Prologue

Feedback ...? Where?

Think of a young child. Assume his parents want to give this kid a happy childhood and let him grow up freely – no rules, no punishments, allowing him to do anything he likes. An ideal environment for the child to become a mature adult person of strong character? However, assume that the mind of the newborn is a tabula rasa containing no knowledge of what is regarded as good and what is bad. The child tries to adapt, trying to identify the rules of the highly complex game of human interaction. When there is no guidance, he does not know what to do to reach approval; whatever he does, most probably he does it in the wrong way – human communication is a delicate thing. The environment reacts to his attempts with reluctance, if not with more or less open disgust. When this continues through the kid's whole childhood, he will have a negative view of the environment, of other people, and what is most tragic, also of himself. The insecurity will always remain there, haunting in his mind. – Frightening view, isn't it?

The keyword here is *response*, or some kind of *feedback* coming back from the environment. It turns out that the role of feedback is essential in almost all fields of human endeavor, and its effects on the overall system behavior are sometimes striking. Below, some examples of active research areas are listed:

- In *cognitive sciences*, the idea of feedback is becoming more and more prominent. The constructivistic learning paradigm emphasises interaction when knowledge structures are created, and the whole human personality can be seen as a result of interacting with one's environment (as illustrated above). The feedback processes among groups of individuals also make it possible that some kind of higher level cognition emerges (cf., the *Delphi method* and pooling of experts).

- In *social sciences*, and when describing the behavior of larger groups of people in general, free will seems to be a joke: People continuously contrast their own behavior against other people's attitudes. This is specially evident in *politics*, where decisions are often made with the next elections in mind. How about *ethics* and *moral*? In the court of law, the precedent cases often affect the future decisions –

but, from the systems theoretical point of view, the system dynamics may become overwhelmingly complex when the rules of the game change constantly!

- In *life sciences*, in biology, the big question is what makes the evolution go against the arrow of time, against the growth of entropy; what kind of interactions between the embryo and its environment make all the different organs specialize? And how about the balance between species in an environment? The same problem settings have been extended also to the inorganic world in the *Gaia hypothesis* – it is assumed that the homeostatic balance on the Earth is maintained by active feedback processes operated unconsciously by the biota.

- In *economics* and in other business processes, the feedback mechanisms are an organic part of the systems. Stock prices go up or down, they are being sold and bought; the problem that emerges in special situations is that when larger groups of analysts follow the same ideas, their actions dynamically change the situation in the market – positive feedback mechanisms tend to turn price drops into catastrophes.

- In *technical sciences* and in process industries, where optimal production conditions are searched for, understanding the implications of feedback loops is specially important. Control actions are necessary to compensate for the disturbances coming from the environment.

However essential the role of feedback often turns out to be, the causal dependency chains may be difficult to detect, because there usually is a delay between the cause and effect in a dynamic system. The effects of feedback cumulate while traversing back and forth in a system, and something qualitatively different, new unanticipated phenomena can emerge. It is no wonder that cybernetics, the science of feedback systems, was one of the starting points of early research in Artificial Intelligence (AI), and later in Artificial Life. Actually, year 2000 happens to be the 50'th anniversary of Norbert Wiener's seminal work *The Human Use of Human Beings* that was a simplified version of his classic book *Cybernetics* in 1948.

How have things matured in 50 years? At least one concrete, large-scale experiment has been carried out: In the late Soviet Union, it was recognized how difficult phenomena we are dealing with – truly, it is not *centralized government* but *self-regulation* of individual entities that cybernetics is all about …!

The role of this book is to visualize the variety of disguises that the feedback phenomena do have in our lives. On the other hand, the goal is to emphasize the similarity of the underlying cybernetic principles – no matter what is the domain field. Hopefully, related studies within different paradigms help to see fresh points of view.

The book is divided roughly in two parts: First, more or less theoretical issues are studied, and in the second part, example domains are discussed in detail. The theoretical part contains chapters on the history and philosophy of cybernetics, overviews on systems and control theory, on game theory, and on chaos research. The latter part contains analyses on brain functions both on neuronal and on cognitive levels, study of feedback mechanisms in an individual and within a population, implications of interactions in political and social life, and effects of feedback loops in industrial markets. Finally, there is the epilogue by the Grand Old Man of Finnish Cybernetics, professor Yrjö Ahmavaara.

Most of the papers were presented during the "Feedback" Symposium, organized at the Helsinki University of Technology, on August 28, 2000, in connection with the Finnish Artificial Intelligence Days (STeP 2000). More information on STeP 2000 can be found in the Internet address `http://www.uwasa.fi/stes/step2000`.

On behalf of all the authors, I wish you pleasant times with our book – and, please, let us have some *feedback*!
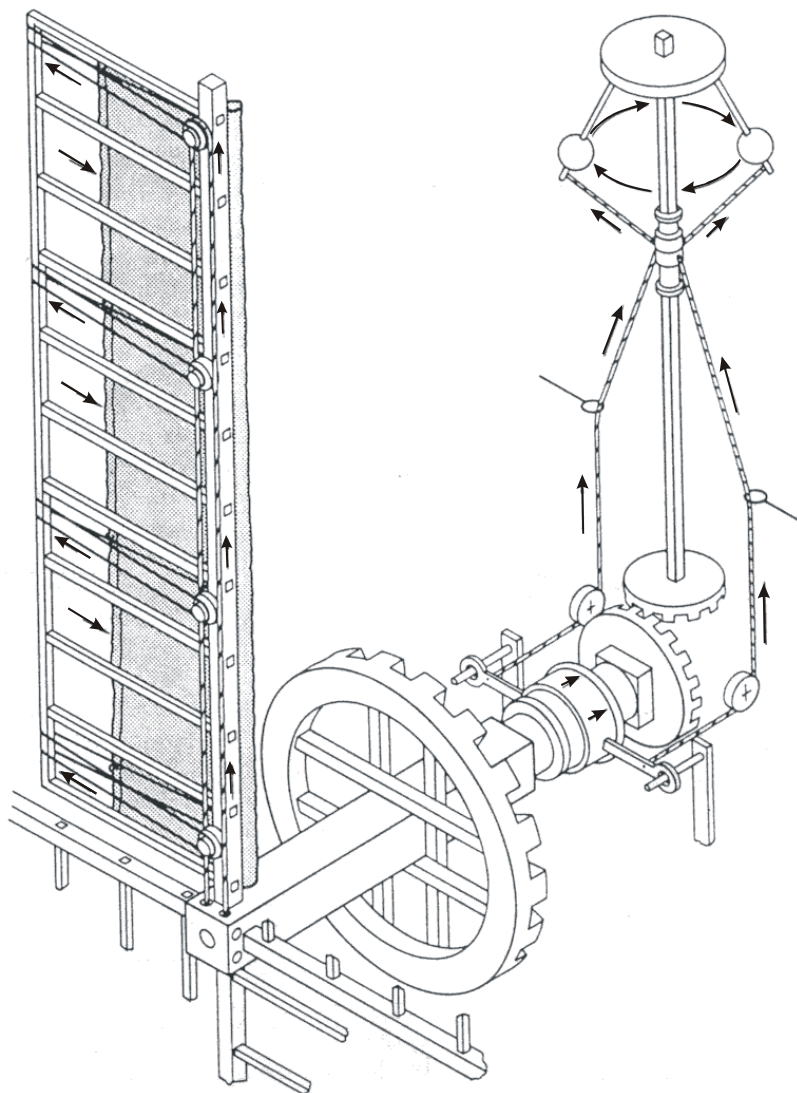
Feedback in practice:
Thomas Mead's windmill speed regulator (1787)