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A development of next generation intelligent construction liftcar toolkit for vertical material movement management

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ABSTRACT

High-rise construction sites, especially those situated in spatially-constrained urban areas, have difficulties in timely delivery of materials. IT-driven management techniques can be further benefited from state-of-the-art devices such as Radio Frequency Identification (RFID) tags and Ubiquitous Sensor Networks (USN), which have resulted in notable achievements in automated logistics management at the construction sites. Based on those achievements, this research develops USN hardware toolkits for hoists, which aims to automate the vertical material delivery by sensing the material information and routing it automatically to the right place. The gathered information from the sensors can also be used for monitoring the overall status. To support the system, a hoist-mountable intelligent toolkit was developed. Its feasibility test was conducted by applying the implemented system to a test bed and then analyzing efficiency of the system and the toolkit.

1. Introduction

Unlike other industries where single standard manufacturing process can be applied to a batch of production items, each construction project requires its own production process highly customized to individual project characteristics. As a result, each construction project has a unique, flexible logistics process for procurement of materials [4]. Therefore, planning of a supply chain management system should be flexible, which would accommodate highly variable project environment, from large-scale urban renovation to high-rise building construction [3].

In such environment, where only limited number of material lifting equipments are available, careful planning for the operation of the equipments is needed for efficient logistics management in construction site [13,19]. According to the precedent research [1,2,6], it was indicated that the efficiency of the lifting equipments varies with regards to the building height, and that planning of the material lifting affects the overall duration of the construction; furthermore, increased building height would lead to exponential increase of the information to be managed such as scheduling and cost, let alone the increased material quantity. Especially in construction sites in spatially-constrained urban areas, planning and managing the logistics of the materials directly affect the construction schedule and the cost; if a problem breaks out, it would trigger cascading problems in other parts in the project which would result in production delays and cost overrun. Many techniques such as Six Sigma, JIT (just-in-time production), Lean Construction have been applied to the area in order to improve its efficiency; however, the industry demands automated system for the management tasks, which have progressed rather slowly [1,2].

This paper describes the development of an intelligent lift car, which is a part of the multi-year national research project in development of the intelligent construction logistics system. The system under development utilizes remote sensing and communication technologies such as RFID (Radio Frequency Identification) and USN (Ubiquitous Sensor Network) to capture the information of material movement and to manage it in an intelligent manner. A toolkit (which consists of various sensors and wireless communication modules) has been developed to convert existing lift cars into the intelligent ones easily. The new lift car is designed to increase the efficiency of vertical transportation, which is crucial for successful on-site logistics, and to improve information management related to it. Several field tests were conducted to assess the capability of the new lift car. Overall goal of the development effort is to propose a new alternative for the next generation construction sites where many parts of their jobs are automated and intelligently controlled.

Fig. 1 illustrates overall procedure of our research work.

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