Detecting tech-driven inequalities: a service design framework

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Abstract

Technological growth is realizing an ever more intelligent and convenient future. But is this future equal, and what role does service design hold in addressing, or exacerbating, these inequalities? The relationship between technology and inequality is fluid, moving from the elimination of existing inequalities to the creation of new ones, and service design has the potential to impact this relationship. However, current literature to identify this potential is limited, with service design's contribution to the technology-inequality-design nexus not clearly identified. This paper analyses the mutual relationship between technology, inequality, and service design, and proposes a novel framework incorporating four dimensions of service design and their links to inequality and applies the framework to autonomous vehicle (AV) technology as an example. More broadly, the framework can be used by service designers to identify different dimensions of hidden inequality within service design.

Keywords: service design, technology, inequality, autonomous vehicle technology

Introduction

There has been a significant transformation in how technologies participate in various aspects of our lives, affecting commercial, communication, learning, entertainment and working processes.

As Selwyn (2004) stated, this technological growth has benefited the public through offering an unprecedented opportunity to address long-existing social inequalities.

One example is the breakthroughs in developing assistive technology, defined as "used to increase, maintain or improve the functional capability of individuals with disabilities” (Technology-Related Assistance for Individuals With Disabilities Act of 1988, 1988, p. 3).

However, some hold the opposite view. Castells (1997) warned of increasing social polarisation and social exclusion that accompany globalisation, business networking, and individualization of labour. The term ‘digital divide’, first coined in a report on internet diffusion in the 1990s, describes “the divide between those with access to new technologies and those without.” (NTIA, 1999, p. xii). The widespread inequalities in information and technology access can exacerbate social inequality and have led to information and knowledge gaps between those ‘haves’ and ‘havenots’ (Schweitzer, 2015).

Service design can alleviate inequality through its innovative capabilities of integrating aims, knowledge, methods and processes of social inclusion, respecting people’s values and evaluating experiences from the perspective of those on societies’ margins. This can create new forms of inclusive social interactions, partnerships and value streams (Joly & Cipolla, 2013; Tunstall, 2020; Kuure & Miettinen, 2017). When technology becomes indispensable and acts as a driving force for service innovation (Gliem et al., 2014), the role of service design in addressing technology-induced inequality becomes more prominent. Will service design reduce or exacerbate inequality? How should service designers detect possible inequality in design? How can social-technical systems become more inclusive and benefit a greater number of people? This paper finds that the role of service design in the interwoven relationship between technology and inequality has not been well defined, and the discussion of design inequality in the service design realm is limited.

Therefore, this paper seeks to explore and answer the following research questions:

1. What is the relationship between technology, service design and inequality?
2. How to detect and reduce possible inequality in service design?

This paper identifies a mutual relationship between technology and service design, and how they may trigger inequality. A framework for service designers is proposed to verify technology-related inequality within the four dimensions of service design, hoping to raise the discussion of possible inequality in the service design realm and promote greater social inclusion. Finally, autonomous vehicles (AVs) technology is used as an example to demonstrate the application of the proposed framework.

The debate on technology and inequality

Jaumotte et al. (2013) show that the observed rise in inequality over the past decades is largely attributed to technological progress. This is driven through the increased premium for education and skills, penalising low-skilled workers. This finding is consistent across both developed and developing economies. Chandy & Dervis (2016) state that the most striking impact of technology on inequality is through substituting traditional tasks undertaken by unskilled workers with technology. Since technology is one important aspect of material wealth, and wealth production is increasingly based on technological knowledge, the digital divide is exacerbated by the inequality of knowledge and information (Fuchs & Horak, 2008).

As technology has advanced, understanding of the digital divide has evolved. At present, the digital divide is defined across three levels: the gap between those with access to the Internet and those without; the gap in skill and speed of information acquisition (Hargittai, 2001); and the difference in learning and productivity outcomes from utilising Internet technologies (Scheerder et al., 2017; Wei et al., 2011). Understanding of what constitutes a digital divide will continuously expand as new technologies, such as 5G and the metaverse, become increasingly adopted into everyday lives. Nielsen (2006) also defined three stages of the digital divide: economic divide; usability divide, and empowerment divide. He argues the latter two stages emphasize the unequal benefit of a new economy and new technology, which alienates those unfamiliar with it.

However, Halford & Savage (2010) argue that technology and inequality are independent entities that do not necessarily exhibit a causal relationship. Instead, technology is neutral, and it is the context in which technology operates – including institutional practices and the structure of society – that shapes its impact on inequality (Mack, 2001). Failed politics and social strategies, rather than technology, increase inequality. Therefore, slowing down technological development is not a solution, and instead governments and institutions should develop new adaptive strategies to address the challenges posed by technological advancements (Pursell, 2016).

The mutual relationship between technology and service design

Rust (2004, p. 24) states “the service revolution and the information revolution are two sides of the same coin.” The relationship between service design and technology is mutual (figure 1), with the former providing the methods and framework to facilitate the deployment of the latter. Shaw et al. (2018) applied service design to the implementation of new technologies in healthcare services. They showed that the role of service design is not in technology per se, but in the overall quality of service delivery that may result from the technology. For example, digital care technology increases the possibilities for communication between patients and doctors (e.g., video consultations), but will have a greater influence if implemented with a service design methodology which actively engages stakeholders when deploying this technology (Sittig & Singh, 2015; Shaw et al. 2018). The success of the technology depends on the framework of service design being constantly tested and corrected, and the service 'fleshing out' the technology to improve its implementation.

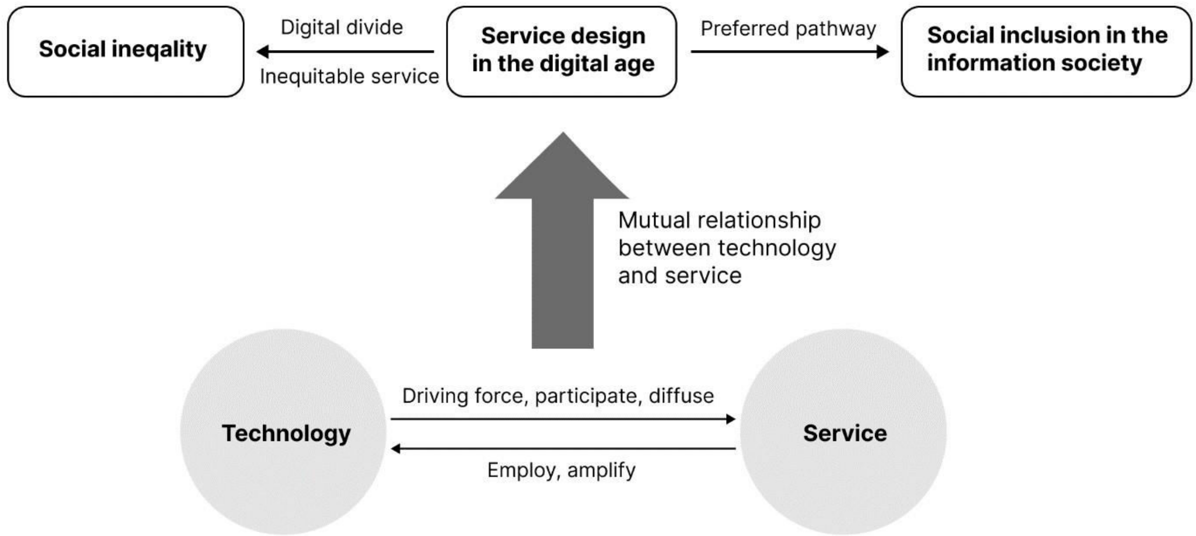

Figure 1. 'Technology - service design - inequality' framework

Introducing inequality as a new parameter within this context demonstrates the mutuality between the variables. Online health consultation technology filters out the digitally excluded – typically older, lower-income, or those with disabilities – who happen to have the worst health status (Salisbury, 2019). During the pandemic, over 65s in the UK could apply for a free coronavirus testing kit through the GOV.UK website. However, a third of over 65s do not have access to the internet (Lloyds Bank, 2020) and are excluded from the free tests. Furthermore, cybercriminals sent 'phishing' text messages to trick users into clicking on a link to a fake NHS website, where they were duped into revealing personal information and incurring financial losses (Conway, 2021). Typically, victims are either the elderly or vulnerable. In conclusion, service design with in technology is likely to perpetuate or ignore the digital divide at all levels without a feedback mechanism for technological inequality.

Throughout the COVID-19 pandemic, many governments implemented contact tracing apps (Gann, 2020), whereby success depended on the availability of a smartphone (accessibility divide), the ability to download the application and link it to

Bluetooth (usability divide), and the ability to use the application to report and obtain nearby viral cases (empowerment divide).

However, inequalities caused by the deployment of technology and services cannot be fully summarised by these three layers alone. In the case of COVID-19, public trust in the security of personal data and the application's effectiveness impact the ability to obtain and track useful information (Gann, 2020). People who have the ability and means to use the application correctly but choose not to due to concerns about their privacy and security is another component of the digital divide phenomenon.

Second, such tracking programmes may offer a new tool for monitoring and repressing marginalised groups (Toh & Brown, 2020). Racialized groups are frequently subject to greater scrutiny in the application of digital technologies such as facial recognition (Jefferson, 2020), perpetuating stigmatisation and marginalisation of subpopulations (Hendl et al., 2020; Fontaine et al., 2021). Technological experimentation may also divert funds away from basic interventions, which are often more effective in protecting the vulnerable during a pandemic (Toh & Brown, 2020). For example, in the early months of COVID-19 hundreds of clinical trials were undertaken to test treatments for the virus without proper coordination, leading to duplication, waste, and poorly recorded research (Bruckner, 2022).

Finally, such technologies and services screen for younger, more affluent, and techsavvy populations, while the poor, elderly, and marginalised are less likely to participate, thereby influencing data bias (Ada Lovelace Institute, 2020). This may undermine public health responses and lead to a misguided relaxation of virus surveillance or other protective measures (Toh & Brown, 2020).

Little attention has been paid to increased inequalities that result from the use of technologies in service systems. While there has been much discussion about the inequalities of technology, the intersection of inequality, technology and service design remains an untouched area of investigation. This means concerns such as privacy protection, racial discrimination, and funding for development technologies are difficult for service design to focus on, as these inequalities are perpetuated by technological and service oversights.

The Service Design Package (SDP) in the Information Technology Infrastructure Library (ITIL)® v4” (figure 2), developed by AXELOS, is a commonly used concept and instruction that indicates key dimensions in service management (knowledgehut, n.d.). It recommends practitioners go beyond traditional IT perspectives of technology, to reconsider four critical dimensions when creating products or services (Whytock, 2022). This framework is also appliable in the design domain and has proved an effective tool in creating value for the customer.

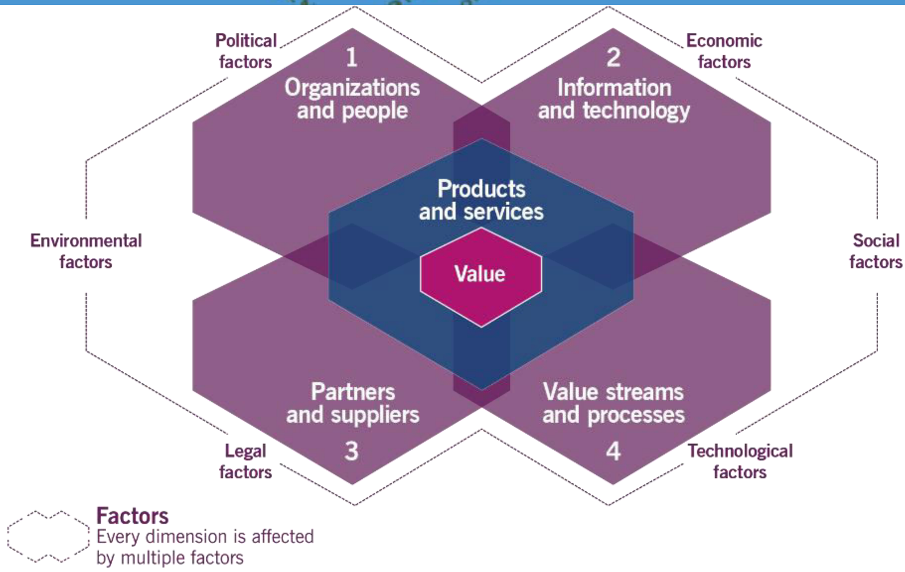

Figure 2. Four Dimension Model (copyright of AXELOS®)

The framework comprehensively covers all dimensions of services but doesn't consider inequalities and exclusions that can derive from any of these dimensions. Hence, a new framework – 'Technology-service-inequality' framework (figure 3) – was developed, which builds on the AXELOS model by identifying potential inequalities in services and providing direction for more inclusive and equal service design.

'Technology-service-inequality' framework

The new framework detects inequalities in the services provided by technologies under the same four dimensions (see figure 2). The interpretation of each element includes recommendations, potential problems, and suggested solutions to inequalities targeting specific communities. These are specific examples within each element, and are intentionally not comprehensive, leaving flexibility for application of the framework across different domains.

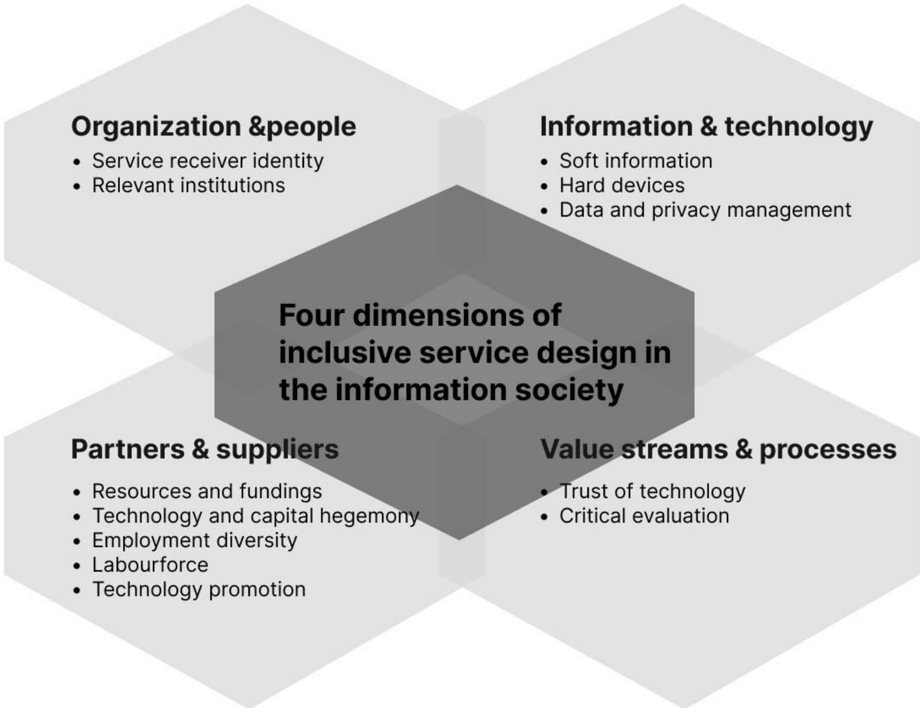

Figure 3. 'Technology-service design-inequality' framework

Organization & People

★ **Service receiver identity**

Service design practitioners should be cautious about whether there is a digital divide that negates potential 'target users', and understand their needs and experiences. In each stage of service design, the diverse identity of target users should be considered, including gender, physical condition, social status, economic status, religion, etc., lest users are unfairly excluded or technologies spread or amplify stigma or discrimination. To map out the multi-dimensional image of users and better include them in the design and development stage to express their insights and needs, design methods such as diverse identity persona, participatory design (Siu & Kwok, 2004; Siu & Xiao, 2020), and ethnographic research can be applied.

★ **Relevant institutions**

Working with representative organizations such as governments and welfare institutions is an effective way to test and iterate the products being designed, improving accessibility and useability. However, designers must acknowledge the risk that such institutions – which usually have the power of monitoring and controlling the public – can discriminate against vulnerable groups.

Information & technology

★ Hard devices

The high cost of accessing and using devices is a notable barrier for users (Vanderheiden, 2008; Brandenburg et al., 2013). Poor ergonomics is another common issue that effects the useability of devices (Weber, 2006). For assistive technological devices, a poor adaptation with newer mainstream devices (or vice versa) isolates those that rely on them (Vanderheiden, 2008). The cost of devices should be reduced and investments made to provide basic accessibility and ergonomic considerations. Those with different motion or sensory capabilities can be invited to test usability during the design process.

★ Soft information

The delivery of soft information content should be simple and easy to understand. Web browsers, applications, software, and other interacting components are platforms that communicate with users. There are growing problems associated with different interaction logic, complex access modes, incompatibility across platforms (Chadwick et al., 2013), translation error, adaptation of other assistive programs such as screen reader, optical character recognition, etc. Designers should apply an inclusive user interface design to promote simple and direct interaction.

★ Data management

Protection and proper management of users' data can improve trust and security. Services that involve storage, management, or use of personal data are accompanied with risks of data breach or illegal usage. These risks are not spread equally across demographics, as users have different levels of awareness and trust towards existing. Service designers can reduce this inequality through monitoring and protecting data privacy.

Partners & suppliers

★ Resources and fundings

Technologies which require intensive raw materials for manufacture or operation can contribute to inequality across commodity importing and exporting economies. Service designers should consider where materials are sourced and promote reuse and recycling wherever possible to alleviate potential resource shortages.

★ Technology and capital hegemony

Technological requirements may create barriers to entry, leading to monopolistic or concentrated markets. While this risks uncompetitive pricing whereby monopolies extract surplus 'rents' from consumers, the flip side of a concentrated market – and subsequent higher profits – is that companies can afford to invest in the development of new technologies. The use of open-source technology may therefore limit developers' access to the original technology's dividends, limiting future development of new technologies. Policymakers need to balance the benefits of concentrated markets with fair competition, and promote collaboration between market leaders and new entrants.

★ **Employment diversity**

A lack of multicultural diversity or gender inclusion in technology companies may enhance discrimination or prejudice against underrepresented groups within the development process and technology itself. Designers can promote diversity and inclusion through the design of a work-friendly environment that attracts a diverse workforce, for example developing a diverse culture, disabled access, gender-neutral toilets, multi-faith prayer rooms etc.

★ **Labour force**

Advanced technology and the application of artificial intelligence risk low-skilled jobs being replaced by machines. These low-skilled jobs are disproportionately held by disadvantaged groups (McKnight et al., 2016). Service designers should anticipate new industries, employment opportunities, and production methods from the widespread use of new technologies and services.

★ **Technology promotion**

The lack of infrastructure or service delivery systems in remote, underdeveloped, and sparsely populated areas may lead to an unequal distribution of technology resources. Service designers can work with local communities and stakeholders to identify their unique needs and challenges, designing solutions that are culturally and linguistically appropriate and leveraging existing infrastructure and resources to deliver technology services. Service designers should consider the different modes of access to technology to maximize accessibility. Additionally, they should consider the long-term availability of technical support and maintenance to ensure technology resources are not neglected.

Value streams & processes

★ **Trust of technology**

Trust in technology has a direct impact on acceptance levels, which can enhance the digital divide. Designers should identify demographic differences in trust in technology and understand how this gap can be bridged through design, to increase the sense of security and access to the technology.

★ **Critical evaluation**

Within the context of this paper, critical evaluation can be considered as the examination of unfair vulnerabilities within the technology. Algorithmic technologies, for example, may wrongly detect identity groups such as sexual minorities, darker skin etc., leading to discrimination. Service designers should monitor these vulnerabilities when deploying technology and provide feedback to developers.

Case analysis and verification

Technological advances in autonomous vehicles (AVs) and autonomous electric vehicles (A-EVs) may one day result in the abolishment of human drivers and the emergence of the "transport-as-a-service" business service model (Arbib & Seba, 2017). In the following section, this technology is used to demonstrate a speculative application of the service design framework to identify potential inequalities underlying AV technology. Given the limited rollout of AVs and the lack of empirical data, this study opts for a speculative form of analysis to demonstrate the framework's application to identify potential inequalities. It is hoped this acts as a catalyst for designers to repeat the speculative analysis approach in other domains to address potential inequalities before they arise.

Organizations & People

★ **Service receiver identity**

A vast spectrum of different disabilities should be considered as potential AV users. Those with visual impairment have needs primarily related to user interface accessibility and their inability to observe situations outside the vehicle. The nonambulatory physically disabled community face challenges in entering the vehicle. The National Association of the Deaf, meanwhile, advocates for all audible information to be communicated visually (Alkebsi, 2017). While autonomous driving could increase independence for those with intellectual or developmental disabilities, it is important to consider how they would handle problems that may require manual intervention (Claypool et al., 2017).

Many inequalities exist when technology is viewed through the lens of broader gender classification. For example, men have fewer financial constraints and thus a greater access to technology. In Saudi Arabia, restrictions on women driving were only lifted in 2018, meaning far more men hold driving licences (Specia, 2019), demonstrating the inertia of cultural norms. AVs are designed using anthropomorphic parameters based on male body data, which may explain why women are 47% more likely than men to sustain serious injuries in a car accident and 17% more likely to die (Mateo et al., 2020). Designers should consider demographics with different identities and capability limitations when designing AV services.

★ **Relevant institutions**

The disabled and elderly communities, as well as social welfare institutions, can play a crucial role in promoting the use of AV technology. Their requirements should be considered in the design and legal development phases of the technology, as well as its subsequent deployment, to teach users how to operate it.

Due to limited financial resources these communities may be unable to access AV technology. The government should consider subsidizing accessibility for these communities, which may involve costly investments but will increase their independence, access to employment, and reduced reliance on state financial support.

Information & Technology

★ **Soft information**

"'Universal design' means the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Wolfgang & Korydon, 2011, p.13). The term derives from barrier-free design, which began in the late 1950s to remove barriers in buildings for people with disabilities. Considering universal design principles in the early stages of AV development – such as through touch, voice command, gesture, and braille output – will encourage adoption of the technology by vulnerable demographics (Claypool et al., 2017). To ensure the consistent implementation of universal design, automotive technology should embed these design principles into their core philosophy, something no company has yet done (ibid).

★ **Hard devices**

To increase accessibility for wheelchair users, a detachable module could be a cheap, optional add-on. Another issue is wheelchair storage and fixation, as well as installation and use after disembarkation without the assistance of other passengers.

For women, the ergonomic design of the driver's seat has always been negligent of their body data. Women have fewer muscle groups in the neck and upper body and a lower bone density than men, and a firm vehicle seat design can amplify damage from a crash (Perez, 2019). Almost all vehicle safety testing excludes a human-sized female crash test dummy (Mateo et al., 2020), and in the rare instance it does, it is only in the passenger's seat. Meanwhile, 62% of pregnant women in their third trimester do not fit into the existing seat belt design (Linder & Svedberg, 2019; Perez, 2019). Technology companies and designers need to consider both genders when developing and testing to increase the equitability of the AV from an ergonomic perspective.

★ **Data management**

The cost and time delay in the development of data protection systems results in vulnerabilities (Litman, 2020). A minor breach could expose sensitive or personal data, while a serious breach may allow hackers control of the vehicle (Lee et al., 2015; Memon et al., 2022). Although cyber defence systems can detect and defend hacking, this comes at a high cost, including the need for regular software updates and changes to established security architecture (Memon et al., 2022). Owners who are unconcerned about information and data security or are unwilling to pay the high maintenance costs involved, are exposed to an increased risk of fraud.

Partners & Suppliers

★ **Resources and fundings**

A-EV technology will impact the price and demand for various global commodities, impacting the economies of commodity exporters. For example, if electric vehicles entirely replace petrol vehicles – which were responsible for 27% of global petroleum demand in 2016 (Kah, 2018) – there will be significant fiscal pressure on oil exporting nations. This could lead to political instability, rising debt, and cuts in social welfare spending, resulting in increased poverty and inequality (Arbib & Seba, 2017).

The lithium market will also be impacted by A-EVs, which depend on lithium-ion batteries. Four major producers control 85% of lithium supply, while the Democratic Republic of the Congo controls 94% of the supply of cobalt, another component of lithium-ion batteries (ibid). Overreliance on commodity exports carries the risk of conflict, political instability, and 'Dutch disease' for commodity-exporting nations. Acknowledging the harm of overreliance on commodities, service designers can introduce innovative systems that change firm behaviour to increase recycling and reduce waste, ensuring the long-term sustainability of A-EV technology. The supply of raw materials can be identified in advance, along with research into the use of alternative materials.

★ **Technology and capital hegemony**

Countries that lack the economic or technological edge to develop A-EVs may have to wait for such technology to disperse across global markets. This will lead to differing rates of technological penetration, exacerbating inequalities across countries. Encouraging the adoption of open-source technology and the dissemination of knowledge will help alleviate this.

★ **Employment diversity**

Women are severely underrepresented in the automotive industry, leading to a lack of female input in vehicle design. According to a Tesla report (2020) women account for only 21% of its US workforce and 17% of its company directors and vice presidents. Tesla is just one example of many, illustrating the AV industry's lack of diversity which may lead to the industry's technology, from development to design, ignoring the needs of underrepresented groups. Service designers should design an inclusive and accessible work environment and ensure coordination platforms that include diverse perspectives in all aspects of the technology development process.

★ **Labour force**

The spread of AVs will increase employment opportunities and economic independence for those with disabilities, as well as a significant change in the overall structure of employment. However, in the short run there is the threat of massive job losses in the transport industry. In the United States, 5 million jobs, or 3% of the workforce, are expected to become obsolete because of AVs (Arbib & Seba, 2017). Policies to improve the career paths, labour standards, and working protections of drivers will help (Leonard et al., 2020), but those whose jobs are indirectly affected should also receive relevant job training and guidance to find new employment opportunities arising from AVs. Service designers can work with AV companies to identify employment threats and opportunities arising from the technology, and design mid-career training programmes to assist those transitioning to new careers.

★ **Technology promotion**

The spread of complementary technology needed to support A-EVs, especially charging stations, will not be uniform. Rural areas will have less charging stations and higher costs and wait times to operate an A-EV (Arbib & Seba, 2017). Snowstorms and icy ground, which lead to complex road traffic conditions that AVs are not yet mature enough to handle, may lead to deployment only in areas with less extreme weather. Overcoming these inequalities necessitates continual investment and innovation, while regulators must consider level of demand density and crosssubsidies needed for the deployment of AVs in each region. Service designers should work with companies and policymakers to ensure there are mechanisms in place to provide support and guidance for individuals and communities who face challenges in accessing these technologies.

Value streams & processes

★ **Trust of technology**

AV technology involves the transfer of control from the driver to an opaque technology that relies on algorithms most drivers cannot understand. Scepticism is understandable and necessitates a standardised testing system of AV technology with high transparency to demonstrate safety levels to the public. Otherwise, resistance to autonomous driving and habituation to manual driving will exclude certain groups from enjoying the benefits. Designers can develop public education campaigns to inform the public about the benefits and limitations of AV technology, for example through pre-experience activities or prototypes for building trust.

★ **Critical evaluation**

There are several well-publicized moral challenges that arise from AV technology: should an algorithm be allowed to decide who to crash into when unavoidable? Who gets prosecuted in the event of an accident? Should the algorithm prioritize the life of the driver above pedestrians? In general, legal systems assume human agency whereby only humans can make and implement such decisions. Growth in artificial intelligence is challenging this assumption, which may require an entire rethink of the existing legal framework based on human decision making.

Given the safety and efficiency improvements that result from AV, it is likely that manual driving may be regulated and taxed in the future, similar to smoking, or restricted to specific areas to become an entertainment experience, similar to horseback riding (Hughes, 2016). Meanwhile the market may crowd out those who drive for pleasure: taking the long-route home to enjoy beautiful scenery may no longer be possible, having the feeling of 'being in control' will also be lost etc.

Bias exists in AVs due to data collection, preparation, and model selection, as well as interaction services (Mateo et al., 2020). In-car AI assistants, for example, are frequently portrayed as female, implying a stereotype of female social identity, and these assistants are frequently subject to verbal harassment. To avoid this stereotype, AI assistants should adopt a more neutral voice and image (ibid).

Conversational AI, according to Stanford University's Gender Innovation Lab (2017), must understand the context of the users' socio-cultural language, such as the fact that many slang terms used by African Americans may be filtered out by algorithms that detect rude comments. These aspects of inequality are hidden behind the technology of certain services and should be carefully detected and addressed.

Conclusion

As technology rapidly progresses, the debate on whether it reduces or exacerbates inequality – as defined over a number of dimensions – increasingly takes centre stage. Service design, which can increase the useability and accessibility of new technologies, is becoming increasingly intertwined with technological developments. In order to detect impacts on inequality within this mutual relationship, a new service design framework has been proposed based on the four dimensions of service design and management. This framework is applied to the AV industry to demonstrate its use in identifying potential inequalities that are hidden within this technology. It is hoped this will stimulate more discussion and research within the service design realm and encourage other designers to apply the framework across other domains to address potential inequalities before they arise.

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