In this study, we propose Locating in Fingerprint Space (LiFS), a wireless indoor localization approach. By exploiting user motions from mobile phones, we successfully remove the site survey process of traditional approaches, while at the same time, achieve competitive localization accuracy. The key idea behind LiFS is that human motions can be applied to connect previously independent radio fingerprints under certain semantics. LiFS requires no prior knowledge of AP locations, which is often unavailable in commercial or office buildings where APs are installed by different organizations. In addition, LiFS’ users are in no need of explicit participation to label measured data with corresponding locations, even in the training stage. In all, LiFS transforms the localization problem from 2D floor plan to a high dimension fingerprint space and introduces new prospective techniques for automatic labeling.

## Overview

### 3.1 Data Collection

User participation is essential in the initial period at the online stage. Untrained users walk in a building following daily activities. Mobile phones, carried by users, collect WiFi RSS characteristics (a.k.a. RSS fingerprints or signatures) at various locations along user movement paths, and the walking distances are also recorded. Walking distances are measured as footsteps from the readings of integrated accelerometers in mobile phones. Similarly, accelerometers also infer the starting and finishing moments of user paths. LiFS harnesses the walking distance between two endpoints (denoted by corresponding fingerprints) along a user path to establish the geographical relationship among finger- prints. During data collection, users can be even unaware of the collection task in which they are actually involved.

### 3.1 system Architecture

The working process of LiFS consists of two phases: training and operating. The major output of training phase is a fingerprint database in which an RSS fingerprint and its corresponding location are associated. The fingerprint database is further used in operating phase to process location requests. We describe the training and operating phases in detail next.

Training phase. The core task of training phase is to build the fingerprint database. We divide this task into three steps:

(1) transforming floor plan to stress-free floor plan;

(2) creating fingerprint space;

(3) mapping fingerprints to real locations.

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The geographical distance between two locations in a floor plan is not necessary to be the walking distance between them due to the block of walls and other obstacles. Hence, we propose stress-free floor plan, which puts real locations in a floor plan into a high dimension space by multidimensional scaling [4], such that the geometrical distances between the points in the high dimension space reflect their real walking distances. Through stress-free floor plan, the walking distances collected by users can be accurately and carefully utilized.

Fingerprint space is a unique component in LiFS, different from traditional approaches. According to the inter-fingerprint distances, MDS is used to create a high dimension space, in which fingerprints are represented by points, and their mutual distances are preserved. In traditional approaches, fingerprints are geographically unrelated, losing the possibility of building fingerprint space.

In fingerprint database, fingerprints are associated with their collecting locations (i.e., fingerprints are labeled with locations). Such associations are achieved by mapping fingerprint space (fingerprints) to stress-free floor plan (locations). In LiFS, the fingerprint database is updated continuously according to newly collected data, such that the database reflects the up-to-date radio signal distribution. As shown in Fig. 1, fingerprint database, as the core compo- nent, connects training and operating phase.

Operating phase. When a location query comes, usually an RSS fingerprint sent by a user, LiFS takes it as a keyword and searches the fingerprint database.

1. **The nearest neighbor algorithm:** we assume that a fingerprint f is collected at the same location as f’, if f’ is the most similar to f in the fingerprint database.
2. **continuous trajectory matching scheme:** to reduce the localization error caused by the fingerprint ambiguity for mobile users. In this scheme, a user’s location is estimated based on his/her moving trajectory, instead of one single RSS report, by measuring successive RSSs and the accompanying mobility information when a user is moving.

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