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A proactive system for real-time safety management in construction sites

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ABSTRACT

Construction sites still present high accident rates. The advent of advanced sensing technologies has motivated the development of unprecedented automated systems, capable of supporting health and safety control. Their application is particularly critical in those cases where regular safety inspections may prove to be inadequate in terms of preventing risks which, because of their specific nature, are unpredictable.
This paper reports the development of a first prototype for the proactive safety management and real-time signaling of potential overhead hazards. It is expected to enhance standard safety policies and assist inspectors and coordinators in executing their tasks. The system performs real-time tracking using ultra wide band technology and implements proactive virtual fencing logics. The development of the system, its laboratory test results, the algorithm optimization, and the final field test results are reported herein. The results achieved demonstrate the capability of proactive logics to reinforce safety management policies and assist personnel in coping with unpredictable hazardous events.

1. Introduction

Construction sites are very complex working environments, due to their dynamic nature and the concurrent involvement of numerous resources and supply components [1]. Accidents on construction sites are a scourge throughout the world [2]. The European construction sector has registered that falls from heights cause the highest number of fatalities, accounting for 52% of all accidents. Second on the list is the number of fatal accidents due to objects falling from overhead accounting for 36% of all accidents occurring on construction sites [3]. This plague also causes other repercussions, such as the social costs entailed as a result of disabilities [4] and the financial burden attributable to early retirement [5].

Despite the decreasing trend in the incidence of both fatal and non-fatal accidents in the European area, the construction sector still remains the most dangerous economic activity field in terms of non-fatal on the job accidents and (together with "agriculture" and "transport") is also one of the three most dangerous fields in terms of fatal accidents [3,6].

In accordance with current legislation [7,8], standard policies for mitigating the risk of accidents rely on increasing workers' safety awareness, through incentives, training, hiring, feedback communication and participation. At the same time a number of coordination and prevention policies, such as erecting temporary protections, guardrails or safety nets, wearing personal protective equipment and planning the coordination of tasks, have to be implemented [9]. Nevertheless, managing health and safety (H&S) issues merely through information and the adoption of a programmatic approach dictated by standard safe work practices, has proved to be less than completely reliable in many cases. Indeed, any changes to design plans during the execution phase often entail new potential hazards. Timely adhesion to rapidly modifying safety strategies thus proves to be hardly feasible given the dynamic nature of construction sites. For this reason there is always the risk that workers may be unaware of changes in the operational conditions or ignorant of newly dispatched safety strategies. Furthermore, coordinators for health and safety matters cannot always and ubiquitously oversee ongoing construction works. Consequently, in many cases the practical application of the regulations in a site's safety plan is left up to the workers, which often results in an insufficient application of mitigation measures.

Hence, the continuous monitoring of the work in progress would conceivably greatly improve the effectiveness of any safety strategy, in that automated management technologies would act as further safety measures supporting standard set-ups [10].

To that end, many researchers have developed original ideas for the site of the future, shown to benefit greatly from the adoption of mobile ICTs, as a means for establishing new islands of automation, new tools and approaches for human resources and knowledge management [11]. Recently marketed ICTs would provide the necessary background for developing a new generation of real-time construction management systems, which could be seamlessly integrated into the current arrangement of the construction work [12]. According to this new vision, the 'construction site of the future' is conceived as a 'smart' working place, where context-aware and self-adapting sensor networks and decision support systems monitor and complement workers' activities, at every level and in real time

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