New Techniques For Assessing The Visual Condition Of Civil Engineering Structures

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Regular inspections of the condition of civil engineering structures such as bridges are vital to ensure they remain safe and fit for purpose. Currently, in the UK, highway structures are assessed using a regime of visual inspections, performed by trained engineers. The inspections cover a range of detail, from a cursory check for gross defects, to a close examination of all surfaces of the structure, including the use of special equipment if required (Highways Agency, 2007). The quality of data collected depends on the ability of the inspectors to observe and objectively record details of defects.

A number of studies have been performed into the reliability and limitations of visual inspections (Gallwey & Drury, 1986), (Jamieson, 1966), (Megaw, 1979). These have been conducted considering the specific cases of visual inspections on bridges (Moore, Phares, Graybeal, Rolander, & Washer, 2001), and also considering visual inspections in other sectors (Schoonard, Gould, & Miller, 1973). These studies have identified a number of factors which affect the accuracy and repeatability of the inspection results, and have found that the data provided by such inspections can vary significantly.

Until relatively recently the condition of highways was assessed using an inspection regime based largely on visual inspections, which were similarly affected by issues of subjectivity, variability and reliability. Research has taken place over the past twenty years to develop and refine the technologies and protocols needed to perform more objective surveys. This development has led to a range of automated systems (Ferne, Wright, & Pynn, 2003) which use machines to gather data related to the condition of the road surface, process and interpret this data and deliver guidance to engineers about the condition of the road. These systems often go as far as to prioritise different sites on a network and suggest maintenance strategies.

It has been suggested (Woodward, 2006) that a similar approach could be implemented on structures, and hence research is underway to investigate the automation of highway structures. The research is focussing on the use of images of the structure, to assess its condition off-site. The aim is not to remove the engineer from the inspection process, but to assist them, and make their job easier. The research is, at this stage, constrained to concrete bridges with relatively simple geometries.

An important first step in the research was to establish whether or not the images contained useful information. It has been found that similar structure condition assessments could be obtained by an engineer on site performing a traditional survey, and an engineer with only images of the structure.

Subsequent work has concentrated on two main areas: image collection, and image analysis.

The image collection work has investigated the practical issues involved in imaging structures. Such issues include image resolution, lighting, removal of parallax, location referencing of individual images and the development of a prototype collection system.

Figure 1: Prototype image collection system, showing camera, flash and distance measurement lasers.

This prototype system makes use of distance measurement lasers and theodolites to determine the position of each image relative to any other image, making it easy to know precisely which parts of the structure are affected by any particular defect.

The image analysis work has attempted to segment the images so that the defects or features present on the structure can be highlighted and classified. The segmentation work has made use of a number of image processing techniques including edge detection, image entropy and wavelet analysis (Gonzales & Woods, 1990) and has achieved promising results to date, although the system performance is not yet at a level where it could be used operationally.

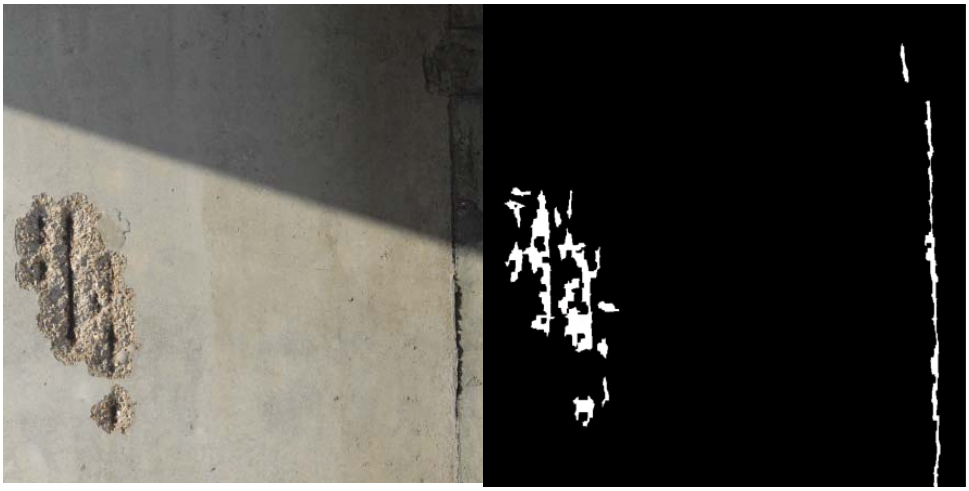

Figure 2: Example of segmentation of a defect from image (left) to segmented image (right).

Processing work has begun to classify the segmented objects into those which should be present on the structure (cabling, drainage, lighting, etc) and those which should not be present on the structure (defects). This segmentation work has explored the use of many basic image processing techniques, and some more complex approaches, following a review of the literature (Abdel-Qader, Abudayyeh, & Kelly, 2003). The current segmentation method uses the local entropy of the image, and Haar wavelets to detect areas of the image in which objects are apparent. These objects can then be characterised and classified.

In addition, research is ongoing to establish what is actually done during a visual inspection of a structure, and how the engineer responsible for the maintenance of the bridge then makes use of and interprets the data collected during such an inspection. This knowledge will help to

inform the development of visualisation methods to enable the manipulation of and interaction with the inspection data in such a way as to convey the maximum amount of information.

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