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Testing in harsh conditions: Tracking resources on construction sites with machine vision

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ABSTRACT

When tracking resources in large-scale, congested, outdoor construction sites, the cost and time for purchasing, installing and maintaining the position sensors needed to track thousands of materials, and hundreds of equipment and personnel can be significant. To alleviate this problem a novel vision based tracking method that allows each sensor (camera) to monitor the position of multiple entities simultaneously has been proposed. This paper presents the full-scale validation experiments for this method. The validation included testing the method under harsh conditions at a variety of mega-project construction sites. The procedure for collecting data from the sites, the testing procedure, metrics, and results are reported. Full-scale validation demonstrates that the novel vision tracking provides a good solution to track different entities on a large, congested construction site.

1. Introduction

Real-time construction site information can be a key factor in improving management processes. The position data acquired provides an additional layer of control over the project and allows for enhanced decision making. This data is primarily acquired through radio frequency (RF) technologies, such as RFID, GPS, and Wi-Fi. In most cases, RF technologies provide a low cost, and low maintenance solution to tracking resources on a site and, as a result, are being embraced by the construction industry and used to track personnel [1,2], large equipment, inventory [3], and materials of all types [4]. However, the size and complexity of many outdoor construction projects often exacerbates the cost and time associated with purchasing, installing and maintaining the position sensors needed to track thousands of materials and hundreds of equipment and personnel [5]. In addition, the attachment of positioning sensors on personnel is often a privacy issue that can create controversy especially with unions, owners and general contractors [6]. These issues can hinder the adoption of technologies for outdoor, high volume resource tracking in the construction industry.

Vision based tracking has been proposed as a potential viable alternative for such cases [1,2]. Vision tracking (particularly 3D) is expected to play a significant role in measuring productivity, analyzing activity sequences, detecting travel path conflicts, and enhancing site safety. It is one of the most anticipated technologies, and holds promise to transform job site tracking and resource management in the construction industry. Brilakis et al. [7] presented a novel 3D vision based automatic tracking method. Although the potential of vision tracking is real, it does have limitations like any other technology. Without understanding and working with the limitations of vision tracking, this technology may disappoint many before its full potential is realized.

This paper presents the full-scale validation outcomes of the novel vision tracking method [7] for the construction industry. The prototype was tested for four months at large-scale construction sites to validate it in the real construction environment. Under the novel vision based tracking method, a pair of cameras is first calibrated to get the internal and external parameters of the cameras and the geometric information between the cameras. Then, the objects to be tracked are automatically identified and matched across both the views. After identification and matching, the objects are tracked in 2D in both the cameras. 3D coordinates are then calculated by triangulation of both the cameras' views in each frame. These 3D coordinates are used to then find the path, speed, direction, etc. of the entity.

The method was tested under the sponsorship of the US National Science Foundation, over 4 months at multiple job sites of three mega-projects in Greece. These projects are a) the Egnatia Odos motorway, a \$9.9 billion highway project with 1650 bridges and 76 dual tunnels [17], b) the Thessaloniki metro, a \$1620 million project with 13 metro stations, and 9.5 km of underground metro tunneling [18], and c) the Aposelemis Dam, a \$50.28 million project with multiple sub-projects that include the actual earth dam, transfer of a regional highway, preservation of a church that lies in the dam-lake, construction of a road, and construction of an earth barrier. These mega-projects were composed of several semi-independent construction sites and provided

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