ESSAI-2024
Self-Governing Multi-Agent Systems
L9/10: Innovation

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Aims and Objectives

- Aims
  - innovation and related terms from different perspectives
  - identify innovation as a process in the context of SGMAS
  - define empowerment and power sensitive design
  - discuss higher orders of cybernetics
  - use patterns of cybernetics for power sensitive design
  - specify a framework for innovation support
- Objectives
  - identify innovation in the context of SGMAS and how to use existing technologies to support innovation and empower communities

Need for Innovation

Reminder...

Learn to Innovate

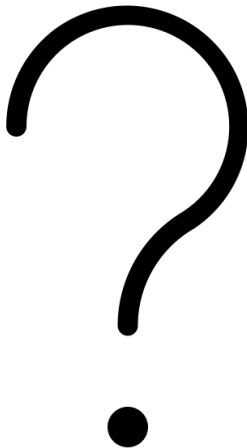Especially during digital transformation humans and technology co-exist.

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This causes unprecedented changes.

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However, existing solutions might not be sufficient.

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Therefore, to adapt we need to learn to systematically **innovate**.

Related Terms & Innovation

Related Terms:

- Psychology & Cognitive Science: **Creativity**, **Inventiveness**, **Imagination**
- Art: **Defamiliarisation**, **Improvisation**
- Economics: **Recombination**
- Philosophy: **Abduction**

Innovation in Management:

- Innovation is related with the decisive marketing of a **novel technological invention**.
- Innovation is the combination of an **outcome**, a **process** and a **mindset**.

*see Breen, 2004, Szczelkun, 2018, Shklovsky, 2015, Love, 2024, Weitzman, 1918, Douven, 2021, and Kahn, 2018.

Commonalities

- **reflection**: there is an environmental trigger
- **generation**: notion of novelty and formation of mechanism to achieve it
- **application**: contextualisation of novelty and grounding the solution in a specific environment

Innovation is the synthesis of three processes: reflection on the environment, the generation of new ideas (in the form of social arrangements), and the application of those to the environment.

$$Innovation = Reflection + Generation + Application$$

- **reflection** requires awareness of the problem (or the process that can be improved)
- **generation** requires envisionment of potential solutions through the creation of variety
- **application** requires the ability to use the variety to solve the problem in the given context (i.e. environment)

- Focus: structural and procedural innovation (i.e. innovation in terms of social arrangements)
- Aim: **re-empower** communities to mitigate existing **societal problems** or avoid **unintended consequences** of current practises and maintain **sustainability**

Innovation for SGMAS

- Focus: structural and procedural innovation (i.e. innovation in terms of social arrangements)
- Aim: **re-empower** communities to mitigate existing **societal problems** or avoid **unintended consequences** of current practises and maintain **sustainability**.

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Innovation for empowerment...

What is Empowerment?

Empowerment is the capability of a community to **exercise control** over their **social arrangements**, (i.e. the set of rules, roles, structures, procedures, policies, norms, conventions, contracts or laws) that individuals in a group **voluntarily agree to comply with**, in order to hold each other accountable.

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This requires requires individuals to have the cognitive capacity to represent and reason about five dimensions:

- self-determination
- competence
- influence
- knowledge
- meaning
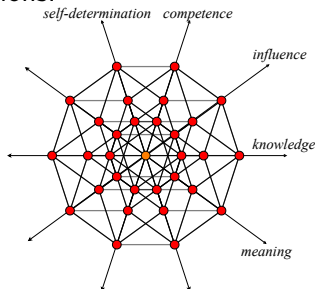
Power-Sensitive Design (PSD)

An instance of Value Sensitive Design the value you want to optimise against is power.

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In the SGMAS context there are two objectives corresponding to design requirements for Power Sensitive Design:

- maximise the power of naturally intelligent components (i.e. humans) and limit the power of artificially intelligent components (i.e. AI)
- maximise the equitability of the distribution of power amongst humans

More on Cybernetics Theory

We can use **cybernetics** to enable **different kinds and levels** of (human community) **empowerment** to emerge.

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This is because of the Law of Requisite Variety (Ashby, 1956) and its extension to the Law of Requisite Complexity (Boisot and Mckelvey, 2011).

- Law of Requisite Variety: there must be **sufficient variety** in the **regulator** to **match** the variety of the **regulated system** for effective self-regulation.

- Law of Requisite Complexity: need for **increasing the complexity** of an **internal** regulatory mechanism to match the **external complexity** of the regulated system.

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The study of higher cybernetics is useful for identifying ways to design power-sensitive systems.

First Order Cybernetics

Recap...

First order cybernetics are described as the **cybernetics of observed systems** (Chepin, 2021), and refer to **self-regulated systems** having an input, an output, and a negative feedback from the output back to the input (Ashby, 1952).

Self-Regulated Systems (SRS)
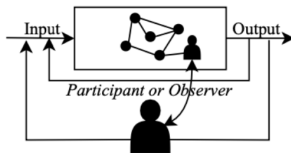
Second Order Cybernetics

Second order cybernetics consider the existence of an **observer**, who can be the system designer or an individual that affects it. They involve **feedback to feedback**, which leads to systems having some level of **responsive awareness** (Davis and Francis, 2023).

SRS affected by an Observer
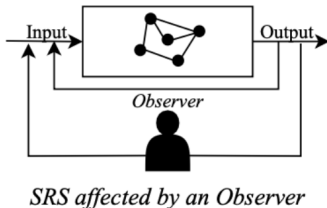
Third Order Cybernetics

Third order cybernetics deal with **active and interactive** systems, in which the **system and the observer co-evolve**.

This means that the observer can **affect** and can **be affected by** the system (Kumar, 2014), both acknowledge their surroundings and the whole system can **redefine** itself.


SRS affected by/affecting an Observer
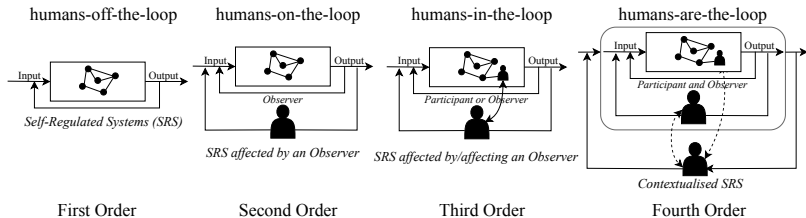
Fourth Order Cybernetics

Fourth order cybernetics refer to **contextualised** systems, **embedded into an environment** and integrated into a specific context (Kumar, 2014).

They are concerned with the notion of **embodied knowledge**, they are **reflective** and **self-aware**, while also possess mechanisms for **self-healing and self-regeneration**.
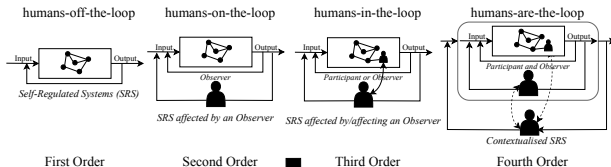

Contextualised SRS
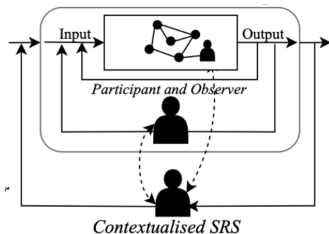
*Embodied knowledge refers to an abstract kind of knowledge that cannot be described in words and explains **what somebody knows by being exposed to a certain situation** (Utopias, 2024).

Higher Order Cybernetics

humans-off-the-loop

Self-Regulated Systems (SRS)

First Order

humans-on-the-loop

Observer

SRS affected by an Observer

Second Order

humans-in-the-loop

Participant or Observer

SRS affected by/affecting an Observer

Third Order

humans-are-the-loop

Participant and Observer

Contextualised SRS

Fourth Order

Order	Type of Empowerment	Type of Disempowerment
First Order	Saves Physical and Cognitive Resources	Resource Loss and Ineffective Regulation
Second Order	Solves Complex Problems	Ineffective Regulation or Manipulation
Third Order	Deals with Social Constructions	Power Misuse and Reaching Detrimental States
Fourth Order	Mitigate Existential Crises	Misinformation and Manipulation

So far...

- innovation
- innovation in SGMAS
- empowerment
- Power Sensitive Design
- Cybernetics for PSD

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Aim: innovation support in SGMAS for community empowerment

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how?

We propose the **co-production between human and AI** to support innovation, **empower** communities and reach sustainability.
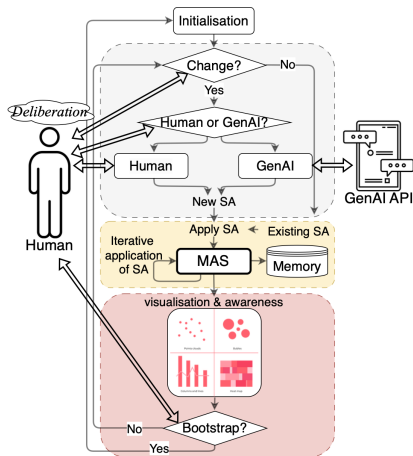
- Multi-Agent System (MAS) Simulations are effective in showcasing unexpected emergence which can **enable humans envision future trajectories of alternative solutions**
- Generative AI (GenAI) links diverse knowledge in an unexpected way which can **enhance human creativity and imagination**
- Humans have *lived experience and expertise* to *validate* recommendations of GenAI and emerging behaviours of MAS, and *apply* them in the given context

  Socially-Guided Machine Learning corresponds to a tool for innovation support for achieving community empowerment.

# Socially-Guided Machine Learning for Empowerment

Using the Socially-Guided Machine Learning (SGML) methodology, we can synthesize *codified social knowledge* and *human expertise* with *GenAI* and *MAS* in order to innovate social arrangements to achieve community empowerment.

Algorithm 1 SGML Framework algorithm
1: Initialise MAS, $reset = false$.
2: **for** m rounds **do**
3:     No SA applied to the MAS and parameters are stored.
4: **end for**
5: Show Visualisation to the User.
6: **while not**($reset$) **do**
7:     Program asks user whether they want to change SA.
8:     **if** User Decides to give a new SA **then**
9:         User gives the SA.
10:         The new SA is given to the program and it is stored.
11:     **else if** User decides to use genAI **then**
12:         Program calls genAI API to ask for a new SA.
13:         The new SA is given to the program and it is stored.
14:     **else**
15:         Existing situation in MAS is maintained.
16:     **end if**
17:     **for** m rounds **do**
18:         SA applied to the system and parameters are stored.
19:     **end for**
20:     Show Visualisation to the User.
21:     $reset = $ User decides to bootstrap.
22: **end while**
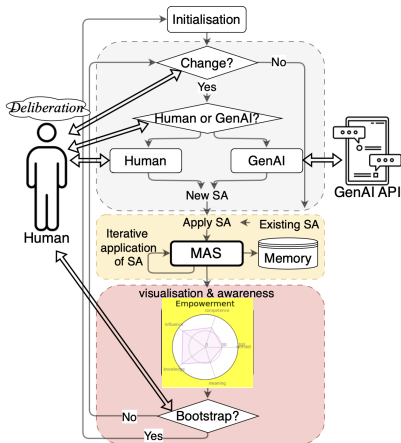
SGML Example of Interaction
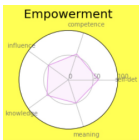
Do you think you need to change? No/Human/GenAI
Your answer was: human
Could you please provide your Social Arrangement?
Program considers the need for empowerment to be: knowledge
The given Social Arrangement is: encourage education, and form
processes for storing and accessing the distributed knowledge.

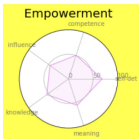Do you think you need to change? No/Human/GenAI
Your answer was: genai
Program considers the need for empowerment to be: influence
Proposed Social Arrangement is: Promote transparency, inclusivity,
and accountability.
Ok or modify?
The updated Social Arrangement is: Promote transparency, inclusivity,
and accountability.

Do you think you need to change? No/Human/GenAI
Your answer was: no

Do you want to bootstrap Yes or No?

Summary

- identify innovation and related terms
- define empowerment
- define Power Sensitive Design
- introduce concepts of cybernetics and use patterns of cybernetics for PSD
- specify SGML framework for innovation support to achieve community empowerment

Takeaway

The significance of socially guided machine learning for innovation support is to assist societies to mitigate societal problems through co-production with AI.

This leads to community empowerment!

(to be continued...)