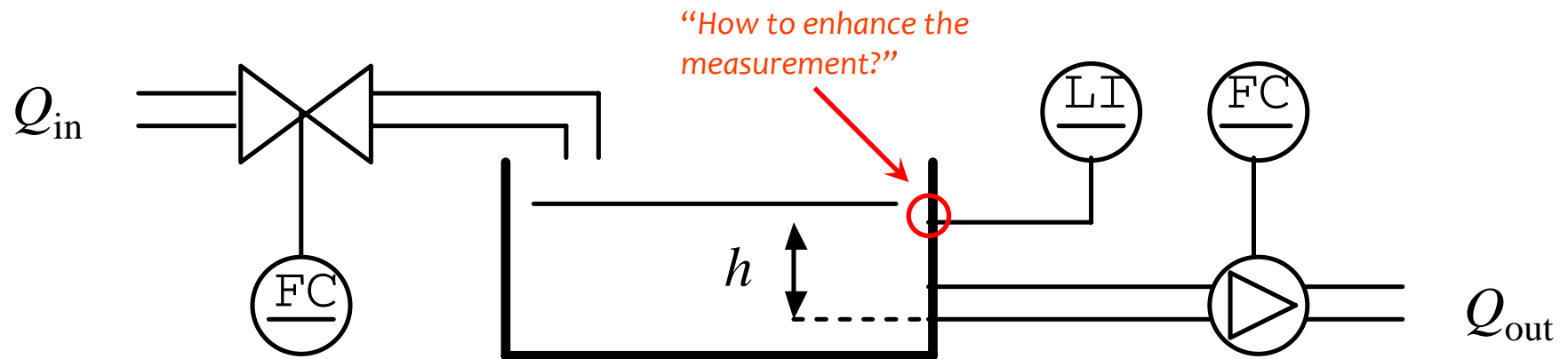

Humans in Loops – Neocybernetic View at Complex Processes

Presentation at
Automation Days 2009

Heikki Hyötyniemi
Helsinki University of Technology
Automation and Systems Engineering



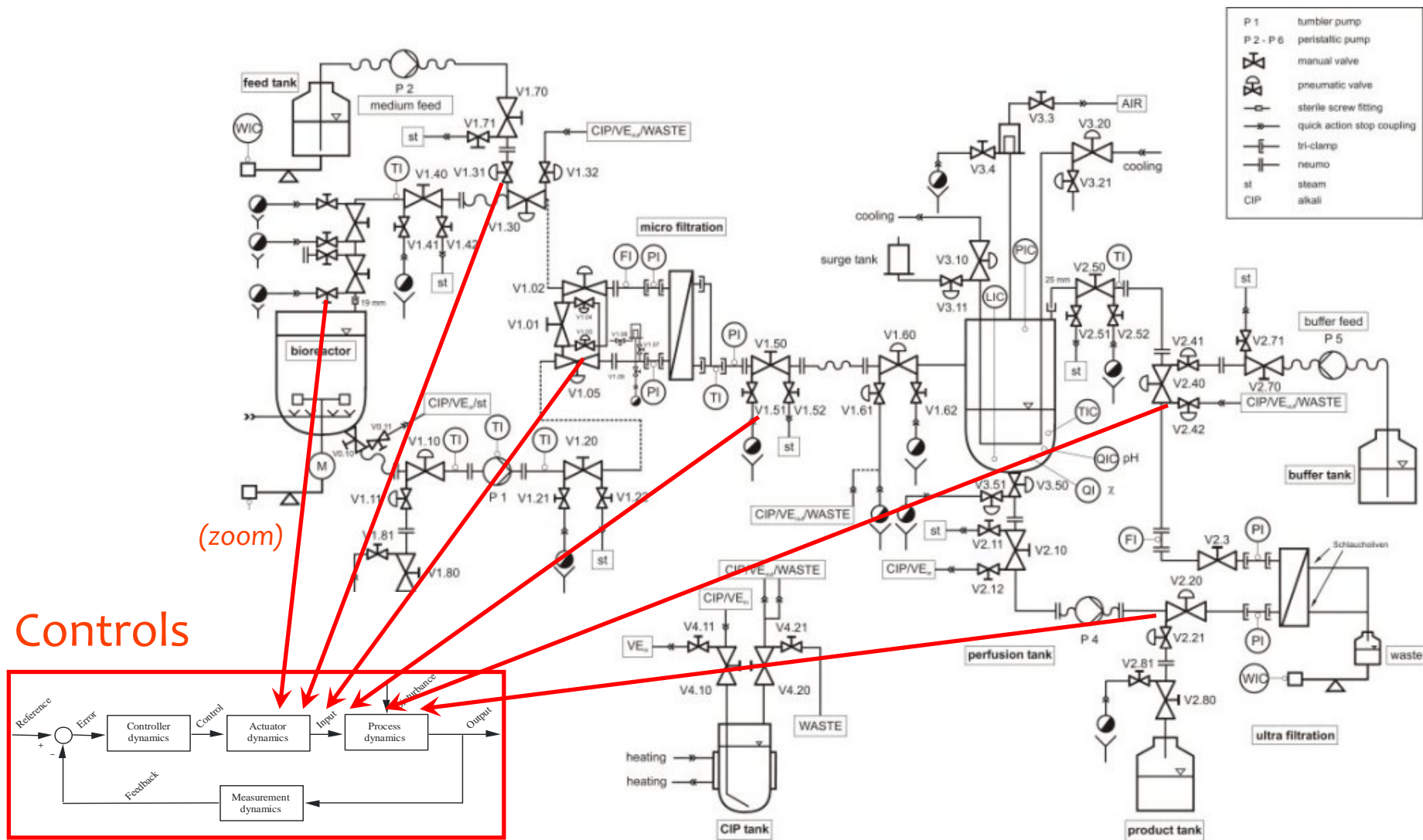
Process levels – EXTENDED



- *Physical level* (formation): Input Q_{in} , output Q_{out} ; based on the actual process structure and its energy/matter flows
- *Information level* (metaformation): Inputs Q_{in} and Q_{out} , output h ; based on what can be measured and what can be affected
- *Knowledge level* (metainformation): Inputs are now the tensions of the system, outputs are its resulting properties



From process flows to information flows ...

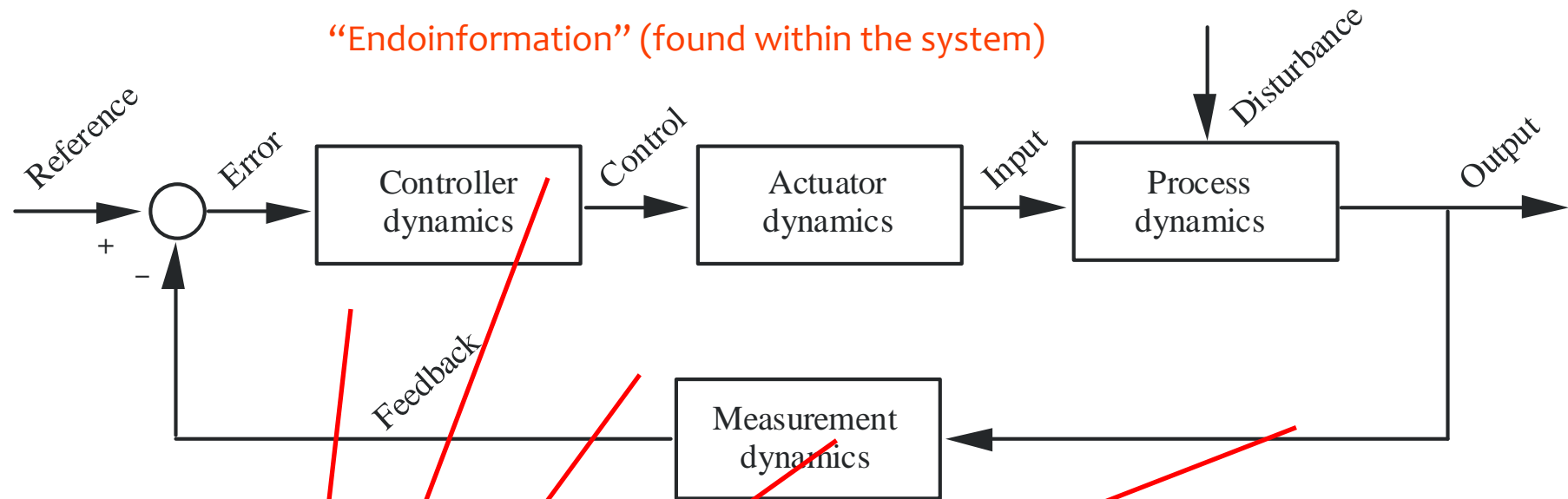


(zoom)

Controls

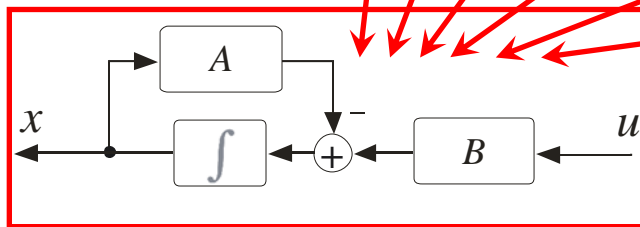


... From information flows to “knowhowflows”



(zoom)

“Controls”



“Eksoinformation”

Large amounts of appropriately chosen external information and understanding



Role of *neocybernetics*

- Evolution that is based on local agents: special structure remaining visible in the closed loop on the global level
- Interpretation: *degrees of freedom* in the directions of interest, *balance among tensions* (physical + economical)
- System becomes *better and better balanced* and *robust* against environmental disturbances
- This applies also to “artificial evolution” implemented by humans when developing industrial plants
- **Neocybernetics offers tools for implementing “higher-level control” in the spirit of “second-order cybernetics”**

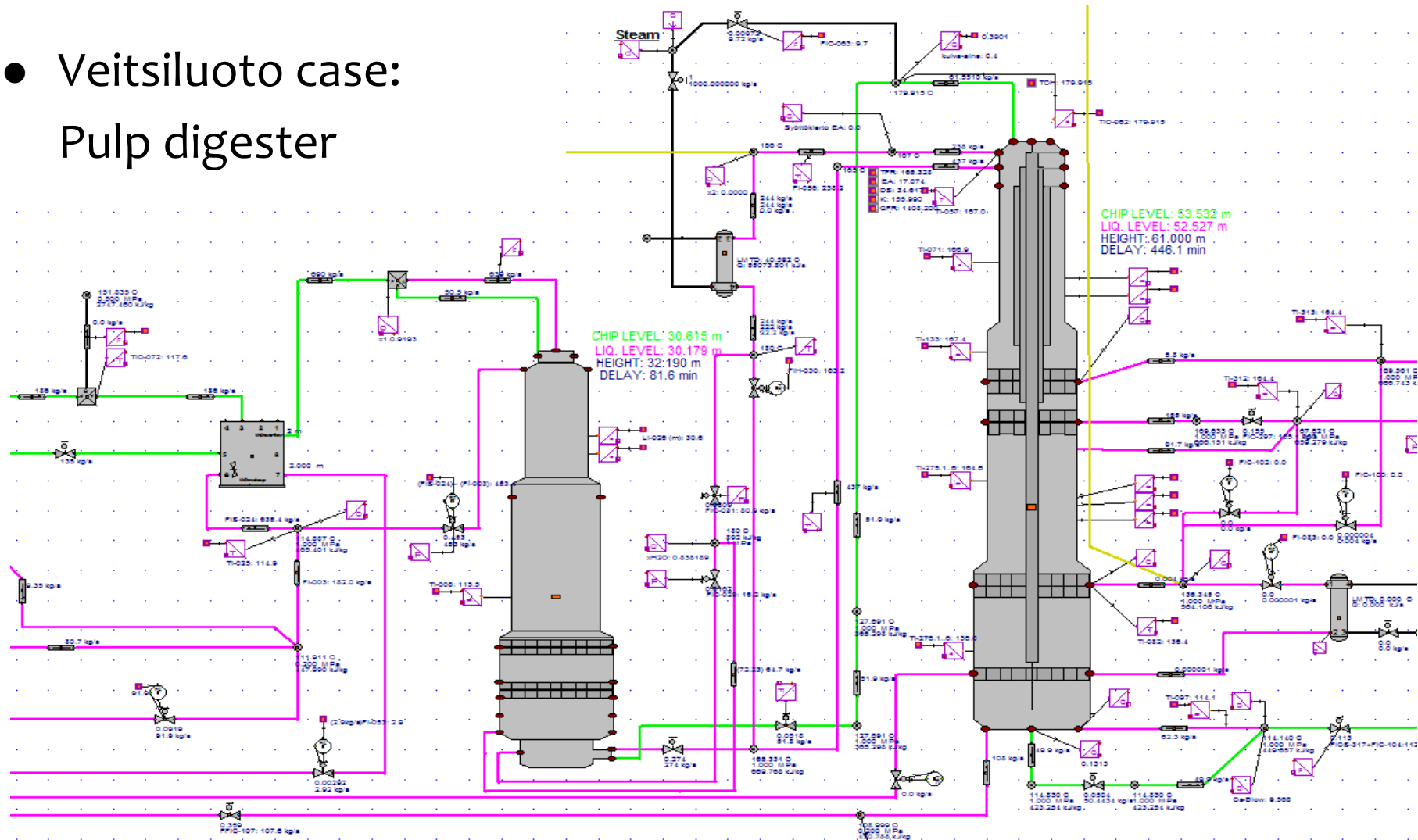


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- Now, there are humans in the system structure...
 - First, study a simple case: *Linearity* assumed
 - Process linearized around a single operating point
 - *Mental model* reduced to a set of *quality measures*
 - Then, degrees of freedom reduce to *principal component subspace axes*
 - Higher-level view: abstract the signals away, concentrate on *qualifiers vs. qualities*
 - Utilize the low-dimensional mapping between the qualifiers and qualities in parameter optimization, etc. ...

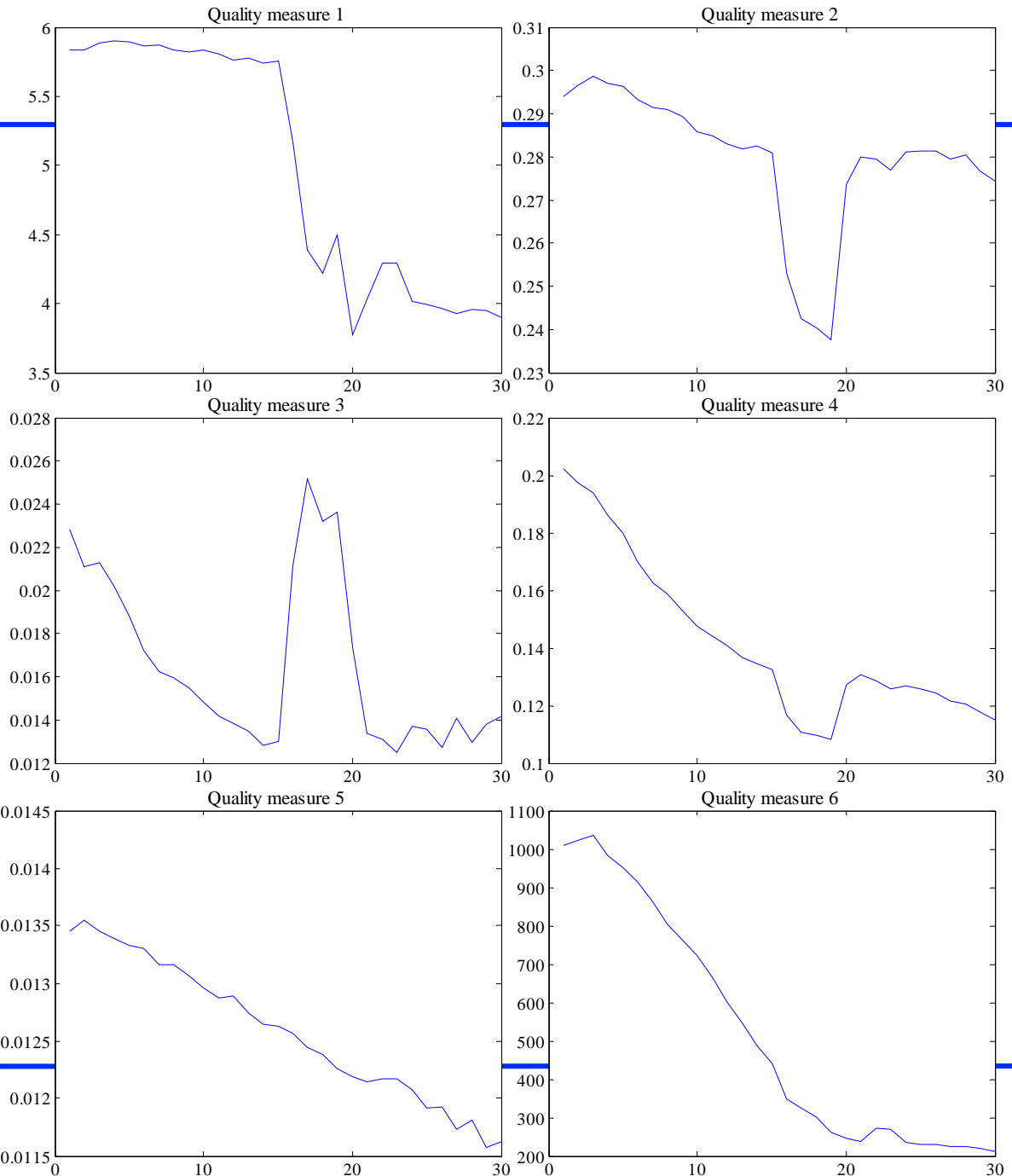
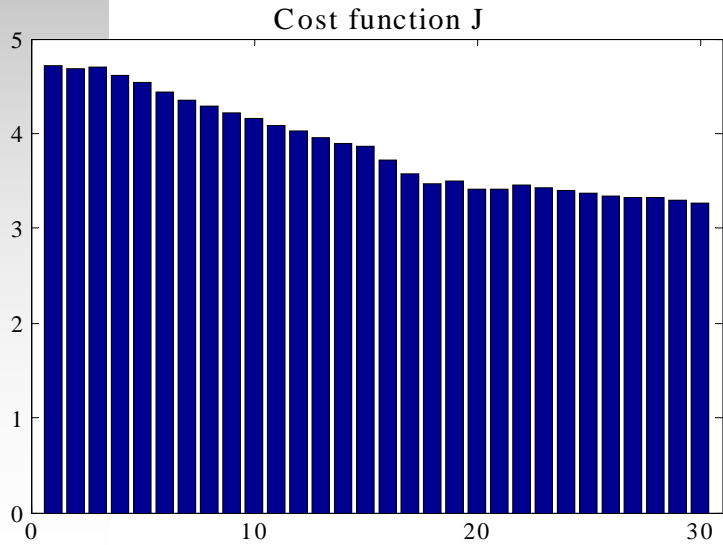


Experiments with the IRT method

- Veitsiluoto case:
Pulp digester

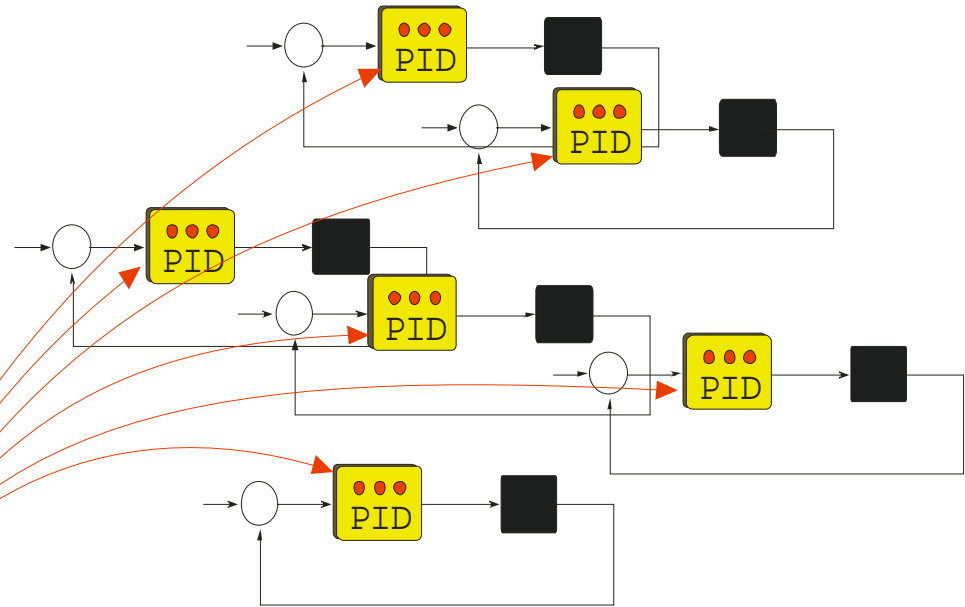


- Optimization in reduced-dimension parameter space

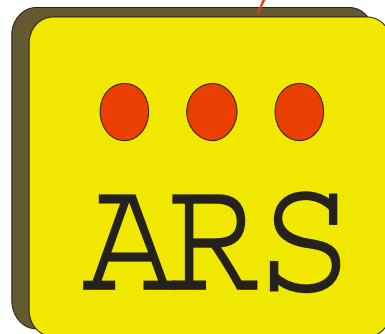


Extending the operator view

- Explicit optimization is often not possible
- The *slopes* of criteria can still be found
- The tuning knobs can be made to reflect *relevance*



Lower-level controllers tuned in a coordinated manner according to a model where control parameters affect qualities



“Neocybernetic expertise”

- More general case: Process consisting of many submodels, expertise with various *categories = prototypes*
- Observation/measurement data correlations are detected and modeled in terms of *sparse coded features*
- Categories/concepts (subsymbolic) can be implemented using sparse coding in a cognitively plausible way
- Reasoning/inference becomes a static pattern matching process in a high-dimensional space
- **Process/mental structures share the same sparse coded model structures and can thus be combined!**

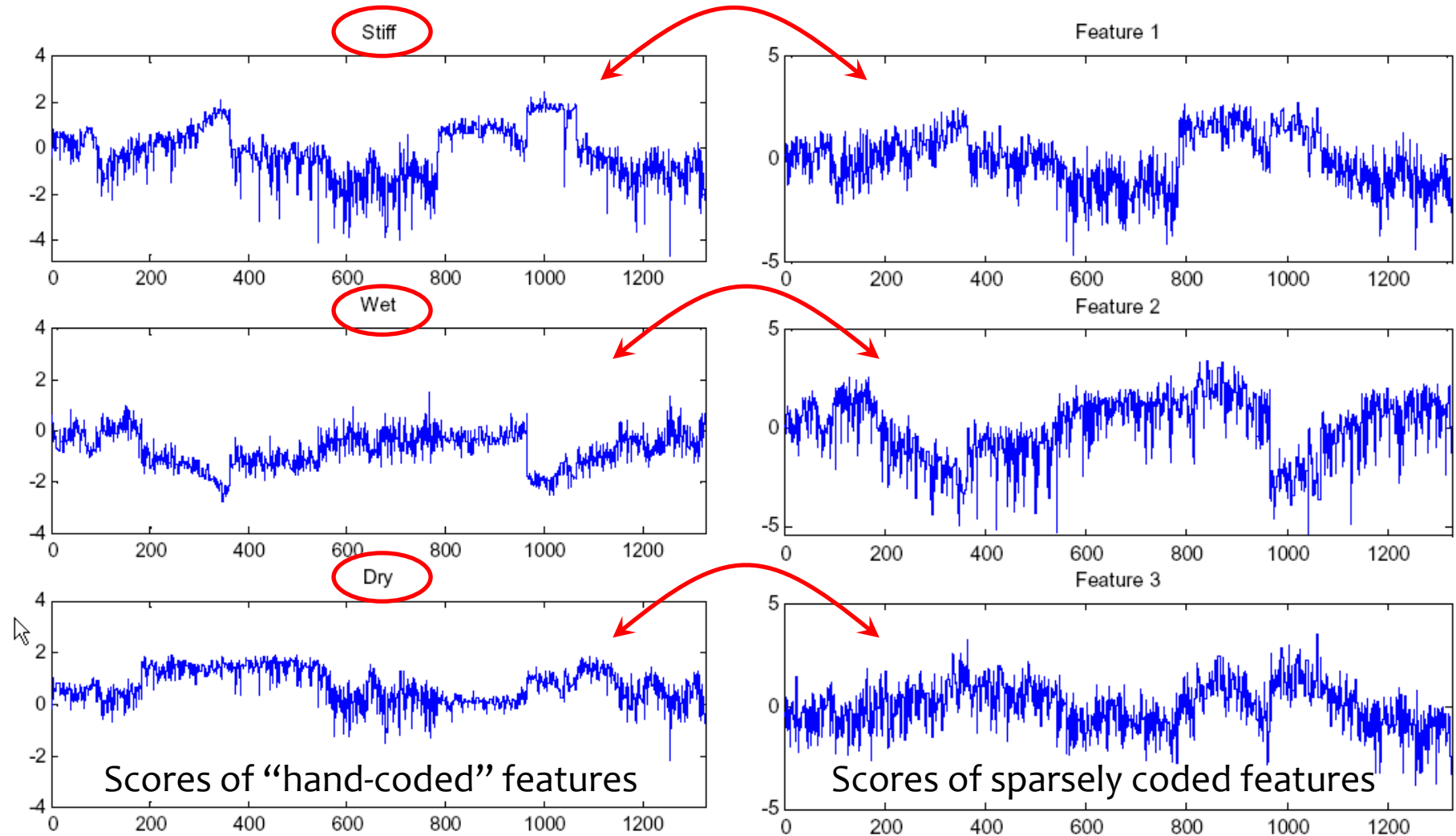


“Conceptual froth types” at Pyhäsalmi

- How operators see the froth



Sparse coding captures categories!



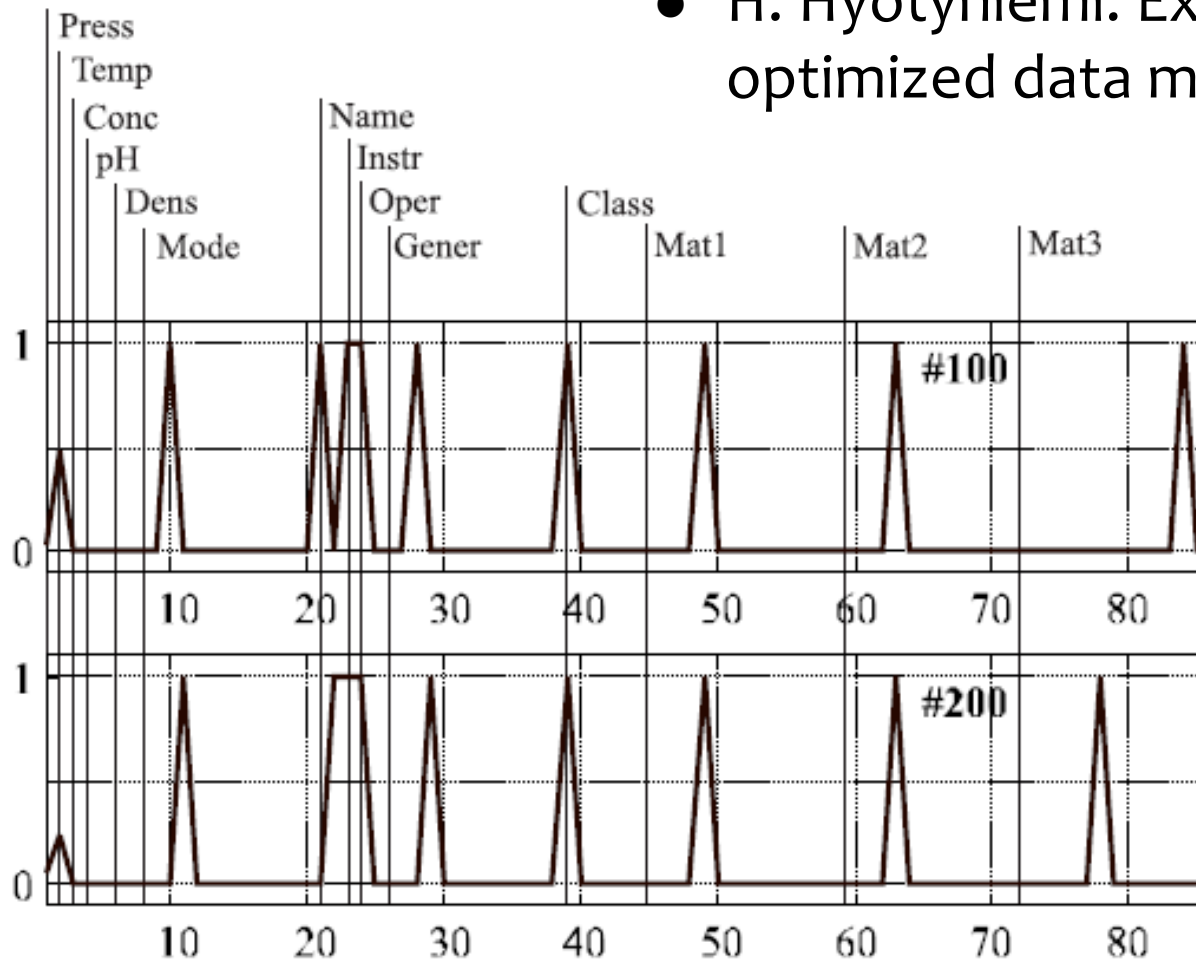
Delphi method

- Exploitation of expertise
 - “The Delphi method is a systematic, interactive forecasting method which relies on 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 from the previous round 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 is believed that during this process the range of the answers will decrease and the group will converge towards the "correct" answer. ...”
- Automation of the method (cf. Case-Based Reasoning):
 - In industry, operator expertise is directly available (measurements + actions)
 - This information only has to be compressed using the cybernetic models
 - Claim: the neocybernetic model of tensions is *just right* for this purpose



How about different kind of expertise?

- H. Hyötyniemi: Expertise: an optimized data model? (STeP 2000)

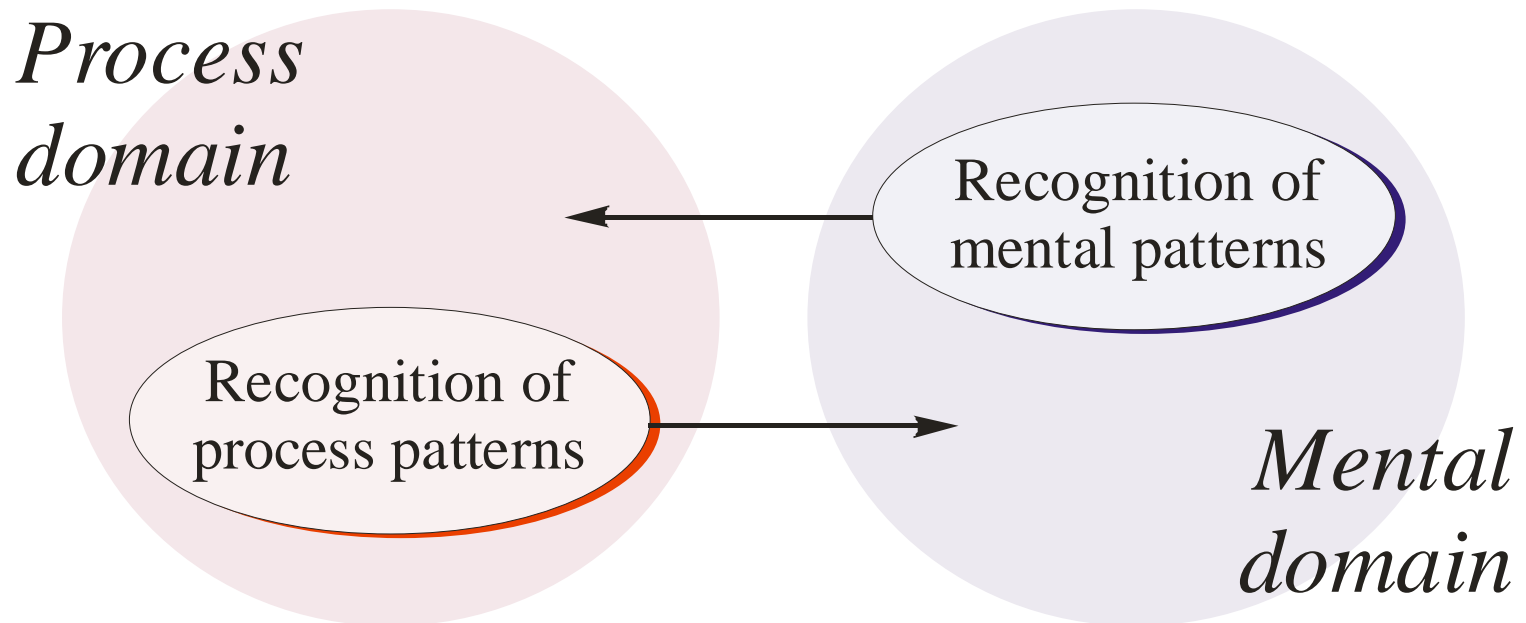


Data courtesy of Neles



Idea of “Second-Order Cybernetics” exploited

- Symmetry: The complex systems “observe” each other, constructing neocybernetic pattern models of each other



“Second-Order Control” in general

- Neocybernetic intuitions combined

