Enhancing Urban Conversation for Smarter Cities – Augmented Reality as an enabler of digital civic participation

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Abstract. This paper presents a perspective on the role immersive technologies can play in the future of urban transformation. Specifically, this paper looks to answer the following questions – How can Augmented Reality be implemented as an enabler of civic participation in the urban transformation process? What specific and novel affordances does Augmented Reality present in this context? And how do these affordances demonstrate a unique interaction paradigm between citizens and cities? We review the current literature on future cities, urban transformation, digital civic participation and augmented reality usage to determine the current state of digitally enhanced urban transformation processes. As a result, we identify an opportunity in which recent developments in Augmented Reality technologies afford entirely new ways of approaching civic participation. We suggest new Augmented Reality technologies can be considered as a novel way to engage citizens in decision making processes and as a result improve the resilience, adaptability and sustainability of future cities. Augmented Reality can allow citizens and other stakeholders to visualise and imagine possible urban transformations, to contribute to an ongoing discussion between citizens and with city councils, and to participate in a feedback loop in which ideas are refined, analysed, and iterated in a collaborative process. We finally discuss challenges, tensions, and open issues of a research agenda aimed at developing immersive technologies for participatory urban transformation.

Keywords: Smart Cities; Urban Transformation; Augmented Reality; Civic Participation; Community-led initiatives; Sustainability.

1 Introduction

A rise in urban populations continues to generate new challenges for the administration and organisation of modern cities. Considering a projected increase of the global population, the United Nations estimates 68% of the world's population to live in cities by 2050, up from the current 55% [1]. Not surprisingly, city administrations are among major movers in exploring and piloting technological innovations that can contribute

to enable a sustainable growth in demand on transport, housing, and other services, in the face of potential challenges and disruptive events. Coupled with the huge economic interests that surround the development and deployment of technologies at the city scale, this push has sometimes resulted in enormous investments focused on creating 'smart' solutions. Oftentimes however, city administrations can focus too heavily on economic or technological outcomes as a means to measure sustainable growth and as a result can fail to align with broader social or cultural context. Abu Dhabi's Masdar City is one such project where a strong focus on sustainability has resulted in innovative developments in solar power technologies. Masdar has then been able to partner with other cities to sell these technologies and support the city economically.

These partnerships help make the city itself financially viable. In terms of economic and technological outcomes, Masdar City has largely succeeded, although in its 13 year life span its population is yet to rise over 1300 people. It is estimated to have a working population of about 4000 as the majority of the population commutes from other parts of Abu Dhabi or Dubai. With its strong focus on technological developments, it attracts many workers from the city, although without a focus on pre-existing social or cultural context, it struggles to offer a reason that workers would actually live there. Currently, much discourse around future cities conducted in industry, in academia and even in science fiction, tend to focus on technological outcomes that enhance buildings [2], transport [3], resources from food to energy and waste[4], and even augmenting human beings[5].

These explorations help to envision and conceptualise the tangible products that technology will develop or the improvements those products will have on the world around us. However, the concurrent mutual influence of these technologies and the communities remains blurred in these visions, which are by their very nature focused on technical challenges and opportunities. Current research is showing that these conceptualisations do not always resonate equally well with all citizen's socio-economic needs and goals. In fact, conceptualisations that eventuate in reality tend to favour the strongest stakeholders, whereas the vast majority rarely have a say [6].

For example, the Hudson Yards development in New York is one that was conceptualised as a technology-driven utopia but post-development is now criticized as an 'enclave for the ultra-wealthy' [7]. Similarly, the recently shutdown development in Toronto by Google's 'Sidewalk Labs' was criticised as surveillance capitalism and a threat to democracy on the grounds of concerns that Google would use resident data to favour their business goals[8]. In less extreme examples such as Songdo, South Korea, the conceptualisation of this high-tech city has been widely praised, although reviews from citizens of the city claim it to be 'a ghost town'[9]. Holland offers a critique of smart cities noting that there is a multitude of visions and definitions focusing on positive change fuelled by technological innovation [10]. From a different perspective, a relatively modest investment in Amsterdam aimed at creating a social media based platform for public debate in which citizens could engage in conversation with the city council to address and prioritise local issues, was very successful [11].

In this backdrop, we imagine a future city in which personalised technologies are used as a platform for citizens and council to collaboratively envision large and small innovations, and engage in public debate around which innovations are more desirable, for whom, and why. Recent advances in the areas of embedded technology [12][13], Internet of Things [14], and virtual and augmented reality [15][16] are opening a range

of opportunities in this space. In particular, augmented reality allows users to envision information in a contextualised and embodied manner by over-imposing digital contents and models to the user's field of view, therefore granting access to potential future developments from a first-person perspective. With AR citizens could literally move within or walk around somebody else's ideas and make available their own for other to experience in the same manner.

We argue there is a need in future cities for tools to improve collaborative conceptualisation and through an exploration of previous literature, we look to answer the questions:

Question 1. How can Augmented Reality be implemented as an enabler of civic participation in the urban transformation process?

Question 2. What specific and novel affordances does Augmented Reality present in this context? And how do these affordances demonstrate a unique interaction paradigm between citizens and cities?

This paper will first analyse the literature surrounding smart cities, urban transformation, augmented reality and current digital citizen participation processes. We highlight a shift in focus in future cities, from solution driven visions, to enabling conversation between council and citizens. As a result, cities look to novel mediums capable of supporting urban conversation and this paper aims to provide insights into how Augmented Reality is an extremely appropriate medium. We identify an opportunity for Augmented Reality to act as the novel technology to enable this conversation due to its specific affordances regarding digital and physical space and experience, and its ability to integrate with other technologies to allow for a multitude of different uses and interactions. We suggest three separate ways in which Augmented Reality will transform the conversation around future public space.

Firstly, with augmented reality, citizens, administrators, and other stakeholders can visualise information about potential development and innovations in a local suburb, envisioning that which does not exist yet, and engaging in discussions within and between communities. Secondly, augmented reality can support new methods to collaboratively participate and shape the future of cities, from very simple ways of voting up or down shared proposals, to more complex ways of manipulating the proposed developments, visualising alternative possibilities, navigating these options, and integrating various media and digital/physical contents. Thirdly, as a collaborative platform open to contributions by all citizens, augmented reality can be the source of more transparent and data driven decision making, supporting an iterative process of discussion, analysis, feedback, and refinement, in which more interested citizens, including marginalised and minority communities, are represented and their voice heard. We then identify some open issues regarding the future of cities that look to enhance urban conversation through technological means and raise questions for future research to explore.

2   Literature Review

We begin our literature review with an exploration of Smart City literature. The concept of Smart Cities is perhaps the most dominant current exploration of Technology and Cities in academic research and popular media. This broad theme offers an appropriate contextual background for understanding the ways in which cities have attempted to implement technologies thus far.

2.1 Smart Cities

The United Nations estimates 68% of the world's population to live in cities by 2050 [1]. On the score of these projections local and national governments around the world are looking to technology as a solution to improve specific urban issues such as traffic and resource management, urban redevelopment and community engagement that may be exacerbated by an increase in the urban population. All of which can have considerable impact on overall long-term goals for sustainability[17], resilience [18] and adaptability[19]. As populations continue to rise and technology becomes a more natural extension to urban life, cities become increasingly complex spaces to govern, plan, research and simply conceptualise. Within the past three decades, this has seen a move in the literature towards the idea of 'Smart Cities'. Much like the evolving nature of cities, the nature of smart city definitions in literature is ever evolving. Smart Cities were originally conceptualised at the turn of the 21st century as cities that utilise technology to monitor critical infrastructure [20] largely aligning with the rise of ICT to aid in planning and maintenance activities. The smart city agenda has sometimes been criticised for being too technologically focused or simply a passing term [21]. Often these critiques emerge in Urban Planning, Design and E-Governance literature where the Smart City term is either being re-used as a solution to more socially focused urban challenges or is discarded in favour of more specific terms such as Digital Era Governance [22] or City of Culture [23]. The more socially focused definitions concentrate on human capital and economic development which see an increase in definitions aligned with the improvement of knowledge, talent, and creativity. Thite [24] conceptualises a smart city as a place capable of nurturing a creative economy attracting knowledge workers to generate competitive advantage, and Komninos [25] understands Smart Cities as "territories with high capacity for learning and innovation". Albino et al [21] note that it is this divide between two different domains that has made it so hard to clearly define Smart Cities. In some instances, the term clearly refers to infrastructure and resource management practices, yet in others refers to culture, policy, and social inclusion.

However, two distinct definitions move towards a hybrid combination of ICT and human capital whilst also closely align with notable successes in Smart City practice in the previous years. Kourtit and Nijkamp [26] define Smart Cities as a promising mix of human capital, infrastructure capital, social capital and entrepreneurial capital, and Caragliu et al., [27] believe "A city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance." Whilst a large collection of

terminology tends to interchange within Smart City literature, certain key themes have developed in the focus of future cities and technology. Desouza et al. [11] suggest that this evolving definition can be understood through three separate themes that help identify the emergence of the Smart City concept and physical Smart City development. Firstly the Smart City Governance and Services theme largely focuses on the intersection of technology and city governance. Specifically interested in the digitalisation of citizen focused services to improve efficiencies and overall quality of life. In its most recent stages it understands the benefits of a platform-based approach looking at ICT products as enablers of outcomes [11]. Secondly, the Smart City ICT/Infrastructure theme notes a research movement towards technologically enhanced public infrastructure. This has a strong focus on the improvements and efficiencies that technological advancements can demonstrate when applied to urban environments. Typically this theme explores Smart power grids, transportation and environmental monitoring. [9] Lastly the Sustainability and Social Capital theme initially developed as a way to investigate the risks of environmental or social decays [28]. While the majority of sustainability discourse is focused on nature and physical environments, recent research has begun to suggest that sustainability must consider the social sphere [11], [29], [30] In light of this, the sustainability theme has begun to recognise benefits of an approach based on a communication network that includes, utilises and evolves citizens in addressing unique urban environmental and social challenges. Interestingly, in practice cities have found success in a somewhat hybrid combination of the aforementioned themes.

A pathway seems to emerge in which cities can utilise an e-governance lens to develop technologically enabled communication channels that allow citizens to engage with decisions around critical urban transformation and the inclusion of ICT-enabled infrastructure – as in the model of 'wise management' and 'participatory governance' put forward by Caragliu et al.'s [27] definition quoted above. As an example, Barcelona has recently shifted their Smart City strategy from one focused on implementation of sensors and devices, to one in which the data of the city is made available to citizens through e-governance services, allowing citizens to engage with the data and address key issues or voice key concerns, which in turn can be fed back into the development of ICT-enabled infrastructure moving forward. Currently, the majority of a smart city's focus is on the research and development of ICT infrastructure to improve specific urban efficiencies. By improving resource maintenance, traffic flow or waste management, it is argued that the city can improve quality of life for its citizens. However, research also suggests that for a city to consider itself truly 'smart', it must make equal investments in its citizens and their ability to contribute knowledge to the unique urban context in which they live. As noted, attempts to gather individual citizen contributions, such as the platform based social media technology from Amsterdam or Barcelona's open data strategy, have proven successful, although are based on well established technologies. We suggest a key gap in the exploration of emerging technologies at granular, single citizen levels. Our research suggests an exploration into what new forms of participation may be possible based on embodied technologies such as AR.

From this analysis of the smart city literature we can note a key theme emerging in future cities that has a strong focus on the ways in which citizens can be engaged digitally with urban transformation processes. Again, in practice we have seen

examples of co-designed urban conversation across Europe such as the MyNeighbourhood projects in Italy, UK, Portugal and Denmark [31]. Through case studies and theoretical studies, this emerging trend in smart city literature highlights an opportunity for technologies that can engage citizens in urban processes.

2.2 Urban Transformation

Similar to the shift in Smart City research, Urban transformation has largely shifted in the previous half century from a logistical and objective planning to a design led social science, partly due to the socio-spatial research that identifies a connection between the planning of physical space and the impact that has on democracy and equality [32], [33]. Often referred to as Urban Regeneration, it is normally considered to be an outcome of the interplay between physical, economic, social and environmental pressures [32] and the transition from manufacturing-based economies to service-based economies. Previous industrial districts are often re-purposed due to their lack of use and the cities' need for new urban developments which is often categorised as 'brownfield' developments [34]. As urban transformation pushes more into the field of design, architecture and civic participation, the ways in which urban transformation occurs have become more subjective and nuanced. In some cases, a design based approach to urban transformation has been seen to have a negative effect on the outcome of the urban area as the individual vision of the designer or the qualitative design processes aren't communicated or documented sufficiently. In this case, other disciplines (traditionally rooted in an 'applied science' approach) criticise the way in which design seems to sit between objective reasoning and intuitive creativity [35]. When the outcome of the transformation does not garner public interest or benefits a particular demographic, it is argued that design often considers end users as a scenic feature in its own artistic design world [36] and for the benefit of a city as a venue rather than a city as a service to its inhabitants [37].

By contrast, research focused on collaborative design processes, point to the opportunities of actively involving citizens in the conceptualisation of urban transformation, leading to collectively owned ideas, mutual support, and sustainable initiatives [38], [39]. Similar to smart cities, literature on successful urban transformation emphasize the key role of inclusion and contribution of the citizens who live, work, or visit the area, and focus on localized, and potentially scalable, transportable innovations [40]. These can utilise design as a way to seed grassroot initiatives, or as a framework that develops a sustainable ongoing urban regeneration process. There is however, as noted above, a tension between the collective focus of urban transformation and the limitations of collaborative and participatory design methods, that ultimately engage individuals with specific worldviews, values, and objectives. For example, the inclusion of citizens is often achieved through websites, surveys and other means to attempt to understand citizens' attitudes and personal wants. It is then the responsibility of the council to attempt to compare qualitative citizen contributions with quantitative data collected from planning and maintenance activities, a task inherently imperfect. From the perspective of city and council, the literature notes numerous benefits to the involvement of citizens. For example, social media posts can be analysed at a large scale to improve mobility management [41]. Furthermore,

citizens can also proactively take advantage of open-data networks to develop their own mobile applications in a rise of participatory innovations [42]. It is therefore crucial to understand the context (social, cultural, political, economic, and of course technical) in which citizens currently interact digitally. How are citizens currently engaged and what are the opportunities for council to align with such methods?

Again, this presents an opportunity into the exploration of what methods are appropriate for aligning with individual citizens at a granular detail. Whilst survey's exist to extract feedback from individual citizens, the survey's themselves lack a sense of context and require abstraction from citizens as to their feelings regarding the specific topic. Embodied technologies, such as Augmented Reality, allow for a more granular understanding of citizens engagement with the space around them at the time they participate within it.

2.3 Digital Civic Participation

Civic participation through digital means has been understood mostly as an enabler of citizen science and digital activism and less so as a key feature in the conceptualization of future cities. Citizen Science literature often looks to include citizens in community tasks through digital means, but these tasks are often constrained to data collection activities with a particular niche research goal. In fact, Citizen Science is largely understood as a way to enlist communities in collecting large amounts of data to study large scale patterns [43]. The majority of these projects to date include animal observation and help to further a global data collective on a particular animal species or phenomenon. In the city context, citizen science is often concerned with the quantitative data that participants can capture or somewhat repetitively process, rather than the data generated by the participants experience in and of itself. In this way, citizen science looks to outsource to citizens the collection of data about a particular phenomenon, in some ways likening citizens to a tool that help to produce data in the same way a sensor may capture information. Examples of citizens participating in these forms of data collection include efforts to collect and share data on weather or air quality from balconies, for example the effort to share radiation levels in the aftermath of the Fukushima disaster in Japan [44]. Yet, whilst through this lens we can see a role for citizen science in future cities, this role is often contingent to addressing specific emergencies or pursuing particular conservation agendas, rather than organically informing or leading a smart city and urban transformation movement wherein citizens are considered an active part of the conversation rather than a neutral data collection tool.

Digital Activism is another digital civic participation practice that has gained a following in the previous decade as more researchers begin to study the changing landscape of social movements and the impact of social media on said movements. The broad conceptualisation of Digital Activism can be understood in three parts, firstly 'Social Movements' begin as a group of individuals with a common grievance and a resulting collective action [45][46]. This resulting collective action and act thereof is considered as Social Activism if the group aims to promote social change [45]. Digital Activism is therefore the promotion of aforementioned social movements through digital technologies [45]. Whilst physical social activism often requires protests and

demonstrations as a way to promote social change, digital activism's activities allow for the promotion of social change through very simple interactions. George and Leidner's [45] extensive literature review categorises ten digital activism activities: Clicktivism, Metavoicing, Assertion, E-Funding, Political Consumerism, Digital Petitions, Botivism, Data Activism, Exposure and Hacktivism. Whilst each activity demonstrates certain contextual mechanisms and impacts, Clicktivism is conceptualised as simply 'liking' or 'following' activist social media, and Metavoicing can be understood as simply 'sharing', 'retweeting' or 'reposting' other social media posts [45]. While some research looks to frame this method of social activism as ineffective or illegitimate, Halupka [47] argues for digital activism – in particular clicktivism - as an activity that is a political act that has relevance for the individual and as such should be viewed as worthwhile regardless of the relatively limited effort.

Citizen science and digital activism can be seen to represent two complementary aspects of a same 'platform', one (citizen science) focusing on quantitative aspects of data collection and processing, the other (digital activism) oriented to promoting narratives and advocating for change. Both, however, gain strength through social media's global reach, somewhat to the detriment of localised relevance and impact. In fact, in many ways, transcending national boundaries to show the widespread and systemic nature of issues at hand can be seen as a measure of success of these initiatives, such as in the case of recent movements, from #MeToo, to BlackLivesMatter, to Extinction Rebellion, and more. On the contrary, in the context of future cities and urban transformation it seems crucial to be able to leverage situated knowledge and localised engagement of people connected to each other through a shared experience of the city, rather than a shared experience of class, gender, or race discrimination. Citizen Science and Digital Activism both are seeing an ongoing increasing popularity with communities and a growing range of tools to participate and enable social and scientific change. Community involvement in urban transformation through digital means is however still somewhat in its infancy. As digital technologies tend to focus on the potential of global engagement in digital communities, urban transformation and digital civic participation tend to return to localised communities and localised public space.

A third approach with a focus on localised communities and civic participation is that of middle-out engagement. Middle-out engagement looks to draw on the collective knowledge of all actors to provide opportunities for collaborative community engagement processes [48]. Specifically, middle-out engagement looks to integrate the objectives of both top-down decision makers and everyday citizens to find a middle ground for all stakeholders within the community [49]. Fredericks and Caldwell's work in this space designed and implemented a number of urban pop-up interventions that look to engage communities through a sense of playful city-making [48]. Frederick's Digitally Augmented Pop-up [48] worked with council stakeholders to decide upon its agenda before enlisting the help of local community stakeholders in the design of its engagement activities. Its implementation was then prototyped with SME's in graphic design and public relations, before eventually being deployed in four different locations across the Sydney metropolitan area. These locations were chosen in collaboration with both council and community stakeholders and as a result included a diverse range of suburbs, communities and cultures. The way in which this engagement approach involves a wide range of stakeholders demonstrates a positive trend towards a modern community's willingness to be involved in urban transformation and the benefits of

diversity in design allow for a wider reaching deployment with a greater opportunity to collect rich-data to inform decision making.

Between citizen science, digital activism and middle-out engagement we note a trend from both council and community stakeholders towards increased collaboration and a familiarity with digital engagement. Extending on these trends, we propose Augmented Reality as a technology that offers affordances aligned with both digital activism and middle-out engagement but adds to these methods of engagement in flexible and meaningful ways. We suggest that Augmented Reality, by providing a means to blend the physical and digital mediums and integrate both [50], can vastly increases the number of options for maintaining a conversation about what the future city could be. Unlike Web 2.0 technologies, Augmented Reality is an inherently visual or auditorily based tool extending the possible conversational options to people of all backgrounds and literacies. Lastly, Augmented Reality offers a way in which the engagement associated with digital communities can be localised into physical public space allowing for conversation and interaction to be more conducive to the possibilities existing within that particular context. With a number of new possibilities around interaction, engagement and maintaining conversation in future cities, the exploration of Augmented Reality in this context could provide valuable insights into future transformation of urban areas whilst simultaneously raising the techno-literacy of a city's citizens [51].

2.4 Augmented reality

Augmented Reality has become increasingly popular in the past decade as smartphone and camera technology has rapidly improved and the applications of mixed reality have extended to consumer applications. However, Augmented Reality in its most authentic understanding has been utilised as a technology to aid human experience for thousands of years. Use of light sources, reflections and informational overlays have augmented reality for users through periscopes, microscopes and a number of other scientific or navigational tools. One such concept is that of 'Pepper's Ghost' [52] which is still utilised as a cost effective AR prototyping technique [53]. In the current discourse however, Augmented Reality is widely understood as a technology that combines real and virtual content, is interactive in real time, and is anchored in 3D space [54], [55]. Originally, Augmented Reality systems required computational power unavailable in small hand-held devices, and as a result throughout the 90's the majority of Augmented Reality systems were developed in tandem with the idea of wearable computing, which McCann and Bryson [56] hypothesise was largely due to the emergence of the world wide web. The web's rising popularity allowed for computer hobbyists to discuss and develop prototypes and build communities not limited to geographical location [56]. Again however, due to the size and bulky nature of the hardware required for these systems, even the wearable computing applications of Augmented Reality were most popularised in healthcare, education and manufacturing. It was not until 2004 that Mohring [57] developed a mobile application for Augmented Reality using a Nokia mobile device. In the following years Augmented Reality began to show itself in day to day life, such as for on-field sponsorship advertisement during televised sporting events [54]. By 2007 and 2008 both Apple and Android smartphones had been

developed with hardware capable of utilising Augmented Reality software, and between 2008 and current day, the rise in both marketing and consumer Augmented Reality applications may suggest a staying power for Augmented Reality technology as a part of everyday life.

More recently, the use of Augmented Reality in industrial contexts such as manufacturing, assembly and maintenance has continued to further the development of wearable devices with a focus on glasses and headsets such as the Microsoft Hololens and Google Glass. Previous literature reviews have widely studied the existing forms of AR applications [58], [59], and a previous limitation has been noted in the fiducial marker system. In most AR applications, virtual information is linked to a physical object and this object is registered as a fiducial marker. It has been suggested that this can be limiting in more dynamic and changing environments [60]. However, recent developments in camera technology such as LIDAR, improved network capabilities and improved spatial recognition software allows for the use of spatial anchors and environment scanning. This allows AR devices like the Hololens to scan environments in real time and create 3D virtual representations of the area. In doing so, it is capable of adding virtual objects to the space without the use of fiducial markers as the device only has to update its virtual scan of the space, rather than the physical area itself. This allows for a more adaptable experience in the face of changing environments, such as urban landscapes. In the case of civic participation, these spatial anchors can be configured by users and therefore create new avenues for collaboration between citizen and council, specifically affording citizens creation of content within urban areas that can digitally interact with council applications and databases. As an example, we can imagine it is the digital equivalent of finding a cracked footpath and leaving a note directly on the cracked cement for the council. However, as this note exists digitally (through AR) it could be instantly communicated to council, similar to a direct message or email. New spatial anchor technology allows users to create a location for content, situating information directly at the physical source of their issue or discussion point.

Immersive technologies in future cities open up new avenues to civic participation processes wherein qualitative and quantitative data can be created, merged, and shared between councils and citizens in an ongoing, digitally mediated conversation. Whilst there are other technologies that share this same affordance, Augmented Reality offers a more personal and embodied opportunity. Currently, the use of ambient displays offers a way in which citizens can interact digitally with the council in a specific geographic location, although they often still exist in the physical world. Ambient Displays often look to present information in a way that is non-intrusive or distracting to the user, and as a result, exist on the periphery of a user's attention [61]. Augmented Reality allows a user to keep their attention on the particular urban environment whilst still looking through the Augmented Reality technology to interpret the urban context. Secondly, the use of council provided digital displays are often standardised in their design to be appropriate for as many interactions as possible [62]. In the case of Augmented Reality, the interface and means of interaction exists specifically for each user and therefore offers more potential customisability. This provides a unique opportunity for a more personal interaction between cities and individuals and extends into the types of relationships that can form between different members of community, not just from council to citizens.

As an example, Augmented Reality (AR) could be utilised to allow citizens to lay a virtual path for the best way to navigate between two train stations. Other citizens could use their AR enabled phones to see and follow the virtual route created by their peers and could leave geo-located comments, likes or other interactions that demonstrate their attitudes towards the particular route they are following. Council representatives could collect the qualitative data (such as the interactions whilst on the route) and marry these with the quantitative data such as which route has the most citizens active at any one time or whether there is a correlation between the most popular and the quickest routes. A key advantage of AR over other existing technologies, such as smartphones or web platforms, is that AR allows for an integration of these technologies with the physical context of the train station. Users can create and utilise the information by literally moving and acting within the spaces, using the world as their personal sketchpad. Navigating space with the assistance of a 2D virtual map such as Google Maps is largely different to the experience of navigating through a physical space, and often when navigating physical space, we rely on a mental map that we have individually conceptualised [63]. Verticality of urban space in particular, such as stairs or other elevated areas are rarely represented in 2d visualisations of space but largely affect the way in which we may choose to navigate.

In addition to being in the space, AR affords a different range of embodied relations to the space and data than is possible through, for example, geo-located mobile apps [64]. With AR devices the user looks at the space through the device, which therefore becomes transparent and enriches the users' experience without becoming the focus of their attention. Smartphone apps need to be read and interpreted, and their contents mapped mentally to the external environment, which remains separate on a perceptual level.

Through AR, we are in the physical space as we navigate it, tracking this information and allowing our subjective navigation decisions to be shared and, crucially, the information we create or consume is also situated in that physical space. Our decisions and behaviour are not solely based on the predetermined map but are improvised and situational. We may take a slightly longer route through the station because we enjoy the mural painted on a particular wall or deviate from our path because of a nice scent of freshly baked bread – something that could not be represented through a 2D map, and as such may not be realised until experienced. However, once captured this information could be added to the appropriate 2D mapping applications enriching the level of information to be interpreted through geo-located applications.

AR allows us to integrate important contextual information in urban space that often largely shape citizens experiences, with important digital information that often largely improve urban efficiency. Our situational decisions and behaviour can be captured and used as a way to further contextualise pre-determined digital maps. As a result, the public space between train stations becomes an area filled with a hybrid qualitative/quantitative data set that demonstrates an ongoing conversation between citizens and councils as to how that space can be improved. This opportunity is one that can only be made possible thanks to the role of immersive technologies as an enabler of the urban transformation process.
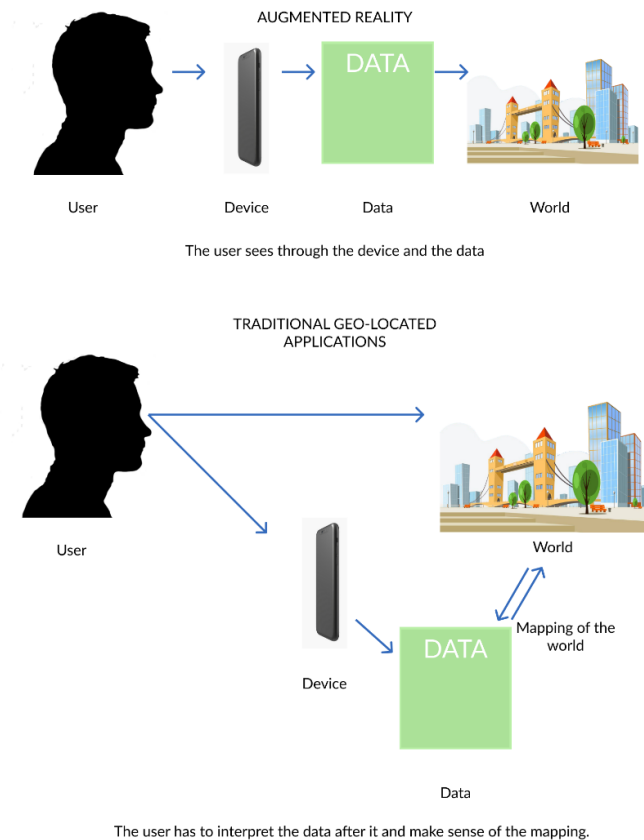
Fig. 1. Comparisons of interpretation through augmented reality

At this point in time however, the use of Augmented Reality in future cities is mostly utilised in consumer applications or areas of expertise and the potential for augmented reality to involve the two is yet to really be explored. A few popular consumer examples are Reitmayr and Schmalstieg's Outdoor Navigation and Information Browsing Head-Up_Display [65], Reitmayr's Model Based Tracking system [65] and more recently, the development of PokemonGo [66]. Each of these applications and their subsequent research put a strong focus on Augmented Reality's potential to assist in individual urban navigation, but rarely align this potential with the urban transformation processes of developers and councils. Piga et al [67] conducted interviews with Real Estate developers, Architectural Firms and Public Administrators noting an interest in AR to improve social sustainability with a crucial importance put on community involvement initiatives. Key topics included place identity and the social impact of urban transformation. Whereas Augmented Reality is often used in this space for architecture, engineering, and maintenance, there is a growing interest in exploring socialised and collaborative uses of augmented reality for a variety of tasks. Research proceeding

under different labels such as collaborative augmented reality [68], Augmented Sociality [69], and more is now looking at augmented reality as a collaborative platform capable to deliver a stage on which physical and digital spaces, object, and actors, come together to enable new forms of collective thinking.

2.5 Summary of literature

Rising populations will increase both the number and scale of urban challenges faced by future cities. Both in practice and research, the concept of smart cities is largely believed to be a path to address these urban issues. The smart city concept has shifted from a solution driven method generated through the implementation of technologies to looking at technology as an enabler of citizens and conversational processes. Simultaneously, urban transformation looks for more concrete and evidenced ways in which to include citizens in active change. Whilst the lens of human centred design offers a number of opportunities, without correct execution and demonstrated benefit it can quickly marginalise citizens further from the urban transformation process. In Digital Activism and Citizen Science we can note a desire from citizens to be involved in larger processes of scientific and social change, and the affordances digital technologies offer to further this inclusion. Playful City-Making demonstrates an interest from citizens into exploring different urban conversations and collaboration methods and highlights an opportunity for new interaction paradigms between councils and citizens. Lastly, Augmented Reality offers a number of customisable and intuitive ways in which conversations can be created between parties and experienced in an embodied manner. Recent developments in AR technologies demonstrate a further push towards accessibility through handheld devices and further improvements in spatial anchor technology make for more adaptable and dynamic possibilities. However, the most recent affordances of AR are only at the beginning of an exploration into its use cases within cities. From the literature reviewed, we identify a demand in urban processes for an inclusion of citizen collaboration through digital means. Therefore, we offer discussions for the following questions:

Question 1: How can Augmented Reality be implemented as an enabler of civic participation in the urban transformation process?

Question 2: What specific and novel affordances does Augmented Reality present in this context? And how do these affordances demonstrate a unique interaction paradigm between citizens and cities?

We propose three ways in which cities can benefit from Augmented Reality as a platform for including citizens in urban transformation processes.

1. We discuss Augmented Reality as an immersive and embodied real-time enabler of dialogue between citizens and councils. As discussed in the literature, Augmented Reality affords an embodied experience of the physical world through digital technologies, as opposed to an interpretation of digital technologies that then guide our decision

making in physical space. This key distinction allows for an entirely novel exploration of how an urban area can be experienced.

2. We suggest by enabling a real-time dialogue between citizens and councils, AR also enables a number of visual, physical and practical co-design tools that engage citizens in unique, contextual and personal forms. The recent development of spatial anchor technology is yet to be explored in the urban context. This paper highlights the novel opportunities this recent technology presents.

3. Lastly, through AR's digital affordances, both citizens and councils contributions to a public space can be stored, retrieved and reflected upon, providing insights that either can represent current urban dialogue, or can shape the ways in which future urban challenges are managed. Furthermore, by digitally storing snapshots of urban context, possible solutions to urban challenges can be analysed and potentially utilised in other suburbs, cities or countries.

3 Discussion

3.1 Augmented Reality as an immersive real-time enabler of dialogue between citizens and councils

As discussed in the Smart City research, future cities require novel ways in which a conversation can be shared in real time between a council and its citizens. Due to the ever-improving hardware of smart phone devices, and more recently the appearance of affordable, off the shelf head mounted displays, augmented reality has become a viable tool in which information can be geographically situated in a physical environment whilst delivered through digital means. For councils and citizens, Augmented Reality allows a conversation to be started about a particular urban transformation at the exact location where that transformation is meant to happen or may have an impact. Whilst traditionally, councils would have to walk door to door, or even in a digital world, send emails hoping to reach the interested citizens; they are now able to pinpoint information for citizens to interact with in their own time with their own device. Furthermore, councils no longer have to be the starting point of this conversation. Through the use of spatial anchors [60], citizens can create their own points of interest and share these with one another, with local business, community activities, or between neighbourhoods, apartment complexes or families. Localising the conversation in both the digital and physical sphere presents an opportunity to harness the benefits of digital social networking effects and traditional physical community initiatives. This conversation offers flexible interaction methods for citizens and imbues a sense of location and context into a digital medium. Where digital platforms technically exist in cyberspace, and physical communities exist in the physical world, augmented reality offers a chance to explore the interplay between the two, positioning digital platforms in physical communities and vice-versa. Not dissimilar to the impact of the world wide web in the early 1990's in developing new global digital communities, Augmented

Reality provides an opportunity to develop new hybrid communities contextualised around localised public space but enhanced by digital possibilities. Whilst enhancing public space with digital possibilities is possible through the use of Ambient Displays or other technologies, a key advantage of AR over commonly available geo-located applications, consists in the rich embodied experience that AR can afford and make possible. Unlike ambient displays, which have a long history of use in participatory community settings (see e.g. [70]) or geo-located mobile Apps, AR lets users explore the augmented world by moving and living in it, taking advantage of peripheral attention and leveraging the rich interplay of virtual and material tools and spaces [69]. This is where Augmented Reality demonstrates its affordances as an immersive and real-time tool, offering a new Spatial Interface for existing digital services. AR allows users to interpret their physical surroundings with digital augmentation supporting their immersion in their current environment rather than trying to replicate or recreate immersion elsewhere (such as Virtual Reality or handheld experiences).

For councils, it has the potential to vastly improve both quantity and quality of communication and community consultation. Much in the way an administrator of a digital platform is able to moderate and interact with other digital community members, councils could moderate and interact with citizens on numerous topic points within a particular suburb. From inclusions of new bus stops to large scale main street property developments, Augmented Reality conceptualised as an enabler of conversation allows for councils to directly communicate with the citizens of a particular suburb. Citizens, on their side, may leverage the opportunities created by a socialised platform to proactively refine their contribution, openly discuss alternatives, reach consensus, and promote causes and initiatives they value.

3.2 Augmented Reality as a tool for the visual, practical and physical co-design of urban transformation

Following the establishment of a mixed reality dialogue between citizens and councils, Augmented Reality offers an opportunity to manipulate digital artifacts in physical space. This practical application of Augmented Reality allows for the conversation to delve into visual representations of ideas as opposed to textual abstractions. More crucially, citizens can walk through and experience the proposed transformations as it would never have been possible with more traditional visuals or models. When citizens wish to contribute ideas, they are no longer limited to their ability to formalise such an idea or deliver it through the exact required medium that council specifies. Instead, they can use Augmented Reality tools to visualise their ideas in the space. This could be everything from lighting, colours and signposting to objects or alerts. Furthermore, where users are unable to conceptualise their ideas in a visual format, they could then post comments, gifs, emojis or links to other images or videos that represent their idea. By mixing reality, Augmented Reality provides the user with all possible methods for them to convey an idea in the way that suits them. Just in the ways we digitally edit and improve documents, images, videos, emails, files and folders, we can apply these same processes to urban environments through the use of augmented reality. However, by extending these digital interactions into physical space these interactions are also afforded the physical context in which they are discussed. Where citizens would

previously have to discuss urban development online or at a local community hall, they can now leave discussions points directly at the site for development. This opens entirely new interpretations to previous digital interactions and introduces means of physical interaction to those who are not familiar with purely digital mediums.

To provide an example:

Fig. 2. Different possibilities of augmented reality participation

A council may be deciding where to place seating in a small public space. As an experiment, the council could place some seating in the space and lock this seating to a spatial anchor so that it is recognised as a digital object in an AR environment. This AR environment could be viewed by any citizen with an AR compatible device but could also be linked to a GPS system or a social media community. Through this device, a

citizen could post a comment on the seat and any other citizen could see the comment in their AR environment, against the location in their GPS, against a social media community that is linked to the seat, or even against an ambient display set up within the public space. This opens up the interaction to four separate digital mediums but is still contextualised by its physical location.

Next, a citizen who doesn't necessarily use a particular digital device could choose to move the physical seat across the physical urban space. This relocation could still be tracked in digital space, so that all the users who digitally interact with the space can see the seat's original position and its new location. This way, the means of interaction aren't strictly limited to those who are familiar with digital technologies.

Lastly, a citizen who may not be able to physically access the space can still contribute via the GPS location. Once this public space has been digitally situated, a citizen could find a picture of seating they would prefer and drop it at the GPS location for others to witness either digitally or at the location.

This example aims to be illustrative of the unique affordances of Augmented Reality, in highlighting the fact that AR is open to a large number of integrations and as such is flexible in the way it is interacted with. As a platform for co-design practice, it allows urban transformation to move away from traditional methods such as surveys, interviews, focus groups and websites that can sometimes enable further biases, or hinder the participants ability to best offer their contribution [71]. By presenting information in a familiar digital format, this tool could alleviate feelings of inadequacy amongst citizens when it comes to typically complex subject matter such as resource management, and instead allows citizens to express their contribution at a higher level, creating, manipulating, or commenting upon (virtual) objects in (physical) space. Whilst these conversations will still require subject matter experts, this format allows to delineate particular questions to the wider public or gain qualitative insights in a more collaborative citizen science format.

3.3 Augmented Reality as a reflective and data driven representation of the above conversation and co-design processes

Lastly, as Augmented Reality captures all contributions in digital space, it also allows all contributions to be digitized, stored and analysed. Big Data and the use of IoT technologies is widely recognised in Smart City literature [72]–[74] for its benefits in monitoring and improving efficiencies of city resources or traffic, however it is often difficult to marry this with qualitative aspects of human behaviour to provide a more holistic picture of city life. Augmented Reality offers an interface to interact with humans within the urban landscape, retrieving qualitative insights where required, such as where inefficiencies have already been noted in public space. These contributions can be categorised, measured quantitatively and qualitatively, and viewed or understood from anywhere in cyberspace. As a council, it will allow for analytics to be performed from the necessary office as opposed to on location and furthers an elimination of paper-based surveys and questionnaires. This in turn, allows for analytics and results to be communicated back to citizens in a time and place that suits them. This removes the physical and time-based constraints of community consultation and instead allows for the fluid conversation in accordance with the complexity of citizens

and council members individual schedules. As noted by Frederick [48] , there can often be difficulties regarding the amount and forms of data generated through middle-out community engagement activities. There are often many variables around the deployment of an initiative in public space that can make it difficult to collect, analyse and draw conclusions. Whilst these challenges certainly remain to exist in Augmented Reality, the technology's digital nature allows for pre-existing data formats to be implemented and pre-existing data analytics tools to be utilised. Augmented Reality's ability to integrate with other technologies that have well established means for data collection allows for design choices to be made that make for more effective data integration and an improved efficiency in analytics. Analytics can be measured through both quantitative means – in order to improve and support evidence based decision making methods – and qualitative means – in order to further understand citizens specific needs, attitudes and values. This offers an opportunity to address some key issues raised in literature: citizens represented as scenic features in design visions [36] or a lack of empirical evidence in supporting decision making [32]. Once analysed, results can then be fed back into the digital overlay at the urban transformation, allowing for updates to the conversation and a more informed co-design process for citizens.

Not only does this present interesting opportunities for reflecting on urban life, but it also presents an opportunity for councils to create a more holistic urban narrative. Urban narratives have been investigated as a powerful tool for communicating the urban planning process to citizens in a way that is personal and specific to individual urban life [15]. As a result, numerous projects have found that co-designing with citizens through the use of narrative is an effective method for garnering community engagement which again helps to address the issues surrounding citizens as scenic features in urban design visions. Using 2d and 3d virtual environments to re-create and co-design urban spaces has been utilised often in urban planning research, although the use of AR to integrate virtual and physical environments is still underexplored. Conclusions from studies in this space often look towards the exploration of digital and real-world integration [15]. Without integration, the narrative that sits behind a particular virtual environment will always be created. That is, a narrative has to be developed for the environment. These narratives can mimic existing narratives within physical space, yet as they exist virtually, they will always remain separate from the physical world. Urban narratives however, are the result of a complex co-existence of physical urban space and individual citizens lives. Therefore, the narrative is inherent in an urban landscape. Through AR, real-world integration can be utilised to capture the existing urban narrative and provide more realistic context to decisions that citizens wish to make with their digital artifacts. Put simply, when an urban transformation takes place, a website may be created online to showcase the proposal and a narrative written to contextualise the motivations for the proposal. As these exist digitally, they are an abstraction of the actual events aiming to take place in physical space and require citizens to visualise through narrative the proposed transformation. If instead, the motivations behind the proposal could be visualised through AR directly above the development site, then citizens could understand the transformation against the existing urban area and the narrative it already has.

Finally, there would be an equal opportunity in this platform for addressing urban challenges in other cities.

Where potential solutions or improvements are captured through this digital platform, we believe there could be interesting replicability in applying such solutions to cities experiencing similar problems. There will be difficulties in ensuring these solutions still address the unique identity of each particular city, but at some level this kind of tool would hold value at a broad scale for best practice suggestions. These benefits would not only be restricted to specific urban issues, but could also offer suggestions for data structures, content moderation and other administrative tasks. Such a platform holds just as much value in its operational replicability as its quantitative and qualitative insights to addressing urban challenges.

4. Open Issues

This paper has put a significant focus on the role Augmented Reality can play in enhancing conversational processes in future cities. We argue that Augmented Reality has the chance to blend the physical and digital worlds combining the benefits of both to improve the experience and the envisioning of public space in future cities. The impacts of such a platform could greatly affect the democratic process. However, while viewing Augmented Reality as an enabler of dialogue, we recognise there are a number of open issues, potential challenges and opportunities that need to be further investigated.

Firstly, we are aware of some of the broader societal concerns that arise through our initial conceptualization. As we look to enable further conversation, we must subsequently question the means of moderation and inclusion. These are somewhat easily identifiable issues although with complex considerations as to their solution. Throughout this paper we have discussed the relationship between councils and citizens and whilst at a macro-level these represent the stakeholders of a city, we have not yet considered communities at a micro-level, or any level in between. People engage with the city in different ways at different times, as individuals, family members, community members, employees of a company, landlords or tenants of real estate properties. These roles overlap and interact in complex ways, that technologies may invariably oversimplify. For example, the need to adapt to simplistic and inauthentic models of 'friendship' in social media is a known reason for non-participation [75]. Furthermore, how to grant or limit participation, and who (if anyone) should moderate the conversation? Should discussions exist at a suburb, neighbourhood, or city-wide level? In face-to-face interactions combinations of social norms and explicit rules dictates the ways and times of participation. In the context of current social media, different social media platforms divide available use cases which in turn shapes potential means of conversation, but as individuals we are simply considered 'users'. As users we have the potential to join certain groups or decide upon who is in our network, but ultimately how would we consider these decisions in future cities? Furthermore, who makes these decisions? Whilst we have described this concept as a conversation between citizens and council, in actuality there are many multi-tiered layers to consider in-between. In this respect, participation has been sometimes described as a tyranny, a way of framing public discourse so that, under the façade of shared and collaborative decision making,

in fact decisions are initially framed and ultimately made by those in a position of power [76].

We must also consider the impact a large scale implementation of digital technologies would have on society. Does this provide us with an opportunity to give a greater voice to the minorities? Or do the moderators of the platform hold power? What about less techno-literate citizens? On the one hand there is clear evidence that communities of users often identified as less 'tech-savvy' can take up technologies when these prove to be relevant to their lives [77], [78], on the other hand, proving such relevance is sometimes challenging when technologies are conceptualized by and for 'mainstream users'. At the moment of writing Social media platforms are under the lens for their role in supporting misuse of information and spread of disinformation and conspiracy theories and it's the greater social impacts this can have [79]. Augmented Reality presents an opportunity to position this digital activity in a physical setting but as a result, we must consider how the risks around inappropriate or inaccurate information would be mitigated.

Lastly, to this point we must consider the balancing act between localising conversation as a way to encourage community engagement whilst not drawing divisive measures between the relevancy of one suburb against another. Current digital mediums for social engagement require some form of categorisation in order to organise users within a system. Whether this is a username, a particular group, or the medium itself, digital technologies require users to adhere to some form of identity categorization that rarely accurately reflects the complexities of their human identity. Extending this to the physical world may further divide community members as they attach their identity to a neighbourhood, suburb or even a particular urban transformation. Where a transformation may take place in a particular suburb, tensions may increase in surrounding suburbs where citizens feel they are unfairly disregarded. Ultimately, as decisions are made and communicated throughout the platform, there will be an increased difficulty in ensuring the community remains engaged and in support of the city's collective goals.

5   Conclusion

A dramatic increase in urban populations calls for novel thinking in future cities. Smart City, Urban Transformation and Digital Civic Participation literature all suggest a move towards further inclusion of citizens in city processes. Examples such as Amsterdam and Barcelona highlight the successful use of digital technologies to enable conversational platforms in cities that engage citizens. These cities however, are yet to explore the opportunities that emerging technologies such as Augmented Reality can offer. Furthermore, research in this space is yet to explore the impact that AR user generated localised content could have on the democratic process surrounding urban space as well as the individual embodied experience of that space. A key affordance that is unique to augmented reality. We see Augmented Reality as a novel tool for developing community platforms in smart cities, enabling civic participation in the urban transformation process through its broad range of affordances and its ability to bring familiar digital interactions into urban space. The way in which AR can integrate

with existing digital mediums affords users the ability to interact with councils in methods that are unique to their needs yet are also able to be stored, replicated and interacted with by other citizens. It provides citizens with the means to share their individual experience with the city and in turn allows them to further interpret the city through other individuals experiences. Lastly, where these experiences and conversations may offer solutions to urban problems, they are able to be reviewed and utilised to improve other aspects of urban life.

We see a role for immersive technologies in future cities firstly as real-time enablers of dialogue between citizens and councils, secondly as a toolkit for co-design and process improvement in urban transformation, and thirdly as a reflective and data-driven representation to support adaptability and sustainability in the on-going process.

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