Alternative Interfaces for Improved Representation in Web-Based PPGIS

Denwood, T.[*1]; Huck, J.[1]; and Lindley, S.[1]

[1] MCGIS, Department of Geography, University of Manchester

Jan 8, 2019

Summary

The use of points and polygons dominate in PPGIS, yet can be ineffective when it comes to representing the way people understand the world around them. This research explores two ways in which citizens' views might be better represented using alternative PPGIS interfaces with a case study in the Outer Hebrides. Firstly, an online application of the A* algorithm is used to allow participants to design new footpaths; and secondly, a viewshed algorithm is used to propose locations for a new wind turbine. We present the preliminary results of both surveys, and explore how alternative spatial units might permit researchers to gain greater insight into participants' spatial thoughts and feelings.

KEYWORDS: PPGIS, Representation, Generalisation, Viewshed, A* Algorithm

1. Introduction

This research assesses how alternative spatial units can be used to better represent people's thoughts and feelings in PPGIS (Public Participatory GIS). A brief overview of the current issues with representation in PPGIS will be presented, followed by background information on the case study used.

1.1. Representation in PPGIS

PPGIS tools are used to collect, compile and present data from a broad range of stakeholders in order to represent individual interests and priorities and support decision-making (Anderson et al., 2009). Many PPGIS examples in the literature use points and polygons to simplify complex social and geographic features into readable formats. Brown (2012) suggests that using a point-based system be it on a paper map or online platform is the simplest way to collect spatial data whilst yielding the highest response rates, reduced levels of bias and greater participation. However, the un-critical use of spatial primitives such as these can, in some circumstances, offer a poor representation of the complex relationships between people and place (Huck et al., 2018). This is because the geographical uncertainty with which people perceive and experience the world moves it away from being purely spatial to incorporate societal and cultural values (Goodchild, 2011; Mackaness and Choudhry, 2013). Although new techniques in spatial representation are emerging (Huck et al., 2014; Godwin and Stasko, 2017), the use of points and polygons still dominate PPGIS. This research seeks to challenge these traditions by developing novel participatory tools in order to better answer two spatial questions relating to the route of a new footpath network and a new wind turbine.

[*] timna.denwood@postgrad.manchester.ac.uk

1.2. Case Study

The isles of Barra and Vatersay in the Outer Hebrides (area c.60km^2, population c.1300) provide a case study for this research. The residents of these islands have already expressed an interest in energy challenges through the production of a Community Energy Plan (Local Energy Scotland, 2018), which identifies transport and electricity as key areas of concern. With just one single-track road circumnavigating the island of Barra, an almost total absence of footpaths and pavements, and high levels of cycle tourism; the transport systems on the isles are overwhelmed. Power infrastructure on the isles is very limited for both electricity and heating, comprising just one connection to the main grid. Consequently, there are high levels of fuel poverty within the population and an over-reliance upon motorised transport (Local Energy Scotland, 2018).

2. Methods

Two distinct questions for the PPGIS survey were drawn from the Community Energy Plan (Local Energy Scotland, 2018):

1. Where would you use or like to see new footpaths on the isles of Barra and Vatersay?
2. Where would you consider an acceptable location for a wind turbine to be located on the isles of Barra and Vatersay?

These questions were asked to participants using two bespoke online PPGIS interfaces hosted at barramapper.co.uk. Data were collected at three workshops on the isles in November 2019. At each stage, participants were given the opportunity to add free text to accompany their contribution, enabling qualitative and quantitative responses to be captured and analysed simultaneously.

2.1. Route Planning Interface using the A* Algorithm

The first part of this research addresses the challenge of generalisation in line-based PPGIS. It replaces the traditional line digitisation model with one in which user-generated ‘anchor points’ are joined not with straight edges, but rather with least cost paths. The use of these least cost paths means that the level of generalisation of each line is standardised, based upon the resolution of the underlying elevation data. Additionally, by masking specific areas in the base-map, the routes are ensured to be physically feasible (avoiding obstacles such as water, steep slopes and other impassable obstacles). Whilst the algorithm will highlight the least cost path to take between locations, the user can edit routes by adding a greater or fewer number of ‘anchor points’ if they so wish, in order to maintain full control over the final path. A screenshot of the interface is given in Figure 1).

Assuming that participants would walk the easiest route (but giving them ultimate control over this), means that the participant can draw realistic paths without substantial effort. The standardised level of generalisation also means that similar inputs will follow the same route, avoiding the need for path bundling, which can draw results away from their intended location. This also allows the resulting dataset to be analysed directly using supervaluation, akin to the use of ‘desire lines’ by landscape architects, whereby paths are routed based on the lines on the ground caused by the greatest number of people walking there. Once a path has been drawn and saved on the map, it remains at a lower opacity so that the participant can view all of their submissions alongside each other.

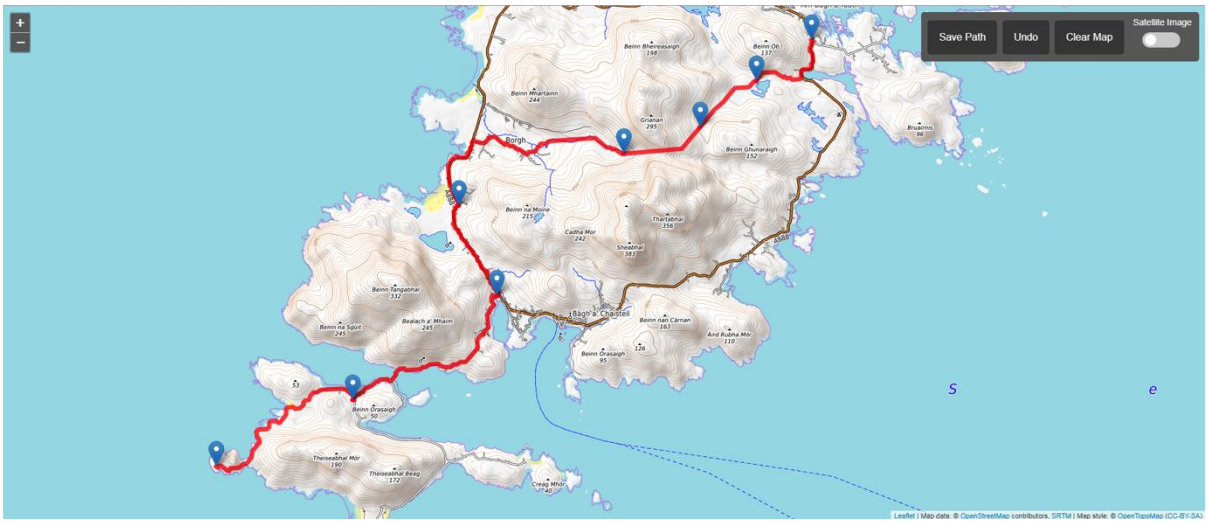

Figure 1 Screenshot of the A* tool at barramapper.co.uk.

2.2. Using Viewsheds as an Alternative Spatial Unit

The second part of this research uses viewsheds as a spatial unit, drawn in real-time when the user clicks on the map. Participants are asked to click on locations from which they would not wish to be able to see a turbine (e.g. their house, or a hill summit with a *'nice view'*), and the map will then be populated with a viewshed delineating the areas in which a turbine could not therefore be placed. In this way, this approach is able to better reflect how they would experience the installation in real life, rather than simply adding points at locations that they believe to be suitable or unsuitable without any contextual information.

This approach enables the participant to make an educated decision, allowing them to see the impact of their decision upon the location of the turbine and so enabling them to balance their desire against the corresponding impact on potential locations for the turbine, and maybe even reconsider. Within the website, multiple viewsheds can be added to the same map, resulting in a composite viewshed of all of the locations at which each participant would not wish to see wind turbines (as shown in Figure 2). Over multiple viewsheds and users, an inverted suitability surface is therefore generated, with the areas containing the fewest viewsheds being the most suitable, and those with the most having the greatest strength of feeling from the community that there should not be a wind turbine.

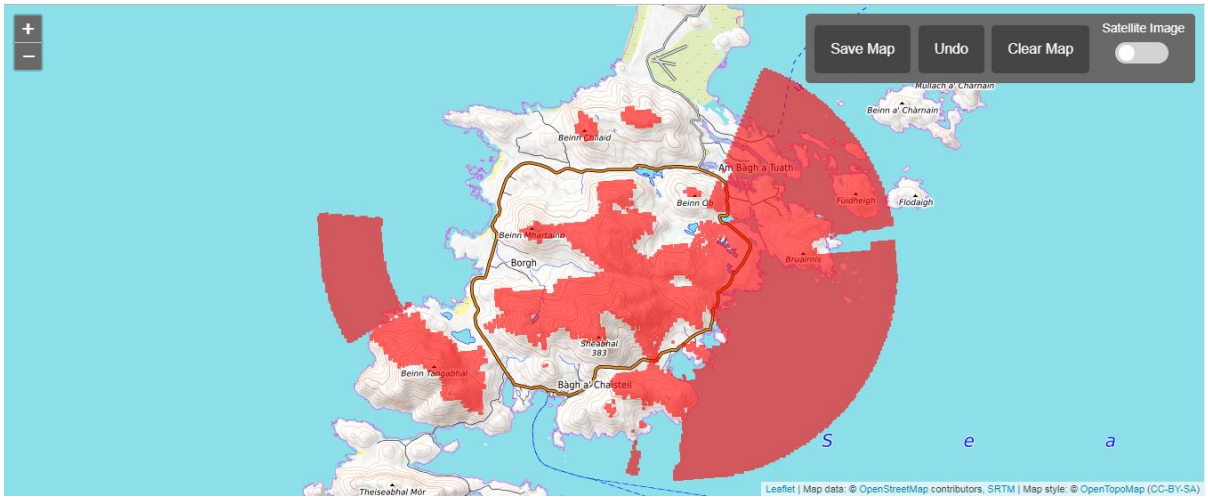

Figure 2 Screenshot of the viewshed tool at barramapper.co.uk.

3. Results

A total of 22 participants (c.2.3% of the eligible population on the isles) attended the three workshops, contributing 107 footpaths and 18 viewsheds. 73% of the participants were over the age of 50 years, with 59% of these identifying as female. The results from both elements of the research will be analysed separately before being discussed in relation to the overall aim.

3.1. Paths

Figure 3 presents the complete dataset produced using the first tool on the website. The darker paths indicate where a greater number of participants desired the same paths to be located and the purple heatmap indicating the areas that received the greatest attention.

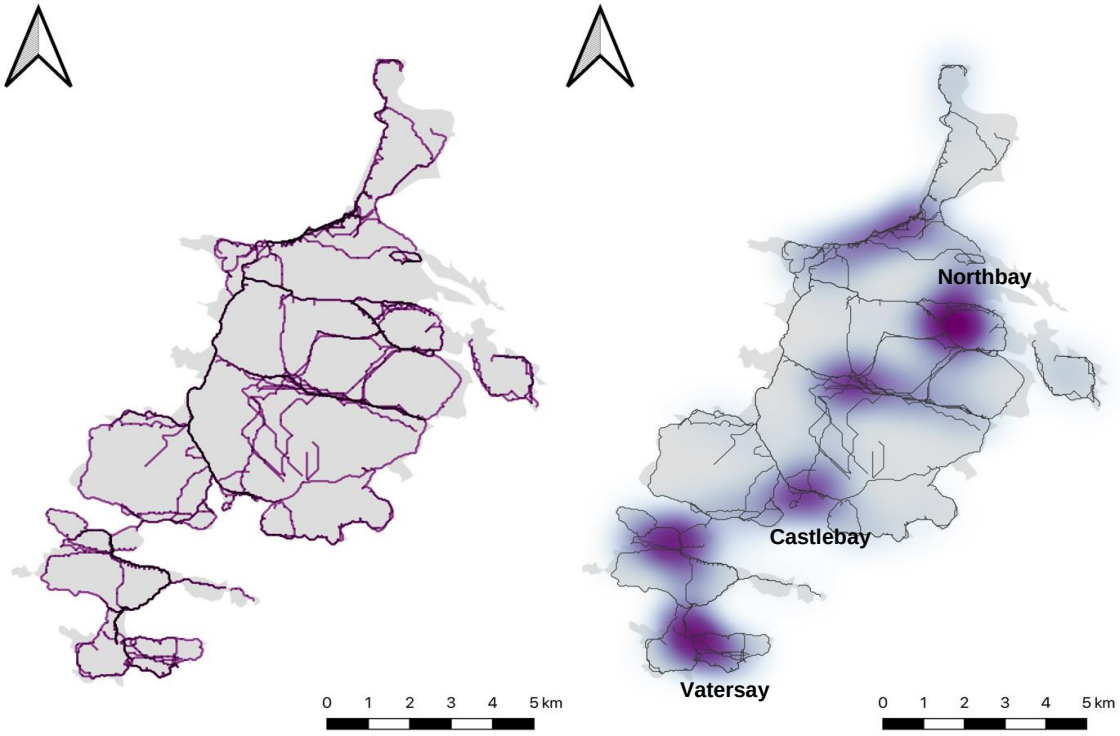

Figure 3 Dataset of 107 potential footpaths designed by residents of the isles of Barra and Vatersay, showing (A) the resulting paths, and (B) a heatmap of click locations.

The output highlights a desire from residents to increase access to the centre of the island as well as increase the number of footpaths in the larger settlements such as Northbay, Castlebay and Vatersay (Figure 3B). Qualitative feedback suggested that from a user perspective the tool was easy to use with participants adding comments including: *"Like that it finds you the easiest route, very neat"* and *"Very easy to use if you follow instructions."*

3.2. Viewsheds

The viewshed tool was designed to identify where participants *would not* wish to see a turbine. In contrast with dominant views in the literature (e.g. Wróżyński, R. et al., 2016), the prevailing view in Barra and Vatersay appeared to be that the benefits of wind energy outweigh visual impact. Residents were therefore generally in favour of having turbines and many participants therefore submitted no viewsheds whatsoever. Qualitative feedback was still obtained from these participants however, such as:

"[The question] should be where you'd like to see a turbine; I have more of an idea that way"

"The wind turbine tool should be the other way round, I would be happy to see them from my house."

The data collected are presented in Figure 4, showing a strong bias towards the south of the isles. However, this was often because as residents were aware of the limitations of the existing infrastructure, as opposed to reasons related to visibility:

"Not got the infrastructure for a turbine on Vatersay."

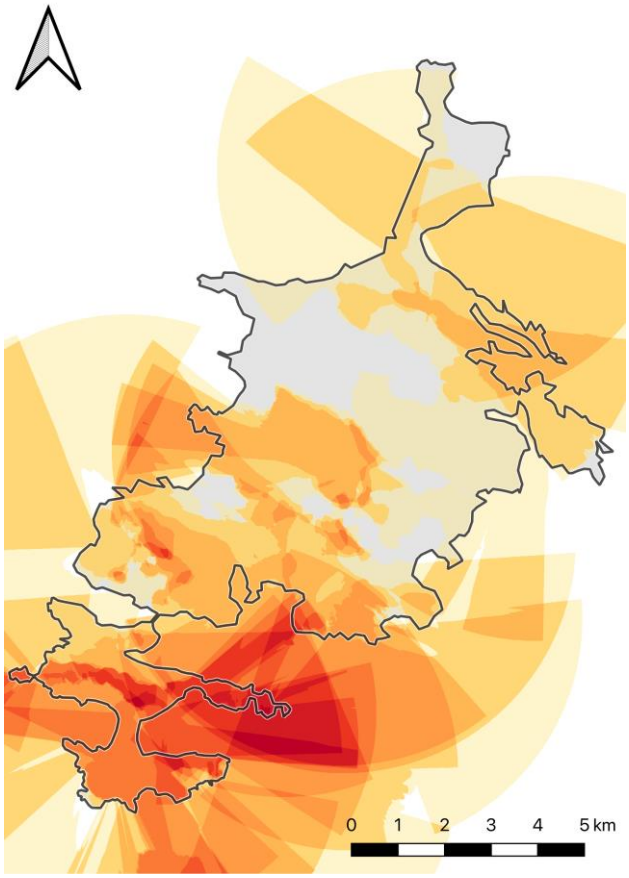

Figure 4 All 18 viewsheds collected from the residents of Barra and Vatersay

Whilst a number of participants did not contribute viewshed data, they still tested the tool and provided feedback. For example one participant initially selected a high peak as a location they would not wish to see a turbine from, then on seeing that this would mean a significant area of the island would also be blocked out changed their mind:

"I wouldn't actually mind being able to see the turbine if it meant we could make more energy on the island, I didn't expect it to be seen for so far though".

This example demonstrates the benefit of this alternative spatial unit giving participants a better understanding of the decisions that they are making.

4. Conclusion

This research suggests that the use of alternative interfaces in PPGIS has the potential to improve representation, and therefore decision-makers' understanding of participants' views. Accordingly, these findings could contribute to developments in the field that could improve democratisation in decision-making.

5. Acknowledgements

This research is being funded by EPSRC (EP/L016141/1) through the Power Networks Centre for Doctoral Training. The authors would like to thank the residents of Barra who contributed openly and generously to this study, with particular thanks to Euan Scott.

The software presented here makes grateful use of the Open Source Libraries: 'Leaflet' (https://github.com/Leaflet/Leaflet), 'proj4js' (https://github.com/proj4js/proj4js), 'raster-js' https://github.com/jonnyhuck/raster-js and 'javascript-astar' (https://github.com/bgrins/javascript-astar). The viewshed algorithm was ported from https://github.com/jonnyhuck/Viewshed. This work made use of the the Ordnance Survey 'Terrain 5' and 'Terrain 50' datasets, available under the 'OS OpenData' Open Data license.

6. Biography

Timna Denwood is currently a second year PhD student in the School of Environment, Education and Development at the University of Manchester. She is part of the Power Networks CDT and interested in developing tools to improve representation and value in public participatory geographical information science.

Jonny Huck is a Lecturer in GIS at the University of Manchester, with research interests in the representation of vague geographical entities in geographical information science and the application of geospatial technologies for the provision of humanitarian aid in the global south.

Sarah Lindley is a Professor of Geography at the University of Manchester, with research interests in environmental processes and geographical information science.

References

Anderson, C., Beazley, K., & Boxall, J. (2009). Lessons for PPGIS from the application of a decision-support tool in the Nova Forest Alliance of Nova Scotia, Canada. *Journal of environmental management*, *90*(6), 2081-2089.

Brown, G. (2012). Public Participation GIS (PPGIS) for regional and environmental planning: Reflections on a decade of empirical research. *Journal of Urban and Regional Information Systems Association*, *25*(2), 7-18.

Bugs, G., Granell, C., Fonts, O., Huerta, J., & Painho, M. (2010). An assessment of Public Participation GIS and Web 2.0 technologies in urban planning practice in Canela, Brazil. Cities, 27(3), 172-181.

Carver, S. J. (1991). Integrating multi-criteria evaluation with geographical information systems. International Journal of Geographical Information System, 5(3), 321-339.

Goodchild, M. F. (2011). Formalizing place in geographic information systems. In Communities, Neighborhoods, and Health 21-33. Springer New York.

Godwin, A. and Stasko, J, T. (2017). Nodes, Paths, and Edges: Using Mental Maps to Augment Crime Data Analysis in Urban Spaces.

Huck, J. J., Whyatt, J. D., & Coulton, P. (2014). Spraycan: A PPGIS for capturing imprecise notions of place. *Applied Geography*, *55*, 229-237.

Huck, J., Whyatt, J. D., Dixon, J., Sturgeon, B., Hocking, B., Davies, G., Jarman, N. & Bryan, D. (2018). Exploring Segregation and Sharing in Belfast: a PGIS approach. Annals of the Association

of American Geographers.

Local Energy Scotland, (2018). Local energy plan for Barra and Vatersay. https://www.localenergy.scot/media/110393/barravatersay-lep-july-2018-final.pdf [accessed 12.12.18].

Mackaness, W. A., & Chaudhry, O. (2013). Assessing the veracity of methods for extracting place semantics from Flickr tags. Transactions in GIS, 17(4), 544-562

Wróżyński, R., Sojka, M., & Pyszny, K. (2016). The application of GIS and 3D graphic software to visual impact assessment of wind turbines. *Renewable Energy*, *96*, 625-635.