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Reliability and validity of environmental audits using GigaPan® technology in parks

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ABSTRACT

Park quality and features can contribute to more engaging places for play and recreation. However, assessing park characteristics remains a challenge. This study measured the reliability of GigaPan® as a method for assessing park characteristics as well as the validity of GigaPan® compared to Google Street View (GSV) and direct observation (DO). A total of 65 target areas (16 parks total) in Pittsburgh, PA were assessed using GigaPan®, GSV, and DO from July 2015–January 2016. For reliability and validity, 14 and 28 variables were examined, respectively. Cohen's kappa was used to assess inter-rater reliability. Sensitivity and specificity were used to measure validity. Of the 14 variables included in the inter-rater reliability analysis, five variables had almost perfect reliability (kappa > 0.80) and three variables had substantial reliability (kappa > 0.60). Of the 28 variables included in the validity analysis, GigaPan® was able to correctly classify 17 of the 28 variables and GSV was able to correctly classify 15 of the 28 variables with a sensitivity > 80%. There were no significant differences between sensitivity and specificity between GSV and GigaPan®. GigaPan® performed similarly to GSV with DO being used as the gold standard. Further, GigaPan overall had high reliability among the features measured. A strength of GigaPan® is the ability to be implemented quickly in the field, making it a viable alternative to GSV particularly when temporality is an important factor.

1. Introduction

The social ecological model specifies that the built environment (BE) can help facilitate or inhibit physical activity (PA) (Addy et al., 2004; Sallis et al., 2006). In particular, parks have been identified as an important aspect of the BE for facilitating PA. Research has demonstrated that park quality and characteristics have been associated with both PA and health outcomes (Bai et al., 2013; Kaczynski et al., 2008; Ferdinand et al., 2012; Ries et al., 2009). Further, it has been suggested that interventions to increase environmental support for PA should target locations such as parks, playgrounds, and sport fields as well as quality and safety-based features such as adequate lighting and opportunities for PA (Addy et al., 2004; Bedimo-Rung et al., 2005; Sallis et al., 1997). Reliable and valid methods of measuring the BE are necessary to better understand the association between park attributes and PA levels (Vanwolleghem et al., 2016).

A number of studies have looked at the relationship between park availability and neighborhood-level socioeconomic status (SES). Most of these studies look only at park availability (e.g., distance to nearest or number of parks) with fewer studies examining the relationship between the quality of parks and SES (Estabrooks et al., 2003; Powell et al., 2006; Timperio et al., 2007). Studies assessing for park quality have generally found lower park quality in lower SES neighborhoods (Estabrooks et al., 2003; Powell et al., 2006; Rigolon, 2016; Timperio et al., 2007). Thus, it is important to have reliable and valid methods of measuring park attributes to better understand complex relationships among SES and opportunities to be physically active.

A number of methods have been previously used to measure the BE, including direct observation (DO), which is often considered the gold standard (Kelly et al., 2014). However, DO of park attributes can be costly and labor intensive (Brownson et al., 2009; Phillips et al., 2017). Other approaches have been used to assess park attributes including self-report measures, analysis of archival data, and web-based audits. Despite the efficiencies associated with web-auditing, a number of

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limitations exist (Badland et al., 2010; Lee and Talen, 2014; Schootman et al., 2016). For example, Google Street View (GSV) limitations may include significant variability of image dates and time, or low image resolution, creating barriers to collecting reliable and valid auditing results (Rundle et al., 2011). Further, some characteristics may be obstructed or difficult to see in the GSV image (Phillips et al., 2017). Therefore, innovative methods of measuring the BE are needed to produce more accurate and reliable data.

An unexplored option for characterizing park attributes is the use of GigaPan ®. GigaPan® is a robotic system for panoramic photography that is used with a camera to generate high resolution panoramic photos that are navigable and can cover large geographic spaces. It achieves this by automating the process of taking many photos within a short time-span and stitching them together via GigaPan® Stitch software. More information can be found at Gigapan.com. GigaPan® differs from GSV in several ways. For instance, although GSV is beneficial in that photographs are free, made readily available, and taken by external sources, this may not be sensitive to temporal changes such as playground renovation. Further, GigaPan® can capture fine grained details that GSV may not be able to capture. Despite the potential advantages of GigaPan® technology, very few published studies have examined the reliability or validity of GigaPan®. Exceptions include use for improving situational awareness and scientific exploration in human and robotic analog missions, in rangeland monitoring for resource management, and for analyzing the community structure of ants in Costa Rica (S. Y. Lee et al., 2013; Nichols et al., 2009; Smith et al., 2014). Only one study has been published regarding the use of GigaPan® for measuring the BE, in which the validity of GigaPan® was examined for measuring attributes of street segments. This study found GigaPan® to be a valid method for measuring attributes of street segments as compared to Google Earth, with DO being considered the gold standard (Twardzik et al., 2018). It is therefore of interest to better understand how Gigapan® performs in parks and recreational spaces as well.

Developing a better understanding of alternative technologies such as GigaPan® provides the opportunity to improve upon current methods of BE auditing. Currently, systems similar to GigaPan® technologies are being developed and more rudimentary versions can be found on common-use cameras, such as cellphones. These panoramic images could potentially be used by community members or citizen scientists to gather information on a variety of situations (e.g. capturing park renovations, crowdsourcing information on local BEs) (Crooks et al., 2015; Hipp et al., 2013). It is worthwhile to determine whether GigaPan® may be used as a reliable and valid measurement tool due to its user-friendly nature and accessibility.

The authors are not aware of any studies to date that have looked at the inter-rater reliability or validity of using GigaPan® to measure park attributes. Therefore, the primary aims of this paper are to investigate GigaPan's® reliability as a method for documenting attributes within specific areas of parks and secondarily examine the validity of measuring park attributes using GigaPan® and GSV, as compared to DO.

2. Materials and methods

2.1. Overview

The present study used three different observation techniques to assess attributes of 16 parks in Pittsburgh, PA. These 16 parks were divided into 272 target areas that could be observed from one vantage point and generally provided a single function (e.g., playground area, baseball field). Characteristics of the parks were documented across each of the three observation techniques using an audit tool from the Bridging the Gap study (Zenk et al., 2014) hereafter referred to as the Park Observation Form. This tool assesses the availability, condition and lighting for different sports features, availability and conditions of various amenities, presence and quantity of incivilities, type of park setting, parking, sidewalks, signage, restrooms/locker rooms, vending machines, trail features, and entrance fee. Details of each observation technique are described below.

2.2. GigaPan

GigaPan® technology was used to take photos of each of the 272 target areas. Field staff in Pittsburgh were trained to use GigaPan® using a three-pronged approach (i.e. reading of manual, in-person training, completing field practice). Subsequently, field staff were provided maps of where to go in Pittsburgh along with a data collection form to document the logistics of each outing (e.g. time, day of the week). Field staff were instructed to avoid capturing individually identifiable information (e.g. faces of people) when taking photos. All GigaPan® photos were taken between August 2015 and October 2015.

Setting up a GigaPan® involved placing the camera (Canon, Powershot S120) onto the GigaPan® device and placing the GigaPan® device on a tripod. Next, the camera was manually aimed at the desired corners of the panoramic photo. The GigaPan® then calculated a matrix of how many photos needed to be taken to cover the selected area. The device automatically adjusted and rotated the camera to take the pictures and an automated trigger engaged the capture button on the camera. After field staff in Pittsburgh captured GigaPan® images they downloaded and stitched the photos using GigaPan® Stitch Software creating a single panoramic for each target area. These photos were sent to staff at University of Michigan (UM) for coding. Coders at UM were oriented to the park observation form and then practiced audits independently. Coded observation forms were then discussed in a group setting until there was consensus among coders. Coders were certified as reliable upon achieving inter-rater reliability of 80% on average across all the items. Audits were then completed and stored electronically.

2.3. Direct observation

Field staff in Pittsburgh were trained in the use of the Park Observation Form. Specifically, a staff member was given written and visual instruction by an external trainer experienced in this particular observation tool on how to recognize the presence of features and how to rate the quality of the features when applicable. Subsequently, the staff member completed practice field audits under the guidance of the external trainer until certified by the trainer to complete audits independently. During data collection, the staff member was provided maps of the target areas that were to be assessed. The field staff member walked each target area and completed the Park Observation Form. All DO occurred between July 2015 and September 2015, with one exception being in January 2016 due to construction causing a park closure.

2.4. Google Earth

Park audits were completed in Google Earth by using a KMZ file to overlay target areas on a map. Each target area was labeled with a unique identifier, which coders were able to see in Google Earth. Park information, including latitude and longitude of the park centroid and boundaries, was predefined for the coder. Training to perform GSV audits was conducted similarly to GigaPan®, in which coders were oriented on how to navigate GSV images. All coders read a manual containing instructions and examples on how to properly code target areas and parks. Coders then performed a series of independent practice audits, which were later discussed in a group setting until a consensus was reached on correct coding methodology. All coders were certified upon reaching a reliability of 80%. Coders also used a digital version of the audit form when coding for target areas in GSV and the data was entered directly into an electronic database.

Prior to estimating reliability and validity, nominal and ordinal variables were converted into dichotomous variables indicating whether or not a variable was present. For instance, the count of playgrounds present was converted to "playground present = 1" and "playground not present = 0."

2.5. Statistical analyses

To determine reliability, 25% of GigaPan® photos were randomly selected for coding by a second rater, thus 65 target areas were used for the inter-rater reliability analysis. All 85 items on the Park Observation Form were evaluated. In order to evaluate inter-rater reliability of dichotomous measures, Cohen's kappa statistic was computed, which is a measure of the proportion of agreement that corrects for the probability of agreement due to chance (Byrt et al., 1993). Cohen's kappa does not perform well when the prevalence of a characteristic is extreme, therefore we also computed the percent agreement (Feinstein and Cicchetti, 1990).

To evaluate GigaPan® at the park level, DO data was used as the gold standard and sensitivity and specificity were computed. Asymptotic 95% confidence intervals (CIs) for both sensitivity and specificity values were estimated (Zhu et al., 2010). To evaluate the relative performance of the alternative measurement methods, CIs were compared. Non-overlapping CIs indicated a statistically significant difference between measures (Knezevic, 2008). All analyses were performed using STATA, version 14.2 (StataCorp LP, College Station, Texas).

2.6. Measures

Variables included in the analysis were grouped into three categories: facilities, amenities, and incivilities. Examples of facilities measures are presence of playgrounds, fields, courts, and open green space, as well as the condition of each of those facilities. Amenities included attributes such as presence of grills or park benches, as well as the quality of those features. Lastly, incivilities included items such as presence of graffiti and drug paraphernalia. Facilities and amenities were evaluated on both presence and classification of being in an okay condition or a poor condition. Playgrounds were considered to be in okay condition if they had some cracks, wear or a few bare spots, but the surface was generally or fully uniform, smooth and safe for use. Additionally, playground equipment (e.g., swings, sand box, jungle gym) had to be present and show little or no rust or damage. Open space was considered to be in okay condition if the ground surface was generally free of obstructions or piles of debris. It could contain some uneven aspects or minor natural or man-made debris but had to be safe overall to walk or run on.

3. Results

3.1. Inter-rater reliability

65 target areas were included in this analysis (i.e., 130 audits between two different raters). Given the issues with Kappa in the presence of low prevalence, the analysis focused on variables with a prevalence above 5%, thus 13 variables were included in the reliability analysis (x = 51.4, SD = 32.8). Additionally, courts and fields were combined into one single variable labeled "court or field present" due to low prevalence, for a total of 14 variables for analysis. The variables "court and field present" and "benches" were both measured for being in okay condition, but due to low prevalence were not included in the reliability analyses. Additionally, none of the variables have a reliability reported for being in poor condition due to low prevalence. Variables were then grouped into three categories: facilities, amenities, and incivilities, and are summarized in Table 1. We adopted standard terminology for expressing the extent of agreement among the raters (Gwet, 2012).

Of the six variables included in the facilities category three had almost perfect reliability (kappa > 0.80), playgrounds present, playgrounds with lighting, and open green space present. Playgrounds in "okay" condition and any courts and fields had substantial reliability (kappa > 0.60). Open green space in "okay" condition was the only variable that had fair reliability (kappa > 0.20). All variables had a percent agreement > 80%.

Of the five variables included in the amenities category, both condition of shelters and condition of trash cans had almost perfect reliability (kappa > 0.80). Benches present had substantial reliability (kappa > 0.60), while shelters present and trash cans present had fair to moderate reliability (kappa < 0.60). All variables had agreement > 80%.

Two incivilities included in the analysis had moderate reliability (kappa > 0.40), litter and graffiti. One incivility had slight reliability (kappa < 0.20), overgrown grass. Two of the three incivility variables had a percent agreement < 80% (overgrown grass, 29%; trash/litter, 66%). Presence of graffiti had agreement of 80%.

Table 1
Summary of inter-rater reliability of target area characteristics in Pittsburgh, PA assessed from July 2015–January 2016.

Variable	N	Prevalence	Kappa	95% CI	Observed agreement
Facilities					
Court or field present	130	12.0	0.78	[0.53, 1.00]	0.95
Playground present	130	26.0	1.00	[1.00, 1.00]	1.00
Condition OK	34	91.0	0.64	[0.00, 1.00]	0.94
Lighting present	34	44.0	0.88	[0.66, 1.00]	0.94
Open green space present	130	35.0	0.83	[0.69, 0.97]	0.92
Condition OK	44	84.0	0.22	[−0.29, 0.74]	0.79
Amenities					
Shelters	130	9.0	0.27	[−0.08, 0.63]	0.88
Condition OK	12	83.0	1.00	[1.00, 1.00]	1.00
Benches	130	24.0	0.62	[0.40, 0.84]	0.86
Trash cans	130	22.0	0.46	[0.21, 0.71]	0.82
Condition OK	28	93.0	1.00	[1.00, 1.00]	1.00
Incivilities					
Litter	130	81.0	0.48	[0.40, 0.48]	0.66
Graffiti	130	28.0	0.45	[0.37, 0.71]	0.80
Overgrown	130	87.0	0.01	[−0.03, 0.09]	0.29

3.2. Validity

The analysis for validity focused on variables at the park level with a prevalence above 5%, thus 28 variables were included in the validity analysis (x = 39.5, SD = 31.3). Results of the validity analysis are summarized in Table 2.

Of the 16 facility variables included in the analysis, GigaPan® was able to correctly classify 13 variables (> 80% sensitivity). GSV performed similarly and was able to correctly classify 10 of the 16 variables (> 80% sensitivity). Both GigaPan® and GSV were able to correctly classify the absence of a variable in 12 of the 16 variables (> 80% specificity). There were no differences between the CIs of GSV and GigaPan® for facilities.

Of the eight amenities variables included in the analysis, GigaPan® was able to correctly classify three variables (> 80% sensitivity). GSV performed similarly, correctly classifying five of the eight variables (> 80% sensitivity). Gigapan® was correctly able to classify the absence of four of the eight variables (> 80% specificity). GSV performed similarly by correctly classifying the absence of five of the eight variables (> 80% specificity). There was no difference between CIs of GSV and GigaPan® for features.

Table 2
Summary of sensitivity and specificity of parks in Pittsburgh, PA assessed from July 2015–January 2016.

Variable	N	Prevalence	GigaPan vs. direct observation				Google street view vs. direct observation			
			Sensitivity	95% CI	Sensitivity	95% CI	Sensitivity	95% CI	Sensitivity	95% CI
Facilities										
Court or field present	16	81.3	92.3	[64.0, 99.8]	100.0	[29.3, 100.0]	92.3	[64.0, 99.8]	100.0	[29.2, 100.0]
Multi-use field present	16	43.8	28.6	[3.7, 71.0]	100.0	[66.4, 100.0]	14.3	[0.36, 57.9]	100.0	[66.4, 100.0]
Football field present	16	12.5	100.0	[15.8, 100.0]	100.0	[76.8, 100.0]	50.0	[1.3, 98.8]	100.0	[76.8, 100.0]
Condition OK	16	12.5	100.0	[15.8, 100.0]	100.0	[76.8, 100.0]	50.0	[1.3, 98.7]	100.0	[76.8, 100.0]
Baseball field present	16	12.5	100.0	[15.8, 100.0]	85.7	[57.2, 98.2]	100.0	[15.8, 100.0]	85.7	[57.2, 98.2]
Condition OK	16	12.5	100.0	[15.8, 100.0]	85.7	[57.2, 98.2]	100.0	[15.8, 100.0]	85.7	[57.2, 98.2]
Basketball court present	16	56.3	100.0	[66.4, 100.0]	71.4	[29.0, 96.3]	100.0	[66.4, 100.0]	71.4	[29.0, 96.3]
Condition OK	16	56.3	77.8	[40.0, 97.2]	71.4	[29.0, 96.3]	88.9	[51.8, 99.7]	71.4	[29.0, 96.3]
Tennis court present	16	6.3	100.0	[2.5, 100.0]	100.0	[78.2, 100.0]	0.0	[0.0, 97.5]	93.3	[68.1, 99.8]
Multi-use court present	16	6.3	100.0	[2.5, 100.0]	93.3	[68.1, 99.8]	0.0	[0.0, 97.5]	93.3	[68.1, 99.8]
Playground present	16	93.8	100.0	[78.2, 100.0]	100.0	[2.5, 100.0]	100.0	[78.2, 100.0]	100.0	[2.5, 100.0]
Condition OK	16	93.8	100.0	[78.2, 100.0]	100.0	[2.5, 100.0]	100.0	[78.2, 100.0]	100.0	[2.5, 100.0]
Lighting present	16	18.8	33.3	[0.8, 90.6]	69.2	[38.6, 91.0]	66.7	[9.4, 99.2]	46.2	[19.2, 74.9]
Skate park present	16	6.3	100.0	[2.5, 100.0]	100.0	[78.2, 100.0]	100.0	[2.5, 100.0]	100.0	[78.2, 100.0]
Condition OK	16	6.3	100.0	[2.5, 100.0]	100.0	[78.2, 100.0]	100.0	[2.5, 100.0]	100.0	[78.2, 100.0]
Open green space present	16	75.0	100.0	[73.5, 100.0]	50.0	[6.8, 93.2]	100.0	[73.5, 100.0]	25.0	[0.6, 80.6]
Amenities										
Shelters	16	18.9	100.0	[29.2, 100.0]	69.2	[38.6, 90.9]	100.0	[29.2, 100.0]	53.8	[25.1, 80.8]
Benches	16	93.8	100.0	[78.2, 100.0]	100.0	[2.5, 100.0]	93.3	[68.0, 99.8]	100.0	[2.5, 100.0]
Picnic tables shaded	16	18.9	100.0	[29.2, 100.0]	100.0	[75.3, 100.0]	100.0	[29.2, 100.0]	100.0	[75.3, 100.0]
Drinking fountains	16	62.5	20.0	[2.5, 55.6]	66.7	[22.3, 95.7]	30.0	[6.7, 65.2]	83.3	[35.9, 99.6]
Parking	16	12.5	50.0	[1.3, 98.7]	78.6	[49.2, 95.3]	100.0	[15.8, 100]	50.0	[23.0, 77.0]
Sidewalk lighting	11	54.5	66.7	[22.3, 95.7]	20.0	[0.5, 71.6]	100.0	[54.1, 100]	20.0	[0.5, 71.6]
Sign name	16	93.8	26.7	[7.8, 55.1]	100.0	[2.5, 100]	60.0	[32.3, 83.7]	100.0	[2.5, 100]
Barrier	16	18.9	33.3	[0.8, 90.6]	92.3	[64.0, 99.8]	66.7	[9.4, 99.2]	92.3	[64.0, 99.8]
Incivilities										
Litter	16	50.0	100.0	[63.1, 100.0]	50.0	[15.7, 84.3]	50.0	[15.7, 84.3]	25.0	[3.2, 65.1]
Graffiti	16	25.0	50.0	[6.8, 93.2]	75.0	[42.8, 94.5]	0.0	[0.0, 60.2]	83.3	[51.6, 97.9]
Overgrown	16	37.5	66.7	[22.3, 95.7]	0.0	[0.0, 30.8]	66.7	[22.3, 95.7]	20.0	[2.5, 55.6]
Broken equipment	16	25.0	25.0	[0.6, 80.6]	91.7	[61.5, 99.8]	0.0	[0.0, 60.2]	91.7	[61.5, 99.8]

Of the four incivility variables included in the analysis, GigaPan® correctly identified one variable (> 80% sensitivity). GSV was not able to correctly classify any of the variables (> 80% sensitivity). GigaPan® was correctly able to classify the absence of one incivility variable (> 80% specificity) while GSV was able to correctly classify the absence of two variables (> 80% specificity). CIs of GSV and GigaPan® for incivilities did not differ.

4. Discussion

The primary goal of this paper was to evaluate the inter-rater reliability of GigaPan® technology for measuring attributes in target areas of parks. Overall, Gigapan® was found to be a reliable method for collecting attribute data in target areas with 57% of attributes exhibiting substantial - almost perfect reliability (kappa > 0.60). Variables with slight–fair reliability (kappa < 0.40) tended to be finer detailed features such as "condition of open green" and "overgrown grass." The secondary goal of the paper was to assess the validity of GigaPan®, versus the validity of GSV, with DO used as the gold standard for both methods. Overall GigaPan® was a valid form of park measurement, with 61% of variables exhibiting high sensitivity (> 80%), and 61% of variables exhibiting high specificity (> 80%). This was comparable to GSV, which showed 50% of variables having high sensitivity (> 80%) and 68% of variables having high specificity (> 80%). There were no significant differences between the validity of GSV and GigaPan® as measurement methods for parks. GigaPan® was a comparable method both to DO and GSV in measuring the features of parks assessed in this study.

GigaPan® has several strengths as a measurement method. GigaPan® offers flexibility in gathering time sensitive environmental measures, which is particularly important for capturing changes in the environment. It can be implemented in the field quickly, while the use of GSV may rely on images from months or years before (Curtis et al., 2013). Additionally, it is feasible to train lay persons to operate the GigaPan device and stitch the images. Further, Gigapan is relatively low cost to purchase. This could result in cost and time savings in comparison with DO as it provides an alternative to training a specific set of data collectors and enduring the costs and time of travel. Despite these strengths, GigaPan® has several limitations. Each GigaPan® photo only allows for one vantage point, making it difficult to view behind obstructions or a variety of angles of characteristics. Further, the images from our study using GigaPan® did not have equal resolution across the entire photo. Zooming in on the farthest ends of a photo resulted in the lowest quality. Since GigaPan® is simply the robotic system for taking panoramic photography the resolution issues likely resulted from camera attributes. Using a camera with higher zoom capabilities would likely address this limitation.

With an estimated 105,000 parks in the United States ready to make an impact on PA and health, parks make up a major sector of the BE (Blanck et al., 2012). It is vital to develop understanding of the impact of parks on health outcomes and the potential for parks to act as health interventions. However, in order to properly study the relationships between park characteristics and health outcomes, new and advancing technology is necessary to measure park characteristics accurately and reliably. Gigapan® is a measurement tool that can be used when DO is not feasible or practical and GSV images are not appropriate for the study area or time period.

This study had several limitations. First, the sample size in this study was small, with only 65 target areas and 16 parks. Due to the smaller sample size a number of features and characteristics were excluded from estimating Cohen's kappa, sensitivity or specificity (Walter et al., 1998). Thus, there are a number of park characteristics that were assessed by coders for which reliability and validity information is not available. Lastly, DOs and the GigaPan® images were obtained at slightly different times so temporal changes may have affected the validity analysis.

5. Conclusions

GigaPan® is a comprehensive technology that could provide solutions to several issues that arise with GSV and DO. GigaPan® provides detailed images of parks, as well as acts as a quick method to capture images during temporal changes in the area. This study may provide insight into other technologies, such as some smartphone capacities, that may be used to measure the BE by taking similar panoramic images. GigaPan® should be considered for future use measuring parks and recreational areas in order to understand the association with PA levels and health outcomes.

Conflict of interest

The authors declare there is no conflict of interest.

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