Adaptive Computing

Research Portfolio

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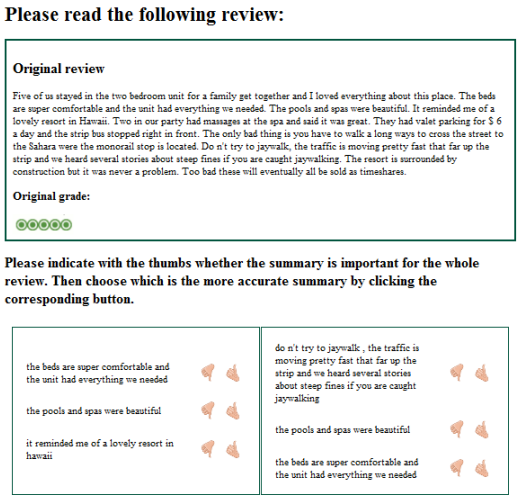
Overview

Ubiquitous User Modeling

- recommender systems
- user profiling
- intelligent information retrieval



Mobile sensing

- localization
- context recognition
- energy-efficiency

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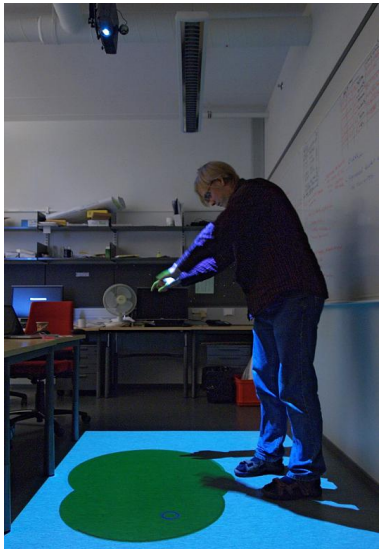


Interaction techniques

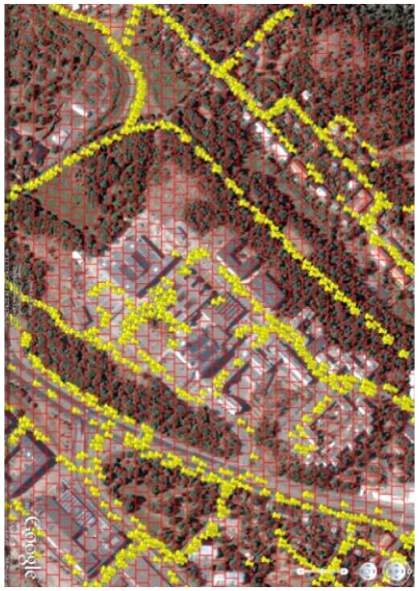
- ambient interfaces
- mobile interaction: vision-based interfaces
- mobile interaction: navigation systems

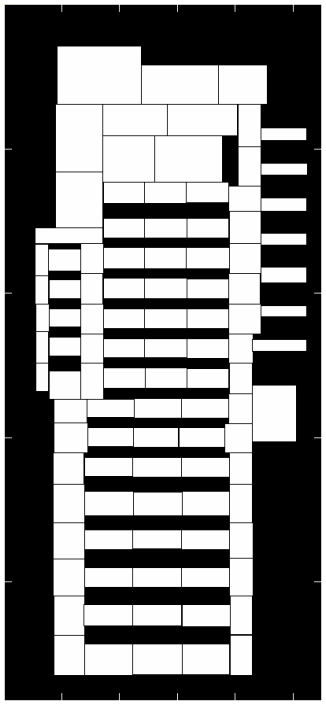
Mobile Sensing

- Goal: collect rich and personally meaningful sensor data from mobile devices in a non-obtrusive way
- Three focus areas:
  1. Ubiquitous localization: accurate and continuous tracking of the mobile client
  2. Sensor analysis: infer high level context information from sensor data, preferably on-device
  3. Energy-efficiency: ensure meaningful sensor data can be collected and communicated in a way that does not drain the battery of the client rapidly

Localization

- On-device GSM localization
  - World represented using a grid, signal variations within grid cellss modeled using Gaussian distributions
  - Particle filtering used for tracking
  - Accuracy: Median < 150m, 95% < 450m
  - Radio maps can be created and updated on a mobile device, multiple clients can share maps
- Indoor WiFi localization (ongoing work)
  - Variation of the GSM work, relies on probabilistic modeling of signal strength differences
  - Particle filtering used for tracking, KLD adaptation used to limit number of particles
  - Deployed in a large supermarket in Finland





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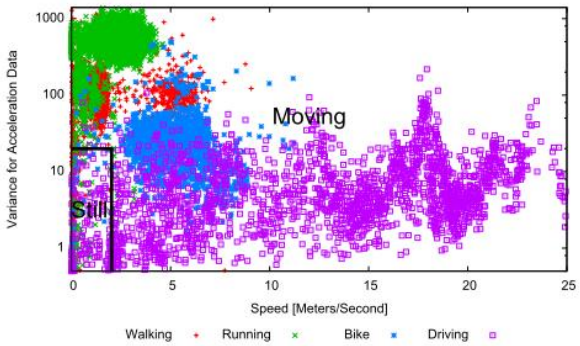
Context Recognition

- Semantically meaningful locations
  - Analyze location traces to determine areas where the user regularly spends time
  - DPCluster: algorithm that models places using infinite Gaussian mixture models
  - Evaluation with 12 datasets: accuracy 74%, recall 68% (f-score 0.71)
- Transportation mode detection (ongoing)
  - Focus on detection of transportation modes using different modalities (GPS, GSM, acc.)
  - Application areas: movement models for positioning, tools for supporting green transportation behavior etc.



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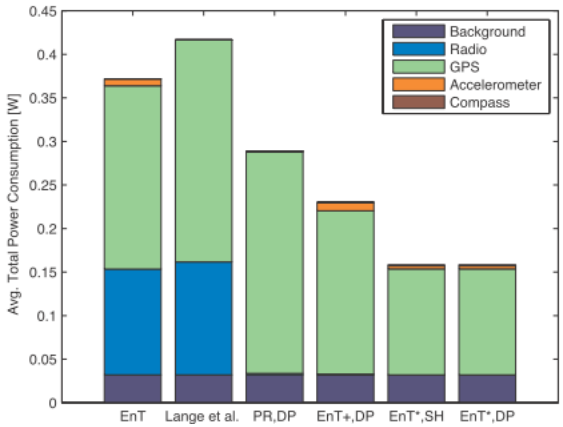
Energy-efficiency

- Data upload strategies for position tracking
  - Update position only when position changed sufficiently with a high enough certainty
  - Best results with Turn and MDL filtering:
    - 3% of samples trigger update
    - lifetime improved from 6h to over 24h
- On-device Position and Trajectory tracking
  - Position updates determined considering movement (acc.), heading (compass) and position changes (GPS)
  - Trajectory simplification used to determine when to update position information
  - Trade-off between power consumption and tracking accuracy



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Selected Publications

- M. B. Kjaergaard, **S. Bhattacharya**, H. Blunck, **P. Nurmi**, "*Energy-efficient Trajectory Tracking for Mobile Devices*", Proc. 9th International Conference on Mobile Systems, Applications and Services (MobiSys, June-July, 2011).
- M. D. Kristensen, M. B. Kjaergaard, T. Toftkjaer, **S. Bhattacharya**, **P. Nurmi**, "*Improving pervasive positioning through three-tier cyber foraging*", Proc. 1st IEEE PerCom Workshop on Pervasive Communities and Service Clouds (PerCoSC, March 2011).
- **P. Nurmi**, **S. Bhattacharya**, J. Kukkonen: "*A grid-based algorithm for on-device GSM positioning*." Proc. 12th ACM International Conference on Ubiquitous Computing (Ubicomp, Copenhagen, Denmark, September 2010). ACM Press, 2010, 227-236.
- **P. Nurmi** and **S. Bhattacharya**: "*Identifying meaningful places - the nonparametric way.*" Proc. 6th International Conference on Pervasive Computing (Pervasive 2008, Sydney, May 2008). LNCS 5013. Springer-Verlag, Berlin, 2008, 111–127.
- **P. Nurmi** and J. Koolwaaij: "*Identifying meaningful locations.*" Proc. 3rd Annual International Conference on Mobile and Ubiquitous Systems: Networks and Services (Mobiquitous, San Jose, July 2006), IEEE Computer Society, 2006.

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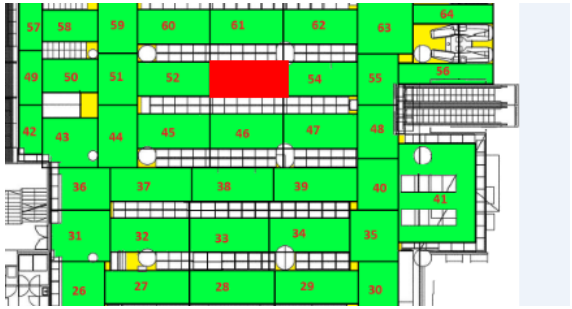
Ubiquitous User Modeling

- Goal: Enabling mobile applications to provide faster access to relevant information by modeling the interests, needs and goals of the user
  1. Recommender systems: provide users with faster access to relevant or otherwise interesting (e.g., serendipity) information
  2. User profiling: analyze sensor and interaction data to obtain fine-grained information about the user's needs and interests
  3. Intelligent IR: facilitate access to relevant digital information on mobile devices

Recommender Systems

- Personalized special offers
  - Identify relevant special offers based on the contents of a customer's shopping list
    1. map list items to product categories
    2. identify additional relevant categories
    3. score categories
    4. map actual special offers to categories, rank according to score



- Advertisement strategies (ongoing)
  - Do personalization and location-awareness improve advertisement selection?
  - User study comparing different advertising strategies in a supermarket environment (planned)

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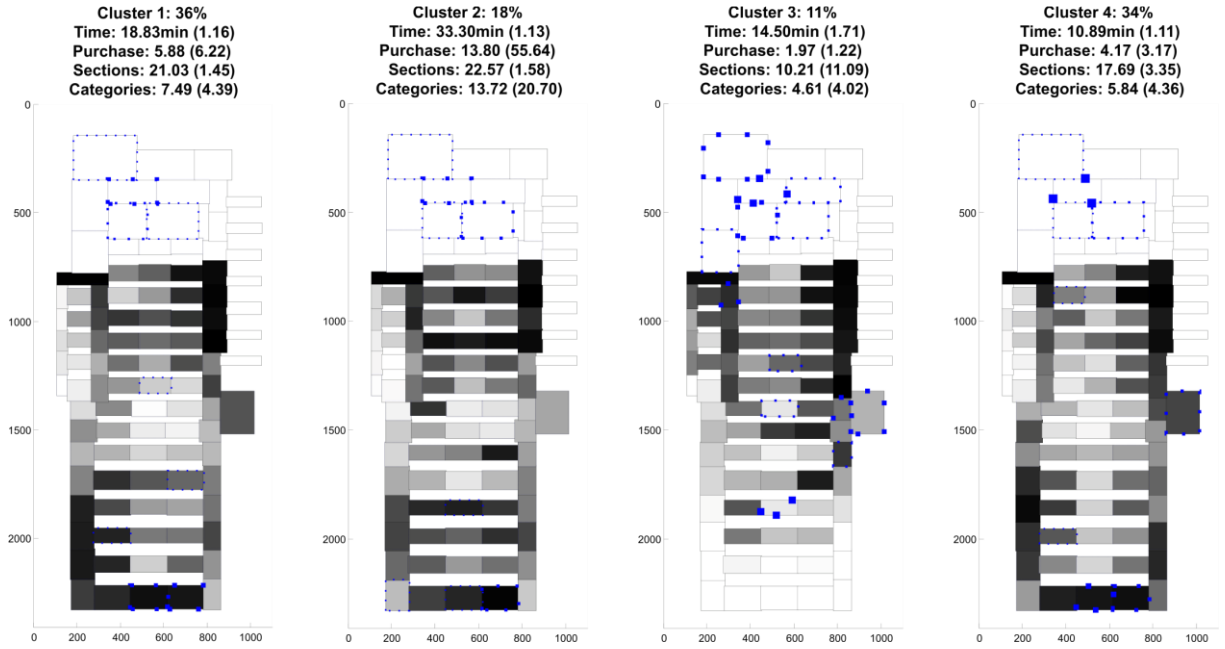
User Profiling

- Path study: detecting shopping styles (ongoing)
  - 102 shopping routes + receipts from a large-scale supermarket
  - Temporal and spatial information correlate strongly with purchase behavior ➔ potential for classifying users into shopping styles
  - Cluster analysis indicated 4-5 clearly distinct shopping styles / behaviors, currently looking into online prediction of s. style



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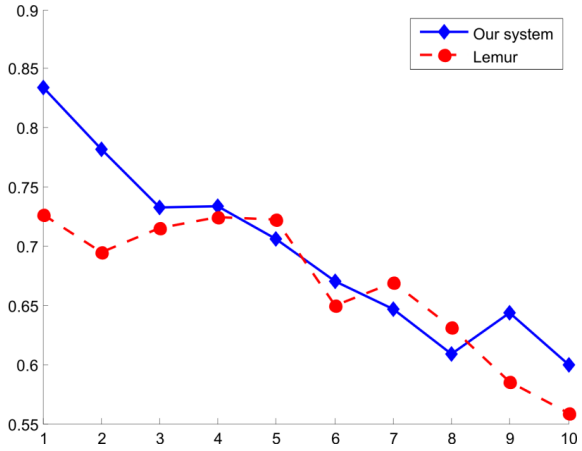
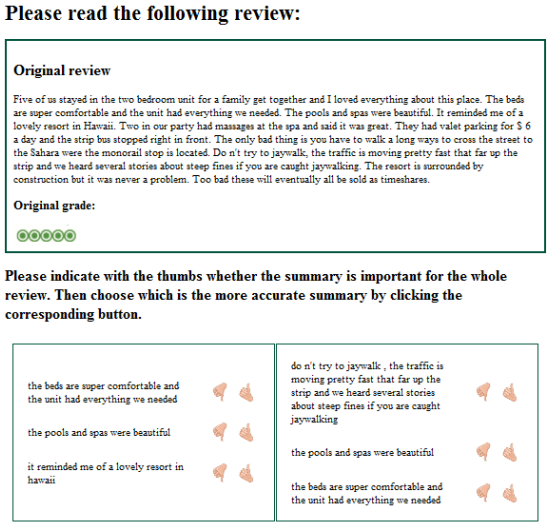
Intelligent IR

- Grocery product search
  - Grocery retrieval engine that maps items on the user's shopping list to products
  - Ranking combines textual match with product popularity
  - Product hierarchy used to assist search
  - 85% accuracy at rank 1
- Sentiment summarization (ongoing)
  - Facilitate browsing of customer reviews on mobile devices by extracting the most meaningful sentence from a review
  - Combines a feature selection metric with sentiment summarization techniques





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Selected Publications

- L. Du, W. Buntine, **P. Nurmi**: "*Bayesian networks on Dirichlet distributed vectors*". Proc. 5th European Workshop on Probabilistic Graphical Models (PGM, Helsinki, Finland, September 2010), 2010, 33-40.
- **P. Nurmi**, A. Forsblom and P. Floréen: "*Grocery Product Recommendations from Natural Language Inputs*." Proc. 1st and 17th International Conference on User Modeling, Adaptation and Personalization (UMAP 2009 , Trento, Italy, June 2009), LNCS 5535, Springer-Verlag, Berlin, 2009, 235-246.
- **P. Nurmi**, E. Lagerspetz, W. Buntine, **P. Floréen**, J. Kukkonen and P. Peltonen: "*Natural language retrieval of grocery products.*" Proc. ACM 17th Conference on Information and Knowledge Management (CIKM, Napa Valley, California, October 2008), 1413-1414.
- F. Boström, **P. Nurmi**, P. Floréen, T. Liu, T.-K. Oikarinen, A. Vetek and P. Boda: "*Capricorn - an intelligent user interface for mobile widgets*." Proc. 10th International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI'08, Amsterdam, the Netherlands, September 2008), 327-330.
- **P. Nurmi**: "*Perseus – a personalized reputation system.*" Proc. IEEE/WIC/ACM International Conference on Web Intelligence (WI, Fremont, California, November 2007), 798-804.

Interaction Techniques

- Intelligent interaction techniques for supporting ambient and mobile interaction
  1. Ambient interfaces: display persuasive feedback, support learning, provide new means for interacting with recommendations
  2. Mobile interaction: focus on specific application areas, currently retailing and navigation systems

Ambient Interfaces

- UbiLight: projector based interaction technique (ongoing)
  - Image projected to the floor, camera and projector mounted on the ceiling
  - Interaction based on gesture tracking (camera or Kinect)
  - Focus on educative content, evaluate whether the interface can enhance learning
  - E.g., prevent oil spill from reaching the shore
- Ambient persuasive interfaces (planned)
  - Peripheral displays for the home (lights etc.)
  - Interfaces for visualizing recommendations in a store environment

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Vision-Based Interfaces

- Camera-based AR
  - Markerless tracking of the camera pose
  - Recognize the shelf that the camera is pointing at
  - Based on SIFT + bag of keypoints algorithm
  - Currently 40% accuracy (baseline 8%)

- Mobile barcode detection (ongoing)
  - Use computer vision techniques to recreate barcodes from mobile camera pictures
  - Contrary to scan-lined based techniques, insensitive to partial reflections that block the camera view and to curved surfaces

Interaction in Navigation Systems

- Influence of landmarks on user attention
  - Can we influence what people register from their environment by selection of landmarks?
  - User study comparing two instruction types with different visual demands
  - Increased visual demand decreases efficiency but does not improve environmental recall

- Auditory interaction (ongoing)
  - Voice personality and gender influence people's attributions of computer generated speech
  - User study that investigated whether type of voice influences navigation performance
  - Matching gender + personality a safe bet, but voice quality matters even more

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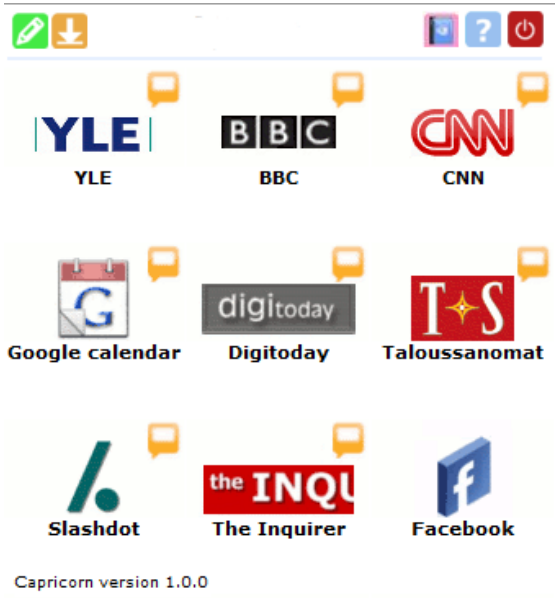
Selected Publications

- **S. Bhattacharya**, **T. Pulkkinen**, **P. Nurmi**, A. Salovaara, "*MONSTRE: A Mobile Navigation System for Retail Environments*", Proc. International Workshop on Smart Mobile Applications (SmartApps, June 2011).
- **P. Nurmi**, A. Salovaara, **S. Bhattacharya**, **T. Pulkkinen**, G. Kahl: "*Influence of landmark-based navigation instructions on user attention in indoor smart spaces*". Proc. 2011 Conference on Intelligent User Interfaces (IUI, Palo Alto, CA, February, 2011), 2011
- **P. Nurmi**, **A. Forsblom**, **P. Floréen**, P. Peltonen, P. Saarikko: "*Predictive Text Input in a Mobile Shopping Assistant: Methods and Interface Design*." Proc. 13th International Conference on Intelligent User Interfaces (IUI, Sanibel Island, Florida,February 2009), 435–438.
- **Jara Uitto**: "*Vision Based Indoor Positioning in a Retail Environment*", M.Sc. Thesis, Department of Computer Science, January 2011.

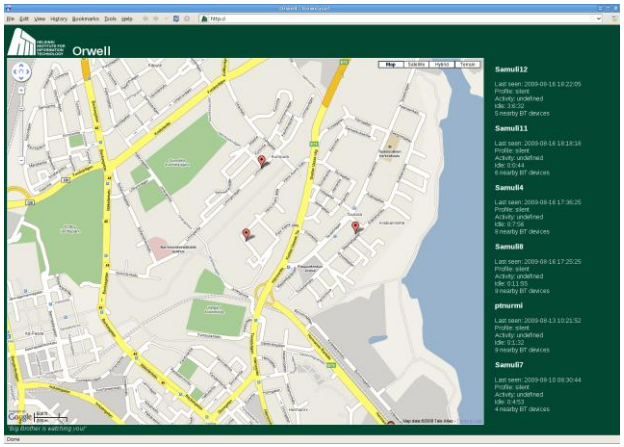
Selected Other Work

BeTelGeuse

Capricorn



Orwell



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