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Visual Data Justice? Datafication of Urban Informality in South Africa Using 360° Imaging Technologies

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Visual Data Justice?

Datafication of Urban Informality in South Africa Using 360° Imaging Technologies

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2019

Abstract

Uneven economic development is closely associated with the proliferation of informal settlements in the global South, a process generally understood to harbour injustices according to a resource access view of society. An understanding of social justice in terms of distribution provides a powerful framework for challenging uneven development, however, a key contention of this paper is that further forms of injustice accrue to the residents of these places over and above issues of distribution. With its focus on sociocultural representations, recognition provides a basis for ‘making visible’ further injustices that threaten dignity and self-identification, which may also act as a preliminary step towards advancing socioeconomic justice for informal settlements.

This paper draws on ongoing research into the datafication of informal settlements in South Africa, including interviews with data activists and experiences of conducting a 360° geovisual imagery pilot study in Kya Sands informal settlement in Johannesburg. In first drawing attention to the limitations of quantitative data for representing injustice, and the problematic effects of conventional framed photographs of informality from aerial and ground-level perspectives, this paper explores the possibilities of ground-level 360° imagery as a realist, non-reductionist form of representation for informal settlements. Three 360° street views were produced to illustrate key possibilities and limitations for advancing recognition, based on the notion that visibility is essential for recognition. Further, the piece reflexively critiques how – through new advancements in image analytics – informal settlement visibility projects risk further engendering injustices of *misrecognition* for these highly marginalized urban spaces.

As such, this paper provides a basis for further inquiry into the relationship between visual data and the social justice principle of recognition, towards an emerging research agenda on *visual data justice*. The paper concludes with recommendations for practitioners and key topics for research. Important items on the agenda include: determining the forms and examples of injustice that can be remedied through datafication, the relationship between misrecognition and maldistribution in the context of datafication, and the acceleration of new injustices due to advances in computer vision applied to ground-level imagery.

A. Introduction

“In contemporary discussions, recognition is often accompanied by visibility as its political partner. Demands for recognition are also demands for visibility” (Oliver, 2001, p.147)

Uneven development is a significant challenge to cities around the world, particularly in low- and middle-income countries with extreme levels of socioeconomic inequality. In many global South cities, recent patterns of urbanization and inward migration have produced a highly variegated and disconnected urban fabric. Nowhere is this more evident than in South Africa, where the world’s highest rates of inequality and uneven development are both a consequence of current socioeconomic injustices and a resolutely *visible* reminder of past apartheid racial policies. The longstanding and intransigent nature of uneven urban development means that injustice is often defined in specifically spatial terms in South Africa. However, as data becomes a key focus of urban governance in the country, injustice is also increasingly understood in the context of datafication, which draws attention to how uneven patterns of data render marginalized spaces and their inhabitants *invisible* to outsiders.

Cities in South Africa actively pursue datafication discourses and ‘smart’ agendas in the globally circulating model (Odendaal, 2015); however for residents and grassroots organizations in Cape Town and Johannesburg, data has also become a means by which everyday injustices can be ‘made visible’ (Odendaal, 2006) in a country with a complex politics of visibility that requires one to be “‘seen by the state’ before benefitting from it” (Parnell and Pieterse, 2010, p.153). Data activism has emerged in this context as a strategy to contest disparities in the provision of basic services guaranteed by the country’s rights-based constitution, including water, sanitation, housing, and education. Quantitative, evidence-driven activism provides an alternative or supplement to the widespread deployment of ‘service delivery’ protests by civil society organizations and residents of informal settlements, which can often be ignored by municipal governments. Growing interest in data activism suggests a tactical shift from the legacy of ‘people power’ in South Africa (Bénit-Gbaffou, 2015), to a new focus on ‘data power’ (Kennedy and Bates, 2017) based on an understanding of data as a powerful actor that can inform effective governance and policy decisions.

In the context of datafication in governance, business, and wider society, ‘data justice’ (e.g. Dencik et al., 2016; Taylor, 2017; Heeks and Renken, 2018) has emerged as a field of theory and praxis that broadly seeks to draw attention to the complex ways that data and social justice are interwoven. This includes efforts to trace how data production, accumulation and analytics (re)produce social injustice (Cinnamon, 2017; Redden, 2018), and work that actively engages with these practices towards the advancement of normative social justice aims, such as emancipation, empowerment, equity, and fairness (Johnson, 2014; Milan and van der Velden, 2016). Engaging both of these dimensions, this piece adds to the literature on data justice in two ways. First, the piece develops the notion of *visual data justice* for advancing the social justice principle of ‘recognition’ (Honneth, 2004; Fraser, 2008). Justice-as-recognition provides a means of identifying and contesting injustices other than those that arise as a consequence of socioeconomic inequalities, the primary target of distributive

social justice reparations. Instead, as a sociocultural consideration, recognition is concerned with the ability to self-identify and to participate as an equal in society. Although economic inequities are important in this context, a focus here on *spatial recognition* foregrounds the more-than-economic causes and consequences of urban marginality. Doing so acknowledges that while urban spatial injustices are clearly aligned with patterns of uneven economic development, further forms of injustice accrue to the residents of these places over and above inadequate provision of basic services. Thus, making injustices of misrecognition visible can be a first step towards remedying injustices of maldistribution.

This project was undertaken in Kya Sands, an informal settlement on the northern periphery of Johannesburg. An effectively invisible space unrecorded and unaccounted for in official maps, databases, and archives, Kya Sands is known to outsiders primarily through visual imagery depicting extreme poverty and hardship (see Figure 1). Taken from above or at a considerable distance, these forms of imagery serve as a symbolic representation that further marginalizes the residents of these spaces (Hecker, 2010; Dovey and King, 2011). The aim of this project was to ‘make visible’ the settlement in a very literal, panoramic way that might overcome some of the limitations and harms of conventionally-framed images. Further, the project is driven by a more general critique of datafication in contexts of informality – that quantitative data are inadequate for representing injustice in its full texture. Three research questions guide this paper:

- What is the role of quantitative data in representing injustice and advancing the needs of marginalized people and places?
- How can consumer-grade 360° imaging technologies be used to produce street-level imagery of informal settlements?
- Can a potentially more progressive form of datafication be realised through street-level 360° imagery?

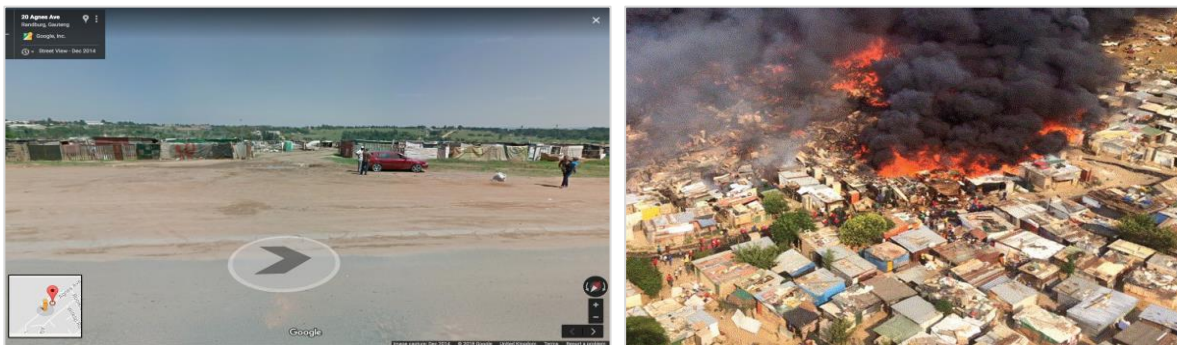


Figure 1: Visually imagining Kya Sands. Google Street View image taken from a distance, and image of a fire taken from a low-oblique aerial perspective.

To answer the first question, the paper draws on interviews with ‘data activists’ working in informal settlements in Johannesburg and Cape Town. Experiences of conducting the street-level imagery pilot study in Kya Sands are used to answer the next two questions.

The following section provides a background and conceptual framework for the paper. The Methods section explains the study site and data collection activities. The Findings and Discussion section initially provides the results of the interviews and pilot study. Through an

exploration of three street views produced about the community, this section then develops the notion of visual data justice, by tracing the possibilities, limitations, and risks of 360° imagery for advancing recognition for invisible urban spaces. This piece concludes with recommendations for practitioners interested in using 360° imagery for informal settlement representation, and a consideration of the future research agenda for visual data justice in light of this project.

B. Background

B1. Urban Fragmentation and Invisibility

In global South cities, new urban dwellers often take up residence in informal settlements on the outskirts of cities, extending municipal boundaries outward, or infilling interstitial spaces along transport infrastructure routes, on land unsuitable for formal structures, or other underused or unwanted urban spaces (Dovey and King, 2011). The notion of urban informal settlements as ‘fragments’ (McFarlane, 2018) both separate from and intimately interconnected with the city draws attention to their highly dynamic, shifting, and heterogeneous spatial arrangement both internally and in relation to the surrounding city.

While the spatial contours of fragmented spaces can be ascertained with relative ease, often little is known about the internal spatial structure of informal settlements nor of the people who live there. For municipal governments, lack of information on informal settlements on the one hand presents an opportunity to ignore the needs of these spaces, and on the other, a significant challenge when intervention is necessary. For residents of informal settlements, life in an urban fragment is similarly ambivalent. Informal settlement living is often defined by precarity and a sense of invisibility and disconnection from the rest of the city. These spaces generally have few municipal, social, or health services provided, and residents working or enrolled in school or university are often required to travel considerable distances. Yet dis-integration from the wider urban fabric may have positive implications for residents seeking affordable temporary shelter or to avoid being caught up in the machinery of the state.

B2. The Datafication of Injustice in Informal Settlements

Advancements in digital technologies and data production have opened up new opportunities to ‘know’ informal settlements. The term ‘datafication’ is often described as a *process* of “rendering into data aspects of the world not previously quantified” (Kennedy et al., 2015, p.1), although it is also profitably interrogated in terms of the wider beliefs and motivations underlying data and data analytics. Van Dijck’s (2014) notion of ‘dataism’ captures the discursive underpinnings of datafication based on an understanding of quantitative data as an objective representation of the world, and also a tool of action and change. Beer (2019) draws attention to a ‘data imaginary’ that frames data analytics as speedy (rapid insights), accessible (easily interpreted), revealing (extracting hidden knowledge), panoramic (all-seeing), prophetic (able to foresee and shape the future), and smart (possessing latent intelligence).

In the case of urban data and the wider smart urbanism agenda, data and data analytics are thusly pursued by governments as the solution for urban challenges. As Kitchin explains, smart city advocates believe that data “provides the raw material for envisioning and enacting more efficient, sustainable, competitive, productive, open and transparent cities” (2014, p.1). For urban residents and civil society organizations, similar beliefs about data and data analytics are powering new modes of data-driven civic action, taking advantage of accessible data production technologies (e.g. mobile phones) and processes (e.g. crowdsourcing, citizen science). As part of this wider phenomenon, diverse forms of ‘data activism’ have emerged in cities around the globe, including in South Africa. Data activism demonstrates an ambivalent resist/embrace relationship with datafication – as Milan and van der Velden explain, the term comprises both “affirmative engagement with data and resistance to massive data collection” (2016, p.61).

Informed by wider datafication discourses, efforts to address urban invisibility through datafication have come in two main forms. The first, on-the-ground mapping and surveying initiatives with varying degrees of local resident participation, is exemplified by the Map Kibera project in Nairobi (Donovan, 2012). This initiative engaged local residents to produce spatial data and thematic maps (e.g. location of hospitals, points of interest, perceptions of safety) of this huge informal settlement in Nairobi which was previously unmapped and largely ignored, despite being home to as many as 1 million people. In South Africa, one form of data activism called a ‘social audit’ has gained widespread uptake within the activist communities in Johannesburg and Cape Town. Social audits are collaborative data collection initiatives between an organization and local residents which aim to draw attention to inadequate service provision. Since 2013, over a dozen social audits have been undertaken, collecting data on infrastructure, services, and hazards in informal settlements, highlighting gaps between expected allocations and the reality on the ground (Social Audit Network, 2016).

A second form of datafication for informal settlements uses aerial remote sensing to capture imagery for conversion into spatial data – the ‘slums from space’ approach (Kuffer et al., 2016). While satellite imagery has a long history of use for mapping cities, unmanned aerial vehicles (UAVs) present new opportunities for mapping these dense and highly dynamic spaces in much higher spatial and temporal resolution. For instance, Gevaert *et al.* (2017) used UAV imagery to algorithmically classify informal settlements for the purposes of upgrading, and Mansell (2018) described the use of DIY balloon-based aerial imaging techniques in a Palestinian refugee camp to assert residents’ ‘right to the city’. With both approaches however, datafication of informal settlements based only on aerial imagery has practical limitations in terms of what can be known about these spaces. It can provide proxy estimates of socioeconomic conditions (e.g. population size, deprivation), but is primarily used only for the production of geospatial framework data (e.g. vector datasets of roads, paths, building footprints, spatial boundaries) (Williams et al., 2016; Mahabir et al., 2018).

Critics of mapping and quantitative data have long drawn attention to the way these forms of representation shape a limited and partial understanding of the world (e.g. Harley, 1989; Crampton, 2001; Aalbers, 2014). For many feminist and diversity theorists, quantitative representation serves to advance the interests of those people and things that are more readily captured by numbers, static categories, and hegemonic forms of knowledge (e.g.

Lawson, 1995). In a study of participatory efforts to include Rio de Janeiro's *favelas* in Google Maps, Luque-Ayala and Neves Maya observed considerable "distance between the richness of the mental map of favela dwellers and the spatial simplification and standardization required by the global digital map" (2019, p.456). With this understanding, quantitative representation will have only limited use for capturing the dynamics and lived realities of life on the ground in informal settlements, which calls into question a variety of data-led strategies that seek to advance justice through datafication.

B3. Visualizing Informality: Vertical, Oblique, Horizontal

Against this backdrop, constructivist and interpretivist forms of knowledge production are also undertaken in an effort to more accurately 'know' informal spaces, including interviews, participatory methods, and ethnographic research. Within this epistemological framing, visual imagery is advanced as a way to represent informal settlements with a degree of objectivity, while avoiding the abstractions of quantification. The privileging of imagery as an instrument of empirical fact is based on a "naturalistic understanding of vision [which] claims that objectivity is achieved by a correspondence between an image and its external referent" (Campbell, 2007, p.379). This linking of seeing with knowing facilitates the now widespread use of aerial images as evidence of on-the-ground conditions, even without converting the imagery to quantitative spatial vector data. The power of vertical aerial images (see Figure 2a) to enable access to remote locations without local grounding provides new opportunities to know these spaces, but they also serve to reinforce power asymmetries with other peoples and cultures, through the subjectifying and dominating effects of the 'god's eye view' (Parks, 2009).

Tilting the camera angle from the vertical (nadir) plane of perspective of most satellite imagery to an oblique (angled) perspective has become common, especially with the advancement of UAVs. Oblique imagery is generally not used to produce quantitative vector data, since the scale of the imagery is different from the image's foreground to background, meaning distance and direction vary. Beyond these practical limitations, oblique imagery can have powerful effects in terms of how spaces are understood, distinct from the effects of vertical imagery's powerful downward gaze. The 'high-oblique' perspective tilts the camera angle to a midway point between nadir and ground-level horizontal, providing the viewer with both a sense of size and context, as well as local detail and nuance. But the 'low-oblique' perspective tilts the camera to a point that captures the ground at around 30° off the nadir view but excludes the horizon altogether (see Figure 2b). This subtle adjustment to the plane of perspective produces imagery that captures the scale of the settlements but excludes the anchoring point of the horizon. As Hecker (2010) explains, this limits the potential for documentary realism – the effect on the viewer is to depoliticize informality and poverty, offering only abstraction and aestheticization¹ of the social realities below:

"the oblique aerial view uses the horizon to seam together the void of the sky and the full of the distant landscape. But what happens when the plane of sight turns

¹ Here, aestheticization is understood as a process in conflict with politicization. For visual imagery, particular artistic elements and decisions can serve to neuter the political potential of representation. Through such a process, politics and power relations "are obscured, becoming incorporated into categories of lifestyle, taste, and patterns of consumption and appreciation of the visual, the sensual, and the unique" (Duncan and Duncan 2001, p.377). This draws in particular on Walter Benjamin's notion of the 'aestheticization of politics', as well as ideas about the political potential of representation developed in the field of visual studies.

toward the ground to bracket off the horizon itself? ... This low-oblique plane of vision refocuses the dialectic between immensity and an ordering line of sight, away from optics of stability and order toward the immensity of the ground below. This technique of closing off the horizon... could also be seen to occupy another interstitial position— existing in between the lofty god-powers of the vertical omniscient view and the horizontal comfort of being in the world” (Hecker, 2010, p.260).

Further tilting the camera lens down to ground-level, the horizontal plane of perspective offers a form of visibility that may be more attuned to the politics and lived realities of those living in informal settlements (see Figure 2c). As Dodge explains, “the action of tilting the camera through 90 degrees and the reduction of verticality can be read as a move from the disembodied ‘view from nowhere’ to a more human-scale and embodied sense of place” (2018, p.955). Taken at the scale of the social, and at a vantage point closer to the subject matter, conventional ground-level photography provides an opportunity for documentary realism that captures the realities of informal settlement living in a way that illustrates injustice but negates abstraction and aestheticization.

Yet Linke (2012) describes how ground-level informal settlement photography is often itself an idealist art form, consumed by global elites drawn in by a carefully-crafted aesthetic of resourcefulness and sustainability that occludes the social disadvantage that a more realist approach might exude. As the author explains, “the conditions of displacement and the impact of poverty on families or communities are expunged from the visual field by transforming poverty artefacts into aestheticized art objects” (p.303-304). The ability to shape a slum imaginary of ‘bare life’ (Agamben, 1998) liberated of any political meaning is made possible through the process of ‘framing’. Frames are a necessary, though powerful and performative aspect of photographs, whether the plane of perspective is nadir, oblique, or horizontal. Framing is an act of inclusion and exclusion; as Judith Butler puts it, it is a “delimiting function, bringing into focus an image on the condition that some portion of the visual field is ruled out” (2007, p.953). Choosing the frame and linear perspective determines the arrangement of objects and composition of the photograph, which, as Cosgrove explains, “determines – in both senses – the ‘point of view’ to be taken by the observer, and ... the scope of reality revealed” (1985, p.48).

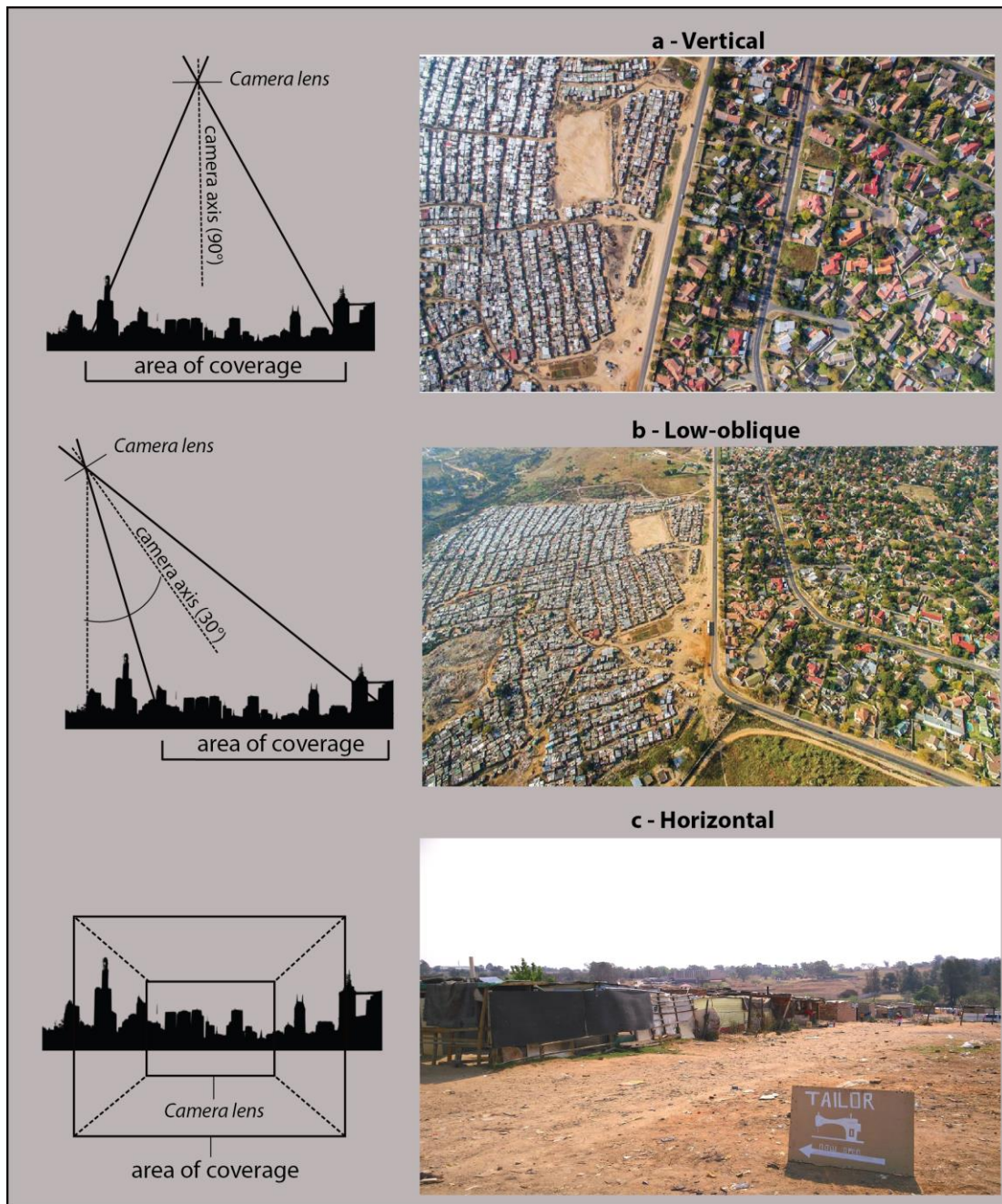


Figure 2 a, b, c: Tilting the camera lens – Kya Sands through vertical, low-oblique, and horizontal planes of perspective. Aerial photos in 2a and 2b from Unequal Scenes project (<https://unequalscenes.com/kya-sandsbloubosrand>). Ground-level photo in 2c by author.

Through avoiding the need to frame the visual field and allowing the viewer to choose the visual perspective, developments in 360° photography suggest new possibilities for visually representing informal settlements, and a potential move away from aestheticization and abstraction towards realist representation (see Figure 3).



Figure 3: Ground-level photo of Kya Sands in 360° (rendered as a flat projection here), and a conventional photo frame as reference. 360° photo by author. 360° perspective diagram from: <https://www.fotoqrafie-tutorials.de/2011/03/18/panoramafotoqrafie-teil-01-einfuehrung-blickwinkel-und-aesthetik/>

Google Street View (GSV) is “practically synonymous” (Alvarez León and Quinn, 2019, p.2) with 360° street-level representation in most settings. GSV was initially released in 2007 in 5 cities in the US, and since has expanded to all continents, however the platform’s coverage is both spatially and temporally uneven. GSV first visited the African continent in advance of the 2010 World Cup in South Africa. A decade later, much of the imagery collected from more marginalized areas of Cape Town and Johannesburg has yet to be updated, meaning users of GSV are presented with an inaccurate representation of these highly dynamic and mutable urban spaces. In contrast, regular updating is standard procedure in many places in the global North. For Kya Sands and many informal settlements in South Africa and beyond, coverage is generally absent altogether. The landscape of 360° imagery production is rapidly expanding however, spurred on by new actors producing imagery for the autonomous vehicle market, the recent availability of low-cost consumer grade cameras and software, and the development of alternative platforms for hosting this imagery outside of GSV (Alvarez León and Quinn, 2019). Since 2013, 360° photo/video cameras have become widely available, from entry-level models that attach to a smart phone, higher spec versions for outdoor sports, to professional grade models used in industry.²

B4. From Socioeconomic to Sociocultural Injustice in Informal Settlements

The social justice principle of ‘recognition’ provides the framework for analysis of this case study. Depending on the nuances of how the principle is interpreted, recognition describes a form of justice bound up in contestations over social status and identity at the level of individuals and societal groups, based on the belief that “human dignity comprises a central principle of social justice” (Honneth, 2004, p.352). An interest in recognition arose in the 1990s as justice theorists identified the limitations in the prevailing normative focus of social justice, distribution. Associated in particular with the influential work of John Rawls (1971), distributive justice efforts often identify injustices in society resulting from the unequal allocation of ‘goods’ and ‘bads’ in society, which could be as broad as income, resources, rights, and freedoms, but in practice, material resources and economic wealth are the most widely recognized focus of distributive justice reparations (Miller, 1999). Justice-as-recognition provides a framework for identifying and addressing forms of injustice associated with sociocultural processes of indignity, disrespect, and stigmatization, which

² An overview of developments in consumer, intermediate, and professional grade 360° imaging, virtual tour software, and related technologies is available here: <http://blogs.exeter.ac.uk/360/developments-in-360-imaging-technology/>

might be related to issues of distributive injustice, but which manifest as status inequalities and threats to agency and identity formation (see Fraser and Honneth, 2003).

Misrecognition then is the paradigmatic injustice under this principle. For Honneth's identity-based model, to be misrecognized by others is a threat to self-realization, autonomy, and the development of an intact identity (Honneth, 2004). Here, (mis)recognition is produced in intersubjective relations, through (lack of) "respect in the political sphere, esteem in the social sphere, and care in the intimate sphere of the family" (Kompridis, 2007, p.278). Alternatively, for Fraser's status-based model, to be misrecognized is a threat to parity of participation in social life caused by institutionalized patterns of subordination (Fraser, 2005). In this interpretation, misrecognition aligns with and is connected to distributive justice in its focus on inequality – misrecognition produces uneven patterns of societal participation, which could mirror or supplement uneven allocations of material resources. Although the two models have been said to be incompatible, Thompson (2009) explains how the ability to participate as an equal in society can be understood as a necessary element to achieving identity recognition in the eyes of others. Thus, full recognition can be achieved by designing institutions and opportunities that ensure parity of participation, which will set up the parameters of a society that fosters relationships of dignity and respect, ensuring self-realization for all identity groups.

Irrespective of a focus on status equality, identity, or their interconnections, misrecognition is understood as a deeply embedded injustice that impacts marginalized individuals, groups, and indeed *places*, over and above distributive forms of injustice. Visual imagery plays an important role in shaping who is recognized, and who recognizes. Whether aerial or at ground-level, techniques of framing and linear perspective in conventional photographs are performative acts of misrecognition, accelerating the 'othering' of already marginalized people and places. Campbell (2007, p.359) explains the symbolic potency of photographs of the Darfur conflict for how outsiders imagine Africa – not as a vast continent with a diversity of landscapes and people but as "a single entity marked by an iconography of despair, disaster and disease".

At the urban scale, conventional photography can contribute to the symbolic discrediting of places, as part of a specifically geographic process of misrecognition referred to as territorial, or spatial stigma (Wacquant et al., 2014). Like Goffman's theory of personal stigma as 'spoiled identities' shaped through intersubjective stereotyping, spatial stigma explains the processes by which residents of defamed places come to be regarded by outsiders as embodied manifestations of them. As Slater explains, "urban dwellers at the bottom of the class structure are discredited and devalued not simply because of their poverty, class position, ethnoracial origin, or religious affiliation, but because of the *places* with which they are associated" (2017, p.113). The effects of this form of misrecognition are both physical and material; research has demonstrated how residents of stigmatized places face additional health challenges (Tabuchi et al., 2012; Keene and Padilla, 2014) and reduced employment prospects (Kallin and Slater, 2014) independent of other factors (e.g. socioeconomic status). Visual imagery is central to the advancement of stigmatizing discourses about informal settlements, because this is typically the key way that outsiders come to know these spaces, diffracted through the power relations, abstractions, and aestheticizations inherent to conventional photographic representation.

Recognition is thus intimately bound up with present and historical patterns of differential visibility, “which has positioned certain bodies as objects of recognition and granted others the power to confer recognition”, meaning “[s]truggles for recognition are also struggles for visibility” (Hesford, 2015, p.536-537, emphasis added). This paper develops the concept of visual data justice as a way of connecting digital visual representation to recognition, foregrounding the power of visual imagery in shaping how people come to understand other people and places. Enhanced visibility through visual representation provides opportunities for neglected and marginalized peoples and places to achieve recognition in the eyes of others; however, central to any notion of visual data justice must be an understanding that visibility itself is essentially neutral – it is in its intentions, effects, and contestations that recognition or misrecognition are advanced. In this paper, this understanding of visual data justice is developed through a 360° street-level imagery pilot project. Findings described below shed light on the potential of non-framed visual perspectives for advancing recognition, and more generally provide a basis for application of the concept to a variety of existing and emerging forms of ground-level visual representation.

C. Methods

The empirical evidence for this piece is drawn from interviews with data activists, and experiences of conducting a 360° imagery research project in Kya Sands, Johannesburg. Kya Sands is a typical informal settlement in sub-Saharan Africa, with shack housing, limited public infrastructure and services, and a presence that is largely invisible in government and private sector maps and databases (see Figure 4). The settlement was initially established in the early 1990s, and is now home to an estimated 20,000 people. Kya Sands is divided into four sub-areas (A,B,C,D) located on a combination of private and state-owned land. State provision (and maintenance) of services is minimal, including communal water standpipes, chemical toilets, and high mast lighting.

Interviews with over 25 data activists in Johannesburg and Cape Town were conducted to gather perspectives on the value of quantitative data for representing and drawing attention to service provision needs in informal settlements.



Figure 4: Kya Sands in Google Maps. The map view depicts the settlement as a blank space, while the satellite view shows the basic spatial structure of the settlement. The blue lines indicate Google Street View coverage. To the east of Kya Sands is the wealthy suburb of Bloubosrand, and to the west is the Kya Sand industrial area.

Next, a 360° imagery pilot study was conducted, as part of a multi-strand, mixed methods project involving researchers from universities in Johannesburg and beyond, with varying degrees of participation from local residents and community leaders. The imagery project used consumer-grade cameras and software to capture the settlement in 360°. Images were taken with a Garmin VIRB360 camera, a mid-range option that features two 180° lenses, automatic in-camera image stitching, and a GPS sensor to record geographic coordinates. Since the settlement is comprised of narrow paths and rough terrain, imagery was captured on foot using a hand held monopod positioned over the photographer's head, who was later edited out.

Images were captured over five days in April, September, and October 2017. The aim was to capture images at regular intervals throughout all of the paths and common spaces of the

settlement, however this was not possible given time constraints and because of concerns over environmental health conditions in some areas (open waste, dirty water). A pragmatic, ad-hoc strategy was developed, capturing key common spaces in the settlement and larger paths. A local resident involved in the larger project accompanied the photographer, assisting with navigation and providing input on the optimal locations to take the photographs and appropriate features to record. The project was discussed with several groups of community leaders who provided permission for the research. A larger public meeting was then held at a local childcare facility to introduce the research team and project to the wider community. Our aim was to engage more fully with any interested community members; generally there was support for the project however there was little interest in developing a participatory research design.

Adobe Photoshop was used for minor post-processing tasks, including general imagery enhancements and removal of the photographer and monopod using the Polar Coordinates projection and Clone Stamp tool. The next step was to assemble the imagery to produce immersive views of the settlement. 360° photos can now be hosted on a small number of Web platforms including Facebook and Flickr, but specialized 'virtual tour' software is required to link the images together for navigation between the images and on an accompanying interactive map. The project initially tested three options; two desktop-based packages, Panotour Pro from Kolor/GoPro and the open source krpano, and the lightweight Roundme web-based platform. Roundme was chosen for its intuitive development interface, social web-style sharing and commenting features, integration with a web based interactive map (Google Maps), imagery and tour hosting, embedding of tours on blogs and websites, and the ability to embed additional text and multimedia to imagery as 'hotspots'.

D. Findings and Discussion

The Findings and Discussion section provides the basis for addressing the three research questions: 1) What is the role of quantitative data in representing injustice and advancing the needs of marginalized people and places? 2) How can consumer-grade 360° imaging technologies be used to produce street-level imagery of informal settlements? 3) Can a potentially more progressive form of datafication be realised through street-level 360° imagery?

D1. Datafication and its Limits for Contesting Injustice

Informed by distributive notions of social justice and discourses of datafication, quantitative, data-driven social audits have become a key strategy for making uneven service provision visible and actionable in informal settlements in South Africa. Interviews with a wide variety of activists and civic data champions provide insight into the aims and outcomes of data-led activism. Data activists aim to provide 'factual' evidence of spatial discrepancies in service provision. One interviewee explained, "we're not working with, like, opinion and subjectivity, well, not necessarily, you know, we're working with data" (Employee, civic data organization). These 'counter-data' (Currie et al., 2016; Dalton et al., 2016; Meng and DiSalvo, 2018) actions are driven by a belief that policymaking requires quantitative evidence. As an interviewee noted, "taking an evidence based approach

enables us to speak on the same terms as government” (Employee, social auditing organization). Quantitative representations of informality are pursued as powerful leverage for drawing attention to distributive injustices, as another interviewee explained:

“You are showing them their facts, to say – it’s a fact that you are paying [a contractor] to do this and we are saying we don’t see the value for that money. So, you need to stop it, or you need to rectify it, or you need to take some people to task to make sure that this money is spent properly” (Interviewee, activist organization, emphasis added).

The findings of social audits are highly contested however, and overall, they have had little success in convincing policymakers to address the serious issues raised. Officials have challenged and dismissed findings by claiming the results are not a real representation of service provision, focusing their critique on technical considerations such as data quality, sample size, and suitability of methods (Rossouw, 2015). An interviewee from an activist organization explains the resistance tactics: “[t]here are various ways that they tried to undercut a piece of evidence that was actually factually true. Attack the sender. [Attack] your method... And once a powerful figure says ‘that’s not true’, where do you go with that?”

A government response to a social audit conducted by the activist organization Equal Education (2016) on school infrastructure sums up the wider official response to social audits: “The WCED [Western Cape Education Department] is always open to constructive critique and analysis of how we operate... *This critique and analysis should, however, be grounded in realism*” (emphasis added). This government response to social audit findings is typical; though initially, the resistance took many activists by surprise. One activist described his astonishment:

“I certainly believed this quite naively in the first few years that, if only you can prove people wrong in the public domain that, in this war of ideas, you put this idea, they put this idea, you tell them that they’re wrong and then somehow that leads to them saying ‘you know what, you’re right, you convinced us and we’re going to change what we do here. We had no idea, you’re absolutely right’” (Interviewee, activist organization).

Overall, the interviews illustrate how attempts to make injustice visible through quantitative evidence have been easily dismissed by governments, with their “greater claims to data” (Rossouw, 2015, p.79). This finding adds further dimensionality to the notion that quantitative data may be unsuitable for representing the lived realities and complexities of informal settlements. It is not just that quantitative data are reductive and shape a partial understanding of the world; when produced by the grassroots, quantitative data are also an easy target upon which governments can focus their resistance and deflection tactics (Cinnamon, forthcoming). Findings here provided the rationale for the 360° imaging pilot study. 360° visual imagery suggests possibilities for digital forms of informal settlement representation that may overcome the limitations of quantitative data and conventionally framed imagery, a contention that is considered in detail below.

D2. 360° Imaging Pilot Study Findings

The 360° imagery pilot study produced a total of 112 panoramic images of the settlement across all four sub-areas (A-D). Selected images were used to produce three separate street views using the Roundme platform. Figure 5 shows the platform in edit mode, with the 360° image viewing panel on the left and the interactive map (Google Map satellite view) showing the position of the images on the right. Navigation between images is possible by clicking on the image ribbon, on the links embedded in the 360° images, or on the thumbnails on the map. The first street view, the *Kya Sands Tour*, was designed as a virtual tour of the settlement, starting from one of the main entry points in to Kya Sands from Agnes Ave (see Figure 6 and <https://roundme.com/tour/258779/info>). The tour is comprised of 27 images from all sub-areas of the settlement. The tour approximates the experience of GSV, although in most places there are larger distances between each image, and fewer opportunities to choose the direction to navigate through the settlement.

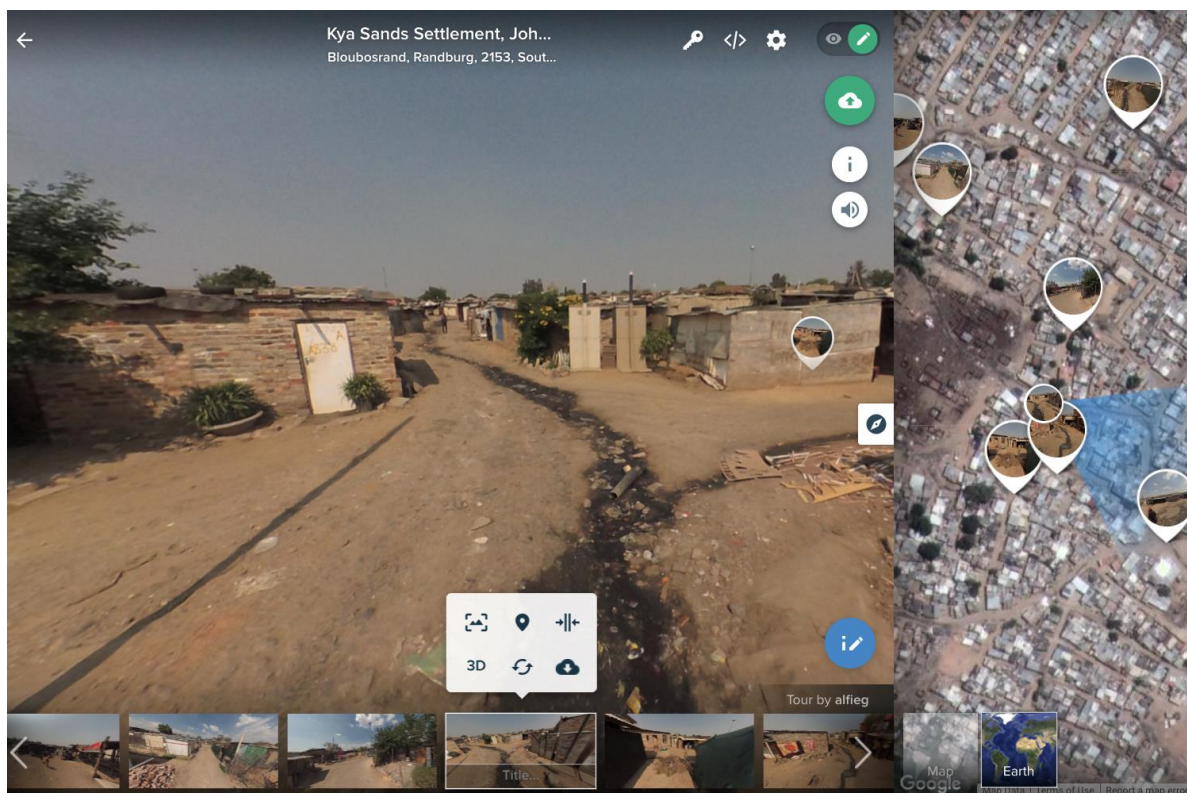


Figure 5: Screenshot of the Roundme interface, in edit mode.

Kya Sands Settlement, Johannesburg



Kya Sands is an informal settlement in the north of the city of Johannesburg, Gauteng Province, South Africa. The settlement was initially established around the early 1990s period, and is now home to an estimated 20,000 people. Kya Sands is divided into four sub-areas (A,B,C,D) located on a combination of private and state-owned land. State provision of services is minimal, including communal water standpipes, chemical toilets, and high mast lighting. Kya Sands is a typical informal peripheral urban space in Sub-Saharan Africa, with shack housing, limited public infrastructure and services, and, because it is largely invisible in government and private sector maps and databases. Google Street View captures imagery of the industrial estate to the west, and the wealthy suburb of Bloubaarsdorp directly to the east, but does not venture into Kya Sands. This tour begins where Google Street View ends, where the pavement turns to dirt, providing an opportunity to see this informal settlement in 360 degrees at ground level. Follow the links through the four sub areas of the settlement.

START

Figure 6: Entry page for the Kya Sands ‘virtual tour’ street view.

Following the overall aims of those engaging in social audit activism in South Africa, and informal discussions with residents about their key concerns about living in Kya Sands, the second street view highlights service provision, infrastructural, and environmental hazard issues in Kya Sands. This *Kya Sands - Services and Hazards* street view includes 10 images from around the settlement (see <https://roundme.com/tour/391902/info>). Images show the placement of municipal services including water standpipes, outhouse toilets, and high mast lighting, as well as informal electricity connections, open water and waste, a recently installed bridge over the stream, and several informal childcare and community facilities.

The third street view was produced to illustrate the nuance and diversity of the settlement, highlighting not only hazards and limited infrastructure but also the broader story of Kya

Sands. Information gathered from the wider research project, as well as the limited amount of information about Kya Sands on the web, were used to compile the *Kya Sands Story*, which made use of Roundme's interactive 'hotspot' functionality to embed text, web links, conventional photographs, and videos into the street view's thirteen 360° images (see <https://roundme.com/tour/391926/view/1354277/>). The story contains various details about the settlement, its history, information about its residents, employment and entrepreneurial activities, the range of building materials used, and the local markets, shops, and community facilities. Rather than using a linear tour structure, no links are provided within the imagery, to encourage the user to navigate more freely by clicking on the image ribbon and map.

D3. Framing, Linear Perspective, and Visibility in 360°

Wider access to 360° imagery production provides new opportunities to represent marginalized areas that might avoid the consequences of framing and fixed linear perspective. Positioned perpendicularly (and imagined oppositionally) to the vertical, ground-level 360° imagery offers an alternative to the subjectifying gaze of the nadir perspective and the abstractions of low-oblique (see Harris, 2015), while also enabling the viewer to navigate through a full panoramic field of vision. This form of imagery may also counter the limitations of quantitative data; as Shapiro (2017, p.2) explains in the context of GSV, "its emphasis on the particularities of place rather than cartographic abstractions of space makes it seem progressive, absolved from the visual-semiotics of scientific rationality or objectivity".

However, as the *de facto* platform for 360° urban representation, GSV has additional powers that can lead to injustices for urban spaces and the people who live there. GSV is generally understood as a "simulation of the city of the present" (Campkin and Ross, 2012, p.148), however its uneven coverage is complicit in shaping perceptions of economic and cultural value. Absent imagery is a signal to viewers that places are not worthy of our virtual or physical attention. Power et al. (2012) describe how GSV's peripheral coverage of a marginalized Irish housing estate – which initially made the area visible only from the distance of a main road – served to advance negative perceptions of the area in the minds of outsiders. Such processes of intersubjective stereotyping are central to injustices of misrecognition, whereby less powerful groups are subject to 'distorted identities' which can impact their dignity and sense of self (Zurn, 2003).

Kya Sands, and many informal settlements in South Africa and beyond, are similarly only visible in GSV from the vantage point of peripheral roads. As a demonstration of the potential for producing street view imagery outside of the GSV platform, the Kya Sands Tour provides an immersive, 360° visual representation of the settlement, picking up where GSV coverage ends. The tour leads the viewer through the settlement, proceeding first through Area A, along the path that crosses Kya Sands stream, through Areas B and C on the west side, and then back over the stream on the footbridge and through Area D. Although the tour does enable the viewer to visually explore all four sub-areas of the settlement, coverage is fragmented; this was due to practical reasons, however the viewer may interpret uneven coverage in ways that could have negative implications for parts of the settlement not covered, similar to the effects of uneven GSV coverage.

The Kya Sands Tour could be made accessible for public viewing on the Roundme platform; doing so would demand more consideration about how such imagery could be used as virtual form of 'slum tourism'. Slum tourism is a highly contested activity held up as both an example of the exploitation of the urban poor for the entertainment of outsiders, and an effective way to draw attention to hidden injustices. If conventional images of informality are understood to aestheticize and depoliticize poverty, slum tourism is often legitimized by claiming that exposing outsiders to lived realities first hand might avoid this – they are not only an aesthetic encounter, but also a moral and epistemological one (Dovey and King, 2012). If recognition is formed through intersubjective relations of respect and understanding, careful slum tourism provides an opportunity to advance not only distributive but also justice-as-recognition claims for informal settlements and their residents. Frenzel et al. (2014, p.431) claim that while slum tours in South Africa expose economic injustices to outsiders including policy makers, they also have symbolic power to challenge sociocultural misrecognition, through "addressing invisibility, overcoming territorial stigma and [the] empowerment of the urban poor". But will *virtual* slum tours have the same effect, without the benefit of physical presence and a tour guide? 360° imagery potentially provides an opportunity for outsiders to experience these spaces in a way that may be sympathetic to reality, but at what point does realism descend into spectacle, and then to misrecognition?

With regards to framing and linear perspective, the viewer is able to manipulate the imagery in any direction, approximating the human eye's position above ground-level and dynamic plane of perspective, which enables an effectively seamless upward, downward, and sideways gaze. Cosgrove (1985, p.48) explains how realist representation of three-dimensional space on two-dimensional surfaces "gives the eye absolute mastery over space" through the rules of geometry, which draws the viewer to the artist or photographer located *outside* of the image. Although the viewer of 360° imagery is empowered to continually change the frame and perspective, the photo capture-position seemingly *within* the image amplifies the sense of the photographer or viewer's 'mastery over space', as inseparable from it. Gazing downward in the images solidifies this sense of being in the image, since the photographer has been edited out and the viewpoint appears to hover above the ground (see Figure 7). Thus it may be said that, akin to the power of aerial imagery, 360° imagery may also exhibit a god's eye view, but much nearer to ground-level. From a visual-cognitive perspective, more attention to how viewers perceive space through this seemingly 'immersive' imagery is needed. From a social and political perspective, more attention is needed to the particular power geometries of immersive imagery, when the geometries of linear perspective are not fixed yet the viewer is still drawn to the photographer located ambivalently outside and within the image.

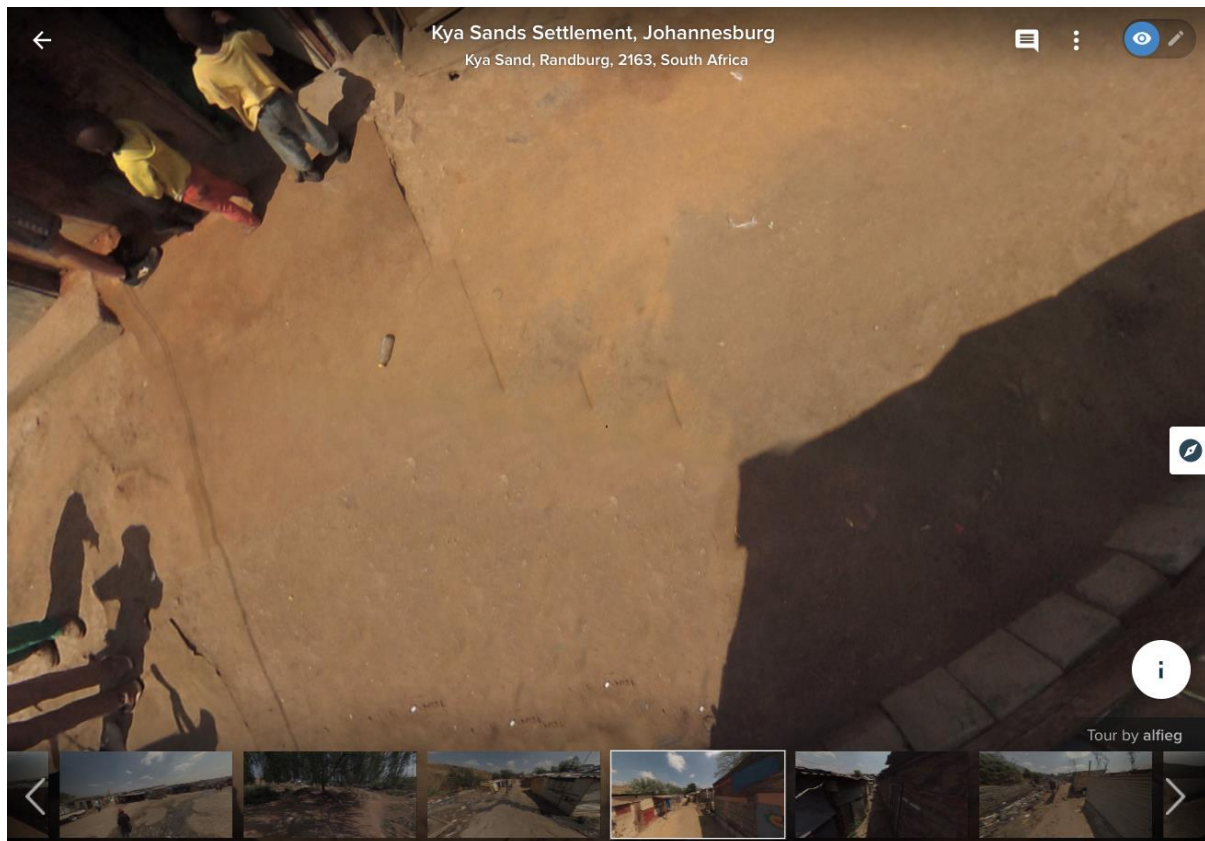


Figure 7: The downward gaze of 360° imagery.

D4. Distribution and Recognition through 360° Street Views

As illustrated in the *Kya Sands – Services and Hazards* street view, 360° imagery could be used to fulfil similar objectives as quantitative social audits, to draw attention to uneven service provision as an issue of distributive injustice. For many social audits, the typical approach has been to ‘let the data speak for themselves’, although as those engaged in this form of data activism have discovered, data are a relatively easy target to contest. Moreover, data may have little to say about injustice in its full texture. Quantitative data is limited in the way that it represents space as a container comprised of discrete objects devoid of context, which is limiting in any setting, but may be particularly incompatible with the fluid, dynamic, and ultimately horizontal ontology of informality.

Dovey and King’s (2011; 2012) work articulates this slippage. As the authors explain with reference to Kevin Lynch’s pioneering work on urban imaginaries, instead of discretized representations, “[t]he image of the informal city... is often found in the interstices of Lynch’s categories of ‘paths’, ‘edges’ and ‘landmarks’” (2011, p.26), which suggests a need for representations that capture informal settlements as continuous, fully textured places. The *Kya Sands – Services and Hazards* street view was designed to document the services, infrastructure, and environmental hazard issues in the settlement in a way that might more effectively represent real-world impacts and wider contexts. Through immersive 360° imagery, the viewer is exposed to the lived realities of collecting water at communal standpipes, open water from leaking standpipes flowing down dirt paths, the dilapidated condition of outhouse toilets, household waste disposed in open spaces, and electricity and flooding hazards (e.g., see Figure 8).

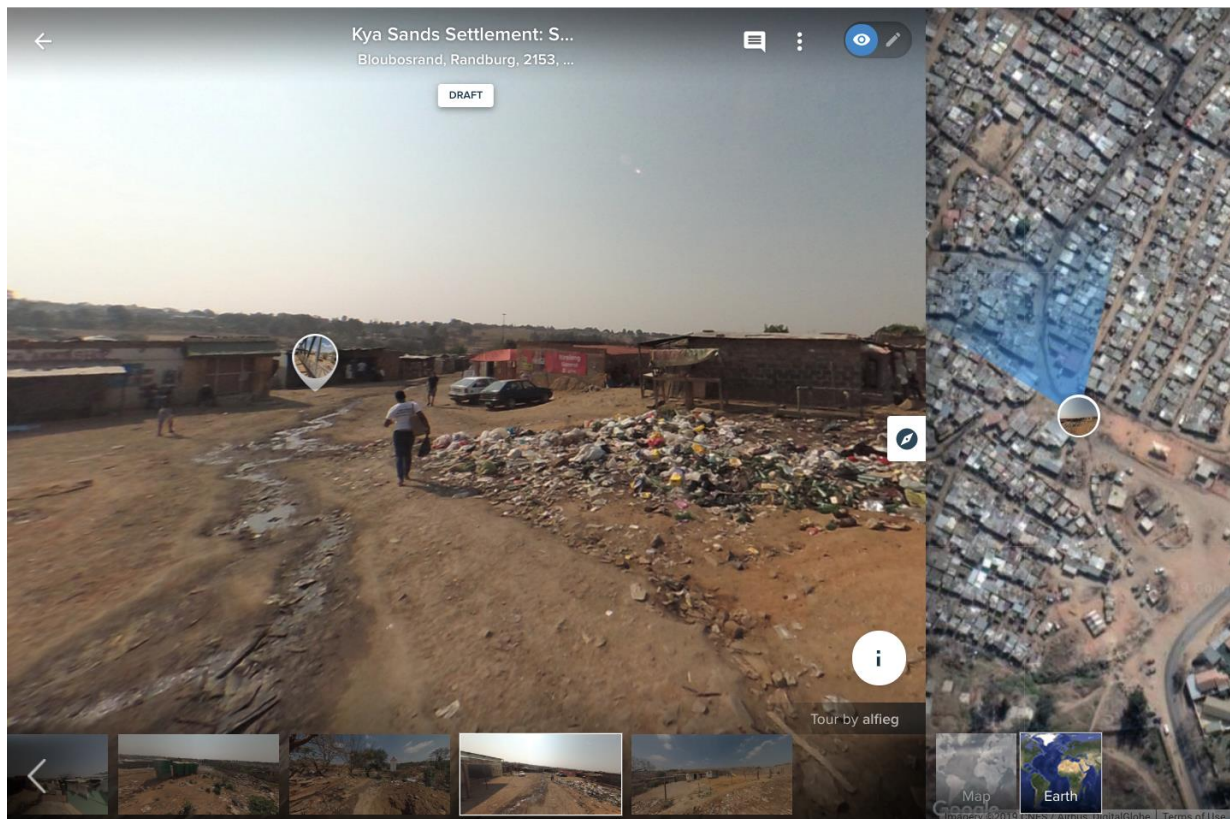


Figure 8: Screenshot of the Kya Sands–Services and Hazards street view showing waste disposal and open water from leaking standpipe.

Although further evidence is needed, this less reductive and abstract form of datafication may prove more convincing and less easy to dismiss by government officials. Social audit findings are typically widely circulated to government officials and online upon completion of the project. The Services and Hazards street view could help to provide the wider context and real-world impacts of distributive injustices, especially if combined with the voices of residents themselves. Instead of a standalone approach, the street views may be best suited to represent distributive injustices alongside other forms of representation. However, a key argument of this piece is that any attempt to advance distributive justice for marginalized places must first seek to establish *spatial recognition* for such places, particularly in settings in which being ‘seen by the state’ is a necessary first step towards obtaining basic services (Parnell and Pieterse, 2010).

This argument provides the basis for the *Kya Sands Story*. As Taylor (1994, p.25, emphasis added) argues, because identities are often shaped by relations of *misrecognition*, “a person or group of people can suffer real damage, real distortion, if the people or society around them mirror back to them a *confining or demeaning or contemptible picture of themselves*.” Drawing on research in a marginalized area of Berlin, Cuny (2018) identifies three visual-representational strategies residents employ for managing and contesting such demeaning representations of the place they live. First, some residents of defamed areas internalize stigma, submitting to outsiders’ perceptions but distancing themselves from other residents they deem to embody the negative characteristics. Second, residents counter and resist negative representations, through production of counternarratives. Thirdly, residents can try to reverse the stigma, by constructing stigmatizing representations of the majority.

Following the second strategy, the aim of the *Kya Sands Story* was to develop “counterstigmatizing images” (Cuny, 2018, p.4) that reveal a more detailed and nuanced picture of the settlement through 360° imagery and further text and multimedia embedded as ‘hotspots’ (see Figure 9). The *Kya Sands Story* can be compared with another visual imagery project designed to tell a hidden story about urban inequalities. The ‘Unequal Scenes’ (<https://unequalscenes.com/>) drone project produces vertical and oblique aerial photos and videos documenting gross spatial disparities in South Africa. These ‘dialectical images’ (Dovey and King, 2012) typically depict urban decay and informal settlements butting up awkwardly against wealthy suburbs and golf courses (including Kya Sands/Bloubosrand, see Figures 2a and 2b). The photographer explains the motivation:

“Inequalities in our social fabric are oftentimes hidden, and hard to see from ground-level... I defy the traditional power structures that keep these inequalities hidden so well from every direction except directly above. If the images provoke uncomfortable feelings of fear, despair, or an unsettling realization of complicity – good. They are intended to.” (Miller, 2018).

These images certainly provoke uncomfortable feelings through a novel visual perspective, and there is a political potency that could be useful for drawing attention to the country’s spatial inequalities. However I argue that their power to make these inequalities visible must be weighed against their power to aestheticize and depoliticize poverty, which can reduce the complexities of life in informal settlements to a universalizing story of suffering and hardship. In the Kya Sands/Bloubosrand Unequal Scenes aerial video (<https://unequalscenes.com/kya-sandsbloubosrand>), the opening text – splashed across a low-oblique perspective of the settlement – declares, “*The story of Kya Sands is a story of ash, smoke, and broken promises*”. This text, combined with the specific aerial perspective chosen, offers little possibility for viewer agency, and little chance of a nuanced understanding of the settlement.

The story of Kya Sands is partially one of poverty and informality, but it is also a relatively well-established residential area with residents that come from a variety of backgrounds and occupations, which may not align with common perceptions of informal settlements. The objective of producing the *Kya Sands Story* was to make visible the rather more complex and diverse realities of informal settlement living, which the viewer can experience in a selective, non-linear, and interactive way. By self-navigating through the settlement, choosing the linear perspective of the 360° imagery, interacting with the additional multimedia content and web links provided in the hotspots, I argue that the viewer is provided greater opportunity to form an opinion of the settlement beyond the suffering trope.

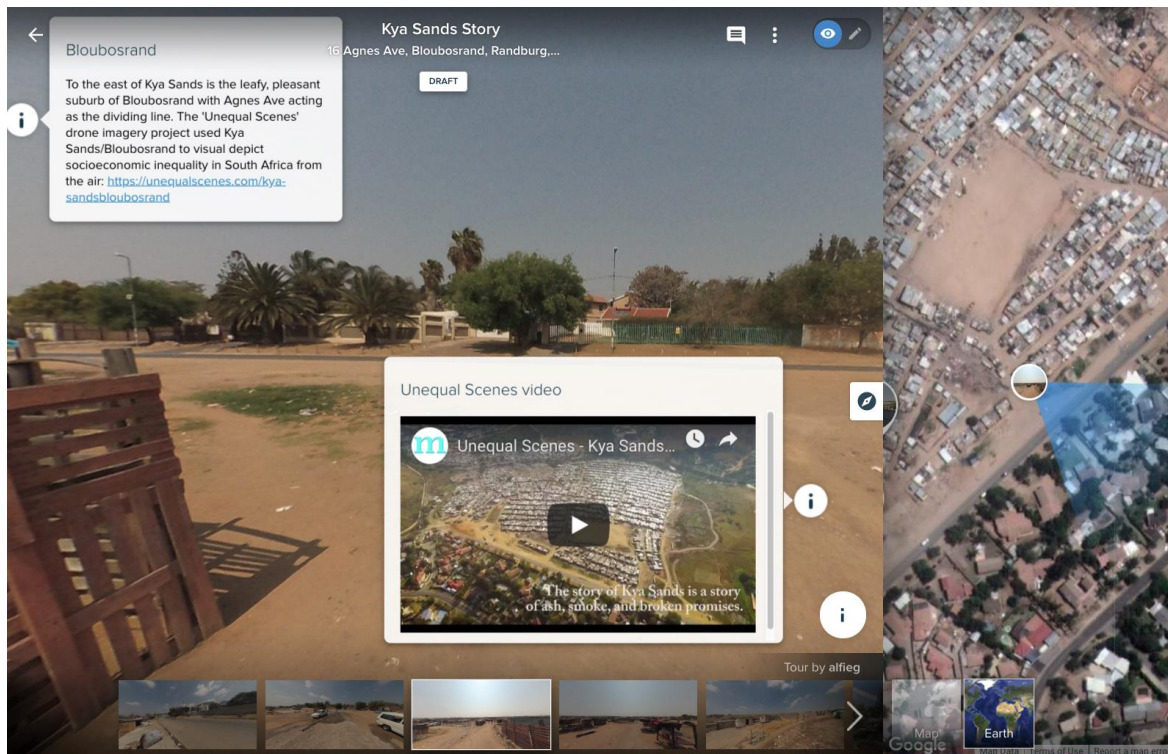


Figure 9: Screenshot of Kya Sands Story showing a 360° image taken at the boundary between the settlement and the neighbouring suburb of Bloubosrand. The image is embedded with two interactive ‘hotspots’ with text, links to further web content, and a video depicting the visual inequalities between the residential areas, as captured by the Unequal Scenes drone aerial imagery project.

D5. 360° Imagery, Exaggerated Seeing, and Misrecognition

The notion that 360° visual representation can lead to recognition rests on at least two key assumptions. The first assumption is that any form of visibility is desirable or at least necessary to draw attention to highly marginalized urban fragments. The second assumption is that this specific type of visual imagery could enable a less reductive form of datafication that might align better with an ontology of informality, sidestepping the limitations of quantitative representation and aerial perspectives. Although the previous section considers these ideas with caution, future research should also pay attention to the potential for additional harms in which enhanced 360° visibility leads to advanced injustices of misrecognition. Here, feminist philosopher Kelly Oliver’s (2001) distinction between good and bad forms of visibility for marginalized groups is useful. Oliver describes good visibility as ‘*responsible vision*’; bad visibility, however, is more complex – it may simply involve invisibility, or it may involve various forms of ‘*exaggerated seeing*’ including hypervisibility, stereotyping, and making a spectacle (p.149). Here I briefly consider one potential unintended use of these Kya Sands street views to illustrate how 360° imaging might be implicated in one form of exaggerated seeing, hypervisibility.

With little information available about the settlement from government or private sector sources, the 360° street views are perhaps the most extensive collection of representational artefacts for Kya Sands. But in moving toward visibility and (potentially) recognition, there is the risk of going too far, of hypervisibility. With the proliferation of digital imaging technologies and image hosting platforms, combined with deep learning artificial

intelligence (AI), imagery is poised to become the biggest source of quantitative data about cities. The status of street views as a potentially less reductive form of datafication disregards the possibility of quantification through emerging forms of image analytics and computer vision, which are ironically referred to as ‘recognition’ techniques. As with aerial imagery, automated feature recognition for ground-level imagery is rapidly developing within an emerging field labelled ‘urban science’, partly due to the push to produce three-dimensional models of urban space for autonomous and smart vehicle markets.

The use of GSV as a tool for virtual auditing of the built environment is well-established (Rundle et al., 2011; Iannelli and Dell’Acqua, 2017), however significant advances in image analytics now enable highly detailed, automated extraction and quantification of objects and people. Some image recognition techniques, such as convolutional neural networks, require little if any human training or oversight. These techniques have been used to estimate land use and socioeconomic characteristics of urban neighbourhoods in fine grain detail (Law et al., 2018; Srivastava et al., 2018). Gebru et al. (2017) analyzed 50 million GSV images using computer vision recognition techniques, claiming to be able to accurately predict local income, race, education, and voting patterns by identifying the make, model, and year of all motor vehicles in a neighbourhood. Dodge describes these processes as “analogous to the use of overhead imagery and remote sensing, but for urban streetscapes” (2018, p.955). However, I argue that undertaking these processes on 360° street-level imagery of formerly invisible spaces could accelerate their hypervisibility to a degree not possible with aerial imagery, precisely because of the detail captured at the ground-level plane of perspective.

Governments and private sector are collaborating on urban analytics problems, with the aim of reducing the cost of data collection using conventional in-situ approaches. While these techniques may provide opportunities to ‘know’ invisible spaces in a rapid and cost effective way, this extreme form of datafication and hypervisibility could accelerate the abstract and reductive understanding of urban spaces, with harmful consequences for residents. Scholars in surveillance studies have drawn attention to the goals of surveillance in the digital era, explaining how contemporary forms of surveillance are rarely concerned with monitoring and disciplining individual bodies. Rather, contemporary ‘dataveillance’ is about segmenting society for capitalist and social control objectives, a process referred to as ‘social sorting’ (Lyon, 2003). Image analytics in urban science is effectively concerned with analogous processes of ‘spatial sorting’ – segmenting space into highly refined categories for capitalist exploitation, or to target and profile the people associated with them (Wood, 2017).

Even though the shift 90 degrees – from vertical, to oblique, to street-level – is conceptualized as a shift from quantitative to qualitative forms of datafication, from abstraction to human experience, from aestheticization to realism, street-level image analytics introduces the possibility of *advancing* injustices of misrecognition as places (and the people associated with them) are defined, categorized, and ranked according to socioeconomic worth or risk. For example, it has become well known that predictive analytics advances processes of social and racial stereotyping, which leads to misrecognition for already marginalized people (Jefferson, 2018). Taylor (2017) describes how machine learning approaches applied to aerial imagery of migrants could be used to categorize behaviours, predict migration patterns, and restrict potential ‘undesirables’ from claiming

asylum. Naik et al.'s (2016) application of these techniques to GSV imagery demonstrates how these forms of analytics, but applied to urban features and based in criminological theory (e.g. Broken Windows Theory), could be accelerated via the ground-level visual perspective, at an "unprecedented resolution and scale" (p.129). In a situation of computer vision, "street-level ceases to be a progressive antidote to the spatial abstractions of aerial imaging, but instead has its own set of power geometries, stemming not from the abstraction of vertical perspective but from abstraction by 'datafication'" (Shapiro, 2017, 3).

For informal settlements, predictive analytics derived from highly detailed 360° imagery will pose considerable threats to the community's ability to self-identify, suggesting caution is needed when engaging in this form of datafication. For the purposes of this pilot study, imagery is likely too low-resolution for these forms of image analytics, and it has not yet been shared widely beyond the project team. Further research will be required to determine whether such imagery advances responsible vision or exaggerated seeing.

E. Conclusions: Visual Data Justice?

E1. Summary

Beyond the distribution of 'goods' and 'bads' in society, further forms of injustice accrue to the residents of informal settlements over and above inadequate access to basic services and exposure to environmental risks. In foregrounding the importance of identity formation and the status hierarchy, recognition provides a basis for considering injustices that threaten the dignity of residents of informal settlements through invisibility, in a country in which visibility is considered a basic prerequisite for equality. This paper draws on interviews from data activists about the role of quantitative data in advancing distributive justice aims, and a pilot study to reflexively consider the potential of immersive, 360° street views for advancing recognition for informal settlements. Through exploration of key issues emerging from the production of three different types of street views for the settlement, the paper provides a basis for further enquiry into the role of 360° imagery and other immersive visual technologies in shaping how informal spaces are recognized by outsiders. Findings from the project provide answers to the three guiding questions.

The first question was *what is the role of quantitative data in representing injustice and advancing the needs of marginalized people and places?* Interviews with data activists suggested that quantitative data on its own has limited potential as a 'tool' of visibility. Since informal settlements often "disappear from the cognitive map of those who allocate resources" (Dovey and King, 2011, p.22), social audits in South Africa are pragmatically designed to make them visible to policy makers, and in doing so, they often highlight gaps between budgeted allocation of services and the reality on the ground. Yet the data themselves have become the target of resistance, providing an opportunity for governments to deflect attention away from the substantive issues, rendering the realities of informal settlement living further invisibilized. Because of this, the findings suggest that quantitative data, on their own, have limited potential to 'make visible' service delivery injustices. This finding adds further dimensionality to a growing understanding that conventional forms of quantitative representation (e.g. statistics, maps, static categories) may be unsuited to an

ultimately horizontal, fuzzy, and dynamic ontology of informality. More broadly, it calls into question the limitations of any attempt to datafy injustice.

The second question was *how can consumer-grade 360° imaging technologies be used to produce street-level imagery of informal settlements?* The idea for the 360° imagery pilot study emerged from three observations: the limitations of quantitative data as described above, wider critiques of aerial approaches to representing informal spaces, and the uneven coverage of Google Street View. Against this backdrop, the pilot study sought to advance the potential for newly-accessible technologies to be used to produce ground-level immersive 360° imagery of informal settlements. The project answered the question by demonstrating how street-level imagery of Kya Sands could be produced using consumer-grade hardware and software and a systematic imagery collection strategy. Three street views were produced for the settlement, the *Kya Sands Tour*, *Kya Sands – Services and Hazards*, and the *Kya Sands Story*. These findings provide a basis for further research and practice into the production of 360° imagery for representing not only informal settlements, but other less visible urban spaces.

The third question was *can a potentially more progressive form of datafication be realised through street-level 360° imagery?* This pilot study provides preliminary evidence of the potential for progressive datafication through panoramic visual representation, but it also raises further questions about the risks of image-based datafication. The Kya Sands Tour was designed to broadly resemble the Google Street View aesthetic and mode of user interaction, providing a ‘virtual tour’ through the four sub-areas of the settlement. Picking up where Street View ends, such tours could provide outsiders a deeper understanding of informal settlements, and more speculatively, they might help to register such spaces as not separate from but intimately interconnected with the wider city. This tour does however raise questions about the potential benefits or harms of virtual slum tourism.

The Services and Hazards street view was designed to illustrate the realities of living in areas subject to limited provision of basic services and exposure to hazards, a goal akin to those of quantitative social audits, demonstrating distributive injustice. Yet, this street view may be less open to resistance and deflection from policy makers compared to the abstractions and reductionism of data-driven forms of representation. The Kya Sands Story specifically diverges from the GSV aesthetic and mode of user interaction, with the goal of telling a more detailed and nuanced story of the settlement compared to the reductionist narrative propagated by framed aerial and ground-level imagery. The lack of framing and linear perspective arguably provides the viewer with a degree of agency and greater chance of a nuanced understanding of the settlement.

These findings thus point to the potential of this imagery for advancing the social justice principle of recognition for informal settlements – a possibility that might more broadly be referred to as *spatial recognition* (cf. Luque-Ayala and Neves Maia, 2019). Yet, as speculated in the final section, when highly detailed, panoramic ground-level imagery is used for other purposes – including automated urban space classification using computer vision techniques – it may have the opposite effect of rapidly accelerating spatial misrecognition, which calls into question the notion of such imagery as a more realistic, sympathetic, or progressive form of datafication.

E2. Recommendations and Future Research Agenda

This piece is driven by the notion that ground-level 360° geovisualities might offer new opportunities to advance recognition for marginalized people and places, however potential is largely speculative at this stage. As a key topic of future enquiry, research should engage potential viewers of such representations (e.g. citizens, officials, policy makers) to understand what the imagery invokes in both residents and outsiders, and what it makes possible in terms of visibility and recognition. This aligns with a call by Harris (2015, p.611); as the author implores, “[t]here is ... a need for more engagement with how different people actually respond to and experience aerial (and ground-level) views, and how different distances from the ground and different planes of vision (vertical, oblique, or low-oblique) shape contrasting relationships with cities”. This paper however suggests a further dimension of enquiry, focusing on how different people respond to and experience immersive 360° views when the frame and fixed plane of perspective are discarded. A follow-on project is in planning, designed around research questions about the added value of a street-level imagery approach for advancing visibility and recognition for informal settlements, compared with quantitative representation strategies. These questions could be answered through a full research study involving participatory design and data collection, sharing of imagery with the community and municipal government, as well interviews with all stakeholders including participants, residents, activist organizations, and public officials.

More generally, findings of the project suggest the following core questions for future research and practice on visual representation of informal settlements:

- How can digital representations be produced in a more participatory way, given the technical nature of imagery collection and management and the lack of formal governance structures in many informal settlements?
- How might a truly ‘insider’ view diverge from a version diffracted through a research process?
- What processes are appropriate for engaging wider stakeholders such as ‘virtual tourists’ and policy makers?
- What forms of image ownership and sharing are appropriate, and is it possible to prevent harms from unintended uses of imagery?

This paper also suggests at least three topics that must be central to the wider research agenda for data justice. First, and perhaps foremost, it points to the limitations of conventional forms of quantitative data for representing injustice. Since a considerable portion of the emerging literature on data justice – particularly the ‘data activism’ strains – hinge on the idea that (in)justice can be datafied (see discussions in Dourish and Gómez Cruz, 2018; Gutierrez and Milan, 2018; Kennedy, 2018), findings from the interviews suggest that more consideration of this basic tenet is needed. Of course, the beliefs of those working in this area are more nuanced, however I suggest that the future agenda for data justice must look more carefully to a much longer history of critical enquiry on the societal impacts of data (e.g. Westin and Baker, 1972). The field of smart cities and data-driven urbanism provides a current, parallel area of enquiry that could be more closely integrated with urban data justice. Amongst other things, work in this area draws attention to a disconnect between perceptions of what data are and what data can achieve, and the reality in practice – their ‘imagined affordances’ (Nagy and Neff, 2015; Baack, 2018). A key

future research question for data justice then is, *what forms and examples of injustice can be remedied through datafication, and which are left invisible by it?* For activism-related practices specifically, *what is gained and lost when energies are shifted from 'people power' to 'data power'?*

Second, in drawing a connection between state inattention to distributive injustices and community invisibility, this research suggests that recognition must be a core concern of data justice, if only as a preliminary step towards addressing inequities in material resources and basic services. A future research agenda should seek to address questions such as *what is the relationship between misrecognition and maldistribution in the context of datafication?* Yet recognition is a contested and often vaguely described notion, with considerable discord over the meaning even in those who espouse it. How and when recognition is achieved (or not) is not objectively and widely agreed upon between stakeholders. Because of the ambiguity, a future agenda for recognition within data justice should seek to develop normative frameworks for assessing data-related (mis)recognition. Fraser's notion of 'participatory parity' (2008) provides one such normative ideal that could be used to judge when recognition has been achieved. This suggests further research questions: *what does parity of participation look like in a datafying world, and what is the relevance of this concept amidst growing resistance to participating in processes of datafication?*

Thirdly, in relation to the above two points, this research suggests that more attention as to the status of visual imagery in relation to datafication must be on the agenda of future work in data justice. A key aim of this pilot study was to develop a non-quantitative digital representational strategy that might overcome limitations of surveys, maps, and other reductive forms of representation. While the findings and discussion suggest meaningful possibilities for representing informality in a way that is sympathetic to informal spaces and their residents, the status of imagery as a somehow more realist and less reductive form of datafication might be highly naïve. This project specifically grappled with a growing sense of unease about the imagery, in part because a limited degree of participation risked our speaking on behalf of the community, but more so because of the potential for unintended uses of the imagery once released for wider access.

The first concern could be addressed with a future project based on a fully participatory design, however addressing the second concern will require considerably more attention. There is growing evidence of individual- and group-level injustices derived from big data surveillance (Dencik et al., 2016), from commercial analysis of digital behavioural data gleaned from use of the web, mobile phones, and smart technologies (Zuboff, 2015; Taylor et al., 2017), and through processes of 'function creep' whereby data collected for one reason is then analyzed for another unjust purpose (Cinnamon et al., 2016; Heeks and Renken, 2018). A small amount of attention has been paid to data injustice in the context of aerial imagery analytics (e.g. Taylor, 2017) however a future agenda for data justice must give more credence to the notion of images-as-data, and specifically, the new forms of analytics they make possible. This will soon become a more 'visible' problem, as AI and computer vision techniques are increasingly applied to photos of people and places in rich, ground-level detail, rendering 'born quantitative' data merely a drop in the urban data bucket.

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Jonathan Cinnamon is a broadly trained human geographer and geographic information scientist with a research focus on datafication and the expansion of digital technologies in urban, health, and development contexts. His work develops methods for data production and visualization for low-resource settings, and attends to the ethical and political implications of data and technologies in processes of social change. This research has been funded by research councils in Canada, South Africa, and the United Kingdom.