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RESOURCES

Geotagging Photographs in Student Fieldwork

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ABSTRACT *This resource paper provides guidance for staff and students on the potential educational benefits, limitations and applications of geotagging photographs. It also offers practical advice for geotagging photographs in a range of fieldwork settings and reviews three free smartphone applications (apps) for geotagging photographs (Flickr, Evernote and Panoramio). Geotagged photographs have the potential to encourage post-fieldwork student reflection on a landscape. A short case study of first-year undergraduates who geotagged photographs as a method of data collection is outlined. This resource paper also briefly discusses the use of student-owned devices in fieldwork which may reduce pressure on departmental budgets.*

KEY WORDS: Geotag, smartphone, technology, fieldwork, learning, Web 2.0

Introduction

Geotagging is a form of georeferencing which adds spatial metadata (usually latitude and longitude) to digital media for effective visualization and analysis (Deogawanka, 2010). The concept of geotagging is very similar to marking waypoints on a hand-held global positioning system (GPS) receiver; however, the geotagging software adds spatial metadata to the digital media rather than adding it to a waypoint. Generally, photographs are the most geotagged digital media; however in recent years, users increasingly geotag other digital media such as videos and micro-blog (e.g. Twitter) updates. Hand-held GPS receivers, such as a Garmin Etrex, have been frequently used during field trips (Fletcher *et al.*, 2003) for a number of years and have been used to enhance student learning through activities such as geocaching and mobile mapping. Over the last decade, users (typically photographers, outdoor enthusiasts and academics) have had the ability to geotag photographs (i.e. adding spatial metadata to a photograph) by using two separate devices: a GPS receiver and a camera both of which are linked by the time and date settings on each of the devices and then synchronized by an additional piece of software on a desktop or laptop.

Whilst this remains a valid method of geotagging, the explosion in smartphone ownership since ~2007 has simplified geotagging for all smartphone users because many

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of the second-generation smartphones (e.g. iPhone 3G and later, HTC models) have both digital cameras and assisted GPS in-built to the device. The relative ease and accessibility of geotagging has "generated a wave of geo-awareness" (Luo *et al.*, 2011, p. 189) with *US News & World Report* listing geotagging photos as one of "50 ways to improve your life in 2009" (LaGesse, 2008). Friedland & Sommer (2010, p. 1) state that "all the major smartphone makers are now offering models allowing instantaneous upload of *geotagged* photos, videos, and even text messages to sites such Flickr, YouTube, and Twitter." Users can upload and share their geotagged images in multi-media repositories such as Flickr and Panoramio; in May 2011, Flickr alone had 146 million geotagged items.

In a recent international survey of geography and bioscience higher education practitioners conducted by the authors, geotagging was repeatedly cited as one area of technology that practitioners expect to see expanding over the next five years, a sentiment shared by Luo *et al.* (2011, p. 205) who suggest that, "with the availability of internet, GPS devices and smartphones, the proliferation and availability of geotagged media will continue to expand". Similarly, Johnson *et al.* (2010) identify the use of mobile phones in education as one of the key areas in which they expect significant growth in the next 12 months. The applications of geotagging in geography and aligned disciplines are wide ranging and are increasingly accessible for both staff and students as only basic technological knowledge is required. In fact, most of the technological knowledge is often already instilled in the student user as mobile technologies are now "woven into all times and places of student lives" (Traxler, 2010 p. 5), so it is unlikely that practitioners will be required to provide additional technical support for student users.

The survey by the authors found that practitioners who would like to use technology in fieldwork identified cost as a key barrier. These results suggest that there is often a conflict between the overall cost of the technology for large groups of students and the limited departmental budgets available for fieldwork. This finding is valid for specialist technologies but in other situations it may be appropriate to consider how student-owned technology can be utilized in fieldwork. Welsh et al. (2011) survey conducted a survey of geography undergraduates ($n = 73$) illustrated how mobile phone ownership has changed and are perceived to change in the next two years (Figure 1). Within this cohort of students, the figures suggest a dramatic shift from 90 per cent ownership of standard mobile phones to 70 per cent of the students owning a smartphone (Figure 1) over the course of five years (2009–2013). Increasingly smartphones are becoming more "affordable and ubiquitous" (Melhuish & Falloon, 2010, p. 4) and "the fastest- growing [mobile technology] sales segment" (Johnson *et al.*, 2010 p. 9). In light of the financial pressures of fieldwork and the rise of smartphone ownership, this paper explores some of themes associated with utilizing student-owned devices for geotagging and specifically reviews three pieces of free geotagging software that can be used with a GPS-assisted smartphone. Some suggested applications for use in geographical sciences and aligned disciplines plus a case study based on a group of first-year undergraduates who used geotagging within a human geography field project are also presented within this paper.

Innovative Field Techniques: Geotagging Photographs in Fieldwork

Fieldwork techniques have continuously evolved overtime to accommodate the changing needs and requirements of the undergraduate student. Kent *et al.* (1997) describe the evolution of field courses from the 1950s when observational 'Cook's tours' were a

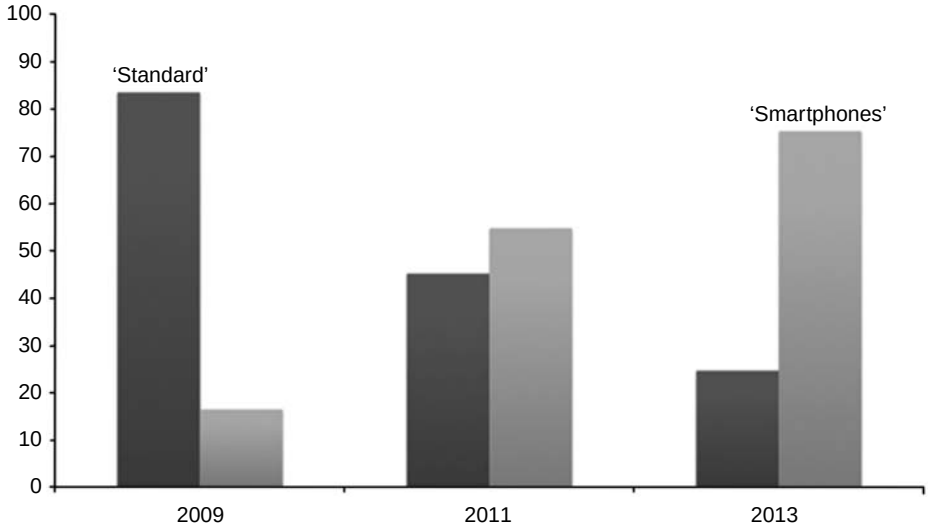

Figure 1. Changes in student mobile phone ownership since 2009 and projected change to 2013 (based on Welsh *et al.*, 2011).

popular structure. Kent *et al.* (1997) go on to describe the modification and refinement of techniques to a participatory style of fieldwork and problem-orientated projects. Innovative field techniques have included student-led field courses (e.g. Simm *et al.*, 2011), digital storytelling (e.g. France & Wakefield, 2011), photography (e.g. Hall, 2009), virtual field courses (e.g. Stott *et al.*, 2009) and reflective diaries (e.g. McGuinness & Simm, 2005).

Geotagging photographs could be considered as an innovative field technique which brings together several existing fieldwork techniques. Photography in particular has been a core technique in geography (Latham & McCormack, 2007) both in teaching (e.g. Sidaway, 2002) and research (e.g. Schwartz & Ryan, 2002) and has several educational benefits such as encouraging student engagement with a landscape (Latham & McCormack, 2007) and encouraging students to "look with intention" (Sanders, 2007, p. 181) and make sense of the landscape before them. Taking photographs also allows a student to revisit areas of the landscape post-fieldwork, thereby extending their learning space and allowing for further reflection outside of the landscape. Geotagging photographs can add an enhancement to this as students can associate the photographs with different parts of the landscape and potentially identify spatial patterns as they have the location information associated with that photograph. This is particularly useful for post-fieldwork reflection as the spatial information can act as a reminder of where the photograph was taken which may help to further interpret the landscape. If students annotate their geotagged photographs and add further reflection on the photographs post-fieldwork, this technique could compliment reflective fieldwork diaries (e.g. McGuinness & Simm, 2005) which themselves encourage critical reflection and can facilitate deep learning.

There are numerous applications of geotagging for both human and physical geography as a method of data collection and student reflection. Some suggestions for practical applications include taking geotagged photographs of:

- shops in clone towns to identify distribution of national chain stores versus independent retailers;
- trees and plants in different areas during tree identification activities, this is particularly useful if students are struggling to identify a plant/tree as they can take the photograph and location information back and investigate further when they have access to the Internet;
- gully systems to show distribution and scale at different locations;
- vegetation successions along a transect;
- signatures of crime such as graffiti, derelict buildings, etc. to identify areas of crime within a larger region;
- coastal erosion along a beach transect to identify spatial patterns of coastal erosion;
- a hazardous region over time to investigate temporal density of crowds in different areas with a view to using these data to better deploy resources for hazard management and
- the human or physical landscape and using the annotation space as a reflective tool.

Clearly, this list is not exhaustive, but gives some idea of the broad nature of this method for cross-disciplinary data collection and how useful the applications would be for gathering both spatial and temporal information.

Review of Geotagging Software

An important point to note is the difference between automatic and manual geotagging. For clarity, the definitions of the following terms within this paper are:

1. *Automatic geotagging*. A photograph is automatically located on a map by the software which makes use of the latitude and longitude stored in the photograph.
2. *Manual geotagging*. The manual dragging and dropping of a pin onto a digital map in the approximate location where the photograph was taken.

It is clear that for the purpose of fieldwork in higher education institutions, automatic geotagging is preferable due to increased positional precision. Manual geotagging is popular with users who want to quickly add some basic spatial information and are less concerned with the exact positioning. This paper focuses specifically on smartphone software that is able to automatically geotag and plot images on a map. The nature of the research questions and the type of analysis required by the user will ultimately determine which application (app) is most suitable for each piece of research. The operating systems considered were limited to iOS (for iPhone) and Android (for HTC and Samsung) because, at present, there are no apps currently available which meet the criteria of this paper for the Symbian and Blackberry OS operating systems.

Software Review

Table 1 shows a comparison of key features of the three main apps selected for review: Flickr, Evernote and Panoramio.[1] The smartphone apps that were selected for review are widely used, offer good user support and are free to download. Both Flickr and Panoramio

Table 1. Key features of free apps suitable for geotagging photographs

	Flickr	Evernote	Panoramio
Computing platforms	iPhone	iPhone, Android	iPhone, Android
Compatible online mapping systems	Flickr maps only	Google Maps	Google Maps
Batch mapping of multiple photographs	Yes	No	Yes
Battery life	3–4 hours, app is only initialized when photograph is taken	To increase spatial accuracy, app must be left running which depletes battery to 1–2 hours max.	3–4 hours, app is only initialized when photograph is taken
Spatial accuracy of photographs	96 per cent accurate to 1m	77 per cent to 1m if app is left running through activity	96 per cent to 1m
Resolution of photograph	Limited to resolution on phone, typically 1.3–5 Megapixels	Limited to resolution on phone, typically 1.3–5 Megapixels	Limited to resolution on phone, typically 1.3–5 Megapixels
Versions users can view photographs	Mobile and Desktop	Mobile and Desktop	Mobile only

are multi-media repositories, whereas Evernote is primarily a productivity/organizational tool. To use all three apps to their full potential (i.e. to geotag a photograph and view on a map), both the mobile and the desktop version of the software are required. Flickr and Panoramio are equally easy to use, the main advantage of Flickr is that the user can view the photographs on both the mobile device and the desktop version of the app. In Panoramio and Evernote, the user can only view the photographs through the desktop version. Whilst all three apps are free, Flickr has a 199 photograph limit (or an additional cost of ~£15 per year for an upgrade to unlimited photographs), whereas Panoramio and Evernote have an unlimited photograph upload. The major advantage of Panoramio over Flickr and Evernote is the integration with Google Maps (for viewing) and the ease of downloading the geotagged points to a file suitable for upload into Google Earth (i.e. with a.kml extension).

Overall, due to the number of features in Evernote, it may be less straightforward to use than Flickr or Panoramio. However, the Evernote app has an additional benefit of enabling the user to geotag a longer note or description of an area if used on fieldwork; a feature which neither Flickr nor Panoramio support. Furthermore, in Evernote, users can add each geotagged image one by one to a Google Map and the image will be automatically geotagged. There is currently no batch option[2] for this, so if a student wants to add 100 + photographs to a map, this could be relatively time consuming.

During trials, Evernote was more accurate when the app was left running on the iPhone; however, this significantly depletes the battery life on the phone which only lasted approximately 2–3 hours on an iPhone 3G. Flickr and Panoramio are both accurate (to several metres) from initialization of the app and neither require the app to be left running. It is best practice to advise students to let any of the apps which they are using to fully initialize so that the satellite signal can be properly detected by the smartphone.

Limitations of Geotagging and Possible Solutions

Whilst the advantages and applications of geotagging are wide, there are some limitations of geotagging using mobile devices. Smartphones are a relatively expensive piece of technology, so it is unlikely that every student will own their own smartphone despite rapidly growing ownership (see Figure 1).[3] Fieldtrips must be designed to promote inclusivity and with this in mind, geotagging with a smartphone is best suited to group work (groups of three to four students), as it is likely at least one member of the group will own a smartphone (based on estimates in Figure 1). Problems that the may arise as a result of group work are not a new concern but it is important to ensure that the student who owns the smartphone agrees to the device being used by all members of the group. Students should be encouraged to set up a group account for the desktop version of the geotagging software which every member of the group should have access to so that all students own and have access to the data, not just the student who owns the smartphone. Another potential issue is student reluctance to use their own smartphone for academic purposes (see case study). One option is for an institution to purchase their own set of smartphones, and in this case a Pay-as-you-Go tariff would be preferable to a set of expensive monthly contracts.

Based on the current availability of 3G in the UK, the method would be most successfully applied to urban and semi-rural areas and less successful in valleys, rural areas and inside of buildings.[4] The method has been tested in the following UK locations:

- Chester, Cheshire (urban, city environment),
- Talacre, Flintshire, North Wales (coastal),
- Slapton, South Hams, Devonshire (coastal, semi-rural) and
- Howgill Fells, Cumbria (rural, valley).

The spatial information was accurate to several metres at all locations with the exception of the Howgill Fells where the 3G signal was too weak to employ this method. The same limitations apply when considering geotagging overseas as the 3G signal may be weak or the use of smartphones restricted. Ultimately, the responsibility lies with the practitioner to test the suitability of geotagging and assess the availability of a 3G signal in the field area before the field trip. 3G coverage will likely improve over time which will hopefully make geotagging with smartphones more achievable in areas with a limited 3G signal both in the UK and abroad.

The availability of a 3G signal whilst overseas and the data roaming charges that this would incur could be an issue in some cases; however, if there is a free Wi-Fi signal available (e.g. in urban areas), then data roaming costs should not present a problem. One possibility in large urban environments (e.g. New York) has been to hire iPads or iPhones for student use at a cost of ~£25 per week, this then eliminates the need for the institution to purchase the device and pay for international data roaming charges. Alternatively, using a local SIM card may be a suitable idea to reduce cost. Another issue raised is the precision of these devices and it has been noted that the precision of the spatial reference points in Evernote alters depending on the duration that the app has been running on the phone and whether the user has closed the app for any length of time.

Case Study

Background

A group of first-year undergraduate geography students (Students A, B and C, see Table 2) used geotagging photographs as one method of data collection as part of an assessed field course in Slapton, Devon. The students wanted to show evidence of increasing house prices along an 8 km transect from an inland location (Kingsbridge, Devon) to a coastal location (Slapton Sands, Devon). Geotagging was an ideal method to collect data for this project and provided students with visual and spatial data to use in their assessed report. A short focus group was conducted with these students after the field trip.

Process

The students were given the choice of the three apps presented in this paper to trial on a student-owned iPhone 4. The group selected Flickr as they had heard of the desktop version, 'it is a well known brand' (Student A) and they felt the Flickr app would be most useful should they want to view the photographs on the mobile device whilst in the field. The students walked along the transect taking geotagged photographs of houses that were for sale so that they could cross-reference the images to photographs in the local newspapers/property websites once they returned to the field centre so that they could establish the price of the houses that were for sale. The photographs were automatically stored online in their virtual Flickr album in the desktop version of Flickr (which is automatically synchronized between the iPhone and desktop account). The students were able to add the photographs to a Flickr map which were automatically geotagged (see Figure 2).

Review of Flickr

Geotagging photographs with Flickr involves the following steps (Figure 3):

1. Sign up for a free iTunes account.
2. Download FLICKR app from iTunes directly onto Smartphone.

Table 2. Characteristics of students who took part in a focus group about their experience of geotagging photographs as a method of data collection

Student A	White male, first-year geography undergraduate, aged 18 with an interest in human geography. Describes his technological knowledge as above average. Owns a symbian smartphone.
Student B	White male, first-year geography undergraduate, aged 18 with an interest in human geography. Describes his technological knowledge as average. Does not own a smartphone.
Student C	White male, first-year geography undergraduate, aged 18 with an interest in human geography. Describes his technological knowledge as above average. Owned the iPhone4 Smartphone used in the case study.

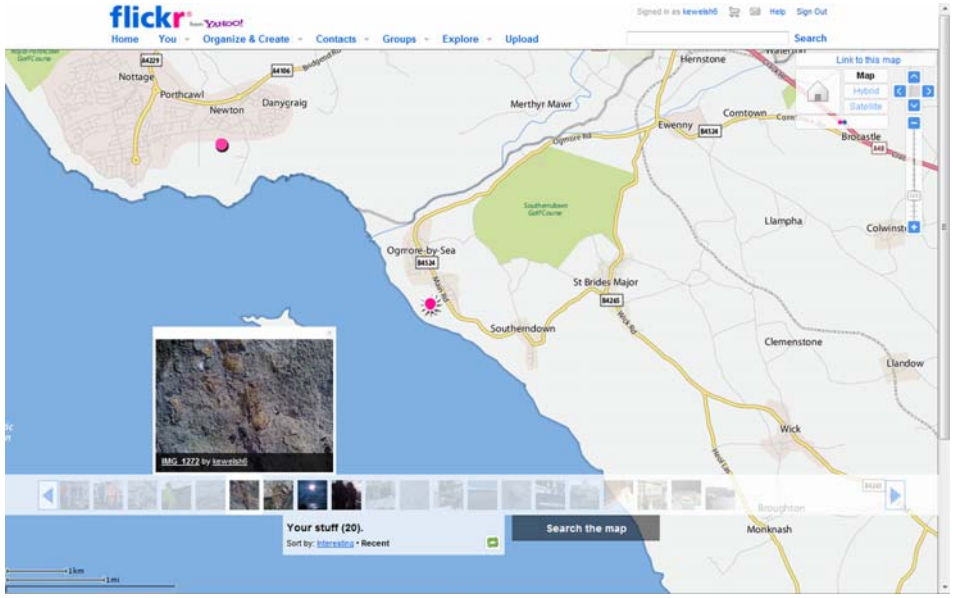

Figure 2. Example of a Flickr map. The dots show location of geotagged photographs. Click on the relevant dot and a thumbnail of the image will pop up near the bottom of the screen, e.g. IMG_1272.

3. Open FLICKR app on iPhone, click 'Allow' if a message appears about using your location.
4. Click camera icon (Figure 3a).
5. Click 'Take Photo' (Figure 3b).
6. Click the camera icon to take the photograph (Figure 3c).
7. If you are satisfied with the photograph, click 'Use' (Figure 3d).
8. Add a title and description (Figure 3e).
9. Ensure that Tag Current Location is set to ON and set privacy level to Private to ensure other FLICKR users cannot view your photographs (Figure 3f).
10. Click Upload (Figure 3f).
11. Picture automatically uploads to FLICKR (Figure 3g). The picture will be stored in the online album and can be mapped from the desktop version of FLICKR. Pictures can also be view on the phone but cannot be mapped on the phone.

The students experienced very few issues with the app. All three students found the app and desktop version of Flickr 'very straightforward' (Student A) to use and stated that only a 'very basic knowledge of how to use a smartphone' (Student A) was required to use the method, re-enforcing the idea that no specialist knowledge is required. The battery did not deplete as the app only needed to be initialized each time a photograph was taken and it did not need to be left running in the background. The students also stated that only one of their points was anomalous and estimated that the point was plotted approximately 50 m away from the actual location. From a practical perspective, because the app uploads the photographs directly to the Flickr desktop account, it saves space on the student's memory card on their phone which may be an issue if they have a large number of apps and digital

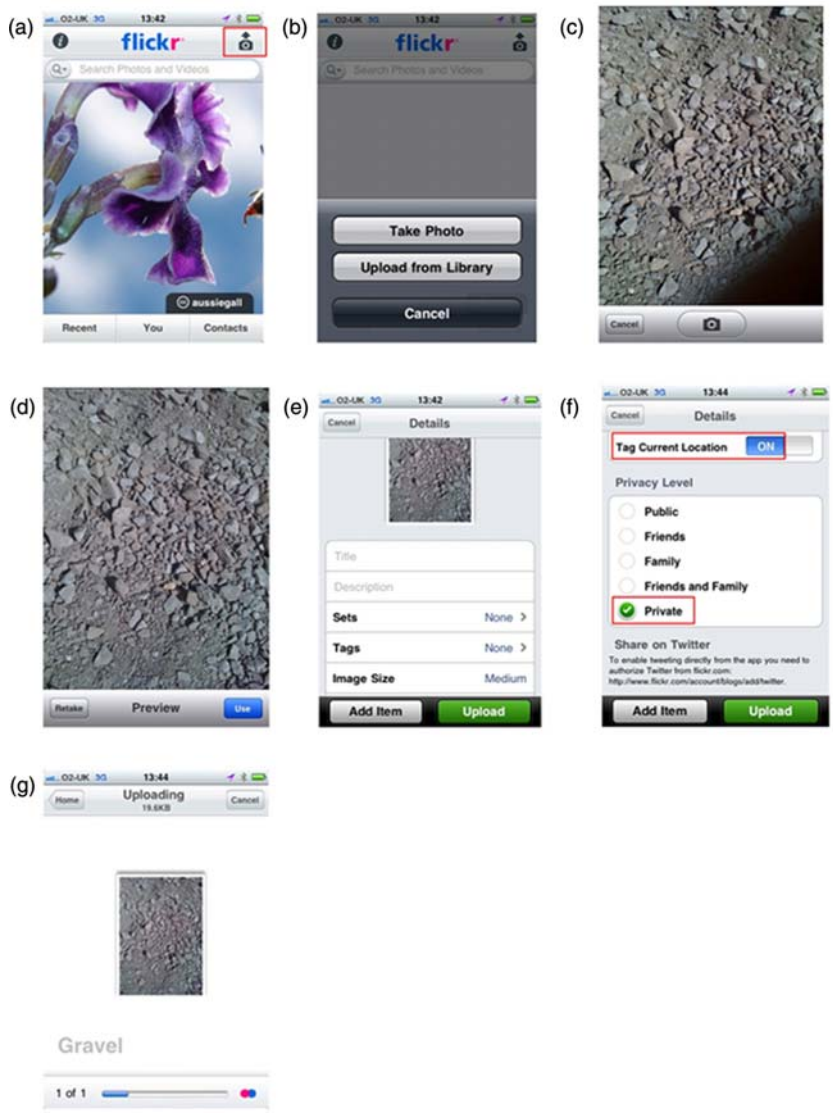

Figure 3. Step-by-step guide on how to geotag a photograph with an iPhone 4 using Flickr.

media on their phones. The two main criticisms of the app were (1) it only worked on an iPhone and (2) the Flickr app did not integrate with Google Earth/Google Maps so the students stated that 'next time they would use something that did integrate with Google Earth' (Student A) such as Panoramio.

Student Reflections

Overall, the students reported a positive experience when using geotagging photographs as a method of data collection describing the method as 'good' (Student C) and

'a straightforward way to collect data' (Student B). One of the major themes to emerge from the students was the increased efficiency of data collection. The students stated that without geotagging photographs, they 'would probably have only collected half the number of data points' (Student B) compared to 'the long way' (Student A), e.g. take a photograph of each house on a standard camera, write a description in their field notebooks and then mark the location on a map. Student C stated that 'geotagging probably saved about two days' worth of data collection' and 'saved time when presenting data visually'. The additional quantity of data (i.e. more geotagged photographs along the transect) that they had collected added to their overall understanding of changes in house prices along a transect as they had more data to support their original hypothesis.

The students also had a basic introduction to spatial data and began to understand rudimentary concepts of Geographical Information Systems (GIS), something which none of the students had prior experience with. No GIS skills are necessary to undertake geotagging of photographs and this reduces time before, during and after the fieldwork as students are not required to learn all the skills associated with GIS at first-year undergraduate level, but can still learn about the method and underlying concepts of GIS, data visualization and spatially distributed data.

Another positive outcome of using this method was that students felt that they had learned a 'key skill' (Student B) which they 'felt sure they would use again' (Student B) and could demonstrate to employers. This suggests that the students felt confident using this method. They stated that although the technology was basic, the 'same ideas could be applied with more sophisticated industry standard technology' (Student A) if it was required by an employer.

Student-owned Smartphones in Fieldwork

Due to the relative expense of smartphones and mobile phone contracts that departments may incur for a large group of students, it is practical to encourage students to use their own non-specialist equipment in the field where possible. Bedhall-Hill (2011) identified that making use of student-owned devices saves student's time when learning to use functions of equipment and saves departments money. However, Jarvis and Dickie (2010, p. 177) suggest that "while many undergraduate students own mp3 players, they were reluctant to have their digital entertainment spaces 'invaded' by academic materials." The students who used geotagging photographs had conflicting views on this matter and their views suggested they were less concerned with mixing academic and social 'space' and more concerned with damaging their equipment. Both Student A and Student B both expressed concerns about using their own mobile phones in fieldwork and mentioned that 'rain' (Student B) and 'proximity to rivers or beaches' (Student A) would be a concern. However, Student C (whose iPhone4 was used in this case study) stated that he 'was happy' to use his smartphone for fieldwork purposes. All three students stated that they would be concerned to use institution-owned technology 'in case there was a charge if the item was damaged during fieldwork' but went on to suggest that if the item was fully insured by the institution and there would be no consequences arising from accidental damage then they would be happy to use institution-owned hardware. This raises an important point, as students rarely state their concerns about using expensive, specialist equipment such as differential GPS (~£20 000) which can give positional accuracy of ~10 cm, yet are concerned about using institution-owned iPhones (~£400). Perhaps this

is because they have a greater awareness of smartphones and appreciate the cost and robustness of them whereas having no prior experience with a differential GPS for example, they seem less concerned about accidental damage to this specialist equipment.

Conclusions

Geotagging of photographs is a useful method of data collection across the undergraduate programme. Geotagging is easy to undertake and is potentially cost effective if departments make more use of student-owned mobile devices. Geotagging has the potential to raise spatial awareness, enable basic mobile mapping, provide basic level GIS skills and could enhance the quantity of data collected. Although the students within this case study used the technique as a method of data collection, geotagging photographs has the potential to compliment reflective field diaries and may encourage further student reflection and understanding of a landscape post-fieldwork. This supports Downward *et al.* (2008, p. 69) who advocated that "future mobile technologies that integrate portable mp3 devices with GPS and live streaming of data will further enrich the integration of learning spaces by promoting real time feedback of observations and queries between these spaces." The students whose views are presented within this paper feel that they have developed a key skill which they suggest will be useful for their future employment and enhancement of their digital literacy. The apps reviewed here are easy to use and a free resource which could be applied to fieldwork situated in urban or semi-rural environments. The responsibility of assessing the suitability of the environment that geotagging photographs could be applied within lies with the practitioner. Geotagging photographs can also be applied in overseas locations, provided that mobile coverage and data roaming costs are taken into consideration.

Acknowledgements

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Notes

[1] Evernote (http://www.evernote.com/); Flickr (http://www.flickr.com/); Panoramio (http://www.panoramio.com/).

[2] Batch processing—applying rules (e.g. geotag) to multiple items in an automated matter. App selection will largely depend upon the data analysis that is required by the user and the nature of the research being undertaken.

[3] An iPhone costs in the region of £450–£600 for the handset and requires either a contract (upwards of £30 per month) or a Pay-as-you-go tariff which includes 3G access (for data roaming when a free Wi-Fi signal is not available) and for data download charges ('downloading' encompasses viewing web pages, listening to audio files via the web). For departmental purchases, a Pay-as-you-go-tariff is perhaps more suitable due to the occasional nature of fieldwork. If fieldwork took place on a regular basis, e.g. weekly, a monthly contract may be more suitable but this would be a decision for each practitioner and department to make based on their own fieldwork needs.

[4] An appraisal of the coverage of the 3G network in the UK is available at http://www.compare3gmobilebroadband.co.uk/3g-coverage-uk.htm (accessed September 2011).

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