Indoor Tracking Using Conditional Random Fields

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ABSTRACT

This work proposes a working prototype of a novel, robust and responsive indoor tracking technique that is extremely computationally efficient (running in under 10 ms on an Android smartphone), does not require training in different sites, and tracks well even when presented with very noisy sensor data. The tracking system requires zero user effort (war-driving, fingerprinting, etc.) – only the floor plan is required.

1. INTRODUCTION

This work develops a working prototype of continuous indoor tracking system that is lightweight and computationally efficient, but also robust to noisy data, allowing it to provide always-on and real-time location information to mobile device users.

We identify maps as the key to providing accurate indoor location. Based on a time-series of observations, such as inertial trajectories or RF scans, the goal is to reconcile the observations with the constraints provided by the maps in order to estimate the most feasible trajectory. The proposed system uses an undirected graphical model, known as linear chain conditional random fields (CRFs) [1] which is particularly flexible and expressive, which allows us to capture correlations among observations over time, and to express the extent to which observations support not only states, but also state transitions.

2. TRACKING SYSTEM

The proposed indoor tracking system fuses all available information using CRFs, an undirected graphical model which is particularly well suited to this sequential problem because it allows us to flexibly define *feature functions* that capture the extent to which observations support states and state transitions, given map constraints. As a user moves through the building, certain paths become unlikely, as they violate map constraints.

More specifically, this process involves four distinct steps: **Map pre-processing** takes a floor plan as input, and produces a graph that a) encodes a set of discrete states (locations), and b) represents physical constraints between discrete states imposed by the map. **Feature functions** are then defined to elegantly model different sensor data including the inertial measurements, RF measurements, visual measurements, user inputs, etc.

Figure 1: Application scenario of the indoor tracking system.

All these inputs are fused together by the potential function. Then **optional training** could be performed to estimate the feature weights. Our system works well without training but training can help the tracking system to capture the special per-site features, which could help improve the per-site tracking accuracy. At last, **inference** algorithms, e.g. Viterbi algorithm are used to efficiently find the most likely sequence of states through the transition graph, culminating in an estimate of the user's location and quality thereof.

The first three steps are performed once for each building. The fourth step is performed online on the user's smartphone to track themselves. Fig. 1 shows an application scenario of the proposed tracking system.

3. DEPLOYMENT REQUIREMENTS

The floor plan is required. No extra infrastructure will be deployed.

4. CONCLUSION

This work has developed a novel continuous indoor tracking system, based on the application of conditional random fields. By experiments with the working prototype we have also demonstrated the system to be robust, lightweight, and accurate.

5. REFERENCES

[1] J. D. Lafferty, A. McCallum, and F. C. N. Pereira. Conditional random fields: Probabilistic models for segmenting and labeling sequence data. In *ICML*, 2001.