Real Tech Support for Robotics

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Abstract

This paper proposes an alternate reading of the *Creative Robotics* agenda. It attempts to formulate a rational for robotics research in the arts that hold promise for delivering contributions to the broader question of coexistence between advanced information processing machines and human beings.

1 Role Models for Robots

The role of robots in human society has been a contested question ever since Karl Čapek coined the term robot in his 1920 play RUR [Čapek 1920]. The dichotomy between the intelligent machine and unexpected consequences arising from (self) interpretation of its protocols continues into Sci-Fi novels, television series and film, leaving the marriage of super-intelligence and social behavior in machines unresolved.

All robotics research inherits this quandary. Before robotics research extended to practical questions of interaction with humans, this problem remained fairly marginal. Technical advances and improvements in industrial production have made previously expensive sensing and actuation technologies affordable, and companies are eager to sell them to a willing audience. But once robots entered the home and the leisure sphere, through toy stores and online resources, the problem of robots amongst people began in earnest to play an important role.

The robotics research community has actively engaged this question in recent years. The new field of Social Robotics [Fong et al 2002] investigates learning and imitation, gesture and natural language communication, emotion, and recognition of usually benign interaction and social behavior. Thus, social robots are usually designed as assistants, companions, or pets, in addition to the more traditional role of servants. As such, robots are designed with the intention that people might have "natural" exchanges with them, and the term natural is most often translated into robots that act like (some) people act and look like (some) people look. Since most humans are more comfortable interacting with their own kind, it is believed human beings would most readily accept the presence of a robot if it appeared as they do. The tradition of dolls, puppets and automata, together with the social robotics agenda have converged in the entertainment industry to cement the validity of familiarity in the design of robots. Whether it is a pet or a companion, an entertainment robot usually "looks like" what it is intended to be perceived as. The most decisive formulation of this hypothesis resulted in the class of humanoid robots. To date, however, even the very best attempts at artificial lifelikeness fall disappointingly short of life itself.

1.1 Post-Mimetic Robotics

In the 1970s Masahiro Mori developed the principle of the *Uncanny Valley*. This principle states the following: As a robot is made more humanlike in its appearance, the emotional response from a human being to the robot will become increasingly positive and empathetic, until a point is reached at which the response suddenly becomes strongly repulsive. At this point the robot resembles a human, but differs from a human in slight but perceptable and cumulatively significant ways. Thenceforth, as the appearance and motion are made to be indistinguishable to that of human being, the emotional response becomes positive once more and approaches human-human empathy levels. Some researchers have challenged this principle, while others have embraced it with certain caveats. Dautenhahn [Dautenhahn 2002], for example, argues that appearance is secondary to movement. Humanlikeness would need to be achieved on multiple levels simultaneously (appearance, motion, speech, behavior, etc) in order to be believable.

The history of the (visual) arts might offer some unexpected guidance for researchers struggling with this question. Artists at the end of the 19th century radically departed from direct forms of representation once technologies that superceded human mimetic capabilities

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were in place. Photography irrevocably altered the role of painting, and film irrevocably altered and augmented the role of photography. In the course of the 20th century, a variety of conceptual, performative and socially engaged art agendas emerged that continued the non-mimetic approach. Even media that use established techniques of drawing and coloring, such as comics, usually achieve believability in character by deviating from common notions of realism, as Scott McCloud observes [Bolhafner 1994].

This observation is conceptually in synch with some of the more interesting new ideas in Artificial Intelligence research. Drescher [Drescher 1991] sees an engineering replica of a universal human learning mechanism as an intractable problem, and a rather useless one at that. Because thinking is always thinking about something – and that something is fundamentally different in the machine than in the human, the synthetic thinking of robots will be very different from our own. Consequently, we need not imitate our own thoughts in the machines we make.

In the Believable Agents research community [Bates, Loyal, Reilly 1992], the notion of lifelikeness is also not equated with mimicry. Believable agents are the union of AI-based autonomous agents and the personality-rich, emotive characters that appear in the dramatic arts (e.g. theater, cinema). Believability is a term used by character artists to describe a property of compelling characters. Believability strives for internally consistent, lifelike and readable behavior in such a manner as to support an audience in suspending disbelief and entering the internal world of the character. This is not the same as realism. Characters are not simulations of people, exhibiting behavior indistinguishable from humans under some controlled laboratory condition. Rather, characters are abstractions of people, whose behavior, motivations, and internal life have been simplified and exaggerated in just such a way as to engage the audience [Mateas 2002].

For these and other reasons that will become apparent below I argue for intelligently designed robotic systems that are informed by the history in the arts and that do not strive for obvious similarity with humans. Furthermore I will expand the argument against mimesis and suggest a form of robot design outside of that which we would "normally expect" from a machine.

2 Querying the Role of Automation

In "The Question Concerning Technology" Heidegger analyzes the reasons for his discomfort towards technology form the perspective of existential philosophy [Heidegger 1955]. He observes that automation technologies create a "standing reserve'" and that this standing reserve, while beneficial to economics, alienates people from their origins. Why worry about grinding grain when you can buy bread, cheaply, sliced and packaged, at your local food market. Heidegger might have argued that this efficiency has a price, and that the price is the difference between the lived experience of the complete cycle vs. the partial but practical experience of pre-prepared goods. Heidegger's observations of second order effects of automation and efficiency on our psyche are useful here.

When we build machines we make statements about the world. We make statements about things that should be changed, about materials that should be properly bent, finely grinded or cautiously heated up. When using computing machines, we implicitly make statements about data and the fact that the output of an operation does something useful to the input. Moreover, the effect of seeing these processes in action generates the belief that they produce something useful, that they truthfully interpret the data they collect and that, well, since it is so complicated, it is best left to the experts to decide how to go about these questions. But must all acts of automation result in such a standing reserve that removes one from original experiences? Must we always believe the experts who build and program the machines that surround us?

3 The Real Tech Support Initiative

The *real tech support initiative* is an attempt to conceive, design and build robotic systems that actively address the challenges of the standing reserve by querying the processes inherent in creating efficient machines. Real tech support is a reinterpretation of the popular coinage "tech support" that we have become familiar with in our daily struggles with ailing machinery. Real tech support interprets the role of automation differently; not as culminating in efficiency and optimal design, but in the thoughts, hopes, illusions and fears that accompany the desire for technologically inspired improvements to the human condition. Under real tech support, philosophical and social considerations are included in the initial parameter set; they are to be addressed with the same level of dedication as the more clearly definable technical questions. A calendar utility designed for a handheld computer under the real tech support design philosophy might periodically remind a user not to work too much, for example.

Machines devised under real tech support often perform no obviously useful work. However, these machines, *critical robots*, alter the flow of efficiency processes and replace them with situations and experiences that bring a person closer to an original experience. Since the real tech support initiative is interested in creating alternatives to efficiency driven automation, it must include in its agenda hard questions of reliability and robustness as standard engineering practices do. With this, critical robots under real tech support exceed the domain of traditional "robots for the arts". Real tech support is, thus, a practical philosophy and a critical engineering practice at once.

3.1 Practical Examples of Critical Robots under the Real Tech Support Initiative

The best way to show the kind of results this approach can achieve is to describe a few examples. The next section will describe four built and tested critical robot systems under the real tech support initiative.

3.1.1 Advanced Perception (1999/2000)

– Animal machine interaction (AMI)

This project was an early experiment in mixing machines and animal societies. Three chickens, Rhode Island Red hens, were held in a spacious cage together with a mobile robot for 60 days. The robot was programmed to share the space with the animals and to not infringe on their habits and movements. A camera mounted above the cage continuously monitored the state of affairs, the positions of all the chickens and the robot. Information from the camera was linked to a computer where the interaction scenarios were monitored. Corrective actions and plans were sent via radio signal back to the robot.

Figure 1: A Rhode Island Red hen pecking a robot

At first the chickens were very anxious about the robot's motions. They would scurry away every time the machine began to move. In order to reduce the anxiety of the surprise effect, the notion of movement by a machine, as perceived by a simple animal, required some attention. Audio queues were added such that the robot "announced" impending movement. This gave the chickens a perceptual queue by which they could know when to expect motion from the machine. Also, the robot would roam around but never hit an animal while moving forward. Over time the chickens got used to this and let the robot approach them to within an inch or so before moving out of its path. A series of different robot behavior algorithms were developed to test how well the chickens remembered the past actions of the robot. As one might expect, chickens have a short memory span. A fuzzy cognitive map based robot controller generated no deeper interactions between the machine and the chickens than a purely reactive system.

With the desire to share the insights from this research with a wider community, a new from of information dissemination had to be explored. In addition to publication in the engineering science community [Böhlen 1999], the results from these experiments were also presented in the form of a gala omelet dinner in an art gallery. A world-famous chef, Rudy Stanish created omelets by secret recipes that have been savored over the years by many dignitaries, even by some US presidents. A professor of philosophy was hired to help the chef. His job was to instigate discussions on theories of perception with the guests as they lined up for an omelet.

The intention in this work was to confront visitors with the cumulative results from the interaction, i.e. the chicken eggs. Would cohabitation with a robot affect the hens to the point that their eggs taste differently? This obvious question acted as a redirection towards a much more important issue. When we judge experiences that do not have prior references, we usually revert to opinion and taste. If one sees three chickens in a cage with a robot and tastes the omelet of the eggs from these animals, one is inclined to pass judgment on the basis of what one knows (how the omelet tastes), not on what one does not know (how the animals experience the robot), and likely to conflate the first with the later.

This experiment was called "Advanced Perception". It was left to the visitors to ponder where the advanced perception was to be found, whether it was in the machine vision system guiding the robot in the cage, the chickens' perception modalities -that are in some ways superior to our own-, or in the idea of an advanced/alternate mode of perception necessary to contemplate solutions for a future in which our technologies kindly intertwine with the world of "lesser" creatures. For details on this project see [Böhlen 1999].

3.1.2 The Open Biometrics Project (2001/2002)

-Transparent extraction of biometric data

The Open Biometric Project proposed an alternate approach to biometrics by challenging hard and fast classification of biometric data. A kiosk-like object asked passersby to place their index finger on a finger print scanner (see below) and then created a probabilistic map of how their finger scan might be tallied.

Of all biometric validation techniques, fingerprint based validation is the most established through out the world. The Open Biometric Project contested the clean fabrication of automated biometric identification. Whoever placed their finger on this machine was shown what kind of information biometric readers extract and how much judgment accompanies the creation of a final decision.

A fingerprint is made of a series of ridges and furrows on the surface of the finger. The uniqueness of a fingerprint can be determined by the pattern of ridges and furrows as well as the singular or minutiae points, local ridge characteristics that occur at either a ridge bifurcation or a ridge ending. The extraction of the minutiae points from a scan delivers the structural basis of identification.

Fingerprint matching techniques that use minutiae-based methods first find minutiae point positions and angles and then compare their relative placements to a reference fingerprint. The constellation and number of minutiae points build the basis for matching one fingerprint to another. Formerly a domain reserved for human forensics experts, minutiae extraction can now be translated into executable computer code. In the machine, both minutiae map and minutiae matching are found within degrees of likeliness and translated into probabilities. The results of these mathematical operations generate information that is valid within certain limits and under certain assumptions. The rules of probability theory ensure that the assumptions are computationally tractable.

Figure 2: The *Open Biometrics Project* in use

All of the underlying processes (signal analysis based noise removal, image enhancement, and feature extraction) are strongly dependent on the premises of probability theory. This robot percolated the decision processes of these mathematical substrata to the surface, and opened a window onto the reality of signal processing constraints that is usually not acknowledged in security applications. Each finger scan was accompanied by a list of the minutiae points and the likelihood (as a percentage) of actually being valid data. As opposed to claiming binary clarity and ultimate authority, the result of a finger scan from this machine was a mathematically precise and open list of probable results. It allowed the user insight into the internals of an otherwise hidden process and made the decision mechanism transparent and open for scrutiny and debate. Even the science of biometrics is prone to error, and neither heightened desire for secure and reliable solutions nor Hollywood thrillers should convince us otherwise. The machine printed this tabulated information as a probability map with all characteristic points of a finger scan, and encouraged users to keep their minutiae map cards handy, just in case a standard black box biometric reader improperly interpreted their fingerprint data.

For more information on this project see [OpenBiometrics 2002].

3.1.3 Unseen (2002/2003)

– A nature interpretation center with second thoughts

Unseen was a nature interpretation center with second thoughts; a knowledge mixing system that dynamically proposed expertise on plants and shared this with its visitors.

Nature interpretation centers are a romantic expression of the desire to understand and experience nature without giving up the comforts of civilization.

Figure 3: *Unseen* in the gardens of Grand Métis, Québec

Interpretation centers attempt to shore up this deficit through visual effects. Following trends in news and entertainment TV, they offer seductive media shows depicting portraits of wildlife busily eating, hunting, cleaning, and so forth—in contrast to the reality where usually nothing much happens.

A public garden offers an interesting conditioning of the natural environment for those interested in querying this cultural malaise. Midway between untouched, pristine land and controlled construction, public gardens are established forms of colonialized wildlife. Following the Linnaean tradition, marked trees and labeled plants promise clear classifications with no secrets. Paved paths and directional cues prevent accidental disorientation and exposure to unstructured spaces. There is no room and no need for questions.

Unseen proposed a very different approach. Set in the Reford Gardens of Grand-Métis on the Gaspé Peninsula of eastern Québec during the summer of 2003, the multi-camera real time machine vision system observed select plants indigenous to the region. The Dogwood, the Wild Sarsaparilla, the Harebell, the Foamflower, the Wild Columbine, the Garden Columbine, the Alpine Woodsia, the Lowbush Blueberry and the Canadian Burnet were under continued observation during the entire summer. Borrowing from data analysis and classification techniques, the system searched for, found and tallied instances of these plants. Short texts, constructed from a large database of acknowledged expert sources, depicted factual data on the plants and on computer screens in a small hut adjacent to the garden. Over the course of the summer, however, the flavour of the texts changed. As the initially sparse garden grew luscious, the system followed the changes and altered its "opinion" on the plants. The texts it created shifted from descriptive to hypothetical, and, having second thoughts, confronted the visitor with imagined future understandings of plant life. *Unseen* was an expert system driven by the very objects it observed. It was an open invitation to look again, with a fresh eye, at a simple garden. For more information on this project see [Unseen 2004 and Böhlen, Tan 2004].

3.1.4 The Universal Whistling Machine (2004/2005)

- Transgressing language boundaries

The *Universal Whistling Machine* (*U.W.M.*) is an experiment in establishing alternate communication channels between humans, machines and animals. Whistle at this machine and it will counter with its own composition, based on a time-frequency analysis of the original.

The impetus for this work was created by frustrating experiences with current computer based dictation systems. Given the unsatisfactory state of machine-based language understanding, it appeared interesting and necessary to experiment with a radically different approach to the representation of language in the machine. Instead of forcing machines to meet us humans on our (linguistic) terms, why not meet halfway, on the level of pure signal, where machines are better posed to perform well and humans still have the capacity to express themselves?

Usually, language is represented by a formal grammar, a set of combinational rules and a vocabulary. But language is more than a box of words and rules by which to combine them. Fuzzy aspects of language such as innuendo defy formal linguistic descriptions and are not even modeled in computational models of language that seek to represent communication in general. Languages are not static, and not fully describable through the grammatical rules that constrain them, however refined the rules may be. Many philosophers of linguistics, semioticians, and writers have pointed this out. Lecercle proposed the term "remainder" as a formal entry into the levels below, above, and adjacent to strait-laced meaning covered by linguists' version of language [Lecercle 1990]. For Lecercle, the remainder is the fallout from the intended use of language. It is the essence of poetry and metaphor, but also of miscommunication, word play, and double-entendre. It is the fuzziness and leakage of meaning amongst words.

Figure 4: *U.W.M.* tested by a discerning young man

But how could one possibly attempt to include the language remainder in computational systems? Is it at all possible, given that the rigor of linguistics seems even tighter in the limited corpora of texts, the defined rules and intelligent but blind numerical clustering methods underlying computational linguistics? In order to prevent varied and flavored meaning and language remainders from being filtered out of computation, it might be worthwhile to investigate varied and less structured forms of knowing, unorthodox methods of input, and unexpected flavors of output. This is not only a difficult problem, but also a poorly defined one. How can one even begin to formulate such issues as tasks, let alone make them computationally tractable? A general solution to this problem is beyond the scope of this work. However, one could suggest a replacement problem, one that can be solved and can serve as a lens by which to look at the original problem. Would it be possible to reduce the complexity of language to a more manageable subset, albeit one that still allows instances of language remainders to exist? Rather than creating a machine that is conceived with hardwired knowledge of a fully structured language, including vocabulary and grammatical system, would it be possible to create a device that is only *primed* for language? Is the ability to perceive and imitate a limited bandwidth of data that is mutually suggestive by machine and user as communication, a precursor to language, and can meaning arise in such a situation?

Playing initially with a variety of input methods we eventually settled for whistling. There are indeed numerous examples of human communication systems based entirely on whistling. This phenomenon was widely reported during the late 1970s in linguistics' circles [Busnel, Classe 1976]. Two of the better-known whistling languages are "el Silbo", practiced on the Isla de la Gomera, one of the Canary Islands off the coast of Morocco, and the whistled language of Kuskoy, a remote village by the Black Sea in Turkey that has only recently been connected to the telephone grid. In La Gomera, the skill is still being passed on to youngsters today.

Whistled languages are generally reduced languages, in the sense that not everything that can be expressed in speech can be expressed by whistling. However, they are far closer to languages than to codes or to simple signalization systems. They are speech-like and carry the vocabulary, the grammar, and in many cases the phonology of the local language they have emerged from, especially at the level of prosody.

Informed by these observations the *real tech support* initiative has designed and built a machine that is immune to spoken language but very sensitive to whistled input. The longer one interacts with the whistling machine, the more varied the response whistles become. Furthermore, multiple whistling machines can whistle with each other when no whistling humans are present. Examples of the kinds of exchanges that people and canaries have been able to generate with the machine can also be found on the project website [UWM 2004 and Böhlen, Rinker 2004].

4. Broader Implications

The robotics agenda I have portrayed in these examples differs strongly from that given by an entertainment industry driven agenda. This alternate agenda is inspired by the wish to carve a different niche for the artist in the age of intelligent machines. The artist need not be confined to the role of the beautifier, to the role of the expert on color matching and to the handy man for visual effects. There are too many instances where artists are delegated to create fancy surface effects for the work of scientists. Such is the case when cosmologists at NASA render their ideas visible for the public with the help of an *artist's rendering*. Supernovae and Mars Express Orbiters [JPL 2004] become visually salient and sellable with the help of graphic rhetoric.

I am proposing a more ambitious role for the artist as a maker in the technology arena. Why not make use of the highly experimental nature of the arts as an addition to accepted research methods? Engineers and scientists are not trained to include issues outside of their expertise into their work to the same degree artists have become accustomed to. The integration of advanced robots into the social fabric - and the creative robotics agenda is a new part of this challenge - touches on so many aspects of our existence that we cannot expect the established science of robotics to meet these challenges without additional support. Alternately, simply adding a playful appendage for "creativity" to the periphery of the current research paradigm holds promise only for even more robots that draw, sing and dance.

4.1 New Forms of Research

We should not continue with business as usual. Making intelligent machines for robust cross-cultural action in the real world will change both our ideas of what robotics research should consider as its object of inquiry and the notion of where acts of creativity start and end. Creativity is part of every endeavor and every discipline, and not limited to a specific practice such as the arts. We need to alter the expectation we have towards the artist. Hence forth he/she will be challenged to leave the comfortable role of the amateur behind and take on the role of the technically competent experimental maker. This new figure should be comfortable with the tools of the engineering sciences, yet retain the intuitive and direct approaches of the craftsperson and remain ready to "play against the apparatus" [Flusser 1983]. As opposed to carrying robotic technologies into the arts, I suggest carrying experimental methods and goals of the arts into robotics research in order to create a new form of inquiry that has real agency on social, conceptual and economic levels.

Robotic research in general can profit from this proposition. For example, the issue of *long-term interaction* between robots and humans can and should be informed from the practice that has always known an intricate mix of engineering skills and intuition: architecture. Architects have always had to find ways of integrating built systems into lived spaces, robustly for long-term interaction. While decidedly low-tech by robotics standards, the elevator might be a good case study for robots that are so effectively integrated into our environment that nobody notices them any longer.

Likewise, the new field of *mixed societies* [LEURRE 2005], the integration of robots and animals, could profit from observations in cultural studies [Agamben 2004] as well as from studio experiments by artists querying the same field before mixed societies was acknowledged as a research domain. While some methods typical of the humanities, such as ethnographic evaluation and social psychology have found acceptance in robotics research, the informal experimental methods of studio artists have not. But the integration of socially robust and pleasurable pervasive technologies into our daily lives will not be achieved along the paradigms of the engineering and social sciences alone. It is time we mixed all forms of knowing to meet this grand challenge. What such expanded disciplines will look like in the future is still hard to predict. Hopefully, the *real tech support* and similar initiatives will be helpful in this context.

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