Past, present and future of tourist tracking

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Abstract

Purpose – *The purpose of this paper is to find out tourism movement patterns via the tracking of tourists with the help of positioning systems like GPS in the rural area of the Lake Constance destination in Germany. In doing so past, present and future of tourist tracking is illustrated.*
Design/methodology/approach – *The tracking is realized via common smartphones extended by an app, with dedicated sensors like position loggers and a survey. The three different approaches are applied in order to compare and cross-check results (triangulation of data and methods).*
Findings – *Movement patterns turned out to be diverse and individualistic within the rural destination of Lake Constance and following an ants trail in sub-destinations like the city of Constance. Repeat visitors and first-time visitors alike always visit the bigger cities and main day-trip destinations of the Lake. A possible prediction tool enables new avenues of governing tourism movement patterns.*
Research limitations/implications – *The tracking techniques can be developed further into the direction of "quantified self" using gamification in order to make the tracking app even more attractive.*
Practical implications – *An algorithm-based prediction tool would offer new perspectives to the management of tourism movements.*
Social implications – *Further research is needed to overcome the feeling of invasiveness of the app to allow tracking with that approach.*
Originality/value – *This study is original and innovative because of the first-time use of a smartphone app in tourist tracking, the application on a rural destination and the conceptual description of a prediction tool.*
Keywords Prediction, Triangulation, Future tools and methods, Lake constance, Movement patterns, Tourist tracking
Paper type Research paper

1. Introduction

The aim of this paper is to introduce a new approach to tourist tracking via smartphone app, exemplifying this on a case study from Lake Constance, a popular tourist destination in Germany. In doing so the paper illustrates past, present and future approaches to, as well as options for, tourist tracking. Movement patterns of tourists in the destination of Lake Constance have so far remained unknown. For our purpose, the goal of tracking tourists is to visualize movement patterns in an interdisciplinary approach straddling tourism and computer science. These patterns are of high importance for the tourism industry, both for designing offers and products and for planning. A future goal will be to derive prediction models from the tracking patterns.

2. Background

2.1 Characteristics of lake constance as a rural destination
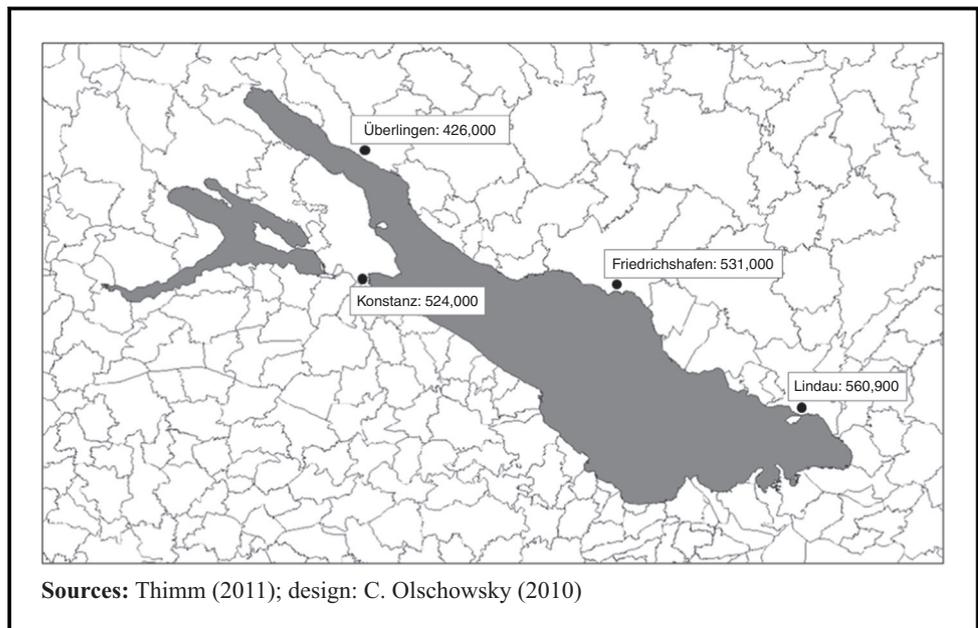
The rural destination of Lake Constance (known in Germany as the Bodensee) is ranked number 2 among area destinations for arrivals and overnight stays in the Southwestern German state of

Baden-Württemberg – only outdone by the Black Forest. It can fairly be described as rural because of the predominantly open countryside around the lake and the presence of only a few small towns, none of them exceeding 100,000 inhabitants (e.g. Konstanz, Lindau, Überlingen and Friedrichshafen). Its unique selling proposition is that it is surrounded by four separate countries: Germany, Switzerland, Austria and Liechtenstein. Hence it was branded as the "Four-Country Region Bodensee" (Vierländerregion Bodensee). Managing such a large cross-border destination poses a challenge, in view of its complexity and the imbalance between resources and demand (Thimm, 2012). Germany, having the longest shoreline, is the biggest supplier of tourism offers and products at the lake and provides most of the infrastructure.

Austria's share of the lake is basically just the town of Bregenz, while Lichtenstein is a tiny principality that does not even border the lake, and Switzerland has priced itself out of the market with its rock-solid Frank far outstripping the euro. As a result, the lion's share of tourists congregate on the German side, especially in and around the towns of Constance, Überlingen, Friedrichshafen and Lindau. Thus Lake Constance does not really have a single urban centre – in this regard it is multipolar (Thimm, 2011) (Figure 1).

Furthermore, most of the tourists at Lake Constance are Germans, especially from the states of Baden-Württemberg and North Rhine-Westphalia. Thus international tourism is rather low at Lake Constance, coming mainly from Germany's neighbouring countries (Switzerland, France and the Netherlands). The two major groups of tourists coming on holiday to Lake Constance are young families with children and elderly couples. The majority of tourists stays 4-7 nights (28 per cent) or 1-2 weeks (27 per cent) and travels independently. Moreover, Constance and Lindau attract a great number of day visitors (more than two million per year for Constance and more than one million per year for Lindau). The Lake Constance destination has a huge amount of repeat visitors: 81 per cent have been there from two to five times while 56 per cent have been there more than five times. Moreover, an analysis of the "Lake Constance Experience Card", a card permitting free or reduced entry to several lakeside attractions, shows that tourist movement patterns are focused on the northern shore (Scherer and Strauf, 2010). Lake Constance is a "driver-centric" tourist destination. Tourists arrive by car and do most of their travelling within the destination by car. This is basically due to a lack of rapid public transport

Figure 1 The multipolar destination Lake Constance showing the overnight stays of the biggest cities (year 2007)

Überlingen: 426,000

Friedrichshafen: 531,000

Konstanz: 524,000

Lindau: 560,900

Sources: Thimm (2011); design: C. Olschowsky (2010)

options (Hoppe *et al.*, 2012). All town and village centres have pedestrian zones and are therefore eminently walkable.

2.2 Development of a smartphone app and alternative logger device integration

In this project a smartphone app was developed that provides access to the GPS component available in nearly all smartphones on the market. The app provides functionality similar to a GPS-logger, while also offering an interface to the user enabling a simple setup for personalized use. The app tracks the movements of a person and despatches impersonalized data to a backbone server storing movement data for a certain period (e.g. one day). An alternative to the app is offered in case a person does not want to install an app on the smartphone or in case the person is not using a smartphone. In this case, a GPS-logger device is used providing a similar functionality like the smartphone app. In the case of the logger, all data can be stored on the device without immediate despatch to the backbone server, while the app would, in turn, use an online connection to the server in order to report the movement profile. Due to the fact that we do not require real-time access to the movement profile, both alternatives are regarded as equivalent. Furthermore, the app comprises a feature tourists can use to comment on restaurants, sites and itineraries. This feature is an extension to pure movement tracking, and so provides more than the logger can. The complete system is implemented as a client-server-architecture. The smartphone app data are stored in a server at the university's premises. Besides providing access via a HTTP-server, the main component of this server is a database storing the movement data as well as additional data introduced by the user (e.g. restaurant recommendations). Data from the loggers are introduced after returning the devices and uploading the data to the server. Since data processing is performed offline, no further real-time restrictions apply. Due to the uncomplicated deployment process for Android smartphones, the project app is based on Android (OS version 4.0 and higher). Technically, it can be easily extended to other platforms like Apple's iOS or Windows Phone from Microsoft. Beside the user interface of the smartphone app, the server backend component offers a GUI for expert users; so they may extract these data for further processing or applying analysis and filter applications already incorporated in the server component.

The market for GPS trackers is evolving quickly; according to ABI Research, the market will pass the $3.5 billion mark in 2019. Nowadays, there are lots of GPS-tracking applications for Android devices available on the market; some are free of charge and some are not, but all have the same goal: to help a user analyse their GPS movement profile. Beside the pure hardware, a suitable app is required to receive data and also provide a user interface to visualize the data. Additionally, and in the background, this app may dispatch the data to a server ready to store data from different users: first, there is the Open GPS Tracker, that can track your travel data with the help of your Android device by storing your GPS locations. This app can plot your route in real time on Google or Open Street Maps. Second, the GeoTracker app (Bogdanovich, 2015) was specially designed for action fans and long distance travellers. It helps the user to track travel data: document the locations on the route and compute the overall distance. The app helps finding the way back home and it supports sharing the route with friends. Third, the GPS logger for Android was considered. It is fast and energy-efficient, and it helps store GPS coordinates at certain intervals on a SD card file (the card can be inserted into the logger device). The app runs in the background while walking, taking a hiking trip or going on a long photo tour.

However, none of these options offers an open and free interface to analyse the data in the way it was needed. So the app has been developed to access raw data and also provide filters and space for the tools required for data post-processing and analysis.

In order to meet user preferences, two different types of trackers were used: the first is the app that needed to be installed in a smartphone, using the phone's capabilities from the embedded GPS sensors. The second is a classical GPS tracker, used as an external device. The app was implemented on Android phones, benefiting from a simple and quick deployment process for apps; that said, the technology is in principle completely independent from an underlying device or operating system. In this case, a pure software solution is added to already existing hardware owned by the tourist. In the second case, for the several reasons explained above, additional hardware (a GPS tracker) is used. The selection was based mainly on price, openness of the

interface for accessing data and ease of use. The final decision was taken for the tracker shown in Plate 1. This tracker is a commercial product but without any interface on the device. The user only has to decide to switch the device "on" or to switch it "off".

3. Literature review

Tracking the movements of tourists is no longer a new topic in tourism studies. Early attempts started in the 1970s and 1980s, using mental maps, self-completion diaries, surveys and interviews (Groß *et al.*, 2013). Keul and Kühberger (1997) even used non-participant observation to track tourists in Salzburg, Austria, and coined the term "ants trail" (Keul and Kühberger, 1996). According to Keul and Kühberger (1996, 1997), the term captures the fact that tourists in a destination all follow the same route, visiting the same limited number of points of interest – in short, they behave like ants following their specific trail. However, tourist movements are generally more complex than other movements like shopping or commuting (Asakura and Iryo, 2007). Freytag (2010) found that repeat visitors behave in a completely different way than first-time visitors. They avoid the ants trail, stay away from the beaten track and try harder to participate in the daily life of the inhabitants of a destination. They follow individual interests like shopping, learning the local language, getting in touch with the local population, taking longer when visiting points of interest, exploring generally untouristed places, etc. This often results into a long-term relationship with the destination (Freytag, 2010). Therefore, their movement behaviour is not as homogeneous as that of first-time visitors, who prefer to visit the iconic attractions and so tend to form an ants trail. Furthermore, first-time visitors are more likely to move around more widely; on the other hand, due to their higher destination familiarity and possibly higher destination loyalty, repeat visitors tend to act more sporadically, focus more on relaxation and return to the hotel during the day (McKercher *et al.*, 2012).

Shoval and Isaacson (2006b) show, in their general overview of tourist-tracking methods, that participant, non-participant and remote observation methods pose problems for the ethics of tracking people, which also have spillover effects in terms of influencing the test persons or in terms of space limitations in the case of camera observation. Van der Spek (2008) focuses, in his overview of tracking technologies, on GPS- and mobile phone-tracking as well as monitoring via video or bluetooth and hybrid solutions. Weber and Bauder (2013) describe and evaluate several methods for tourist tracking: observation, for instance, e.g. implies difficulties over the legal implications of tracking people plus the undesirable influence of the movement patterns of tourists who realize they are being followed. Mental maps, being inner representations of space, are prone to highly subjective perceptions of routes and landscapes and so were also excluded from this study. Due to problems with data protection, non-representativeness and inaccuracy, methods like crowdsourcing and GMS were not taken into consideration. The authors furthermore point out that tracking devices must be small, passive and not invade privacy, so as not to influence tourist behaviour. Digital tracking arrived with the new millennium (Groß *et al.*, 2013). It was enabled by the development of new technologies like GPS, smartphones and mobile devices generally (Weber and Bauder, 2013). The writings of O'Connor *et al.* (2005) and Pavón *et al.* (2004) indicate that

Plate 1	The GPS logger
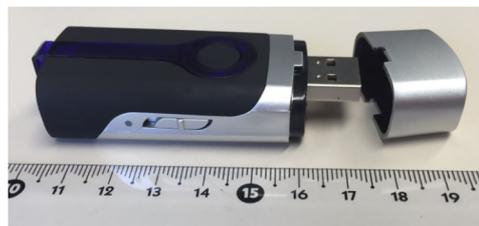
Source: Author Ralf Seepold

observational methods (cameras, infrared detectors) and individual methods like keeping travel diary have often been replaced by mobile devices that allow tourist movements to be monitored in a much more precise way (Edwards *et al.*, 2010). Asakura and Hato (2004) give a condensed description of the development of GPS-technology and its implementation in tourism. An overview of current techniques for tracking tourists is given by Xia and Arrowsmith (2008). Movement patterns are of increased relevance for decision makers in destination management and tourism planning (Lew and McKercher, 2006). The analysis of movement patterns can reveal tourism congestion, or identify times and areas that show a low frequency of tourism up to areas, or indicate points of interest that have an unusual low frequency of tourists. Lau and Mckercher (2006) point out that tourist tracking via mobile phone totally failed in their study of Hong Kong because the tourists refused to cooperate. Tourists resisted this method because they felt observed and monitored on a scale where their privacy was invaded in an inacceptable way; and they considered tracking via smartphone to be far too invasive. Furthermore, the authors stressed the importance of a multi-method approach in tourist tracking, in order to balance the advantages and disadvantages of the different methods. On the other hand, mobile devices like smartphones are delivering more and more services to daily life, so this rejection may change into a more positive attitude towards application: Egger and Jooss (2010) pointed out that all kinds of m-commerce like mobile ticketing are on the rise since location- and time-independence, convenience and low fees are success factors driving these m-services. Therefore, mobile applications are developing more and more dynamically, paving the way for new services and solutions in the tourism business. Ubiquity is, according to Höpken and Fuchs (2010), the key feature behind mobile applications leading to new marketing channels in tourism. Tourist tracking has been especially applied in towns or cities like Salzburg (Keul and Kühberger, 1996, 1997), Görlitz (Modsching *et al.*, 2006), Jaffa (Shoval and Isaacson, 2006a), Akko (Shoval, 2008), Kobe (Asakura and Iryo, 2007), Beijing (Leung *et al.*, 2012), Taipeh (Lin *et al.*, 2009), Paris (Freytag, 2010; Bauder *et al.*, 2014), Hong Kong (Shoval *et al.*, 2011), Canberra and Sydney (Edwards *et al.*, 2010), Sydney and Melbourne (Edwards and Griffin, 2013) and several islands, e.g. Vanuato (Pearce, 1988), Fanø (Nielsen *et al.*, 2010) or Vancouver Island (Murphy and Rosenblood, 1974). Intra-attraction studies along the lines of, e.g. the summer palace (Xiao-Ting and Bu-Hu, 2012) are, however, rather rare. In the present study referring to the Lake Constance destination, a cross-border rural setting is targeted with its specific requirements and peculiarities.

The following research questions emerge from this literature review and further desk research (e.g. website analysis):

RQ1. What are the movement patterns of tourists at Lake Constance?

RQ2. Is there a difference between the movements of repeat visitors and first-time visitors?

RQ3. What are strengths and weaknesses of the different approaches (app/logger/survey)?

RQ4. What follows for the development of tourism offers/packages/planning?

RQ5. What are the past, present and future implications of tourist tracking?

4. Methodology

After developing a prototype of the app in summer semester 2014, this β version was tested in winter semester 2014/2015 on a limited number of dummy data and subsequently improved. In view of the fact that Easter, Pentecost and the summer months are the peak tourist seasons at Lake Constance, primary research was carried out between April and June 2015. To compare and cross-check different approaches to tourist tracking, a survey and a GPS-logger were used in parallel with the said objective. The logger was tested in summer semester 2015, so during this time just one device was used. The participants for logger, app and survey were randomly chosen at tourist spots like Constance, Meersburg, Lindau, Mainau Island, Friedrichshafen, Hagnau and Wasserburg. Tourists could be easily identified – they were carrying or using a camera, carrying a knapsack, dressed casually, reading a travel guide or map. The easiest way of recruiting them as participants was to approach them at tourist hotspots, e.g. at the tourist information office or in an ice-cream shop, or elsewhere while

they were out taking a stroll on a lakeside promenade or relaxing on benches. Another ploy was to strike up a conversation with hikers, before asking for their help with the tourist-tracking project. The weather was an important factor in finding participants: the better it was the more likely they were to support the research. The function of the app was explained with the help of a poster, since apart from the tracking the app provided links to information relevant for tourists, along with a travel diary, CO_2-tracking and counting the number of calories burned. These features were intended to make the app more attractive to participants, generating additional benefits for them. The answers they gave to the structured survey were fed directly into laptops. The logger, in testing mode only, was handed out to tourists at Constance Train Station, the harbour area and the tourist information office. Regarding the app, participants were searched for in Constance only, while the survey covered more locations around the lake. The data sets generated by the different approaches differed.

Survey: 94 data sets (breakdown: Constance: 50, Island of Mainau: 11, Meersburg: 22, Hagnau: 2, Friedrichshafen: 5, Wasserburg: 1, Lindau: 3).

Logger: four data sets (due to testing mode), Constance.

App: two data sets, Constance.

Due to the test mode of the logger and the small (survey) to very small (app) sample size, it should be stressed that the study is of an exploratory nature.

The tracking methodology should be modular in its core architecture and open to external client inputs (via GPS-logger, smartphones or other types of sensors), and it should support smart techniques for group clustering (Datko *et al.*, 2014a, b). The core system should be prepared for online and offline data upload, and the client should provide features according to its own possibilities. In case of powerful clients, this may include online data access and a graphical user interface, while a logger may have no graphical user interface at all but only a button to turn the device on. In the future, different devices may appear on the market, while the core system remains robust against this kind of future change. However, the device needs to offer an API for encapsulation into the platform.

Figure 2 shows the systems architecture of the server and the client that is connected via JSON (Introducing JSON) to the server. The connection link does not imply that this is a direct communication connection or that it provides real-time data transport. With the document-oriented database MongoDB running on the server, all collected user data is permanently stored for post-processing. The server application backend retrieves information from the database for backend charged via (in this case) a network link running JSON. This link is used for sensor data (e.g. GPS positions) but also for additional user input (e.g. ratings). The HTTP-server will receive JSON objects containing user GPS logs and user-written ratings.

To realize the GPS-tracking functionality in the mobile application a GPS Manager Class is used, which includes a GPS/location API (Figure 3). The map has been created via Google Maps (© 2015 GeoBasis-DE/BKG (© 2009), Google). After the user has installed the application, there is a one-time setup dialog window displayed to the user. During this dialog, the registration also takes
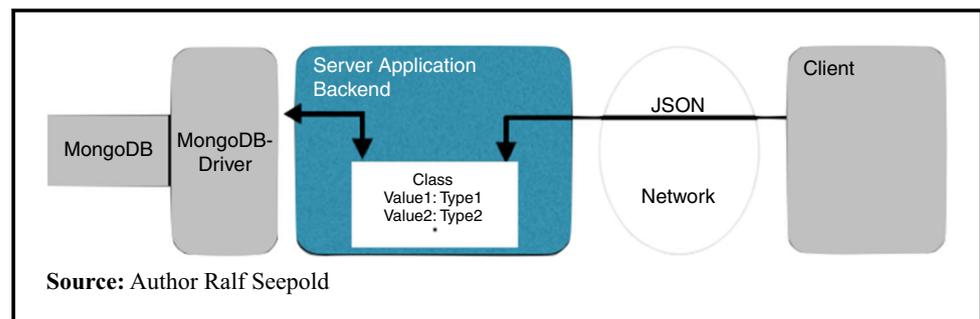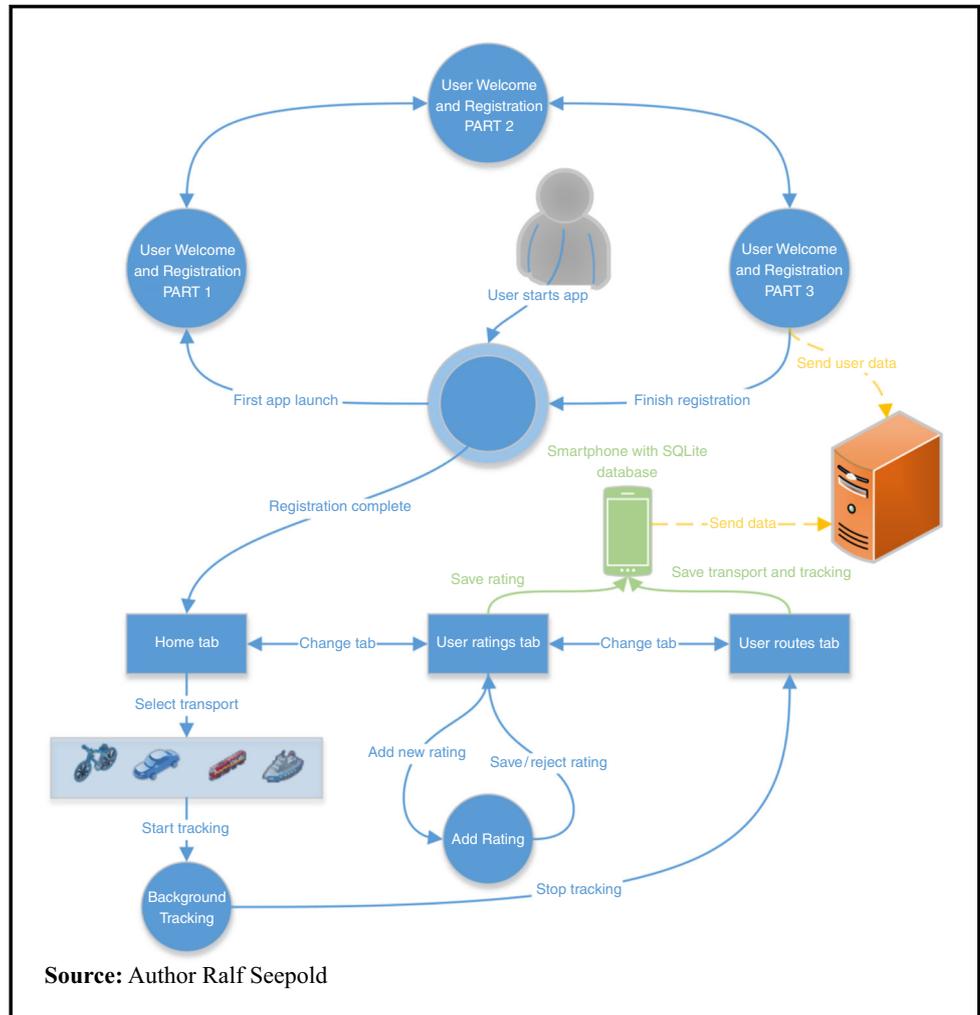
Figure 2 Client server architecture

Source: Author Ralf Seepold

Figure 3 Workflow

Source: Author Ralf Seepold

place. The main tab menu is divided into three different tabs, each having a different function. To change the tab, the user has to click on one of the two remaining tabs. The home tab will be the main (home) screen. Here the user can select from four different modes of transport and start the GPS-tracking function. Different colours for the visualized tracks indicate the mode of transport: red→car, green→pedestrian/cyclist, yellow→bus/public transport, orange→ferry. Furthermore, the user selects the type of transport with the help of an icon. In the user ratings tab the user can see his ratings. Each rating is ordered according to five possible stars (from the maximum number (best rating) down to no star). Via the action bar new icons can be imported, which allows the changing of the rating scale.

This interdisciplinary project combines a quantitative and a qualitative approach. Quantitative data were collected via loggers and the app, with the survey's quantitative and qualitative results complementing the exclusively quantitative approach of these devices. Theoretically, the app also allows the collection of qualitative data (e.g. via the travel diary), but this feature was not activated by the participants. The methodology follows the concept of simultaneous triangulation of methods and data, which is in line with former tourist-tracking research. For instance, Weber and Bauder (2013) used triangulation too, combining GPS-loggers, a survey and the analysis of travel guides, while Bauder *et al.* (2014) worked with a combination of GPS-loggers and a survey.

5. Findings

5.1 Triangulation

Since the app used in this study failed as a tracking technique, it can only be assumed that triangulation of the app/survey and the logger/survey would have led to the same result, since the technology behind them is the same. On the other hand, it is possible that using the app leads to a different movement behaviour on the tourist's part, precisely because it is interactive and thus may influence the tourists' movement patterns. It was proven from other studies (see above) that triangulation *per se* makes sense, because it balances or even neutralizes the disadvantages of the methods applied. This is clearly the case for the triangulation of logger and survey. On the other hand, the app offers chances that the logger and the survey cannot provide, therefore a triangulation of all three of them could still make sense. The logger does not influence tourist movement significantly, a finding in line with earlier studies, e.g. Chantel-Messer (2013). The app featured a data protection declaration. Around 65 tourists downloaded the app or promised to do so later in the day. Actually only two tourists registered via the app and only one activated the tracking mode. This participant, a repeat visitor, de-activated the tracking mode after just 380 metres, when walking in the old town of Constance.

However, each method applied in this study has its advantages and disadvantages (Table I).

Clearly, the app has so far failed as a tracking technique. The disadvantages and obstacles are too high to use it as a tracking method, according to the findings of this study. The loss rate from tourists being interested and downloading the app or promising to download it later (ca. 65) to tourists registering (2) and tourists activating the tracking mode (1) is far too high. Furthermore, any sample could easily be biased, because elderly people often do not have a smartphone but are an important tourist group at Lake Constance. Also, the added value of the app (e.g. calories or CO_2-tracking) did not outweigh the disadvantages. Thus the findings of McKercher and Lau (2009) can be confirmed – smartphone tracking is too invasive and leads to a refusal by the tourists to cooperate. However, marketing via social media among people who are more into new media, and therefore app affine, could offer a new approach. Survey and logger were used in this study independently. The logger being just one in a test mode worked without any problems and participants were easy to find. The only detail that could be improved was that the logger does not yet work indoors, which

Table I	Advantages and disadvantages of approaches in tourist tracking		
	Logger	*App*	*Survey*
Advantages	Is forgotten – tourists moves naturally Tourists cooperate easily Big sample size possible No smartphone required	Delivers additional information like mode of transportation, travel diary Can provide additional benefit like CO_2-tracking, calorie burning, etc. (enlargement towards quantified self)	Big sample size possible Tourists cooperate easily Qualitative in-depth-interviews possible
Disadvantages	Can get lost Cannot record and deliver as many information as the app Does not work indoors No real-time capability Need to be returned (risk of loss)	Tourists do not cooperate easily – app is considered as too invasive Does not work indoors Download procedure takes time Some elderly people do not posses a smartphone Sometimes technical malfunction High-loss rate from download to activation and use No differentiation between pedestrian and bike and between bus and train Marketing has to be improved, e.g. via social media	Duration of stay at points of interest cannot be collected properly Tourists have difficulties in describing or remembering their route

can be solved by a Wi-Fi or a bluetooth option in the future. Via the survey the highest amount of data sets was collected. The only disadvantage was that the results may be biased because tourists do not remember their route well.

5.2 Movement patterns

Movement patterns turned out to be diverse and highly individualistic within the rural destination of Lake Constance, while following an ants trail in sub-destinations like the town of Constance. Repeat visitors and first-time visitors alike always visit Constance and stay in the old town with the principal church and the Statue of Imperia as favoured locations. This was confirmed by the logger tracks and the survey results. The survey further showed that Constance and Mainau Island are the top tourist hotspots independent of the location of accommodation around the lake or whether the tourists were repeat visitors or not, followed by Meersburg, Lindau, Friedrichshafen and Radolfzell. Thus tourists do not only always return to Lake Constance, they also visit the same places again. Therefore, the movement patterns at Lake Constance are concentrated on the bigger towns there, but also on Mainau Island and Meersburg (a very small town but a popular day-trip destination); however, within the towns, the movement patterns show the same ants-trail pattern as the studies of other towns previously showed. Thus – although Lake Constance is a rural destination – tourism there is heavily focused on the several towns scattered around the lake. The rural area, which comprises most of the expanse of the destination, does not play a major role regarding the lion's share of tourists and their movements.

6. Limitations

The research limitations of this study result especially from the small sample size. Thus, the results must be interpreted as tendencies that still require proof in the form of a representative survey. However, the present findings are in line with those from former studies of towns and cities, and thus can be considered relevant. Since the logger was accepted regardless of age, several potential app participants, especially elder ones, did not possess a smartphone – therefore, any study with smartphone apps will be biased. This may be overcome in future when digital natives reach retirement age. Furthermore, the time budget for this study was limited to the period from April to June 2015, due to students' groups being deployed for data collection; this was not an ideal time, since the peak tourist season at Lake Constance is July/August – when the summer holidays in Baden-Württemberg coincide with the semester break.

7. Outlook – tourist tracking on track to tourist prediction

Tourist tracking is by no means a new field of research. Technology and methodology have advanced over time, and the underling questions regarding tourist movement patterns have evolved too (Van der Schaik, 2008). The technical possibilities of the app and its application to tourism should be examined further. If a bigger sample size of app tracking can be achieved, the results may lead to new insights into tourist movement patterns. The travel diary feature allows the tourist to comment on locations he or she is visiting and offers a whole new range of analysis options. Gamification may increase the attractiveness of the app even further and overcome the present reluctance of participants to use it. Triangulation of two or three methods should be intensified in order to find the best combination of tracking methods. Another aspect to deepen would be tourist typology: with a suitable app new categories of tourists' attributes could be explored that are of interest for rural destinations like Lake Constance. Another important aspect is finding out more about the movement patterns of tourists that specifically move around in the rural, non-urban spaces around the lake. These movement patterns are still completely unknown, but there can be no doubt of their relevance. Tourist tracking via smartphone app offers new opportunities regarding new kinds of data that could be collected. Marketing of the smartphone app should proceed via more suitable channels like social media. The app can constantly be modified, adding or removing features in line with evolving needs in the tourism industries. Thus the measurement of tourist movement patterns via app could become

very specific and tailored to the demand. The feeling of invasiveness while being tracked by an app is a problem for tourist tracking that may or may not be overcome in future. On one side, people are used to revealing everything about themselves in social networks; on the other side, they want to keep their private data protected. So far it is unclear how attitudes to this will evolve. The study was conducted in a purely German context with a high amount of elderly people. A younger society or one more open to tracking tourist routes in another cultural context could react differently. Another point of interest is how, and in what way, an app tracking a tourist influences the tourist's movement. In this regard, a triangulation of app and logger would surely yield results. Quantified self is another keyword that has become relevant with regard to smartphones: measuring the self, be it as a result of personal interest or advanced narcissism, may be added to tracking apps in various ways: speed, distance, number of sights visited – the possibilities are endless and the combination with tracking has yet to happen. Furthermore, the development of a prediction tool based on an algorithm might be a rewarding perspective. The aim would be to predict tourism appearance and density on a daily basis, as is already possible, e.g. in the crime prevention sector: Predictive Policing assigns probabilities of future crime events in space and time and displays crime risks based on an algorithm calculating criminal behaviour patterns. As a result, cities send police officers to areas where the probability of crime events is high, with the aim of preventing them from ever happening at all. Atlanta and Los Angeles, e.g. were able to reduce crime rates – using this prediction tool – by 10-20 per cent (Pred Pol). Applied to the tourism sector, an algorithm based on tourist movement patterns could be developed to predict tracks, scale the density of tourists and so enable the tourism industry to manage visitors in a highly detailed and specific way. Furthermore, if a prediction feature was added to the app: tourists would be able to avoid large queues, or a high density of tourists at tourism hotspots, by altering their route or postponing their visit.

One of the key future tasks will be the implementation of so-called "heat maps". That means visualizing spots in the web interface: showing areas with a high density of people and, as a corollary, areas with low-travel frequency can also be detected. For implementation of these maps certain clustering techniques will be needed. Basically, this means collecting a high amount of GPS coordinates and aggregating those close to each other into a single cluster. One possibility is the OPTICS algorithm (Ankerst *et al.*, 1999). This algorithm supports the clustering of individual spots (GPS coordinates) into larger sets, while respecting different clustering parameters. As an additional extension, the clustering could incorporate a time dimension showing location-based cluster-density information. This information could be used to explore the problem of predicting future behaviour from time-dependent data from the past.

8. Conclusion

The aim of this paper was, first, to identify movement patterns in the rural destination of Lake Constance taking first time and repeat visitors into account; second, to compare the different tourist-tracking approaches; third, to depict the consequences and options for the tourist industries; and finally, to shed some light on the past, present and future of tourist tracking. The results showed that tourists focus on the bigger lakeside towns, but also on day-trip attractions like Mainau Island and Meersburg. Within the towns, the movement patterns follow the often-cited ants-trail pattern, no matter whether tourists are first timers or repeat visitors. The study further showed that triangulation always makes sense, in order to balance the different approaches and to counter their respective disadvantages. The app-tracking technique has not so far succeeded, but it does offer avenues for further improvement regarding features and marketing. The consequences of success for the tourism industry will be manifold: tourist movements can be planned in an optimized way and steered on a daily basis; offers and packages can be correspondingly adjusted and predicted. A final point:, past tourist-tracking research has been focused more on exploring movement patterns *per se* and nothing else; the present focus is on amelioration of technical issues in different types of destinations; as for what the future may hold, we are looking at sophisticated prediction tools that allow completely new governance schemes for tourist destinations.

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