Economic and Synergistic Pedestrian Tracking System with Service Cooperation for Indoor Environments

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ABSTRACT

This paper describes an indoor pedestrian tracking system that can economically improve the tracking performance and the quality and value of services by incorporating other services synergistically. The tracking system obtains position, orientation, and action of pedestrians continuously and accurately in large indoor environments by utilizing surveillance cameras and active RFID tags for security services and 3-D environment models for navigation services. Considering service cooperation and co-creative intelligence cycles, this system can improve both the tracking performance and the quality of services without significant increase of costs by sharing the existing infrastructures and the 3-D models among services. The authors conducted an evaluation of the tracking system in a large indoor environment and confirmed that the accuracy of the system can be improved by utilizing the infrastructures and the 3-D models. Synergistic services utilizing the tracking system and service cooperation can also enhance the quality and value of services.

Keywords: Human Behavior, Indoor Environment, Map Matching, Pedestrian Dead-Reckoning, RFID Tag, Sensor Fusion, Service-Engineering, Surveillance Camera

INTRODUCTION

Tracking technology, which measures the position and orientation of a human, is one of the fundamental technologies for realizing location-aware services and for analyzing human behaviors induced by provided services by an objective indicator. Previously, we have proposed an indoor/outdoor pedestrian tracking system (Kourogi et al., 2006) based on Pedestrian Dead-Reckoning (PDR) using wearable self-contained sensors for realizing location-aware services such as pedestrian navigation, and improvement of quality of services through analysis of pedestrian traffic and actions. We have also developed a museum guide system (Okuma et al., 2007) that presents recommendation routes and content based on the position DOI: 10.4018/joci.2011010101
and orientation of the user from the tracking system in a large indoor environment (four floors, 2,500 to 2,700m² each). Over the past three years, we have carried out practical experiments and user studies of the museum guide and tracking systems in the actual field and have been improving the systems based on feedback from users who operated the systems in the field.

For a navigation service, the service providers first create and place maps and annotations as content before operating the service, and then the navigation system presents them based on the position and orientation of the users. After the operation of the navigation, the service providers consider how to improve the service from subjective evaluations of the users by questionnaires, interviews, and action analysis of the users based on the tracking logs. In each step of the service cycle, efficiently creating content, realizing good user experience and effectively analyzing user’s actions have been desired. Actually, they and Ishikawa et al. (2009) have promoted efficiently providing the navigation service and have improved user experience based on feedback from the users by developing an 3-D indoor modeling system which uses the pedestrian tracking system for efficiently creating maps and a lightweight client using iPhone 3G (Figure 1) for displaying maps and content to the user.

However, there are still many issues. In particular, a calibration of human walking parameters for our pedestrian tracking system is a significant factor disturbing good user experience. The tracking system has to calibrate user’s walking parameters which can be used to estimate walking velocity corresponding to the walking locomotion for estimating precise location of the user before using the system. For the calibration, the user has to walk several times at various walking speeds, and it is burdensome to the user. Moreover, the parameters that are estimated in advance are not necessarily effective because the walking parameters change based on user activity. Therefore, it is necessary to estimate the walking parameters according to the present condition of the user without burdening the user. Furthermore, the costs for introduction and improvement of the pedestrian tracking system have to be low and reasonable in order to apply the system to actual service fields. The cost problems for operating services are well considered not only for the museum guide service but also for the other services.

We propose the following approaches for improving the tracking accuracy of the pedestrian tracking service and addressing the cost problem for the improvement.

- Dynamic walking parameter estimation and error correction of pedestrian tracking by utilizing existing infrastructure such as surveillance cameras and active RFID tags
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