Spatial Pattern Analysis of Secondary School Students’ Leisure Tracks

Hans-Jörg STARK

Abstract

The GIS debate in teaching and the promotion of spatial technologies in secondary school has been very lively in the past few years. The “Map your World” project is one of the most successful representations of this movement. Many of these initiatives require a significant amount of time, skills and equipment. The proposal presented in this article describes the development and usage of an easy to use web-based application that allows both for students and teachers to monitor, investigate and discuss their spatial leisure behaviour. It also fosters the awareness and risks of modern tracking technologies which comes with smart phones and similar devices.

1 Introduction: Two Teaching Initiatives

1.1 The HiTec! project

The School of Teacher Education at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) wants to promote the interest of secondary school students in technical disciplines. Hence, they started the project “HiTec!” with the goal to create special lessons and tutorials from four selected domains. These lessons are prepared by an interdisciplinary research team and are provided to teachers at secondary school level for free. One of the four areas is the field of Geomatics, from which the existing project “Map your World” has been chosen to describe the proposed work.

The “HiTec!” initiative allows only a time frame of approximately four lessons for each of the four technical topics to be covered. That’s why it was necessary to find a new concept for “Map your World” which is applicable for a reduced time frame. As a result, “Map your World” as part of “HiTec!” had to focus on another educational objective. The course development needed to address issues as the time frame of just four lessons and the challenge to include both theoretical and practical topics in such a short time.

1.2 The Map your World project

“Map your World” as a project was founded in 2009 at the Institute of Geomatics Engineering at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW). It is basically a project for secondary school students to become familiar with both modern geo-sensor technologies such as global navigation satellite systems (GNSS) and concepts of contemporary cartography and web-mapping applications like Google Maps and others. In addition to these basic intentions, the project aims to reveal the
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Complex and, with all of its applied technologies, quite often very demanding task of making a map (Stark & Treuthardt 2012). So far, “Map your World” has had its focus mainly on the map-making process including the concept of volunteered geographic information (Goodchild 2007). The integration of “Map your World” into teaching demanded a minimum of lessons. On the one hand, the introduction into the basic concepts of geo-sensors and map-making required at least two to four theory lessons. On the other hand, the practical introduction that covered the handling of the hardware, the operation of the sensors and the final post-processing of the collected geo-data involved another two to four lessons.

GPS tracks of the students’ fieldwork existed from an earlier “Map your World” project in Schaffhausen, Switzerland. Based on these tracks, a new approach of analysing the students’ tracks has been developed. Henceforth, the focus within the “HiTec!” project shifted to the analysis of students’ patterns of movement and their leisure behaviour. Thus for the “HiTec!” project, students carried a GPS logger for a specified time, such as a week or a few days. Especially in their leisure time, they are asked to have the GPS logger with them to record the places they go to and also document the routes they take. As a result, the tracks of a class of secondary students within a given perimeter existed and were available for further investigations. Of special interest were the popular places they go often too. This information is also of high value for planning experts in areas like urban planning. How to introduce planning aspects to high school students is well documented in the study of Beckett & Schaffer (2005) who worked on a technology-supported urban planning simulation in a workshop focused on city planning and community service but these aspects are beyond the focus of the “Map your World” project.

2 Input Data and Data Processing

The base input dataset consist of raw GPS tracks that came from any kind of GPS-enabled sensor devices. In the “Map your World” project, low-cost GPS loggers were used (see figure 1).

![Fig. 1: Navilock NL-457DL EasyLogger](image_url)
These loggers have the ability to store the tracked positions as values of longitude and latitude in the World Geodetic System and enable you to read them out later. Another great advantage of these devices is that they are lightweight, smaller than a pen and thus fit into any pocket and are easily carried. The Navilock NL-457DL EasyLogger contains a small software package that allows for the settings of the signal logging. The configuration settings of the Navilock NL-457DL EasyLogger were optimised to obtain the best possible tracking results for empirical studies.

Since the GPS signal coverage is not given at all times and under all circumstances, the computation of positions is sometimes error-prone. This is either because too few satellites are available or the satellite signals are disrupted and the detection of the current position is impossible. To avoid processing inaccurate GPS tracks, some post processing of the raw GPS data is performed before the spatial pattern analysis. The main goal is to detect and erase outlying positions (see figure 2). The applied filters are, on the one hand, large time slots between consecutive point registrations and, on the other hand, segments with too large speed values (above downtown speed limit).

![Fig. 2: Raw GPS tracks (left); post-processed GPS tracks (right) showing erroneous tracks (bold lines) extracted from applied filtering](image)

YOSHIDA et al. (2010) propose further methods to optimise the quality of GPS tracks but within the presented application these methods have not been taken into account because the achieved quality and the log settings which the Navilock NL-457DL EasyLogger provides are sufficient.

3 Methods of Analysing Spatial Patterns of Leisure Behaviour

3.1 General Research on Spatial Patterns of Leisure Behaviour

Spatial patterns of leisure behaviour on small scales have been investigated for quite some time (MERCER 1970; PEARCE 1987; SHOVAL & ISAACSON 2007) and have been widely supported since the advent of GNSS (SHOVAL 2008). Recent studies have had their focus on either the economic aspects or capacities of existing infrastructures (SWEET & CHEN 2011; SMALLWOOD et al. 2012). Besides these general aspects, the view and needs of
pedestrians came into focus of international research (Spatial Metro 2008; Spek 2009). Shoval & Isaacson (2006) studies of pedestrian spatial behaviour proposed applying tracking technologies and introduced GNSS as one of these technologies. Schlich et al. (2004) focussed in their studies, among other things, on the interrelation between types of activities and closeness to home. They discovered that “there is a tendency to perform fewer leisure activities near home. But still, about one-quarter of all leisure activity locations are found within walking distance from home”. However, they say nothing about the characteristics of the leisure locations that are visited more often than others. Yet the information Schlich et al. (2004) provides is of high relevance as a general statement. Modsching et al. (2006) investigate tourists’ spatial behaviour in the city of Görlitz based on real tracking data. Similar research has also been carried out by Nijhuis (2008). They both use a density map to provide the results of their spatial pattern analysis. The density map represents a grid of cells of equal size. The number of GPS tracks that cross each cell is determined. For Modsching et al. (2006), the final metric of a cell is the relative number of visitors.

3.2 Analysis of Spatial Patterns based on GPS tracks: The Density Map

The approach Modsching et al. (2006) have used to create a density map is also the base upon which the leisure behaviour of secondary students is analysed within “Map your World”. After the pre-processing of the raw GPS tracks, the data of all students is uploaded into a central database via the internet. The extent of the spatial dimension of the study area is defined at the creation of a new project and is also stored in the database. Based on the spatial dimension and the dimension of the resulting density map, the size of a grid cell is computed. Unlike Modsching et al. (2006), “Map your World” does not compute a relative number of visitors but uses an absolute counting approach developed by Golub (2011). Since there is always a certain inaccuracy in GPS tracks, it may be misleading to take only those grid cells which are touched by a GPS track segment into consideration. Golub’s approach allows for the application of a kind of tolerance by using a radius r parameter. The basic concept is as follows: For each GPS segment, the minimum bounding box, which is extended by the given radius r, is computed. Within this bounding box for each pixel, the distance to the segment line is computed and, based on the inverse distance, an estimator of closeness is computed. If the pixel falls outside of the buffer that is defined around the line with the distance r, the pixel receives a null value. Fig. 3 illustrates this algorithm. The computed values are dimensionless.

Fig. 3: Computation of grid cell values for different segment lines with given radius $r = 1$; the image on the left shows a diagonal line and the computed grid cell values. The images in the middle and on the right show the computed grid cell values for two segments of different positions and orientations that cross.
This procedure is repeated for each segment in all collected GPS tracks. The cell values are summed up and result in the density map. Fig. 4 shows a detail of the density map of some sample tracks in the city of Basel, Switzerland.

Fig. 4: Density map for a set of GPS tracks in Basel without backdrop map data (left) and with backdrop map data from OpenStreetMap

4 Results – Web Application

As a result, a web-based application was developed that can be used both to upload GPS tracks from students and also to analyse the collected data. The application is created with the Django web framework on the server side using Python and, on the client side, the graphic user interface is built with GeoExt that combines Openlayers as a map container and Ext JS as the JavaScript framework for rich and dynamic user interfaces.

To run the application, the teacher has to set up a new project (see figure 5).

After the registration with a name and a password for the new project, the teacher also defines the perimeter of the area of interest. The students are able to upload their GPS tracks directly from the logger via a standard web browser. There is no additional software plug-in necessary. In addition to the GPS tracks, the students are asked to enter their gender and age. This additional information can be used for further analysis.

Once all the data is uploaded into the central database, the application is ready for analysis. The main web page shows the map in the centre and, and on the right side the different map layers to be used (see figure 6). Five different background layers are available. The resulting density map along with the hotspot layer can be switched on or off.
Fig. 5: Web interface for project opening

Fig. 6: Main webpage with density map and hotspots and applied filters
Also available below the map, a few filter options to be applied if necessary: It is possible to analyse only GPS data that was collected within a specific time window or from students within a specific age range or of a specific gender. Both the time and the age filter can be set by using a dynamic slider. The gender filter is specified by checkboxes.

After all the settings are chosen, the button at the lower left corner is to be pressed to compute the density map which then appears within a few seconds in the map window. Along with the density map, the application also provides a layer of hotspots that indicate the pixel areas with the highest pixel values. This hotspot layer helps to find the places where students have been the most or stayed the longest. There is a slider on the right side that allows for reduction or increase of the number of hotspots to be shown on the map.

The basic idea of this application is that both the teacher and the students are able to navigate easily in the map within their study area. They can go through different analyses and discuss the computed density maps. For example, they may want to know where the hotspots are on the weekends or in the afternoons between 2pm and 6pm for girls, etc. The maps shall foster the students’ awareness of their habits and the deductive spatial patterns they leave. A special focus in the analysis in class is what their depicted paths tell about their private lives.

In addition to the spatial dimension, there is also an interest in the temporal component. The GPS tracks also contain the time stamps of the registered positions. Based on this information, the application also provides video sequences of the density maps. These video sequences can be downloaded, studied and discussed in class or individually.

Last but not least, one of the main focuses of this project initiative is to make the students aware of tracking with smartphones and similar devices, which these days can be performed without the user’s knowledge.

5 Conclusion and Outlook

The project initiative developed an easy to use and widely accessible web application that allows for both the teacher and the students to analyse and discuss the spatial patterns of leisure behaviour. The time constraint of only four lessons can thus be fulfilled. A great advantage of the presented approach is that the teachers do not have to invest a great deal of time in preparation and learning of new software like GIS or data editors as it was with the former “Map your World” design. The founders of the initiative provided a complete set of GPS loggers to interested classes. Apart from the very easy handling of the GPS logger, the students and teachers are only asked to be able to navigate within a standard web browser and provide basic map navigation skills. There is the option to use the provided GPS loggers but this is no pre-requisite. Any GPS sensor can be used for the collection of the tracks, be it a smartphone or a more sophisticated GPS device that is designed for outdoor activities.

Since the GPS loggers only track outdoor activities, the project may be extended to filter locations that were entered and left after a longer time. Hence popular indoor places may be detected and shown on the map as a separate layer.
It can be assumed that there is a difference when performing the project either in winter or summer time. The students probably spend much more time outdoors in warmer months than they do in winter. No research or comparison has been conducted on this issue yet.

Another aspect that is of interest is the self-declaration of popular places by students. Similar to www.cooltownstudios.com, students can define and potentially rate their most popular places on a map. This basically ‘a-priori’ definition can then be compared to the spatial pattern analysis and may lead to an interesting discussion of perception and facts.

In addition to all the fascination of the freely available GNSS, research has shown that positional accuracy is sometimes not sufficient (MADISON & NI MHURCHU 2009). But for the existing project and its goals, it can be assumed to be appropriate. The main concern of this project is not primarily the highest spatial precision but increasing spatial awareness.

Another upcoming concern about GNSS is that while GPS is normally trusted, there seems to be a serious issue about purposely distracting or even killing satellite signals for position detection (HAMBLING 2011). Hopefully this is only a rare phenomenon.

During the time writing this article two classes of secondary school students are working with the presented “Map your World” project. In the future further improvements on the project design will be applied and first ‘best practices’ will be elaborated based on the pupil’s experiences. Since the individual projects are password-protected no public view is possible. At the time of writing the project is only available through a temporary URL. General information to the project will be available on the web at a project specific URL.

References


