Using Google Maps to collect spatial responses in a survey environment

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Introduction

Internet surveys are well-established as a way of gathering data; they are commonly used to support academic research in many geographic and environmental fields (e.g. Wheaton *et al.*, 2006; Turbow *et al.*, 2008; Li *et al.*, 2010; Park & Selman, 2011; Haklay, 2002). Attention has also been given to their strengths and limitations as a research method (e.g. Madge & O'Connor, 2002; Berry *et al.*, 2011; Roth, 2006). Their primary benefits include wide (potentially global) reach, convenience for respondents, flexibility of design, and ease of data entry (Evans & Mathur, 2005). However, representativeness of respondents can be a significant weakness (Peng, 2001), barriers may exist in terms of variations in respondents' technological expertise, system configuration and spatial cognition ability (Evans & Mathur, 2005) and many of the issues associated with traditional research methods still apply in the virtual arena (Madge & O'Connor, 2002).

This paper specifically considers the collection of spatial data responses within a survey, rather than the general use of online surveys themselves. Widely used third-party services such as SurveyMonkey (SurveyMonkey, 2011) allow those without relevant authoring experience to create web-based surveys, but are generally limited to free-text or multiple choice responses. This permits simple answers and selection, rating and ranking exercises, but any spatial information is commonly in the form of postcodes or place/street names.

Such responses are not suitable for more complex spatial questions often of interest to geographers, such as 'which route did you use to explore the beach?' (Coombes & Jones, 2010) or 'which area would you define as your neighbourhood?' (Minnery *et al.*, 2009). Asking respondents to draw on paper maps is one solution (e.g. Coombes & Jones, 2010), but data processing may be time-consuming and error-prone. Conversely, dedicated online mapping and GIS options such as those based on ArcGIS Server may be used to gather spatial information, but with relatively limited opportunity to collect additional data and survey responses (Bearman & Lovett, 2010). A method of capturing complex spatial information within a larger web-based questionnaire is therefore potentially very useful for researchers in geography and related disciplines.

An Application Programming Interface (API) for an online mapping service such as Google Maps (Google, 2011a) offers one way of eliciting spatial responses within a bespoke survey, although the relative novelty of this type of solution means it has received little attention in web survey design literature (e.g. Couper, 2008; Fielding *et al.*, 2008). The 'building blocks' provided by an API - tools, data structures and functions – allow a web service such as Google Maps to be relatively easily customised, interacted with and embedded within another page.

We outline two examples from recent work where the Google Maps API (GMAPI) has been used to provide an interface for spatial data input within a traditional research survey. Neither commercial tools such as ArcGIS Server (ESRI, 2011), nor the technical resources to run an open-source solution such as OpenLayers (OpenLayers, 2011), were available; the projects build on a moderate existing level of HTML experience and therefore illustrate an accessible method for others with similar resources. We discuss issues related to these specific implementations, and more general considerations about the use of such tools for research.

GMAPI was chosen for these case studies largely due to the dominance of Google Maps in online mapping (Ellul et al., 2009). Google Maps is the leading online mapping provider with over 15% of the travel website market share, which includes travel booking and airline websites as well as online mapping. This is in comparison to less than 2% for nearest competitor Bing Maps (Hitwise, 2010a, 2010b). This dominance suggested that using GMAPI would give the greatest chance of existing user familiarity with the interface and base mapping. Bing Maps also offers an API (Microsoft, 2011), but Google's underlying cartography is arguably clearer. The existence of resources to assist with development was, however, a more significant motivation for choosing GMAPI. Online documentation, tutorials and user forums are more developed, and experience among colleagues and contacts was also higher.

Case studies

In each case study a Google Maps interface was embedded in a longer online survey. This translated respondents' mouse clicks into latitude-longitude coordinate pairs, which were then recorded in a database with other questionnaire responses. The web servers and databases were provided by the central University computing service.

Countryside recreation in the Norfolk Broads

This case study investigated locations for countryside recreation in the River Ant catchment of the Norfolk Broads. An online survey was used (in tandem with an identical in-person survey) for reasons similar to those discussed by Wherrett (1999); primarily to access a wider population than would be possible from fieldwork alone, particularly in terms of including recreation away from obvious facilities such as visitor centres. Participation was invited via email contacts and relevant online forums; 71 responses were received (additional offline responses are not considered further in this paper).

The survey used a simple form-based questionnaire written using HTML, PHP and JavaScript. It featured multiple-choice and free-text responses in addition to a map-based question; all user responses were written directly to a MySQL database. The map-based question (Figure 1) asked respondents to digitise a single point, line or area feature to show their preferred location for a chosen recreational activity. GMAPI was also used on the introductory page to illustrate the area of interest. The survey only examined recreation preferences and did not assess the map interface.

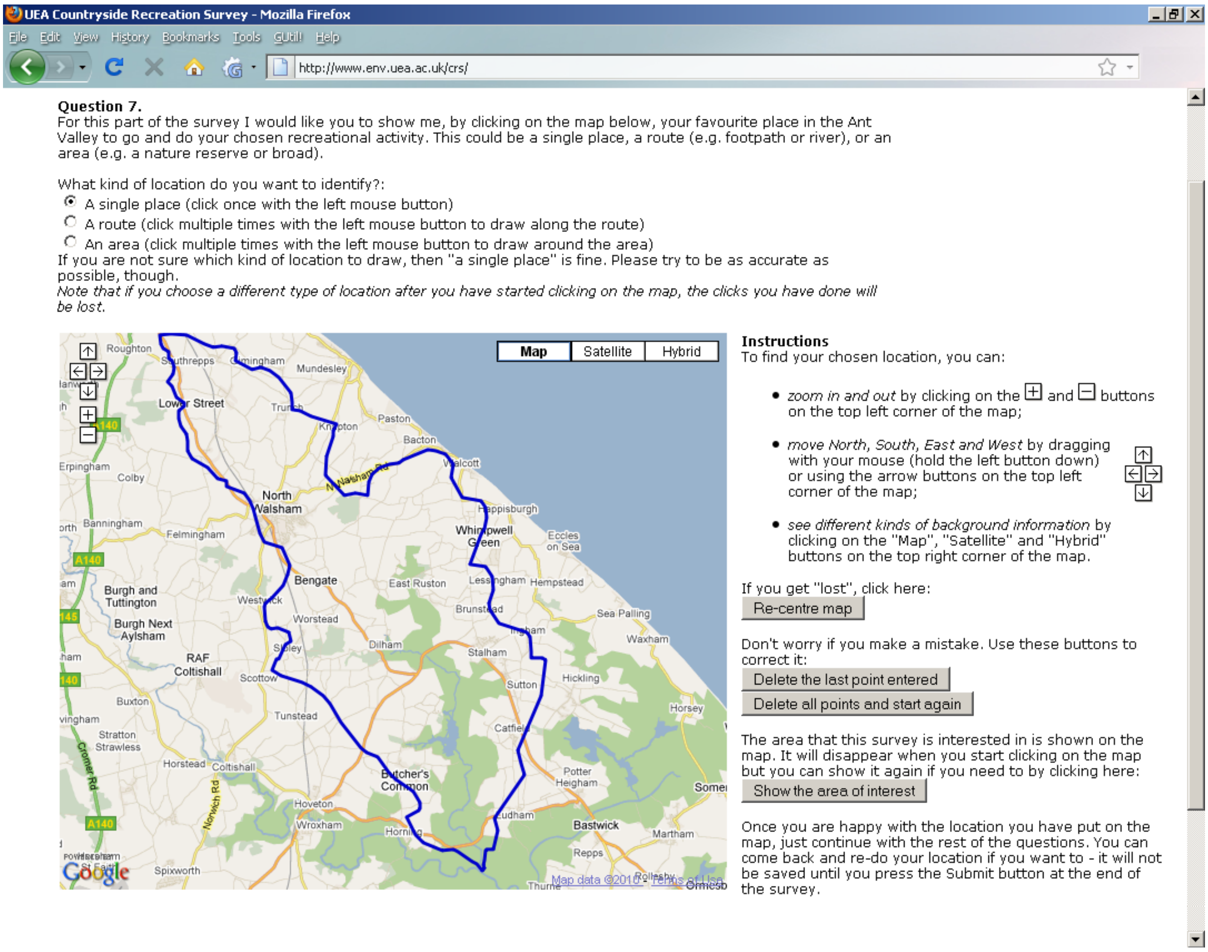

Figure 1. Screenshot of Google Maps interface requesting input. The respondents were allowed to pan and zoom the map, and choose the base layer © 2011 Google

Sonification of uncertainty in spatial data

This case study compared the usability of visual and sonic methods of representing spatial data, building on previous work (Bearman & Lovett, 2010). Using sound to represent data (sonification) has developed rapidly over the last 20 years (Hermann 2008), but few examples have looked at sonification with respect to spatial data; the method offers a potential way to communicate additional information while avoiding visual saturation. Respondents completed a series of tasks using UK Climate Projections 2009 (UKCP09) predicted temperature and predicted temperature range data (Jenkins et al., 2009). The data were represented on the map by a colour scale and/or an audible scale; for the sonic representation, the mouse pointer triggered musical notes according to the value of the data cell or legend item beneath it. Respondents (n = 71) used the mouse to 'paint' on the map (Figure 2), highlighting areas that met certain criteria with reference to the visual or sonic scale. The questionnaire used HTML, PHP and JavaScript to gather these spatial responses and, via multiple choice, additional respondent information. As for the recreation cast study, they were written directly to a MySQL database.

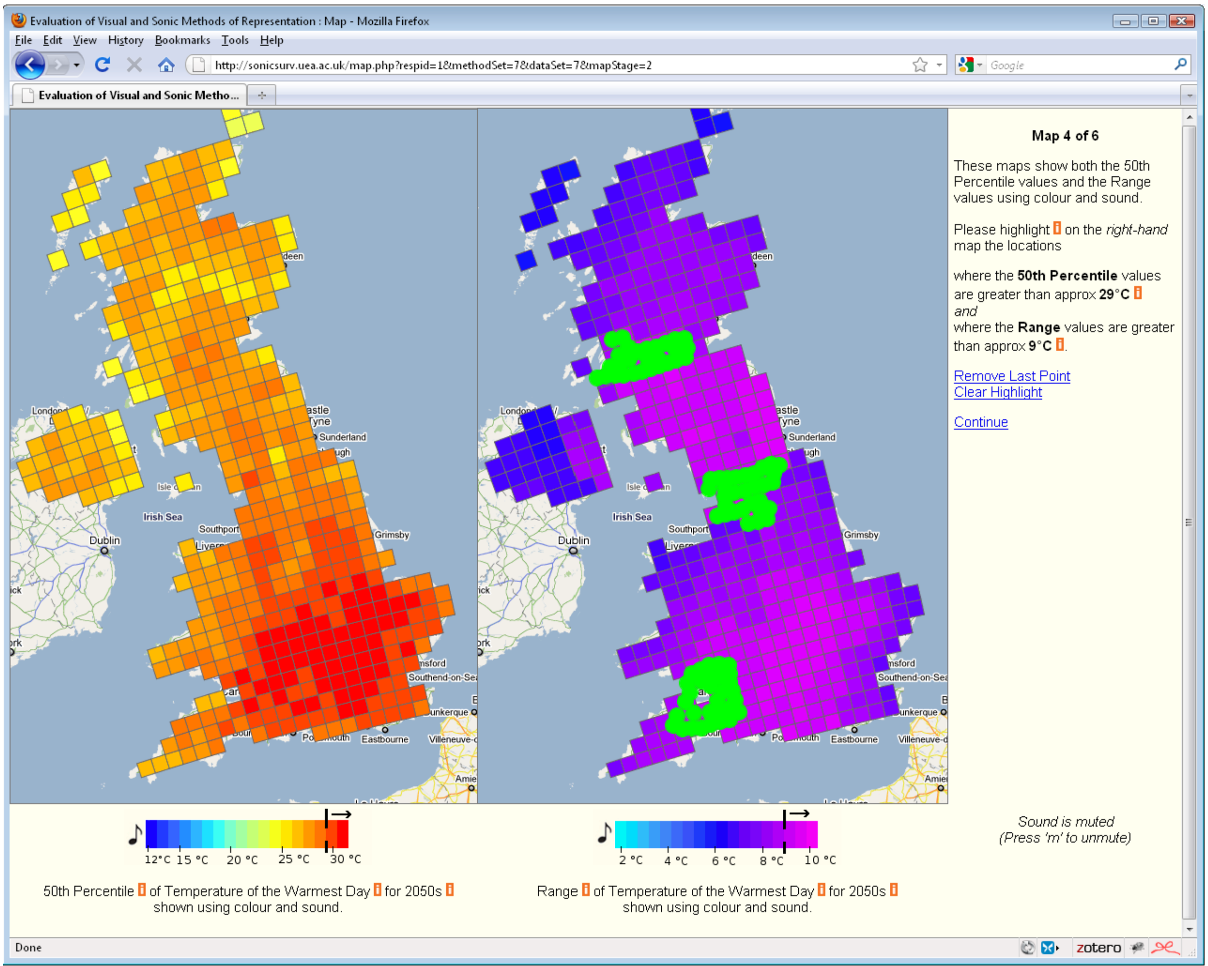

Figure 2. Screenshot of Google Maps interface with UKCP09 overlay and areas highlighted. The respondents were not allowed to pan or zoom the map © 2011 Google

An internet-based approach was chosen for this work due to its ease of use for participants; a similar study using ESRI's ArcGIS 9.2 highlighted its complexity (Bearman and Lovett, 2010). Evaluations were mostly run in small groups (6-8 people) and were followed by a discussion session where qualitative data on participants' views of the sonification method and map interface were gathered.

Related research

Google Maps and Google Earth are well-used for presenting spatial information to varied audiences, both in an official capacity (e.g. Brent Council, 2011; Westminster City Council, 2011) and via more informal 'mashups' (e.g. MapTube 2011; Google Maps Mania 2011). They are also used in the collection of Volunteered Geographic Information, allowing spatial information to be input and re-resented on the same mapping base (see Goodchild 2007; Heipke, 2010). While the use of Google Maps to gather spatial responses has seen limited use within professional public opinion research (Sinibaldi *et al.*, 2006, in Couper, 2008), a literature search has not revealed other academic work that has, as part of an online questionnaire, specifically requested (and used in later GIS analysis) the type of spatial information gathered in the two case studies.

Ellul *et al.* (2009) report on a community mapping website requesting and sharing user-entered spatial data; storage methods do allow for future GIS analysis of that data, but this was beyond the scope of the project. Rosser & Morley (2010) used GMAPI within a Facebook application to gather data on vernacular areas, extending earlier work on capturing fuzzy areas (Evans & Waters, 2008) using raster data. This paper, contrastingly, focuses on the input of more definite (vector) location data, using GMAPI as a spatial data gathering tool within a research questionnaire.

Discussion

Design and coding

The case studies were begun with sound knowledge of basic HTML but relatively low levels of other coding experience, and extensive use was made of online resources to make the maps look and behave as desired. The recreation survey used GMAPI v2 for JavaScript since it made use of two tutorials covering the creation of a digitiser function using GMAPI v2, and linking it to a MySQL database (Google, 2011b, 2011c respectively); additional assistance came from the Google Groups help forum. The sonification survey was based on the same examples but moved to v3 of the GMAPI, adding a Flash element to handle the sound (Ribeiro Amigo, 2006).

Although it is hard to give a definitive figure, the authors, without significant experience of JavaScript or Flash, were able to use the API to the level required by these applications after the equivalent of around four weeks of concentrated work for the recreation survey, and a further three weeks for the sonification study (which was based on the former). This was felt to be acceptable for case studies of this size. Much use was made of online support, both passive (tutorials) and interactive (forums) for GMAPI, whereas assistance from colleagues was more important for the PHP and MySQL techniques used to integrate each map and questionnaire, and record participants' answers. Around half of the time spent solely on the sonification study was to solve a moderate number of small problems with the API relating to the sound elements of the interface. Moving from an initial solution that worked in a purely technical sense to a robust and user-friendly survey also took an additional week or more in each case study; while this was not solely due to GMAPI, efforts to create a clear interface that would elicit the required information did add to the time taken. Piloting is essential, arguably more so than for 'traditional' online surveys without the spatial element, and should include less spatially- and technologically-experienced users.

Compatibility and reliability

Both case studies were developed for the Firefox 3.5/3.6 web browser, the current versions at the time. Wider compatibility with other browsers was important for the recreation case study, and Compatibility Mode (MSDN, 2009) was used to address map display problems in Internet Explorer v8. The more complex coding for sonification would have required significantly more work to ensure compatibility across browsers, and because the survey design meant that Firefox was sufficient, this was not pursued. Since that case study, such as HTML5 (Hickson, 2011) which would reduce the incompatibility of the sound aspect. Nonetheless for larger surveys it would be necessary to test implementation using alternative browsers and hardware, to ensure potential respondents were not excluded.

Both case studies relied on Google Maps performing as expected when the survey was administered. Observation of the sonification study suggested that 2-5% of sessions saw map tiles received slowly or not at all from Google's servers; although specific feedback was not solicited, it is felt that this could cause users in unsupervised surveys to abandon sessions. Future applications should both log uncompleted surveys and allow users to refresh pages without losing responses. Performance is not only reliant on the remote service - some sonification evaluation sessions had to be rescheduled due to local network disruption, but such problems potentially affect any online survey.

Base data recency and quality are important factors, particularly the spatial registration of imagery (Goodchild, 2009). Low geolocation accuracy of imagery would be significant for surveys where respondents use images to delineate features of interest, and further consideration should be given to the level of precision of data collected by this method as compared with its likely accuracy. This issue is further discussed below.

The GMAPI interface used to customise the interaction with the map may also change. For example, the sonification study suddenly began to display additional, unwanted controls on the map interface. As the same issue affected many other API users, solutions soon became available through relevant forums, but this does highlight the issue of relying on a service that may change without notice. GMAPI operates on a series of rolling changes with new minor versions being released every 3 months and each version only being supported for somewhere between 9 months and 3 years (Google, 2011d). This timeframe is stated in the documentation, and while RSS feeds and email alerts about new versions are available, they were not widely publicised during these projects. Google recommend developing the application with a specific version of the GMAPI and, once launched, testing against new versions as they are released every 3 months.

Depending on the nature of the survey and the length of time it is designed to operate for, unexpected changes of the GMAPI may or may not be problematic. If potential change is an issue, it is possible to permanently freeze the API available by buying Google Maps API Premier (Toon 2011, pers. comm.). An alternative solution is to develop the desired application based on an open source product, such as OpenLayers. Open source software on a locally-administered machine gives control over version updates, but adds to the complexity of development and requires a source of base mapping or imagery, meaning it may not be appropriate in all cases. During the case studies (mid-late 2010), OpenLayers was at a sufficiently early stage to be little-known outside the core 'open geo' community, and was therefore not considered as an alternative to GMAPI. Whether it could have competed in terms of capabilities and available support is not clear. It is a wider issue that the pace of technical development in the field of online mapping (and indeed generally) outstrips that of traditional academic publishing, which perhaps explains the small amount of relevant research. Furthermore, while growing social media use among experts in this field allows easier sharing of relevant developments, awareness of available tools does not easily translate into the level of familiarity required to apply them in research. Even where they are used, the work tends to use the technology to achieve a particular research aim, rather than critically assessing its application.

The maps in use

Both case studies used KML (Keyhole Markup Language) file to overlay information on the base map. KML allows spatially-referenced raster images or vector features to be displayed on 2D maps and 3D digital globes (OGC, 2011). The relevant functionality within GMAPI appears to be less well developed than other capabilities, and some problems were experienced. While the recreation survey's simple study area outline displayed without problem, the sonification data occasionally required a browser refresh to load all KML data; this was less problematic in a supervised survey environment but could affect data input and cause frustration and potentially abandonment in surveys conducted alone. Interaction could also be problematic: in the countryside survey clicking on the map to digitise also cleared the study area boundary from the map. This may have been beneficial in removing map clutter while digitising, but the behaviour was neither documented nor planned. The sonification study required the KML object values to be returned on the MouseOver event, to allow the more passive interaction required for this map, but this was not possible using the Google Maps API. As a work-around, the values were manually hard-coded before the evaluation into a JavaScript array, and the values were read from that.

The countryside survey also revealed problems digitising concave polygons in that Google Maps by default interprets mouse clicks within the presumed area of an unfinished polygon as a click on the polygon feature itself, rather than a click on the underlying map, and so is unable to retrieve latitude and longitude values. In this case, time limitations meant that only an explanatory message and request to click beyond the feature being drawn were implemented, possibly frustrating users. Investigation after the case study highlighted a way to pass the click through to the map (Google Groups thread, 2007). A workaround would be to outline polygons using a line digitiser function. Since both area outlines and true line features are recorded as a series of coordinate pairs, reconstruction relies on the 'point, line or area?' question in the survey (see below) in any case. The sole difference is that the area would not appear as a filled polygon on the map. More complex features, such as polygons with holes, have not been considered here and may present further problems.

Data obtained

The spatial data obtained from the recreation survey was written to a database table containing latitude and longitude (to eight decimal places) along with respondent ID, digitising order and feature type; these were subsequently imported to ArcGIS as a collection of points, and then reconstructed as lines or polygons where necessary. This type of output is easy to store and can be processed using the increasingly available tools for GPS data.

Analysis continued by buffering the point and line features and combining them with the polygons to create a 'heat map' (Figure 3a) showing how many times each area had been indicated. It is clear that there are issues with the accuracy of digitising, which will have implications for the ongoing analysis. Examination of the line data, for example, revealed examples for waterborne activities that were 400m from the river (Figure 3b). Without feedback from respondents it is not possible to say why this was done. User instructions could perhaps be improved, although detail must be balanced with manageability. A refinement for any similar application of GMAPI in future would be to record which zoom level and base map settings the user chose while digitising, or even to restrict digitising to certain zoom levels. Asking for additional descriptive information (e.g. "riverside walk from A to B") could provide further support. Many web-based route mapping and sharing facilities based on Google Maps (e.g. MapMyRun, 2011; Bikemap, 2011) offer the ability to create routes that automatically snap to existing roads between digitised points, rather than having users digitise each individual turn; while this is useful in principle, the follow capability is limited to the road features appearing in the underlying route database. OpenStreetMap (OSM) data, for example implemented via OpenLayers, may offer more scope for following other features including rivers and paths, but data completeness, particularly in rural areas, is patchy (Haklay, 2010), and not all desired inputs relate to mapped features.

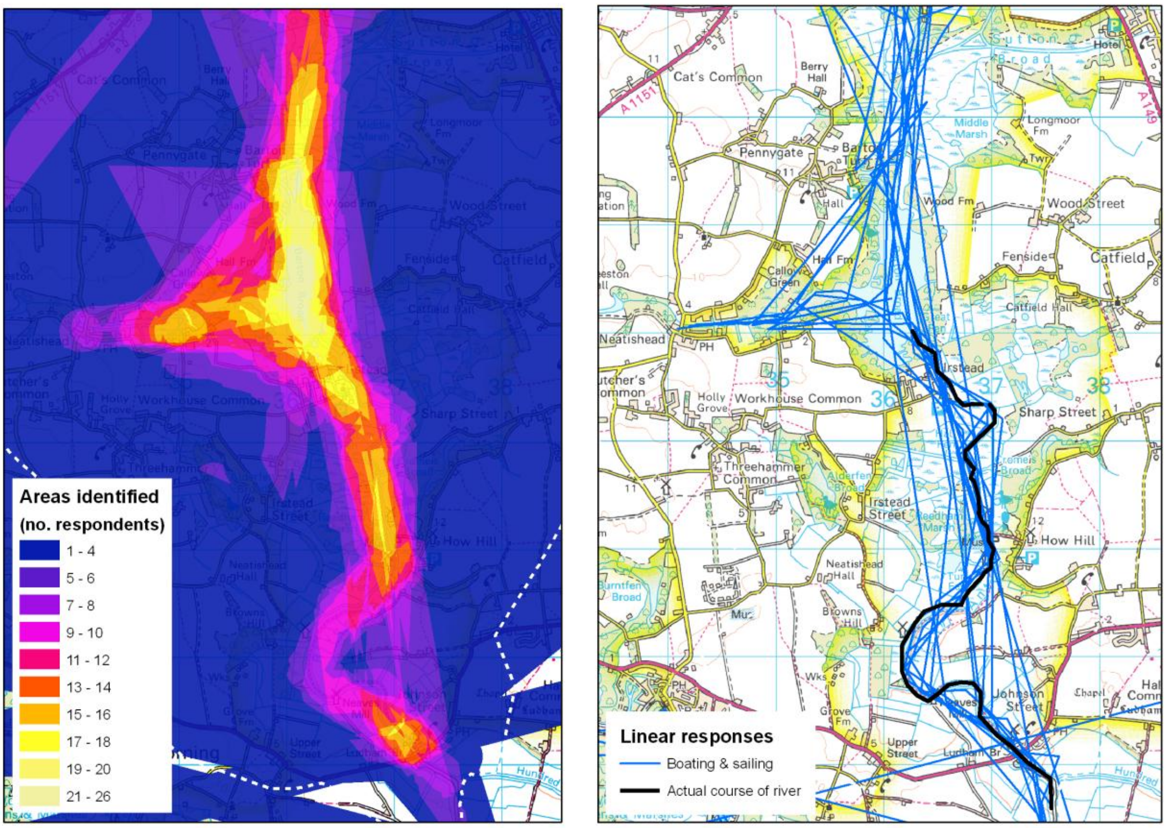

Figure 3. (a) Heat map of combined user responses; (b) illustration of digitising accuracy for responses relating to sailing and boating locations © Crown Copyright/database right 2011. An Ordnance Survey/EDINA supplied service

The sonification case study also stored users' input as individual points in a MySQL database, to be processed at a later stage in the analysis. This processing was not particularly complex, but a Python script was created to process the data automatically for each of the 426 maps (71 participants, each with 6 maps). Manual checking highlighted two particular issues: firstly, that the relatively large size of the paintbrush tool may have led users to believe a particular square had been selected when the precise point location actually lay in an adjacent square. Secondly, some users drew an outline around the area of interest rather than highlighting the whole area (see Figure 4 for an example). These issues could be addressed by more detailed instructions, or through a slightly different map implementation allowing individual cells to be marked as selected.

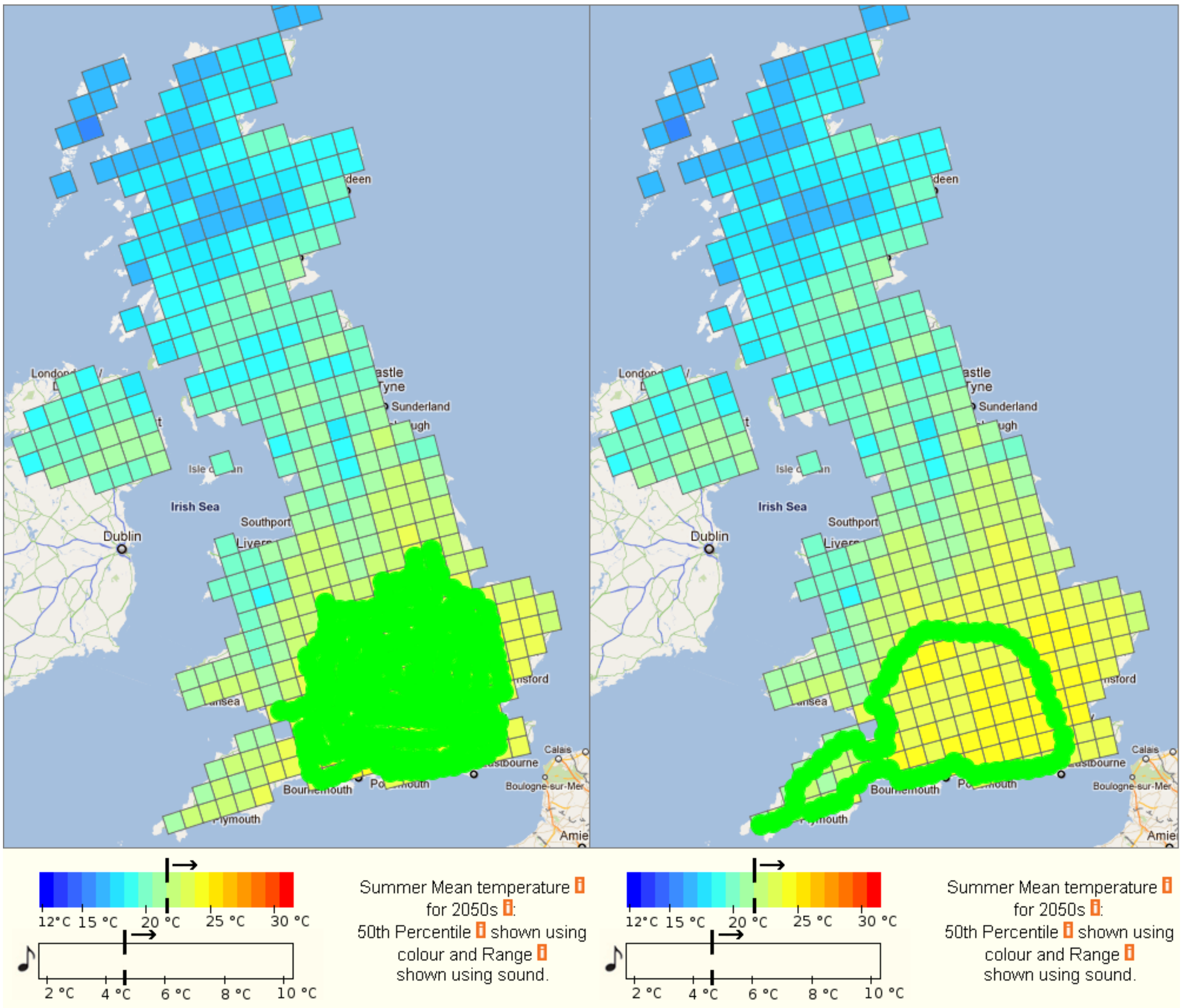

Figure 4. Two examples of highlighted areas provided by participants. If an outline was provided (like the example on the right) this was filled in manually by the author before the analysis was completed © 2011 Google

Using maps within questionnaires can increase task complexity and result in mistakes being made by the respondents, as seen in the two case study examples. Although allowances can sometimes be made during data processing, there is a clear need for piloting surveys with a variety of people and using the feedback to ensure clear, unambiguous instructions.

Methodological issues for academic research

The concept of reproducible research is well-understood (Brunsdon, 2011); from a published paper and publicly available information any capable academic should be able to duplicate a set of results from work in their field. When computer techniques are involved in any stage of research, the methods can become very difficult to reproduce later because of the rapid pace of technological development. File formats and scripting languages can be superseded, and methods from only a few years ago may not be easily transferable to currently-available software. This is an acknowledged problem given the growing necessity of archiving digital data, and is generally addressed via either emulation of obsolete technical environments or migration of digital objects to a currently accessible format (Brown, 2006: 86).

Such issues are particularly relevant to this work due to the number of third-party online components involved. Neither migration nor emulation is likely to be straightforward in this case. As already discussed, the Google Maps API code will be updated, as will browser software, HTML standards and, over a longer term, computer operating systems and hardware. While options exist for bringing some of these aspects under internal control, such as Google Maps API Premier, others can only be adjusted for by survey authors, usually in a reactive manner and via community channels rather than official technical support.

In an effort to improve the reproducibility of these case studies screenshots or videos of the evaluation process have been recorded, and are available for download (see Web Resources) with a copy of the commented source code and flow charts of both the programmatic sequence behind the survey, and the intended user progress through it.

Conclusions

Google Maps API offers a useful and accessible (to both authors and respondents) way to elicit precise, spatially-referenced responses within research surveys when more complex and costly geospatial solutions are unavailable. There are some limitations to the information that can be obtained, and considerations to be made when designing a survey using GMAPI, that require careful thought about the intended use, but on the whole it provides a means by which a spatial element can be introduced into a questionnaire without being the primary focus of the research.

Regardless of the exact platform, any survey that is to be completed unsupervised needs to be carefully designed. There must be clear instructions and robust error trapping for both the non-spatial and spatial parts of the survey, but these may well be more important for map-based input since respondents are likely to be less familiar with providing such information. In particular, and depending on its importance to the research in question, close attention should be paid to the matter of digitising accuracy. If higher accuracy is needed, there is potential to address this via either user instructions or map interface settings, but the absolute limit will always rest with the underlying map data. This is one of several factors which are not under authors' direct control, something which may be of concern.

Technically, there are unknowns related to the persistence and consistency of GMAPI over time that increase the importance of conceptual documentation of its use, as well as a reference copy of the final code. However, it offers significant advantages over other methods of eliciting spatial information within traditional online surveys. If use of GMAPI for survey purposes continues to be developed and progress shared, it has the potential to become an accessible and extremely useful tool for research data collection across the spectrum of geographic disciplines.

Web Resources

Examples of the case studies mentioned in the article, source code and other relevant information are available from www.nickbearman.me.uk/go/bearman_appleton_2012. Additionally, these are further duplicated at:

- ShareGeo – source code and overview of both case studies
- The Countryside Recreation Survey - www.env.uea.ac.uk/crs/
- Vimeo – video demonstration of the Sonification case study - http://vimeo.com/17029341

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