AALTO

–

Emperor's New Clothes?

Presentation at MoA'09
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- *Aalto University* is created in the beginning of 2010 through a merger between the Helsinki School of Economics (HSE), the University of Art and Design Helsinki (TaiK) and the Helsinki University of Technology (TKK)…

HSE+TaiK+TKK=
AALTO-UNIVERSITY

- … Is this all just plain optimization?

… or is there some *synergy* on some deeper level?

Emperor's new logo

aa"lto u!nive rsit?y

a!alto ylio?p is"to

aal?to u"niver sitete!t

- … Something wrong in communication?

  … or incompatible systems?

  … or, simply, plain *sloppiness*?

Actually – I am an optimist about Aalto!

- Heikki Hyötyniemi, prof. at TKK since 2001
- Special interest on AI and complex systems in general...
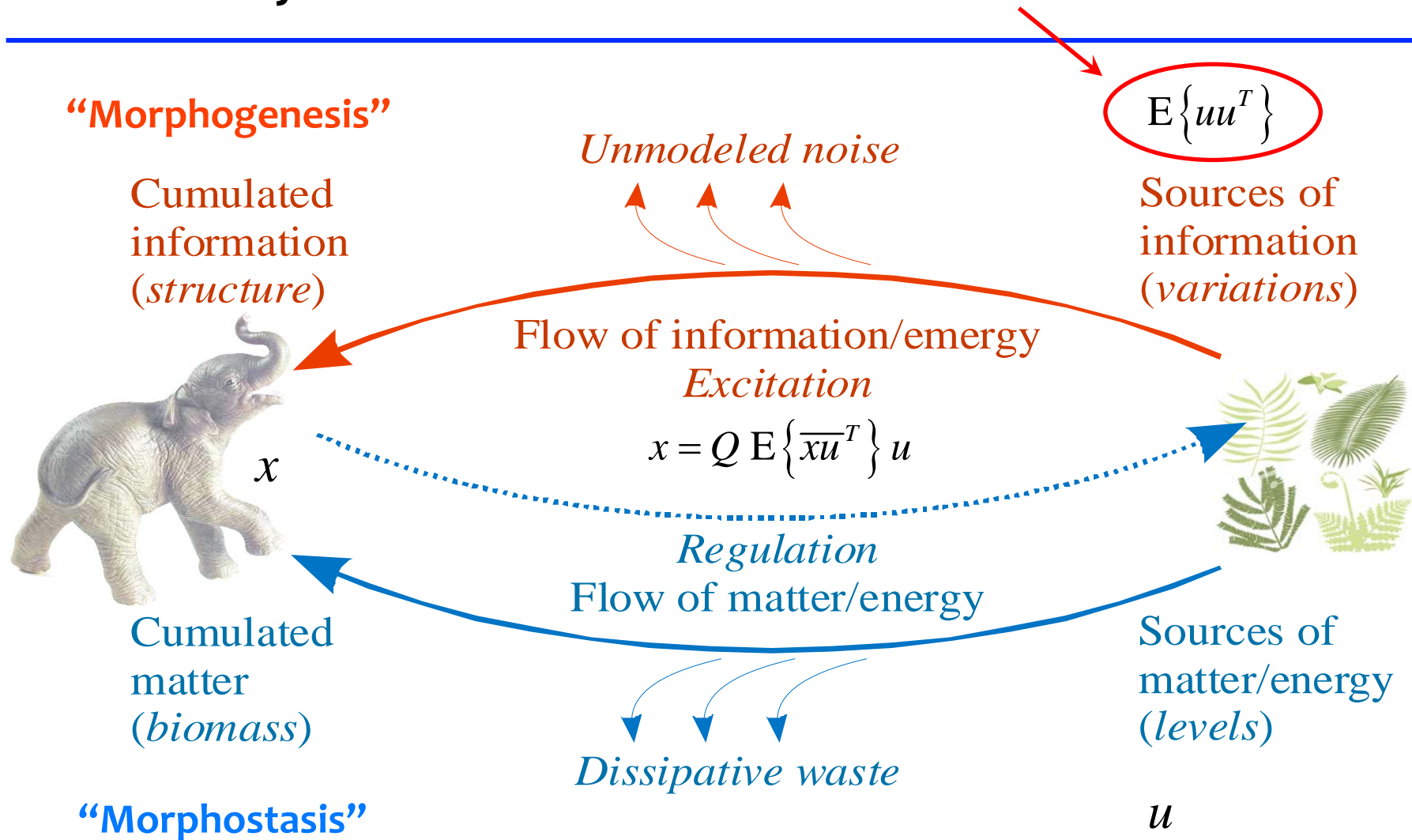
"What couples the domain fields is *neocybernetics*"

Emphasis on understanding nature...

...based on efficient conceptual tools
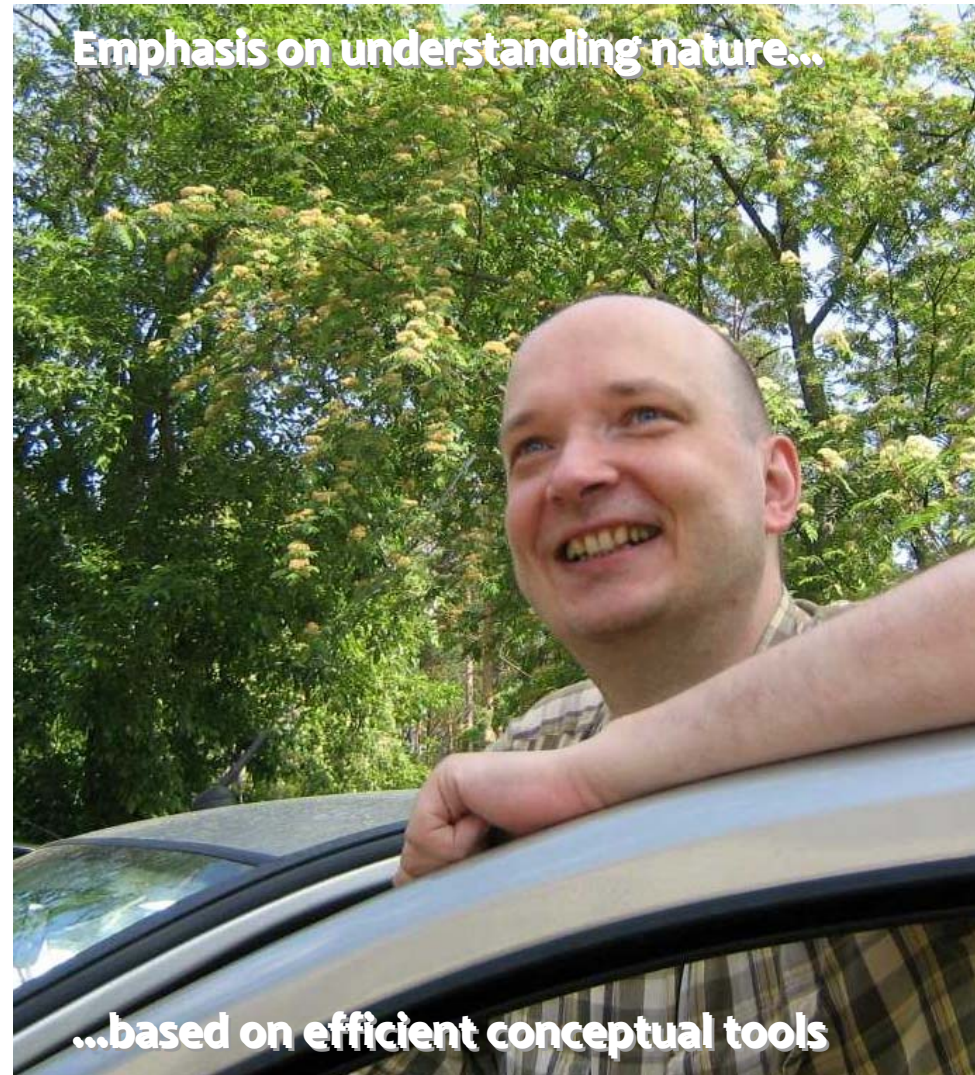
Neocybernetics: Approach to reach *emergence*

- Starting point: research on *neural networks*
- It has been observed that, given vectors of external excitations u and internal activivities x, local *Hebbian learning* in synapses can be characterized as $\bar{x} = q\, \mathrm{E}\{\bar{x}\bar{u}^{\mathrm{T}}\}\, \bar{u}$
- There is competition for activity as *exploitation* means *exhaustion*, implementing *negative feedback* through the environment, resulting in *self-regulation* and *self-organization*
- Self-organization: The neuron grid implements *principal component analysis* and *sparse coding* for input data
- If inputs are seen as resources, this strategy represents *evolutionary optimality* – extension to other fields, to general *distributed networked agent systems* becomes possible

Neocybernetics: *INFORMATION* formalized

$$\mathrm{E}\left\{uu^T\right\}$$

"Morphogenesis"

Unmodeled noise

Sources of information (*variations*)

Cumulated information (*structure*)

Flow of information/emergy
Excitation

$$x = Q\,\mathrm{E}\left\{\overline{xu^T}\right\}u$$

x

Regulation
Flow of matter/energy

Cumulated matter (*biomass*)

Sources of matter/energy (*levels*)

Dissipative waste

u

"Morphostasis"

- **Based on solid mathematics...**

  skipped here!

From (28) one can write yet another expression for the covariance:

$$\mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\} = \left(Q^{-1} + \mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}\right)^{-1}\mathrm{E}\left\{\bar{x}\bar{u}^{\mathrm{T}}\right\}\mathrm{E}\left\{uu^{\mathrm{T}}\right\}\mathrm{E}\left\{\bar{u}\bar{x}^{\mathrm{T}}\right\}\left(Q^{-1} + \mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}\right)^{-1}.$$

Eliminate the matrix inverses by multiplication, so that

$$\left(Q^{-1} + \mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}\right)\mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}\left(Q^{-1} + \mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}\right)$$
$$= \mathrm{E}\left\{\bar{x}\bar{u}^{\mathrm{T}}\right\}\mathrm{E}\left\{uu^{\mathrm{T}}\right\}\mathrm{E}\left\{\bar{u}\bar{x}^{\mathrm{T}}\right\}, \tag{40}$$

and observe the commutativity of the matrices:

$$\left(Q^{-1} + \mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}\right)^{2}$$
$$= Q^{-1/2}\,Q^{1/2}\mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}^{-1/2}\mathrm{E}\left\{\bar{x}\bar{u}^{\mathrm{T}}\right\}\mathrm{E}\left\{uu^{\mathrm{T}}\right\}\mathrm{E}\left\{\bar{u}\bar{x}^{\mathrm{T}}\right\}\mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\}^{-1/2}\,Q^{1/2}\,Q^{-1/2}$$
$$= Q^{-1/2}\,\theta^{\mathrm{T}}\,\mathrm{E}\left\{uu^{\mathrm{T}}\right\}\theta\,Q^{-1/2},$$

and, further, because of the diagonalizing properties of θ,

$$Q^{-1} + \mathrm{E}\left\{\bar{x}\bar{x}^{\mathrm{T}}\right\} = Q^{-1/4}\,\theta^{\mathrm{T}}\,\mathrm{E}\left\{uu^{\mathrm{T}}\right\}^{1/2}\theta\,Q^{-1/4}, \tag{41}$$

or

$$\mathrm{E}\left\{\bar{x}'\bar{x}'^{\mathrm{T}}\right\} + Q^{-1/2} = \theta^{\mathrm{T}}\,\mathrm{E}\left\{uu^{\mathrm{T}}\right\}^{1/2}\theta, \tag{42}$$

Some examples about modeling of input data

- A neocybernetic system consists of a *hierarchy of balances*
- These balances are not static but *dynamic equilibria*
- The balances can be seen as *attractors* in the data space
- System is *elastic*, the balance being determined by inputs
- The system yields along the degrees of freedom (DOF)
- The DOF's can be interpreted as defining *feature axes*
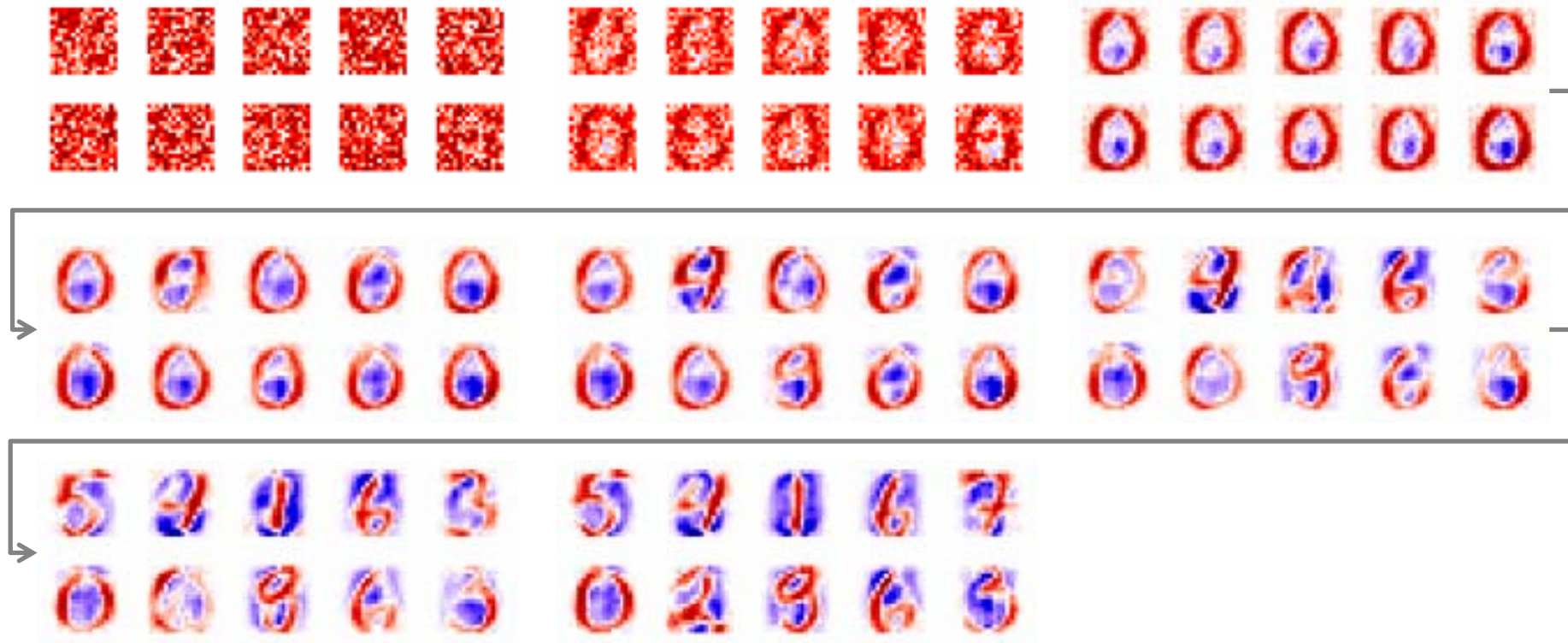- Weighted features sum up to environmental *patterns*

  ... More concrete, please ...!

- Thanks to Petri Lievonen who implemented the simulations!

Data: *handwritten digits*

- The more there are available features (memory locations), the *sparser* the representation becomes (here 10 features seen)
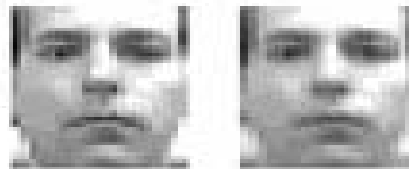- Visual cortex has been observed to do sparse coding, too!
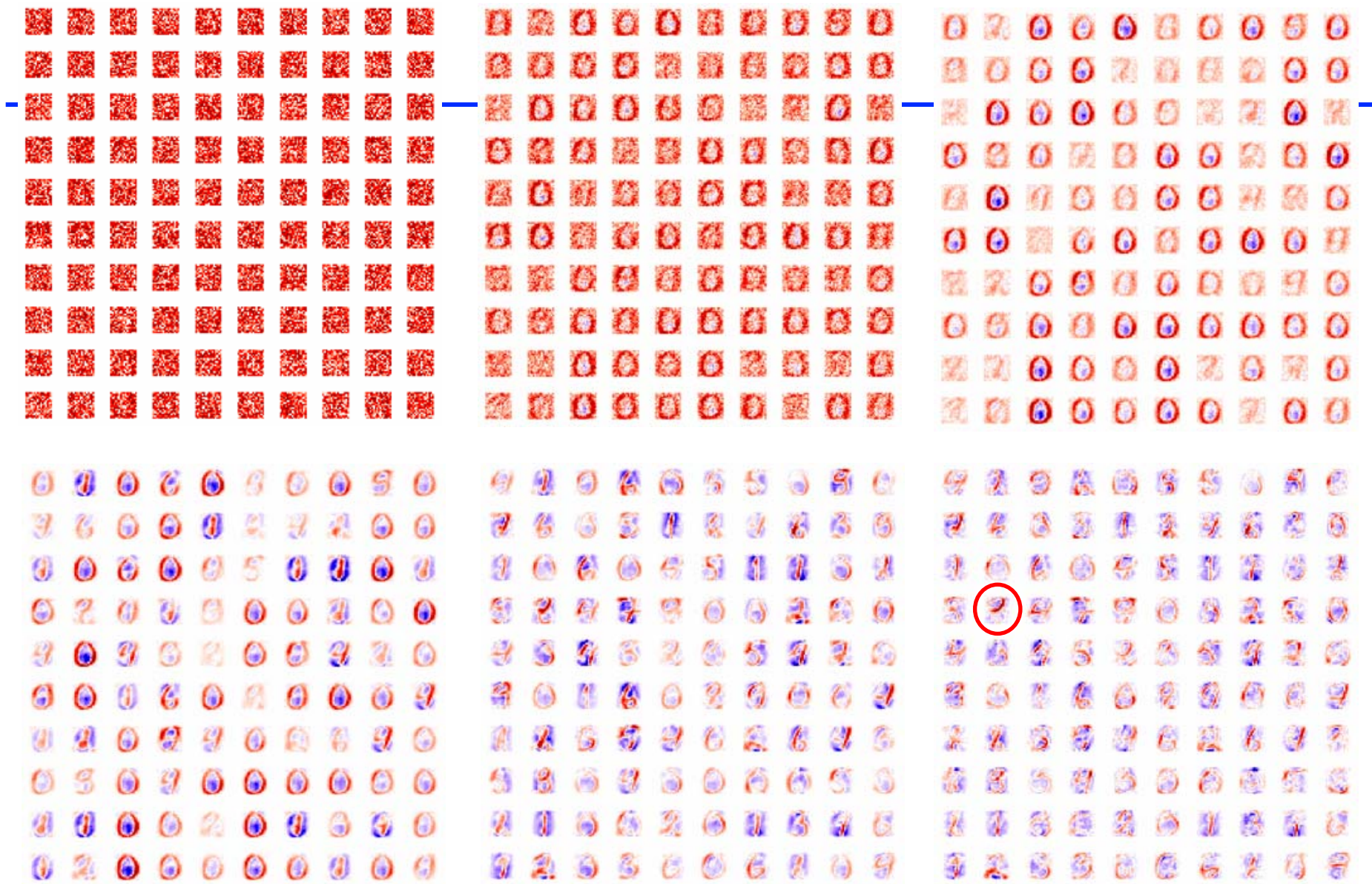
Data: *faces*

- Resulting in *eigenfaces*
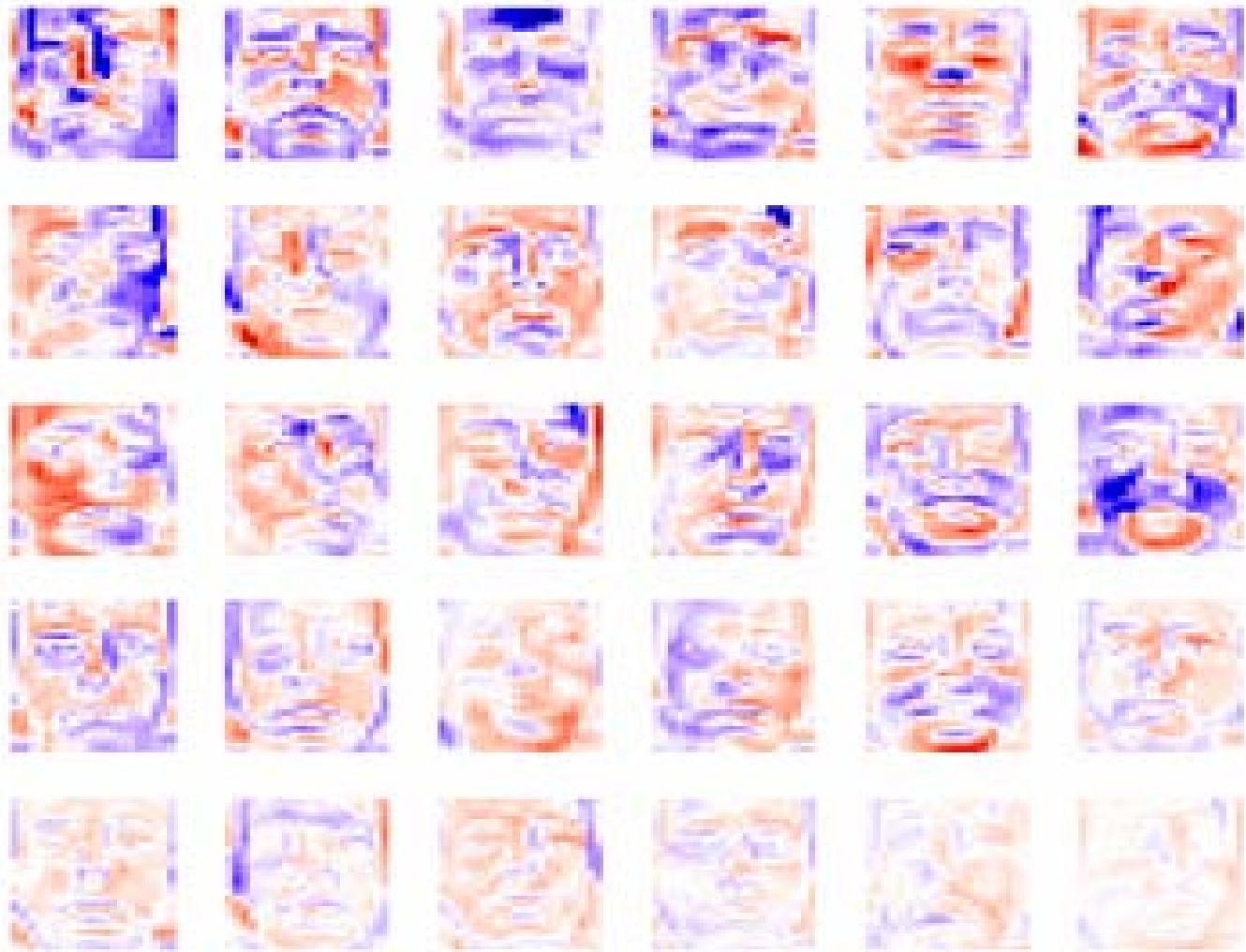
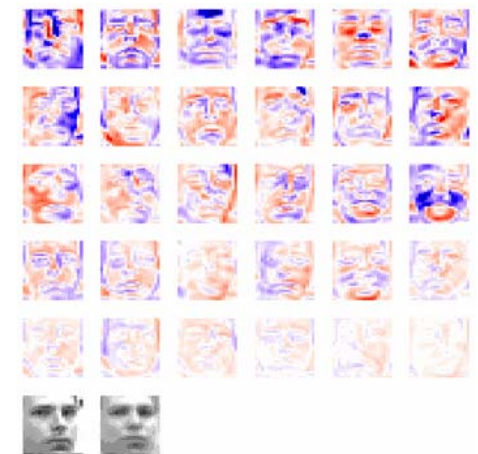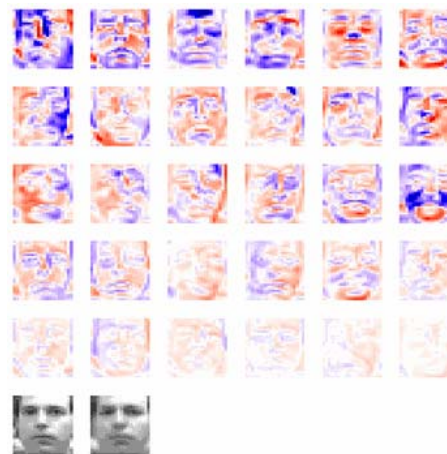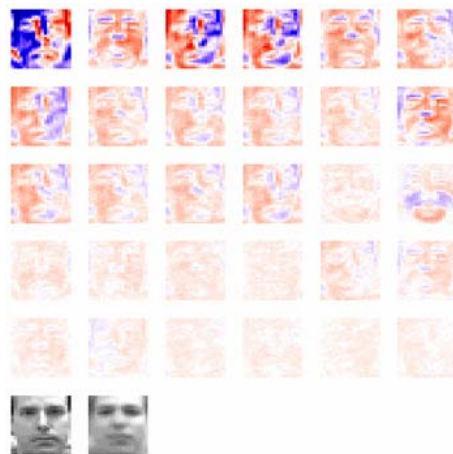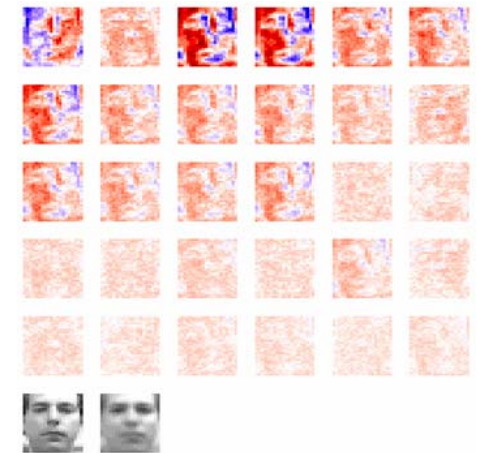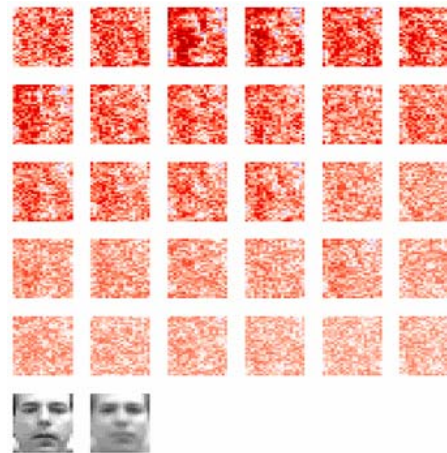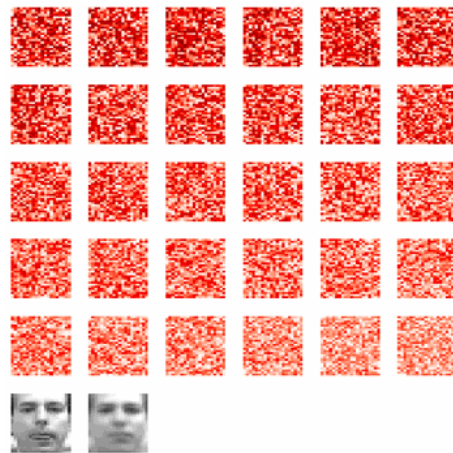Input data   Reconstruction using the "model library"

Data: *faces*

SAMPO systems[*]

- A neocybernetic system eternally grinds data – indeed, it is a kind of

  Self-**A**dapting **M**achinery **P**rocessing **O**bservations (and Producing Order / Providing Ontologies)
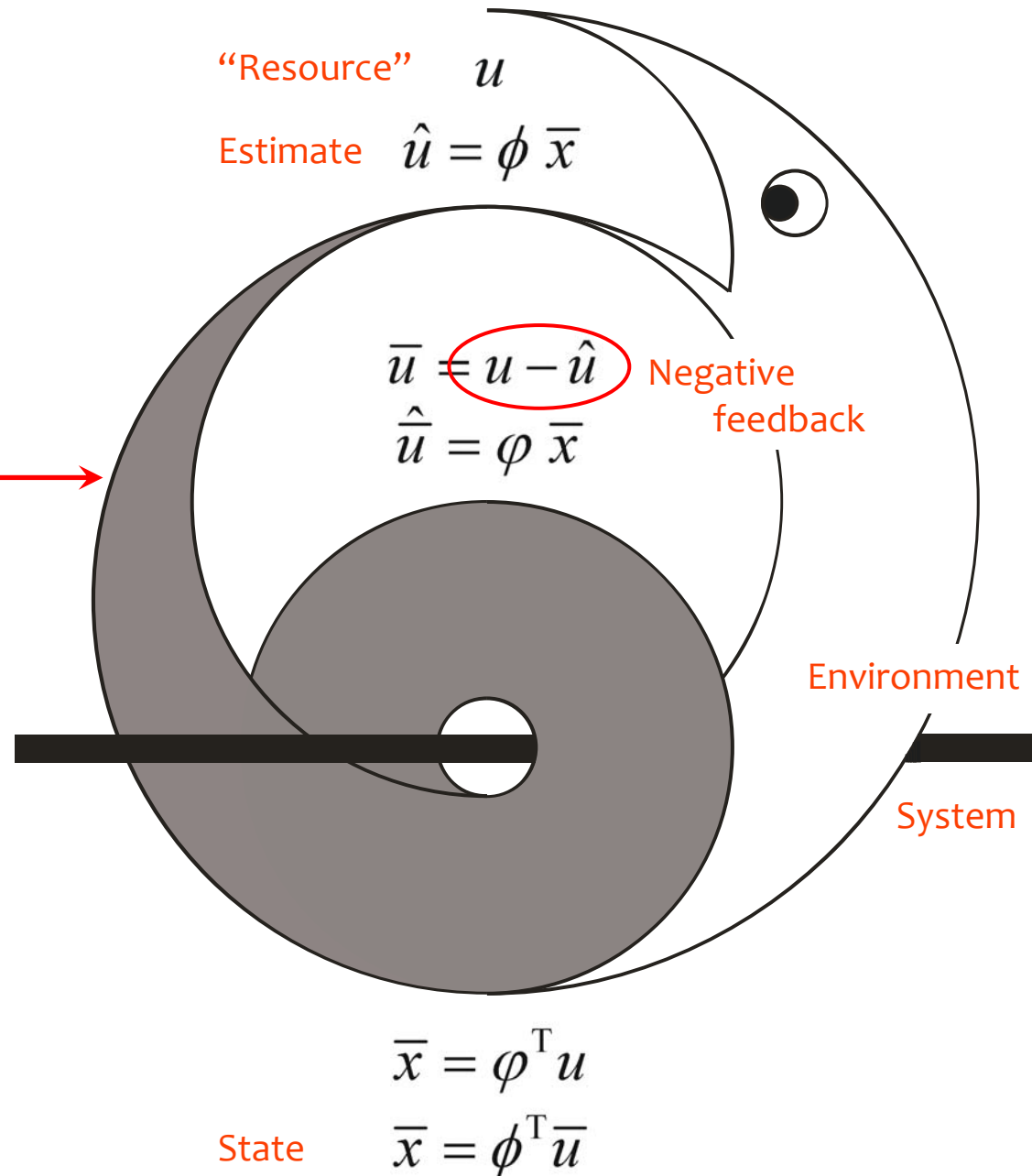
  Claim: Because of their *optimality*, such models just must be *universal!*

  In Kalevala, Sampo is the magic mill producing all kinds of wealth and wisdom

Focusing on flows

- Neocybernetic system is a "mirror" mapping between the *potential* and the *actual*
- *Ouroboros* eats its own tail – eliminating its own livelihood

"Resource" u

Estimate $\hat{u} = \phi\, \bar{x}$

$\bar{u} = u - \hat{u}$ Negative feedback

$\bar{\hat{u}} = \varphi\, \bar{x}$

Environment

System

$\phi^T = Q\, \mathrm{E}\{\overline{xu}^T\}$ — Real

$\varphi^T = \left(\mathrm{E}\{\overline{xx}^T\} + Q^{-1}\right)^{-1} \mathrm{E}\{\overline{xu}^T\}$ — Virtual

$\bar{x} = \varphi^{\mathrm{T}} u$

State $\bar{x} = \phi^{\mathrm{T}} \bar{u}$

If environment …

Environment

If environment is captured by model ...

Environment

System in interaction
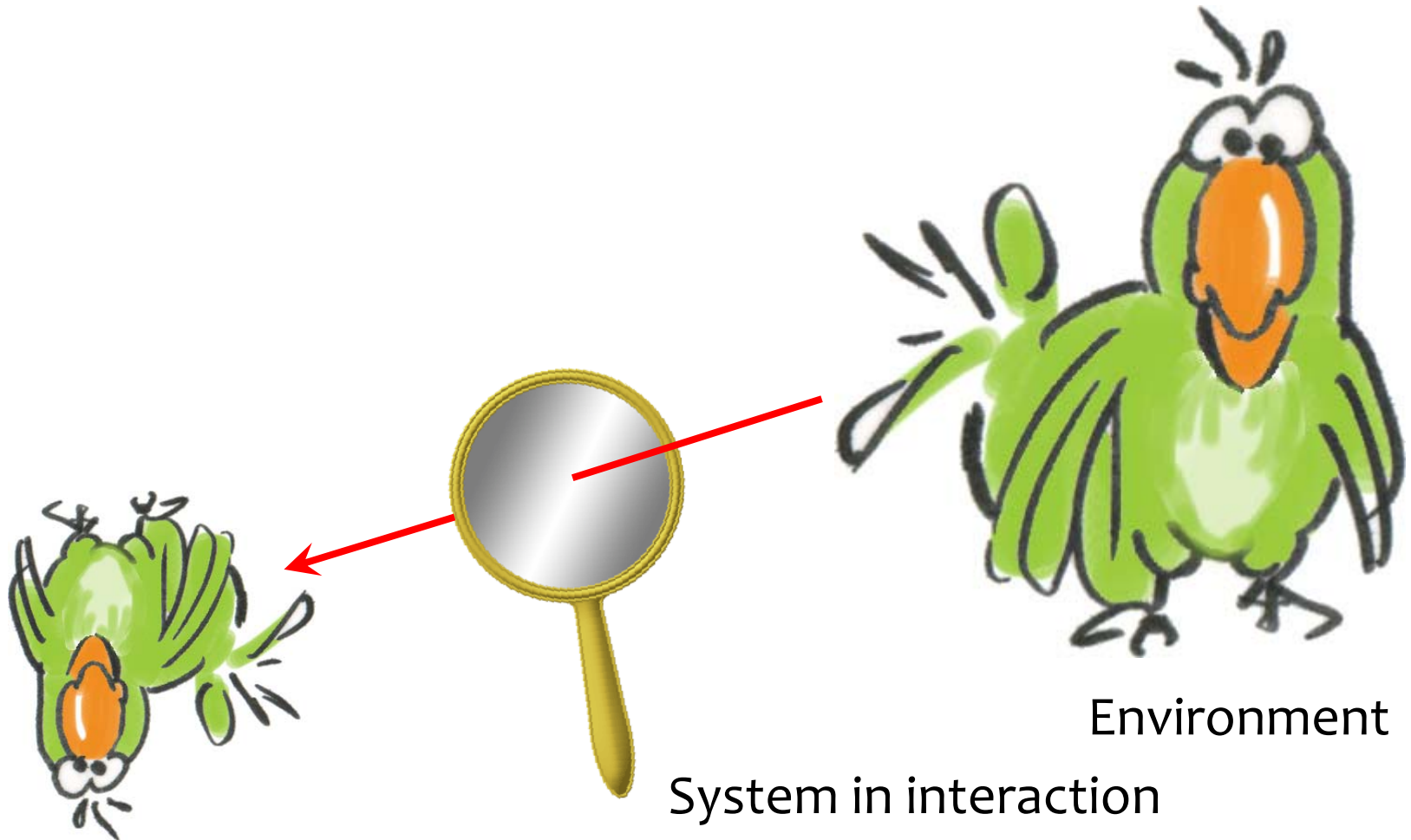
If environment is captured by model *too* well ...

Negative feedback

COLLAPSE !

Environment

System in interaction
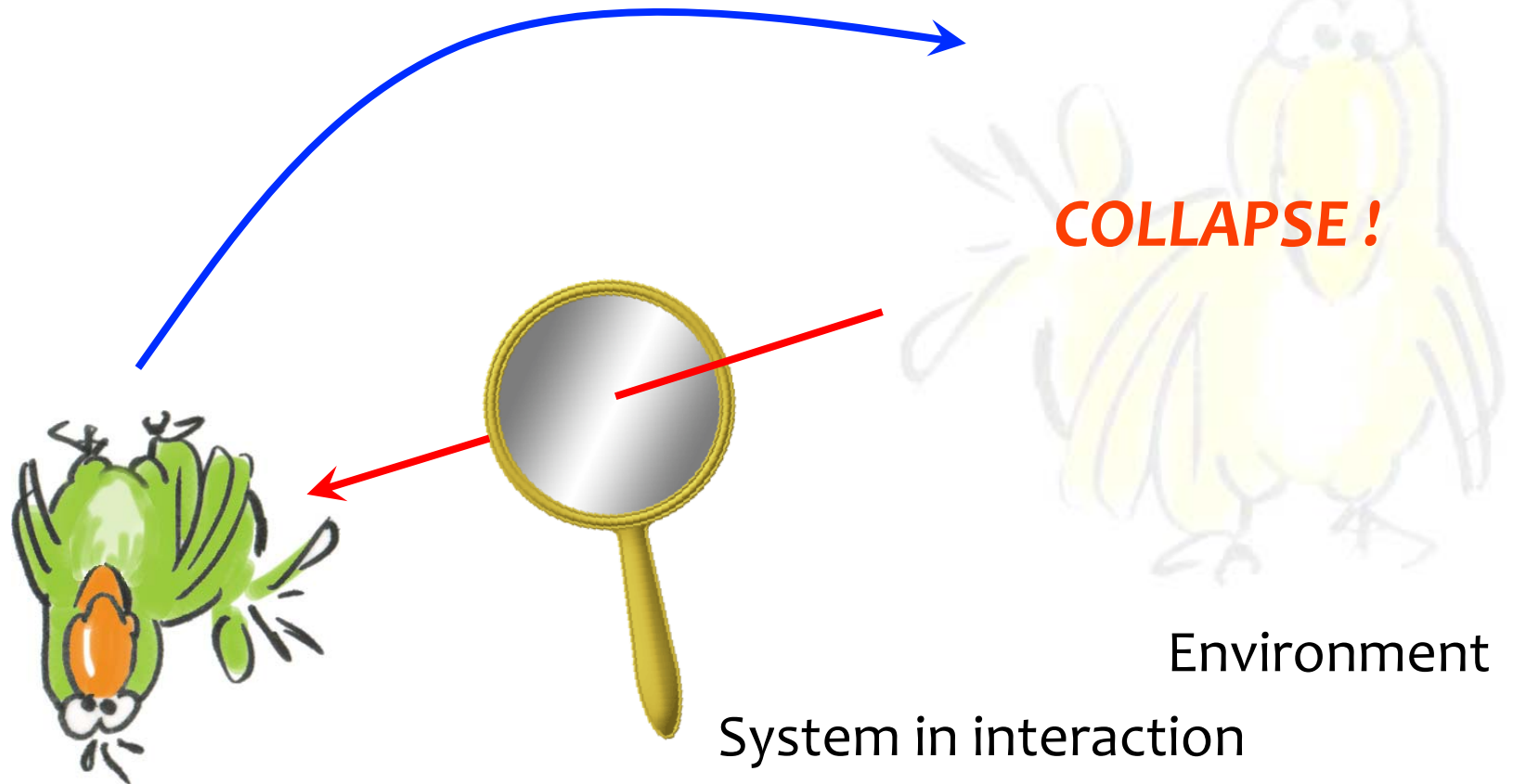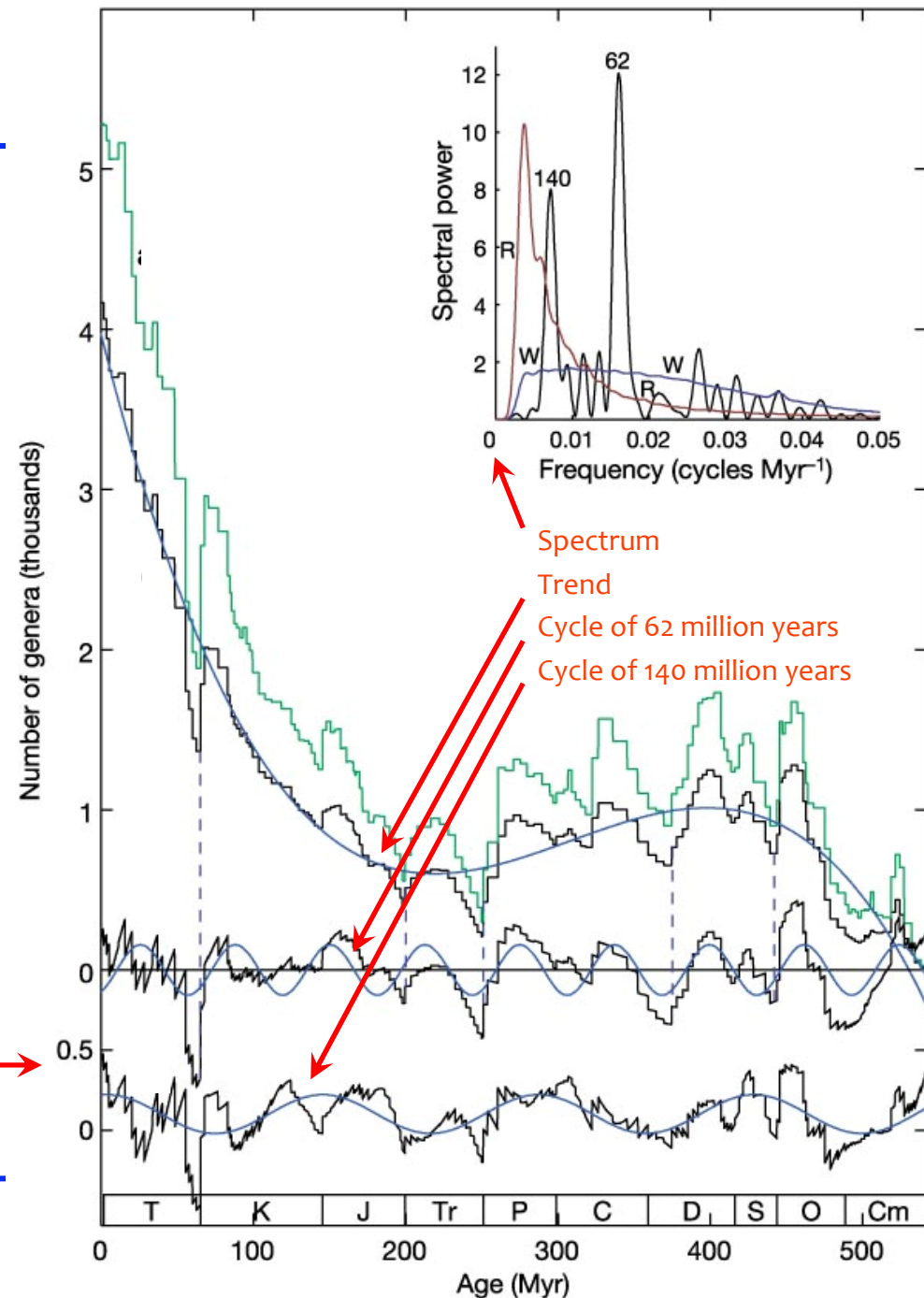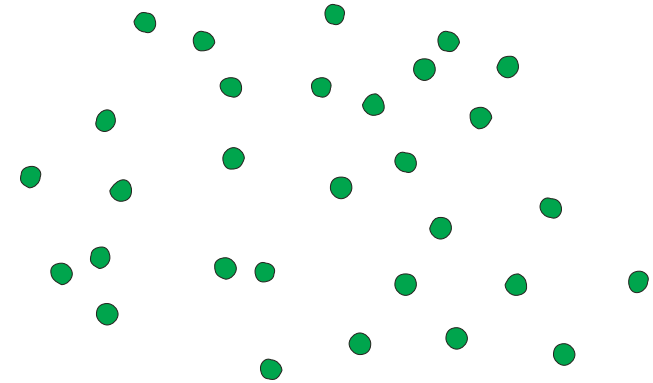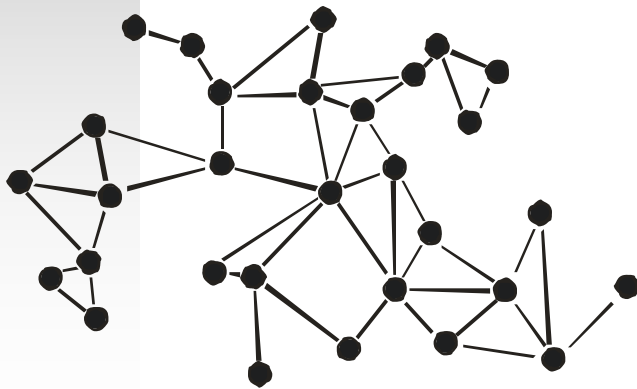
Example?

- For some reason, massive extinctions seem to take place in 62 million year cycles

- Dinosaurs died about 62 million years ago…

- Do you need some meteors to explain extinctions? Or is this simply because of evolution dynamics?

Rohde and Muller (2005): Cycles in fossil diversity. Nature 434

Spectrum
Trend
Cycle of 62 million years
Cycle of 140 million years

- If visual cortex works according to neocybernetic principles, perhaps also *cognition* and *intelligence* can be explained so – and, further, perhaps also *intelligent organizations* do that?
- In evolution, systems get stiffer ... but to survive, a cybernetic system needs fresh information = uncontrolled freedoms!

Example of *cybernetization*

- Trends in working life – example TKK (and AALTO?!):

1. Towards better understanding of the system and gaining more information (input)
   - Supervision of working time, questionnaires, more paper work
   - Terminology: "Transparency", "efficiency"

2. Towards more efficient exploitation of information (control)
   - Expansion of administration, new "planners", organizational changes
   - Terminology: "Near-boss", "developmental discussions", "competitiveness", guidance in the form of "strategies", "missions and visions", ...

- Result: Freedoms/diversity explicitly eliminated
   - Is this not the cybernetic destiny? Is there any alternative?
   - In a research institution, *there should be*

When the degrees of freedom are eliminated, when functioning halts, sooner or later there is a collapse?

Downfall of empires – and today's emperors?

- **During Pax Romana, there was very good control – there were no enemies, no excitation – optimization according to the immediate needs – army got ruined – collapse after a disturbance**

Roman Empire
Contested territory
Invaded a few times for a few years

Trying to postpone the inevitable...

... You are really stubborn. However, I will never return your questionnaire on how I spend my working time. The reason being:

1. Either the results are never used for anything — then they are completely useless.

Or, worse:

2. The results are applied for better understanding and controlling of my work.

And, truly, this is what I really fear, and this is the reason I will never answer any such questionnaires.
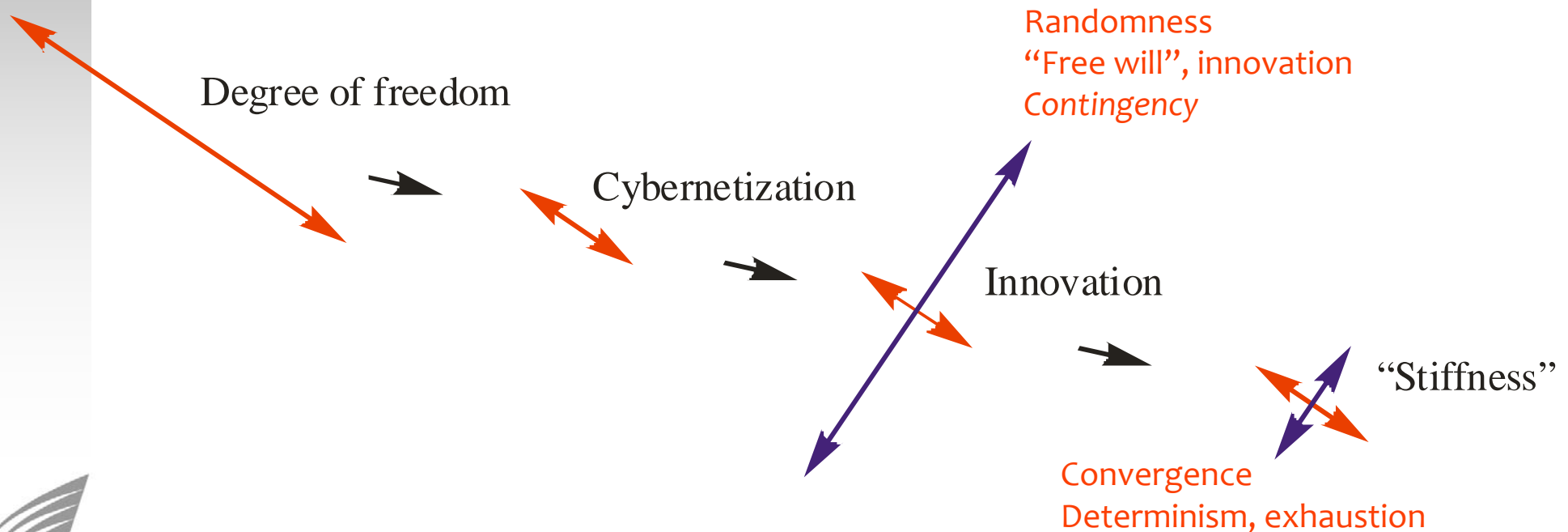
Yours Sincerely,
XX

Jean-Paul Sartre:

"We have to fight against institutions everywhere"

… or bravely facing the challenges?!

- As degrees of freedom become modeled and controlled, becoming new constraints, new innovations are perpetually needed to define new degrees of freedom – otherwise the system dimensions "collapse".

Degree of freedom

Cybernetization

Randomness
"Free will", innovation
Contingency

Innovation

"Stiffness"

Convergence
Determinism, exhaustion

Where to find the degrees of freedom, then?

- Arthur Schopenhauer once said that *art* can free us from the *rat race*

- Actively search for patterns – find your *own* freedoms!

- Diversity should be valued rather than mere optimality (remember – optimality in markets *caused* the chaos)

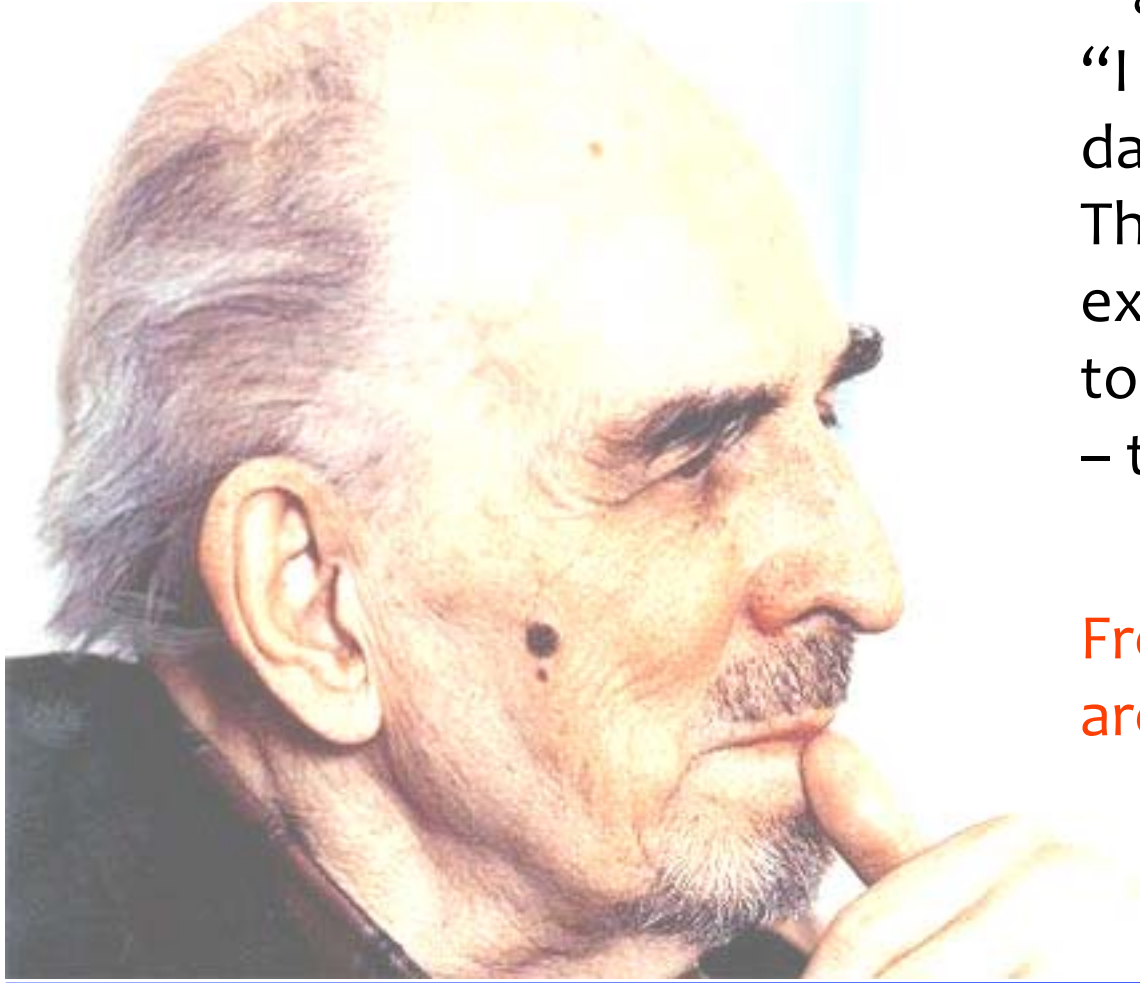- But to detect the freedoms you first need to know *constraints*

Synergy

- At HSE they play with the constraints, optimizing within the given sets of constraints

- At TaiK you make art, playing with freedoms, not letting the real world disturb you (?)

- At TKK we do engineering, finding smart compromises, trying to escape the given constraints...
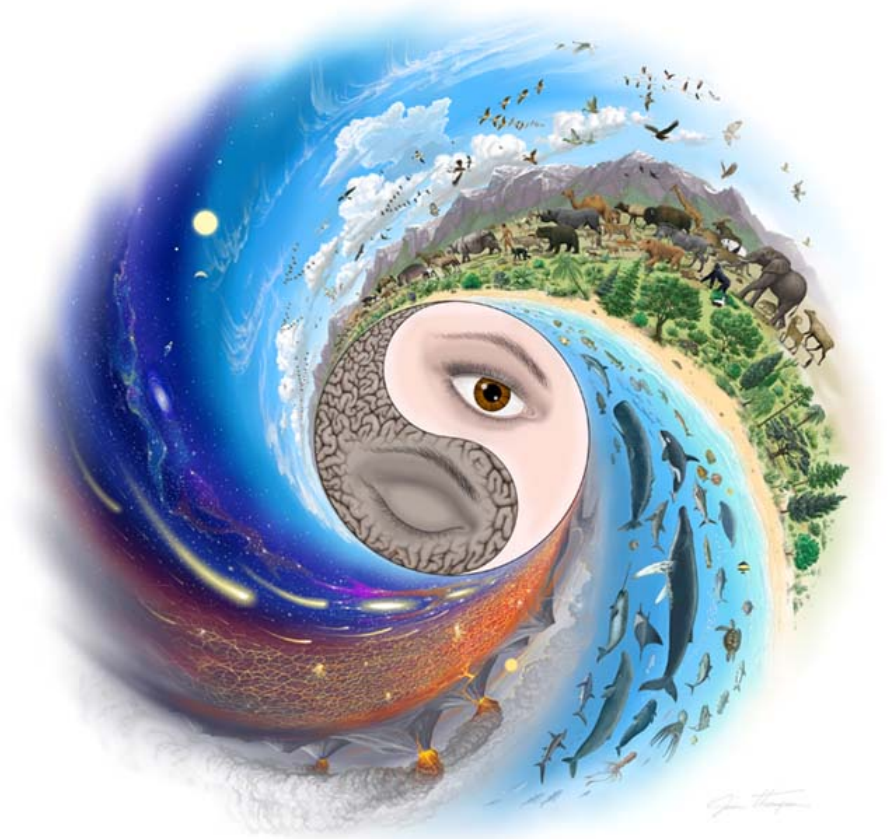
One more view: Value of Freedoms…

- Ingmar Bergman:

"I throw a spear into the dark – that is intuition. Then I have to send an expedition into the jungle to find the way of the spear – that is logic."

Freedoms and constraints are bound together!

… and the Value of Constraints

- Pablo Picasso:

  "Forcing yourself to use restricted means is the sort of restraint that liberates invention. It obliges you to make a kind of progress that you can't even imagine in advance."

  Freedoms are *induced* by the constraints!

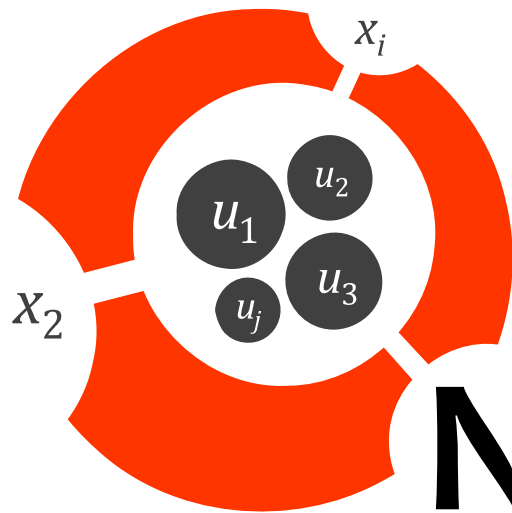 You need to know the present to make the future…

Miyamoto Musashi: *The Way of a Samurai*

1. *Always think in a honest way.*
2. *The Way is practicing.*
3. *Get acquainted with all arts.*
4. *Know the Ways of all professions.*
5. *Detect the benefit and loss of all things.*
6. *Practice your intuition and understanding of everything.*
7. *See the invisible.*
8. *Recognize the details.*
9. *Do not do anything unnecessary.*

Know both freedoms *and* constraints!

- See **`neocybernetics.com`**

Neocybernetics

$$x_i \overset{\pm}{\underset{\geq 0}{=}} q_i \mathrm{E}\{x_i u_j\} u_j$$

$$\tfrac{1}{2} \boldsymbol{x}^{\mathrm{T}} \langle \boldsymbol{x}\boldsymbol{x}^{\mathrm{T}} \rangle \boldsymbol{x} - \boldsymbol{x}^{\mathrm{T}} \langle \boldsymbol{x}\boldsymbol{u}^{\mathrm{T}} \rangle \boldsymbol{u}$$