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New scenarios for safe mobility in urban areas

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NEW SCENARIOS FOR SAFE MOBILITY IN URBAN AREAS

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Shifting perspectives on autonomous vehicles

Using laser scanning technology to engage the public via the analysis of journeys seen 'through the eyes' of autonomous vehicles

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Abstract
It is likely that Autonomous Vehicles will have significant social, cultural, spatial and environmental implications and that the interaction between humans, automated vehicles and physical environment will provide an array of challenges. This paper aims to explore the use of innovative visualisation approaches, to foster discussion on possible scenarios involving AVs. It is argued that such an approach might be used to help conceptualise human experiences with the potential to enhance understanding of the complex human-machine associations. Presenting journeys from different perspectives and reconceptualising the context through the eyes of AVs emphasised the nuances of experience between the machines, urban space and human bodies. Unexpected user-technology interactions will emerge as humans are not always passive followers and can be apprehensive when it comes to accepting such a novel technology as self-driving vehicles. The focus applied in the methodology and data capture was on inclusivity of data, showing not only movement but also noise and human experience of a space. The integration of AVs on public roads will rely on technical innovation to ensure that vehicles can operate safely yet, the study of the perceptual and ethical effects of technology and potential influences on society via engaging the public will help to manage expectations and create platforms for mutual learning.

Keywords
Autonomous vehicles; Urban space; Human-machine coexistence.

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1. Introduction

'[H]umans are sentient beings, capable of interacting with and negotiating AVs in and through their own ways' (Yeo & Lin, 2020, p.2).

It is anticipated that by the 2030s Autonomous Vehicles (AVs) will be widespread on European public roads, yet the progression to autonomous driving and consequently '*the evolution of mobility*' will indeed create a very high level of uncertainty (Staricco, 2020). AVs when conceptualised as low-cost, clean, widely available door-to-door transport hold the potential to significantly change people's travel behaviour, and this will have an immediate effect on spatial planning as well as having numerous implications for society, cultural associations with mobility and environmental issues. It is anticipated that autonomous vehicles will play a significant part in unsettling the transport and mobility status quo (Alessandrini, 2015; Fagnant & Kockelma, 2015; Faisal et al., 2019), with implications in numerous aspects, such as congestion, energy consumption, social equity, economy, land planning and use. (Bahamonde-Birke et al., 2018; Milakis, 2019; Smolnicki & Sołtys, 2016) Introducing AVs to our urban areas may also fuel a temptation for urban sprawling processes, encourage long commute distances, contribute to urban sprawl and the further expansion of the city (Legacy et al., 2019).

Many cities in Europe have already started testing AVs, where the integration of new mobility solutions on public roads, often with complex mixed mobility scenarios, will be crucial (PAV, 2020) as potentially 'drivers, pedestrians, and cyclists will have to manoeuvre in an environment with vehicles of varying levels of automation for decades to come' (Botello et al., 2019). The notion of full automation of vehicles is often regarded as a possibility for the distant future (Wolf, 2016), where users will have the ability to use mobile phones, work, socialise or even sleep during a drive (Habib & Lynn, 2020; Kun et al., 2016). However, there remains limited knowledge about autonomous vehicles among the general public (Wolf, 2016), and the implications for our living environments. The interplay between humans, automated vehicles and the physical environment will provide an array of challenges, myriad of issues and uncertainties, as well as presenting significant technical and social research subjects.

This study aimed to re-frame the issues and questions oscillating around AVs so that the focus shifted from technological advancement towards understanding and addressing those problems and challenges faced by people. As the technology has an inherent ability to locate itself in a physical context, there is an opportunity to extend the prevailing arguments to encompass social, cultural, spatial and political issues, by *'putting technology 'in its place' in terms of both understanding and respecting the contexts in which it might be deployed'* (Cohen et al., 2020).

This shift of perspective towards the people, and to the problems they face, provided a research context which at once addresses how AVs may be a 'solution', whilst drawing on advanced sensor and data technologies within the vehicles themselves.

The acceptance and interaction with new technology, and its adaptation into the everyday life of communities, can often be met with initial skepticism (Brooks, 2017). It can be argued that the prospective AV-induced socio-spatial implications and concerns are often correlated with the potential increase in travel time, higher trip generation, as well as vehicle kilometers travelled and consequently - traffic congestion (Childress et al., 2015), the potential conflicts with other road users - pedestrians and cyclists (Gavanas, 2019; Millard-Ball, 2018; Parkin et al., 2018), the reduced incentivisation of using public transport and encouragement of active mobility (Botello et al., 2019; Stariocco, 2020).

As apprehensions about the potential negative implications of AVs are identified and debated, emerging issues of safety – real and perceived – introduced in an urban environment in the context of existing and novel transport modes and technology will be crucial. After all, fully autonomous vehicles are potentially the ones that can fuel the '*epoch-making changes*' in mobility patterns (Staricco, 2020), but where there is still a necessity for such technology to be introduced within the wider context of a need to reduce urban air and

noise pollution, and to significantly reduce CO_2 emissions from both the vehicles themselves and supply chains associated with the manufacture of the vehicles and the generation of energy (possibly from renewable sources, of course).

Visual representation of the effects of technology used by autonomous vehicles could potentially lead to an enhanced understanding of the travel experience and interrelationships between the AV users, other vehicles, pedestrians and the physical context of the built environment.

This paper aimed to explore the use of innovative visualisation approaches, to communicate and foster understanding and discussion of the scenarios involving AVs. The paper utilised digital data capture of real environments to illustrate the environment as viewed by the technology. The research then employed an exploratory methodology, to situate that technical outcome, and the data collected, within a social and stakeholder-focussed, context.

It is argued that such an approach holds the potential to enhance public engagement and understanding of the complex human-machine associations. In so doing, the research helps to conceptualise human experiences and interactions when encountering autonomous vehicles travelling through space.

2. Through the eyes of autonomous vehicles

'Technology plays a central role when discussing C/AVs, as all of the other effects ultimately stem from its operation, how it is perceived, and how people react to it' (Bottello et al., 2019).

How is the world navigated and how does it look through 'the eyes' of AVs? The algorithmic and all-encompassing volumetric images produced continuously by the sensor/LIDAR technologies in AVs yield an astonishingly detailed 360° 3D record of the surroundings. Recreating that record through the use of a mobile laser scanner - during a potential journey - enabled the research to help in understanding the experience and illustrate how physical elements might interact with human aspects of the journey – for both passengers and pedestrians. Providing this insight from the perspective of AVs played a significant role in addressing issues of safety from the perspectives of vehicle passengers and other road users, as the technology enabled a reliable deconstruction of the experience, measuring the objective physical characteristics of the context while moving through the surroundings. The resulting visualisations provide an abstracted view of the world, which prompts and welcomes fresh perspectives and observations.

2.1 Laser scanning as an engagement tool – a study in Aberdeen

Consideration of the resilience of cities, technology and transportation systems may be enhanced by efforts to think spatially. In so doing, viewers are enabled to more clearly perceive and better understand the factors that generate movements and reactions of people (Kirzek et al., 2021).

As part of the public and stakeholder engagement process, a portable laser scanner was used to depict and visualise the journey of an AV through 'real' environments (Fig.1, 2 and 3). The captured data was then analysed and presented as a tool in engagement workshops enabling a deeper insight into the mapping technology and a way of learning the conditions of the physical context as well as subtle familiarisation exercises to possible futures.

It is argued that this use of technology and visual resources can act as a springboard to conversation and positive engagement in order to apprehend the interlinked phenomena of the urban realm, people, imminent technological advances and future mobility options.

The contribution of such technology in participatory approaches to planning seems to offer an accessible and inclusive method through which one can envision and reconcile the complexities of mobility, personal needs, interactions and design of the built environment with the levels of familiarity with AV technology among participants (PORTIS, 2020).

Three-dimensional mobile laser scanning technology has been extensively applied in AVs to perceive their surroundings and collect information on geometrical qualities of the physical environment in real-time, detect and track obstacles, boundaries, other cars, and pedestrians (Brummelen et al., 2018; Martines Diaz et al., 2018; Zhu et al., 2017).

Laser scanning technology as rapid, precise spatial data acquisition, documentation and mapping is also an established technology in architecture, 3D printing, engineering, construction, surveying, archaeology and built heritage with a wide range of applications (Tait et al., 2016; Zlot et al., 2014).

This study aimed to reach beyond the primary purpose of scanning and explore whether data obtained from the scanning device, corresponding directly to potential routes of AVs within the city, that supported the visualisation of a detailed record, would prompt thinking about the micro-interactions between individuals and technology.

Presenting the journeys from different perspectives and reconceptualising the codified surroundings through the eyes of AVs emphasized the importance of noticing the nuances of experience between the machines, urban space and human bodies – *'inhabiting and feeling machines'* (Yeo & Lin, 2020 - p.1). Arguably, in this context, autonomous vehicles can be perceived as 'true social aliens' (Hancock, 2019) – independent and responsive in our realm yet nonhuman, deviating and making machine errors not always following common human patterns of interpretation or learning.

The issue of integration of AVs into modern transportation may pose complex questions requiring a transdisciplinary approach concerning ramification of the pace of technology innovation versus 'non-algorithmic and non-optimal humans' (Hancock, 2016) and more generally societal readiness to accept technological fallibilities. *'When we change the face of transportation (…), we will change the nature of society itself'* (Hancock 2019).

Figures 2 and 3 illustrate LIDAR data collected on-site, using a mobile scanning device. This mimics the data collected by LIDAR sensors within AVs, where the data is used to identify dangers of collision. This research aimed to explore how issues concerned with the introduction of AVs can be framed to directly address issues faced by stakeholders (and not only direct end-users). This mirrors previous work by the authors (Belkouri & Laing, 2020), which demonstrated how LIDAR visualisations can be used to prompt and stimulate stakeholder engagement. That AVs collect such data as part of their operation is notable, and prompted this study.

Fig.1. Photo showing the context of research and potential AV route in Aberdeen [Google street map]

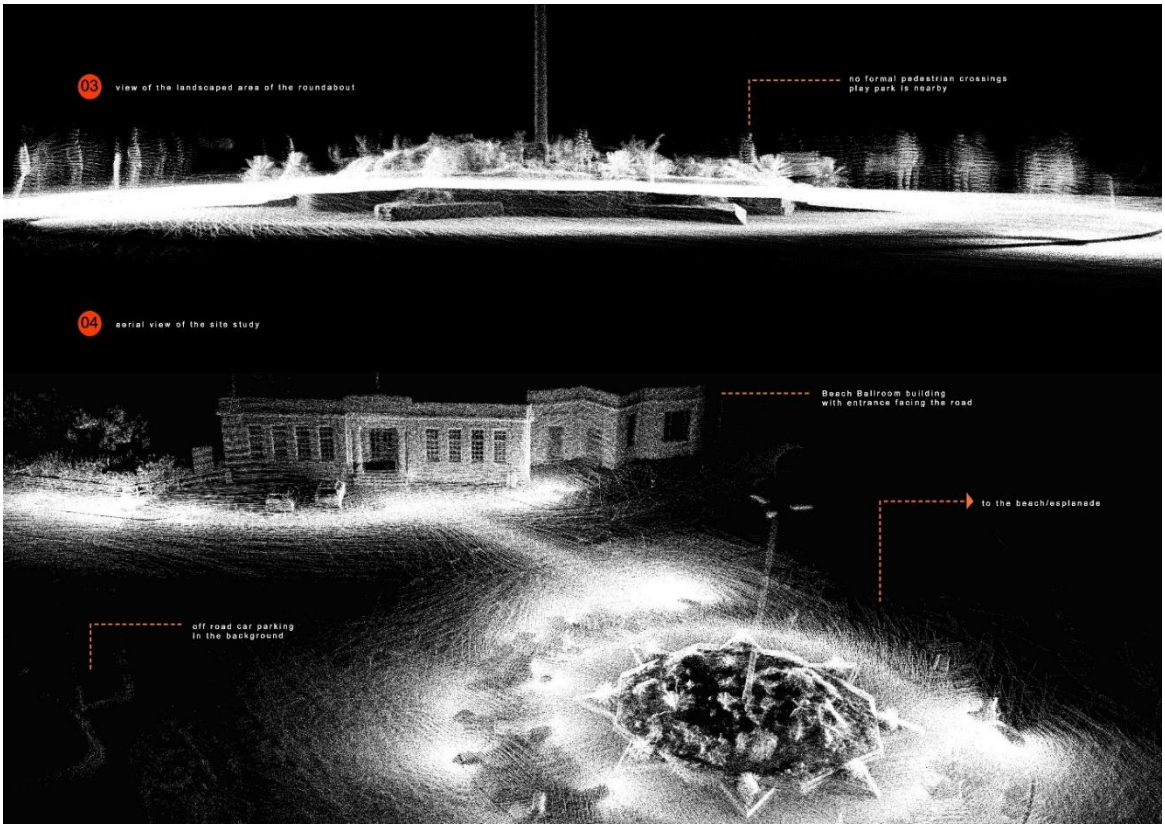

Fig.2. 3d render of a busy roundabout in Aberdeen retrieved from laser scanner [author owned]. The image indicates the complexity and unpredictableness of the car/human interactions

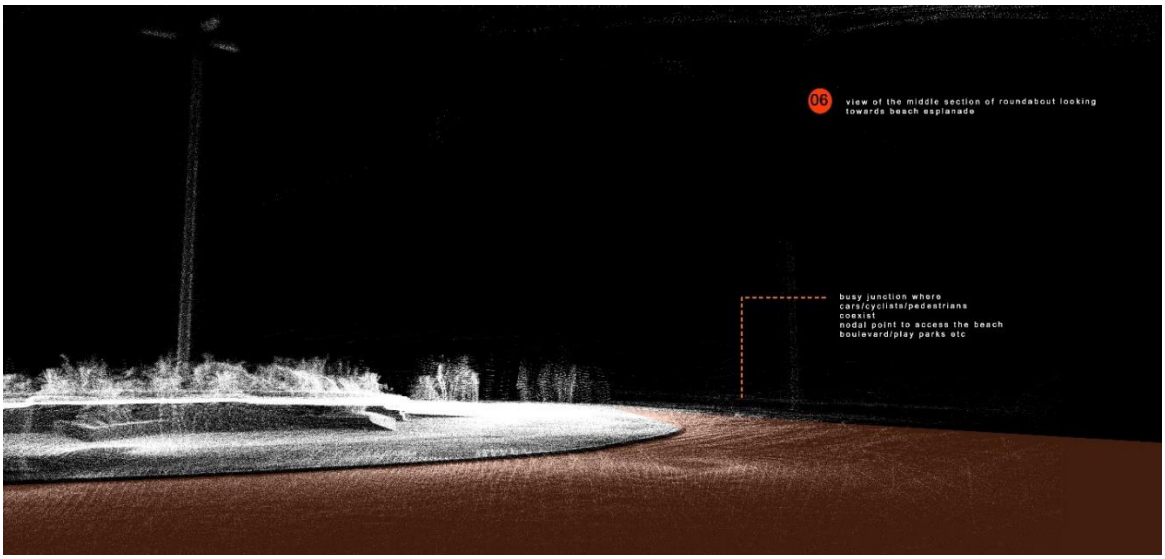

Fig.3. 3d render of roundabout showing pedestrians crossing the street; retrieved from laser scanner [author owned]

2.2 Exaggerating glitches and scanning errors

In 'The Dreamlife of Driverless Cars' project, Scan LAB studio weaved a 3D laser scanner through the streets of London to simulate how driverless vehicles 'might perceive - and misperceive - the world' by unveiling captivating perspectives of the city as seen from the vehicles perceptive instruments (Fig.4) exaggerating glitches and scanning errors (Manaugh, 2015). The city as is appears eerie yet also encompasses all the vast surroundings and endless scenarios – an intermingling of buses, cars, cyclists and people with urban realm – static elements of the environment.

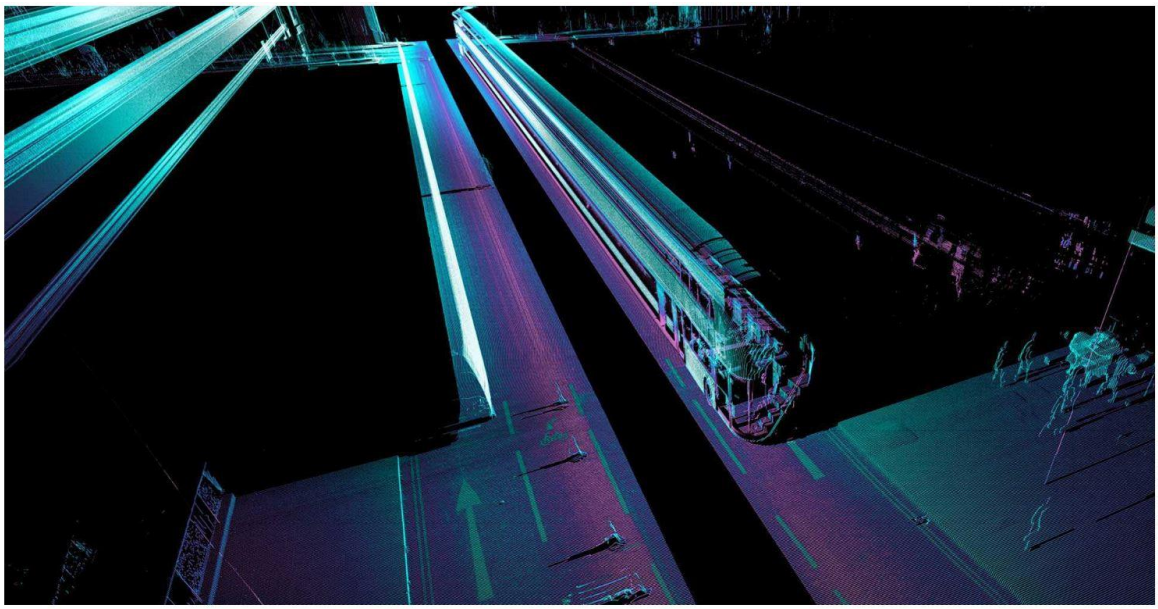

Fig.4. Images of London retrieved from laser scanner depicting double-decker bus as a continuous mega-structure. Credit.: ScanLAB Projects for The New York Times 2015 [Available from: https://www.nytimes.com/2015/11/15/magazine/the-dream-life-of-driverless-cars.html]

Cities are in constant flux affording unpredictable scenarios, which will have to somehow be fully anticipated and programmed for in the robotic future. How will seeing the city through the eyes of the vehicles be any different to the experience of a person on board, possibly sitting passively at the 'drivers' seat? Urban resilience in this case can be regarded as a way to best adapt to inevitable future situations by exhausting options of machine-human learning and understanding to fully and amicably function in real near future contexts. In the face of the expected gradual automation in cities, the uncertainties and unpredictableness of rather organic machine-human interactions will have to be carefully considered. Human behaviour is difficult to foresee and far away from being automated, autonomous vehicles somewhat need to acquire *'additional social intelligence'* (Camara et al., 2020 - p. 1) to function in complex socio-spatial environments.

Laser scanning has been treated in this instance not only as the technology associated with vehicles computation but as a springboard for discussion on car-human-environment vulnerabilities and as an engagement tool to induce a smooth transition to a safer, automated urban future. This is arguably an extension of previous studies (Tait et al., 2016) which explored the use of digital data capture to enable user engagement, where the strengths (adoption, discussion, participation) greatly outweighed any weaknesses or barriers to adoption (due to widespread availability of potential technologies). By showing moments of devices' misinterpretation through the eyes of *'unblinking machines'* - ghostly, somewhat unsettling depictions of everyday street life, it emphasizes the need for discourse on nuances of *'fundamentally inhuman, perspective on the built environment'* (Manaugh, 2015).

3. What is the future of mobility?

'The emergence of AV technology and the drive from the IT and automobile industry falls squarely into the area of ***corporate storytelling*** *and should arguably therefore be subject to further critical discourse across the urban planning and transport planning literatures.*' (Legacy et al., 2019 - p.10)

Over the past 100 years, the dominance and realm of private car ownership has become the most prominent mobility system. Urry (2007, p.120) described a somewhat bleak state of the contemporary situation as '[p]eople inhabit congestion, jams, temporal uncertainties and health-threatening city environments through being encapsulated in a domestic, cocooned, moving capsule, an iron bubble.' This statement further indicated a sort of alienation experienced by being in - inhabiting - the car as '[the] world of anonymized machines,

ghostly presences moving too fast to know directly or especially to see through the eye' (Urry, 2007 - p.124) and not experiencing surroundings, local contexts in a meaningful way. Perceiving and sensing the world through the (car) screen became a dominant way of living in the contemporary world.

Modern societies have become reliant on cars as daily transportation. It can also be implied that people have exhausted the use of cars on the streets – making roads 'killing fields' of late modern societies' (Urry, 2007 - p. 272). The number of fatal accidents on the roads has been steadily increasing, together with the general world population and vehicles (WHO, 2018). Adorno wrote as early as 1942: 'And which driver is not tempted, merely by the power of the engine, to wipe out the vermin of the street, the pedestrians, children and cyclists?' (1974: 40 quoted in Urry, 2007 - p.123). What is more 'cars have increasingly overwhelmed almost all environments, so everyone experiences such environments through the protective screen and increasingly abandons streets and squares to omnipotent metallic iron cages' (Urry, 2007 - p. 130). When motor vehicles first appeared, not many predicted the overwhelming scale of car accidents (frequently involving and harming non-car users), how the environment will become polluted, new spatial and social inequalities created often due to unsafe and inaccessible infrastructure when on average being parked most of the time. Thus, it can be argued that autonomous vehicles too will lead to some unanticipated and complex difficulties that will have to be faced and any discussion on the future of smart, autonomous mobility systems must be grounded on the notion of existing infrastructure and transport modes with all positive and undesirable consequences that have been associated with it. The especially critical approach should be adopted to better prepare for the changes and possibly influence how the future of mobility could unfold as AVs tend to be perceived as the major transformative agent in mobility and planning since the mass diffusion of the private motor vehicle (Legacy et al., 2019).

'It is believed that that AVs may reinforce existing automobility-based hegemonies whereby the future of mobility will see that the car remain centre-staged and individually owned. Conversely, others envisage future economies based on sharing which may offer opportunities to meet many of the emerging challenges of the twenty-first century city'. (Legacy et al. 2019, p.12)

The gradual introduction of autonomous vehicles into existing built environments could potentially be seen as an opportunity for a major rethinking of transportation systems in cities that challenges prevailing car-centric visions to the point of facilitating more sustainable mobility and making space for walking and cycling. In that respect, AVs could be seen as potentially most innovative and promising (Fagnant & Kockelman, 2015), yet at the same time potentially most disruptive that would profoundly remodel our cities and socio-spatial organisation (Legacy, 2019; Yigitcanlar et al., 2019). It can be argued that the research in social science could play an inevitable role in acknowledging the implications of existing and new inequalities in spatial planning and infrastructures and play an active role in recommending alternative routes to achieve sustainable future mobilities in the context of existing architecture and physical context determining the success of technology as highlighted by Graham, 2010 (quoted in Cohen et al., 2020) '*We should not wait for an AV-related infrastructural disaster'.*

3.1 Possible scenarios

It has been suggested that the idea of introducing self-driving transport vehicles to the context of contemporary cities is often perceived as the 'technological fix to the challenges of 21 st urban development' (Yeo & Lin 2020; Faisal et al., 2019). Often the interconnectivity of technology and the city is presented as a possible remedy to overcome the multidimensional challenges of global urbanization such as climate change, congestion, and greenhouse gas (GHG) emissions (where transport, being an essential part of the city, is accountable for approximately a quarter to one-third of GHG emissions (Faisal et al., 2019; Yigitcanlar, 2016). However, the normal practices of urban design and management draw as much on the humanities and an appreciation of human life, as they do on technology. "What actually complicates this process is the limited

social science scholarship on the impact of AVs on our cities and societies. The engineering literature is well developed, but the corresponding social science insights are only now emerging." (Yigitcanlar et al., 2019 - p.12).

It is crucial to anticipate and understand possible scenarios, as the change in mobility patterns is imminent and inevitable as AVs are functioning on the roads already (Yeo & Lin, 2020). The apprehension associated with new technology and the moral dilemmas of security, '[d]ystopic digital Orwell-ization of self and society' (Urry, 2007 - p.276) need to be considered together with wider issues of ethics and safety. A spectrum of emotions can be associated with introducing such a novel technology as self-driving vehicles on the roads, oscillating between excitement and enthusiasm to the uncomfortable feeling of the helplessness that can be experienced (Martines Diaz et al., 2018; Wolf, 2016) when we devote ourselves to the hands of technology – overriding algorithms of a robotic device. Is the system acceptable – what about fluctuating conditions, physical, weather concerned or rhythmical - the ever-changing city choreographies - often extremely unpredictable scenarios? Are initial mistakes made by the machines necessary for us to learn from? Can the algorithm ever evolve beyond human perception and conceivable understanding? Are AVs likely to provide a nuisance on the road or salvation to society?

Some of the recent demonstrations of AVs highlighted the issue of pedestrians stepping in front of cars, taking advantage of the safety features creating an issue of the 'freezing robot problem' (Brooks, 2017) and actively exploiting the predictable and safe behaviour of autonomous vehicles (Millard-Ball, 2016). The environment perception in AVs stems from an integration of built-in sensor systems positioning the laser technology at its centre in active object detection (Brummelen et al., 2018; Khatab et al., 2021). One of the key features for safe and efficient driving systems in AVs is the development of algorithms that anticipate actions as well as communication of all agents to gain an understanding of the patterns and diverse types of road behaviour (Madigan et al., 2019).

4. Ethics/algorithmic morality - 'human agency vis-a-vis automation' (Yeo and Lin 2020, p. 5)

Alongside discourses on technological innovation and technical issues still to be overcome in AVs comes the consideration of its social, cultural impacts on individuals and society (Atkins, 2016; McKinsey & Company, 2016). The pace of change regarding ethical considerations (JafariNaimi, 2017) and the potential environmental benefits in the reduction of CO_2 emissions (Winkle, 2016; Davila & Nombela, 2012) are arguably of greatest concern. Indeed, one of the main reasons to introduce the technology is an improvement to safety and reduction in fatal accidents due to human error and distractions. However, the technology itself cannot eradicate all (fatal) accidents as they will occur due to software or machine mistakes and failures (JafariNaimi, 2017).

'AVs are, at present, sufficiently foreign that the human exercise of empathy toward them fails us: We cannot predict how they will respond to the unpredictable, and therein lies a social science challenge. How do we consider the social ramifications of objects that will pervade society when we cannot even imagine how these interactive, autonomous objects will respond to the boundary conditions that will unquestionably emerge time after time? Rare events are by definition rare, but a one-in-a-million likelihood event will happen millions of times per year if our streets are filled with self-driving machines.' (Hancock et al., 2019).

What can be learned and implemented in possible AV futures, and how human-machine interactions can realise the promised potential, remains a key consideration. The social experience of traffic for passengers in the automated vehicle and that of people walking or driving alongside will undoubtedly evolve when AVs are introduced at scale on public roads. As Thrift (1996, p. 1468 quoted in Yeo et al., 2020) explains: '*no technology is ever found working in splendid isolation as though it is the central node in the social universe.*

It is linked—by the social purposes to which it is put—to humans and other technologies of different kinds. The autonomous vehicles will not exist in a space vacuum and will have to be integrated into intricate and complex multidimensional urban and social system constructs.

As humans are not always rational and passive beings when it comes to seamlessly accepting novel technology (Yeo & Lin, 2020), discussion about 'creative forms of robot abuse' (Nourbakhsh, 2013 - p. 59) is valid in describing possible future scenarios. In one instance - 'the Chips' autonomous tour guide robot whose seemingly naïve politeness every time someone stepped in his way by saying 'Excuse me' was abused by people until the phrase was changed to: 'Excuse us. You are blocking my path, and I am giving tour to the people behind me. Please let us continue' (Nourbakhsh, 2013 - p.59). It proved to be a successful way to turn people's behaviour around and treat the robot with respect. Yet, *'[e]ngineers have not yet found and may not be able to specify ways to characterize how our autonomous machines respond to the unlikely and the pathological'* (Hancock et al., 2019). The human–autonomous robot social context is a complex one, as 'there will be a plethora of willing people interested in testing legally indistinct boundaries to entertain themselves at a robot's expense' (Nourbakhsh, 2013 - p.60). In terms of AVs most people will probably use them in 'ordinary ways', others, however, might 'creatively' manipulate and misuse it beyond the designed purposes by hacking the technology to commit acts of crimes (Yeo & Lin, 2020; Carter, 2019; Tarantola, 2017; Rasouli & Tsotsos, 2019). This paper argues that the use of digital data capture technology can be used to effectively represent aspects of the human experience when using autonomous vehicles, and also of the surrounding physical environment. The costs associated with such technology have decreased significantly in recent years, partly through the development of robust photogrammetry techniques (3D modelling from photographs), and through wider availability and complimentary use of laser scanning and LIDAR technologies (see, for example, Fassi et al., 2011). Therefore, it is argued that the approach described herein could be readily applied in much wider contexts, and across other sites and scenarios.

Urban dwellers' use of AVs, including unexpected technology interactions and experiences, will certainly emerge and must be accounted for in the discourse of the way the technology is currently framed - as an all-encompassing fix to the urban development and mobility challenges (Yeo and Lin, 2020). The understanding of unpredictable future society and technology coexistence will be crucial in urban hard to predict realms - accommodating people, architecture, temporary structures, and all the good, bad, accidental, and most unlikely occurrences.

5. Summary

It has been suggested that we have achieved a 'critical juncture' (Docherty et al., 2017 - p10) in attempting to somewhat shape how autonomous vehicles (AVs) will influence mobility systems and shape the future (Legacy et al., 2019). The reason for the discussion about AVs and their integration into actual context is to envision, critically appraise, better prepare for the changes and potentially influence how it unfolds. The current dominant narratives of AVs are oscillating around technocentric ways of approaching the subject. As there are still many unknown unknowns surrounding the subject - it felt essential to include discussion on possible scenarios unfolding in near future and fathom potential influences on society of integrating AVs via engaging the general public in the process to manage expectations and create platforms for mutual learning.

'A city could decide to prioritize livability and active travel. Such a city would then allow deployment of C/AVs as long as they further that goal. In essence, the suggestion is to not allow technology to set the strategic agenda, but to employ technology to achieve strategic goals'. (Botello et al., 2019)

The paper specifically considers the AV as mapping tool as it moves through an environment, and the capture and visualisation of the complex effects which AVs may have on perception, experience and behaviour. The output of the integrated technology - the contextual images extracted from laser scanners, specifically the ones 'exaggerating glitches and scanning errors', in this study acted as a springboard to inclusive social-

scientific research that would concern major as well minor alterations to peoples' daily lives as users and nonusers of technology by '*reframing questions and highlighting uncertainties and contingencies'* (Cohen et al., 2020).

In this regard, the research concerns not only the users of a vehicle but also how the vehicle might interact with and sense or detect its surroundings. It is suggested that further study could usefully concern the behaviour of occupants of the AVs during a journey and that digital data capture might provide a method to facilitate such work. The research made innovative use of laser scanning – mobile LIDAR in particular - which was intended to enable a close consideration of the data and images AV technology produces. This situated the technology within human space and place, facilitating engagement with stakeholders.

This paper sought to explore how innovative methods of data capture and visualisation might be used to help stimulate debate, facilitate understanding, and help to open a dialogue with potential end users. As noted by Cohen et al. (2020), *'the technology, if it is to succeed in its own terms, must work with and incorporate the social complexities of the real world.'* This research suggested that there was great value and originality in using the visualization approaches illustrated to engage stakeholders early in the process of its development and regulatory deployment.

That the emphasis taken in that data capture was on inclusivity of data, and a desire to capture the movement, noise and human experience of a space, is critical. As discussed, the introduction of AVs on public roads will rely on technical innovation to ensure that vehicles can operate in a practical sense. However, the study of the social, perceptual and ethical effects of AVs is at least equally important. The notion of 'autonomy', as independent of human control, itself indicates the need to look at the issues of spatial, social, ethical and cultural human-nonhuman coexistence from the widened, relational and potentially more sensitive perspectives to fully realise the transformative possibilities of the autonomous city and impacts of technology on people, their lives and spaces in the urban realm.

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Image Sources

Fig.1: Google maps. (2021). Photo showing the context of research and potential AV route in Aberdeen;

Fig.2: Belkouri, D. (2020). 3d render of busy roundabout in Aberdeen retrieved from laser scanner;

Fig.3: Belkouri, D. (2020). 3d render of roundabout showing pedestrians crossing the street; retrieved from laser scanner.

Fig.4: Images of London retrieved from laser scanner depicting double-decker bus as a continuous mega-structure.
Credit.: ScanLAB Projects for The New York Times 2015 [Retrieved from: https://www.nytimes.com/2015/11/15/magazine/the-dream-life-of-driverless-cars.html]

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