Enabling Surface Cleaning Robot for Large Food Silo

av

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Abstract


Working conditions in the dry cleaning and sanitation of confined interior spaces are often extreme, and workers need overall protection with tight clothing, helmets, face mask, earmuffs, and respirators. The environment is dirty, noisy with bad visibility and heavy with a high static work load. Dry cleaning is mainly practised in silos for grain, foodstuff and flour, etc. The inside of the silo is a hazardous environment due to many factors such as an unsafe oxygen level, engulfment, biological, mechanical, electrical, and atmospheric hazards. The requirements of the EU norms related to hygiene and food quality indicate that silos should be cleaned frequently and cleaning is obligatory after a silo is totally emptied. Therefore, there is an increased societal need for silo cleaning and a natural necessity to replace humans by robot manipulators in executing this risky and dangerous job.

This thesis presents a new concept of a flexible crawling mechanism for an industrial food cleaning robot, which is evaluated from the viewpoint of the capability to work inside a large food silo, scanning the desired surface, and performing the cleaning task. The main research questions investigated in this thesis are about: how to select the most important characteristics in designing a robot to fulfil the surface cleaning operation of a large confined space; how the crawling movement affects the dynamic behaviour of the robot mechanism; how the cleaning process affects the dynamic behaviour of the robot mechanism; how to develop the control of the robot to realize the locomotion and the cleaning process.

The structure of the robot and the cleaning technology are well defined after an overview of the existing technologies and solutions for cleaning large confined spaces. The robot design is based on a suspension and crawling system, using minimal actuators, where the force of gravity is well used to simplify the control system and to stabilise the robot. Further, the static and dynamic analysis of the mechanical system is studied. In addition, the control architecture of the system is performed, where the required sensors and control algorithm are given. A scale model testing has also been used to verify the locomotion of the concept, while simple controllers and algorithms are used to manage the motions of the prototype.

Keywords: Confined space, surface cleaning robot, motion control, static and dynamic analysis.

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