Synthetic sensory-motor systems for new ecological niches.

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Extending life to new environments: the grandest challenge of all

The real grand challenge for life on Earth is, as it has always been, to conquer new ecological niches. And this challenge has been taken up successfully from the seas to the surface of the earth, to the skies. But nature's evolutionary techniques imply a gradual colonisation of new ecologies: and there are limits to the ecological niches that traditionally evolving living entities can colonise. Life has reached these limits: there may be other colonisable places in the Universe, but the vast emptiness of space between here and there presents an unbridgable gap for traditional evolution.

Yet there is energy available from star light within some parts of space to support life, though the distances between the energy sources is very large. We can build electronic systems which can survive these low energy periods, and perhaps transport them to other stellar systems. But what is gained by simply transporting automata? Is this "the conquering of space"?

One possible solution is building truly enormous spaceships with complete ecologies, to travel space. Unfortunately, the time problem remains intractable: the science-fiction scenario of generations upon generations living on such ships does not seem attractive unless one is fleeing from some cataclysmic event on Earth. Rather than waiting for such events, let us consider an alternative. What if we could design/evolve some form of cyborg[1], an entity which

- had the longevity of suitably designed electronics
- had the capability of evolutionary reproduction to permit colonisation of novel energy landscapes

so that it could really move what we might consider as life to other planets?

Altogether this is a very tall order. But the outcome is very far-reaching. Realistically, this is so far "beyond the horizon" as to be "beyond several horizons"! Nonetheless, one can consider what these nearer horizons might be:

We suggest that these include:

1. "Humanising" electronics. Really this means building (or perhaps growing) minds that can interface with the sensors and energy providers that are appropriate to novel environments. (Indeed, this begs the question of what a mind is, if we are considering building one, or alternatively begs many ethical questions if we are considering growing one.)

and/or

2. Instrumenting biology. This means developing interfaces to senses built out of (e.g.) electronics. Clearly this is necessary if we determine to grow parts of the system.
3. Developing synthetic evolutionary systems, for use in a novel environment.
4. Developing energy transducers for whatever energy sources are available, and energy stores for periods when the energy is not available.

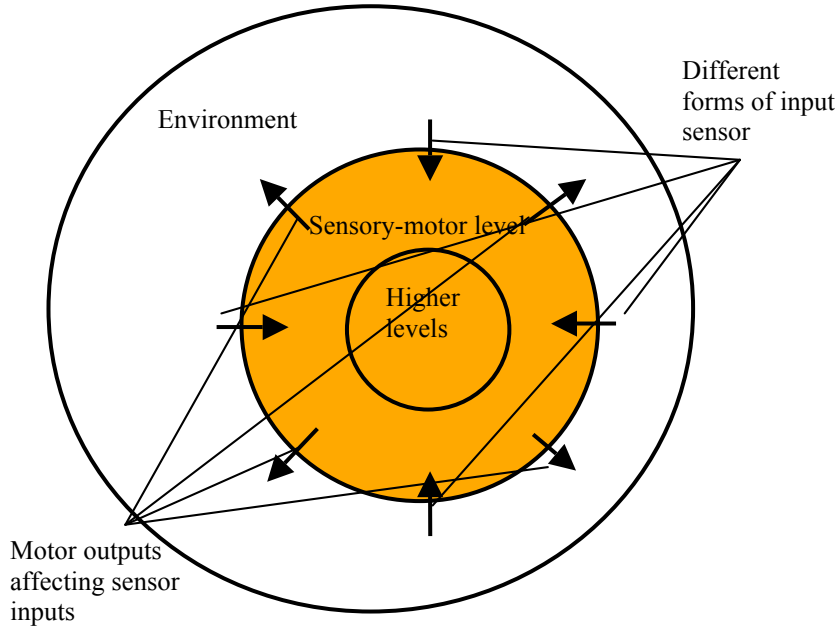
There are many other arising from such a project, and they come from a variety of different fields: they would be necessary for this whole system to come together.

I am proposing a designed system here. However, the designed element is really intended to jump over what seems otherwise to be an insurmountable gap through space to other perhaps more hospitable environments. A more holistic view might place our capability to design such a system as nature's answer to the evolutionary leap problem: that is, to suggest that having conquered all the available spaces on Earth, nature "designed" human intelligence and ingenuity to allow life to be transported across the huge divide separating Earth from other habitable planets. It is in this sense that transporting life to other parts of the Universe is the grandest challenge of them all.

[1] a fictional or hypothetical person whose physical abilities are extended beyond normal human limitations by mechanical elements built into the body.

Where to start from? What might one do now?

Grounded cognitive systems with integrated sensory-motor systems that work in real environments are a start towards this end. These receive a variety of different sensory inputs, and will be able to move part or all of themselves in order to alter this input.



We propose that these systems should learn from the signals impinging on their sensors what form their sensory system should take. The systems would be armed with a number of different types of sensor, some complex (such as artificial retinas sensitive to different parts of the electro-magnetic spectrum, artificial cochleae (for infra-sound, sound and ultrasound), infra-red sensors, as well as chemical sensors), and some perhaps simpler ones too (e.g. pressure sensors), and that the systems learn to interpret their sensory environment by moving in their environment, thus changing the sensory stimuli. Although some aspects of the sensory-motor processing will be built in, most will be adapted by using the effect of movement on the sensing system. In this way the system will be able to make the most of the sensory information it receives.

How does this differ from current robotics? The overall aim is that the sensory-motor technology be part of a larger overall system, part of the system's environment (or user) interface. What makes this part of the proposal new is the ability to detect and adapt to novel forms of energy flux. This proposal is the first step towards much more autonomous systems, systems that can realistically interpret an unpredictable environment. This is the enabling technology for much more effective ubiquitous usage of computing technology.

Such capabilities are a prerequisite for building long-lived semi-autonomous systems, capable of providing robust ubiquitous computing where the design environment is not fixed, nor entirely specified, as well as for more fully autonomous systems, (including as self-repairing systems) which would be required for more challenging applications.

What else might be required? If we want to include neuro-biological systems then we would also need bidirectional prosthetic systems which can send signals bidirectionally to and from neural systems. And if we desire to eventually build in some other eventually discovered environment, we would need energy harvesting and storing systems and adaptive colonizing systems.

And finally:

I know that this doesn't fit with the ethos and immediate requirements of this parlous world, concerned as it is with commerce, comfort and certainties, but it might provide something to strive for on our crowded planet.