Clear Speaking about Machines: People are Exploring Mars, Not Robots

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Abstract

The primary responsibility of all scientists is to ensure the integrity of their work. For cognitive and social scientists, this means first and foremost preserving clarity about what we know about people, and not allowing descriptions of technology to demean or obscure the reality of how people think, behave, and live. Without this clarity, engineering requirements analyses, tool design, and evaluations of people will be confused. A sharp, uncompromising understanding about the nature of people is essential if we are to design and fit new technologies that are appropriate and successful for NASA's mission operations.

Introduction: How scientists talk about robots

Scientists, in conversing with the public, as well as each other, often use anthropomorphic terms that are not appropriate for today's machines. For example, the initial NASA press release about the Mars Exploration Rover (MER) stated:

> **July 28, 2000** -- In 2003, NASA plans to launch a *relative* of the now-famous 1997 Mars Pathfinder rover. Using drop, bounce, and roll technology, this larger *cousin* is expected to reach the surface of the Red Planet in January, 2004.... This new *robotic explorer* will be able to trek up to 110 yards (100 meters) across the surface each Martian day.... "This mission will give us the first ever *robot field geologist* on Mars…" said Scott Hubbard, Mars Program Director at NASA Headquarters. (NASA 2000, italics added)

Besides casting the machinery as part of a biological family, this statement described the new Mars rover with phrases that would appear throughout the five year (and continuing) mission: "an explorer" and "a field geologist." The official Jet Propulsion Laboratory web site announced when the first rover landed: "Spirit Lands On Mars and Sends Postcards — A traveling robotic geologist from NASA has landed on Mars and returned stunning images of the area around its landing site in Gusev Crater…"(JPL Press Release 2004-003). Posted mission reports regularly ascribe machine initiative to remotely controlled actions: "Spirit collected additional imagery of the right front wheel."[1]

The confusion, of course, is that people are exploring Mars using robots: The machines have no scientific goals (let alone personal interests, including survival), no ability to use time wisely on any given day (let alone plan the mission strategically), no ability to decide what data to record (let alone perceive meaningful distinctions in the photos and measurements), and no ability to relate data to geological or biological hypotheses (let alone conceive new interpretations).

Referring to the robots as if they are people has negative implications for the space program. For example, the MER principal investigator, Steve Squyres, stated at the *NASA Symposium on Risk and Exploration*:

> We are very far away from being able to build robots - I'm not going to see it in my lifetime - that have anything like the capabilities that humans will have to explore, let alone to inspire. And when I hear people point to Spirit and Opportunity and say that these are examples of why we don't need to send humans to Mars, I get very upset. Because that's not even the right discussion to be having. We must send humans to Mars. We can't do it soon enough for me. (Dick and Cowing 2005)

Squyres aptly states the facts: "The rovers are our surrogates, our robotic precursors to a world that, as humans, we're still not quite ready to visit" (Squyres 2005, p. 378). Indeed, each MER is a kind of mobile laboratory, including a microscope, spectrometers, and cameras, that are remotely controlled by computer programs laboriously

[1] When something goes wrong or a problem is solved, attention shifts to the people behind the scenes: "The operations team has successfully commanded Spirit to drive using only 5 wheels" (Spirit Status for sol 778-783; Release Date: 3/16/06).

designed and transmitted from Pasadena, California to Mars every day.

One might rationalize the terminological problems with MER by excusing the journalists and public affairs officers, because only engineers should be expected to use precise, scientific terms for describing machines. Of course, the history of artificial intelligence (AI) research demonstrates the contrary—computer scientists have notoriously used anthropomorphic language to describe their programs (McDermott 1976). Thus, we have so-called expert systems, intelligent tutoring systems, and autonomous agents. More recently, the human-robotic interaction (HRI) community often uses the terms “collaboration” and “teamwork” with little discriminating consideration of what these words mean in human affairs (Clancey 2004).

Although one might meaningfully refer to a team of robots, as we refer to a team of oxen, or even a human-robot team playing a ball game (Argall 2006), some HRI researchers group the robots with the person in control, as if driving an ox cart were a “collaboration” between the driver and beasts: “Rather than viewing robots as semi-autonomous tools that are directed via human supervision, we envision robots that can cooperate with humans as capable partners” (Braezael, et al. 2004, p. 2).

Engineers are of course entitled to idealistic visions, but imagination and reality are confused in descriptions of current technology in scientific papers and official press releases alike. Instead of disciplined descriptions (what is a partner?), a free-for-all has developed that is indistinguishable from mass advertising, as in this blurb for AIBO, a robot modeled after a dog: “a unique companion, gradually adapting itself to your environment, capable of expressing emotion, very skilful and with an inherent desire to entertain” (Sony 2006).

A Human-Centered Approach

Science and engineering descriptions of machines must respect and be grounded in scientific studies of people. In developing technology for practical purposes, a balance must be struck by the creative motive to replicate nature (“biologically inspired” invention) and the realistic requirement to provide useful, cost-effective tools.

In either case, whether pursuing engineering for its own sake or to solve a practical problem (e.g., making lunar exploration safer and more effective), an engineer cannot rigorously use terms like “explorer,” “geologist,” “collaboration,” “teamwork,” as a specification for machine behavior without understanding what these terms mean in human affairs. This approach is often called “human-centered computing” (HCC) because it grounds both AI research and AI-based tool development in the study of human practices and needs (Hoffman, Hayes, and Ford 2001).

The starting point for HCC is clear thinking about the differences between people and current technology. If we start instead with an inflated view of machines, we get a diminished view of people, and the design process focuses instead on mitigating human failures. Thus, fantasized, idealized machines become the yardstick for critiquing human work and reason.

HCC research aims to be scientific by treating the differences between people and machines with integrity. We call certain programs "model-based" rather than "knowledge-based"—because they contain models, not knowledge. We distinguish between coordination, cooperation, and collaboration (Clancey 2004). We call MER robots laboratories, not geologists.

The nature of the MER rovers should not be confusing or difficult to describe, because aside from some path-planning and obstacle avoidance, they do not take any actions without being explicitly programmed (Squyres 2005; Hubbard 2005). Further, MER does not even use 1970s model-based inference to post hypotheses and plan behaviors. Thus there is no question about whether the rovers reason or judge, for they do not make any decisions about the scientific work.

When we do deploy a system with model-based planning and “self-programming,” you can be sure scientists and engineers will refer to the rovers as forming and testing hypotheses, just as they have described expert systems. But model-based machines have no ability to conceive ideas; they can classify data, relate categorizations to action plans, and sequence and compose abstract plans into detailed programs. Such manipulations of “semantic networks” provide a mechanism that is quite limited compared to how human conceptualization dynamically adapts and re-coordinates perceptual-motor categories and sequences (Clancey 1997).

To develop machines that can collaborate or even be servants, we need to understand these human relations, roles, and practices. Even a servant must interpret commands with respect to a social background, and adapt to unexpected circumstances, especially when unsupervised. What are the underlying perceptual and conceptual capabilities that make trust, teamwork, and collaboration possible? I have argued (Clancey 2004) that higher-order consciousness, with a dynamic concept of the self, inherently socially oriented, is necessary to collaborate in projects (e.g., scientific exploration, constructing a lunar outpost).

On the other hand, it is questionable whether an astronaut would actually want a robot that viewed itself as being a peer. This would mean for example, that the robot had the right to leave the project and go work for someone else, or to prove to people that it is capable of doing independent work, etc.

Furthermore, if robots are truly so capable, and cheaper and safer than sending people to Mars, why aren't we using them in coal mines, rather than endangering human lives? Surely it would cost less to develop a robotic miner and send it into a mine than to send a robotic geologist to Mars. But unfortunately, human lives cost less than robotic miners; and interplanetary probes cost less than human space flight.

Conclusions

What is the effect of human-robot interaction research on human culture? As for earlier technological metaphors applied to people (e.g., the brain is a telephone switchboard), the concept of "humanoid robot" is reductionist, serving to focus but also stall engineering. In particular, in the realm of space exploration, the idea of humanoid automation has deflected attention from a broader range of machinery (e.g., drills, automated trucks) and sensing and monitoring systems (e.g., for life support).

For the public, and perhaps indeed many scientists, the "robotic geologist" and "robotic explorer" metaphor has been taken literally, to mean that we do not need to send people to explore Mars, for we already have robotic explorers on the surface. This confusion extends to a kind of "Wizard of Oz" phenomenon: Transfixed by the images of Mars, we mythologize "the little rover that could"; and few attempt to grasp the complexity of the scientists' work "behind the curtain."

On the plus side, for those with a critical eye towards idealistic and poetic talk, the existence of these robotic tools provides concrete examples for clear speaking about machines: We can articulate better what we mean by identity, consciousness, society, responsibility, commitment, etc. by contrasting everyday human experience with the now starkly simpler and visibly determined, programmed behavior of these robots. And we can visualize better metaphors to guide engineering, such as a "robotic burro" (Hirsh et al. in press).

In conclusion, I believe that the primary responsibility of all scientists is to ensure the integrity of their work. For cognitive and social scientists, this means first and foremost preserving clarity about what we know about people, and not allowing descriptions of technology to demean or obscure the reality of how people think, behave, and live. Without this clarity, engineering requirements analyses, tool design, and evaluations of people will be confused. A sharp, uncompromising understanding about the nature of people is essential if we are to design and fit new technologies that are appropriate and successful for NASA's mission operations.

And finally, let us not become lost in an AI researcher's Pygmalion dream. When asked why we don't simply send robots to Mars when they eventually are more capable, rather than send people at greater expense sooner, Chris McKay, a NASA planetary scientist replied, "Even if computers progress so much that they can go to Paris, taste the wine, eat the food and come back and tell me all about it, I'd still want to go myself."

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