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STS.711 Intro to STS

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Writing A Machine:

Technical Critical Practice

I. Introduction

In this paper, I will explore the proposal that technological artifacts, in addition to written texts, can be created as part of discourse in the field of science and technology studies, and can be as valid a contribution as academic papers. My main argument is one of symmetry: if we can read a text and write a text within STS, and read a machine as a text, I assert that it is valid to write a machine as a text. I would argue that the machine, be it computer program or Model T, can convey information that cannot be conveyed in the written text. I will argue that this is similar to the role of imagery in conveying information: it enables information transfer that is not possible with text alone.

I begin by summarizing the arguments in favor of reading artifacts as a text, and the role that such artifacts can bring to a more complete understanding of the role of technology in society. I continue by exploring a diverse selection of machines that have been created by a variety of contemporary technologists, historians, artists and publishing practitioners, and try to understand how their work is both presented and received. I discuss the roles that building technology can and cannot play within critical discourse, formally introduce the notion of technical critical practice, and finally attempt to summarize the argument with a call for an expanded role for building technology in STS.

II. Reading a Machine

Academia has a long-standing tradition of writing texts in response to other texts. S&TS, growing from roots in history and philosophy of science, has embraced that method of discourse while exploring other avenues for gathering information, learning from disciplines of anthropology, critical studies of literature and media, and sociology, incorporating methods such as ethnography as fundamental tools of the trade. However, the nature of science and technology studies implies that texts are not uniquely privileged to be the only primary source considered as worthy of discussion.

There appears to be a tendency in STS towards privileging the text over the artifact itself. Academic detachment allows discussions of topics as diverse as bicycles (Pinch & Bijker, 1987), of bubble chambers (Pickering, 1995), and of the Internet (Hughes, 1998); while it is clear the authors are extremely knowledgeable about their topic, it is not implied that said authors could, say, fix a flat tire, track a neutrino, or install a server themselves, and it receives special notice when such an event occurs, such as Woolgar's response when he assembles a PC:

> I could not believe I was to be trusted with putting one of these things together. Like my students and most others new to this experience, I was amazed that mere novices were encouraged to handle the very insides of such a revered item of technology. (Woolgar, 1991)

The argument for reading a machine as a text within the discipline is, I think, most clearly presented by Michael Mahoney in his paper *Reading a Machine* (Mahoney, 2003). He reads the Model T Ford as a text that makes clear Henry Ford's intentions: it was a machine that required assembly line processes, that…

> "…is cheap only if it is produced in volume. And the only way to produce in volume is to produce by machines. That is an essential meaning of the Model T read as a technological text: it is a machine built by machines. Its design makes sense only if it is built by machines. Hence, to have designed it is to have had in mind a machine-based system of production, in scheme if not in detail."

Mahoney uses the term machine "generically for the products of technology", a practice I will continue here. A software program, a physical artifact, a computer system, all fall under the rubric of machine.

A similar approach is taken by Traweek in the second chapter of her study of physicists and the machines they use. (Traweek, 1988) She describes how the detectors different groups use serve as a mnemonic devices for thinking about the various groups' models for scientific method: each is the 'material embodiment of a research group's version of how to produce and reproduce fine physics."[1]

For her and for her subjects, the characters of these machines – cobbled together, neat, dirty, unreliable or conventional – serve as representations of the characters of the

[1] To take a more semiotic approach, Barthes, in a defining text of postmodernism, (Barthes, 1971) states that "the Text is *radically symbolic: a work conceived, perceived and received in its integrally symbolic nature is a text.*" (Italics in original.) As critical readers, we can indeed read a text as a symbol; Barthes' work endorses with equal strength the creation of machines as text. Barthes' work also leaves open the interpretation of where the text stops. A Text can be a single book, paper, or program, or a much wider set: the text of anthropology literature, for example, is arguably a complex text about the Other. It's questionable whether we need to go into this here.

If we are to read the Internet as a text, say (Hughes 1998 Ch. VI), it is a complex machine that has many authors and readings. And my god, if we open up that box who knows where we'll end up.

group that own and have built them. Far from being black boxes, they are rich sources of narrative and projection, very transparent boxes indeed to the groups that built them, in a process of continual modification and improvement.

III. Machines Being Written

If we accept Mahoney's and Traweek's justifications, then clearly the machine can be read as a text. I propose that, by symmetry, we should be able to write the machine as a text. In this section, I present a selection of authors of machines in a variety of disciplines, including technology, art, and science and technology studies.

I divide these authors into four sections: the technologists, who primarily see themselves solving problems in a technological context, the historians, who write machines to more deeply understand historical context in science and technology, the artists, who write machines in critical response to society, and the publishing practitioners, who, like the artists, write machines in critical response to society, but also publish in academic journals.

These arbitrary categories merely serve to organize the examples, and to point out the diversity of uses that writing machines can serve. Furthermore, this is not in any way intended to be an exhaustive list of those engaged in writing machines, but rather a relevant sample. It serves to demonstrate the wide variety of purposes for which machines can be written: in each example, the machines ask different questions and are written for different purposes.

A. The Technologists

Josh Mandel & Keith Winstein: Library Access to Media Project

Mandel and Winstein, both students at MIT, built an elaborate system that uses the campus-wide analog cable television network to legally broadcast music on demand that campus residents select over the internet. (Schwartz, 2003) The system is specifically designed to address the legal limitations on music broadcasting:

> The critical language is subparagraph 6 of § 106: "in the case of sound recordings, to perform the copyrighted work publicly <u>by means of a digital audio transmission</u>" (emphasis added). As long as our transmission (over MIT cable) is analog (like most television), we do not need Norah Jones' or EMI's permission to play her song, nor do we need their permission to play the song over the radio. If we were to transmit the music to students digitally instead (e.g., over MIT's computer network), we would have to seek permission (which we believe would be excruciatingly difficult to obtain for most songs, with no acceptable bulk- licensing procedure available) or try to obtain a "mandatory" license under 17 U.S.C. x 114 (2000), which forbids "interactive" or on-demand services. (Winstein, 2003)

This is primarily designed as a functionary, technological object for the residents of MIT's campus to use. The authors are not unaware of its critical response to societal, technological and political pressures, but it is first and foremost a technological undertaking: a working piece of technology in response to a set of limiting factors. – many of which happen to be legal and political in nature. However, it can easily be read as a critical response:

> If that back-to-the-future solution seems overly complicated, blame copyright law and not M.I.T., said Jonathan Zittrain, who teaches Internet law at Harvard and is a director of the university's Berkman Center for Internet and Society. The most significant thing about the M.I.T. plan, he said, is just how complicated it has to be to fit within the odd boundaries of copyright law.
>
> "It's almost an act of performance art," Mr. Zittrain said. Mr. Winstein, he said, has "arrayed the gerbils under the hood so it appears to meet the statutory

> requirement" - and has shown how badly the system of copyright needs sensible revamping. (Schwartz, 2003)

Zittrain's analysis seems entirely reasonable: as I hope to show by further examples, I believe there is a power inherent in actually creating such a machine that would not be served by merely conjecturing on paper that such a system could, hypothetically, exist.

B. The Historians

Otto Sibum

Sibum sees writing machines by rebuilding key devices in the history of science as a useful tool, furthering the understanding of how scientific 'facts' came to be created and understood:

> The process of reconstructing the objects is potentially an extremely rich resource for an historian of science. (Sibum, 1994)

Perhaps the most well-known example is Sibum's reworking of Joule's experiments on the mechanical equivalent of heat, in which Sibum collected publications that detailed the experimental setup, and provided evidence of methods used and results produced. He then built a replica of Joule's paddle-wheel experiment, from which Joule derived the relation between mechanical work and heat, and established what is now known as the first law of thermodynamics. Building the machine made it clear how unintuitive the realizations that Joule came to would have been for most people at that time. Sibum states that his building of the physical devices was a key step towards understanding the role played by the practical knowledge Joule gained from his background as a beer brewer. (Sibum, 1995)

Klauss Staubermann

A similar practice in the history of science can be found in Klauss Staubermann. Staubermann's doctoral research revolved around the reconstruction of Zöllner's astro-photometer, a device designed to compare an artificial star with a real star by means of a half-transparent screen which allowed simultaneously observation of the two together., and matching the brightness and color of the artificial star to the real star by polarization. (Staubermann, 1998) This was an elaborate process, which included building optical components, brass and wooden parts, and even mixing a custom blend of gas to replicate the town gas used by Zöllner used to create the artificial star. Staubermann credits the writing of this machine as a key part of his research:

> The outcome of my work shows that the rebuilding of a complex instrument can become the most informative source in the process of reworking scientific practice. In the case of the instrument, my own experience led me from the assumption that the photometer was always an astronomical device to a richer and more precise understanding that the instrument is better seen as a projection device which subsequently formed part of an astronomical discipline. By rebuilding the instrument the historic sources fall into place, and by reinterpreting the historical sources the instrument acquires a more dynamic career.(Staubermann, 1998)

It is interesting to note that this process was not a blind recreation of the original device, but included redesigns and compromises for ease of construction where such changes did not impact the functionality of the original: Staubermann. For example, it was found easier to recreate the functionality of the calibration (collimator) telescope by edging the scale into the glass cylinder surrounding the gas flame, rather than inside the telescope. (p59) As such, even rewriting a historical machine is a creative act, with room for both practical and whimsical changes.

C. The Artists

Krzysztof Wodiczko

Wodiczko's theoretical framework is centered around the idea of interrogative design: he believes in designing artifacts that question the necessity for their own existence. Wodiczko writes in his manifesto for his theory of interrogative design:

> The oldest and most common reference to this kind of design is the bandage. A bandage covers and treats a wound while at the same time exposing its presence, signifying both the experience of pain and the hope of recovery… The proposed design should not be conceived as a symbolic representation but as a performative articulation. It should not "represent" (frame ironically) the survivor or the vanquished, nor should it "stand in" or "speak for" them. It should be developed with them, and it should be based on a critical inquiry into the conditions that produced the crisis. (Wodiczko, 1994)

Wodiczko has built several sets of designs that work in this way. For example, he spent a long time working with homeless people in New York City to build the optimal shopping cart for the homeless: a compact design with a space for recyclables, a lockable section for valuables, brakes, an extendable sleeping area and good handling. After significant ethnographic studies and multiple design iterations, the cart was presented to one of Wodiczko's homeless informants at a large press conference.

The point, of course, is that such an object should not need to exist, that designing an optimal shopping cart for the homeless is obscene, and underscores the need for social and political action. Once again, simply writing about the possibility of such a designed shopping cart would not have had the same impact as the built artifact. Furthermore, Wodiczko in effect enlists all other shopping carts used by the homeless as artifacts to convey his message: his device 'queers' all other carts, making them ask the same questions.

Natalie Jeremijenko

Natalie Jeremijenko actively contributes to several scholarly communities. (Jeremijenko, 2002) She has made major contributions to the field of human-computer interaction, such as her work *Dangling String*, installed at Xerox PARC, in which a motor attached to an Ethernet connection moved whenever traffic passed through the network. This was used as the quintessential example of Calm Computing: the notion that computer interfaces can be clean and simple, and fade into the background when not needed . (Weiser & Brown, 1996)

She has also made unique contributions to science and technology studies and public understanding of science. An excellent example of this is her *One Tree* project, which directly addresses questions of nature vs. nurture. A single tree was cloned one hundred times in a biology lab. Each seedling was then grown to a sustainable size, and the trees were planted in different locations around the Bay Area: each therefore reflects the different regional microclimates, physical and chemical stressors. Jeremijenko and her team have published a map of a bike tour of the trees: the map also emphasizes this cultural and historical context, showing locations of PCB contamination and lead pollution, legacies of the area's industrial past.

Treating Jeremijenko's work as a series of written machines gives a way to understand common themes between their different modalities, such as recognizing the experiential or felt element of her work: the public experience is in intrinsic part of the piece. For example, her Feral Robotic Dogs project involves upgrading robotic toy dogs with video cameras and with sensors that direct the dogs towards high concentrations of volatile organic chemicals. Typically, the dogs are modified in workshops by middle school students who then take them to empty sites zoned for future middle schools: Jeremijenko states that in the search for affordable real estate, many schools in the US have been built on old landfill and hazardous waste sites. The video cameras are placed under the robotic dogs' tails, pointing back towards the teams following the dogs as they sniff their way to contaminations. As such, the documentation formed is not of the bobbing dog-head view, but the experience of the watchers following the dogs, and their reactions and interpretations are key parts of the project. The Feral Robotic Dog project affords reflection in many ways, contributing to a deeper public accessibility of science, technology and policy.

Chris Csikszentmihályi

Csikszentmihályi is an associate professor at the MIT Media Lab, a fact that informs much of his current work. His machines, and the discourse he creates around his machines, is ironic commentary on the role of technology and technologists in society, as exemplified by MIT. An early project, *DJ I, Robot*, was a machine that performed the duties of a disk jockey, mixing and scratching dance music on vinyl. (Csikszentmihályi, 2003) For Csikszentmihályi, however, what made the project important was not the technical considerations involved in such a task, but the critical discourse he engaged in by talking to the mass media. He presented it as a replacement for the all-too-fallible human disk jockey, prophesizing, tongue-in-cheek, that his invention would replace all DJs in the future: a familiar rubric of technology-replacing-humans.

Similarly, his 2001 project *Afghan Explorer* (Csikszentmihályi, 2002) is presented as a robotic journalist, able to go to places that frail human reporters, embedded in US Army units – and under the political control of the Pentagon – are unable to go: if we're able to send a robot to Mars, why not Afghanistan? Again, Csikszentmihályi presents to the media as an eventual replacement for all human reporters: it is striking how few do not react strongly to the assertion that their jobs could be performed equally well by a remote-controlled cart with a few cameras and microphones.

Cziksentmihalyi makes important points about the role of technology in society, and the role of humans in technology. Much of his work is ironic commentary on the rhetoric of machines replacing humans, something that seems particularly common to hear from professors at MIT. He presents himself to technologists as one of them; by building these device it enables him to reach a significantly different audience than would be possible through the publication of a paper in, say, *Social Studies of Science*. However, it's not clear to this author that the technologists in question understand the commentary in the devices, and that they are not just seen as yet another whiz-bang technology from the Media Lab that the creator claims will change the world.

D. The Publishing Practitioners

Gaver, Martin, Dunne & Raby

Gaver, Martin, Dunne & Raby, all currently or until recently associated with the Royal College of Art in London, have created both machines and accompanying written texts as their primary form of social and political criticism.

Dunne & Raby's book *Herzian Tales* (Dunne, 1999) explores several machines the authors have built as part of their placebo project and then placed in the homes of their subjects. These machines have various properties that play with our understanding of science: one is a chair that transmits vibrations to the user, which the authors claim is in response to radio waves the device senses in the environment. A similar project is the electro-draft excluder: pit doesn't actually absorb radiation in any form, but makes the user feel more comfortable. (Dunne & Raby, 2001)

Gaver & Martin have, together and separately, written several machines that explore and question our notions of what technology is and does. A recent project, *The Drift Table*, is a coffee table with a central porthole showing an aerial map of Britain. It responds to weight placed around the perimeter of the table, and will drift in that direction. This is not a technology of efficiency: it is a technology of experience, playing with notions of furniture, of technology, and of place.

A perhaps more critical point is made by their *Dawn Chorus*: a birdfeeder designed to teach songbirds new tunes using operant conditioning principles. In so doing it questions the role of man in nature: What is appropriate? What is inappropriate? The device makes clear analogies to the other changes man makes in nature, and is a powerful way to encourage reflection on these important principles.

In all of these examples, the written or presented response includes documentation of how subjects reacted to the pieces: the users who had the Placebo Project pieces in their homes for months, the user who took trips with the Drift Table, weighing down sides of the table as he navigated with a road atlas. The reactions to the project become an important part of the way it is presented.

Michael Mateas

Mateas' work centers around the production of large-scale systems that encourage users to reconsider their assumptions. His recent system, *Terminal Time,* is a cinematic history of the last millennium ideologically colored by periodic choices made by the audience along the way. At three points, audiences are asked to answer questions like "What is the most pressing issue facing the world today?" Responses are collective: volume is used to measure levels of affirmation. The system then generates a history from its library of video clips and provides a voiceover that reflects an extreme version of the ideology of its audience. (Domike, Mateas, & Vanouse, 2002)

> Terminal Time is a history "engine:" a machine which combines historical events, ideological rhetoric, familiar forms of TV documentary, consumer polls and artificial intelligence algorithms to create hybrid cinematic experiences for mass audiences that are different every single time. History as it was meant to be told! (www.terminaltime.com/project.htm)

In performance, the audience is presented with one showing of *Terminal Time,* and then there is a brief question and answer period. They then see a second showing, giving them the chance to change their answers and see the changes that differing biases bring to the presentation, which continues to be presented in the documentary style with which we are familiar and trust.

I think the most powerful part of *Terminal Time* actually happens after the audience has finished interacting with the piece: the next time the audience sees any other documentary. It encourages the viewer to question the ideologies behind the next 'factual' documentary they see by Nova, by the BBC, by Fox. Perhaps this is the true power of writing a machine: it affords extrapolation, much as Wodiczko's elaborate optimized shopping cart for the homeless re-queers every shopping cart you see being used by a homeless person, and enjoins you to ask not "Why isn't that homeless person using a better shopping cart?", but "Why does that person have to push their belongings around in a cart at all? Shouldn't we do something about it so they don't have to be homeless?" It is not that this property is unique to the machine – Pinch & Bijker (1987) no doubt changed the way you reacted to bicycles for some while – but machines particularly afford such a response.

Phoebe Sengers

Sengers' work has centered around questions of scientific and technical practice of artificial intelligence and human-computer interaction, with particular emphasis on the critical technical practice: using critical theories from literature, cultural and science studies to inform technical work. Critical technical practice proposes that scientific and technological research be reflexively aware of its own assumptions, culture and creations: in essence, applying the critical discipline of science studies to technological and scientific production. (Agre, 1987)

For example, her *Influencing Machine* uses emotionally-laden art images presented on postcards to modify the child-like drawings it produces as output. (Hook, Sengers, & Andersson, 2003) What's interesting beyond the functionality is the discussion it promotes in those observing the machine. It encourages those who interact with the machine to reconsider and reflect on what machines can and should do: can machines produce or have emotions? Is this a valid thing for machines to do, and in what ways? How can one evaluate a machine that promotes these ideas of experience and emotion over traditional metrics of efficiency and productivity? What is particularly interesting is that the machine encourages reflection by both non-technical and technical communities: the former considering what machines could do, and the latter reconsidering what questions the machines they build should answer.

Sengers has also used technology to question assumptions in society, rather than technology itself. Her *Industrial Graveyard* project presents a small lamp being overseen by a larger 'guard' lamp, which is in turn controlled by the user. As a critique of technical practice, it questions the atomized behavior structure behind much agent-based artificial intelligence, resulting in schizophrenic, irrational-seeming agents. Her narrative-based structure produces coherent and lifelike responses, a significant improvement on the choppy and unsituated approach produced by current agents approaches to knowledge representation. However, it also serves to question psychiatric practice that reduces patients to a pile of data – clinical reductionism – and, further, the schizophrenic structure of postmodern life, imported from technology in an unthinking manner. (Sengers, 1998)

Other Machine Authors

The various authors presented here are not the only researchers writing machines in critical contexts. Simon Penny's robots (Penny, 2000), Warren Sack's work on conversational analysis (Sack, 1999), and Lucy Suchman's ethnographic-based work on situated actions (Suchman, 1987), have all influenced the field of machine writing; Wardrip-Fruin et. al.'s Impermanence Agent (Wardrip-Fruin, Moss, & Chapman, 2001) is an interesting example of a consciously second-generation approach to critical technical practice[2]

IV. What Machines Can Be Written?

Given this body of work, what can we say about writing machines? There are several key questions that need to be answered: I will not attempt to answer them all here, but they are worth asking. For example, what machines can be written? What is it possible to say with a machine? Are there limitations on what can be said with machines?

Many of the machines presented above, notably the work of Wodiczko and Cziksentmihalyi, are culturally critical and normative. They identify issues the authors see as problematic in society, and they see their work as a way to encourage discourse, discussion, and perhaps promote change around these issues.

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[2] There is also large amount of work done under the umbrella of Participatory Design, particularly in Scandinavia, (Ehn, 1988) would all, in many ways, look very similar to the practice of critically writing a machine I identify here. The latter deserves slightly more mention than I have given it: it is perhaps best summarized by Langdon Winner – brought to my attention by (Wardrip-Fruin, Moss, & Chapman, 2001):

One distinguishing feature in some Scandinavian approaches, for example, is to take seriously the design of technological devices for the qualities of social life they sustain and the everyday political habits they nurture.... Another point of departure in some of the Scandinavian approaches is that they affirm as both social policy and research method that impending technological developments should not be regarded as something external to the lives of those who will eventually be affected… Another promising feature in much of this work is the recognition that technological development can fruitfully draw upon a much richer array of human fundamentals than the mechanistic technical and economic models that have prevailed until now. One can draw upon models in philosophy and anthropology, and sociology to ensure that systems are not spawned and nurtured by a one-dimensional rationality. This means that beyond the critique of instrumental rationality lies a body of understanding and fruitful practice that one can begin to teach the next generation of technical professionals and ordinary citizens.... The overall promise is that [we] will see the rise of an orientation toward planning and design that can produce qualitatively superior systems, ones that are fully respectable in an economic and technical sense, but which incorporate a much wider spectrum of democratically relevant features in their shape and performance. Hence, democracy can be manifest in the process, in the evolving creation of technical knowledge and practice. Perhaps it will even be tangibly apparent within the lasting forms of the technological devices and systems in widespread use. (Winner, 1994)

But again, I'm worried that this is outside of the scope of this article, and if it isn't, this quote is going to take some unpacking.

The normative text is an entirely valid method of discourse in STS – indeed, one can argue that STS is inherently a normative discipline. (Jasanoff, 1996) However, there are several other modes of discourse that the machine and its accompanying text allow. For example, the work of Sibum and of Staubermann, as detailed above, shows the role of writing machines in historical, analytical context. A similar justification underlies the building of Babbage's *Difference Engine* by Swade and the staff of the Science Museum, London. (Swade, 2002)

There are also other questions that determine what can be written with a machine. One advantage to writing a machine is the wide variety of media available to the author: Mateas' work *Terminal Time* is a large-scale documentary-style cinematic presentation, users interact with Sengers' *Industrial Graveyard* on a computer screen, and Csikszentmihályi sees the channel for much of his work to be major media publications.

V. Machines & Their Accompanying Texts.

Many of these machines are also accompanied by written texts. Not all: different authors have different priorities in their balance between writing machines and written text. For example, Dunne & Raby have published several books; Gaver is a prolific writer of journal articles, and is one of the most referenced authors in the field of human-computer interaction, and Sengers and Mateas both write extensively in their multiple scholarly fields.

Conversely, Jeremijenko, Csikszentmihályi, and Wodiczko do not, as a rule, publish their work in a formal, scholarly manner. Jeremijenko, for example, frequently speaks at conferences ranging from *Doors of Perception* to *4S*, but generally does not write papers: her machines and installations are her preferred means of communication. Similarly, Wodiczko uses his machines as his voice: in fact, much of his book *Critical Vehicles* (Wodiczko, 1999) consists of photographs and documentation of his projects, and collected interviews with Wodiczko by reporters, scholars and other artists.

I do not feel there is a problem with these differing approaches to conveying information. There is no failure in a built machine having a written accompaniment. Perhaps the clearest analogy is that of a caption on a photograph: it does not diminish the value of the photograph, or imply that the photograph could be replaced by the caption.

The analogy to the photograph and to the image is a useful one. In technical disciplines, it is common to convey information in the form of imagery, and it is accepted that there is information that cannot be conveyed in a textual format. Engineering historian Eugene S. Ferguson described the utility – and indeed, necessity – of the use of images as "an essential strand in the intellectual history of technological development." (Ferguson, 1977) Much as photographs, pictures, and graphs can play roles in thinking that cannot be replaced by text, the machine can provide an opportunity for critical reflection that cannot be replaced by merely more of one of its component parts.

VI. What are the limitations on writing machines?[3]

The largest barrier to the wholesale acceptance of machine-writing as critical practice within science and technology studies is the inability of a non-technical audience to either read the machines as written or participate in the discussion by writing machines themselves.

In many ways, this is a barrier with which science and technology studies is familiar: an investigation of the ways of high-velocity particle physicists may require learning to read the output of a bubble chamber as a precursor to learning to read the physicist. However, the difference between that case and this that we are discussing is that we are considering reading and writing machines within the discipline, and not the writing of machines by an Other.

Part of the problem is alleviated by simple good scholarship. In writing a machine as in all other writings, it is the responsibility of the author to ensure that their audience can read and understand the work on a level necessary for the author to make their point. Related to this is the fact that it is not necessary to understand the inner workings of the machine to be able to understand the rhetorical point of a machine: Mahoney (2003) does not expect us to be able to assemble a crankshaft, and Sengers (1998) does not expect us to be able to read C++ code. For example, is that the work of all the

[3] Furthermore, here are no inherent creative limitations on writing a machine in a critical discipline. It is easy to assume that there is only one role that machines can play: Dalston & Galison describe scientists for whom:

"…machines offered freedom from will - from the willful interventions that had come to be seen as the most dangerous aspects of subjectivity." (Daston & Galison, 1992)

This is not the role that machines need to play in a critical discipline.

practitioners above is in no way incomprehensible or unclear: evidently, this is not an enormous problem.

However, there is a potential difficulty in that current practitioners in the field may not have the technical skills necessary to write their own machines and thus participate in a discussion in this manner. I believe that this limitation may be an obstacle to widespread acceptance of writing machines as critical discourse in the field. We accept that extensive working knowledge of a field is not required to understand it well enough to contribute to science and technology studies, although different metrics may be necessary to contribute to the field itself. (Collins & Evans, 2002) However, working knowledge sufficient to contribute to technical practice may be substantial, and I see no way around this other than to acknowledge the barriers and encourage collaboration as a means to surmount them.

VII. Technical Critical Practice[4]

These points made, however, I wonder if there is a role for a new kind of critical communication that does require technical knowledge: in short, technical critical practice. This concept is a play on Agre's concept of critical technical practice (Agre, 1987) which advocates critical reflection as a fundamental tool in the repertoire of scientific and technological practice, because it enables the researcher to understand what impasses are trying to tell them and so inform their work. For example, he shows

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[4] I had thought I was the first to use the term 'technical critical practice.' However, Wardrip-Fruin & Moss cite personal correspondence in which Sengers suggests it as an alternative nomenclature for their "second wave critical technical practices". (Wardrip-Fruin et al., 2001) Foiled again!

how a deconstructive analysis can inform new directions in artificial intelligence research:

> "1. Find a metaphor that underlies a particular technical subfield. An example of such a metaphor is the notion of disembodiment that underlies classical AI.
> 2. Think of a metaphor that is the opposite of this metaphor. The opposite of disembodied agents would be agents that are fundamentally embodied.
> 3. Build technology that is based on this opposite metaphor. …This technology will inevitably have both new constraints and new possibilities when compared to the old technology." (Agre, 1987)

As such, I define *technical critical practice* as the practice of building technologies for critical purposes. This can be within a critical discipline, such as science and technology studies or literary studies, or within a larger cultural or artistic context, such as the Scandinavian Participatory Design movement. This practice is perhaps closest to Wardrip-Fruin et. al.'s (Wardrip-Fruin et al., 2001) excellent analysis and notion of 'second-wave critical practice', but remaining primarily rooted in critical practice. Technical critical practice involves leveraging technical expertise to produce critical discourse, much as writing papers involves leveraging rhetorical and discursive expertise for the same end.

It is my hope that technical critical practice can be as informative in the critical discipline as critical practice is in the technical discipline. As such, there may well be cases in which those writing machines must, say, learn C++, or to assemble a crankshaft. Sibum (1995), Staubermann (1998), and Swade (2001) all show novel understanding derived from their technological approaches to critical practice. It is an exciting prospect: what if Voskuhl were to build a music-playing robot[5]? (Voskuhl, 2004) What novel understanding could result from that process? What if Helmreich were to build an artificial life system (Helmreich, 1998)that was grounded in principles he agrees with?

This brings to the forefront an important question. If Helmreich were to build such a system, would he be a science and technology studies researcher any more? Would he not be… one of Them?

VII. The Issue of the Other in Technical Critical Practice

I believe this is the key problem with writing a machine in technical critical practice. If we were to engage in technical practice, would we not be one of them, and lose our crucial impartial critical standpoint? The advantage of distance between subject and observer is articulated by Haraway:

> One cannot 'be' a cell or a molecule – or a woman, colonized person, laborer, and so on – if one intends to see and hear from these positions critically. (Haraway, 1991)

This tension of identity between Us and Them is a key issue in the field. Keller was one of the Them, but now writes as one of Us. (Keller, 1995) Labinger, one of Them, wrote suggesting that there should be more of Them in Us, and perhaps more of Us in Them (Labinger, 1995) and weathered a storm of replies. Scott, Richards and Martin

[5] What, indeed, if Voskuhl were to build a music-playing robot? Let us explore this as a thought experiment. Voskuhl, as a twenty-first century graduate student, does not have equipment, technical skill, or tacit knowledge inherent in the complex of practices and knowledges inherent in eighteenth century clock-making. She does not have access to a suitable collection of clockmaking tools. Nevertheless, as the historians mentioned before (Sibum, 1995; Staubermann, 1998) have shown, it is not inconceivable that she could acquire such skills and tools.

argument for involvement in the issues they are studying (Scott, Richards, & Martin, 1990), departing from the academic detachment We pride ourselves on, and Collins replies with his opinions on whether such action is appropriate for Us. (Collins, 1991)

But we do not assume that we have an impartial critical standpoint in the first place. STS is a useful place from which to view the practice of science and technology, but, we admit, it is not inherently privileged over any other viewpoint. (Bloor, 1976) Some would say that our point as a discipline is to encourage others to display the same honest humility in their assertions of the truth. (Jasanoff, 1995) We do not have a gods-eye view, nor do we wish to have one. For example, as fellow academics with a set of collegial and institutional commitments, how can we criticize other academics? If we say that writing machines renders us ineligible to critique those who write machines, does not writing texts render us ineligible to critique those who write texts? Of course not. This tension can provide a deeper understanding and critical viewpoint:

> I prefer to call this generative doubt the opening of non-isomorphic subjects, agents, and territories of stories unimaginable from the vantage point of the cyclopean, self-satiated eye of the master subject. (Haraway, 1991)

I venture that the ambiguity and perspective inherent in having a foot in two camps gives an enormous advantage to the self-critical and reflexive scholar, something STS claims as a key tenet.[6]

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[6] I worry that this may feel like sleeping with the enemy to those with wounds still bleeding from the Science Wars. I think I'm going to have to put a paragraph in about that, but it'll be hard to avoid treading on anyone's toes.

So what is the advantage to STS in embracing this new form of discourse? Some might argue that STS has been doing perfectly well mediating ideas through written and spoken words, and needs no supplement thereto. I would argue that the inherently interdisciplinary nature of technical critical discourse can provide mutability and an critical opportunity, increasing the scope and relevance of STS in both breadth and depth. It also gives the opportunity to bring the perspective of STS into the heart of technology: when Mateas presents *Terminal Time* to the American Association for Artificial Intelligence, it is bringing these fundamental ideas about representations of truth and accuracy in technology to an audience who, unlike us, do not deal with them on a daily basis.

I feel that technical critical practice is an opportunity for the science and technology studies as a discipline to learn and grow, as so to continue to provide relevant critical discourse. It is high time we in STS claimed this practice as our own and reveled in the understanding it can bring to ourselves and others.

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References

Agre, P. (1987). *Computation and Human Experience*. Cambridge: Cambridge University Press.
Barthes, R. (1971). From Work to Text.
Bloor, D. (1976). Knowledge and Social Imagery. In (pp. Chapter One, p7).
Collins, H. (1991). Captives and Victims: Response to Scott, Richards and Martin. *Science, Technology and Human Values, 16*, 249-251.
Collins, H., & Evans, R. (2002). The Third Wave of Science Studies: Studies of Expertise and Experience. *Social Studies of Science, 32*(2), 235-296.
Csikszentmihályi, C. (2002). Afghan Explorer. http://compcult.media.mit.edu/afghan_x/
Csikszentmihályi, C. (2003). *DJ I, Robot*, http://www.dj-i-robot.com/
Domike, S., Mateas, M., & Vanouse, P. (2002). The recombinant history apparatus presents: Terminal Time. In M. Mataes & P. Sengers (Eds.), *Narrative Intelligence*. Amsterdam: John Benjamins.
Dunne, A. (1999). *Herzian Tales: Electronic Products, aesthetic experience and critical design*.
Dunne, A., & Raby, F. (2001). *Design Noir*, http://www.doorsofperception.com/Features/details/9/?page=3
Ferguson, E. S. (1977). The Mind's Eye: Nonverbal Thought in Technology. *Science, 197*, 827-836.
Haraway, D. (1991). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective (Chapter 9). In *Simians, Cyborgs, and Women* (pp. 183-203.). Cambridge MA: MIT Press.
Helmreich, S. (1998). Silicon Second Nature: Culturing Artificial Life in a Digital World.
Hook, K., Sengers, P., & Andersson, G. (2003). Sense and sensibility: evaluation and interactive art. In *Proceedings of the conference on Human factors in computing systems* (pp. 241--248): ACM Press. http://doi.acm.org/10.1145/642611.642654
Hughes, T. (1998). *Rescuing Prometheus: The story of the mammoth projects--SAGE, ICBM, ARPANET/INTERNET, and Boston's Central Artery/Tunnel--that created new style*: Pantheon Books.
Jasanoff, S. (1995). Cooperation for What?: A View from the Sociological/Cultural Study of Science Policy. *Social Studies of Science, 25*(2), 315-317.
Jasanoff, S. (1996). Beyond Epistemology: Relativism and Engagement in the Politics of Science. *Social Studies of Science, 26*(2), 393-418.
Jeremijenko, N. (2002). *Jeremijenko notes*, www.cat.nyu.edu/natalie/
Keller, E. F. (1995). The Origin, History, and Politics of the Subject Called 'Gender in Science': A First Person Account. In S. Jasanoff & e. al. (Eds.), *Handbook of Science and Technology Studies*.
Labinger, J. A. (1995). Science as Culture: A View from the Petri Dish. *Social Studies of Science, 25*(2).
Mahoney, M. (2003). Reading a Machine (Revised). In. www.princeton,.edu/~hos/h398/readmach/modelt.html
Penny, S. (2000). Agents as Artwork and Agent Design as Artistic Practice. In K. Duatenhahn (Ed.), *Human Cognition and Social Agent Technology*. Amsterdam: John Benjamins Publishing Company. http://www-art.cfa.cmu.edu/Penny/texts/Kerstin_Chptr_Final.html

Pickering, A. (1995). *The Mangle of Practice: Time, Agency and Science*. Chicago: University of Chicago Press.
Pinch, T., & Bijker, W. (1987). The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems* (pp. 17-50).
Sack, W. (1999). Stories and Social Networks. In M. Mateas & P. Sengers (Eds.), *Proceedings of the Workshop on Narrative Intelligence, Cape Cod, MA*: American Association of Artificial Intelligence. http://www-2.cs.cmu.edu/afs/cs/user/michaelm/www/nidocs/Sack.pdf
Schwartz, J. (2003, 27 October 2003). With Cable TV at M.I.T., Who Needs Napster? *New York Times*, p. 1.
Scott, P., Richards, E., & Martin, B. (1990). Captives of Controversy: The Myth of the Neutral Social Researcher in Contemporary Scientific Controversies. *Science, Technology and Human Values, 15*, 474-494.
Sengers, P. (1998). *Anti-Boxology: Agent Design in Cultural Context.* Carnegie Mellon University, Pittsburgh, PA.
Sibum, O. (1994). Working Experiments: Bodies, Machines and Heat Values. In R. Staley (Ed.), *The Physics of Empire* (pp. 29-54). Cambridge.
Sibum, O. (1995). Reworking the mechanical value of heat. *Studies in the History and Philosophy of Science, 26*(1), 73-106.
Staubermann, K. (1998). *Controlling Vision - The Photometry of Karl Friedrich Zöllner.* Unpublished Ph.D Dissertation, Darwin College, Cambridge.
Suchman, L. (1987). *Plans and Situated Actions*: MIT Press.
Swade, D. (2002). *The Difference Engine: Charles Babbage and the Quest to Build the First Computer*. London and New York: Penguin.
Traweek, S. (1988). *Beamtimes and Lifetimes*. Cambridge MA: Harvard University Press.
Voskuhl, A. C. (2004). Bewegungen, die offenbar Rührung zu verrathen scheinen: Automatenbau und Automatenkunst in Aufklärung und Frühromantik in Deutschland. In B. Orland (Ed.), *Artifizielle Körper - lebendige Technik. Technische Modellierungen des Körpers in historischer Perspektive. Reihe: Interferenzen* (Vol. 9). Zürich: Chronos Verlag.
Wardrip-Fruin, N., Moss, B., & Chapman, A. (2001). The Impermanence Agent: Project and Context. In M. Eskelinen & R. Koskimaa (Eds.), *Cybertext Yearbook 2001* (Vol. Publications of the Research Center for Contemporary Culture #72): University of Jyväskylä, Finland. http://www.impermanenceagent.com/agent/essay2/
Weiser, M., & Brown, J. S. (1996). The Coming Age of Calm Technology. www.ubiq.com/hypertext/weiser/acmfuture2endnote.htm -
Winstein, K. J. (2003). *Engineering an Accessible Music Library: Technical and Legal Challenges*: Massachusetts Institute of Technology. http://lamp.mit.edu
Wodiczko, K. (1994). Interrogative Design. In *Critical Vehicles: Writings, Projects, Interviews* (pp. 16-17). Cambridge MA: MIT Press.
Wodiczko, K. (1999). *Critical Vehicles: Writings, Projects, Interviews*. Cambridge MA: MIT Press.
Woolgar, S. (1991). Configuring the User: The Case of Usability Trials. In J. Law (Ed.), *A Sociology of Monsters: Essays on Power, Technology, and Domination* (pp. 57-101). London: Routledge.