Robotics and AI are industries capable of creating great and essential social good. They are also gendered industries, creating gendered technology, which will have a huge impact on all of our lives in the future, disproportionately so for those not in the ‘norm’, as their voices will be silenced and traditional means of social balance may not keep up with technology.

In robotics and AI research fields and commercial industries, the average representation of women is below 5%. When women are involved it is usually in ‘non technical’ roles. Not only is there already a huge skills shortage in robotics and AI – and computer sciences more generally, but the lack of equal participation and representation of women has a huge impact at every level, including reward, leadership, innovation and design.

The problem seems to start in schools, where girls with potential in STEM are often side-lined through a) overt discrimination, b) unconscious bias, c) male dominated environment, d) stereotypes in curricula, e) lack of encouragement and support moving forward. Some solutions at this level include girl only groups, female role models/lecturers/leaders, active mentoring (male or female), male champions speaking out in support and encouragement, and curricula material that is entertaining/interesting for girls of target age/culture/background.

But what is the point of leading more young women to STEM careers when the workplace culture remains toxic? Salaries are on the whole 15 to 20% lower for women of comparable merit, and at every rung on the career ladder, fewer and fewer women receive promotions. At the same time women are routinely considered less intelligent, less skilful, less experienced and ‘less technical’ than their male colleagues. They are passed over for important or high profile projects. They are not groomed for success, instead they are often explicitly expected to ‘have difficulty managing work/life balance’ [Gartner] in a way that men are not. At the same time women also end up bearing the bulk of the responsibility for trying to change toxic work cultures, while men can remain oblivious or acquiescent. But if leadership doesn’t set the tone, then no one else is in an organization is able to follow. And leadership is rarely female.

I am the Managing Director of Silicon Valley Robotics, the non-profit industry association supporting innovation and commercialization of robotics technologies. Silicon Valley is leading the world in the development of robotics and AI. As a woman who has experienced the digital gender divide on many levels, including my own career and my children’s experiences, I was highly motivated to create a leadership role in the nascent robotics industry that would allow me to first-hand gauge potential problems and improve outcomes.

It is critically important for young women interested in entering the field to see role models. One of my initiatives has been the annual “25 Women in Robotics You Need to Know About” list that is published on a global robotics network. This has increased good outcomes for many of the women featured as we include a range of career stages, roles and industries. Women featured on the list have received more publicity, speaking engagements and media coverage, and this has resulted in increased investment, endowments and career opportunities.

The list also encourages women to enter the field, but once in research or industry, women are frequently isolated due to the low proportion of women in the field. Many companies have trouble even getting women to apply. Assuming that they are open/nontoxic to hiring women, small start-ups often simply don’t have any idea what best hiring practices look like. I created an article [‘How to hire women’](https://medium.com/silicon-valley-robotics/how-to-hire-women-8005bf5363bd#.8pmk0klfe) for robotics start-ups outlining best practices such as; a) including a diversity statement, b) vetting language for gender specific terms, c) conducting blind interviews, d) having women on your interview committee, e) images of women in the company visible online, f) doing unconscious bias training, g) sharing job posts with networks with higher concentrations of women etc. h) holding women centric events and i) championing your women in public.

Organizations which successfully retain women take an active role to; a) promote an inclusive culture b) recognize talent and accomplishments equitably c) actively mentor and champion women d) promote peer support networks, and e) aren’t afraid to publicly commit to diversity.

Once there are several women in a workplace, it’s common for women to self organize informal peer mentoring get togethers. But the majority of workplaces don’t offer this critical mass, so I have started the Women in Robotics network, to connect these local initiatives in a broader fashion. Our goal is to inspire more women in robotics to organize their own events and provide more opportunities for women outside of supportive workplaces to gather. Several hundred women have joined the network through word of mouth. We have held several very well attended events in San Francisco, and we have also had spin off events in Brisbane (AUST), Bristol (UK), Toronto (CAN) and Denver (CO USA) and at conferences and tradeshows.

While historically speaking robotics, AI, computer science and all the STEM fields have been highly gendered, some fields have shown improvement over the last 50 years, while others haven’t. Medicine, biology, chemistry and ‘life based’ sciences now have a much higher concentration of women than ‘hard’ sciences. This may relate to broader perceptions of the power and usefulness of the fields, or the inherent nature of the technology.

In either event, the time is right for these roadblocks to be removed. Many studies show that the majority of women appreciate working on something that solves problems for people, not purely for the technology or knowledge. Robotics and AI has recently shifted from one of the least pragmatically useful STEM disciplines to one of the most applied, creating many opportunities for robotics and AI to be used for social good.

At the same time, robotics and AI are starting to use methodologies from many of the ‘soft’ sciences and creative disciplines, borrowing from biology, neuroscience, chemistry, mathematics psychology, visual effects, film making and animation for swarm robotics, neural networks, nanorobotics, soft robotics, and human robot interaction. This creates many opportunities for more women to be engaged in the field.

But so far I am addressing simply roadblocks and solutions for getting more women into STEM careers. Lack of women in STEM leadership roles has many profound impacts, limiting innovation, reducing the range of solutions and social good addressed and perpetuating gendered technologies. Lack of input into design of robotics and AI systems can lead to unintended gendered consequences that are felt globally.

Lack of women in the venture capital industry, where only 7% are active partners in top investment firms also contributes to an increasingly skewed set of companies progressing via funding. Statistically startups with female founders are less likely to get funding unless there is a female investment partner in the room, and female founders tend to receive less funding. [Bloomberg, TechCrunch]. There has been some recent improvement as VCs do the math and discover that there’s a competitive advantage in backing women.

It’s proven that diverse teams are more creative leading to more innovation. Ironically the world considers startups to be beacons of innovation culture. The truth is that a startup is a very small team focused on solving/building one thing – to the exclusion of everything else. It is difficult for a startup to practice diversity, and yet we have an almost infinite need for a set of technology solutions that map to real world problems. This requires more diversity in thought, and life experience, specifically unlocking deep domain knowledge from other fields. If valued properly, this could provide a pathway for robotics and AI to engage with women from all walks of life.

And when it comes to the development and application of technologies, it is a myth that technology is ‘neutral’. Not only is technology developed by gendered teams, this perception of ‘neutrality’ ensures that the voice of the missing inputs is not seen as important. Consider the cautionary tale of seatbelt design and crash test dummies! While seatbelts and airbags have saved millions of lives, they have been proven to kill women. Crash test dummies were standardized to an average white male physique, and then mandated for all vehicle testing. This led to technology design that was good for anyone near the ‘norm’, but the results became very bad the further away from the white US male average you were. This has huge impact on both women and small men from countries like Vietnam, Italy etc. In spite of this issue being well known since the 1960s, it was the 2000s before this was changed in regulatory testing in any systematic way.

Robotics is the embodiment of AI technologies and will have a physical impact in the world. Design decisions are critically important. As Langdon Winner said, technology can be used politically to empower certain groups, but it can also implicitly disempower, through inherent affordances, capabilities and design decisions. Technology is not ‘neutral’.

The problems start with the data we collect and then how we act on it. Our Increasingly personalized and quantified world is creating a shape of human that tends towards the privileged male – consider the story of seatbelts and crash test dummies. This problematizes not just male / female difference but also makes life worse for anyone at end of scale from the ‘norm’.

And we are moving away from the idea of social equality into a world of customized individual experience. Whatever your biased worldview is, AI will be able to support and conceivably enhance it. We are reducing our exposure to oppositional viewpoints and creating personal filter bubbles.

And as our technologies become more social, we are perpetuating social stereotypes.

Robotics and AI technologies together will transform the world. This has the potential to do incredible good – we can double food production, make the world safer, healthier and happier. But robotics and AI also has the capacity to do bad, perhaps simultaneously. The spread of smart technology will cause an exponential increase in the amount of data that is collected, and provide an exponentially greater number of ways for that data to be acted upon in the real world. Robots are, after all, just AI and sensors in a physical form.

For the last 50 years, robots have been confined to limited roles behind closed factory doors, because they have been large, expensive machines incapable of operating safely around people. Robotics technology has become smaller, cheaper and safer, and these ‘collaborative robots’ will be able to work alongside people dramatically changing the nature of work that robots can do. Witness the spread of the robot vacuum cleaner! There are now more than 15 million Roombas in homes, and iRobot is just one of many companies producing robot vacuum cleaners, which now account for more than 20% of vacuum cleaner sales globally.

But robot vacuum cleaners are very primitive compared to the next wave of robots, and they are fairly transparent in design and operation. We find them ‘cute’. As more robots roll out, many of them will have sophisticated social interfaces. This is necessary, because for robots to operate safely and smoothly in the world, they must interact with people, including ordinary unskilled people, or people who don’t have access to a control tablet or computer screen.

The first wave of smart devices is already trickling into our lives. These devices will respond to our voice, use cameras and other sensors to recognize us, and display faces, gestures and emotions to convey information to us.

This raises many issues, not least privacy, transparency and security. Who owns this data? Who stores it? Who has access to it? What use is made of it? These are not inherently new issues, as we’ve already considered them in regard to the Internet, but the scale and scope of the problem is shifting, as evidenced by concerns over topics like drones and privacy.

What is inherently new however relates to the underpinning robotics and AI technologies. Machine learning is to both. At present, machine learning operates in comparatively narrow areas and is not ‘general purpose’, but recent advances in unsupervised learning and the ability to make inferences about a much wider range of unstructured data mean that machine learning approaches can soon be incorporated into almost any system.

One of the first problems is that these systems will not be transparent. Very few people will have the expert knowledge and access to understand what is happening in a system. Instead we will see a platform approach, similar to the roll out of voice assistants, where a few companies with expertize in developing NLP (natural language processing) combine with other components of the hardware/software stack and create a packaged platform. A black box, like Siri or Cortana, which everyone else operates on top of.

We have already seen dramatic failures of machine learning in social/cultural domains, like Microsoft’s Tay. Until now machine learning has only been useful in narrow domains, of seemingly neutral knowledge, ie recommendation engines for films, books and other purchases, insurance quotes, flight schedules, traffic mapping etc. It turns out that these fields were not really socially neutral, For example, searching for examples of male or female professions would show, worker vs home maker, doctor vs nurse. Similarly black faces were either unrecognized by systems, or negatively correlated to criminal stereotypes.

There is inherent ‘regression to the norm’ in the collection and manipulation of data. If you do not fit the norm, you will be marginalized or demonized. This will occur in many more ways in the future than we have ever experienced before. This will occur both secretly, in black box data collection and manipulation and algorithms, and it will occur publicly with the spread of robots.

Robots are the embodiment of AI technologies. As they become more sophisticated and capable of more interactions than a Roomba, we are also creating pseudo social creatures. Some companies are creating humanoids and there is already a clear tendency to perpetuate gender and racial stereotyping. We are seeing female service attendants and male security and authority robots. This is just the tip of the iceberg.

We are building both virtual, nonphysical gender stereotypes into our social interfaces, starting with chatbots, voice assistants and artificial intelligences, but continuing on to every new robotic device that we will interact with in the future. Social interfaces will become the norm for operating technology and many studies show that we like female service providers, as warmer and more friendly, but rate male agents as more intelligent and trustworthy. So already designers are creating female personalities for subservient roles, and male personalities for dominant roles. Technology is repeating and exaggerating our cultural biases.

A robot is a construct and does not operate in any way like a human or animal. While we may all be rationally aware of this, we all behave as if a robot is alive when we have a social interaction. Humans are just designed that way. We anthropomorphize. We see things as alive. For millennia, our instinctive anthropomorphization has kept us alive, alert to predators and helped us forge strong social bonds to enhance our survival.

Robots lie. And that is their nature. No, that is anthropomorphizing them! Robots are constructs and social interaction is being crafted into them for reasons that start with safety but are primarily driven by commercial purposes. Robots will be very skilful manipulators of human emotion and behavior. Sadly, a robot/AI will not need to be sophisticated enough to fool you for long, to sustain a conversation or to be socially useful as a companion or helper. Those capabilities are still a long way off. Robotics, AI and machine learning remains a very blunt tool when used on our complex social world.

Right now however, robots/AI will be able to insert an opinion or trigger into our lives in many, many more ways than we can catalogue here. Already our Alexas offer to order the next album from the artist we’re listening to (licensed by insert label here); our automobiles offer to direct us to the closest gas station (sponsored by insert brand here); and all our online activity routinely advertises to us.

Now imagine this in the context of a ‘Cambrian Explosion of Robots’ as Gill Pratt, head of the DARPA Robotics Challenge, described it. Robots of every shape and size will soon be in our lives. And they will all be connected and capable of collecting data, identifying us and triggering small behaviors in our daily lives. All of this will be built on a black box of decisions made with stereotyped data aimed at triggering stereotyped behaviors, clothed in a sympathetic personality casing. We may well be happy with this!

We talk about the democratization of technology as a powerful positive thing, but that implies that each individual has access and control over technology. In reality, we are becoming divorced from our technologies although they are becoming more intrusive in our lives. As technologies become more universal they regress to the norm, become opaque to us, and what is worse, they worse promise us individualization and customization, which creates a filter bubble effect. Our technology interactions are no longer socially obvious or mediated by socially accepted laws and customs. While this is potentially negative for everyone, the impact will be disproportionately greater for minorities and diversities, weakening the visibility of discrimination and limiting opportunities to operate as groups, which are more powerful than individuals.

Silicon Valley Robotics promotes [5 principles of ethical design for robots](https://medium.com/silicon-valley-robotics/what-is-good-robot-design-5810111621fe#.vuaeqsxyv), adapted from the 2010 EPSRC workshop on Principles of Robotics. The 5 core principles are:

* **Robots should not be designed as weapons.**
* **Robots should comply with existing law, including privacy.**
* **Robots are products: and as such, should be safe, reliable and not misrepresent their capabilities**
* **Robots are manufactured artefacts: the illusion of emotions and agency should not be used to exploit vulnerable users.**
* **It should be possible to find out who is responsible for any robot**

Following these core principles should prioritize good design and guide companies towards to ‘design down’ practices, whereby only features that are necessary are included. An example would be to avoid giving robots faces, if they don’t need them. Or to avoid creating adult female personalities if a gender-neutral child personality would work as well. ‘Design down’ will reduce complexity of these already complex systems and also increase transparency. Robots will seem more like robots and less like people or agents, and we will tolerate their imperfections better as our expectations will be lower. This is when gender neutrality can be implemented, and also a modular approach to more transparent systems that allow better oversight and understanding.

My original research area considered the way in which we exhibited unconscious bias in ‘neutral’ technologies by ascribing names to objects. Names that reflected characteristics such as gender, leading me to propose that we start a global practice of using gender-neutral pronouns for objects. Particularly as the more personality that we ascribe to robots, the more it seems that robots are fitting into a social and psychological category called ‘slaves’. Perpetuation of slavery is not good for society.

It is hopeful that some researchers suggest that humans are capable of maintaining a dual or learned awareness of robots being ‘half alive’, having the characteristics of both alive/people and inert/objects. This awareness is effectively a completely new ontological category, as the human race has never experienced living with ‘half alive’ things before. Things that can behave and look like people, but aren’t. But there is insufficient evidence yet to show that we have evolved a psychological or social code around ‘half alive’ things. We may behave more lovingly to some things, but most evidence so far shows that we will behave more callously. And this in turn hardens us towards people that look similar, and displays callous behavior to other bystanders who in turn may be influenced by it.

We are poised at a watershed moment, where we might soon be living in a society where our technology makes us happy. But if individual happiness is no longer connected to broader social good then how can we reconnect it? As we have not yet achieved an equal quality of life for all members of society, we can’t afford to surrender so much of a human rights-based approach, to lose our motivation and ability to act as a society with shared goals.

There is great good will in the robotics and AI communities to improve the world. It is not always informed by best practices for the ethical design of robots and autonomous systems but there is much interest in developing these guidelines. However, as the components for robotics and AI systems become much more affordable, the spread of technologies will increase rapidly, without regulation. We need to be the evolutionary governors of this ‘Cambrian Explosion of Robots’.

Regards, Andra Keay

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TWO RECENT REPORTS ON NEW SERVICE/SOCIAL ROBOTS:

<https://svrobo.org/downloads/service-robotics-case-studies/>

<https://svrobo.org/downloads/service-robotics-case-studies-2/>

ADDITIONAL MATERIAL FROM SILICON VALLEY ROBOTICS:

<https://medium.com/silicon-valley-robotics/how-to-hire-women-8005bf5363bd#.8pmk0klfe>

<https://medium.com/silicon-valley-robotics/what-is-good-robot-design-5810111621fe#.vuaeqsxyv>