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Autonomous cleaning system for Dubai International Airport

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Abstract

This paper outlines the development of a robotic system designed to clean the outer surface of elliptic tapered structures such as Dubai airport concourse. The designed system consists of two identical cleaning satellites connected to a main unit and provides cleaning coverage up to 83° tilt from the horizontal surface of the concourse. The controller design, sensors, localization, and employed communication techniques are presented in this paper along with the final results of the implemented prototype. The system features redundant locomotion to ensure safe and reliable operation while maintaining autonomy and flexibility.

Keywords: Autonomous systems; Localization; Robotic cleaning systems

1. Introduction

Considering all the recent innovations and techniques employed in building construction together with luxurious exterior architectural designs, most newly constructed buildings in the UAE are not just simple cubical structures but rather more complex eye-catching elements of the cities. Not being an exception, Dubai International Airport catered for a staggering 24.7 million passengers in 2005 [1], flaunts wonderful concourse terminals with intricate elliptical designs as shown in Fig. 1.

The beauty of the terminals comes at a cost though. Maintaining such a structure clean poses a key challenge and it has become a priority for the Dubai airport authorities to

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Fig. 1. Elliptic tapered structure of the Dubai International Airport concourse.

design a safe and autonomous robotic cleaning system for the concourse surface. The proposed system should be in line with the current architecture and should not affect the airport structure during its operation and its entire life time.

There have been two previous attempts [2] to overcome this complicated challenge at the American University of Sharjah. The second design is shown in Fig. 2. In this design two identical cleaning robots equipped with mechanum wheels (providing omni-directional movements) were utilized to achieve the objective. However the overall system lacked redundancy and safety.

Keeping the mobility of the previous version, the present prototype is designed to improve safety and take into considerations reliability and ease of implementation for the cleaning module.

Different other models of cleaning robots already exist, particularly for floor treating. The interest in cleaning vertical or highly curved surfaces is tremendously increasing, especially for dangerous jobs that risk the operator's health and safety. There are three major categories for these machines based on the utilized locomotion method [3–7]:

- *Multi-limb locomotion*: This mechanism is based on arms and grippers and can be used for complex surfaces. Legged structures with two to eight legs are predominant. More limbs typically provide redundant support and often increase load capacity and safety. These benefits are achieved at the cost of increased complexity, size, and weight.
- *Wheeled locomotion*: This approach is also used for surface-climbing applications. It is suitable for even terrains like glass walls, concrete or brick walls and steel walls. However, the climbing action still needs the support of gravity-defying means such as vacuum pads combined with a lifting mechanism.
- *Linkage motion locomotion*: This approach is a sliding frame construction where the main elements of the robot slide relative to one another. They need special control strategies, but such constructions are especially well suited for climbing applications.