

Moravec's Paradox

Moravec's paradox is the discovery by artificial intelligence and robotics researchers that, contrary to traditional assumptions, high-level reasoning requires very little computation, but low-level sensorimotor skills require enormous computational resources. The principle was articulated by Hans Moravec, Rodney Brooks, Marvin Minsky and others in the 1980s. As Moravec writes, "it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility."^[1]

Linguist and cognitive scientist Steven Pinker considers this the most significant discovery uncovered by AI researchers. In his book *The Language Instinct*, he writes:

The main lesson of thirty-five years of AI research is that the hard problems are easy and the easy problems are hard. The mental abilities of a four-year-old that we take for granted - recognizing a face, lifting a pencil, walking across a room, answering a question - in fact solve some of the hardest engineering problems ever conceived... As the new generation of intelligent devices appears, it will be the stock analysts and petrochemical engineers and parole board members who are in danger of being replaced by machines. The gardeners, receptionists, and cooks are secure in their jobs for decades to come.^[2]

Marvin Minsky emphasizes that the most difficult human skills to reverse engineer are those that are *unconscious*. "In general, we're least aware of what our minds do best," he writes, and adds "we're more aware of simple processes that don't work well than of complex ones that work flawlessly."^[3]

The biological basis of human skills

One possible explanation of the paradox, offered by Moravec, is based on evolution. All human skills are implemented biologically, using machinery designed by the process of natural selection. In the course of their evolution, natural selection has tended to preserve design improvements and optimizations. The older a skill is, the more time natural selection has had to improve the design. Abstract thought developed only very recently, and consequently, we should not expect its implementation to be particularly efficient.

As Moravec writes:

Encoded in the large, highly evolved sensory and motor portions of the human brain is

a billion years of experience about the nature of the world and how to survive in it. The deliberate process we call reasoning is, I believe, the thinnest veneer of human thought, effective only because it is supported by this much older and much powerful, though usually unconscious, sensorimotor knowledge. We are all prodigious Olympians in perceptual and motor areas, so good that we make the difficult look easy. Abstract thought, though, is a new trick, perhaps less than 100 thousand years old. We have not yet mastered it. It is not all that intrinsically difficult; it just seems so when we do it. [\[4\]](#)

A compact way to express this argument would be:

- We should expect the difficulty of reverse-engineering any human skill to be roughly proportional to the amount of time that skill has been evolving in animals.
- The oldest human skills are largely unconscious and so appear to us to be effortless.
- Therefore, we should expect skills that appear effortless to be difficult to reverse-engineer, but skills that require effort may not necessarily be difficult to engineer at all.

Some examples of skills that have been evolving for millions of years: recognizing a face, moving around in space, judging people's motivations, catching a ball, recognizing a voice, setting appropriate goals, paying attention to things that are interesting; anything to do with perception, attention, visualization, motor skills, social skills and so on.

Some examples of skills that have appeared more recently: mathematics, engineering, human games, logic and much of what we call science. These are hard for us because they are not what our bodies and brains were primarily evolved to do. These are skills and techniques that were acquired recently, in historical time, and have had at most a few thousand years to be refined, mostly by cultural evolution. [\[a\]](#)

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“I was developing a passion for painting with words and spent endless hours searching for the right adjective.” Eric Hoffer, (Truth Imagined, p. 19).