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Using reference RFID tags for calibrating the estimated locations of construction materials

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Effective automated tracking and locating of the thousands of materials on construction sites improve materials management and project performance. Utilizing location sensing technologies such as RFID, GPS, Ultra-wideband, infrared, and others help to achieve this objective; however, they generally provide imperfect data which results in lack of accuracy, precision and robustness. One possibility of improving the precision, accuracy, and robustness of such systems is the use of reference tags. In this paper active RFID tags are employed as reference points at known and fixed locations on a construction site and are used to calibrate the location estimation of other materials on the site. Materials on the site are uniquely attached with RFID tags and are subject to tracking. The basic principle of the calibration technique using reference points is to adjust the estimated location of neighboring tags by adding a unique offset vector to each individual tag location-estimation. In a two level approach, first the locations of all tags are estimated using a proximity method. Then a unique offset vector is calculated and added to each individual tag location to calibrate the estimated location in level 1. The offset vector is a weighted average of the shift-vectors between the observed and the true location of the reference tags. The weights are based on the relative distance between the observed location of the target tag and the reference tags. The experimental results show that calibrating the location estimates using reference tags can successfully deal with the challenges of a very noisy and dynamic environment and imperfect construction data and improve the precision of the estimated locations.

1. Introduction

Deficiencies in materials management have been recognized by Thomas and Smith [19] as the most significant and common factor affecting construction productivity and have been estimated by Nasir [12] to cause an overall reduction of about 40%. These deficiencies often occur due to some factors such as, lost or damaged materials, multiple handling of materials, materials required but not purchased, materials purchased but not received, sporadic and out-of-sequence deliveries, errors in the material takeoff, variances for additional material requirements, and materials that are issued to crafts and are then not used or installed [3,19].

An efficient materials management system can increase productivity, avoid delays, reduce man hours needed for materials management, and reduce the cost of materials due to decrease in wastage. Implementation of conventional and manual materials management practices continues to vary widely, however, and this variability and the inability to handle exceptional circumstances such as snow cover and congested delivery patterns limit their potential to improve project performance, thus attention is increasingly becoming more focused on the automation of at least some aspects of materials management.

Late deliveries, re-handling and misplacement of components, incorrect installation, and other problems inherent in the existing manual methods of locating highly customized materials can lead to delays in the project schedule and increases in labor costs [4]. Having an accurate and automated site materials management system that can identify, localize and detect the movement the materials on the site can have a significant positive effect on the materials control problem and associated shortages and can also facilitate automated material receiving and inventory control.

Recent advances in sensor technologies and sensing systems have enabled the deployment of a range of simple to complex sets of sensors in construction environments to detect materials' location and their movement across the site. Many locating technologies and data sources have therefore been developed [2,4–6,8,15,17,18]. However, the acquired data from these sensors are imperfect due to the limitations of the physical components and the high noise ratio of the construction environment. Developing a method for materials movement detection that deals with uncertainties and imprecision while having a reasonable implementation cost is thus a significant challenge. This method also needs to be robust to high levels of measurement noise in construction and be able to easily adapt to the

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