INSIGHTS ON THE FUTURE OF BUILDINGS AND INFRASTRUCTURE DAMAGE ASSESSMENT

The merger of a reasonably mature and mainstream technology such as Unmanned Aerial Vehicles with cutting edge Artificial Intelligence is to provide a safer, faster and more productive inspection workflow.

CONCRETE DAMAGE ASSESSMENT

The maintenance and repair of large concrete infrastructure is rather costly, e.g. in Europe, €4-6 billion are spent annually on maintenance of concrete infrastructure, let alone to associated costs that derive from traffic disruptions. In Denmark, the number of required inspections is expected to increase in the next few decades as the build-boom concrete structures of the 60'ies and 70'ies exceeds expected service life.

Solutions to monitor structures usually consists in embedded sensors to detect structural stiffness changes or corrosion initiation. The results from these are then associated with the presence of damages in concrete. However, such monitoring systems are common to modern infrastructure with long service life, i.e. much of the existing ageing concrete structures ought to be inspected in the traditional way, i.e. by eye, hand and non-destructive testing.

In concrete damage assessment, crack detection is crucial since they indicate inherent structural or material deficiencies and represent a path to aggressive agents to reach the reinforcement and trigger the onset of corrosion. Thus, the earlier a crack is detected, the better the chance to counter the its side effects.

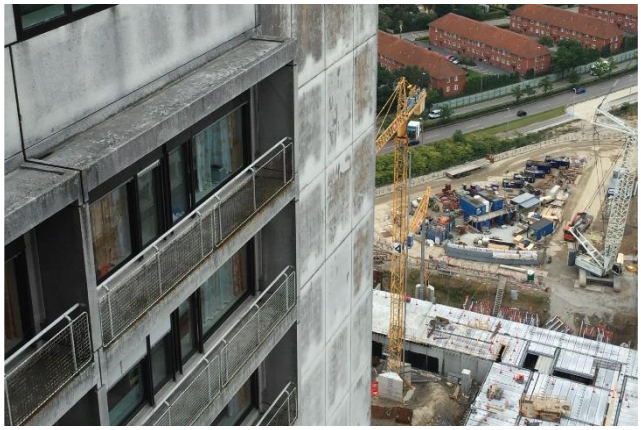

Fig. 1: *The concrete façade inspection in Herlev Hospital was performed using ropes and lifts.*

When performing damage assessment tasks, a visual inspection provides an easy mean to detect cracks that are apparent on the concrete surface. However, in large structures, visual inspections are rather costly, time consuming and difficult, let alone the safety aspects when dealing with areas that are difficult or dangerous to reach, e.g. the slab decks and pylons on bridges, facade elements in tall buildings, see example in Fig. 1.

To facilitate that, companies are making use of unmanned aerial vehicles (UAV, here referred to as drones) for visual inspection of structures. This trend is supported by the fact that the UAV industry reached a point where they can provide reliable, easy to use, and affordable drones, improving damage assessment efficiency.

Fig. 2: Drone flying over a construction site.

DRONE DATA AND ANALYSIS

Though commercial drones are becoming easier to operate, it does not translate into an easier damage assessment workflow – i.e. from data collection to assessment. The biggest challenge lies in the latter, since drone-assisted inspection yield a much larger dataset than that from visual inspection using cameras and notebooks. Extracting meaningful insights from such amount of data is complex, so the time saved by using a drone to collect data from a structure can easily be spent on data analysis.

Today, for the purpose of damage assessment, the data analysis is done mostly manually, often outsourced to cheap labour countries, by technicians who register features such as concrete cracks and spalling on images. Hence, the provision of automated methods to assist inspectors on the assessment of data from concrete structures, e.g. to automatically identify concrete cracks, is a step towards a more efficient drone-based inspection.

In such scenario, computer vision is a technology that can be deployed to improve inspection. Most of the existing crack detection system, however, relies on conventional image processing methods (e.g. thresholding and edge detection) to identify cracks. Though reliable to some extent, this approach provides a shallow abstraction that cannot encompass the complexity of conditions that a concrete surface present, e.g. surface roughness, light, and humidity. This complexity makes it virtually impossible to code a method that covers all features in concrete surfaces.

Deep learning algorithms such as Convolutional Neural Networks (CNN) offers means to overcome the limitations in crack detection using image processing. CNNs have successfully been applied to image classification in various fields, while featuring a great level of generalisation and learning capabilities. Features like these are paramount to detect damages such as cracks in concrete in a robust and reliable manner.

TOWARDS AI-ASSISTED INSPECTIONS

As both the number of companies that rely on drone-assisted inspection as well as the amount of data collected in concrete damage assessment will grow, the need for development of Artificial Intelligent (AI) tools that will assist inspectors to retrieve meaningful insights, cheap and fast, from data is essential.

To this end, the Danish Technological Institute works towards developing a “Data-as-a-Service” solution for the benefit of drone-based inspection of concrete structures. The goal is to create a first generation of an automated crack detection system based on AI (particularly, Deep Learning). The initial version of the system was developed and demonstrated in a controlled environment in late-2017, see Fig. 3.

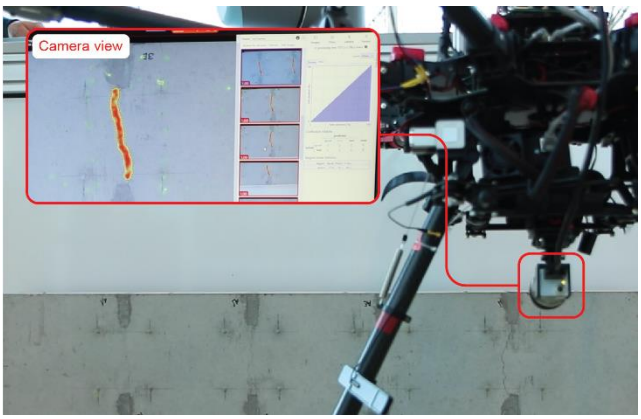

Fig. 3: AI-based crack detection system tested in controlled environment at Teknologisk Institut.

At present, our automated crack detection system is being further developed and upscaled, and it will be validated in late-2018. Specifically, we are a) utilising a large image dataset with various concrete surfaces to train the AI system and b) coupling image metadata such as camera position and distance from the object to compute the width of cracks. Also, our project activities focus on performing automated flights using tethered drones, thereby extending flight time and facilitating real-time data assessment

While AI constitutes a path towards automated inspection, the system mirrors the knowledge used during its training – similarly to a well-trained human. Hence, human expertise is crucial in the development of an appropriate tool. Also, to enable AI systems to evolve, a feedback system with corrections from an expert in the field on inspections is crucial. Thus, AI-based inspection is likely to be deployed as a tool that assists inspectors - the envisioned scenario for the future workflow of damage assessment in structures is shown in Fig. 4.

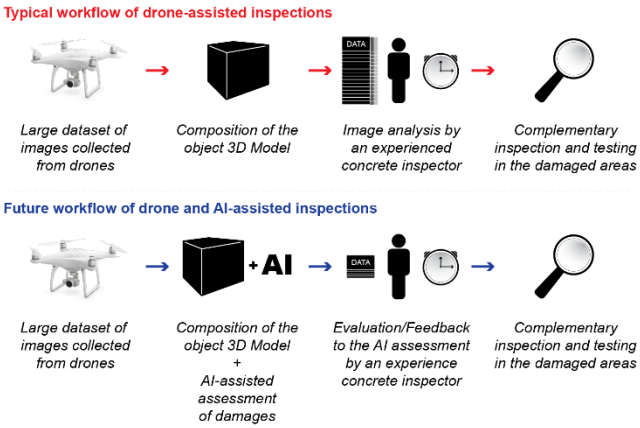

Fig. 4: The future of concrete damage assessment – Drone and AI-assisted inspection workflow.

The end goal of merging the reasonably mature technology of drones with cutting edge AI is to provide a safer, faster and more productive inspection. This creates new possibilities for increased effectiveness in asset management by making unbiased, periodic structure monitoring and/or damage assessment feasible.

INFORMATION

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