Do-It-Yourself Street Views and the Urban Imaginary of *Google Street View*

Abstract

Google Street View (GSV) is the *de facto* platform for street-level visual representation in most settings; however, its coverage is highly uneven due to a range of political, legal, technological, and economic factors. GSV's spatiotemporal disparities are most evident within cities, and this advances a distorted urban imaginary of *absences*, *fragments*, and *obsolescences*. This paper traces key developments in 360° imaging poised to expand the production and consumption of street-level imagery, including new actors, platforms, technologies, and data production approaches. Then, engaging with consumer-grade imaging technologies and the notion of do-it-yourself urbanism, this paper develops a DIY street view approach as one new mode of producing street-level imagery. Drawing on the findings of a pilot study, the paper considers key practical issues for street-view production, the benefits and risks of DIY approaches in relation to corporate and crowdsourced imagery initiatives, and the politics of urban representation in 360°. Findings suggest that the DIY approach offers the potential for a more "careful curation" of space in 360° street-level representations; however, there are considerations specific to this "third way" that require further attention.

Keywords

panoramic photography; *Street View*; urban visualization; DIY imaging; platform urbanism

Introduction

> *Hello you guys. I wanted to share this picture I found on Google's website. It shows every place that* Google Street View *has been to. They went all over Europe. To Iceland. To the northernmost and most remote areas of Norway. Even to places in Greenland. But not to the Faroe Islands. Don´t you worry. My SheepView 360 will change that. I'll show Google, what they are missing out on! (Visit Faroe Islands, 2016).*

A 2016 blog post by an employee of Faroe Islands tourism initiated a grassroots campaign to lobby *Google Street View* (GSV) to include the small archipelago in their global database of street-level geolocated imagery. As a stunt, sheep were fitted with 360° cameras, capturing panoramic photos and videos to draw attention to their efforts to convince Google to visit the Faroe Islands. This initiative, though tongue in cheek, illustrates three issues central to this paper: the uneven coverage of GSV and its perceived impact on economic development and tourism, the importance of the platform for shaping how outsiders imagine places, and the potential for alternative approaches to street-level imagery production. Engaging with all three, this paper explores the

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consequences of uneven GSV coverage for cities and advances a do-it-yourself (DIY) approach to street view production.

For places or people affected by GSV's uneven coverage, the Faroe Islands example illustrates several possibilities. One option is the plead the case to Google; however depending on the location, it may also be possible to lobby another corporate platform such as Microsoft's *Bing Maps Streetside* (available in many cities in the United States, and sparsely in a few cities in the United Kingdom, France, and Spain), Tencent or Baidu (in Chinese cities), or Yandex (in Russian and some Eastern European cities). Another option—doing it yourself—is now a growing possibility. The high cost of specialized cameras and software and the technical requirements needed to collect, process, and host imagery have limited the production of 360° street-level imagery to large scale operators; however wider access to cameras and "virtual tour" technologies is setting up the possibility of diversifying the production of street-level imagery.[1] GSV is open to public contributions, which—along with newly available cameras and software—has initiated a new industry of photographers offering 360° imaging services. Approved photographers can use the "*Google Street View* Trusted" designation, although anyone can contribute images to the platform as standalone unlinked "Photo Spheres." Contributions, however, are subject to acceptance criteria and other terms and conditions[2], which limits the possible uses of GSV by the public. Moreover, some users may be unwilling to use the platform to host imagery if they are concerned about Google's capital accumulation strategy built on free labor and the monetization of user data and contributions (Thatcher et al., 2016; Alvarez León, 2016).

The open-source, crowdsourced OpenStreetMap (OSM) project provides a model for a future street-level imagery initiative to rival GSV, and two key imagery platforms have been developed with this aim, Mapillary and OpenStreetCam. Both are closely integrated with and draw their inspiration from OSM, however each has yet to experience a similar level of public uptake as OSM. Furthermore, competition between them, and their underlying commercial motivation driven by volunteer labor has meant that some have questioned "*what a truly open street-level imagery platform would look like?*" (Alvarez León and Quinn, 2019: 4, emphasis added).

Focusing on a slightly different question, this paper instead explores another prospect for diversifying the production of street-level imagery, using a more independent, micro-scale approach. This paper develops the notion of do-it-yourself (DIY) street views as a form of "do-it-yourself urbanism," the tactical, experimental, and micro-scale practices that often evolve outside of government and corporate planning practice (see Finn, 2014; Mould, 2014; Iveson, 2013; Spataro, 2016). Like other forms of DIY, an application to urbanism is based not only on the belief that anyone is capable of action, but that a sole focus on technocratic knowledge production and "elite expertise" are barriers to positive change in cities, whether the objective is economic development, social justice, or otherwise (see Deslandes, 2013; Heyman, 2010). Within this context, emerging developments in 360° imaging posit new possibilities for DIY approaches to street view production, as a third approach along with corporate and crowdsourcing platforms. Using consumer-grade technologies, this paper considers the benefits and risks of a DIY street-view approach, against a backdrop of distorted perceptions of cities shaped by GSV's uneven coverage, explained below.

Absences, Fragments, Obsolescences: The Urban Imaginary of GSV

Although 360° imaging (also called panoramic, spherical) has a much longer history, the 2007 addition of *Street View* to Google's suite of mapping and geolocation platforms (also including Maps and Earth) was a watershed moment[3], introducing linked and navigable 360° imagery to the average Web user. In the 13 years since its release, GSV has become synonymous with virtual urban representation to the point where it is now, for many people, "*seamlessly integrated into everyday urban experience*" (Campkin and Ross, 2012: 147, emphasis added). GSV is widely used by individuals for navigation, enhancing spatial awareness, and virtually exploring unknown spaces. Community groups, urban planners, and journalists use GSV as a research tool to augment or produce new spatial knowledge. Educators use GSV as an immersive experiential learning platform, to teach spatial concepts, gain place-based knowledge, or promote an understanding of social and cultural diversity (Shih, 2015; Alderman and Inwood, 2014). In academia, a veritable genre of "GSV for research on cities" has emerged, with proponents claiming it enables rapid and inexpensive data collection, with less intrusion into study sites compared with *in-situ* observations (e.g.

Rundle et al., 2011). GSV is used to virtually survey or audit the built environment, including streetscape design for cycling and walking (Vanwolleghem et al., 2014), urban green space (Li et al., 2015), public transit accessibility (Hara et al., 2015), and risky spaces (Iannelli and Dell'Acqua, 2017).

Discourses of "seamless integration," however, serve to mask GSV's highly uneven coverage. Initially introduced in five US cities, GSV has continually expanded and now includes imagery from all continents. Users can explore some remote and off-street spaces including national parks, the South Pole, the Great Barrier Reef, and even the International Space Station. At the global scale, the geography of GSV mirrors national development status; most high-income and many middle-income countries have coverage, yet most low-income nations are excluded altogether (See Figure 1). Looking at the scale of cities however provides a clearer illustration of uneven spatial coverage. Significant differences are evident between cities (e.g., between Global North and South cities), however a close look *within* most cities in the world will highlight a variegated landscape of spatial coverage, which is likely to covary with indicators of socioeconomic status (see Fry et al., 2020). Further, the *temporal* currency of images is also highly uneven, with some areas captured regularly and others only once (if at all). Coverage in GSV is thus a spatiotemporal phenomenon, which suggests several initial issues to consider if it is to be used for any practical, experiential, or research purposes—whether imagery exists in an area of interest, the level of spatial completeness within the area, and when the imagery was captured.

<Figure 1 about here>

GSV's uneven spatial and temporal coverage shatters the notion that it is a "simulation of the city of the present" and not just another partial, reductive, and biased urban representation (Campkin and Ross, 2012: 148). Critics of maps have long drawn attention to the ways that spatial representations not only describe but also enact state territorial geography (see Aalbers, 2014). Renewing this "maps as power" (Harley, 1989) critique, research on the political economy of digital mapping and spatial data has focused attention on a new landscape of cartographic power in the age of the corporate geolocation platform. Two distinctive characteristics of contemporary geolocation

economies identified in this literature are relevant here—the powerful role of information technology companies, and a scalar focus on the urban as the key "site, subject, and seat of data capture and production practices" (Leszczynski, 2016: 1695, see also; Zook and Graham, 2007; Shaw and Graham, 2017). In the age of globalizing smart city discourses (Joss et al., 2019), Shaw and Graham's (2017) notion of the "urbanization of information" captures this two-part shift in which Google and other geolocation companies are empowered to shape the physical spaces of cities through control over data flows and representations. As the authors explain:

> Google has become a dominant force in the informational reproduction of urban space for the vast majority of cities. Particularly in the global North, it is Google that now occupies a type of informational right to the city, and it will be Google that can increasingly control a city's surplus production or best further its own vision and ideology of how it might develop… This is the city of Google (912).

Spatial and visual representations of cities are neither neutral nor inert; they shape what is known about, and how people come to imagine and understand urban space (Shelton, 2017; Aalbers, 2014). As the *de facto* form of 360° street-level representation in many places (Alvarez León and Quinn, 2019), GSV's uneven spatial and temporal coverage contributes to an urban imaginary of *absences*, *fragments*, and *obsolescences*. This has material consequences for places subject to GSV's distorted representation. While Graham et al. (2015: 89) argue that "[p]laces invisible or discounted in representations are equally invisible in practice to many people," representational absences, fragments, and obsolescences remain open to scrutiny by users—and each type may have distinct implications for shaping urban imaginaries. In studies of representation, research has explored the effect of absences on map readers' ability to interpret physical space, the development of cartographic techniques for visualizing the "presence of absence" (Robinson, 2019), and the performative power of absences in intersubjective identity formation, since "[s]ocial relations are performed not only around what is there but sometimes also around the *presence* of what is not" (Hetherington, 2004: 159; Degnen, 2013). Wider attention to urban marginality, meanwhile, affords some insight into the effects of visual representations when cities are represented fragmentally (e.g. McFarlane, 2018; Graham and Marvin, 2001). Due to

the interstitial locations of areas such as informal settlements and low-income high-rise developments, the spatial contours of these places are generally known to outsiders but the geographies and ways of life inside are left to the imagination, which can advance a particular and pernicious form of othering for their residents (Dovey and King, 2012; Power et al., 2012). Regarding the third form, obsolescence is unique in the sense that representation is spatially present and unfragmented; yet it is temporally outdated, which may or may not be understood by viewers. While people typically construct an understanding of places through a "multitude of present and past discursive and physical layers" (Graham, 2010: 422), the purported realism of immersive geolocated imagery ascribes it an undeserved finality (Shapiro, 2017: ; reference removed for peer review).

For users of GSV, accurately interpreting the "patchiness of the GSV world" (Hoelzl and Marie, 2014: 264) requires an understanding of the variety of technical, economic, legal, and political factors that determine whether (and how often) a given street is visited by the Google car[4]. Politically, both India and China have banned GSV outright. Legally, GSV is absent in some countries due to local privacy laws, notably in Germany. Poor road or telecommunication infrastructure and local bylaws make it challenging to collect imagery in other settings. Overall however, GSV users are likely to interpret uneven coverage as an indicator of social, cultural, and economic value (see Gilge, 2016), given Google's now widely understood reputation as a private enterprise built on the economics of user data monetization and advertising. For GSV, the platform's "appropriation of visual information" has become economically successful through integration with Google Maps, Search, and the company's wider value-generation ecosystem (Alvarez León, 2016: 7). Thus, it follows that Google's decision to provide coverage in most cases is a simple cost-benefit analysis that weighs the significant costs of imagery collection and processing against the potential for a return on investment. Although reasons for uneven coverage might be more complex, GSV's absences, fragments, and obsolescences are largely determined by potential for the generation of *economic value*, yet they also serve to *symbolically devalue* places as unworthy of users' virtual or physical attention (see Slater, 2017; Wacquant et al., 2014).

Aims and Research Questions

Against a backdrop of uneven coverage in GSV, the power of the platform to shape perceptions of cities, and new opportunities for producing 360° imagery, the aim of this study is to demonstrate how DIY street views could be produced as a form of micro-spatial urban practice. The following questions guide this paper: *What would a DIY street-view approach look like? How does this approach align or diverge from existing corporate approaches and new crowdsourced imagery initiatives? What are the benefits and risks of wider production of 360° street views?* To answer these questions, this paper draws on findings from a pilot study in Exeter, UK designed to produce street views for areas of the city where GSV coverage is absent, fragmented, or obsolete (described in the next two sections). The Discussion section draws on study experiences and feedback from potential users to highlight practical challenges for producing DIY street views, benefits and risks of a DIY approach in relation to corporate and crowdsourcing initiatives, and the politics of 360° representations of urban space.

DIY Street Views: A Pilot Study

Exeter is a socio-economically diverse city in the south west of England with a population of approximately 130,000, and an increasingly important regional center for tourism, education, public administration, and the retail economy. The idea for the pilot study emerged at a local economic development meeting on the digital presence of small businesses and community organizations. One issue noted by participants was uneven GSV coverage in the city, with participants focusing on two related reasons why this was an issue for businesses and organizations. Participants felt that that inclusion on the platform was important for local tourism and development, and that exclusion could have reputational impacts if users interpret absences or partial coverage negatively. Overall, spatial coverage of GSV in Exeter is high, as shown in Figure 2. A closer look however reveals a patchwork of spatial absences, fragments, and obsolete imagery, including culturally and economically important parts of the city (See Figure 3). Key absences include Cathedral Yard and Cathedral Close, streets adjacent to the city's historic cathedral, streets in the Princesshay outdoor shopping center, and the pedestrianized Gandy St. Coverage is fragmented for High Street and the Quayside, and

the area of Cranbrook on the periphery of the city has imagery that is both fragmented and obsolete.

<Figure 2 about here>
<Figure 3 about here>

From an assessment of GSV in Exeter, we categorize four different types of streets with uneven coverage: *pedestrianized streets and spaces, vehicle restricted streets, streets on private land, and new streets* (See Table 1). These categories may also apply to other cities that have generally good GSV coverage.

<Table 1 about here>

The Production Approach of DIY Street Views

Based on the above analysis of GSV coverage, three areas of Exeter were chosen as study sites. The first site, High St and Gandy St together comprise a core part of the city center's retail, dining, and nightlife district. This district further attracts tourists and shoppers due to close proximity to the city's key historic and cultural amenities, described by a local community website as "the jewel in the cultural crown of Exeter" (Gandy Street, 2020). The second site, the Quayside and River Exe area is a mixed retail, cultural, and historic district connected to the middle and upper-income neighbourhood of St. Leonards on the east side of the river and St Thomas, a lower- and middle-income neighborhood to the west of the river. As a former industrial and shipping district, the Quayside has gone through several periods of urban renewal and regeneration. However, recent flooding of the River Exe at the Quayside and adjacent neighborhoods combined with ongoing construction of flood control barriers have hampered attempts to increase the profile of the area to tourists and local residents alike. The third site chosen was the satellite community of Cranbrook, the first "new town" built in the County of Devon since the Middle Ages. Work on Cranbrook began in 2011 with approximately 2000 homes completed by 2019. Today Cranbrook is a diverse, growing community of approximately 3000 people, however the community has struggled to attract visitors and new residents in part due to inadequate provision of services and infrastructure, and media reports sensationalizing crime statistics in the area (DevonLive, 2019).

<Figure 4 about here>

Figure 4 outlines the project steps, from developing the idea through to imagery processing, street-view development, and the final dissemination phase. In Phase 1 (Project design and imagery collection), an initial assessment was conducted to determine whether the location is public or privately owned and if the data collection should be done on foot, bicycle, or vehicle. Next, the choice of hardware is important given varying cost and functionality. 360° imagery has traditionally been made by combining multiple images taken with a rectangular frame camera which are then merged using photo-stitching software, a relatively straightforward but laborious process. Many consumer 360° cameras are comprised of two ultra-wide angle lenses (~180°), and feature automatic stitching in-camera or when loaded into the camera software. For this project the Garmin VIRB 360 was chosen because of its automatic image stitching and built-in GPS sensor, to facilitate image processing and geolocation.

Imagery collection required several practical and aesthetic decisions. Regarding camera positioning, images were captured from the center of the street where possible. In some areas, imagery was captured from street margins (close to buildings) due to vehicle and pedestrian traffic and road safety laws, resulting in a less visually symmetrical image. Similarly, the position of the camera in relation to the ground is a key consideration; too low and the imagery will have an awkwardly low horizon, too high and it will be focused above an average person's eye level. After testing a camera placed on a tripod operated remotely by the photographer, the final decision was to use a monopod connected to the camera and held approximately a half-metre over the researcher's head (later edited out). For longer streets characterized by little fluctuation in visual detail (e.g., of the built or natural environment), fewer, spatially distant images were captured compared with areas with greater visual interest (assessed subjectively). Regarding time of day, images were captured at off-peak times to avoid pedestrian and vehicle congestion and closer to midday to avoid shadows cast by buildings, objects, and people (including the photographer), in order to reduce image post-processing (described below).

Phase 2 (Imagery processing and development) involved processing the imagery and developing the "virtual tour." Following GSV and other street view platforms, faces

and other personal identifiers were blurred using Adobe Photoshop's Elliptical Marquee and Gaussian Blur Tools, and the monopod, researcher, and unwanted shadows were removed from images using the Polar Coordinates projection and Clone Stamp Tool. There may, however, be applications in which blurring sensitive information is not necessary or ideal; indeed it is not a legal requirement in many jurisdictions (including the UK, see McPherson, 2009), and so the choice to do so may be more ethical, aesthetic, or pragmatic than legal. The last step of Phase 2 involved linking and geo-referencing the images in the virtual environment. Options include low-cost platforms designed for the average web user, expensive desktop software packages with advanced functionality, and open source software requiring programming skills. The web-based *Roundme* platform was chosen for its range of functionality including intuitive development interface, social web-style sharing and commenting tools, integration with web-based interactive maps, and "hotspot" links (for embedding additional multimedia, text, and web content within images). Images were uploaded to *Roundme*, geo-located on the interactive map, and then joined with navigation links in the images.

Options in Phase 3 (Project dissemination) include hosting and sharing imagery publicly via web platforms, retention for private viewing, or embedding on a personal website or blog. For this project, the street views were made publicly available on *Roundme* and embedded on a project website (http://blogs.exeter.ac.uk/360/).

Results

The street view for Gandy St and High St is shown in Figure 5 (all street views are available on the project website and *Roundme* platform). For Gandy St, images were captured at regular distance intervals (approximately eight meters), from the center of the pedestrianized street. For the High St section, images were captured at eight to ten meter intervals, taken while walking from a position between the center of the street and close to buildings to avoid vehicle traffic but still retain a relatively central positioning.

<Figure 5 about here>

The Cranbrook street view is shown in Figure 6. Images were captured at varying intervals of eight to twenty-five meters, from a position closer to the margins of the street. Much of the new town has long, wide streets with little fluctuation in

environmental details, so longer distances were sufficient; although in certain areas a smaller gap was chosen to reflect more visual detail.

<Figure 6 about here>

The Exeter Quay and River Exe street view is shown in Figure 7. Images were captured at varying intervals, fifteen to twenty meters along the river's pedestrian and cycle path, and 5-10 meters at the Quay area. This street view was also enhanced using *Roundme*'s hotspot functionality to demonstrate the potential for producing street-level imagery that diverges from the practical and aesthetic norms of corporate imagery platforms. Using flooding risk as a theme, this street view enables the user to navigate through linked 360° imagery of areas subject to flood risk and mitigation initiatives, and explore interactive location-based flood information including text, videos, and web links.

<Figure 7 about here>

Although the aim of the study was exploratory, the street views were shared with a sample of relevant local business owners and organizations, to gather feedback to feed into future development. Respondents were asked to provide their perspectives on GSV coverage in their area, and to interact with the street views and answer questions pertaining to aesthetics, potential value, usability, and use cases for DIY street views. A total of 18 responses were received, highlighting potential benefits, limitations, and risks of this approach.

Discussion

This section draws on pilot-study experiences and user feedback to address the project research questions, highlighting three key issues—practical considerations for DIY street-view production, the benefits and risks of DIY approaches in relation to corporate and crowdsourcing initiatives, and the politics of 360° representations of urban space.

Practical Challenges for Producing DIY Street Views

Findings from the pilot study suggest that DIY street views could be produced with consumer grade technologies, a structured imagery collection approach, and a

basic level of skills in image processing and Web design. However, more attention to the needs, perspectives, and capabilities of potential producers and consumers is needed. The DIY approach was guided by specific criteria that could be relevant for individuals or community organizations that wish to produce their own street views—ease of use, ease of dissemination, and low cost. However, capabilities are likely to vary; indeed, feedback highlighted a much broader range of technical ability than we expected. As one respondent explained, "I had difficulty initially understanding how to move between photos and around the map, however I figured it out after some practice" (Quay area community organizer). Another respondent suggested that detailed training instructions would have to be provided for less technologically savvy users, despite the use of a web-based platform designed for average web-users.

Beyond usability, some respondents highlighted a perceived disconnect between the aims of the project and the use of a corporate platform to develop and host the DIY street views. As a respondent (Gandy St. business owner) explained, "I felt the website was easy to use and would allow me to access and distribute these photos rather easily, but I think relying on a private company may be an issue for some people. What if they decide to start charging for the service? Do I need to register to use it?" Although a basic level of access is provided for free, *Roundme* has varying user fees depending on features used and the scale of the project. Further, *Roundme* and other web-based virtual tour platforms subject users to agreements consistent with wider practices in "platform capitalism" (Srnicek, 2017). This includes the collection and retention of personal data, metadata, and user content (*Roundme,* 2018), which may limit its appeal for some users/applications. The ability of corporate platforms to profit from user experience is facilitated through discourses of sharing; as the platform's privacy policy states: "[h]ere at *Roundme* we aim to give you a convenient and hassle-free way to share your photos with the world. To provide you with the best experience, we are going to collect certain data about you, and by using our service, you indicate that you agree to it" (*Roundme*, 2018). For critics of platform capitalism and the "sharing economy" (Richardson, 2015; Cockayne, 2016), drawing attention to the duplicitous nature of these platforms provides a "necessary counterweight to a narrative…which depicts [them] as diverse and redistributive" (Langley and Leyshon, 2017: 14).

Similarly, respondents noted that Google provided the base map for imagery geolocation and map-based navigation (the Maps application programming interface (API) is integrated in *Roundme*). Currently there are few options available to produce DIY street view imagery in which corporate mapping platforms are not used in some way. Most virtual tour software offers either Google or Microsoft *Bing Maps* integration, but currently only the Pro Version of the *Panotour* software offers integration with the non-corporate *OpenStreetMap*. As a workaround, many platforms enable the user to upload a static map image (usually to produce indoor tours). An OSM static map was used for the Exeter Quay street view, which enables the user to pan but not zoom in or out (See Figure 7). The thumbnail map symbols (links to the 360° images) had to be geolocated manually, through a drag and drop process. Although in this project the term DIY is used in reference to "DIY urbanism" (further discussed below), most virtual tour platforms are proprietary and closed source meaning there are limited possibilities for "hacking" the technologies, a key principle of "DIY mapping" (see McConchie, 2015). The open source (though not free/libre) desktop-based *krpano* software is perhaps the most hackable option, with open source code and a variety of plug-ins available. Although not currently available, users on *krpano*'s forum have requested an OSM plugin (see *krpano*, 2017). If more advanced technical skills and resources are available, and if "no corporate Web platforms" is a key priority, *krpano* might be a more suitable DIY option.

On the other hand, many respondents expressed that platform functionality may be central to the potential value of DIY street views. Feedback suggested that the social web-style sharing and commenting tools of *Roundme* could appeal to organizations that wish to distribute street views widely, attract viewers, and gauge user interest. Feedback also consistently identified the platform's interactive hotspot features, highlighted in the Exeter Quay street view, as an enhancement that could attract further attention. For instance, several respondents from that study location speculated on the possibility of embedding interactive multimedia in the street views to showcase local businesses in an area, adding local retailer information, links to websites, and video content. Although the DIY street views broadly resembled the GSV aesthetic, future research should consider ways to enhance street-level imagery in light of extended functionality now available in virtual tour software. Moreover, the enhanced features of 360° cameras,

including panoramic video and spatial audio, suggests the possibility of novel forms of immersive street-level visualization. Using these features in combination with virtual reality (VR) hardware to visualize imagery that is not only 360° but also 3D audio-visual, opens up the possibility to produce street-level imagery on an elevated aesthetic and affective register. Similar to the current project, potential use cases and issues of usability and accessibility should be core considerations for future research in this area.

DIY Street Views and the Wider Landscape of Street-Level Imagery

"I enjoyed interacting with the 360 images, it reminded me a lot of the first time I learned about the Street View on Google Maps" (respondent, Quay area business owner). As illustrated by this quote, much of the feedback focused on comparison with GSV. Although this was expected, the DIY approach described here actually suggests a third mode of street-level imagery production distinct from not only corporate, but also emerging crowdsourcing initiatives. Although GSV is "practically synonymous with street-level imagery" in most countries (Alvarez León and Quinn, 2019: 2), significant developments in the street-level imagery industry are underway, including new actors, platforms, imagery production approaches, and end uses. Major technology companies including Google and Apple are developing advanced models of data collection as part of self-driving vehicle projects. The imagery will be necessarily more advanced, integrating the LiDAR depth-sensing data necessary for autonomous navigation (Ulanoff, 2017). A point cloud-based 3D street-view platform would be a significant advancement over GSV's pseudo-3D representation, but it remains to be seen whether it will have uses beyond this application, and if it will be released for public use.

Smaller actors in the private sector are now offering custom street-level imagery services. Applied Streetview (2019) provides professional clients with proprietary technologies to produce their own 360° imagery and street views. Although marketed for applications in construction and infrastructure maintenance, one client deployed their technologies to produce comprehensive street views of 10 major cities in Morocco, a country not covered in GSV (see http://carte.ma/). Like the Faroe Islands example, exclusion from the platform was understood as having consequences for tourism and economic development, and ultimately, how the country is perceived by outsiders. As

one blogger put it, *Carte.ma* can be the new "100 percent Moroccan StreetView," because "Google has not found it appropriate to integrate Morocco into its famous StreetView service, despite Morocco's position as a tourist hub" (Kingofgeek, 2014). In comparison to the approaches taken by corporations and small companies, many respondents pointed out that DIY street views might fill a niche for those interested in highly localized, low-cost, accessible, and self-reliant approaches. For Finn (2014: 383), DIY urbanisms more generally have three core characteristics: 1) actions are instigated, financed, and implemented by individuals and groups rather than municipalities or corporations; 2) actions generally emulate or augment official planning and design; and 3) the intended beneficiaries are members of the public. For Iveson, "[o]ne of the most powerful aspects of some of the practices being grouped together under the banner of DIY urbanism is that their participants are not content with lobbying for a better city sometime in the future" (2013: 945). This notion was explicitly reflected in the perspectives of respondents; doing-it-yourself under accelerated timescales was noted as a key potential benefit of DIY street views.

Feedback also highlighted the potential of an image production approach that is resolutely small in scale. As one respondent explained, "I'm not sure if this would reach a wide audience, but it might be well suited for showing recent changes to our community, or maybe they could be produced to document a local fair or event" (Cranbrook resident). Gilge describes how GSV is a "highly engineered production," that uses sensors and algorithms to capture and process the imagery "rather than through a careful curation of each street data point" (2016: 471). Careful curation may be precisely what the DIY approach described here might offer to local groups. The notion of careful curation aligned with the perspectives of multiple other respondents, including several from the city center site who expressed excitement about the possibility of maintaining accurate, detailed, and up-to-date imagery, since High St and Gandy St are continually subject to economic change and redevelopment.

A focus on careful curation however, is likely to be at odds with any project that wishes to challenge GSV in the manner of the crowdsourced OpenStreetMap project. Many of the respondents did express concern about the limited potential for scaling-up DIY street-view initiatives. Indeed, one community organizer queried about the

possibility of integrating the DIY street views into GSV to enable seamless navigation between areas covered by the platform and those in the pilot study. For projects seeking seamless integration, more explicitly engaging in a philosophy of do-it-together (DIT) rather than DIY could be appropriate, through a street-level image crowdsourcing platform such as Mapillary or OpenStreetCam. Both projects are closely connected to OpenStreetMap's large global community of volunteer contributors and use a Creative Commons license for maintaining open access to imagery, however they are both operated by private interests. Mapillary is currently the most successful with around 20,000 total global contributors since its inception in 2014 (Ma et al., 2019). However, coverage is much less complete than GSV apart from a small number of minor aberrations (Juhász and Hochmair, 2016), which likely indicates a localized effort to improve coverage using a DIT approach. Critiquing the focus on "full coverage", Quinn and Alvarez León's (2019: 1251) analysis of city-scale coverage demonstrates that Mapillary and OpenStreetCam might represent a more globally even (if considerably incomplete) spatial distribution of imagery collection compared with GSV's somewhat "all-or-nothing approach". As these platforms continue to increase their footprint and contributor base, they may be more able to assuage key respondent concerns about the DIY approach; project sustainability, integrated coverage, and wider reach. However, there are drawbacks to these platforms akin to those that may detract users from contributing to GSV. Alvarez León and Quinn (2019) also explore the creation of value on Mapillary and OpenStreetCam, highlighting how volunteer labor is leveraged through the gamification of contributions and a crowdsourcing discourse of "sharing," enabling the accrual of both economic profit and image property rights to the platforms' parent companies. While contributors may be unwilling to engage on these terms, practically, these platforms are used primarily for conventionally-framed street-level photography (e.g., from dash-mounted cameras), which currently limits their appeal for a do-it-together approach to 360° street view production.

DIY Street Views and the Politics of Urban Visibility in 360°

> "These photos really capture the whole area! But I don't know if that's always a good thing" (respondent, Quay area).

Feedback from the respondents suggests that increased visibility through 360° representation could positively impact perceptions of local areas, although as the quote above indicates, some respondents specifically queried whether visibility would necessarily lead to positive representations of place. Street-view imagery exists at the intersection of two powerful ways of knowing and representing the world, cartography and photography, and yet there has been limited criticism of the performative power of GSV imagery, at least compared to the critique of Google's Maps and Earth platforms (Shapiro, 2017; Gilge, 2016)[5]. Through *differential visibility,* GSV has a persuasive role in shaping how urban places are imagined—the visual, immersive nature of the imagery affords it potent discursive authority (Elwood and Leszczynski, 2011: 7). As Shapiro (2017: 2) contends, "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."

Techniques of urban representation are not uncontested, and more attention to the specific benefits and risks of 360° visual technologies should be a core consideration for those wishing to produce their own street views. Indeed *invisibility* can be a strategy of resistance or survival, and the *literally panoptic* nature of 360° panoramic imagery can enable a particularly intimate, unabstracted, and total form of spatial intrusion and surveillance (see Hoelzl and Marie, 2014; Elwood and Leszczynski, 2011). Care should be taken to consider the ramifications of more information and enhanced visibility; however advice on best practices is ambivalent—there are positives and negatives for both the people (Wiles et al., 2012) and places (Donovan, 2012) captured by visual and digital technologies.

In some instances, visibility can be a powerful tactic to counter distorted imaginaries of a local area, which may have been shaped by its absence from GSV. On the other hand, as Power et al. (2012) describe, negative beliefs about an area can also be enhanced through *visibility* in GSV, especially when that coverage is fragmented or obsolete. The authors describe how Moyross, a housing estate in Limerick, Ireland, was initially absent from GSV, viewable only from "safe" vantage points at the periphery. When full coverage was included, imagery was captured prior to significant reconstruction and development, meaning GSV represented this area as absent and

fragmented initially and then obsolete, which the authors implicate in the amplified stigmatization of this area. The perspective of Cranbrook respondents suggests a similar process at work there, given that GSV's coverage of Cranbrook is also fragmented and obsolete. Interestingly, respondents were familiar with the spatial and temporal unevenness of local imagery, with several expressing concerns that GSV represents the area as outdated and unfinished rather than a fully functioning town. As a "new town," early negative media portrayals have contributed to the ongoing marginalization of the area and its inhabitants. Known to some outsiders as "Crimebrook" due to inaccurate reporting of crime rates (Cole, 2017), several local respondents mentioned the importance of accurate media portrayals and the need to control how their community is represented online.

A DIY approach might be undertaken by local residents and organizations in Moyross, Cranbrook, or other areas in order to contest 'territorial stigma' (Wacquant et al., 2014), the negative symbolic imaginaries of place that can materially and physically affect the lives of local residents (Keene and Padilla, 2014; Kallin and Slater, 2014). For this purpose, drawing on more politicized articulations of DIY urbanism might be appropriate, driven by aims of resistance or contestation (Spataro, 2016). Newly accessible imaging technologies combined with an overtly politicized DIY imagery approach could be deployed by residents of these areas to produce "counterstigmatizing images" (Cuny, 2018), informed by a longer history of "countermapping" (Peluso, 1995).

Relatedly, several respondents also noted the likelihood of contestation over control of the imagery, suggesting that ownership will be a key issue for those interested in DIY imaging. For respondents from Cranbrook, a key concern was the possibility of image manipulation by outsiders, leading to further stigmatizing the community. As one respondent explained, "Once these are put online, how can we ensure that they aren't photoshopped to show this place in a bad light?" (Business owner and new resident of Cranbrook). Although respondents were concerned specifically with the link between representation and reputation, a further risk of DIY street view production that should be considered is the use of the imagery for spatial profiling (Dodge, 2018). Here, a distinction between 360° imagery as visual representation or quantitative data is useful

(Hoelzl and Marie, 2014; Shapiro, 2017: , ref. removed for peer review). Beyond mere visual representation, recent developments in data extraction from imagery (using machine learning and manual techniques) illustrates how 360° images could be a powerful source of data for profiling areas (and their residents) according to the risk of crime, insecurity, and public disorder (Zhang et al., 2019; Marco et al., 2017). As society is becoming more aware of the harms and biases of data technologies such as predictive policing and facial recognition, more attention to the potential use of 360° image analytics for urban recognition is also required, irrespective of how imagery is produced. Respondents from the two other study sites (city center and Quayside) also expressed concern over imagery ownership; however, concerns were quite different, focused primarily on responsibility for maintaining and updating imagery. Overall, the nuance and variation in perspectives point to the ambivalences of visibility in 360°, the differential impacts of digital and visual technologies, and how such differences are shaped by urban imaginaries.

Conclusion

The widespread use of GSV accrues to the private corporation an ability to symbolically define the value of urban spaces. GSV contributes to the creation of a distorted urban imaginary which can affect places and people represented by spatially and temporally uneven coverage. However, as the market for 360° urban representation gathers pace, new technologies and imagery collection approaches are starting to challenge the dominance of the GSV platform and its image of the city, including new corporate and crowdsourcing street-level imagery initiatives. Drawing on the notion of DIY urbanism and using consumer-grade 360° imaging technologies, this paper presents the case for a further, more independent and micro-scale mode of street-level imagery production.

Evidence from the pilot study provides a basis for developing street views using low-cost, consumer grade technologies and a structured, systematic approach to imagery collection, processing, and hosting. This approach needs not be oppositionally positioned as a challenger to GSV, nor to emerging crowdsourcing projects such as OpenStreetCam and Mapillary. As Gerlach (2015) contends in relation to the OSM project, “the minor is profoundly anti-foundational; it might spotlight the everyday or

the mundane, but without playing into the hands of a front-loaded scalar politics that reduces it to 'localism', 'grassroots' or a subaltern politics." Instead, this study suggests a third way; that DIY street views can offer a locally-focused, micro-scale, and flexible option for the careful visual curation of urban space, which might be of particular interest to local interest groups and grassroots organizations. Although not explored in detail here, the approach potentially also offers the opportunity for more overtly oppositional tactics of "counterimaging;" but a more overtly politicized version of DIY would be needed. Overall, the study highlights the potential of novel imaging technologies to be used to produce street views using a DIY approach. However, the study also underscores that the approach does not necessarily provide a ready-made solution to issues of usability and accessibility, project sustainability, the ambivalences of enhanced visibility, and the challenges of attracting viewers and integrating with other imagery platforms.

Notes

[1] For a review of development in 360 imaging technologies see: http://blogs.exeter.ac.uk/360/developments-in-360-imaging-technology/
[2] https://support.google.com/contributionpolicy/answer/7422880?hl=en&ref_topic=7422769
[3] *Campkin and Ross (2012) discuss the 'prehistory' of Google Street View.*
[4] *GSV imagery has also been captured with the 'trekker' backpack, snowmobiles, and tricycles.*
[5] There has however been significant critique of *Street View* for other reasons, especially in relation to privacy and data protection (see for example Leszczynski, 2012; Geissler, 2011)

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Notes on Contributors

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Table 1: Categories of streets with absent, fragmented, or obsolete imagery in Google Street View, city of Exeter in 2018.

Figure 1: Global Google Street View coverage in 2018: Produced By Eugen Simion, CC BY-SA 4.0. Animation available at: https://commons.wikimedia.org/w/index.php?curid=45823854. See also: https://www.google.com/streetview/understand/#where

Figure 2: Screenshot of Google Street View coverage in the City of Exeter, 2018

Figure 3: Screenshot of Google Street View coverage in Exeter city center, 2018. Many important streets in the city center are not covered by GSV, including High St, Gandy St, the Princesshay outdoor shopping center, and streets adjacent to the city's cathedral. Some user-contributed single Photo Spheres do cover some of these areas.

Figure 4: Steps and key considerations involved in producing DIY street views

Figure 5: Screenshot of the Gandy St street view

Figure 6: Screenshot of the Cranbrook street view

Figure 7: Screenshot of the Exeter Quay and River Exe street view. Information hotspots contain information and links to multimedia content such as videos on flood risks to local businesses. The accompanying map is a static image from OpenStreetMap.