Master thesis / Research project

Analysing human movement trajectories:
visualization and extraction of meaningful interactions

Context
Patients living with dementia are traditionally cared for in closed departments of nursing homes. In a large project, researchers will evaluate how an open living environment, where patients can move freely, affects patients' quality of life. For this thesis/research project, the focus lies on visitors and people living in the immediate surroundings of a nursing home. They will also be affected by the changes, as they will get more exposure to patients with dementia. In a first round of data collection, we asked park visitors to carry a GPS tracker while visiting the park.

We suggest two student projects to work with this trajectory data. One will focus on the visualisation of human trajectory data, while the other will focus on the extraction of interaction moments from those trajectories.

Useful courses to have followed: *Information Theoretic Data Mining*, *Urban Computing*

Key terms: Minimum description length principle, change-point detection, visualization, human mobility and interaction

1) Change Point Detection and Visualization of human movement trajectories

Goal: The overall aim is to use an existing data set to create a visualization of movement patterns. To achieve a good visualization, several methodological challenges need to be overcome:
Methodological challenge I: find a way to deal with the noise in the data
Methodological challenge II: find a way to extract stop-and-go segments/change points from the data

Research questions: Which algorithms exists to detect change-points/way points in trajectory data? What are their characteristics and can we use them on the collected data? How can we translate the extracted information into an appealing visualization?

Realisation
Bachelor students:
Use an off-the shelf method to extract change points from the data
Visualize the data in a meaningful manner
(Test the "intuitiveness" of the visualization with expert group)

Master students:
Compare several methods for segmentation and change point detection and evaluate on the existing data set
AND either a theoretical (thesis project) or practical extension (research project):

- theoretical extension: come up with your own minimum description length (MDL) based method to extract change points / segmentations
- practical extension: collect your own data set and validate your findings on that data set (visualize the data in a meaningful manner)

2) Automatic Extraction of Interaction Moments from human movement trajectories

Goal: The overall aim is to automatically extract interaction moments between visitors from an existing set of trajectories. To achieve this aim, several challenges need to be met and overcome:
Methodological challenge I: find a way to deal with the noise in the data
Methodological challenge II: find a way to extract stop-and-go segments from the data

Research Questions: How can we learn what meaningful interactions are from the data? How long are those interactions? Can we use additional information to learn better from the trajectory data?

Realisation (master students only)**:**
Extract change-points with off-the-shelf methods and compare them
AND either a theoretical (thesis project) or practical extension (research project):

- theoretic extension: Come up - and use your own MDL - based method to extract meaningful interaction moments
- practical extension: create an interaction dataset as ground truth for future work and/or compute a simulation to validate results on

Literature

Methods for change-point detection:
Pattern Recognition and Classification for Multivariate Time Series:
https://www.dai-labor.de/fileadmin/Files/Publikationen/Buchdatei/tsa.pdf
Change-Point Detection in Time Series Data via the Cross-Entropy Method:
https://mssanz.org.au/modsim2017/A5/sofronov.pdf
Segment Neighbourhoods: Auger, I. E. And Lawrence, C. E. (1989) Algorithms for the Optimal Identification of Segment Neighborhoods, Bulletin of Mathematical Biology 51(1), 39–54

Examples of trajectory visualization:
Combining GPS&survey data improves understanding of visitor behaviour, Duncan East, Patrick Osborne, Simon Kemp, Tim Woodfine, Tourism Management, 2017.
Understanding the tourist mobility using GPS: Where is the next place? Weimin Zheng, Xiaoting Huang, Yuan Li, Tourism Management, 2017
Exploring visitor movement patterns in natural recreational areas, Daniel Orellana, Arnold K. Bregt, Arend Ligtenberg, Monica Wachowitz, Tourism Management, 2017

Examples of how to deal with real-life human movement trajectories:
Using GPS Technology to Quantify Human Mobility, Dynamic Contacts and Infectious Disease Dynamics in a Resource-Poor Urban Environment:
https://doi.org/10.1371/journal.pone.0058802
GPS-Based Location Extraction and Presence Management for Mobile Instant Messenger:
https://link.springer.com/content/pdf 10.1007%2F978-3-540-77092-3_27.pdf