Damage Detection and Monitoring for Tunnel Inspection based on Computer Vision

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Abstract

The deterioration of the underground infrastructure of the major cities around the world, due to the ageing, has become a topic of great concern among engineers. Visual inspection, as part of the routine maintenance procedures, is a common practice used in the *condition assessment* of infrastructure to ensure its safety and serviceability. This practice, however, is labour-intensive, costly and inaccurate and, therefore, a new system based on computer vision technology is presented in this thesis, aiming to tackle these inadequacies.

This thesis proposes a novel mosaicing system for inspection reporting, which can create an almost distortion-free mosaic of tunnels, thus allowing a large area of tunnels to be visualised. The system relies on *Structure from Motion* (SFM), which enables the system to cope with images with a general camera motion, in contrast to standard mosaicing software that can cope only with a strict camera motion. The system involves the automatic robust estimation of a 3D cylindrical surface using a *Support Vector Machine* to classify 3D points to improve the accuracy of the estimation. It is shown that some curvatures are observed in the mosaics when an inaccurate surface is used for mosaicing, while the mosaics from a surface estimated using the proposed method are almost distortion-free.

New feature matching algorithms aiming to improve the performance of SFM systems are proposed. These algorithms apply a *spatial consistency* constraint to match features with a similar topography, in contrast to other matching algorithms that rely on matching based on the similar appearance of local image patches. The Shape Context and Random Forest algorithms are combined in the proposed algorithm, revealing promising results.

The final contribution is a new change detection system for monitoring cracks in multi-temporal images. The system can cope with images with a general camera motion achieved by geometrical registration using SFM, unlike other systems that assume fixed or controlled cameras. The system performs photometric normalisation to cope with illumination variation in the images, and also a motion-invariant change detection algorithm is applied to handle deformable objects. It is shown that the results from the proposed change detection system are still impractical for use with tunnel images from a real environment, and further study is required.