Mobile 3D Printing Techniques for Construction Engineering: Outdoor Navigation and Printing Quality Control

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Abstract

In traditional three-dimensional (3D) printing, large-size 3D print machines, restricted print sizes of structural components and unstable printing quality limit its application in construction engineering. This paper proposes a mobile 3D printing technique for construction engineering. In this technique, a mobile 3D printing construction robot (M3DPC-Rob) is developed that takes advantage of a movable platform and flexible mechanical arm to cover the printing range of ordinary residential buildings. In order to locate the robot accurately in outdoor environments, an outdoor positioning and navigation method based on reflective columns is proposed. Furthermore, a quality control process is developed and modified to improve the quality of the printed line width. The results of a case study reveal that the outdoor navigation and printing quality control techniques of M3DPC-Rob show sufficient and steady accuracy that meet the requirements of construction engineering.

Keywords: 3D concrete printing; mobile construction robot; outdoor navigation technique; printing quality control technique; reflective-column-based absolute positioning method.

1 Introduction

The three-dimensional (3D) printing technique, as an emerging type of intelligent construction technology, has attracted much attention in recent years. Compared with traditional construction methods, the 3D printing technique requires less human labor, saves more building material and shows higher construction efficiency, which lead to lower construction costs [1]. Furthermore, the 3D printing technique can build architectures without formwork [2] and print structural components having complex shapes, which bring great convenience in construction engineering and inspire more innovations in both design and construction.

Nowadays, there are more and more studies focusing on research in, and application of, the 3D printing technique in construction engineering. Most of these studies emphasize the mechanical performance of suitable 3D printing material such as mortar, paste with small aggregate particles and concrete. The printability, fresh mechanical properties, hardened mechanical properties, durability [3] and fiber orientation effects [4] of those typical printing materials are researched and suggested design criteria are given. Most research shows that the materials used in 3D printing have

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