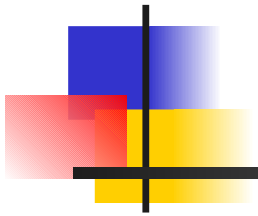

Mobile Habits: Inferring and predicting user activities with a location-aware smart phone

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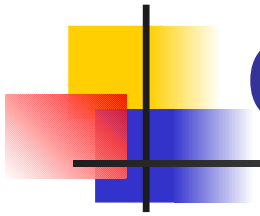
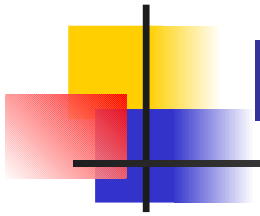
University of Trento, Create-Net



Outline

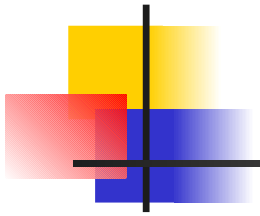
- Introduction
- Related work
- Challenges
- Project proposal
- Conclusion



Introduction (1/2)

Location-aware systems are used in

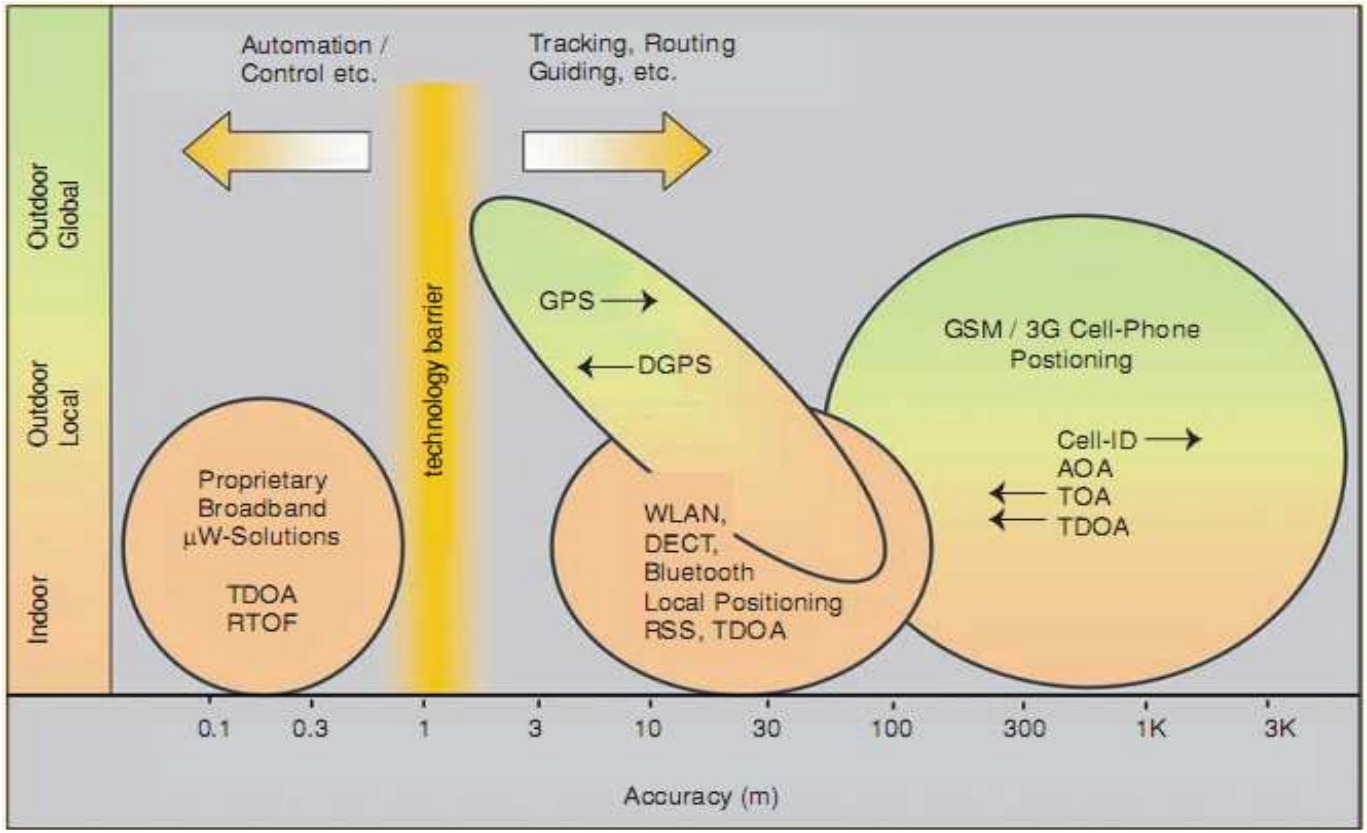
- Logistics, search-and-rescue
- Medical care, assisted living
- Tourist guides
- Higher level: activity recognition
  - Adaptive mobile services
  - More relevant web search
  - Activity monitoring for elderly



Introduction (2/2)

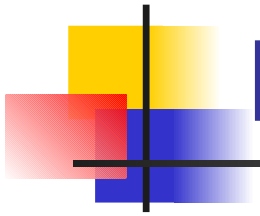
- From the location traces one can infer
  - Where the user is (position)
  - Whether the environment is familiar (personal place perception)
  - What the user is doing (activity)
  - What he is going to do (intentions)

Related work (1/4)



Comparison of wireless positioning technologies

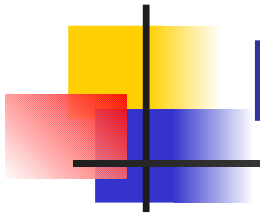
Figure from Vossiek et al. Wireless local positioning. *IEEE Microwave Magazine,4(4):77–86, p.80.*



Related work (2/4)

- Positioning frameworks
  - Aggregate the advantages of different methods
    - Examples: PlaceLab[1], Location Stack[2]
  - Mostly use GPS and Wi-Fi, primitive GSM
  - Require laborious calibration
  - Only few can run on a mobile device

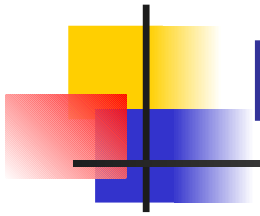
- LaMarca et al. Place Lab: Device Positioning Using Radio Beacons in the Wild. *Pervasive 2005, LNCS 3468, 116–133.*
- Hightower et al.The location stack: a layered model for location in ubiquitous computing. *IEEE Workshop on Mobile Computing Systems and Applications, 2002, 22–28.*



Related work (3/4)

- Recognition of personally important places (place extraction)
  - Different approaches
    - GPS signal loss in buildings[1]
    - GSM Cell-ID transitions[2]
    - Wi-Fi+GSM fingerprints[3]
  - Time & distance thresholds
  - Binary decision on importance

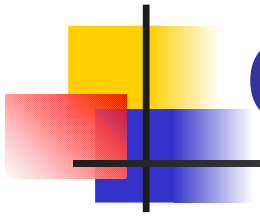
- Ashbrook and Starner. Using GPS to learn significant locations and predict movement across multiple users. *Personal and Ubiquitous Computing, 7(5):275–286, 2003.*
- Laasonen et al. Adaptive On-Device Location Recognition. *Pervasive 2004, LNCS 3001, 287–304.*
- Hightower et al. Learning and Recognizing the Places We Go. *UbiComp 2005, LNCS 3660, 159–176.*



Related work (4/4)

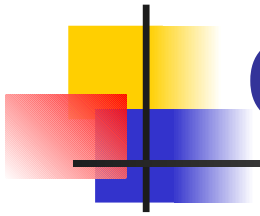
- Activity recognition by location
  - Examples: RealityMining[1], LifeTag[2]
  - Place implies activity (usually)
  - Modes of transportation: stationary, walking, driving[3]
  - Use only one technology, usually GPS
- Activity prediction
  - Rather young topic[4]
  - Basic methods and evaluations

- Eagle and Pentland. Reality mining: sensing complex social systems. *Personal and Ubiquitous Computing, 10(4):255–268, 2006.*
- Rekimoto et al. LifeTag: WiFi-Based Continuous Location Logging for Life Pattern Analysis. *LoCA 2007, LNCS 4718, 35–49.*
- Anderson and Muller. Practical Activity Recognition using GSM Data. *Tech. Report CSTR-06-016, University of Bristol, 2006.*
- Mayrhofer. An Architecture for Context Prediction. *PhD thesis, Johannes Kepler University of Linz, Austria, 2004.*



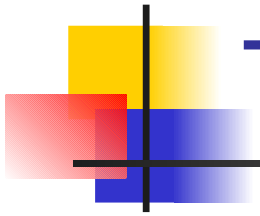
Challenges (1/2)

- Localization
  - Every single method has limitations (coverage, accuracy, power consumption, etc)
  - Sensors have various output formats
  - Location estimates are usually noisy
  - Calibration is necessary
- Place extraction methods
  - Choice of the “importance” threshold



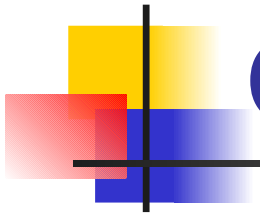
Challenges (2/2)

- Activity recognition and prediction
  - Currently outdoors or indoors only
  - Long-period and quasi-periodic patterns
  - “Schedule change” problem
- General: limited resources



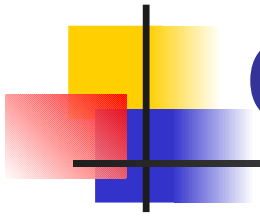
The aim

- Improve the performance of activity recognition and prediction methods for mobile devices
  - Performance = accuracy, robustness, range of activities



Objectives (1/2)

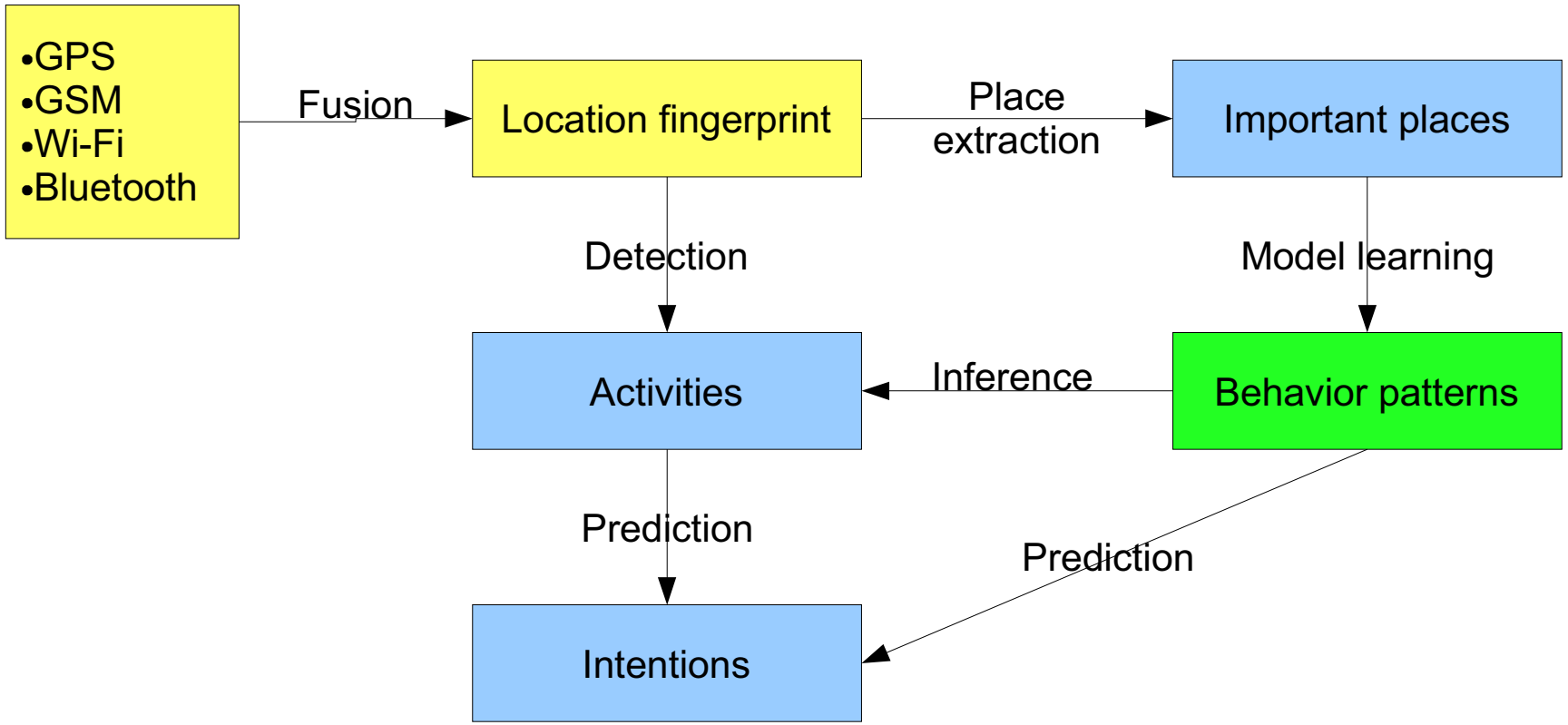
- Review the state of the art
- Develop a framework for accurate indoor and outdoor positioning
  - Using hardware of a smart phone
  - Consider privacy issues
- Analyze and develop place extraction methods
  - Optimize for multi-sensor positioning
  - Address “importance threshold” issue

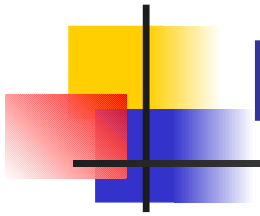


Objectives (2/2)

- Analyze/develop activity recognition methods
  - Explore possible auxiliary data sources (time, day of week, recent calls, web services…)
  - Explore how domain knowledge can improve recognition
- Analyze/develop activity prediction methods
  - Consider long- and multi-period activities
  - Address “schedule change” problem

Proposed approach (1/3)

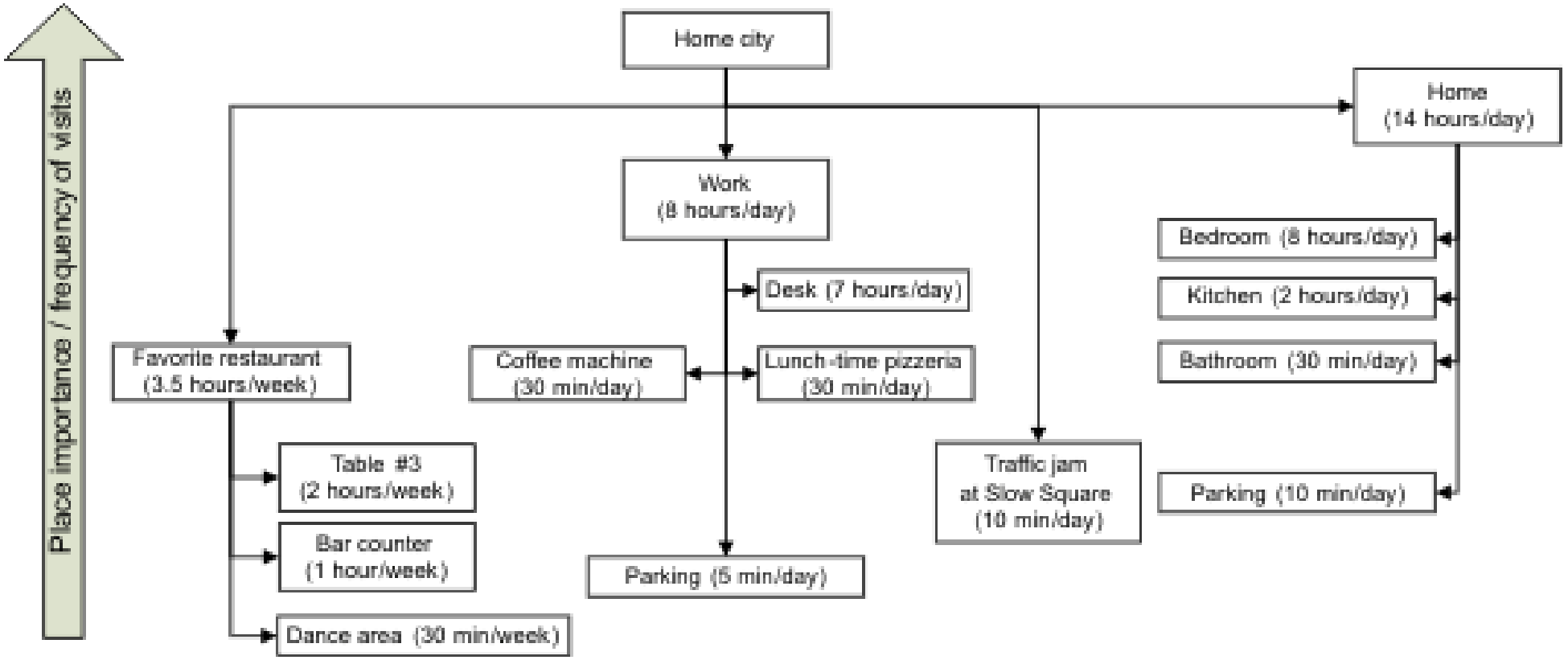


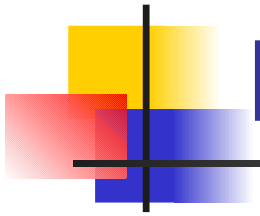


Proposed approach (2/3)

- Positioning framework
  - Multi-sensor (GPS, GSM, Wi-Fi, Bluetooth)
  - Hybrid coordinates (fingerprints)
    - No need for calibration
  - On-device computations
    - Secure and robust
- Place extraction
  - Importance rank instead of binary decision
    - Detection of “less important” places
    - No more false positives/false negatives
    - Enables coarse-grain estimations

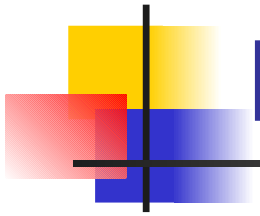
Place importance ranking





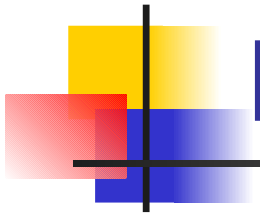
Proposed approach (3/3)

- Activity recognition
  - Place implies activity
  - Use movement history/traces
  - Use wireless environment changes
- Activity/place prediction
  - Schedule change detection by error rate monitoring



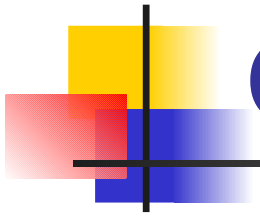
Novelty / contribution

- Positioning framework
  - Ubiquitous coverage
  - No need for calibration
- Place extraction method
  - Importance ranking
- Activity recognition methods
  - New activities and better accuracy
- Activity prediction methods
  - Detection of schedule changes



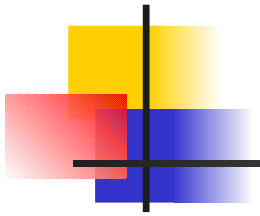
Feasibility

- Separate components have already been demonstrated
- GSM positioning prototype is already done



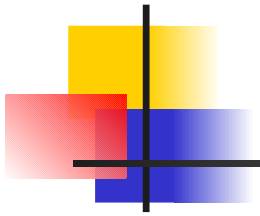
Current state and future work

- Current state
  - Development of data collection application
- Future work
  - Real-life data collection
  - Development of analysis methods
  - Evaluation



Conclusion

- Recognize and predict mobile user activities from location traces
  - Using smart phone as a sensor
  - Both indoors and outdoors
  - Recognize personally important places
  - Detect user behavior changes
- Work in progress



Thank you!

Questions & Answers