GPS HRN
GLOBAL POSITIONING SYSTEM in Health Research Network

NEWS UPDATE

January 2013

Cyclist's radius of action – GPS-derived activity space

Thomas Madsen
University of Southern Denmark

The association between the built environment and walking is well studied, but there is an absence of literature concerning the relationship between the built environment and cycling for transport. Many major cities and countries have discovered the potential for the bicycle to replace the car for shorter trips in everyday transport, and are consequently looking for ways to improve cycle mode share. This could mean changing the built environment; for example, land use mix, retail floor area ratio, parking facilities, cycle paths and cycle friendly intersections appear to be related to bicycle use. Some of these factors are also related to walking; indeed, some studies have shown that walkability index scores are also positively associated with cycling at the zone level. One potential problem in using walkability scores to 'calculate' bikeability is the obvious difference between walking and cycling, primarily in regards to travel speed and therefore radius of action.

Following a study on environmental factors related to cycling as active transportation, a discussion on the radius of action for various segments within everyday transport arose. The study measured walkability within zones used in the Danish National Transportation Survey (DNTS), and showed positive association with cycle and walking trips and negative association on passive transportation (Madsen et al. 2012). The association was diminished by including educational level, age and city in a multiple regression model, suggesting that active transportation is related to a variety of behavioral factors. Furthermore, the size of the DNTS zones seemed somewhat reasonable when studying walking, but as the Danish cycling culture is well developed (many people cycle over large distances), there might be a need to reconsider the size of the cyclist's radius of action. Many cyclists can easily cover 5 km, and in many Danish cities, this will mean that they will be able to cycle all over the city. The question is: do cycle all over the city, or only in a certain area of the city? Perhaps our geospatial analysis should encompass cities instead of neighborhoods or at least find a more suitable buffer or activity space.

In order to better understand where cyclists go, we conducted a GPS study on regular cyclists in Denmark's second largest city, Aarhus. The cyclists were recruited from an IPEN (International Physical Activity and the Environment Network) study, where people have answered questions on transport mode and stated if they were regular cyclists (cycling > 1 time per week). Our GPS study of cyclists' radius **(continued on next page)**

Note from the editor

Hello everyone

Happy New Year!

I hope you all had a productive and enjoyable 2012. In this issue of the GPS-HRN newsletter we feature an excellent contribution from Thomas Madsen, PhD student from the University of Southern Denmark. We were fortunate to have Thomas spend some time with our research centre last year; his ongoing work developing the 'bikeability' index is essential for identifying neighbourhoods that are unsupportive of cycling.

We also have an excellent article by Dr Jon Moon, President of MEI Research Ltd. Dr Moon is doing some superb work combining custom smartphone apps, sensors, real-time data transfer, and web services for utilisation in health research. For those of you interested in smartphone technologies, I strongly recommend you visit his website (actipal.com) to learn more about the ActiPal system.

On another note, you may be aware that several GPS-HRN members are working towards a collaborative initiative that aims to standardise GPS data collection and processing protocols while providing a platform for ongoing collaboration and data sharing. While it is still very much a work in progress, I will keep you abreast of any major developments.

Please remember to post any GPS-related news or information you come across on our website: www.gps-hrn.org.

All the best

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(continued from previous page)
of action is part of ongoing research into standardizing GPS procedures in health research and in time allow for meaningful comparisons across studies and populations.

Of the 92 respondents that participated in the study, 81 returned the GPS receiver with sufficient data to be included in the final study. A QStarz BT-Q1000X GPS receiver was used to collect positional data, and respondents were instructed to wear the GPS whenever they cycled for a period of seven days (Wednesday to Wednesday). After retrieval of the GPS receiver, the raw GPS data were uploaded to PALMS (see GPS-HRN Newsletter #7) and the process of selecting the data filtering parameters began. Choosing the settings in PALMS that best reflect human behavior was more complicated than expected. For example, it is difficult to know when a cycle trip is a trip or merely a pause due to traffic or other reasons (meeting a friend, stopping to answer the cell phone, mechanical problems etc.).

In Figure 1, GPS tracks from one respondent are shown with an activity space polygon drawn around the tracks. The question in hand is whether this activity space mimics this person's 'real' activity space or if it is just a 'behavioral snapshot'? From the travel diary we know that the person received some kind of treatment on a location furthest away from home, and it is likely that this is not a regular activity and hence does not represent 'normal' transport patterns.

Figure 2 shows results from the analysis of walkability and active transportation and highlights the challenge when attempting to make sense of the remaining 80 GPS datasets. Several papers have addressed this challenge and discuss the use of activity space, home range, kernel density estimation, daily life centers (hotspots), road network buffer, and relative time travel zones. Our final analyses will likely include similar or identical methods.

We now need to find a way to calculate the best buffer around the waypoints/tracks to create a feasible activity space or area in which we can develop a bikeability index for future use. At present time the method described by Shannon Zenk and colleagues (Health & Place, 2011), among others, of using standard deviation ellipses seems like an appropriate choice. They describe how the calculated activity space based on standard deviation ellipses resulted in larger areas than the residential neighborhood. We believe that this method will yield larger areas in our study as well, which will better reflect cyclists' transport behavior.

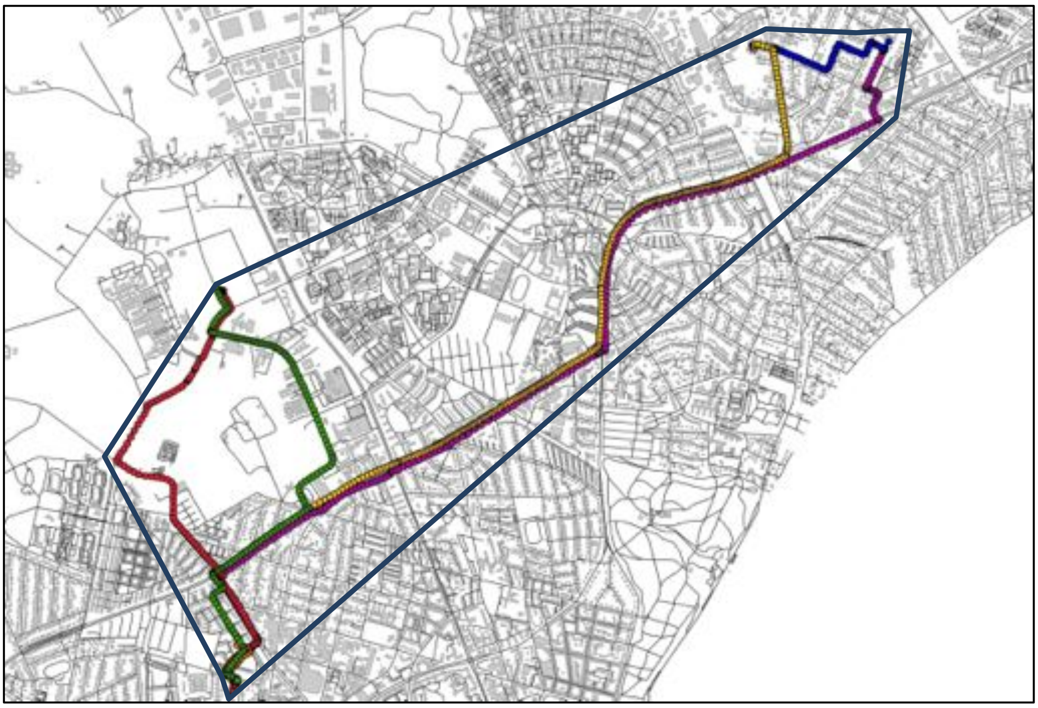
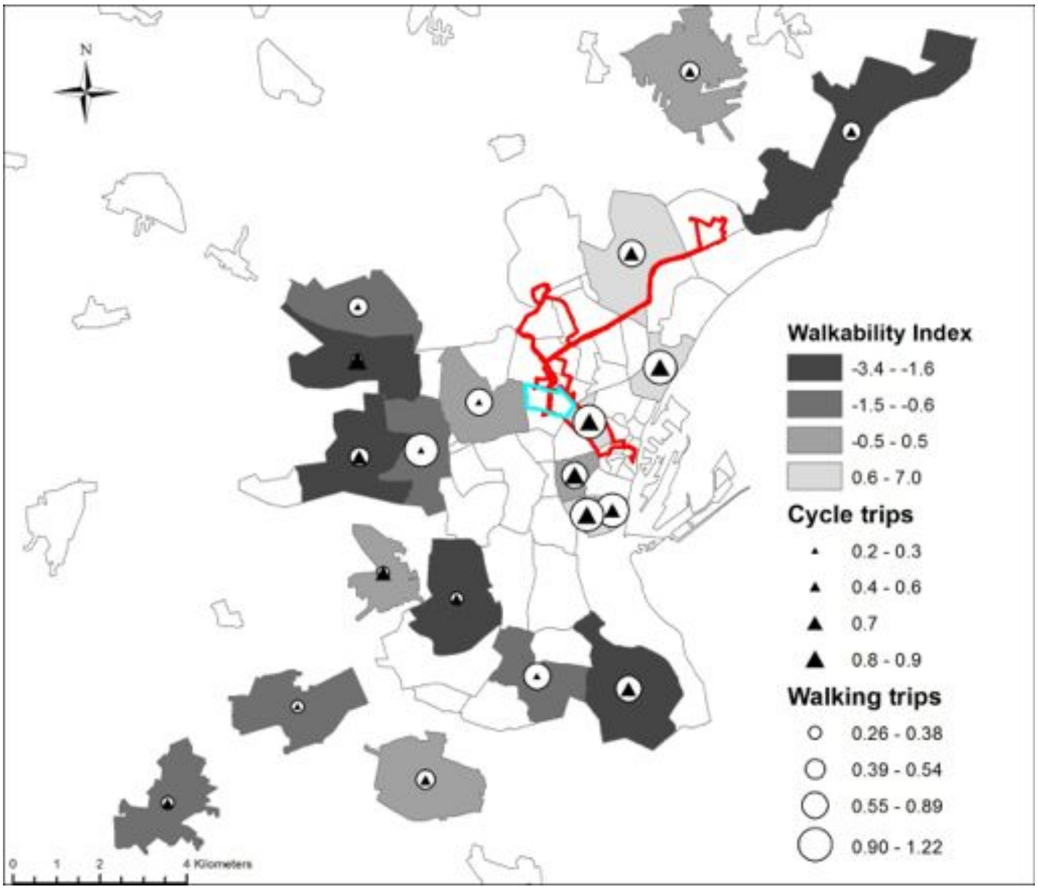


Figure 1. Six GPS tracks from one respondent on one day. Different colors represent the trips. The tracks show different routes to the same destinations, indicating that the build environment affects the route choice. The blue polygon represents the person's activity space for that day.

Figure 2. Twenty DNTS zones in Aarhus with Walkability index scores, cycle trips and walking trips as well as GPS track (red line) from one respondent living in the turquoise DNTS zone. It is obvious that most cycling is outside the residential zone, indicating that another zone definition is needed.



Technology update: Free smartphone apps for logging sensor data

The potential of smartphones as all-in-one monitoring and intervention delivery devices for health research is becoming increasingly obvious. Dr Jon Moon's article on the following page outlines how smart mobile devices can be integrated into a custom-designed data collection and management system that allows multiple health behaviours and contexts to be monitored in real-time. At a more simplistic level, there are a number of generic smartphone applications that allow GPS and accelerometer sensor data to be logged for manual retrieval after a specified time period. These basic applications are a good way for researchers new in the area to get a feel for the types of data that can be collected on participants' existing devices. Here are two examples of data logging apps freely available for the Apple iOS and Android platforms that you may wish to try.

DataLogger+

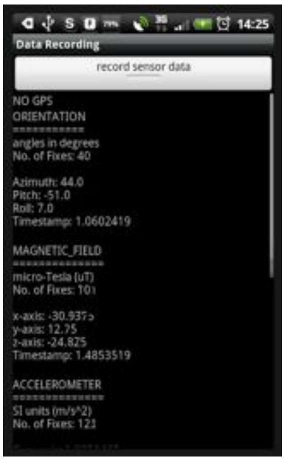
Centre for Mobile Education and Research

This easy-to-use app allows users to simultaneously capture data from multiple sensors on their Apple iPhones, iPod touches, or iPads. Data from the onboard accelerometer, gyrocope, teslameter, GPS receiver, battery, and microphone can be viewed in real time and logged for export in CSV or XML format. The frequency and scheduling of the data collection can be specified. There is even a filter function that allows users to access basic descriptive statistics for a given session. Importantly, this app continues to log data in the background.

Data Recording

Thomas Wolf

While perhaps not as user friendly as the DataLogger+, the Data Recording app allows users to observe and log data from a range of sensors onboard any smartphone that runs the Android operating system. Accessible sensors include accelerometer, gyroscope, teslameter, GPS receiver, and light sensors. The data collection period can also be specified. At present the app cannot run as a background service, although the developer plans to remedy this in future releases.



Recent Research

P Baranski & P Strumillo

Enhancing positioning accuracy in urban terrain by fusing data from a GPS receiver, inertial sensors, stereo-camera and digital maps for pedestrian navigation

Sensors, 2012, 12(6), 6764-6801.

J Beekhuizen, H Kromhout, A Huss & R Vermeulen

Performance of GPS-devices for environmental exposure assessment

Journal of Exposure Science and Environmental Epidemiology, 2012, doi:10.1038/jes.2012.81.

BJ Boruff, A Nathan & S Nijenstein

Using GPS technology to (re)-examine operational definitions of 'neighbourhood' in place-based health research

International Journal of Health Geographics, 2012, 11(22), doi:10.1186/1476-072X-11-22.

P Collins, Y Al-Nakeeb, A Nevill & M Lyons

The impact of the built environment on young people's physical activity patterns: A suburban-rural comparison using GPS

International Journal of Environmental Research and Public Health, 2012, 9(9), 3030-3050.

GF Dunton, Y Liao, E Almanza, M Jerrett, D Spruijt-Metz & MA Pentz

Locations of joint physical activity in parent-child pairs based on accelerometer and GPS monitoring

Annals of Behavioral Medicine, 2012, epub ahead of print.

T Kim, K Lee, W Yang & SD Yu

A new analytical method for the classification of time-location data obtained from the global positioning system (GPS)

Journal of Environmental Monitoring, 2012, 14(8): 2270-2274.

DM Tuan Nguyen, V Lecoultre, Y Sunami & Y Schutz

Assessment of physical activity and energy expenditure by GPS combined with accelerometry in real-life conditions

Journal of Physical Activity and Health, 2012, epub ahead of print.

Managing sensor and survey studies

Dr Jon Moon
MEI Research, Ltd

In 2007 we realized (along with everyone else) that cheap wireless sensors combined with smart mobile devices to form body area networks (BAN) would dramatically change studies of freely-living individuals. BAN can combine objective sensing with ecological momentary (subjective) assessments (EMA) through a rich and familiar user interface. Later, researchers learned that they might drown under the flow of data and complexity of managing devices, participants and communications in real time. An automated solution was needed to make such studies manageable.

Grants to MEI Research from the US Department of Agriculture (USDA) created the modular "ActiPal" BAN software that includes capability to gather continuous readings from any sensors on board an Android device (accelerometer, GPS, RFI location, gyroscope), collect data from other sensors linked to the BAN, administer remotely-configured EMA surveys, and gather dietary intake reports. We will soon be expanding to iOS devices. The USDA projects produced numerous ActiPal modules, and each time another ActiPal component is written for a study it becomes available to other investigators. We have found that this accumulation approach reduces the cost of software by up to 80% compared to other options. ActiPal is native software (it is compiled for the specific smart device) and does not require an internet connection to operate. This ensures that it functions in any situation to capture sensor data and EMA locally.

The Figure illustrates an approach we have taken with "PiLR Healthware", a server platform, to manage a BAN, such as ActiPal, and other moving parts in a study. As participants are enrolled they are assigned to a BAN device (either their own smart mobile or one provided by an investigator) and linked to other available sensors such as heart rate and physical activity monitors (Panel 1). This ensures that data uploaded from the BAN are associated with that participant. Communications between the BAN and PiLR are nearly constant when there is an internet connection, but are initiated by the mobile client to save battery and processing resources. Work on PiLR at MEI is funded, in part, by the US National Cancer Institute.

The fastest growing application of PiLR Healthware with BAN is to collect and integrate objective and subject-reported data. This enables objective data to be "context aware" and enhances EMA to be effective and "actionable". Through a web interface investigators can setup EMA instruments (usually surveys), assign them to individual participants or groups, and determine when surveys are delivered (Panel 2). EMA triggers may be based on time, location, level or type of physical activity or events marked by participants (for example, deciding to smoke). Progress is being made now with "ecological momentary intervention" (EMI) where objective information triggers timely interaction with a participant. For example, arrival at, or departure from, a specific location (e.g., home, restaurant, intersection) results in a conversation with a participant (e.g., about mood, menu choice or route).

Progress of the overall study or of each participant may be viewed in a real-time dashboard (Panel 3). Raw data by subject or across the study are available from the dashboard, as are summaries prepared by statistical and categorical algorithms. The investigator can use the dashboard to review progress of the study, participant compliance and data quality. One particularly helpful report is the "App Log" from the BAN that describes program and device status (time, internet connected), actions taken by the participant (on charger, took a survey), and delivery of prompts and notifications.

Raw data and summaries may be prepared automatically by processing plug-ins and reported (Panel 4), or data may be exported to more sophisticated processing systems such as PALMS or statistical packages like Matlab or SPSS (Panel 5). More and more we are eliminating intermediate and cumbersome steps, such as having to download data separately from each device to a PC application, then exporting and finally uploading again before a PALMS or other process can be applied.

MEI provides customized technologies needed by institutions and investigators. We seek, as well, to understand the science behind tools that we build, including in metabolic energy balance, physical activity, behavior management and, more recently, addiction. Many configurations of ActiPal and PiLR are available and ready to be used in a variety of studies.

For more information, contact Jon K. Moon, PhD, President, MEI Research, Ltd, 4210 Park Glen Rd, St Louis Park, MN 55416.
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http://meinergy.com/ http://actipal.com/

MEI Research

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Research profile

Active Living Research Unit

University of Southern Denmark

The Active Living Research Unit was established in January 2006 and reorganized in January 2010 with the ambition of developing research-based knowledge about the significance of physical space for movement. The aims of the research unit are to conduct interdisciplinary studies of physical environments for play, sport, outdoor life and physical activity triangulating the theories and methods of sociology, anthropology, psychology, epidemiology and cultural analysis.

Furthermore, the unit seeks to develop existing theories and analytical models into a more nuanced understanding of the links between space and movement. This implies developing methods for the collection of knowledge about the links between space and movement. The goal is to create practically oriented knowledge that can qualify international and national partners in their work to establish spatial environments more conducive to activity for play, sport, and outdoor activity as well as for recreational and transport-related physical activity.

The research unit's ambition is to make its mark internationally with research results published in highly regarded periodicals and English-language books. At the same time the group will continue to initiate and conduct large-scale studies that maintain and gradually extend the number of group members, so that the Active Living Research Unit play a central role in the national and international research field in the future.

Selected research projects

- School yards, Playspot, Active transport, Club fitness and Environment (SPACE). Contact: Jens Troelsen.
- When Cities Move Children (WCMC). Contacts: Charlotte Demant Klinker and Jasper Schipperijn.
- Improving Infrastructures for Leisure-Time Physical Activity in the Local Arena (IMPALA). Contact: Mette Toftager.
- Sports facilities in Danish local authorities. Contact: Jens Høyer-Kruse.
- Bikeability: Cities for zero emission transport and public health. Contact: Thomas Madsen.
- International Physical Activity and Environment Network Study (IPEN). Contact: Lars Breum Skov Christiansen.
- TRYG in the great outdoors – Risk and safety in relation to outdoor activities. Contact: Søren Andkjær.
- DGI byen's project Go-Active on Vesterbro in Copenhagen. Contacts: Lise Specht Petersen and Jan Toftegaard Støckel.
- Valuing detours in the community. Contact: Jens Troelsen.

IPEN
INTERNATIONAL PHYSICAL ACTIVITY AND THE ENVIRONMENT NETWORK

IPEN was launched by Professor Jim Sallis (USA), Dr Ilse DeBourdeaudhuij (Belgium) and Professor Neville Owen (Australia) at the International Congress of Behavioral Medicine in Mainz Germany in August 2004.

Physical activity habits are determined by multiple levels of influence – personal, family, social, environmental, economic and other factors. Ecological models of health behaviour have been used to synthesize research at these different levels, and to focus attention on relationships of particular physical activities with specific attributes of physical environments, including the built environment.

While physical activity environments will vary within countries, the greatest and most informative sources of variation in the relationships of environmental attributes with physical activity are likely to be between countries. The IPEN initiative seeks to stimulate, inform, and support systematic and rigorous studies of physical activity and the environment, in as many countries as possible.

Please contact Jacqueline Kerr (jkerr@ucsd.edu) or Nicole Bracy (nbracy@projects.sdsu.edu) if you would like more information.

www.ipenproject.org

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