# Social Impact of Artificial Intelligence - Lecture 18.4

Topic:

- Sustainability

# Sustainability - 1

- The sustainability crisis has many facets, including the climate emergency, global inequity, biodiversity loss, and scarcity of water and food resources.
- Sustainability is the ability to maintain the balance of a process in a system over the long term.
- Ecological sustainability is the ability of an ecosystem to maintain ecological processes, functions, biodiversity, and productivity into the future.

# Sustainability - 2

- Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state.
- In social systems, resilience is enhanced by the capacity of humans to anticipate and plan for the future.
- Sustainable development is the ability to recognize and meet the needs of the present without compromising the ability of future generations to meet their own needs. [Brundtland, *Our Common Future*, 1987].

# Sustainability - 3

- Sustainable development requires satisfying environmental, societal, and economic constraints.
- In *An Essay on the Principle of Population*, Malthus [1798] was focused on the imbalance between population growth, which has grown exponentially, and the supply of food, which is limited. He wrote:

  > *This natural inequality of the two powers, of population, and of production of the earth, and that great law of our nature which must constantly keep their effects equal, form the great difficulty.*

- The global planetary system must satisfy the constraint that the consumption by the growing population is limited by the food production of the Earth.
- That is just one of many constraints that must be satisfied for our planetary system to be sustainable and resilient.

# Sustainability - 4

- What is the relationship between sustainability between computation, in general, and AI, in particular?
- Computation is a double-edged sword with respect to sustainability.
- Our computational and communication networks have been significantly beneficial to sustainability.
- Computation has a sustainable dynamic, dematerialization, replacing atoms with bits, saving many resources
- But many resources are consumed and wasted.
- Mining for the materials needed for computers, devices, and batteries can have serious environmental effects.

# Sustainability - 5

- At the end of the short product lifecycles, many million tonnes of electronic waste are produced each year, with devastating environmental consequences, especially in the Global South.
- The power used by massive cloud servers is another major resource consumed. In particular, the training of large models requires huge computational resources.
- AI is characterized as a technology of extraction by Crawford [2021].
- Mining of some cryptocurrency coins, such as Bitcoin, and the verification of cryptocurrency transactions are also major resource sinks.
- Countering these trends is the green information technology movement, which aims to design, manufacture, use, repair, and dispose of computers, servers, and other devices with minimal energy use and impact on the environment.

# Sustainability - 6

- Computational sustainability applies techniques from AI, computer science, information science, operations research, applied mathematics, and statistics for balancing environmental, societal, and economic needs for sustainable development [Gomes, 2019].
- Two main themes:
  - Developing computational models and methods for offline decision making for the management and allocation of ecosystem resources
  - Developing computational modules embedded directly in online real-time ecosystem monitoring, management, and control
- AI plays a key role in both themes.

# Sustainability - 7

- In *Planetary Boundaries: Exploring the Safe Operating Space for Humanity*, Rockstrom *et al.* [2009] identified nine critical boundaries on the Earth's biophysical processes to ensure the sustainability of the planet.
- The boundaries are goal constraints on:
  - climate change
  - rate of biodiversity loss (terrestrial and marine)
  - interference with the nitrogen and phosphorus cycles
  - stratospheric ozone depletion
  - ocean acidification
  - global freshwater use
  - change in land use
  - chemical pollution
  - atmospheric aerosol loading.

# Sustainability - 8

- One constraint on anthropogenic climate change requires atmospheric carbon dioxide concentration to be less than 350 ppmv (parts per million by volume). The pre-industrial value was 280 ppmv; in 2009 it was 387 ppmv and 412 ppmv in 2023.
- The rate of biodiversity loss is determined by the extinction rate (number of species lost per million per year). Its boundary value is set at 10; it was greater than 100 in 2023.
- Constraint satisfaction is at the core of computational sustainability.

# Sustainability - 9

- The United Nations specified 17 Sustainable Development Goals (SDGs) [UN, 2015].
- The SDGs cover the nine biophysical planetary boundary constraints and extend them to cover human social and economic goals such as reducing poverty, hunger, and inequality, while improving health, education, and access to justice.

# Sustainability - 10

- Many systems, using the full spectrum of AI methods, including deep learning, reinforcement learning, constraint satisfaction, planning, vision, robotics, and language understanding, are being developed to help achieve the SDGs.
- Multiagent techniques based on Stacklberg security games can enhance public health, security, and social justice. [Perrault, 2020]
- Multiagent methods also address the so-called tragedy of the commons which is at the heart of sustainability concerns [Hardin, 1968]. Ostrom [1990] showed that institutions for collective action can evolve to govern the commons.

# Sustainability - 11

- AI scientists and developers have some of the skills required to address aspects of global warming, poverty, food production, arms control, health, education, the aging population, and demographic issues.
- They have to work with domain experts, convincing them the AI solutions are not just new snake oil.
- Some of the positive environmental impacts of intelligent vehicles and smart traffic control were presented in Lecture 18.3.

# Sustainability - 12

- Environmental decision making often requires choosing a set of components that work together as parts of a complex system.
- A combinatorial auction is an auction in which agents bid on packages, consisting of combinations of discrete items.
- Determining the winner is difficult because preferences are usually not additive, but items are typically complements or substitutes.
- Work on combinatorial auctions, already applied to spectrum allocation (allocation of radio frequencies to companies for television or cell phones), logistics (planning for transporting goods), and supply chain configuration, could further be applied to support carbon markets, to optimize energy supply and demand, and to mitigate climate change.