On the study of AI metabolism (a position paper)

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Can AI remain within planetary limits?

Motivations

➔ AI systems are becoming **ubiquitous**, transforming infrastructures and societal functions.

➔ Their expansion generates significant **resource demands** and **environmental pressures**.

➔ Key **systemic effects—rebound, leakage, and lock-in**—are often overlooked.

➔ A **socio-metabolic lens** reveals conditions for **sustainable AI** within **planetary limits**.

Social Metabolism

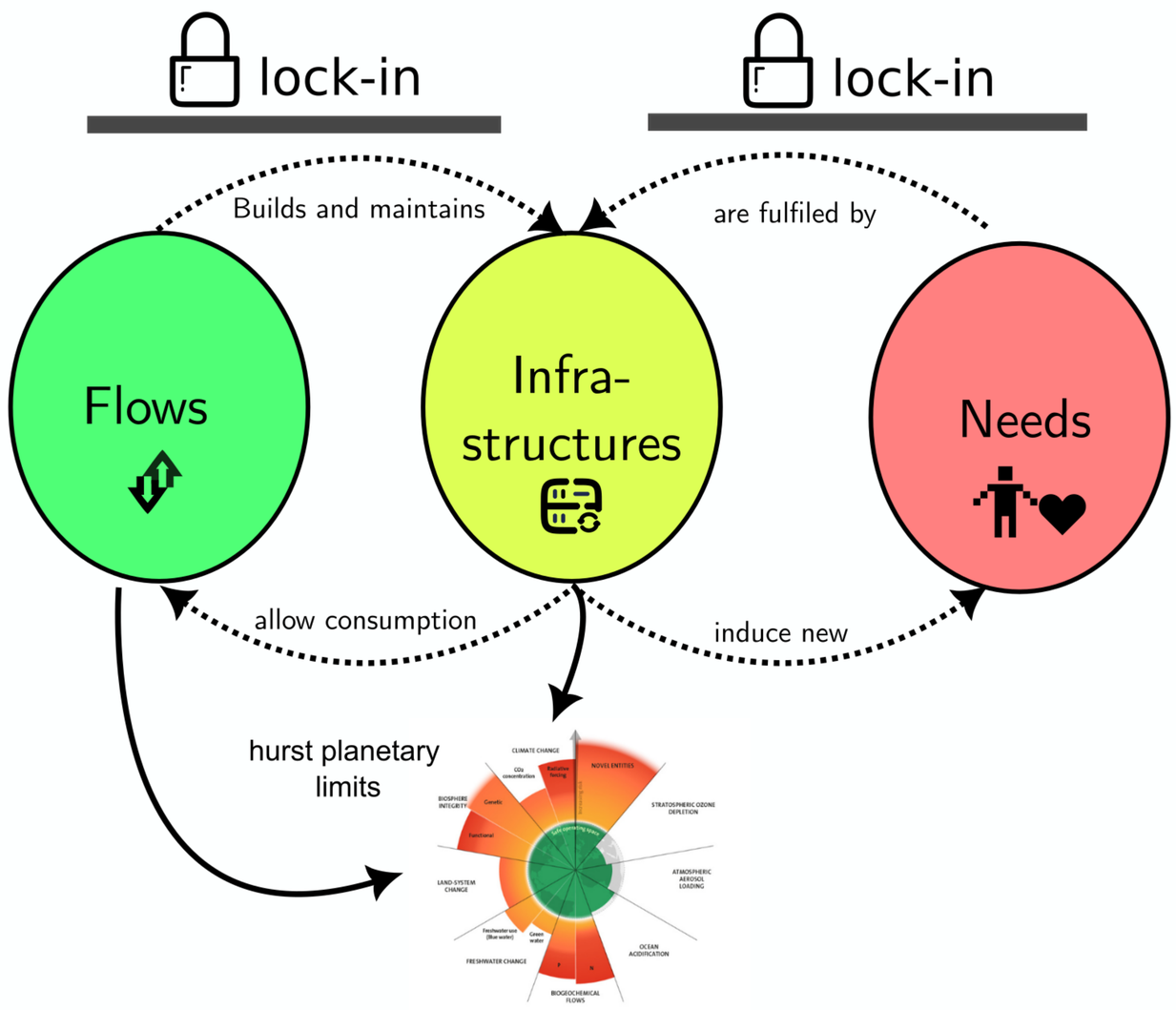
➔ Social metabolism studies biophysical flows between **societies** and their **environment**.

➔ It links **resource** use, **infrastructure** dynamics, and societal **needs**.

➔ It captures **indirect effects**, such as feedback loops and externalities.

➔ Applying it to AI reveals **hidden dependencies** and long-term **sustainability risks.**

Flow-Infrastructure-Needs model for AI



Flows

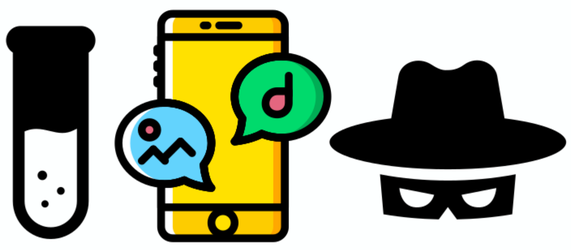
➔ Short-lived **material** and **informational** resources essential to AI life-cycle tasks.
➔ They include **non-renewable inputs** and raise issues like **privacy** and **resource scarcity**.

Infrastructure

➔ includes **physical, informational, human**, and **regulatory** components enabling AI systems.
➔ both **moderates resource use** and **stimulates new needs**, reinforcing **unsustainable expansion**.

Needs

➔ individual and collective **goals** fulfilled by AI-enabled services, based on **Max-Neef's framework**.
➔ AI can act as a **synergic satisfier, pseudo-satisfier**, or destroyer, with long-term effects on well-being and sustainability.



Future work / goals

This research aims to evaluate whether a **controlled landing scenario**—sustainable AI within planetary limits—is physically and socially achievable. Future work will operationalize the FIN model to guide this assessment.

➔ **Identify** AI applications that provide long-term societal benefits with minimal resource intensity.
➔ **Apply** the FIN model to case studies to map flows, infrastructures, and needs.
➔ **Design** frugal AI strategies, including edge-based solutions.
➔ **Analyze** cultural, economic, and regulatory factors enabling or blocking controlled landing.

The ultimate goal is to determine whether sustainable AI is feasible and, if so, under what systemic conditions.

References

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