Evaluating Matching Probability of Activity-based Map Matching in Indoor Positioning

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ABSTRACT

If users are known to perform specific activities at specific locations within a building, then indoor positioning could be achieved by monitoring user activities and matching them to specific locations in a preloaded floor map. This is the fundamental idea behind activity-based map matching (AMM). For example, the user's smartphone could use the accelerometer readings to detect whether a user is using an elevator, and then match the current location of the user to the nearest elevator (nearest from the current estimated position) in a preloaded floor map. AMM therefore could be used for frequently recalibrating location estimators to ground-truth values. This is especially useful for recalibrating pedestrian dead reckoning (PDR), which can estimate indoor position if started from a known location, but the accuracy degrades as a function of distance travelled from the original known location. PDR uses the accelerometer to detect steps and estimates the distance by counting the number of steps taken at a given direction. Since the same accelerometer can power both the AMM and the PDR, the combination provides a completely *self-contained* indoor positioning and navigation solution, which could be readily implemented in a personal mobile device. Thus, AMM provides a new opportunity for the mobile device to learn its location without relying on any interactions with in-building infrastructure, which can be useful if the infrastructure fails (e.g., during an emergency), provides inadequate coverage, or poses privacy concerns for the user.

AMM, however, is not perfect and could potentially cause mismatches, i.e., the user's position could be matched to a wrong elevator when the nearest elevator is selected, especially when many elevators are installed in a building. To the best of our knowledge, the issue of *matching probability* of AMM has not been discussed in the literature. In this paper, we present the following two new contributions:

1. We propose a methodology to compute the matching probability of an AMM. Our methodology takes the locations of all elevators (or escalators) in the map as an input and computes the matching probability for each elevator for a given error model and accuracy of the location estimator.
2. We compute the matching probability of all escalators in the Sydney Airport using the floor maps publicly available on the Web.

Our study reveals the following interesting results:

- Intuitively it seems that matching probability is a strict function of location estimation accuracy, i.e., higher the accuracy of location estimation, the better the prospect of matching to the correct

escalator. However, we show that this is not necessarily the case for all the escalators in the Sydney Airport and provide a mathematical explanation of this behavior.

- The worst case matching probability for Sydney Airport escalators can be as low as 40%, while the best case is 96%. The average matching probability is between 60-80% depending on the accuracy of the location estimation.
- Matching probability for one escalator can vary significantly from another in the same floor. This knowledge can be useful for a pedestrian navigation system (PNS) that intends to use AMM as a viable technology for location recalibration. For example, if the matching probability is below a target threshold at a given floor area, the PNS may choose not to use AMM in that area.

KEYWORDS: Pedestrian dead reackoning, Activity-based map matching, PDR recalibration