AS-74.4192 Elementary Cybernetics

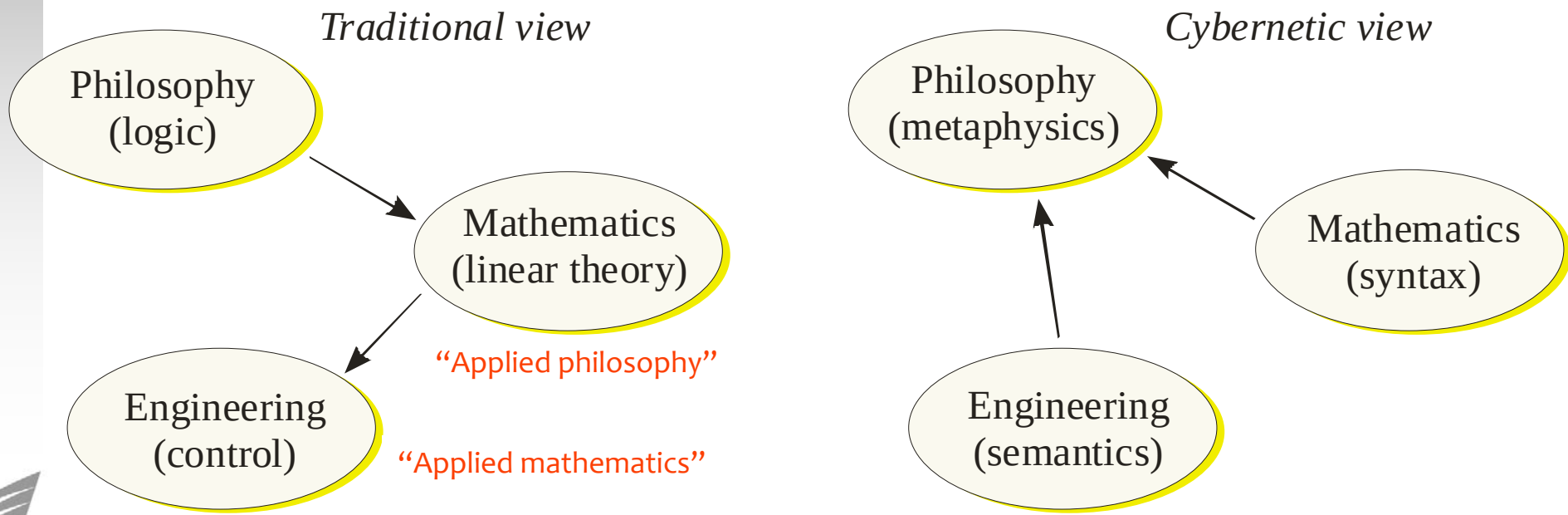
Lecture 6:

Role of Control

HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Automation and Systems Technology
Cybernetics Group

Claim to be studied

- Mathematics gives the language for discussing philosophies
- Control understanding gives the *meaning* and *relevance* to the philosophical discussions



First, a very different thing: *Regression*

- Assume that, given $\bar{x}$, one would like to estimate u_j, so that on average one would have $\hat{u}_j = \bar{x}^T f_j$ close to u_j
- For this purpose, define the quadratic cost criterion (where the size of vector f_j is also emphasized)

$$J(f_j) = \mathrm{E}\left\{ \left(u_j - \bar{x}^T f_j\right)^T \left(u_j - \bar{x}^T f_j\right) + b\ f_j^T f_j \right\}$$

or $f_j^T B\, f_j$

- Differentiating + setting gradient to zero

$$\frac{dJ(f_j)}{d\ f_j} = \mathrm{E}\left\{ 2\bar{x}\bar{x}^T f_j - 2\bar{x}u_j + 2b\ f_j \right\}$$

$$= 2\mathrm{E}\left\{\bar{x}\bar{x}^T\right\} f_j - 2\mathrm{E}\left\{\bar{x}u_j\right\} + 2b\ f_j$$

$$= 2\left(\mathrm{E}\left\{\bar{x}\bar{x}^T\right\} + b\ I\right) f_j - 2\mathrm{E}\left\{\bar{x}u_j\right\} = 0$$

- Solving this

$$f_j = \left(\mathrm{E}\left\{ \bar{x}\bar{x}^T \right\} + b\, I \right)^{-1} \mathrm{E}\left\{ \bar{x} u_j \right\}$$

so that

For $b = 0$ traditional *least-squares regression*
Otherwise *regularized regression*

$$\hat{u}_j = f_j^T \bar{x} = \mathrm{E}\left\{ \bar{x} u_j \right\}^T \left(\mathrm{E}\left\{ \bar{x}\bar{x}^T \right\} + b\, I \right)^{-1} \bar{x}$$

- Multiple regression formulas can be combined so that

$$\hat{u} = \mathrm{E}\left\{ \bar{x} u^T \right\}^T \left(\mathrm{E}\left\{ \bar{x}\bar{x}^T \right\} + b\, I \right)^{-1} \bar{x}.$$

- Does this not look familiar? – But remember that the above derivation was only formal minimization of the cost criterion!

Back to agenda: Feedback through environment

- Study the formula: The "experienced environment" is now

$$\tilde{u} = \underbrace{u}_{\substack{\text{actual} \\ \text{environment}}} - \underbrace{\phi x}_{\text{feedback}}$$

- Formula ϕx determines the exploitation of the environment as mapped through the latent variables x

  = "What is really consumed by the system"

- Looking at the "clever agent" formula closer (Lec. 4)

$$\phi x = \mathrm{E}\left\{\overline{x}u^T\right\}^T \mathrm{E}\left\{\overline{x}\overline{x}^T\right\}^{-1} x$$

  it turns out that formula ϕx simultaneously gives the reconstruction of the environment...!

Case of the "clever agent" ...

- Model.
  - It turns out that the neocybernetic strategy constructs the best possible (in the quadratic sense) description of the environment; the *latent variables* are

$$\overline{x} = \mathrm{E}\left\{\overline{x}\overline{x}^T\right\}^{-1} \mathrm{E}\left\{\overline{x}u^T\right\} u$$

Principal subspace analysis

- Estimate.
  - It turns out that the neocybernetic strategy constructs the best possible (in the quadratic sense) estimate of the environment state; regression estimate is

$$\hat{u} = \mathrm{E}\left\{\overline{x}u^T\right\}^T \mathrm{E}\left\{\overline{x}\overline{x}^T\right\}^{-1} \overline{x}$$

Multilinear regression

- Control.
  - If exploitation means exhaustion, the neocybernetic strategy integrates modeling and estimation *to eliminate variation in the environment* maximally.

- For the *selfish agents*, on the other hand, one has

$$\phi = \mathrm{E}\left\{\overline{xu}^T\right\}^T Q$$

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

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

where one can solve for $\phi = \mathrm{E}\left\{\overline{xu}^T\right\}^T Q$:

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

- Again, this is the regularized regression formula to *u*!

... so the "selfish agent"

- Model.
  - It turns out that the neocybernetic strategy constructs the best possible (in the robustness sense) description of the environment; the *latent variables* are

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

Feature extraction

- Estimate.
  - It turns out that the neocybernetic strategy constructs the best possible (in the robustness sense) estimate of the environment state; regression estimate is

$$\hat{u} = \mathrm{E}\left\{ \overline{x}u^T \right\}^T \left(Q^{-1} + \mathrm{E}\left\{ \overline{x}\overline{x}^T \right\} \right)^{-1} \overline{x}$$

Regularized regression

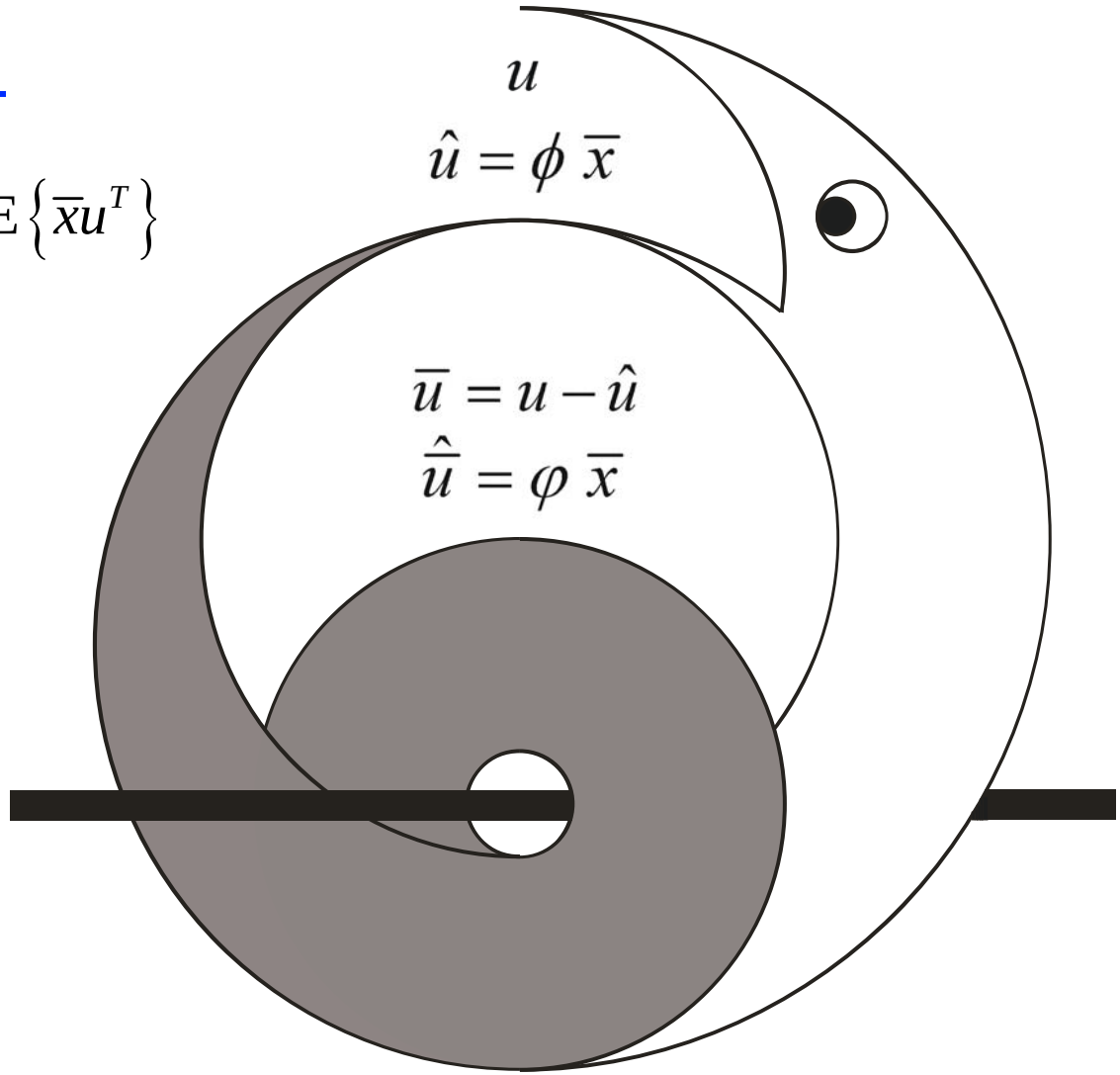
- Control.
  - The neocybernetic strategy integrates modeling and estimation *to eliminate variation in the environment in a robust way*.

“Ouroboros”

$$\phi^T = Q\,\mathrm{E}\left\{\overline{x}\overline{u}^T\right\} = \left(\mathrm{E}\left\{\overline{x}\overline{x}^T\right\} + Q^{-1}\right)^{-1}\mathrm{E}\left\{\overline{x}u^T\right\}$$

$$\varphi^T = \left(\mathrm{E}\left\{\overline{x}\overline{x}^T\right\} + Q^{-1}\right)^{-1}\mathrm{E}\left\{\overline{x}\overline{u}^T\right\}$$

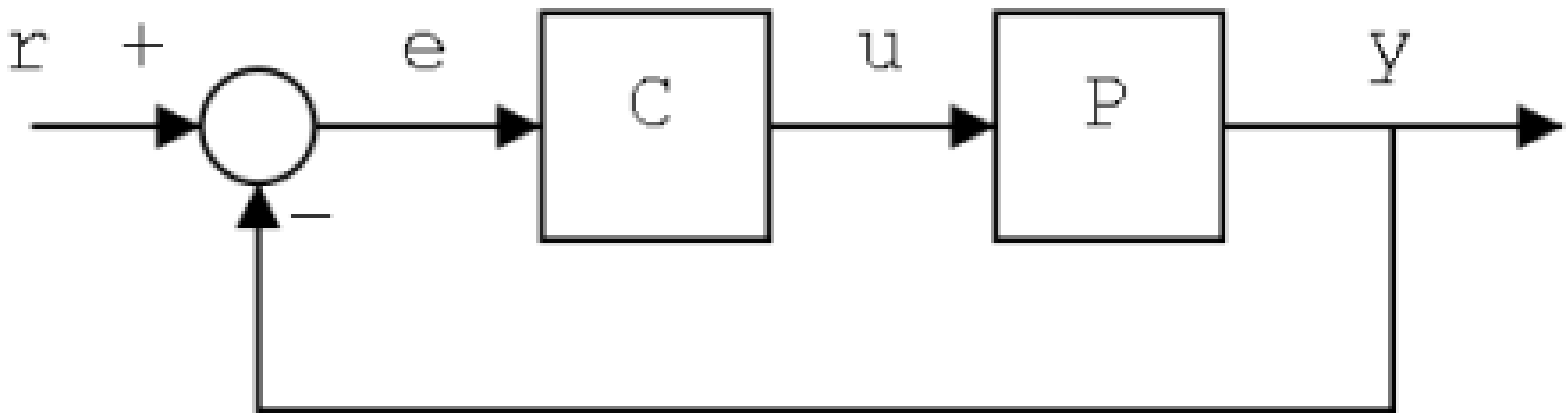
- There is a strange dual symmetry...
- Circulation binds the environment to the system, *u* being “eaten up”
- Simultaneously, “elasticity axes” get instantiated



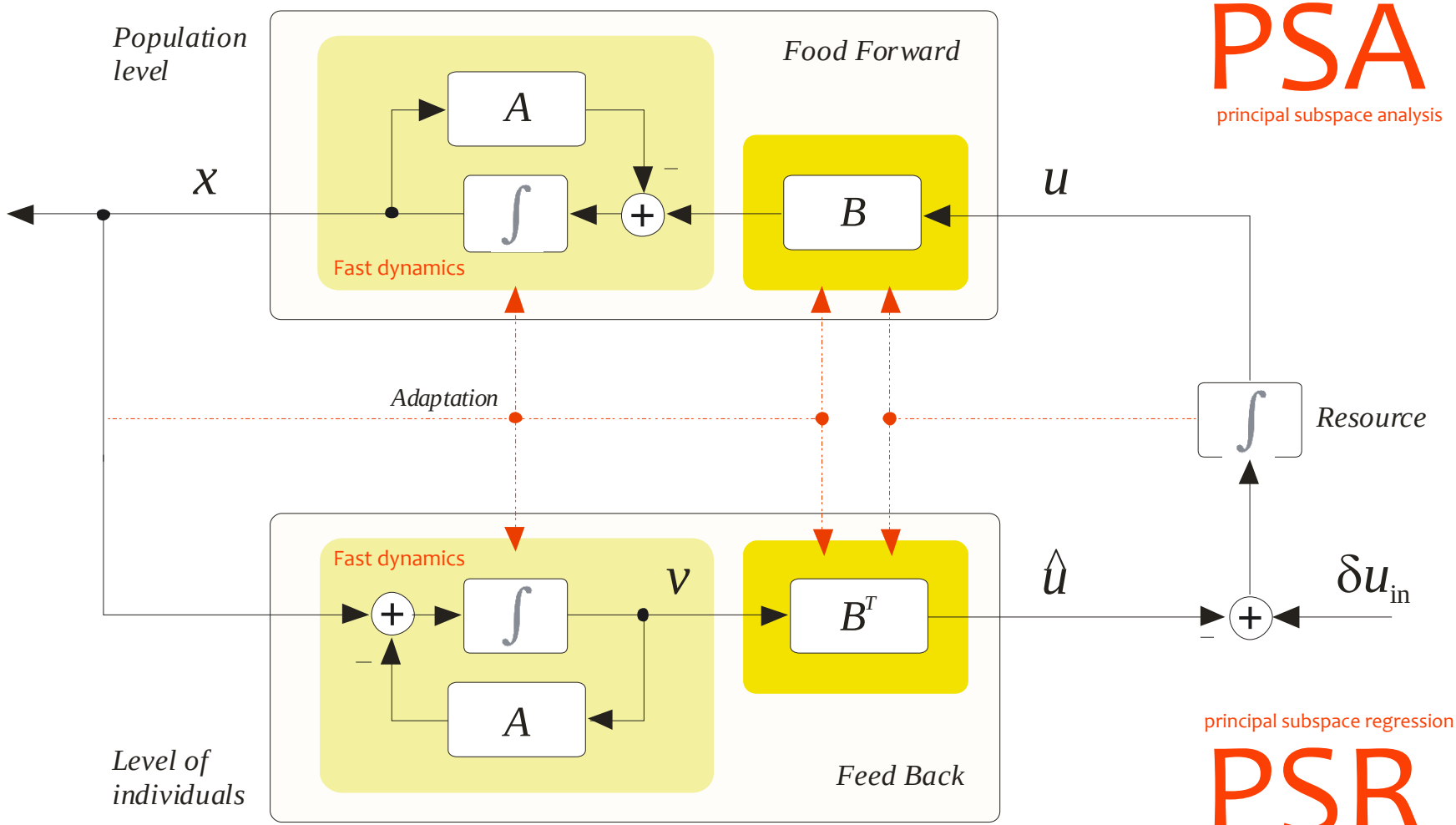
HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Automation and Systems Technology
Cybernetics Group

Model-based control

- Neocybernetic strategy does not implement whatever feedback ... it is the **best possible model-based control**, no matter what are the vector dimensions
- This control is implicit, and it is an **emergent functionality**, caused by the adaptation in the local agents and non-ideality in the environment

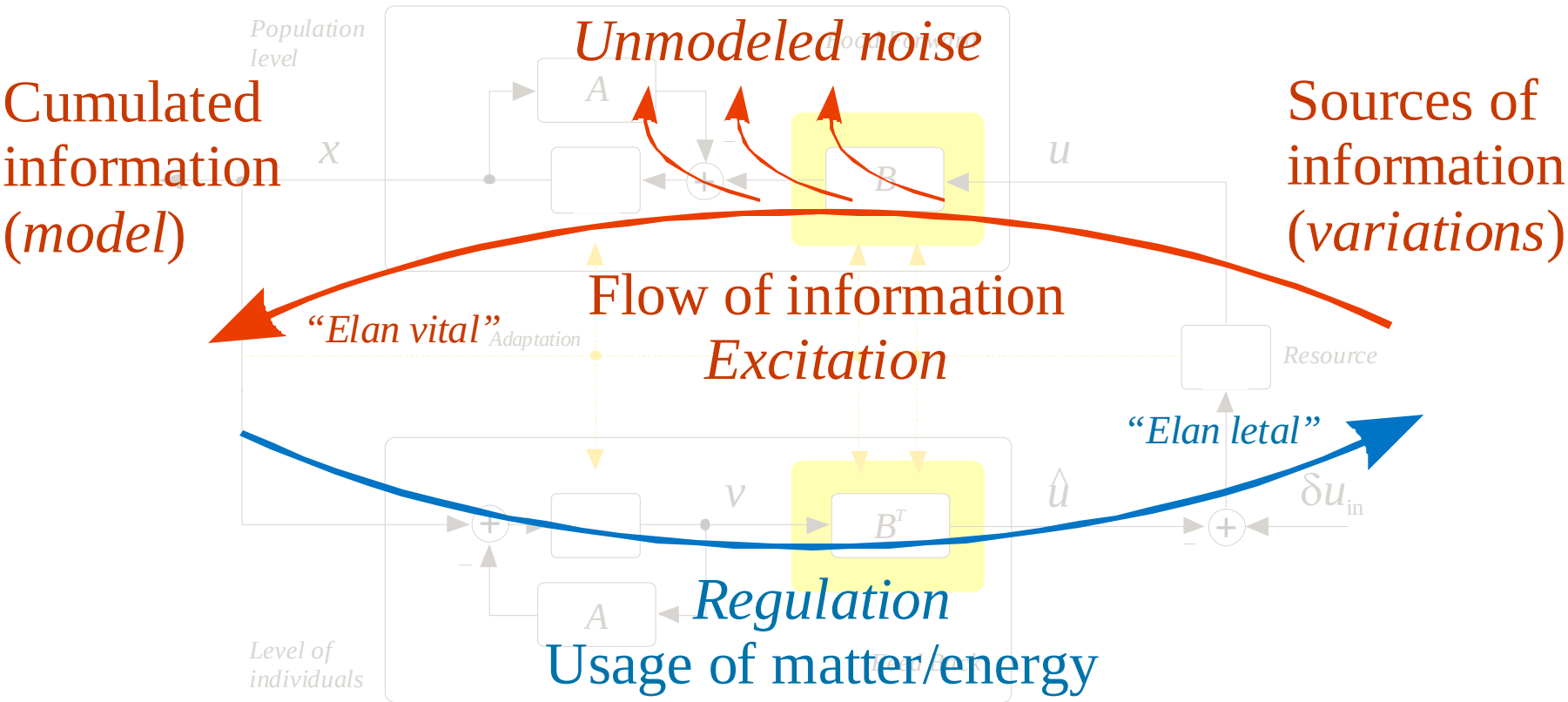


Heraclitus: “The way up and the way down …”!



Cybernetic system seen as a controller

- Information theoretic view only – a closed loop constructed



Information – from *to in-form*, in the sense of **to give form**

- These results are related to age-old cybernetic observations:
- Ross Ashby (1952) – Law of Requisite Variety:

  "*The amount of appropriate selection that can be performed is limited by the amount of information available*", or

  "*For appropriate regulation the variety in the regulator must be equal to or greater than the variety in the system*"
- Stronger version – Law of Regulatory Models:

  "*Regulator must not only have adequate amounts of variety available, but also be or have a homomorphic representation of that system*" (see also Wonham: Model *inverse* needed)

- Less concrete – on the other hand more general ... *see later*

Key point is *compression*

Information: Mind over matter

- The dualism between information vs. matter/energy (traditionally mind vs. matter) deserves to be studied closer
- The age-old dilemma of dualism is solved in a peculiar way in a cybernetic system: "Marriage of information and matter"
- Extraction of information from a real-life system necessitates exploitation of matter/energy

  Upstream: Construction of a model = information flow

  Downstream: Construction of feedback = matter/energy flow

- Full closed loop control system is constituted only if both mechanisms are present

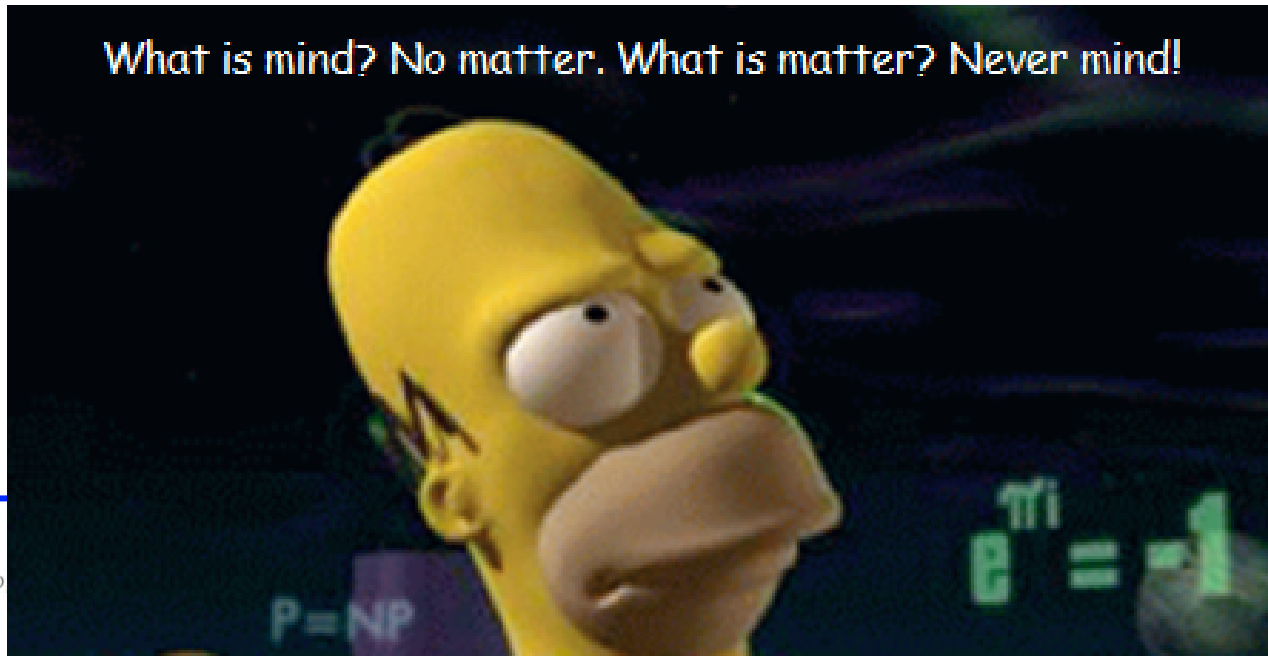
HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Automation and Systems Technology
Cybernetics Group

Note: The feedback loop is virtual, it does not need to be explicitly implemented by the agents

- In the neocybernetic perspective, some age-old dichotomies vanish as there is a continuum between ends (see Lec. 7)

  … But some dualisms re-emerge!

- Indeed, the once so outdated Cartesian dualism between mind and matter seems to become acute again

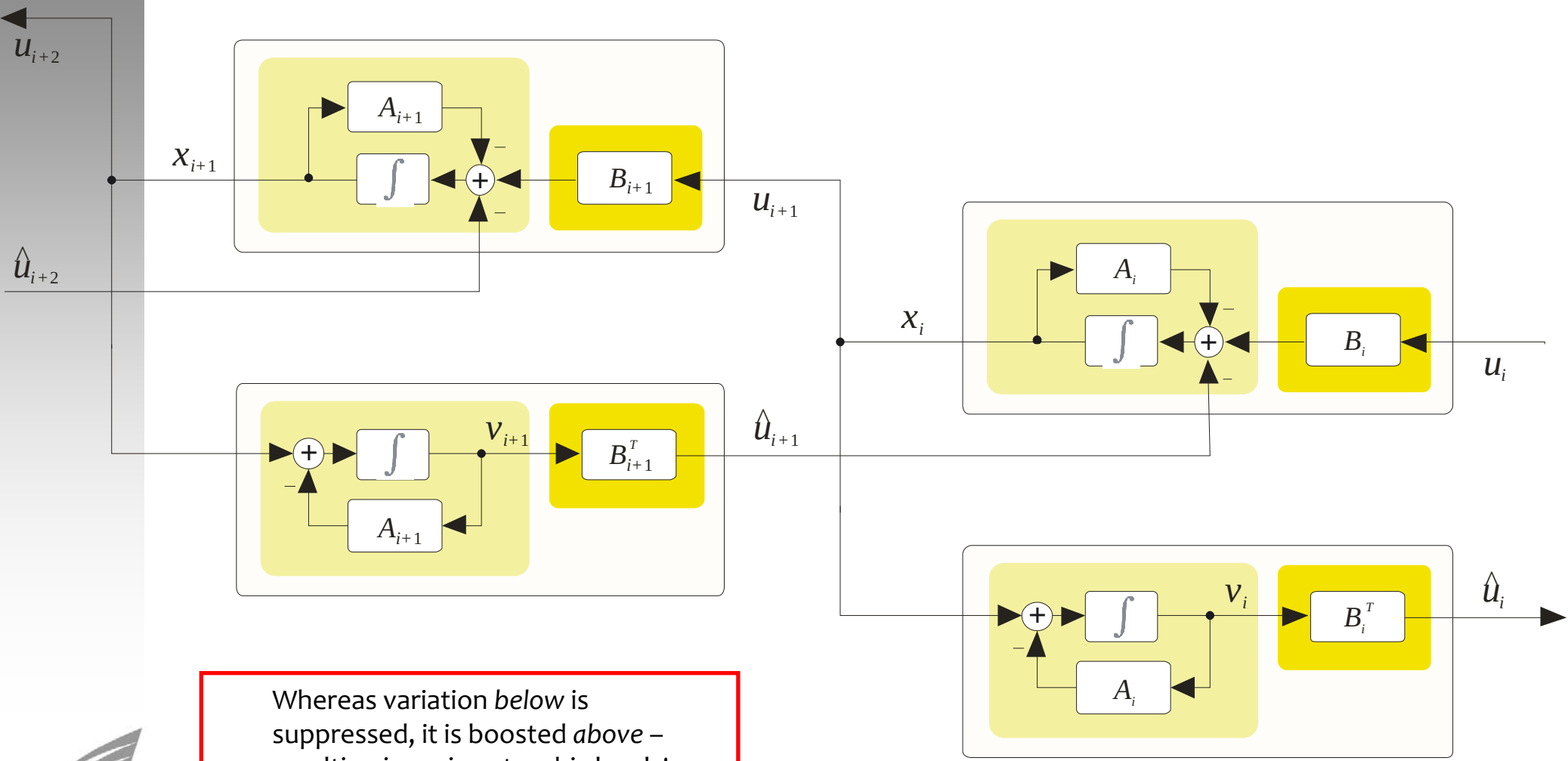


Flows of information and matter combined

- Starting point: Local level feedback loops – final result: Global level feedback control
- Model based control = The best control there is

- Erwin Schrödinger: *"Living system sucks neg-entropy (orderliness) from the environment"*
- Variation is suppressed by the control system; in another perspective, variation is the "nourishment" for higher-level systems
- Variation that is sucked from the lower level cumulates on the higher level – making it possible for yet higher-level systems to exploit it...

Succession of trophic layers



Whereas variation *below* is suppressed, it is boosted *above* – resulting in various trophic levels!

"Generalized diffusion"

- Looking at the overall closed-loop controller structure, the internal system details can be abstracted away

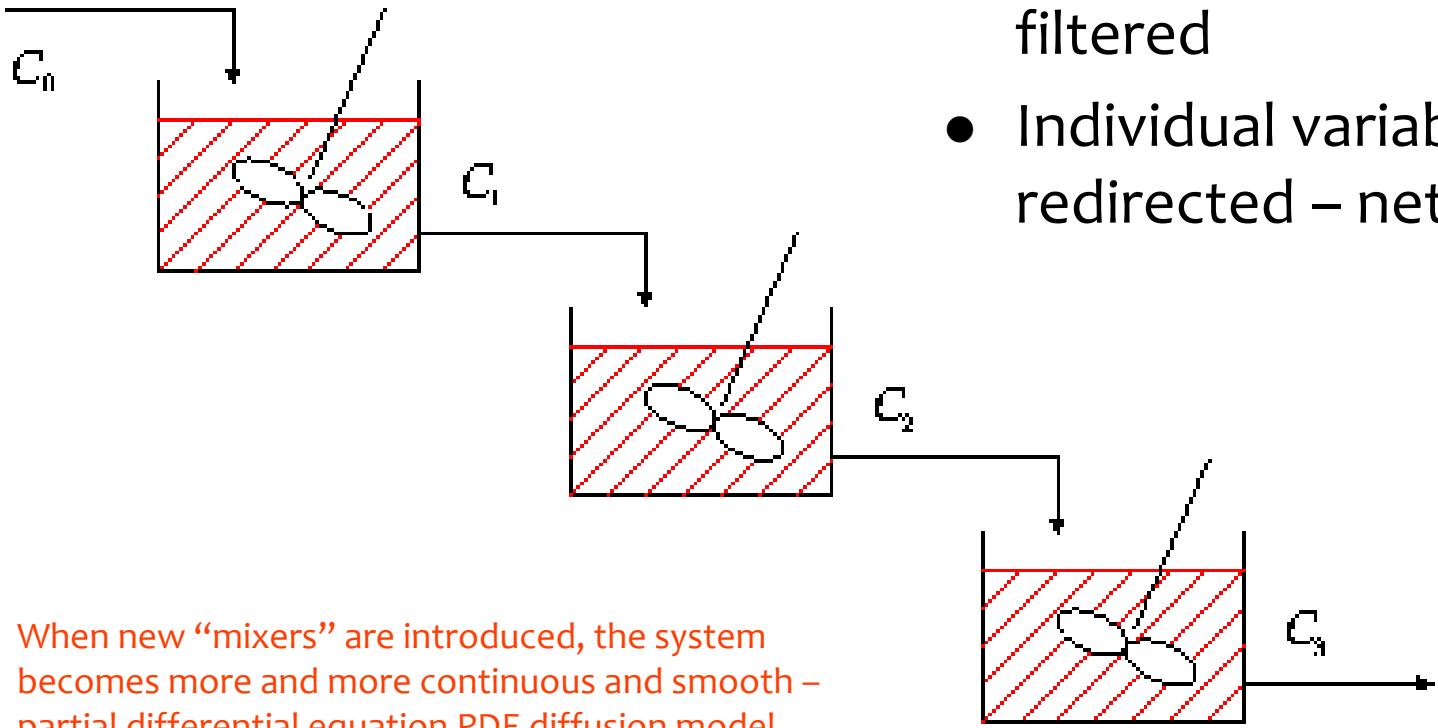
$$\frac{du}{dt} = -\phi\phi^T u + \delta u_{\text{in}}$$

- The "most relevant" data directions tend towards balance, the rest (null space) following uncontrolled Brownian motion
- There is a "structured leakage in the resource reservoirs"; this can also be characterized as "directed diffusion"
- Spatial axes are abstracted to be represented by causality flows in block diagrams
- The same feedback structure emerges in different scales

Feedback model with A: Lumped parameter approximation of a parabolic PDE system!

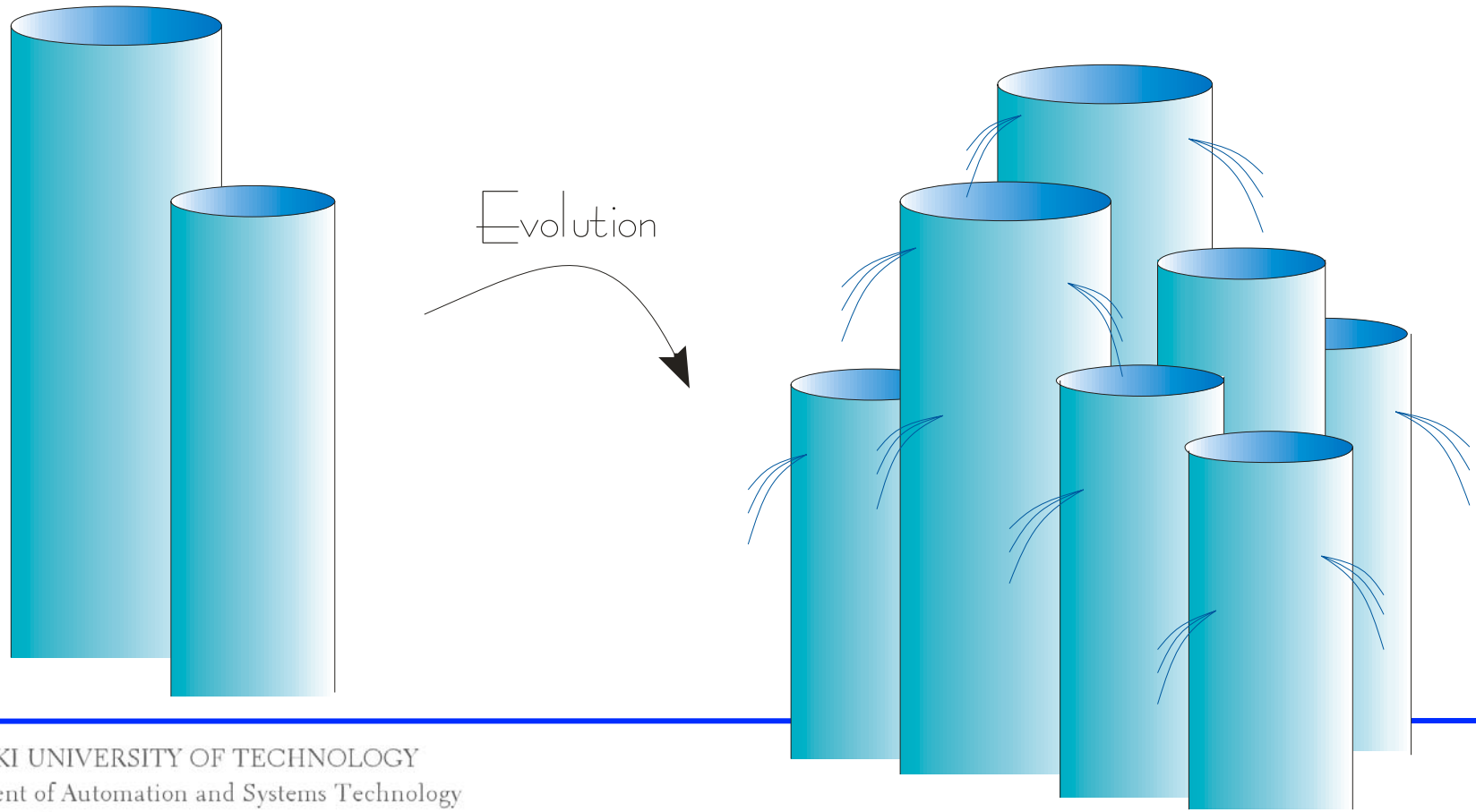
Distributed modeling of the environment

- Potential flows from trophic layer ("ideal mixer") to another (note that the flows are not scalar variables but vectors)
  - Changes in resources get filtered
  - Individual variables can be redirected – network



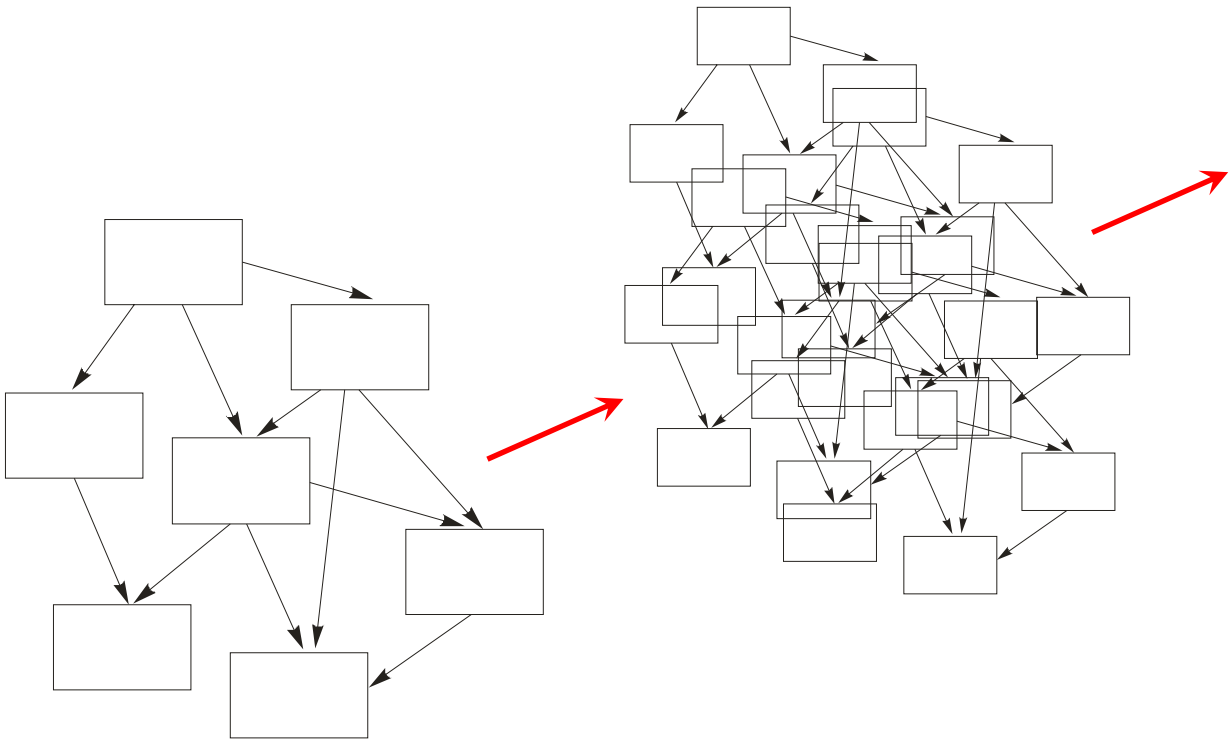
When new "mixers" are introduced, the system becomes more and more continuous and smooth – partial differential equation PDE diffusion model

- Information reservoirs get exploited, and differences vanish, “drops in potential” becoming smooth and continuous

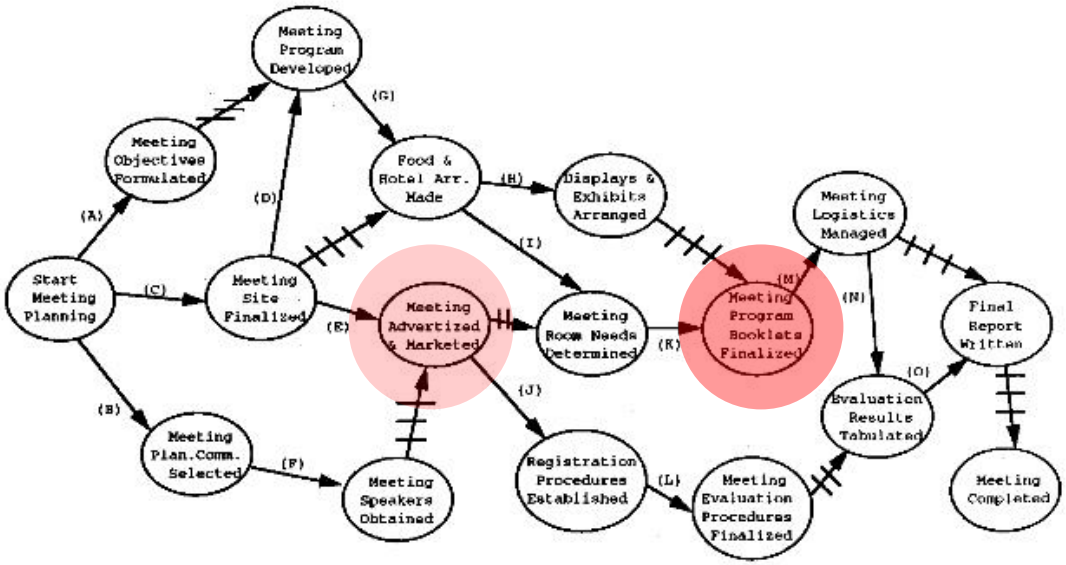


Gradients & diffusion *abstracted*

- Assume intuitive topology among systems
- Block diagrams become real “flow charts”!



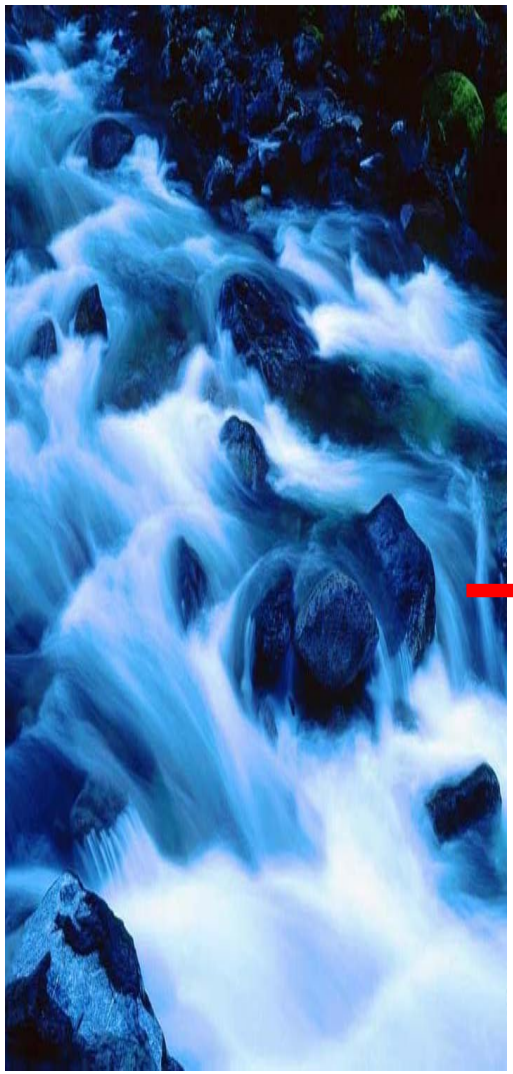
Concrete “diagram evolution”?



- For example, study a project plan.
- Similar projects are repeated…

  …but there are often problems to follow the plans.

- Uncertainty is like turbulence causing variations in projects
- Variance – strong interest – money invested – development
- Procedures are polished, graphs are extended gradually
- Finally: equalization of flows, “homogeneity” of uncertainties

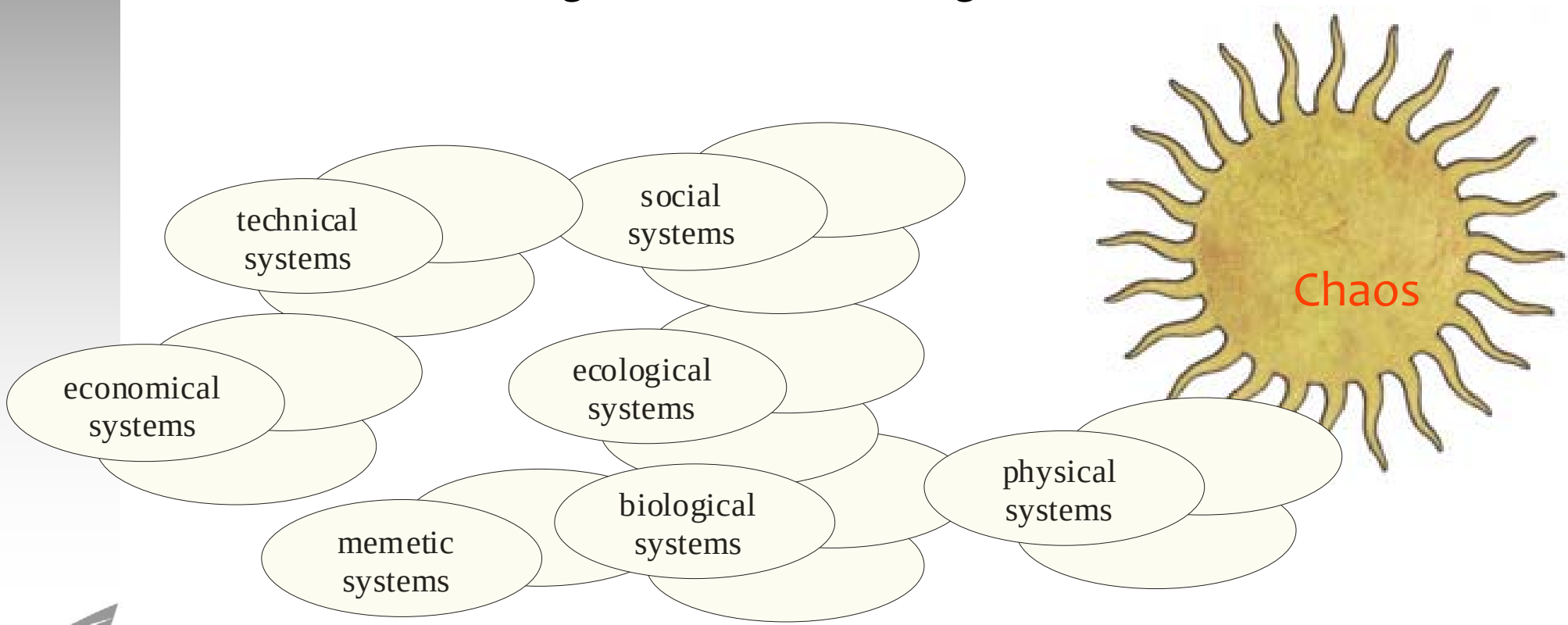


- Still, remember that equalization of variances is NOT the goal of evolution on the global scale

- Rather, extreme distribution of information is the typical result (see Lec. 12!)

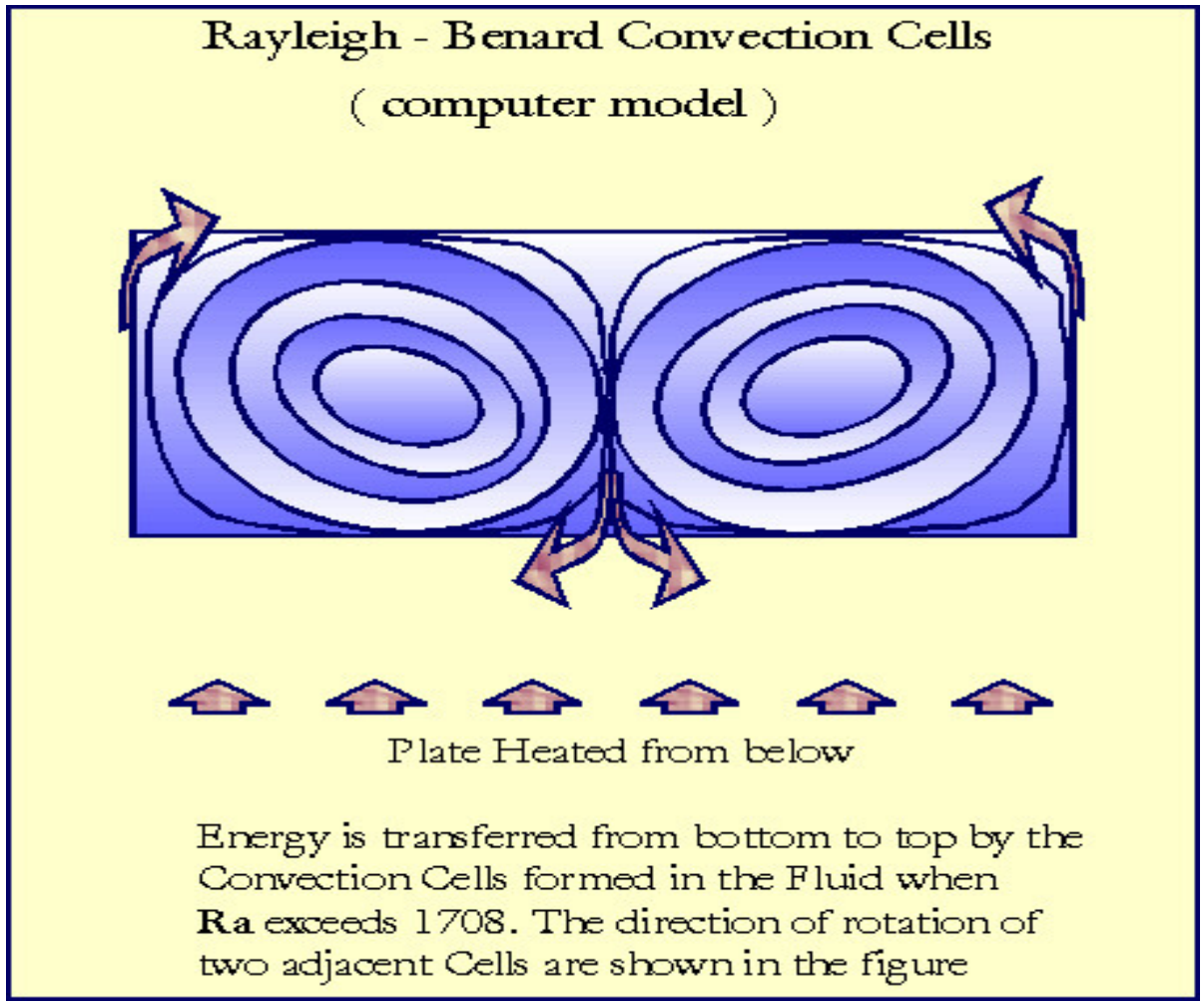
Overall view

- The question is not where the diversity comes from, but why there is *something* instead of *nothing*!



Sources of information

- Bénard process: "Physical level" self-organization
- *Not cybernetic*: no "memory" (?)
- Also other such climatological, etc., processes create variation that is used as information in cybernetic ones



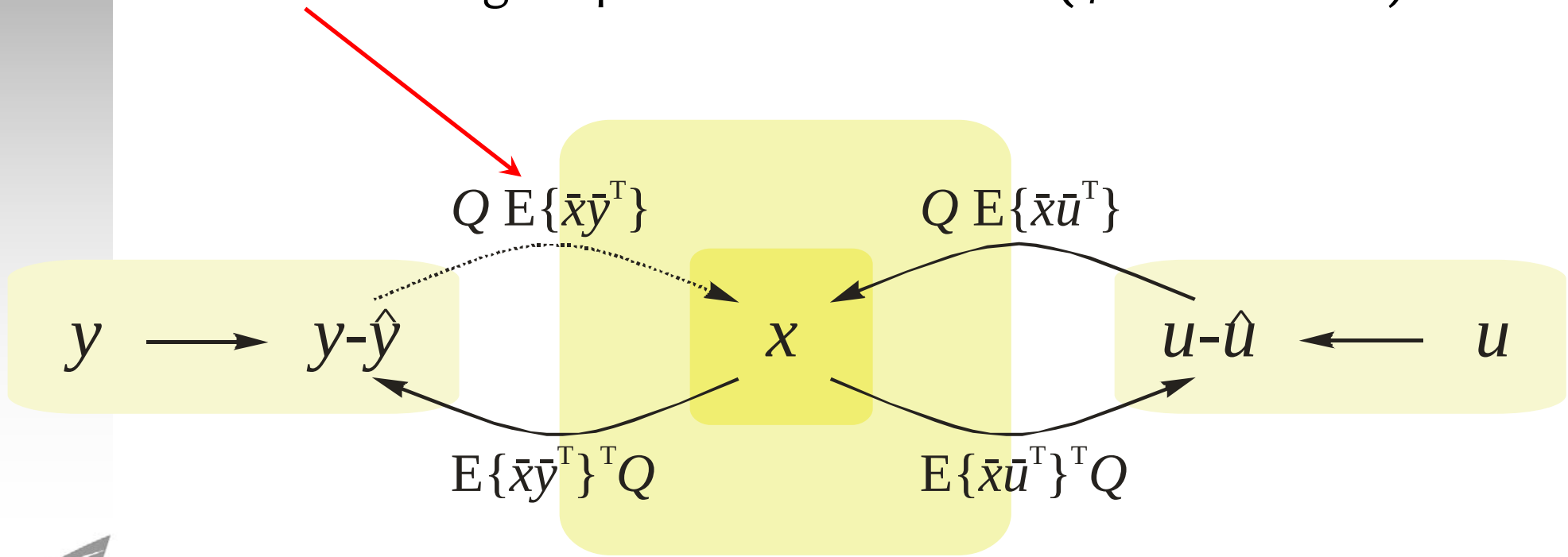
Planetary motion creates the original information – changes in temperature, ...

Controls in ideaspheres?

- Where there is pure information flow and intelligent actors, there is no implicit control – but the control is usually *explicit*
- As soon as things become known, they are used for control:
  - Social sciences try to understand society – legislation, etc., is employed to exploit this understanding to control and balance behaviors
  - Natural sciences try to understand nature – technology is employed to exploit this understanding to "control" (exhaust) available reservoirs of resources
- Also in human life: Everything is modeling and control
  - One studies and learns new things to better understand the world (= model), to be capable of earning more money – to spend for exploiting resources
  - Even **arts** is part of this *rat race* – it offers new ways to see the world, new tools to understand and then exploit it (compare to Schopenhauer!)
- The goal of life is increased exploitation and consumption?

Technical exploitation of theoretical knowledge

- The neocybernetic structure – novel regression methods?
- PCR + SCR ("sparse-coded regression") straightforward
- "PLS" – taking output also into account (I/O alternation)?



Adaptation taken to the limit

- What happens in the limit, assuming that the adaptation processes continue infinitely, system becoming optimized?
- The internal dynamics are no more essentially faster than the outer-level system dynamics, x and u time scales get nearer
- The system becomes more and more unstable ... and?

- There is an interesting connection to optimal LQ control theory: Assume that the criterion is

$$J = \int_{t_0}^{t_1} \left(x^T(t) Q x(t) + u^T(t) R u(t) \right) dt + x^T(t_1) S x(t_1)$$

then the dynamic system that minimizes this looks like –

This far control was "static", signals were let to converge

- Boundary value problem minimizing the optimality criterion can be expressed as an unstable model:

$$\begin{cases} \dfrac{dx}{dt} = -Ax + Bu = -Ax - BR^{-1}B^T v, & x(t_0) \text{ given} \\ \dfrac{dv}{dt} = Av - CQ^{-1}C^T x = Av - Q^{-1}x, & v(t_1) \text{ determined by } x \end{cases}$$

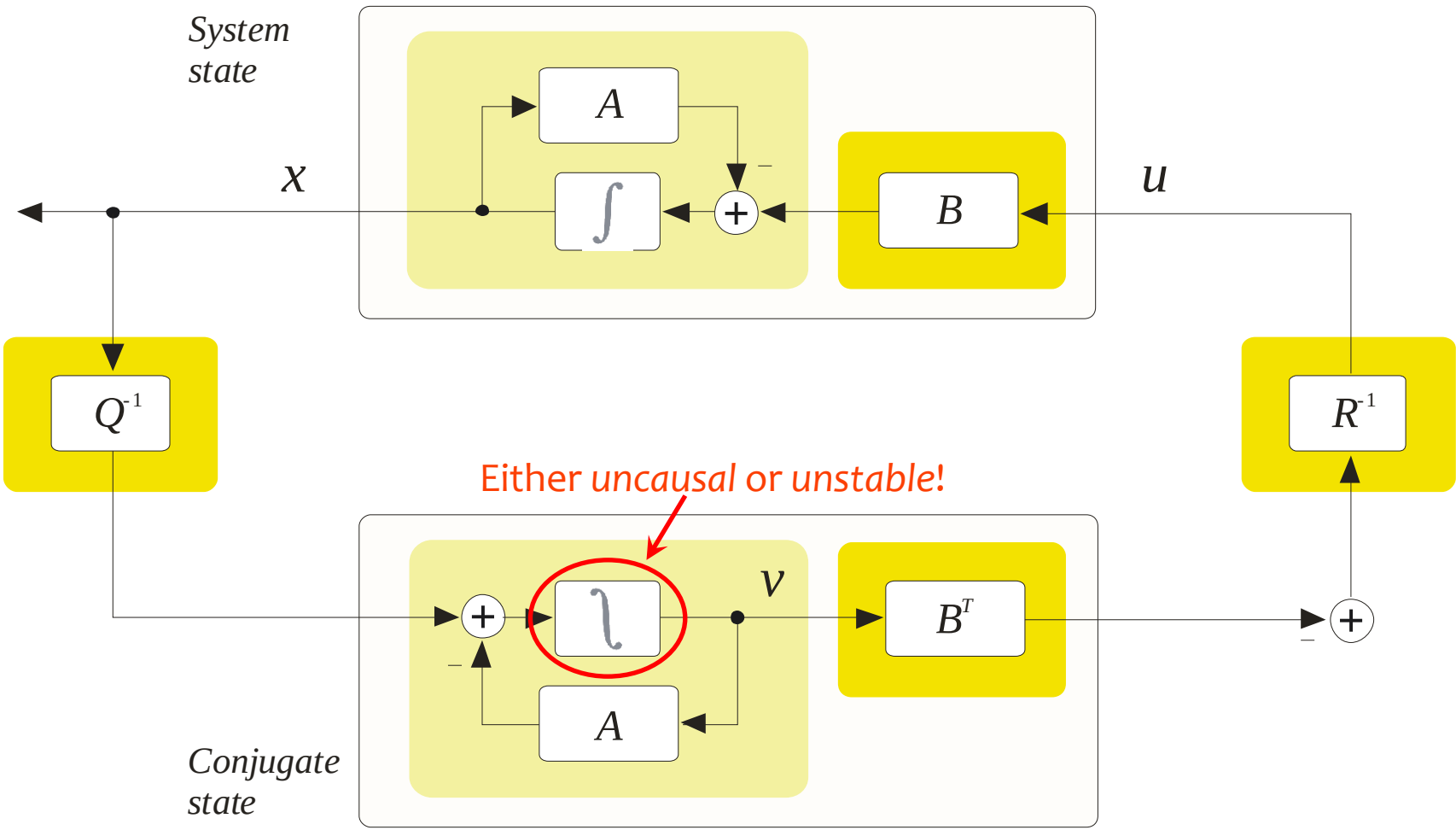
or as an uncausal model:

$$\begin{cases} \dfrac{dx}{dt} = -Ax - BR^{-1}B^T v \\ \dfrac{dv}{d(-t)} = -Av + Q^{-1}x \end{cases}$$

- Note "inversion" of system!
- Optimal for the given model – the model has to be correct!

Often, $Q = I$ and $R = I$

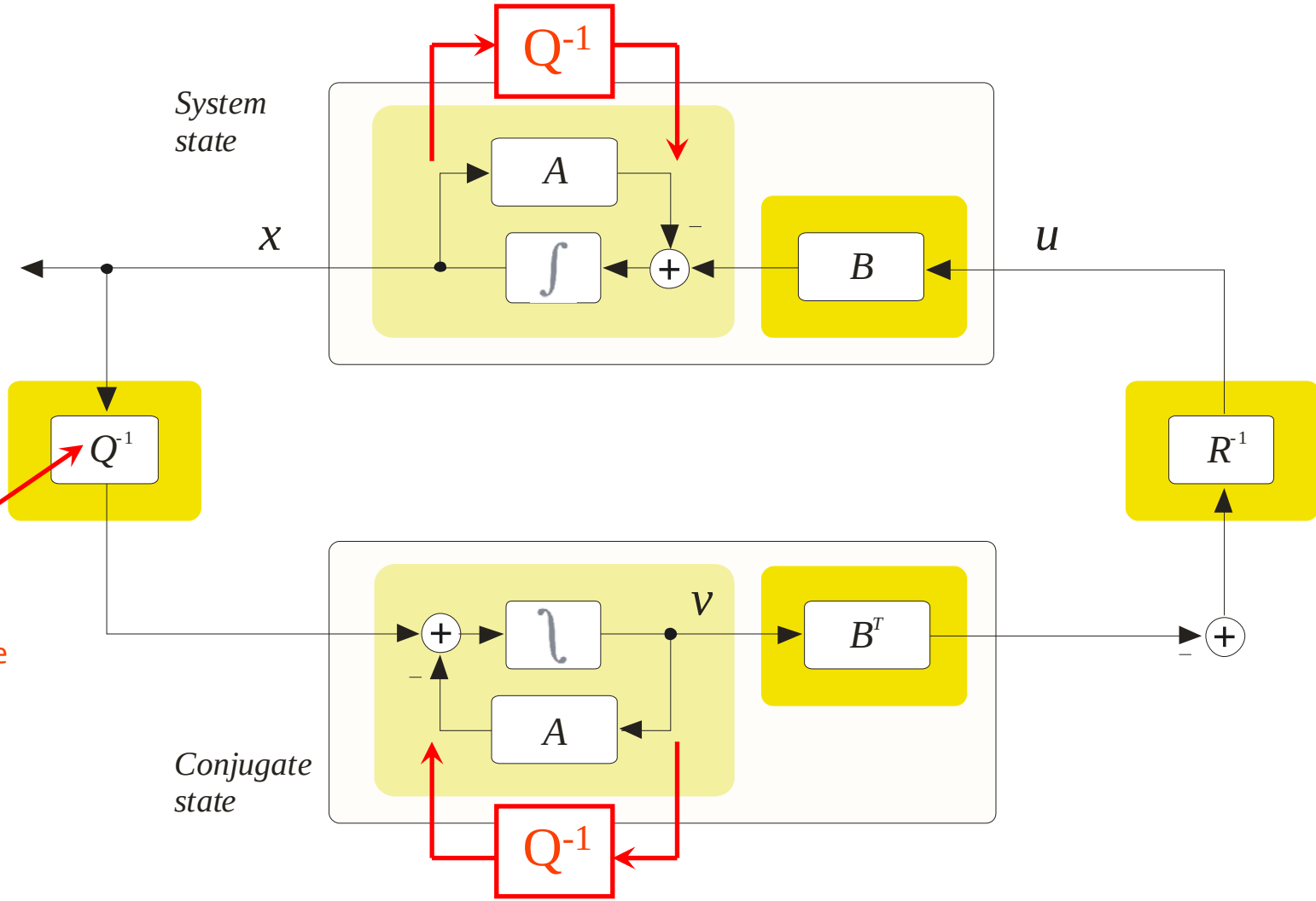
Optimal control



HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Automation and Systems Technology
Cybernetics Group

In "stationary" state, when derivatives vanish, this structure equals the neocybernetic model

Robust control?



How control looks like in practice

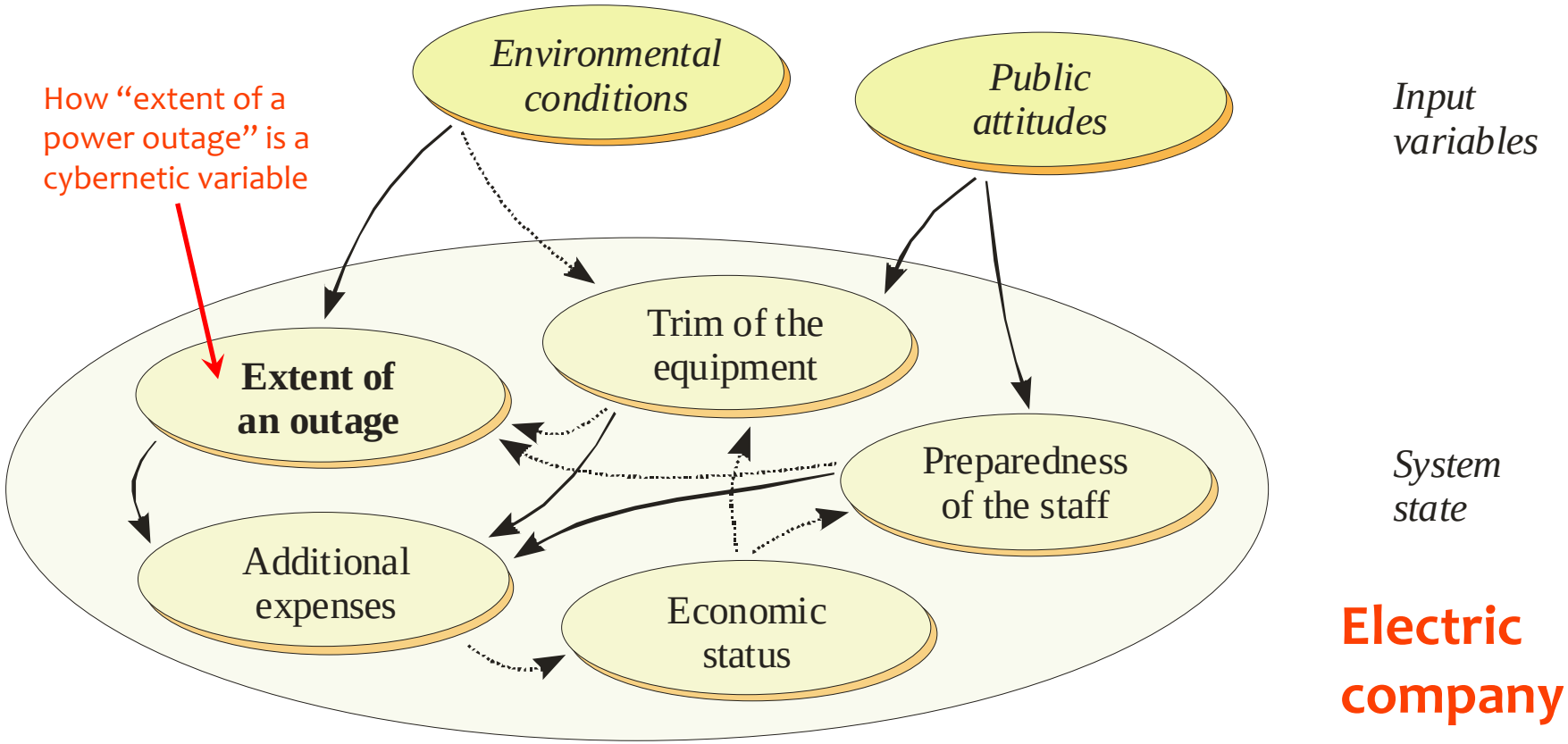
- Case 1: "Stupid agents"
  - Only *some* of the disturbance is eliminated (there is "stiffness")
  - Looks like *buffering*: The system yields as there is pressure from outside
  - Example – Le Chatelier principle in chemistry:
    - "If a chemical system at equilibrium experiences a change in concentration, temperature, volume, or total pressure, then the equilibrium shifts to partially counteract the imposed change"
  - "Mutual control" of neighboring systems – examples:
    - In politics, as well as in marriage and even when bringing up a child, there is search for the limits; if there is no balancing counter-tension, there is no limit for how far a system can push its neighbors
- Case 2: "Clever agents"
  - *All* modeled variation is exploited or eliminated...

Case 1 – Non-trivial application of "buffering"

- The **Delphi method** is a systematic interactive forecasting method for obtaining forecasts from a panel of independent experts.
- The experts answer questionnaires in two or more rounds.
- After each round, a facilitator provides an anonymous summary of the experts' forecasts as well as the reasons they provided for their judgments. Thus, participants are encouraged to revise their earlier answers in light of the replies of other members of the group.
- It often turns out that during this process the range of the answers will decrease and the group will converge towards the "correct" answer.

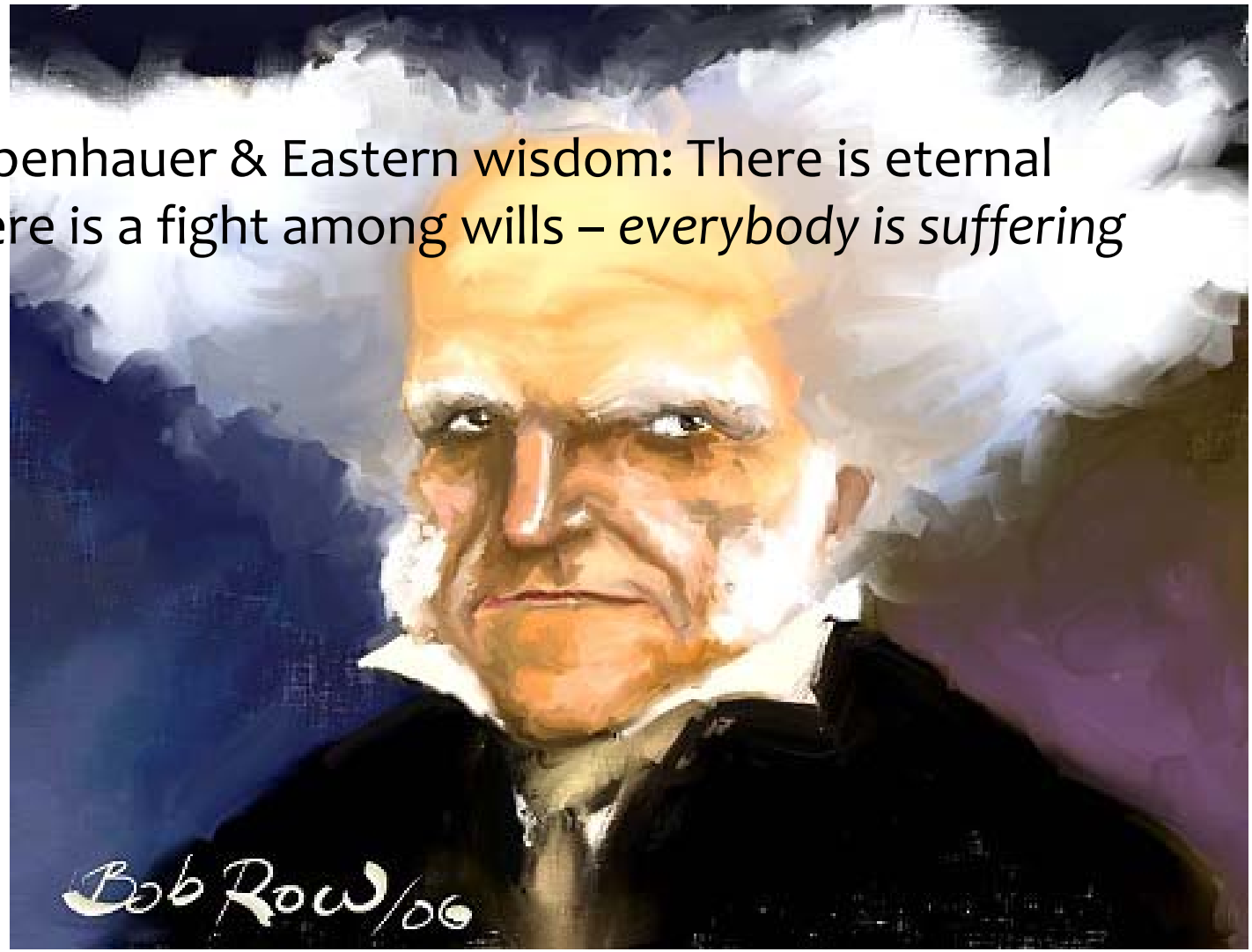
Networks of cybernetic equilibria

- As long as the tensions do not balance each other, there will be adaptation in the system – system yields when disturbed:



Universality of pessimism

- Arthur Schopenhauer & Eastern wisdom: There is eternal struggle, there is a fight among wills – *everybody is suffering*

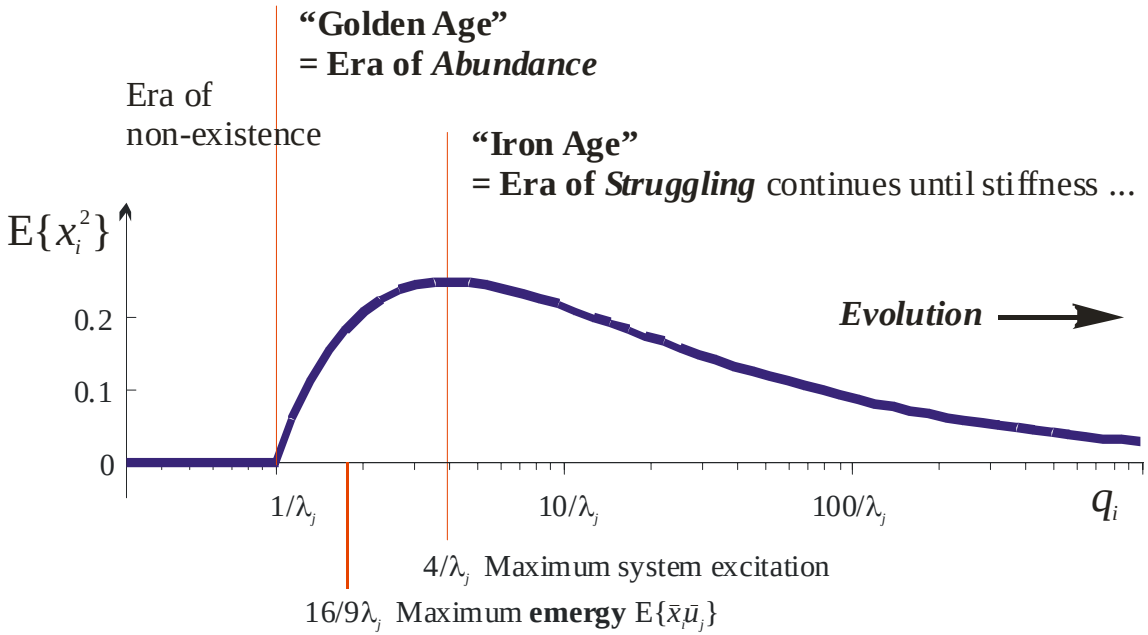


- Formula of Lec. 4:

$$\mathrm{E}\left\{\overline{x}_i^2\right\} = \frac{\sqrt{\lambda_j}}{\sqrt{q_i}} - \frac{1}{q_i}$$

- Maximum reached

$$\mathrm{E}\left\{\overline{x}_i^2\right\}_{\max} = \lambda_j / 4$$



for $q_i = 4/\lambda_j$, meaning that then there is *balance* $\mathrm{E}\left\{\overline{x}_i^2\right\} = \overline{\lambda}_j$!

- Thus, the system of selfish agents can maximally inherit 1/4 of the original information.
- Next, study the case of social/clever agents that can exhaust *all* of the available information...

HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Automation and Systems Technology
Cybernetics Group

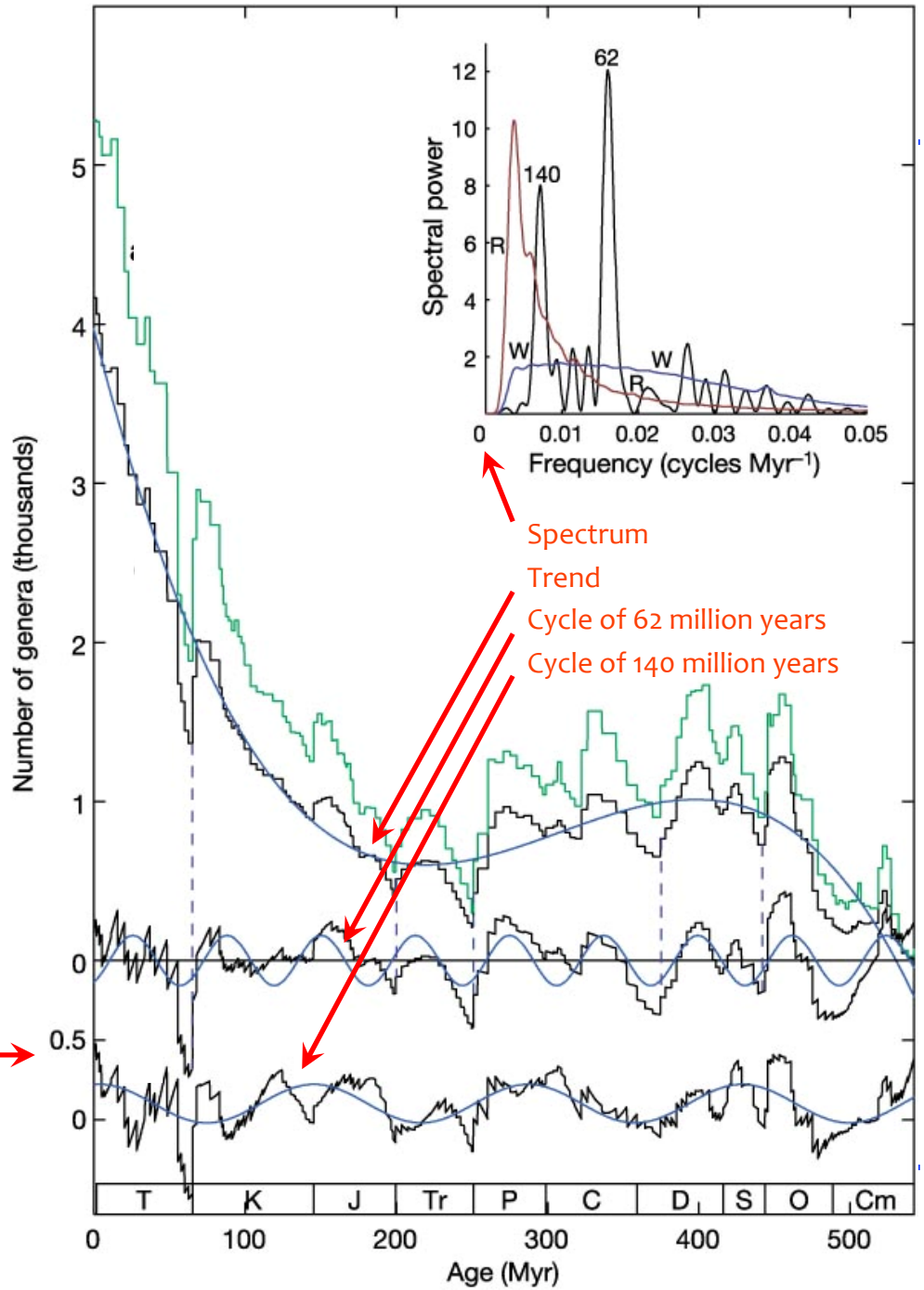
In above, remember that variations (in information units) can be converted to standard deviations (in u_j units) by taking square roots

Case 2 – Available intuition: *Adaptive control*

- Adaptation is the key property in truly cybernetic systems = they are *adaptive control systems*, trying to implement more efficient controls, eliminating variation ever better
- There is intuition available if one has control engineering background: One can understand what happens in such cybernetic systems where all information is exhausted
- Why are adaptive controllers notorious in control engineering? Why do they behave in a pathological way?
- The reason for "explosions" is *loss of excitation*: Good control eliminates information – the very basis of the model
- This takes place in all loops of simultaneous model identification and control that is based on that model

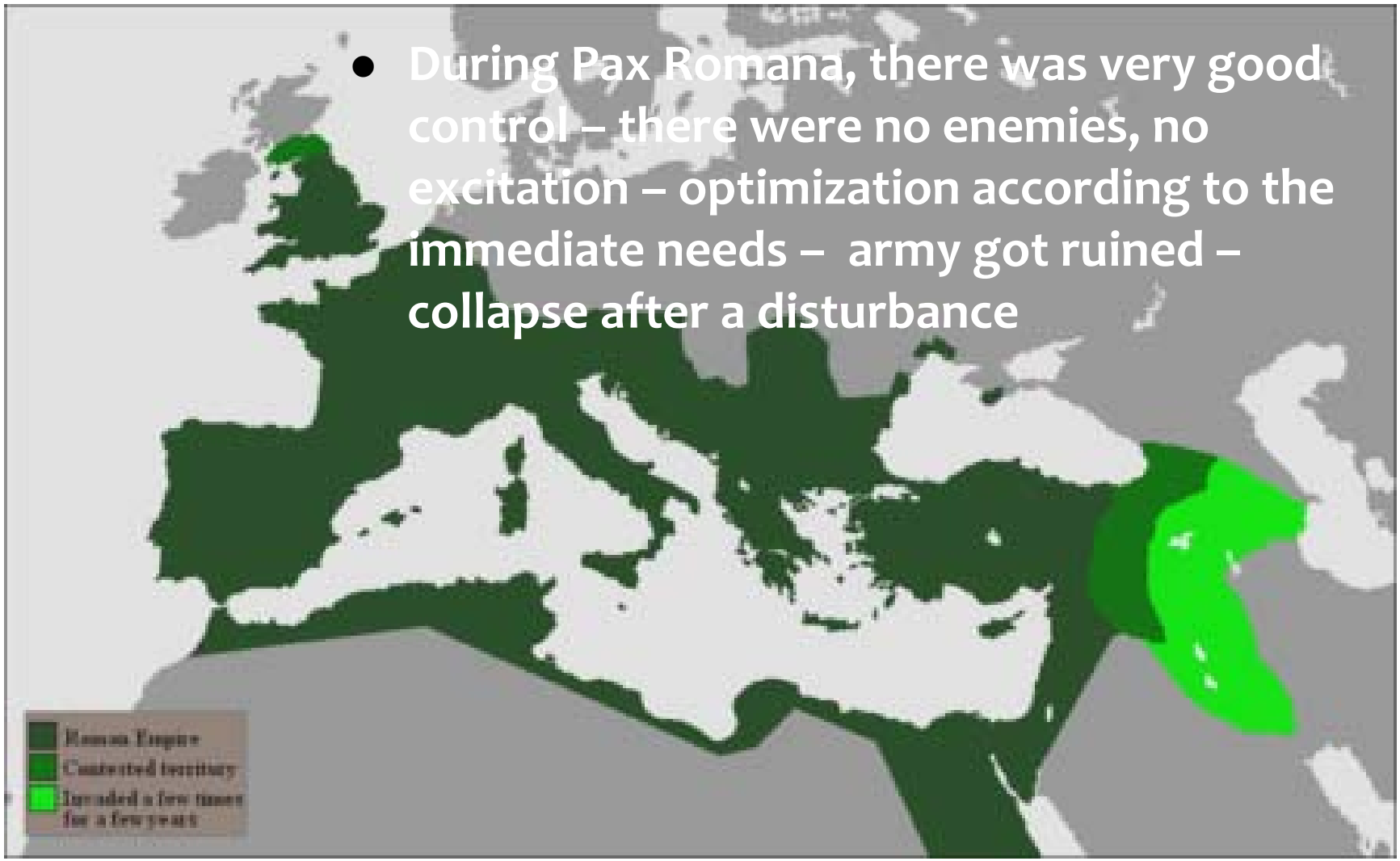
- For some reason, massive extinctions seem to take place in 62 million year cycles
- Dinosaurs died about 62 million years ago…
- Do you need some meteors to explain extinctions? Or is this simply because of evolution dynamics?

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



HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Automation and Systems Technology
Cybernetics Group

Downfall of empires

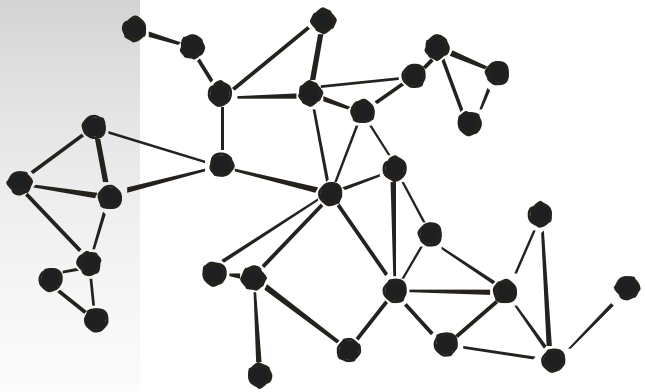


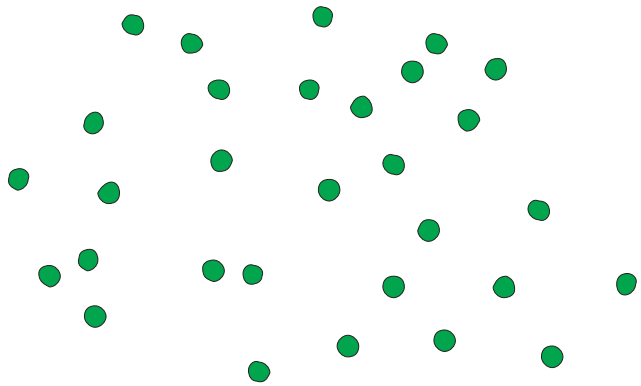
- During Pax Romana, there was very good control – there were no enemies, no excitation – optimization according to the immediate needs – army got ruined – collapse after a disturbance

- But the army must neither be artificially too much valued
- There must be a *balance*; for this, there must exist *excitation*, and competition for resources
- Cybernetics = stay on the edge!

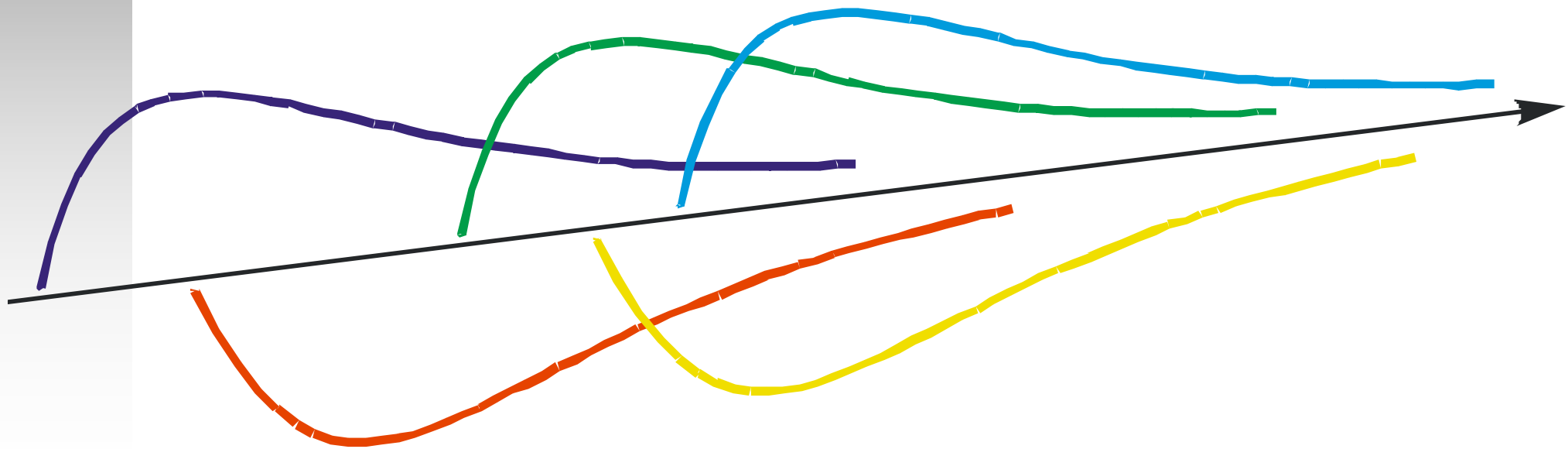
Systems do not “eat orderliness”!

- Counterintuitively, cybernetic systems “eat chaos”, searching for information (covariations), changing these degrees of freedom into constraints or fixed structures that cannot sustain development of systems any more





- Innovations can deliver fresh information, new *degrees of freedom* (more about these during the next lecture)
- Intertwined innovations – development can be rather smooth



- Compare to product life cycles / birth & death of individuals

Routes to unstability

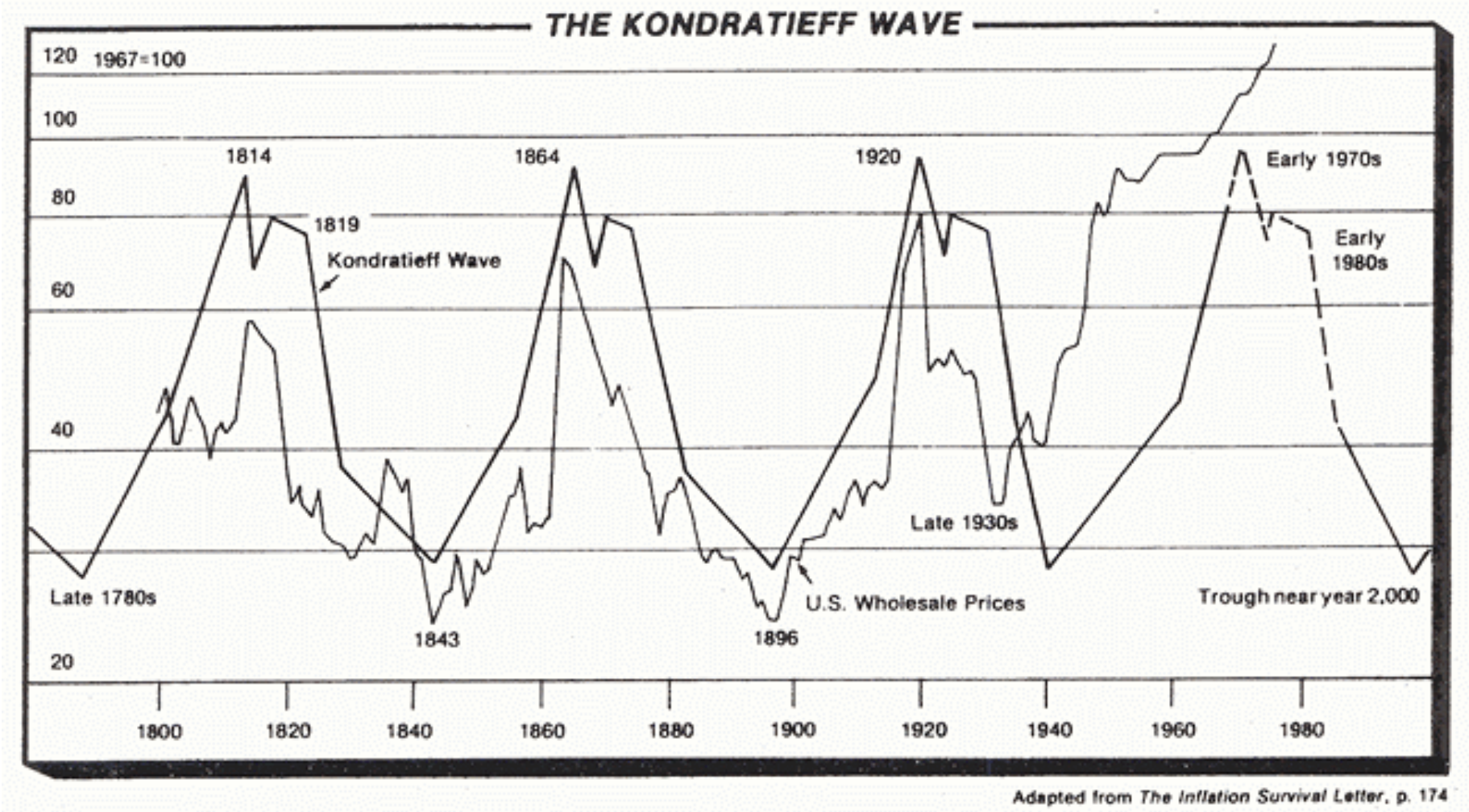
= "you lose" = "you collapse"

- Staying on the edge between order & chaos is difficult!
- There are two approaches to implementing enhanced adapted controls in a cybernetic system:

1. Making controls more accurate – this is the straightforward strategy, resulting from better capturing the data properties (more polished modeling of observations)
2. Making controls faster – for example, taking samples with shorter intervals (examples found in "quartal capitalism" and in modern politics!)

- In both cases, this adaptation leads to loss of excitation, increasing sensitivity, and thus problems with stability

Similarly, cycles in economy



HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Automation and Systems Technology
Cybernetics Group

Stock market is in balance by definition –
still, there is a fractal sequence of collapses

- **George Soros:**

  "The salient feature of the current financial crisis is that it was not caused by some external shock like OPEC raising the price of oil or a particular country or financial institution defaulting. The crisis was generated by the financial system itself. This fact – that the defect was inherent in the system – contradicts the prevailing theory, which holds that financial markets tend toward equilibrium and that deviations from the equilibrium either occur in a random manner or are caused by some sudden external event to which markets have difficulty adjusting. The severity and amplitude of the crisis provides convincing evidence that there is something fundamentally wrong with this prevailing theory and with the approach to market regulation that has gone with it. To understand what has happened, and what should be done to avoid such a catastrophic crisis in the future, will require a new way of thinking about how markets work." …

What happens after a collapse?

- Local "catastrophes" = robust built-in way of regeneration
- Death of cells in an organ / individuals in a population are such local catastrophes, giving room for fresh individuals
- What is more interesting, catastrophes deliver information = fresh variation for the higher-level system to learn, mapping the "spectrum of the possible" in the environment
  - Spikes in neuron networks are local collapses – but they cumulate into information (level of activation) on the higher level
  - Ancient empires – what is there to learn? – The next level of *culture* is *cultivation* – understanding "what it is to be a human"
  - *Natural philosophy* – a collection of paradigms getting to their dead ends; only scientific revolutions (Kuhn) can open the deadlocks when paradigms get too rigid (self-controlled) – Compare also to Hegelian *Weltgeist*

“Intelligent Experiment Design”

- Identification in technical systems
- Carried out by a human

So, how to find out the natural responses of a system?

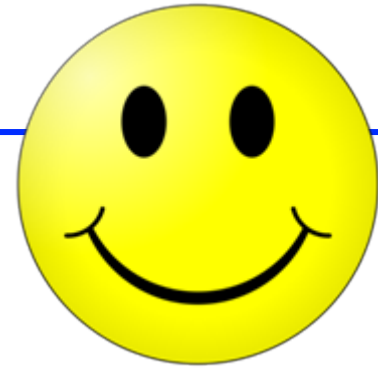
- First, let the system stabilize, eliminate external disturbances
- Apply a strong impulse in the system
- Record the dynamic effects + stimulated frequencies
- Implement the controls that exploit the system properties.

- “Identification” in natural systems
- Carried out by the *system*

How to find out the natural responses of the *environment*?

- Let the system stabilize in the cybernetic deadlock
- Apply a catastrophe in the environment
- Experience the dynamic effects + stimulated frequencies
- Somehow adapt to take the environment better into account.

How to avoid “human catastrophes”?

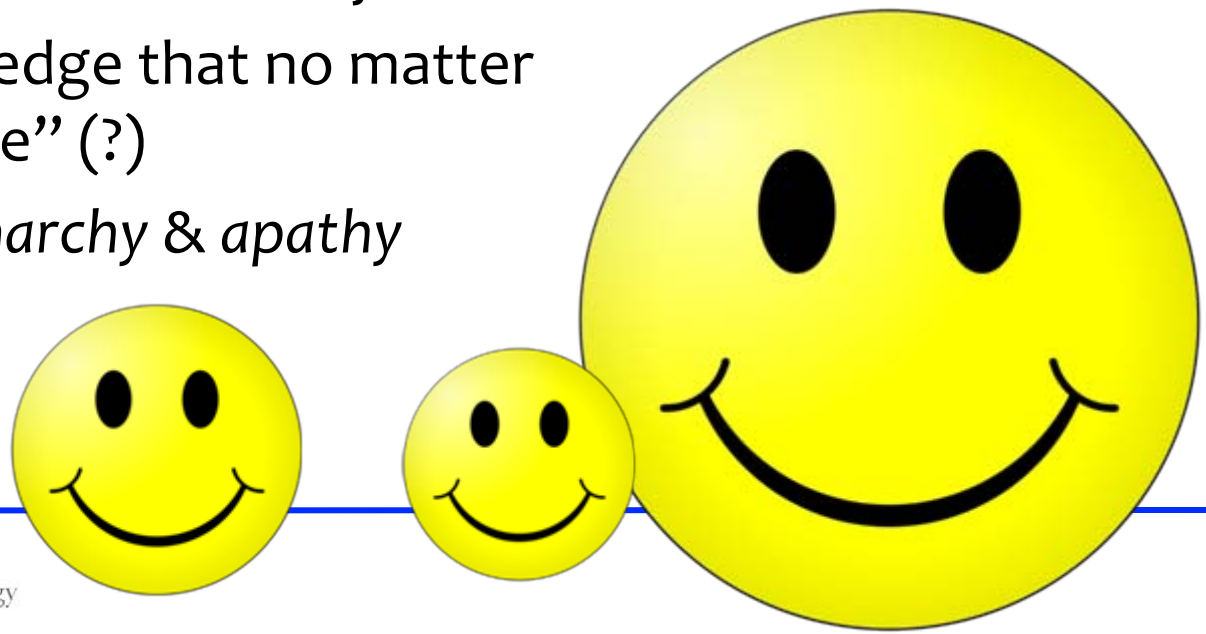


- In a real society, there are always differences – or unjustice and unequality among people?

- What comes to an individual, the goal is not extreme balance (in the Eastern sense), but also some *excitation* is needed
- *Physiologically*, the autoimmune system needs “tuning”, and *mentally*, challenges and diversity is needed

  Happiness = Knowledge that no matter what, “I will manage” (?)
- Challenge: Avoid *anarchy* & *apathy*

No excitation – *hysteria* on the human level as well as on the society level



Ergodicity

- Ergodicity is a statistical concept; ergodicity is *more than stationarity* (along time axis)
- Slightly misused, this concept helps to gain fresh information without having to wait infinite times
- Ergodic theory:

Time-average equals space-average

- Assuming that the environmental conditions remain the same, one can collect *simultaneous* case information from different locations in space and calculate expectations over them (that is, *spatially* rather than *temporally*)

Systems not-yet-seen

- There must exist civilizations ahead of us – Fermi Paradox: Where are they?
- Key point: All civilizations that are sustainable value fresh information – otherwise, there is a collapse
- Where to gain new information from in the limited universe?

- **Claim:** *"They" do not want to contact us not to disturb us*
- Variety of life forms is unexhausted – to be always surprised, to have always new information, study "cosmic biodiversity"
- Be a "universal gardener of systems" to be happy ever after!

Inferior cultures "die of shame"!

Beyond Year 1984 – *cybernetization*

- Trends in working life – example TKK:

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?

- Developments are all-embracing – an individual cannot successfully fight against the natural system dynamics
- Note how even the terminology is selected – who could object something like “transparency” or “efficiency”?
- Indeed, even the language is a memetic sphere becoming more cybernetized along with its application domains
- Luckily, Finnish language can sustain such developments to some degree (?):
  - It cannot host “smalltalk” where social controls have buried the message; Finnish utterances still convey clear meaning
  - Perhaps it really is “uncultivated”, being nearer to nature, being capable of addressing phenomena in the real world?
  - Furthermore, there are strong mechanisms for regeneration of new words.

The same in research work

- A scientific system itself is a cybernetic system, consisting of a population of independent actors = researchers
- Thus, scientific system is a control system, evolving towards better elimination of variability or uncertainty
- As the scientific system becomes "better controlled", there are stronger tensions in terms of competition
- A *paradigm* determines "correct" ways to do research, defining standard problems and methods – *standard science*
- ***Measurement*** *with evaluations, impact factors, peer reviews*
- ***Control*** *in terms of funding, etc.*

Trivialize problems, make things better quantifiable

- One has to actively struggle against cybernetization!?

Science is a game of memes and minds – it must be *fun* to survive

… 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"

Final note

- The discussions among sociologists are “challenging”
- It would be great if the process semiotic system theory could cast some light there...

- For example, there are various unexplained processual characteristics in modernization:
  - Economization → “Explained” in terms of *efficiency / transparency*
  - Bureaucratization → – ” – *enhanced control*
  - Democratization → – ” – *better coupling to information*
  - Secularization → – ” – *more appropriate models*
  - Individualization → – ” – *sparsity pursuit*
  - Pacification → – ” – *search of balance, etc.*
  - ...