From Frankenstein to the Roomba: The changing nature and socio-cultural meanings of robots and automation

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1. What is automation?

Automation is defined as 'automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labour' (Merriam-Webster 2014). The term automation was first used in 1912. Robot first appeared later, in 1921 in a Czech play by Karel Čapek to describe a mechanical man. Both terms have been and continue to be imbued with divergent meanings and affect.

To understand the role and importance of automation and robots it is critical to look not only at their technical and industrial contexts but also at the social and imaginary that produces and surrounds them. Automation and especially robots have been present in Western popular culture for centuries – from Mary Shelly's Frankenstein in 1818 to contemporary Terminator films - and in many instances associated with fear and destruction.

Yet, in and around these forceful representations a diverse assembly of automation built-into mundane and ordinary interactions (photocopy machines, coffee makers, vacuum cleaners etc) that we take for granted in everyday life. Automation and Robots are also enduringly present in much Western discourse and technological imaginings of the future (such as hover boards and jetpacks).

This paper will briefly address automation's origins, promise and threats and how it continues to be imbued and influenced by a range of socio-technical actors which shape how we tell stories about, invent and use automation/robots in our everyday lives. In doing so it aims to ascertain key factors that have influenced and continue to shape Australia's uptake and innovative participation in the global robotic/automation market.


Source: (1) and (2) Public domain images

2. The birth and enduring presence of Ludditism

The origin stories of industrialised technological innovation and development are important to assess the present as well as the future of automation and robots.

A person who resists or feels threatened by new technology is often called a 'luddite'. The term luddite first emerged in 1779 during the technological revolution in the English textile industry; human operated weaving machines were being replaced by automated devices. Workers believed that this technological innovation would take their jobs. Led by a fictionalised character Ned Luddite, who was created to avoid direct criminalisation, workers broke into factories and destroyed the new machines.

235 years later the legacy of ludditism remains relevant today. The threat of automation taking human jobs is a stubborn trope in contemporary society and can be seen to shapeand in many ways limit automation perceptions and innovation. Miller and Atkinson (2013) suggest that there is a 'rise in the new ludditism' in relation to the relationship between technological change (particularly in the form of automation) and larger concerns over job security and fears about the future:

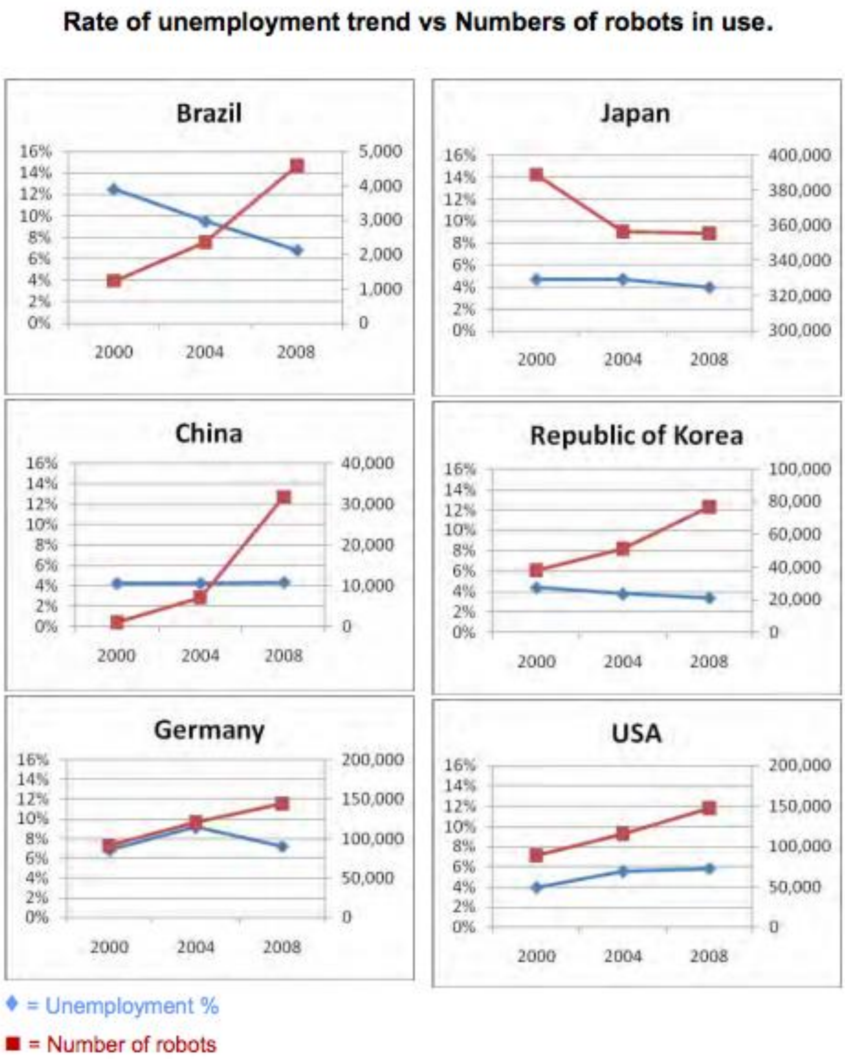
> *Over the last century whenever unemployment rates have risen there have always been some who blame the machines. Some even argued we were heading toward mass permanent unemployment. But what is different today is how widespread the neo-Luddite view has become and how well received it is in Western society (2013:1).*

This fear is so persistent that the International Federation of Robotics (IFR 2014) dedicates a webpage to attempt to dispel the myth - 'Robots create jobs' - and also publishes reports entitled 'Positive Impact of Industrial Robots in Employment' (2011, 2013). These reports put forward global statistics that illustrate how increases in robot productivity correspond to decreases in un-employment (apart from Japan). (See fig below).

Ludditism remains a useful device when thinking about contemporary consumer attitudes towards automation and robots. Some for instance argue that an aversion to robots comes from being fearful not only of what they might replace but of not knowing what they do and perceiving no purpose for them. This makes them easy to undervalue and dismiss. Grishin (2013) explains how meanings (and relationships) around robots can change:

> *"if [people] don't know what a device is doing they call it a robot. Once the device starts to do something useful, they are not called robots. They are called vacuum cleaner, car, aeroplane, coffee machine. And a lot of the stuff that we use today on regular basis, twenty years ago people called a robot'.*

This argument suggests that once we gain insight into the point and purpose of a technology, when it becomes personal or domesticated, it becomes less oblique and threatening. This perspective has been well argued in the social sciences (see for example: Lie and Sørensen 1996; Lally 2002; Haddon 2011) and is useful when considering automation and robots in the contemporary Australian context.



Source: IFR (2011)

3. Fordism and Post-Fordism

To understand the changing nature automation in western society it is also important to locate its origins in relation to Fordism and Post-Fordism.

Fordism has been the basic form of technology production since the beginning of the twentieth century. It is named after Henry Ford and the assembly-line mass industrialisation of Model T Fords, which were built under the banner of any-colour-you-want-so-long-as-it's-black. Fordism describes the mass production of standardized goods and mass consumption by homogenous consumers in a capitalist society. It is a concept used in contemporary social theory in relation to economic, production and consumption practices and systems. In a Fordist society, the automation process is focused more on the producer than on the consumer.

In the 1970s Fordism was succeeded by Post-Fordism. Here the focus is more on the satisfaction of individual consumers needs. According to Slater and Tonkiss, post-fordism is based on 'flexible, responsive production of more differentiated ranges of goods to ever more culturally differentiated consumers' (2001:179). In consumer-led capitalism, technological projects incorporate more than simply a logo, a name or a trademark. They embody feelings, relationships and values. It marks a shift towards the importance of relationships, information, knowledge and sign values.

Although robots have been a reality in industrialised manufacturing since the 1960s, it is only recently that they have started to enter into other markets and locations such as the home. This is a result of lower costs, technological miniaturisation and the diversified interests of a consumer market. Here, they operate in more intimate, personalised contexts, designed to assist with daily mundane activities – such as cleaning, care, health, entertainment.

Source: 'Robots That Care', The Telegraph (Naughton 2011)

3. Changes to the market

<u>- Australia's automation/ robotic history</u>

In Australia, robots were initially embedded in industrial and manufacturing fields – ie. repetitious mass industrialised assembly line production of similar items.

'Unimate' was the first industrialised robot installed in Australia in 1974. It was a US robot - '1,800kg steel arm with a grip at the end, the unit obeyed a step-by-step commands stored on a magnetic drum memory' which performed spot welding (PACE 2013). It was introduced into the automotive industry by Ford.

By the 1970s, robots were being used in a range of industrialised contexts – from automotive to white goods and farming. Their tasks were simple and repetitive.

The first Australian Robotic company started in 1972 - Machine Dynamics. Other start-ups innovated with robotic designs in the field of sheep sheering (PACE 2013).

In 1982, according to the ASTEC *Robots* report, there were 150 robots were in use in industry and manufacturing in Australia. They were used in industries of fabrication of metal products and transport equipment. The key benefits of these technologies were seen to be related to productivity, labour costs, product quality and safety and working conditions. All robots at this point had been imported to Australia from elsewhere. The main inhibitors to growth in this sector at this time were attributed to the lack of skills to run and manage them. However, it was anticipated that the robot market would grow to 1200-1600 in 1990 and possibly enter into mining and rural industries such as wool production. The report recommended the following strategies for developing the Australian robot market: tax incentives, import tariff protection, opportunities for local users to access robots and new training opportunities starting at tertiary levels in electronics, mechanical engineering and computer skills.

In a follow up to the 1982 *Robots* report, ASTEC's (1983) report on *Technical Change and Employment* identified the importance of the role of Government in supporting continued technological innovation. It highlighted:

- Australia's innovative success in product design but notes how 'the record for exploiting ideas commercially could be markedly improved' (1983:5)

- Interdisciplinary collaboration is critical - 'innovation involves a complex interaction between scientists, engineers economists and market specialists with the additional need for adequate venture capital' (ibid).

- Replicate successful innovation bodies elsewhere – such as the National Research Development Council (NRDC) in UK. This could enable opportunities for collaborative practice, co-ordination or technical assistance as well as finance/marketing expertise.

- The need to promote commercial innovation more effectively in Australia

- More training – basic understanding of science and technology is critical. 'To take maximum advantage of technological change it is essential to invest in human skills, not just in equipment' (1983:7).

Less than a decade later, ASTEC (1989:25) reported that there has been a growth in manufacturing robots from 150 in 1982 to 950. Robots were being used within mining industry, car manufacturing, biscuit packing lines, nuclear waste contexts and telephone assembly units.

Source: Mining Australia (Validakis 2013)

Australia is leading the world in robotic mining. They are being used in only one other place – Bingham Canyon Mine in the US. One of the barriers for adoption of large-scale automated systems is the high cost. However the scale of the investment and running costs of mining have enabled Australian companies to embrace cutting-edge technologies.

Rio Tinto and BHP Bilton are the primary players in this field. In these contexts automated mining trucks navigate via a network of sensors (GPS and radar) around a defined course in the mine.

Rio Tinto first started to trial automated vehicles (19 in total) in Pilbara in 2008. It is anticipated that this will be closed to 150 by 2018. The Australian Centre for Field Robotics (ACFR), located at Sydney University, has been instrumental in this development. In 2007, the ACFR in collaboration with Rio Tinto launched The Rio Tinto Centre for Mine Automation with the aim to 'implement the vision of a fully autonomous operated mine' (ACFR 2015).

Many advocates argue that the main advantage of the automated system is human safety (Spence 2014), however there are other benefits, such as: 24 hour day shifts, 7 days a week, increased output, decreased fuel consumption and reliability. Another reason this application

However, public perception of robotics lagged behind the promise of science and technology to solve problems or innovate new solutions. ASTEC's *Developing long-term strategies for, science and technology in Australia – Findings of the study: Matching science and technology to future needs 2010* (1996) reports on a distinct distrust of Government and new technology by young people:

> *Approximately 80 per cent of young Australians (interviewed in a national opinion poll) thought governments will use I&CT to watch and regulate people more Almost 0 per cent considered that computers and robots are taking over jobs and increasing unemployment and one third considered computers and machines will eventually take over the world (1996:67).*

Box 11.6. Opinions of Young Australians on Specific Future Effects of S&T

Specific effect of S&T in the future (n = 802)	Agree (%)	Disagree (%)	Don't know (%)
S&T offer the best hope for meeting the challenges ahead	69	28	3
Science will find ways to conquer new diseases	87	11	2
S&T will find ways of solving environmental problems without the need to change our lifestyle	45	52	3
Science will find ways to produce enough food to feed the growing world population	39	58	4
Computers and robots are taking over jobs, increasing unemployment	58	40	3
Computers and machines will eventually take over the world	35	62	3
Governments will use computers and technology to watch and regulate people more	78	20	3
Advances in computers and other technologies will make democracy stronger, giving more people more control over their own lives and governments	43	51	6
S&T are alienating and isolating people from each other and from nature	53	43	4

Source: ASTEC 1996a

Source: ASTEC 1996

20 years on and the global market for robotic technologies continued to advance. In 2000 the United National Economic Commission for Europe (UNECE) reported a worldwide boom in robot investment.

> *What was the evolution between 1998 and 1999? World market for industrial robots surged by 15%, mainly as a result of skyrocketing sales in the United States (+38%) and the European Union (+16%). Hesitant recovery in Japan (5%) but more pronounced in the Republic of Korea (70%).*

Reasons for this include: decreasing prices of machinery, economic growth, and more sophisticated robot designs. This boom was followed by falling sales between 200-2003. The world market for multipurpose industrial robots surged again in 2004 (UN and IFR 2005:31). (In these reports Australia is nearly always coupled with Asian data).

Advancements in sensors were also viewed as a driving force for change and innovation at this time:

> *Engineers in the 1990s first sought to solve this problem by developing sensory technologies that enabled robots to make small adaptations in their pre-programmed moves to account for variations in their environments. Early examples include seam tracking welding robots, vision systems and quality control sensing, and more recently integrated vision and distance sensing systems (PACE 2013).*

Fourteen years later, the growth continues. IFR (2014) reports that China is the biggest robot market in the world and robot sales reached record levels in Asia/Australia. Over 100,000 new robots were installed in Asia/Australia in 2013, up 18% from 2012.

Source: A sheep-shearing robot in Western Australia in 1980 (PACE 2013)

<u>- The changing global robot market</u>

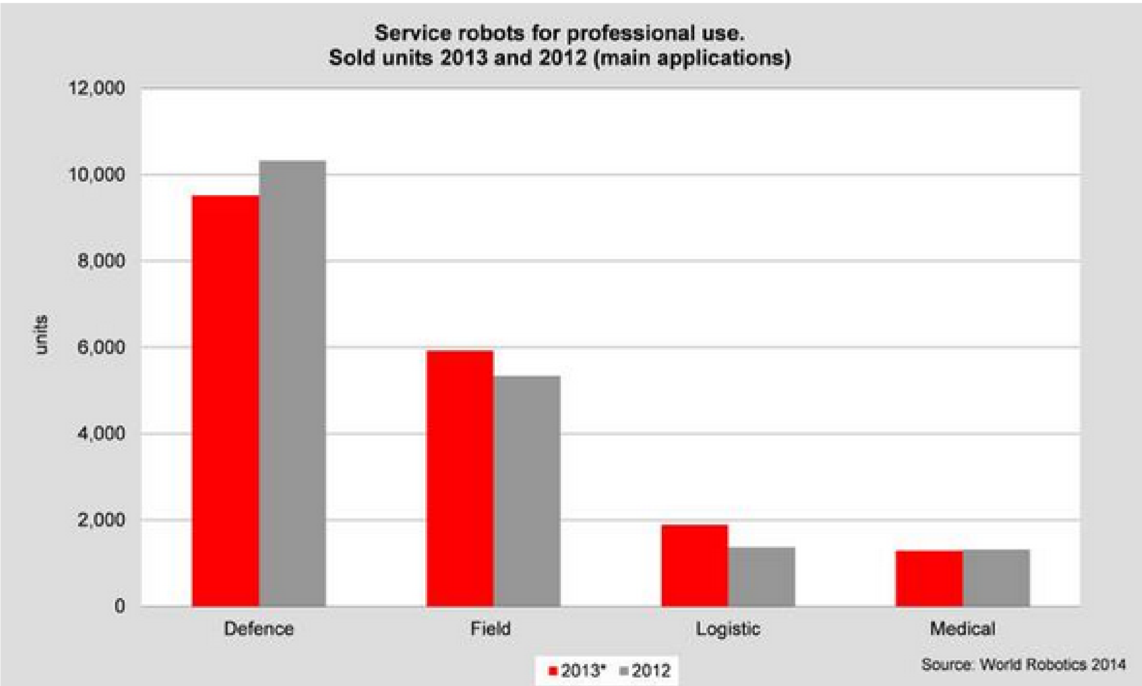
The robot market has changed and expanded in the last 30 years with the development of new smaller, targeted consumer markets. Previously dominated by industry and manufacturing, there has been a shift in line with reduced cost, size and increased technological capabilities into more domestic and personal service provision - such as home cleaning and maintenance, health care, telecommuting devices and home entertainment

> *The next generation of service robots will be used in industry, but some are forecast to become "Consumer products". This implies major new manufacturing activity. As quantities will be large, and precision and consistency are critical, this new manufacturing is going to need robotics. Alongside this is the employment of a whole new workforce (IFR 2013:62).*

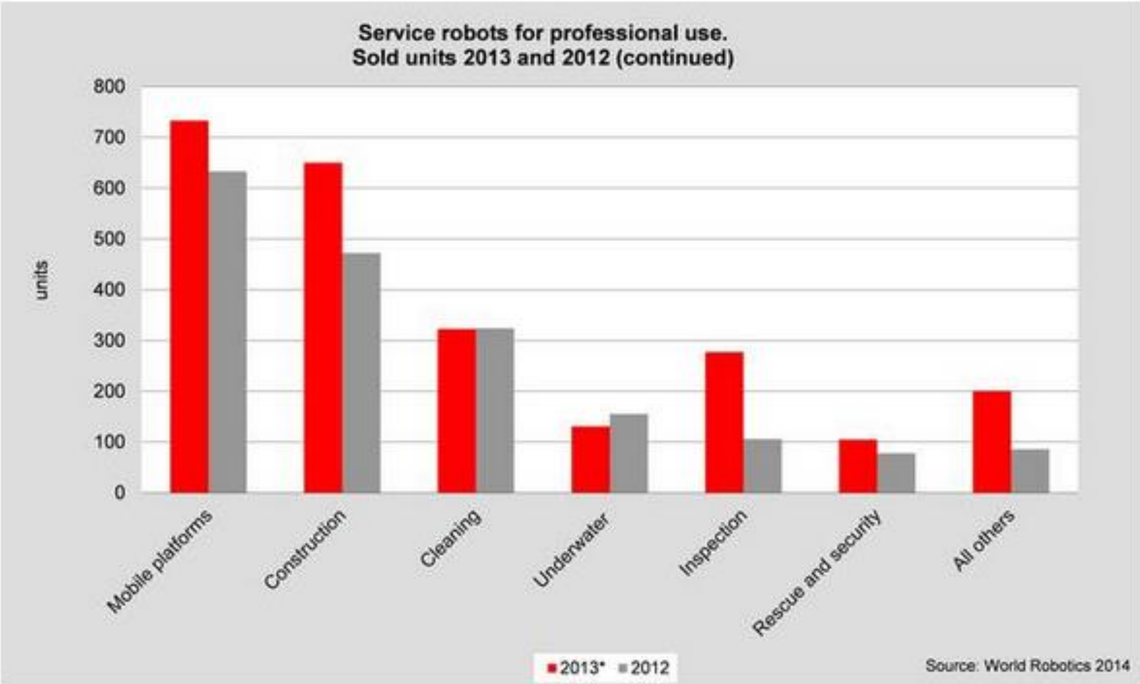
The IFR quote a report by the Robotics Industries Association (RIA) about the future of the global robotic market. Reflecting key themes in the post-fordist argument above, the RIA forecast the critical need to respond to shifts in consumer culture toward smaller, customised and targeted products and services:

As stated by the US Roadmap, "Robotics technology has historically been defined by the automotive sector and driven by price and the need to automate specific tasks particular to large volume manufacturing. The new economy is much less focused on mass manufacturing, however, and more concentrated on producing customized products. The model company is no longer a large entity such as GM, Chrysler, or Ford but small and medium sized enterprises…. The need in such an economy is far more dependent on higher degrees of adaptation, ease of use, and other factors that enable small runs of made-to-order products. According to the European Roadmap, the future of robotics will be one of much greater ubiquity. Miniaturization and new sensing capabilities will mean that robotics is used in an increasing number of industries, including those with small and varying lot sizes, materials and product geometries" (RIA cited in IFR 2013:62)

The IFR (2013) forecast the market for service robots for professional use from 2014-2017 to be US$18.9billion. This includes robots for defence applications, self guided vehicles, maintenance and cleaning, medical robots, public relation robots (for museums and supermarkets), construction and demolition, and surveillance and security.

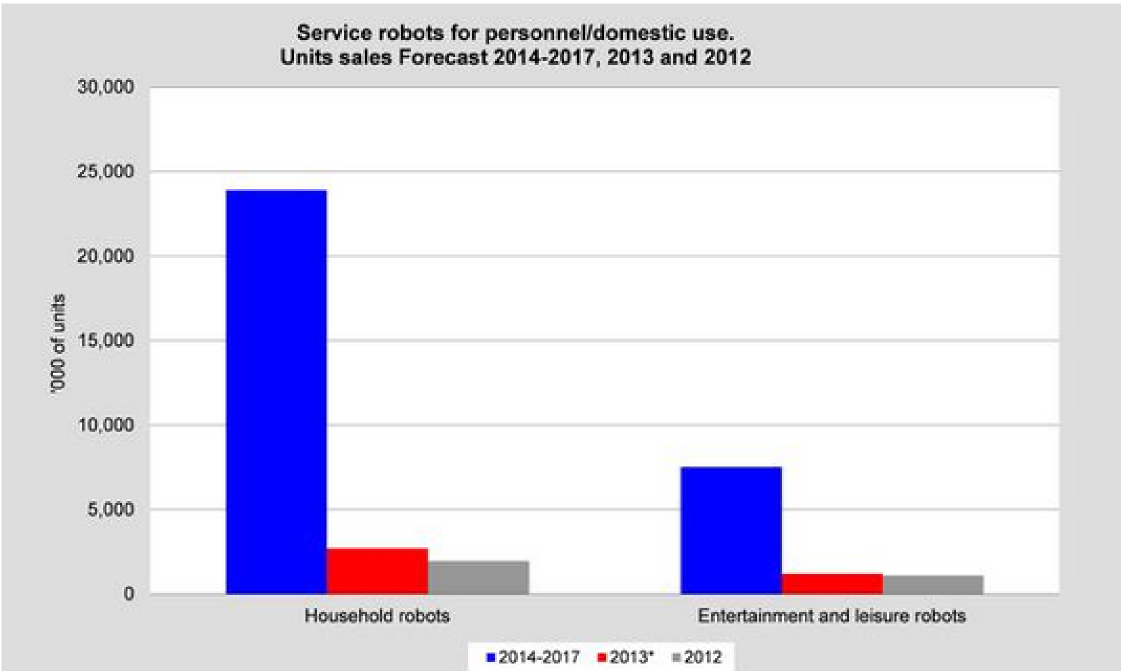


Source: IFR (2014)



Source: IFR (2014)

From 2014-17 the personal service robot market is expected to reach US$6.5billion. This includes cleaning robots (lawn-mowing, window cleaning, vacuums), toy robots, education and research robots, health care and disability assistance.



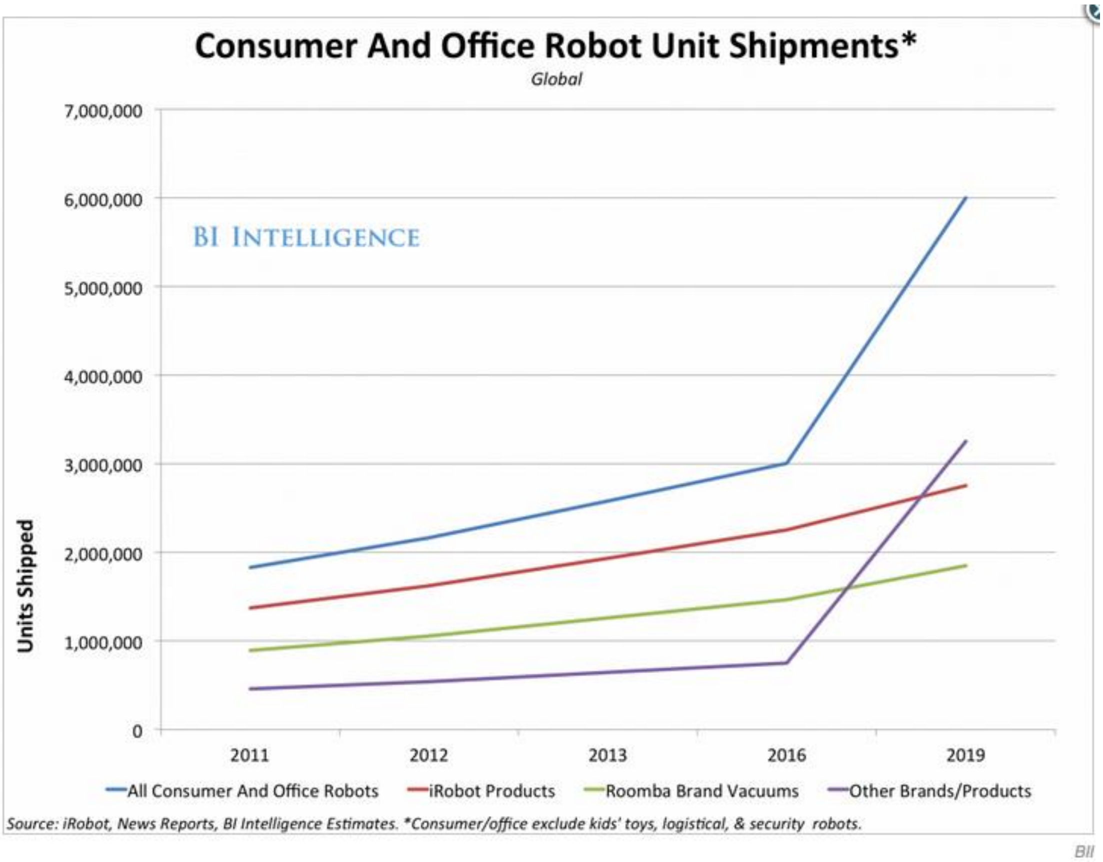
Source: IFR (2014)

There are conflicting forecasts of this new category. According to a Business Insider Intelligence report (Marcelo 2014), the home/ personalised service market (consisting of vacuuming, cleaning and entertainment etc) is forecast to grow to only $1.5billion by 2019, which although smaller than the IFR forecast, is still allegedly seven times faster than the forecast market growth for manufacturing robots.

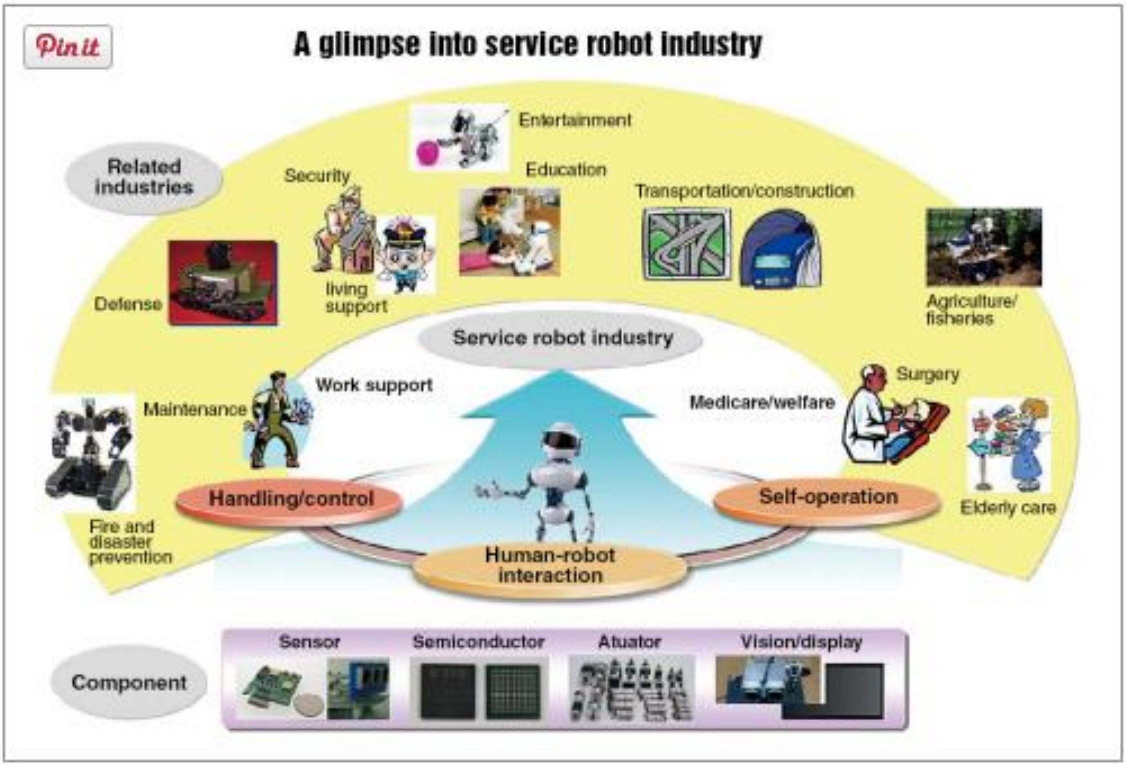
Despite the differences in forecasts what remains consistent is clear awareness of the potential and promise of this new market.

A report by Business Insider Intelligence (2014), cited in Marcelo (2014), argues this growth is due to three factors:

- Automation does not need constant supervision
- Automated technologies can be controlled and managed by the internet and mobile computing market which is embedded within everyday life and contexts of consumers. Ie. the internet of things
- New forms of automation – assistive intelligence. Devices do not simply follow instruction, but respond and 'predict' users needs



Source: Marcelo (2014)



Source: The Korea Herald (2011)

In Korea and Japan the increase in the robot market lies in the ‘service’ category. This relates in part to the needs of a growing affluent aging population. Birth rates have dropped and Japan is aging faster than any other country. By 2012 it is estimated that senior citizens will account for over a third of the population (The Economist 2013). At present prototype care robots take the form of medical assistants.

An example is PARO, a social robot in the form of a robotic seal used for therapeutic purposes by people with dementia. PARO was designed by a Japanese firm - Kinoshita Care. It was produced in response to Japanese Government support for R&D in the field of nursing. The Government outlined four key areas of interest: transfer care, mobility assistance, dementia care and continence care.

Another example is RIBA-II – a Robot for Interactive Body Assistance – designed by Japanese Research Foundation RIKEN in collaboration with Tokai Rubber Industries. This robot was designed in recognition of the repetitious task of lifting and moving patients, and often the cause of injury for care givers. Robots are well suited to this task.

However, one of the main challenges with this new developing market lies in ethical decision-making. At present these types of robots are designed for and well-suited to repetitive labour saving tasks, such as monitoring, lifting, taking temperatures and prompting patients to take medication. Designing a robot that can adapt to more ambiguous conditions or incomplete tasks and respond appropriately to a spectrum of emotional responses from a patient is a complex task.

The growth of this market can be related to differences in cultural understandings about the use and applications of robots. In the West, robots feature most significantly in popular culture as threatening technological forces. Although framed as 'entertainment' these communication mediums are nevertheless critical in shaping people's perceptions about technologies. In Asian countries they have been far less associated with these negative personality traits (Bell 2013).

- Sources of R&D support

Bekey et al (2008) conducted a study of the robotics market in Japan, Korea, US, France, Germany, Italy, Span, Switzerland, UK and Australia. They found intrinsic cultural and economic factors that shaped robotic innovation:

- Japan, Korea and the EU markets had more support from state based funding than in the US
- Labs around the world differed in focuses and interests:
- US lead the world in space and defence
- Japan and Korea lead the world with service, care and personal robots, including entertainment
- EU had programs that focused on urban transportation and elderly care and home service
- Australia was dominant in application related to mining and cargo handling

Bekey et al (2008) conclude by re-iterating that a culture of experimentation, interdisciplinary collaboration and financial support is critical to achieving success in the field of robotics. A concise national program and strategy for robotics drives technological innovation in countries such as Korea and Japan.

> *The most striking difference in research and development programs in robotics across the continents can be seen in the level of cooperation and collaborations between government, academic and industry (2008:99)*

Importantly, strength and size are not the driving forces in the market.

The authors stress how smaller countries such as Japan, Sweden and Italy all have a significant presence in the robotics market. There are more start-ups and spin offs in Europe than large countries like the US, even though it is well known for its entrepreneurial culture. Europe, Korea and japan also have more networks and robotic organisations. There were none noted by the authors in the US at the time of publication in 2008.

Also, the authors note the cultural shaping of robotics innovation:

> *The fundamental driver for robotics in the United States comes from military programs and Department of Defence interests. In Europe, Japan and Korea, these drivers are social and economic factors. Robotics is viewed to be an important industry, while Asians have identified an important role for robots in an aging society (2008:100)*

Area	Degree or Level of Activity			
	United States	Japan	Korea	Europe
Input				
Basic, university-based research (Individual, groups, centers)	*****	***	***	***
Applied, industry-based research (corporate, national labs)	**	*****	****	****
National or multinational research initiatives or programs	**	*****	*****	****
University–industry–government partnerships; entrepreneurship	**	*****	*****	****
Output				
Robotic vehicles: military and civilian	****	**	**	**
Space robotics	***	**	N/A	***
Humanoids	**	*****	****	**
Industrial robotics: manufacturing	**	*****	**	****
Service robotics: nonmanufacturing	***	***	****	***
Personal robotics: home	**	*****	****	**
Biological and biomedical applications	****	**	**	****

Source: Bekey et al (2008:7)

4. Automation's promise

- Designing new relationships

Traditionally, robots have been tasked with automated repetitive applications requiring little human interaction, such as loading cargo, assembly line manufacturing, spot welding etc. Increasingly they are become integrated into everyday life in smaller, more intimate contexts. They are in homes, workplaces and offices.

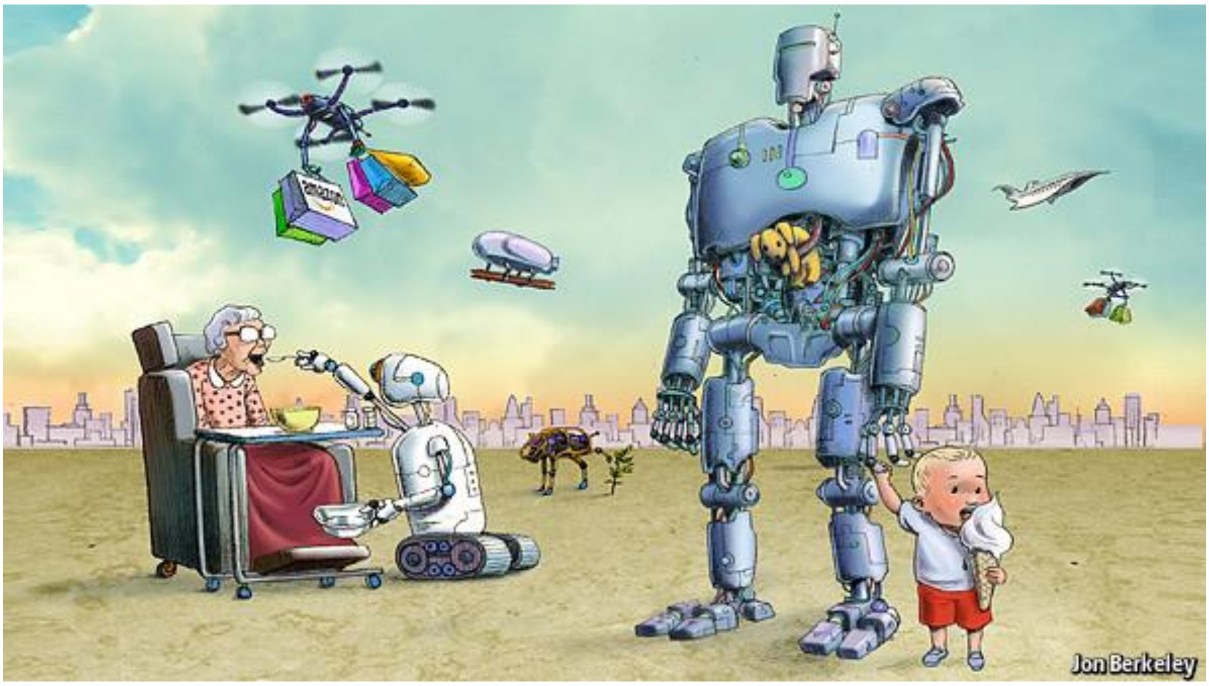
Bell (2013) emphasises how new automated technologies are most often designed for interactions rather than for relationships. She provides the example of the Furbi - an automated device that talks - to Siri - an automated device that listens. The latter is an object that we don't just interact with but we could potentially develop a relationship with. Bell argues that new automated technologies have enacted a dramatic shift - technology has the capacity to listen to us and this offers the potential to develop not only new consumer markets but also shift how we conceptualise robots in everyday life.

Central to building 'social robots' it a deep understanding of human sociality:

> *… one goal of building a sociable robot is to gain a scientific understanding of social intelligence and human sociality. Another goal is to design robots that can interact with people on "human terms". Accordingly, it is important to consider the specific ways in which we understand and interact with the social world. If done well, humans will be able to engage the*

> *robot by utilizing their natural social machinery instead of having to overly and artificially adapt their way of interaction' (Breazeal 2002:6).*

An example is the Roomba, an autonomous robotic vacuum cleaner. While this is less interactive with humans, it is a device that senses and responds to the environment. In doing so, it has been imbued with human characteristics and features in popular Youtube videos and the @SelfAwareRoomba has 23,900 followers on twitter.



Source: The Economist (2014)

<u>- Expanded forms of delegation</u>

One of the familiar socio-technical arguments, borne of ludditism, is that technologies will take things from us. This is regularly played out in relation to robots and yet there are many examples of how automated technologies have been put to work to do things that humans can not or do not want to do; from assembly line manufacture and photocopying to more technical jobs such as bomb disposal (Carty 2014) and minimally invasive robotic surgery.

The recent introduction of driverless cars delegates the act of driving to a robot. They have already been allowed on roads in test conditions (BBC 2014b). This is the most recent form of socio-technical delegation, from which emerges familiar anxieties as well as new ones pertaining to regulatory issues and system design:

Benefits	Issues
- Fewer accidents - Less road rage - More fuel efficiency - Less need for parking - Safer interactions with other road users: ie. cyclists, pedestrians	- More people traffic congestion and pollution may increase (this new technology does not get people *out* of cars) - Current regulation will need to be revised to address who is responsible if/ when a crash occurs - What kinds of politics are already built-into the system/ algorithm?

- New distribution models

Robotic technologies are being used to explore new distribution models:

- Amazon delivery drones – Amazon is in the process of experimenting with Kiva Robot unmanned drones to deliver 5kg packages to customers within 30 minutes

- Print on demand books – POD uses digitized technology book printing robots to print short run publications with a fixed price per copy. Often they are done in store thus eliminating delivery time/costs – eg. the Harvard Book Store book making robot http://www.harvard.com/clubs_services/custom_printing/

- Swarm-bots – self assembling or self organising robots that work together on a defined task. Recently researchers from Harvard worked with over 1000 tiny robots that create complex behaviour without 'any guiding central intelligence' (Lee Hotz 2014)

5. Automation's threat

- Too smart? Too human?

Another key trope is that automated technologies pose a threat to our survival. Smart objects may just become too smart and undermine our personal safety. As robots and other automated devices become smarter they are often situated in dystopian futures whereby we lose control and they take over the world.

> *Robots came into the world as a literary device whereby the writers and filmmakers of the early 20th century could explore their hopes and fears about technology, as the era of the automobile, telephone and aeroplane picked up its reckless jazz-age speed. From Fritz Lang's "Metropolis" and Isaac Asimov's "I, Robot" to "WALL-E" and the "Terminator" films, and in countless iterations in between, they have succeeded admirably in their task. (The Economist 2014)*

This anxiety is played out in the contemporary western robotics market in the nature and ubiquity of robots. A classic technologically deterministic approach to how some think about technological relationships is Winner's (1977) 'technological imperative'. He argues that technologies have become so ubiquitous and intertwined with everything in our lives that they generate a sense of feeling out of control. We are dependent on them. He also talks about this in terms of 'technological drift' whereby societies have to deal with the possibility of 'going adrift in a vast sea of unintended consequences' (1977:89).

This anxiety is also played out in relation to how robots look. Marcelo (2014) writes about one of the major obstacles for the growth of the robot market is 'the well-studied revulsion that most people feel toward robots that are too humanoid in appearance'. As Bell (2013) argues, the way different groups narrate, create and respond to and interact with robots is culturally and socially shaped, and which differs according to situated experience.

- Built-in politics

'Safety' is often put forward as one of the core benefits of automated technologies. Automated vehicles in mining contexts are viewed as being safer than human drivers. This is because humans get bored and tired performing dull, repetitive tasks. They fall asleep and make mistakes. Similarly, driverless cars are often mired in discourse around safety. They are viewed by many as potentially causing fewer accidents, as they will not be affected by or trigger road rage and will have better fuel efficiency.

However, it is critical to remember that these are not neutral technologies. The algorithms built into the computing are not universal, or placeless. Rather they come from humans who are socially, culturally and historically shaped, and as a result the technology needs to be examined for the inherent complications already built into the design. For example, the idea of safety can be explored by asking: Who is safe? How might a driverless vehicle respond to a crash scenario? Will its first responsibility be to protect the occupants or cargo of the vehicle? Or will it seek to minimise the harm of other more vulnerable victims – such as a pedestrian or cyclist or animal? Will the actions of the vehicle in this scenario be scripted more by legislation or insurance? Who is ultimately responsible for the crash – the vehicle designer, the vehicle owner, the urban planner?

- Ethics of distance (Militarisation of robots)

Automated technologies have long been produced and used within military contexts. Krishnan (2009) argues that 'remote-controlled' weapons have been around since WW1. Examples include land mines, aeroplanes and precision-guided munitions. More recently however, drones have occupied much media attention. Although used in The Gulf War for intelligence and reconnaissance purposes, they are increasingly being used for unmanned air strikes. Unmanned ground vehicles have also been used in Iraq and it is projected that military robots could become reliable enough to go into battle unaccompanied (Mohan 2007).

In this context anxieties around robotic technologies that become more advanced and human get played out in different ways to arguments earlier. Here, the concern is that they may enact an ontological shift.

> So there is this interesting tension in the popular image of the 'robot' of being an automaton – a machine that is completely predictable and completely controllable and obedient – and the concept of an artificial man with own intensions and desires and therefore equipped with an inherent capability if unexpected behaviour, disobedience and even rebellion (Krishnan 2009:8).

Google's recent purchase of militarised robotic company – Boston Dynamics - has also generated anxieties around the integration of surveillance and robotic technologies.

5. Conclusions

- Like all technology, robots are socio-material constructions and made up of many discrete technologies (including advanced sensors, motors, computers, cameras, and AI software such as computer vision, machine learning and path planning). They cannot be understood as separate to the social and material context in which are made, used and make sense. This also means that they are not fixed or static and are not infallible.

- Strength and size are not the driving forces in the market. A clear national program and strategy, collaborative networks and Governmental support for robotics drives technological innovation

- Robots are often seen as neutral technologies, universal and on-size-fits-all. It is important to recognise and analyse their built-in politics and the multiple ways in which they are made meaningful in different contexts and cultures.

- Critical importance of educating general public in role and importance of technology development to avoid Ludditism - which is the fear of new automated technology taking jobs and an enduring trope in relation to the robotic market that can inhibit uptake and innovation.

- Australia has been dominant in the robotic market in relation to large-scale applications - mining and cargo handling. It responded quickly and successfully to the emergence of automation in the 80s.

- While industry and manufacturing remains core to many robot/automation companies, the newer focus on consumer/ health care and domestic products is growing. Global robotic market is shifting toward smaller, targeted and customised consumer models. For instance, aged/heath care robots are being designed to respond to the needs and requirements of an ever expanding aging, independent and affluent global population

- Developments in miniaturisation and sensors support the growth of sociable robots equipped to respond and engage with humans and which which we can have relationships with rather than simply interact.

- Training is critical. Understanding of science and technology underpins innovation. 'To take maximum advantage of technological change it is essential to invest in human skills, not just in equipment' (ASTEC 1983:7). This should start in schools, not just in tertiary education.

- There is a critical need to understand the point and purpose a robot serves in order to embed it in everyday life – ie. it becomes a vacuum cleaner, a coffee maker, otherwise it remains a 'robot'.

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