GPS HRN
The GLOBAL POSITIONING SYSTEMS in Health Research Network

NEWS UPDATE

January 2012

An Introduction to PALMS

PALMS Project Team
UC San Diego

PALMS (Personal Activity Location Measurement System) is an easy-to-use web-accessible service for locating physical activity in time and space. PALMS was developed by researchers at University of California, San Diego (UCSD) in the Center for Wireless and Population Health Systems, Calit2, and the Department of Family and Preventive Medicine, School of Medicine. PALMS was funded by the National Institutes of Health, Gene-Environment Initiative, (Grant 1 U01 CA130771).

The main function of PALMS is to store, process and merge time-stamped data from sensors worn by free-living humans. It is being developed and maintained to support three kinds of users: a) those who want to analyze their own data; b) those who might wish to share their data with others as well as explore how data from others can add value to their own data; and c) third party users of PALMS data who might have research questions of their own that can be explored through the use of PALMS data that are offered by the primary researchers who initially collected the data. We envision a community of users that helps shape PALMS in the future, and that it be governed in a way that protects researcher rights and responsibilities, participant anonymity, and regulatory requirements from such entities as HIPAA and FISME.

PALMS presently accepts and processes time-stamped data from accelerometers, heart rate monitors, and GPS devices. In the future, capabilities to process data from other sources, such as wearable environmental sensors, will be included. PALMS is flexible so that data from updated versions of existing devices as well as new devices can be added at minimal cost. PALMS can aggregate epoch-based data into more manageable files, for example, by day, participant or event. PALMS output files can be exported into other software packages, such as SPSS, ArcGIS, and in KML files for visualization.

One of the features of PALMS is its calculation functions, which identify variables of interest, including trips, transportation modes (e.g., walking or vehicular), physical activity intensity, and personal activity location cluster points. PALMS allows users to select parameter settings to meet their specific study needs. This enables researchers to assess the impact of various parameters on their results, save parameter protocols for replication in other studies, and share them with researchers interested in advancing the field of location and activity measurement.

We are currently validating the PALMS algorithms in an NIH funded trial. A total of 714 protocolized travel trips were made by trained researchers. They carried 2 GPS models set to collect data every 5, 15 and 30 seconds. Trips across four transportation modes (bus, car, walk, cycle) were made in open space locations or downtown corridors (with more signal interference from buildings) with either continuous transitions across modes or with planned pauses. Start and end times of the journeys were noted to provide an annotated 'truth' file to match to the processed GPS data. Sensitivity and specificity were tested and algorithm classification was considered correct if transportation mode was correct for 85% of the trip. We are discovering that the accuracy of the trip prediction can be greatly affected by location and pauses and are working with researchers in Denmark and Hong Kong to collect more data to identify the factors that impact algorithm precision. In the future, we hope to integrate more sophisticated algorithms into our suite (e.g. based on machine learning, or other open source

Note from the editor

Hello everyone

I hope you have all had a very Merry Christmas and Happy New Year.

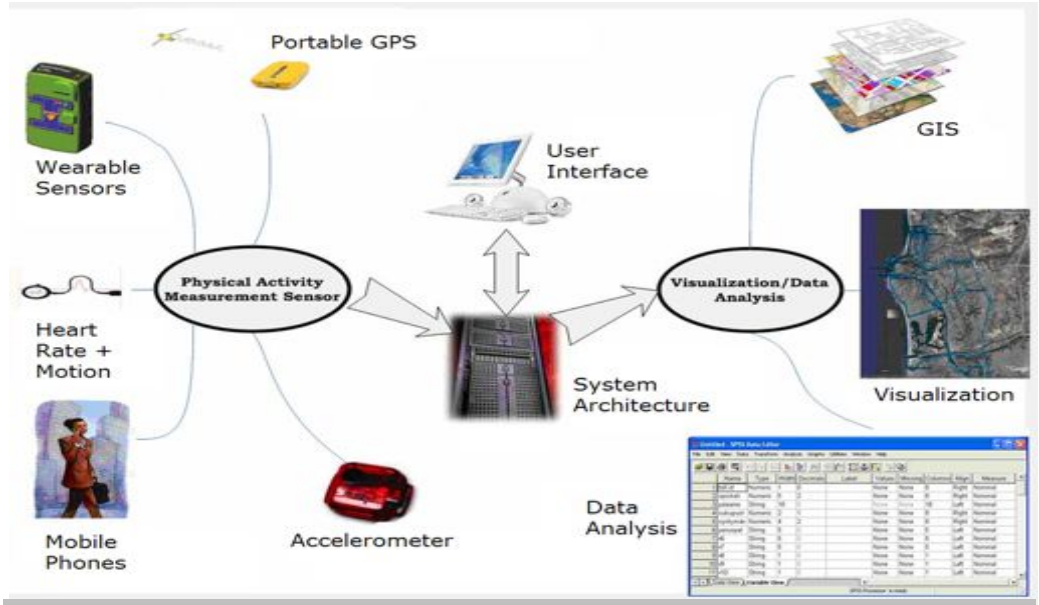
The new year brings with it some exciting changes to the GPS-HRN. As we near 200 members we have undergone a recent restructure to strengthen our strategic focus. Dr Jacqueline Kerr (Treasurer) and Dr Jasper Schipperijn (Communications Officer) will join Prof Schutz (Chair), Dr Melody Oliver (Secretary), and myself (Vice Chair) on the new Executive Committee. We hope that with the new structure we will see some real progress with our international collaboration.

This special issue of the GPS-HRN newsletter focuses on the PALMS initiative coordinated by our colleagues at UCSD. PALMS is an online platform for processing and merging data collected from activity/location sensors (such as GPS and accelerometers) that I'm sure will be of use to many of you. Having used it myself, I can safely say that PALMS can save users from spending untold hours manually processing their data.

I would also like to draw your attention to the next meeting of the GPS-HRN, which will take place at the 2012 Annual Meeting of the ISBNPA in Austin, Texas (May 23-26). We intend to use this meeting for both general networking and to discuss the formation of a multi-country partnership for obtaining joint research funding. I will send an email with the date and location nearer the time. I do hope to see you there.

All the best

Dr Scott Duncan, Lead Editor
AUT University
Auckland, New Zealand
scott@gps-hrn.org



Overview of the PALMS system

programs). We welcome collaborations with other researchers to test and improve PALMS algorithms and can provide our annotated data set for other researchers to compare to their existing processing systems. Our validation and processing protocols are available for researchers to use to test the conditions under which GPS may function best in their region.

During the development of PALMS, we have collected GPS, heart rate and accelerometer data in several studies. Based on this experience we have developed materials that are available to help researchers work with different devices, collect data from participants, and test PALMS parameters.

PALMS has been developed to meet user needs. There are currently 56 users from 9 countries. We are keen to support more users and respond to user feedback. PALMS is currently freely available online to those with a valid username and password. Please contact PALMS staff at: palms@ucsd.edu to request a username. Technical support and topic expertise is also available. Initial consultation is provided at no cost with additional services available at reasonable prices. For additional up-to-date information and/or to share experiences and learning, please visit the PALMS Wiki at: http://ucsd-palms-project.wikispaces.com/

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

Recent Research

PJ Krenn, S Titze, P Oja, A Jones & D Ogilvie

Use of Global Positioning Systems to study physical activity and the environment: A systematic review.

American Journal of Preventive Medicine, 2011, 41(5): 508-515.

J Kerr, S Duncan & J Schipperijn

Using Global Positioning Systems in health research: A practical approach to data collection and processing.

American Journal of Preventive Medicine, 2011, 41(5): 532-540.

S Mavoa, M Oliver, K Witten & HM Badland

Linking GPS and travel diary data using sequence alignment in a study of children's independent mobility.

International Journal of Health Geographics, 2011, 10:64.

B Noury-Desvaux, P Abraham, G Mahe, T Sauvaget et al

The accuracy of a simple, low-cost GPS data logger/receiver to study outdoor human walking in view of health and clinical studies.

PloS One, 2011, 6(9): e23027.

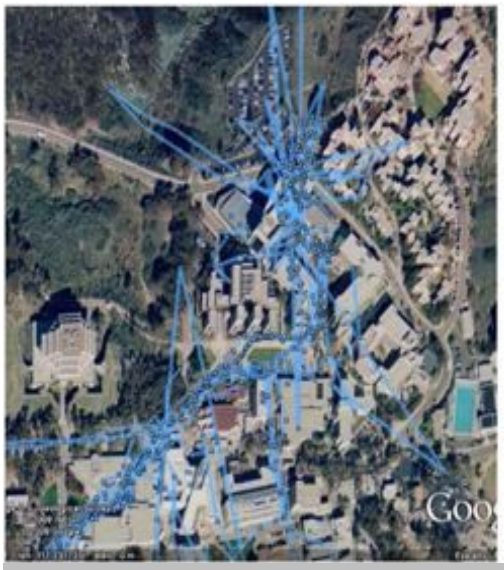
The 2012 Annual Meeting of the International Society of Behavioral Nutrition and Physical Activity will take place at the Four Seasons/Austin Convention Center, May 23-26.

A meeting of the GPS-HRN will be organised to facilitate general networking and to discuss our plans to secure funding to support a multi-country collaborative initiative. The date and location of the meeting will be confirmed nearer the time.

If you would like to express your interest in attending this meeting, please email Scott Duncan at scott@gps-hrn.org.

A closer look at PALMS GPS data processing

Fredric Raab
UC San Diego



GPS data before and after processing by PALMS

PALMS processes time-stamped data from GPS dataloggers, accelerometers (Actigraph, ActiCal), heart rate monitors (ActiHeart, ActiTrainer, BioHarness) and merges each data stream to the desired interval. The processing algorithms are driven by a set of parameters and threshold values. The default values are visible to the researcher, and can be modified and saved. Optimal settings can be tuned to the study's population and research questions.

The GPS processing algorithms clean the data, removing the errors caused by indoor jitter and outdoor multipath reflections. Once the errors have been removed, the data is analyzed to detect indoors/outdoors positions, trips, locations and modes of transportation.

The processing is done in multiple passes; the output of one pass becomes the input of the next. A typical sequence of passes would be: preprocess data, clean data, detect trips, detect locations, and classify mode of transportation.

The preprocess pass computes derived variables (duration, distance traveled, direction (bearing), speed, acceleration, elevation delta) from the inputs supplied by the GPS (timestamp, latitude, longitude, elevation). These calculations are straight-forward spherical geometry.

Some GPS devices can be configured to report the number of satellites detected overhead, the number used to compute the position, and the signal strength of each satellite. If this information is available, the preprocessor can imply if the GPS was indoors or outdoors. By considering the ratio of satellites used / satellites detected and the total signal strength, the indoor/outdoor condition can be estimated.

The derived variables are used to clean the data. Excessive speed, acceleration, distance traveled, and/or elevation deltas are often caused by multipath reflections (satellite signals bouncing off near-by buildings). These points can be removed from the dataset. Likewise, small movements (> 10 meters), or back-and-forth movements are typical of indoor jitter. And these points can be removed. When removing points, the derived variables of the adjunct points are recalculated.

Trips are detected based on the distance traveled over time. If in one minute, the user is more than X meters away from the current position, then the current position is marked as the start of a trip. As long as the person keeps moving at greater than X meters per minute, the positions are marked as mid-points of the trip. When the person stops moving for Y minutes, those positions are marked as pause points. When the person is paused for a total of Z minutes, then the trip has ended. The initial pause point is remarked as the trip's end point and the other pause points are marked as stationary points. (Note: X, Y and Z are parameters that can be defined by the researcher. Typical values are X = 30 meters; Y = 3 minutes; Z = 5 minutes.)

The location detection algorithm uses trip start points, end points and (optionally) pause points as the initial location estimates. For each of these points, the algorithm counts the total number of GPS positions within X meters of the location. It then looks for overlapping locations (within X meters of each other) and the location nearest the majority of total positions is marked as the center of the cluster. The other overlapping location estimates are removed.

Once locations are determined, the algorithm reconsiders detected trips based on parameters supplied by the researcher. For example, the researcher may choose to discard trips less than a minimum duration or length; or trips that occur solely within one location.

Once trips are reconsidered, the mode of transportation can be implied. The algorithm uses the N-percentile of speeds over the course of the trip, and classifies the mode based on cutoff values. A problem arises on multi-modal trips, i.e.: walking-vehicle-walking. If pause points and changes in speed are identified, then analysis is done over each of the trip segments, resulting in a better classification.

PALMS can merge data streams collected at different epochs. For example, GPS data may have been collected every 10 seconds, accelerometer data every 15 seconds and heart rate every 60 seconds. PALMS will align each data steam to the interval desired for analysis by the researcher. This is accomplished by adjusting the timestamps to align to a common timeline and integrating over-sampled data streams.

For additional information about PALMS dataflow, calculations and output variables, please visit the PALMS Wiki at http://uscd-palms-project.wikispaces.com.

PALMS user profiles

Drs Ester Cerin and Teresia O'Connor

Dr Ester Cerin at the University of Hong Kong and Dr Teresia O'Connor at the USDA/ARS Children's Nutrition Research Center at Baylor College of Medicine, in Houston Texas are collaborators and PALMS users since 2010. They are working on a project aimed at assessing the feasibility of simultaneously collecting accelerometer and GPS data in Latino preschool children in Houston, Texas in order to subsequently pilot test a model of environmental (neighborhood) and social (parental and cultural) influences on young Latino children's physical activity. The pilot study is funded by the Eunice Kennedy Shriver, National Institute of Child Health and Human Development.

While attending the first annual PALMS Users Conference in February 2011 they were able to spend time with the PALMS group and learn the program. Since then, they have been able to access the program remotely to process and help analyze data on a small sample of 15 children to pilot test the protocols and algorithms, the results of which will be presented at the 2012 Robert Wood Johnson Active Living Research Conference in San Diego. They are currently collecting data on 80 Latino children in Houston for 7 days to further test the feasibility of combining and processing such data. "*If we had to develop the algorithms and validate them from scratch, this project would be much more cumbersome and costly. By collaborating with the PALMS group, we can assure that we are using standard processing protocols and help them by refining and testing their algorithms with younger samples and in new geographic locations*."

Dr. Cerin is also conducting a study aimed at validating the current PALMS algorithms using data collected in Hong Kong. Hong Kong is an ultra-dense metropolis posing particular challenges to GPS data collection due to its exceptionally hilly terrain, numerous covered and underground pathways, and urban canyons. To be useful to international researchers, PALMS algorithms need to be cross-validated in diverse geographical locations with varying urban forms. In this sense, Hong Kong represents an ideal location because it significantly differs from the site where validation data for PALMS were collected (San Diego, USA).

Dr Jasper Schipperijn

Dr Schipperijn is a researcher in the Institute of Sports Science and Clinical Biomechanics, at the University of Southern Denmark. He has been a PALMS user since 2009. Dr Schipperijn and colleagues have collected GPS and accelerometer data on over 800 teenagers in Denmark at two time points to assess the impact of an urban renewal project on physical activity patterns and locations, as well as schoolyard interventions.

Dr Schipperijn spent time with the PALMS team in San Diego in 2010 and 2011, testing different versions, providing feedback on the system, and helping to develop tools to integrate PALMS more easily into ArcView GIS. He attended the 1st PALMS User's conference at UC San Diego in February 2011.

Like others, Dr Schipperijn found that PALMS enabled him to merge and process his GPS and accelerometer data without having to develop the algorithms himself. Many projects have to cobble together some software with available funds and expertise. They are often temporary solutions and only apply to the research project in question. PALMS was designed to prevent each new group re-inventing the wheel with every new device or research question. The PALMS algorithms and parameters are flexible to allow users to "program" PALMS to fit their project needs and the cyber infrastructure that is the backbone of the system provides an architecture to accommodate new devices, data types, and algorithms.

Dr Schipperijn notes "*Without the PALMS flexibility and great expertise behind the PALMS algorithms we would simply not have able to carry out our project as planned. Besides the obvious technical advantages of being a PALMS user, we also feel that becoming part of the PALMS user network has been invaluable in facilitating contact to other researchers around the world working with similar issues*."

PALMS developer profile

Dr Jacqueline Kerr

Dr Kerr moved to San Diego in 2004 and has been working with Drs Sallis and Patrick at UC San Diego, focusing on research related to the field of Active Living. She has been a co-investigator on the PALMS project since its start in 2008 and continues to help seek funding to support its maintenance, including a project in over 200 Latina women to test PALMS in a new population group. Her role on the PALMS project has been to outline the PALMS functionality, as a typical GPS and accelerometer user trying to identify where physical activity takes place. She has also been responsible for user outreach, organizing the 1st PALMS User Conference, and helping to develop user and participant materials. She has also designed and supervised data collection for the PALMS validation study.

Dr Kerr is collecting GPS and accelerometer data in several of her NIH-funded projects and provides support to many other collaborators to write grants that include this type of data collection. With Dr Sallis, Dr Kerr has helped collect GPS and accelerometer data on over 800 teenagers in Seattle and Baltimore as part of the Teenagers' Environment and Neighborhood (TEAN) project and will collect GPS and accelerometer data on over 500 older adults as part of a follow up to the Senior Neighborhood and Quality of Life Study (SNQLS). She is also leading a Multilevel Intervention for Physical Activity in Retirement Communities (MIPARC) where over 300 older adults are instrumented every three months for a year to assess whether the intervention, which includes community improvements, affects their physical activity patterns and locations.

Dr Kerr is a leader of the GPS in Health Research Network and would like to help lead a grant that collects GPS and accelerometer data in multiple countries around the world to better assess the relationship between built environments and physical activity.

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