aimodel/1000008	GPT-3 Large	1.37e+21
3.	https://greenai-kg.org/entity/aimodel/1000013	GPT-3 175B	3.14e+23
4.	https://greenai-kg.org/entity/aimodel/1000020	ELECTRA-1.75M	3.1e+21

Get the number of floating-point operations (FPO) that were needed to train the AI models.

Green AI Knowledge Graph

- Proof-of-concept Knowledge Graph, modeling 40 AI models and 1975 statements.

Competency Questions

- 15 competency questions based on 79 Green AI-related papers.
- Some exemplary compenency questions:
  1. How many floating-point operations (FPO) did the AI Model need to be trained?
  2. How much kg of CO2eq did the AI Model generate?
  3. How much energy in kWh did the training of the AI model take?
  4. In which region is the hardware used to train the AI Model? (Background: In a carbon-friendly region?)
  5. Did AI Model A or AI Model B generate more CO2?

Use Cases

- Research Data Management – Modeling the environment Information of AI models next to extisting ontologies and knowledge graphs.
- AI Systems – The Ontology allows the modeling of serveral measurements for each AI model.
- Society – The Ontology complies with the rising public awareness for Green AI and environmental studies.