INNOVATIVE METHODS FOR WATERWAY INSPECTION: AN APPLICATION TO CANAL-TUNNELS

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Inland navigation is a prime transportation vector, whether for freight or tourism, and represents a more environmentally friendly alternative to road transport. The maintenance of fluvial infrastructures is not only a matter of heritage preservation, but also a commercial necessity and a security issue. Their documentation and periodic inspection is challenging due to the variety and huge number of structures to be considered. For example, Voies Navigables de France (VNF, the French operator of waterways), manages more than 6700 km of waterways (including more than 4000 structures). Filling in the VNF structure database (called BDO) is, for the moment, performed through systematic and exhaustive technical surveys of the structures carried out on site by agents. It is a major effort, may hinder navigation and endanger operators. For this reason, it is necessary to develop highly efficient methods that are minimally invasive to fluvial traffic and require as little human intervention as possible. In this presentation, we focus on a particular type of structures, namely canal tunnels, but the proposed methodologies could concern other waterway structures.

Although there are only a small number of canal tunnels (e.g. in France, 33 tunnels are still in operation, for a total of 42 km of underground waterways), they are key to safe navigation. Located mostly on small gauge canals, they attract heavy touristic traffic. I this paper, we illustrate how up-to-date technologies (3D reconstruction by photogrammetry, high frequency bathymetry and pattern recognition techniques) may be used to design automatic tools for the detection of deterioration on structures and to produce accurate 3D models including both under- and above-water parts of the tunnels, even in the absence of GPS signal. In addition to this work on 3D reconstruction, we also explore the use of machine learning algorithms to detect defects automatically on the above-water parts of the tunnels.

With regard to 3D modelling, a doctoral work funded by a Cerema scholarship from 2014 to 2017 allowed us to explore the whole-tube 3D imaging of canal tunnels by combining photogrammetry and high-frequency bathymetry sonar surveying. More specifically, we address three aspects in our presentation, namely:

- evaluation of a recent technology in 3D sonar recording in a lock, showing that elements larger than 5 cm can be seen in the sonar model (see Figure 1);
- Development of a 3D reconstruction pipeline based on image and sonar data acquired dynamically from a boat. Photogrammetry was used both to build the vault model and to compute the boat trajectory, which is necessary for georeferencing sonar data in the absence of GPS signals (see sample result in Figure 2);
- Quantitative evaluation of the 3D model against a reference model of the tunnel, obtained from static laser and sonar acquisitions using an original processing pipeline, showing a centimetric accuracy for photogrammetric reconstruction and a decimetric accuracy for underwater reconstruction.

In addition, we present the pattern recognition algorithm that we implemented to highlight defects in the infrastructure automatically, with detection performances higher than 90% (see Figure 3).

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(a) (b)

Figure 1: Views of a lack of rubble stone on laser (a) and sonar (b) models of a canal wall

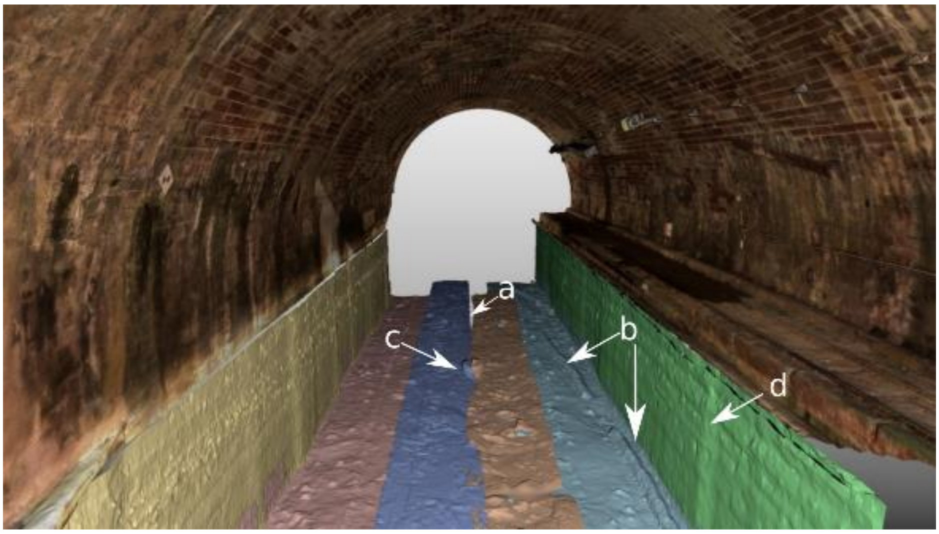

Figure 2: example of 3D model of a canal tunnel obtained from SONAR and image data

Figure 3: Water leak detection (in blue) in images of a masonry tunnel

Even if steps still need to be taken before a complete automation of the process can be achieved, this research has shown the feasibility of documenting engineering structures such as canal tunnels in 3D. The proposed techniques could also be generalized to areas where the GPS signal is inoperative. They are complementary to more classical bathymetry methods. Moreover, we have shown the feasibility of automatically detecting defects in the structure via pattern recognition methods, which may be generalized to other structures and to underwater elements.

In line with this collaborative research, and as part of its evolution towards digital technology, the so-called RES'O FLUVIAL 2.0 project, VNF is launching a first innovation partnership for high-throughput collection of images of the linear components of its network (mainly embankments and dikes), from the waterway. The aim is to automatically pre-inform (using shape recognition technologies) the condition field in the VNF structure database. Moreover, the images will be made available through a geolocalized interface (similar to Google Riverview).