Complexity is observed everywhere. When we look around us, we see many systems that are mind-bogglingly complex. But as human beings we profoundly dislike complexity. We thrive in environments whose important traits are widely predictable, and we go to great lengths to prepare our environments precisely to that end. The most important way to do so is technologically and, despite occasional disappointments, this has been very successful. The complexity of Nature can be borne with humility as long as the preparation against the pitfalls of the natural environment can be carried out to relative satisfaction.

To make matters worse, the late twentieth century has seen the rise of difficult-to-handle complexity in artifacts. This means that the struggle against complexity has to cope with a new front brought about precisely by the methods devised to fight it in the first place. This kind of undesired artificial complexity is a real insult to engineers and technocrats and, at second glance, a true challenge.

In modern artifacts the highest complexity is in an embedded computer and the accompanying software. For practical purposes, the complexity such systems can attain is unlimited. I am typing this on a universal machine, which can do all sorts of information processing tasks a machine can possibly do (notwithstanding its finiteness, which infrequently causes trouble that can somehow be helped with hardware extension). This is good because it has been relatively expensive and I will not need a different one for a slightly different purpose. On the other hand, it means that my machine is capable of a huge universe of possible behaviors. The overwhelming majority of them I will never be willing to experience.

In the terms defined by von Foerster (e.g., [13]), we have come to the point where we are capable of building truly nontrivial machines. He defined a trivial machine as one showing a simple predictable response as opposed to a nontrivial machine with internal state, which also changes in response to conditions in the environment. My desktop computer periodically talks to other machines somewhere in the world to change its behavior according to...
the latest threats of infectious code floating around on the communication lines.

It is only a couple of years ago that rebooting would have put this machine into a reproducible and desirable state. Reverting to a defined previous state is still possible — but completely useless if the machine is supposed to be connected to the Internet, in which case the (formerly) desirable state will be corrupted to unusable or worse within hours if not minutes. Thus, all networked computers in the world are now bound to the wheel of progress in order to remain as useful as they used to be, and much more so if new functionality is required. And we have already passed the line, where the same becomes true for conceptually much simpler things such as telephones.

In this situation, our artifacts become conspicuously comparable to living beings. They are complex in themselves and have to cope with a complex, unpredictable, and in substantial parts malicious environment. Their interactivity may potentially even require computing models beyond the Turing machine. The classical computing models proceed from fixed input data to a fixed output. Although interrupts of any kind are causing their share of trouble in everyday computer use they do not seem to be properly reflected in theoretical computer science. One of several approaches to better account for this is given in [14].

Robotics and artificial intelligence are other domains of engineering where the interaction with the environment is infamously difficult. And indeed, for a household robot to be of any use it must be highly complex in order to be able to deal with commonplace difficulties like cluttered floors. But their user interface may not be very complex. It should be enough to advise a robot to “clean up that mess over there” and leave it to the machine to figure out the details. So the task for an engineer is to build highly nontrivial machines and trivialize their interfaces as best as possible.

The hope that this is possible rests on the observation that such systems exist around us. Our fellow humans, for example, can be advised very simply to do tasks like the one above, and the possible difficulties encountered can be overcome in various ways. It is therefore worthwhile to learn from the natural sciences, and especially biology, in order to build such machines.

In nature, things usually get the more complex the closer we look. In the history of physics, the closeness of look went from rigid bodies over indivisible atoms to a whole zoo of elementary particles. Still, there is hope that going to still higher energies, or looking even closer, will end the complexity and simplicity will prevail at the end of the endeavor. In biology, complexity is observed on all levels. The behavior of plants and simple animals is relatively predictable most of the time. By looking closer it is revealed that myriads of processes interact in very complex manners to keep the whole system stable and predictable. A rough but workable theory of how a bacterium will react qualitatively in many situations is relatively simple; a good theory of how the details of its cell work to produce this behavior is a very distant dream.