MINING DATA FROM MOBILE DEVICES

Algorithms: Sensing

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Overview

• Indoor localization
  • Low-level activity detection
  • High-level: in next part (context)

Indoor localization

Overview

• GPS not available indoors
• Cell tower triangulation is far too coarse
• Use other signals instead to infer location or proximity

RSSI (Received Signal Strength Indicator)
Accelerometer (dead-reckoning)
Audio (ambient noise)

Localization
Proximity
Mapping

WiFi-based localization

[Ladd et al., IROS 2002]
• Signal propagation and attenuation models work reasonably outdoors
• Indoors, signal strength is determined by building geometry, which may change (doors open/close, movements, etc) – very hard to model

• Supervised learning approach:
  • Bayesian localization framework
  • Sensor fusion using HMM (people walk slow enough)
  • Accuracy of up to 1m

Andrew M. Ladd, Kostas E. Bekris, Guillaume Marceau, Algis Rudys, Dan S. Wallach, Lydia E. Kavraki:

WiFi SLAM (GP-LVM)

[Ferris et al., UCAI 2007]
• SLAM: Simultaneous Localization and Mapping (robotics)
• Gaussian Process (GP):
  \[ Y_i = f(X_i) + \epsilon \]
  • Latent Variable Model (LVM): position is unobserved
• Assumptions:
  • Similar locations have similar RSSI – squared exponential kernel
  • Instead of odometry data, assume “office building” constraints on:
    • Distance between successive positions
    • Change in orientation between successive positions
    • Alignment of parallel line segments

Brian Ferris, Dieter Fox, Neil D. Lawrence:

WiFi SLAM (GP-LVM)

[Ferris et al., UCAI 2007]
• Initialization: Isomap
• Localization error ~ 4 ± 0.6m

Brian Ferris, Dieter Fox, Neil D. Lawrence:
RSS-space tasks

- May not need mapping to (Euclidean) spatial coordinates
- Proximity detection
- Geo-fencing
- Substantially simplifies processing
- Still need some way to filter noise, esp. if a large number of APs and/or measurements are not available

Commercial applications

Example: AisleLabs

Integration of data from radio-based localization systems (e.g., iBeacon, BLE-based) for providing analytics dashboards

Overview

- Indoor localization
- Low-level activity detection

Activity detection

- Active area of research (esp. in networking / ubi-comp)
  - Could probably do an entire tutorial on just this 😊
  - Becoming mainstream: Android APIs

Low-level (this part):
- Am I standing/falling, walking/driving, etc?
- How is my mood?
- ...

High-level / “context” (later):
- Out with friends, looking for a restaurant
- Commuting to work, drive or take public transit?
- ...
Fall detection
[Sposaro, Tyson, EMBS 2009]

- Use accelerometer data to detect fall
- Relatively simple threshold approach:
  - Acceleration exceeds a threshold
  - Followed by a "still" period
  - In a 90° changed orientation

- Challenges: false positives
- A lot of work in this area

Classification for activity detection

- How about detecting more than a single type of event? E.g.,
  - Standing vs. sitting
  - Walking vs. cycling vs. driving
- Challenges:
  - Phone data can be very noisy (loose phone, many factors)
  - Efficiency of on-phone classification
  - Population variances (one size does not fit all)
  - Sampling frequency (power draw)
  - ...

Population-based activity detection

- Collecting data requires substantial effort
- What if we could also use data from other "similar" people?
- "Community Similarity Networks" – 3 similarity measures:
  - Physical similarity (age, height, weight, well-being measures)
  - Lifestyle similarity (mobility patterns, activity distributions)
  - Sensor data similarity ("set": duplicate elimination)
- Performs better than out-of-the-box semi-supervised methods

Android activity recognition API

- Classifier [?] now available in Android APIs
- Apps can request one-shot estimates or event stream

```
public class ActivityRecognitionIntentService extends IntentService {
    ... 
    @Override
    protected void onHandleIntent(Intent intent) {
        ... 
        if (null != ActivityRecognitionResult.hasResult(intent)) {
            ActivityRecognitionResult result = ActivityRecognitionResult.extractResult(intent);
            DetectedActivity mostProbableActivity = result.getMostProbableActivity();
            int confidence = mostProbableActivity.getConfidence();
            int activityType = mostProbableActivity.getType();
            // IN_VEHICLE, ON_BICYCLE, ON_FOOT, STILL, UNKNOWN, TILTING, ...
        } 
    }

    ... 
```


Recap

- Indoor localization (focus: WiFi RSS-based)
- Low-level activity detection

Other:
- Localization using other modalities (e.g., ambient noise: Color app)
- Face detection and recognition (e.g., screen unlock)
- Power consumption logging and mining
  - ...
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