GENERATION OF EFFECTIVE SAND-BLASTING TRAJECTORY FOR AN AUTONOMOUS ROBOT IN STEEL BRIDGE MAINTENANCE

by

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

Steel bridges are vulnerable to corrosions, which results in conditions demanding regular maintenance in terms of de-rusting and re-painting. Current practices mostly rely on human workers with manually operated sand-blasting equipment to remove the rust or paint. This approach is labour intensive, tedious and, most of all, causes health and safety hazards for the workers, due to toxic dust arising from the removed lead or asbestos-based paints. Thus, an autonomous steel bridge maintenance system is very desirable, and the motion control of a robotic arm is identified as a key system requirement.

This thesis is concerned with studies on algorithms for generating an effective trajectory to be followed by an industrial robot arm used in sand-blasting. It is crucial in the context of productivity that the motion of the arm should follow a trajectory that aims to maximise the coverage of the blasted area and minimise the arm movements. The problem is challenging due to the changing environment underneath the bridge and the risk of colliding with obstacles. Furthermore, the trajectory generation process is complicated because of the many requirements imposed, such as minimum arm travel distance, minimum number of turns and minimum time to complete the blasting.

The problem is tackled in this research by beginning with an assignment of the blasting area, where a hexagonal coverage pattern is adopted to allocate blasting targets. The sequencing of blasting spots on the blasting surface, constituting the path to be

followed by the blasting nozzle, is determined through the use of a genetic algorithm as a sequence-finder for its applicability and flexibility in many engineering design problems. The order of blasting spots (that is, the path of nozzle) is then transformed to robot joint angles, that is, trajectory, by a genetic algorithm amended inverse kinematics approach. Furthermore, a method based on three-dimensional force-fields is used to safeguard the robot against collisions with obstacles. The resultant trajectory, in the form of a series of joint angles commands are fed to a Denso VM-6083D-W industrial robot for sand-blasting.

The effectiveness of the generated trajectory is verified by simulations and experiments. It is shown that trajectories can be derived for blasting surfaces with satisfactory coverage. The developed method is further demonstrated in generating trajectories for a number of blasting surfaces of different sizes, to the extent of the work space, at various locations and orientations surrounding the robot arm. An experiment is conducted, on a mock-up robotic blasting system, by driving the robot arm in accordance with a generated trajectory.

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