MINING DATA FROM MOBILE DEVICES

Algorithms: Sensing

Spiros Papadimitriou, Tina Eliassi-Rad

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
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

WiFi SLAM (GP-LVM)

[Ferris et al., UCI 2007]

- SLAM: Simultaneous Localization and Mapping (robotics)
- Gaussian Process (GP):
  \[ Y = f(X) + \epsilon \]

- 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

- Initialization: Isomap
- Localization error ~ 4 ± 0.6m
WiFi GraphSLAM

- Assumption that similar RSSI corresponds to similar locations is not true in signal-sparse environments
- Additionally, can use phone sensors for basic odometry

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

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?
  - …

Overview

- Indoor localization
- **Low-level activity detection**

Fall detection

- 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

- Public dataset (Reyes-Ortiz et al., donated 2012):
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

Mood detection

[LiKamWa al. 2013]

- Can cellphone usage patterns reveal user’s mood?
  - Communication patterns
  - App usage patterns
- Accuracy 66%, improved up to 93% over time
- Vs. self-reported, 32 users

Android activity recognition API

- Classifer [?] 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 (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
  - ...

MINING DATA FROM MOBILE DEVICES

Algorithms: Sensing

Spiros Papadimitriou, Tina Eliassi-Rad