AerialCrackView – Crack Monitoring in Concrete Bridges through Multi-Spectral Image Processing Acquired by Unmanned Aerial Vehicles

Summary

In the last decades, Portugal made a significant investment in new infrastructures. With the current economic and financial crisis, this has suddenly stopped. Now, the priority must be the development of innovative methods aiming at assuring the maintenance of existing structures and at minimum cost. In this scope, inspection and diagnosis methods are of utmost interest, given that interventions in all relevant infrastructures are always planned based on results of periodic (visual) inspections. In the case of concrete structures, the characterization of cracking (initiation, propagation, and pattern) plays an extremely important role to monitor their structural health. However, current inspection methods are rudimentary and work intensive (inspectors take hand notes and pictures that later upload to their desktop computers to write a report), prone to human error (since crack widths are measured using crack rulers at random spots) and expensive ('underbridge' trucks are rented to observe underneath bridge decks). Therefore, the development of a semi-automatic method to detect and characterize cracks in concrete bridges and to monitor their evolution in time, based on processing images acquired with unmanned aerial vehicles (UAV), represent a breakthrough regarding the current state-of-the-art.

In the present project an innovative method, named Aerial Crack View, is under development. The main objective established was to automatically, exhaustively, and in a broad sense characterize and monitor the crack pattern evolution of concrete bridges. The work plan proposed to fulfil this main goal comes strictly in line with the excellent results of the fundamental research previously conducted by the team, and it will allow deepening the knowledge in this frontier research topic, by developing a method for on-site application. The project is carried out in the following two main domains: (i) image acquisition, and (ii) image processing. Specifically, Aerial Crack View use robotized aerial vehicles to automatically perform the photographic survey of critical sections of the structure, being later performed the digital processing of the multispectral images obtained for automatic identification and characterization of cracks. The project is focused in concrete bridges, including however, in a second plane, other structures, such as dams and buildings. For the successful implementation of the project, the work plan was divided in four tasks.

1. Multispectral Image Processing: Concrete laboratorial specimens were produced, considering cracking combined with other concrete anomalies. Then, a digital data-base of multispectral images of all laboratorial concrete specimens was created and, finally, all multispectral images of the specimens were processed by an innovative method developed (Figure 1).

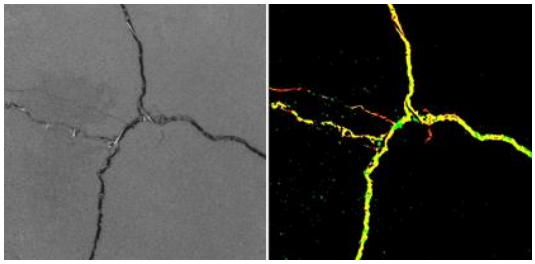

Figure 1. Example of laboratorial tests: a) original image; b) classification map.

2. Monitoring Image Features: An automatic method for tracking the crack evolution on concrete surfaces by digital image correlation is under development. The method is being applied and tested in the digital data-base created in task 1. In addition, it is being taken into account other anomalies commonly found on concrete surfaces and mainly considering natural targets.
3. Unmanned Aerial Vehicles (UAV): A multi-sensor UAV specifically dedicated to perform the inspection of bridges and, eventually, other Civil Engineering structures (e.g. dams and buildings) is under development. The development is divided in two main stages: (i) building a smaller UAV platform for validation the design methodology for sensor fusion; (ii) building a larger UAV platform to survey real structures. Currently, the tests in the smaller platform are being performed and the last adjustments in the sensors applied (Figure 2).

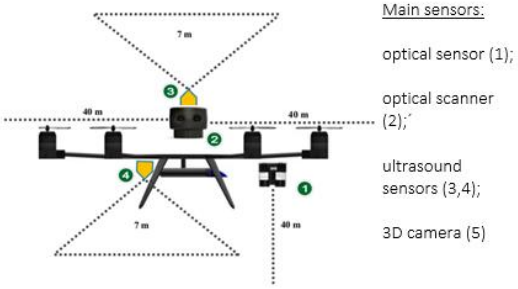

Figure 2. A multi-sensor UAV platform.

CERIS : Civil Engineering Research and Innovation for Sustainability

Project Reference

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Leading Institution

IST-ID – Associação do Instituto Superior Técnico para a Investigação e o Desenvolvimento (Portugal)

Partners

UC – University of Coimbra (Portugal), IF – Infraestruturas de Portugal, S.A. (Portugal), LNEC – National Laboratory of Civil Engineering (Portugal), Armando Rito, SA. (Portugal), SkyEye (Portugal), Ingeniarius (Portugal)

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CERIS

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Project Website

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4. Method Development & On Site Validation: After the validation of UAV platform and of the image processing procedures (Tasks 1 to 3), the new Aerial Crack View method will be applied for bridge inspection. The Aerial Crack View will be capable of automatically surveying the critical areas of the structure and characterising the evolution of its crack patter, combining the use of UAV and digital processing and correlation of multispectral images.

Objectively, this innovative method will be much more precise and accurate since the full-length of cracks will be recorded (instead of measuring random singular points), much faster since most of the procedure will be automatically conducted, and inexpensive since 'underbridge' trucks will be replaced by low-cost unmanned aerial vehicles (UAVs). This will allow to perform better, faster and with lower costs bridge monitoring and, in addition, to decide faster and to make, whenever needed, maintenance/repairing/rehabilitation operations earlier.

Finally, the relevance of the project and its benefits to society and business sector are also evident through the interest and participation of IF – Infraestruturas de Portugal, S.A., providing data regarding the adopted case studies; LNEC – National Laboratory of Civil Engineering) responsible for load-tests, inspections and monitoring operations in bridges; Armando Rito, SA, the most internationally awarded Portuguese bridge design office; SkyEye, one of the very few companies operating in Portugal with unmanned aerial vehicles; and Ingeniarius, a technological company specialized in robotics and automation.

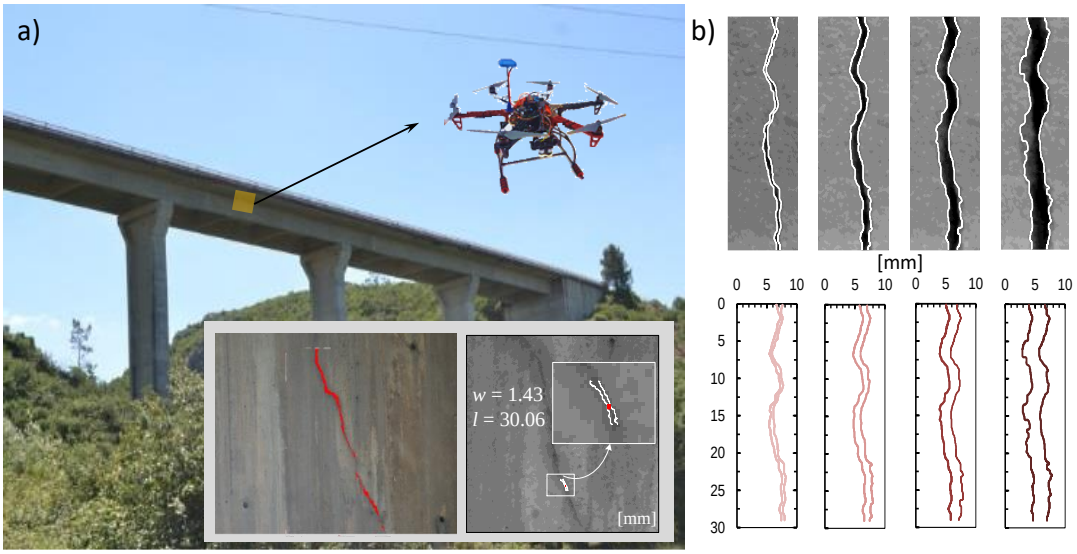

Figure 3. General view of the method: a) image acquisition and processing; b) crack monitoring.