Demonstration Abstract: Collaborative Localization Using Inter-device Particle Filter Data Fusion

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ABSTRACT

A lot of recent researches have addressed indoor localization by integrating portable/wearable communication and sensing technologies. While GPS dominates outdoor localization, indoor localization schemes have to consider different types of observations [1] and even use hybrid techniques [4] to fuse various sensor inputs. In this work, we observe that via M2M communications, when two devices meet up, which we call "M2M encountering", they can collaboratively calibrate each other's location instantly. For instance, when applying *Particle Filter* (PF), a widely used fusing technique, on inertial sensing data, the localization result may diverge over time. We propose a concept called *inter-PF*, which takes M2M encountering opportunity to conduct a ranging action between two PFs, and show that it can converge the positioning results more rapidly, hence providing higher accuracy.

Keywords

Collaborative localization, dead reckoning, M2M communication, particle filter, wireless positioning.

1. INTRODUCTION

Human location is one of the most important types of context information in our daily lives. However, in indoor or places where GPS signals are obstructed, we have to utilize and fuse different sorts of sensing data under various environment conditions. Amongst the sensors that may be exploited, this work considers M2M (machine-to-machine) communication as a fusion tool.

In this work, we observe that M2M communication can create additional opportunities to increase the quality of lo-

Figure 1: The concept of M2M encountering and collaborative localization.

cations. Comparing to the conventional particle filter approaches, this discovery allows the localization system to be less dependent on infrastructures and auxiliary signals. We introduce the concept of *inter-device particle-filter* (*inter-PF*) and propose a collaborative localization method using M2M as another data fusion source. Assuming that the location system operates in a building where there exists multiple users who wish to locate themselves, the M2M encountering scenario is illustrated in Fig. 1. Under this assumption, we introduce concept of *inter-PF*, which utilizes M2M interactivity to create extra location indications, therefore provide additional opportunities to adjust the particle weights and converge the locations.

We demonstrate the localization system using smartphones equipped with the IMU sensors and several infrastructural beacons. The M2M encountering activities are realized using the BLE ranging amongst the mobile devices. Our result greatly extends the concept in [2, 3].

2. LOCALIZATION WITH M2M ENCOUNTERING

We consider an indoor area with wireless infrastructure and a group of users requesting for location services. We exploit both *intra-* and *inter-PF* techniques for localization.

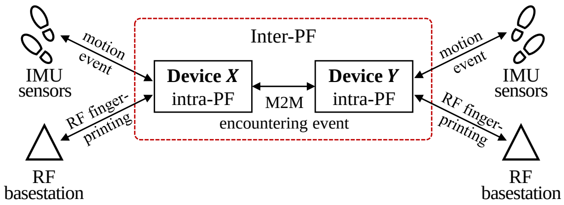

Figure 2: The basic concept of intra-PF and inter-PF model.

The goal of *intra-PF* is to fuse the observations on motions and RF signals made by individual users, while the goal of *inter-PF* is to fuse the observations made by multiple users, amongst which M2M encounters occur. Fig. 2 illustrates the main concept.

To enable *intra-PF* data fusion, we assume that each mobile device is equipped with inertial sensors and an RF interface, and the area is installed with RF beacons for fingerprinting localization (in this work, we use BLE). To enable *inter-PF* data fusion, we assume that devices are able to perform RF-based ranging to find their relative distances (in this work, we use smartphones and BLE beacons for this purpose).

The entire collaborative localization scheme can be separated into four primary modules: *a*) IMU motion detection module, *b*) RF fingerprinting module, *c*) M2M encountering module, and *d*) the particle filter.

Basically, the PF module runs iteratively through the particle sampling, weighting, and re-sampling stages. Each iteration is triggered by a motion event detected by the IMU detection module. Then the system checks whether there are location indicators provided by the BLE RF fingerprinting module and ranging indicators provided by the M2M encounter module. These opportunistic indications, if any, are fused with the motion event by the particle weighting module. Finally, the particle re-sampling redistributes the particle set, outputs the estimated location, and loops back waiting for the next motion event.

3. DEMONSTRATION SCENARIO

Our localization system enables the tracking of multiple users in the target environment covered by infrastructural wireless beacons completely or partially.

We perform the field experiment in the fifth floor of the Department Building of Computer Science, National Chiao-Tung University, Taiwan. The experiment scenario is illustrated in Fig. 3. Two subjects A and B traverse 50.85m along the longest edge of the hallway in opposite directions at casual walking speed ($S_i = 0.76$m). According to the configuration, subjects A and B is initially beside the BLE beacons, and both subjects meet each other in the center of the hallway.

The distribution and the standard deviation chart of the particle sets is illustrated in Fig. 4. We can see after M2M encountering, the particle sets converged and the standard deviation of the particles distribution drop significantly, which means we can use the event of M2M encountering to converge the positioning results more rapidly, hence providing higher accuracy.

We will demonstrate the real-time localization system by allowing multiple attendees to move around with Android

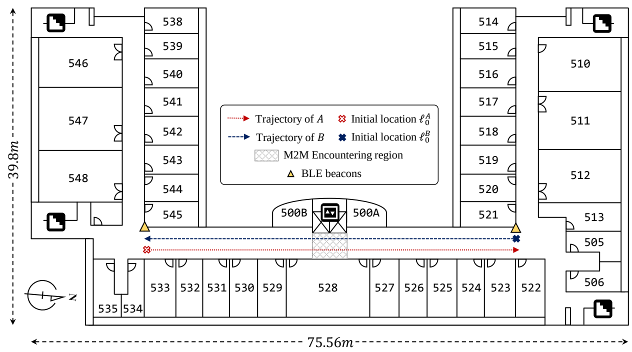

Figure 3: Experiment scenario in NCTU EC 5F

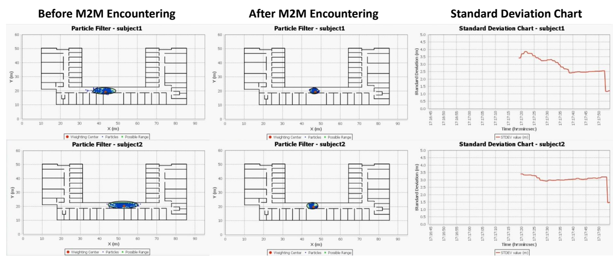

Figure 4: M2M Encountering

smartphones, on which the M2M Trac (APP) are installed. For the infrastructure deployment, we will setup several BLE beacons with battery on the corridor or in the target rooms, and use smartphones with BLE beacons to do self localization and collaborative localization. We transfer the positioning requests and responses by Wi-Fi, hence we will deploy a Wi-Fi base station to provide transmission capacity in local network. Besides, the floor plan and beacon map (e.g. beacon MAC, position) are as well required.

After that, we will display the distribution, centroid and convergence of the particle on the server control panel, and the positioning result will also display on smartphones.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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