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Automated Image Learning to Improve Sewer Pipeline Inspections

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Abstract: The need for faster, more reliable and more objective need for sewer inspections and their analyses have been recognized. In Finland, only much less than 5% of the sewer pipelines are inspected annually. Of the inspected pipelines, approx. 60% has been found to be in good condition, and 8% of the inspected pipelines need some actual means to repair or replace in near future. In this project, a method to use machine learning technique to inspect and analyze the sewer inspection filming was piloted by two consultants. Both pilot projects proved that this technique is auspicious and feasible method to help and accelerate the speed of pipeline inspections, when the CCTV inspection is made with a digital filming and scanning camera. DigiSewer® was used in this piloting project. Further development steps will include the use of a screening method with a cloud-based data transfer, improving the process of sewer inspections further including the information of operational condition of the pipelines.

Key words: CCTV-inspection, digital filming, DigiSewer®, machine learning technique

1. Introduction

Helsinki Region Environmental Services Authority (HSY) is the largest and leading water utility in Finland. Its area of operation has about 2,800 km of sewer pipelines and 2,400 km of storm water pipelines. HSY serves around 1.2 million people in the Helsinki Region (Fig. 1). In Finland, there are approx. 50,000 km of sewer pipelines.

Annually approx. 120 km of the sewers and storm water pipes altogether are inspected with a CCTV inspection method. The situation is similar in all the cities and towns in Finland.

Currently the method includes manual labour, manual inspection, and manual interpretation of results and observations, thus the method is highly dependent on the author of the inspections. The current method causes very inaccurate and unreliable observations and interpretations, which causes several rounds of viewing and interpretation (Fig. 2), and, thus, slow and still imperfect results.

In the Exeter University, UK, the research is focusing on automated interpretation of traditional CCTV-inspections, without digital filming [1].

Globally, digital filming methods are used across all continents in more than 30 countries [2], and the US is the largest market.

Furthermore, a screening method using an Envirosight ® camera system was used in the same area of operation. It is possible to increase the volume of sewer inspections up to 10 times as compared to the current situation.

In the HSY, a pilot project was made with digital filming and automated image learning (machine leaning technique) to improve the sewer pipeline inspections.

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Key figures	Helsinki Metropolitan Area (4 municipalities)	Helsinki region (Helsinki Metropolitan Area + 10 KUUMA municipalities)
Square area	770 km²	3 670 km²
Number of residents (2015)	1 106 500	1 402 000
Dwelling units (2013)	567 000	712 000
Population density (2014)	1 434 residents/km²	382 residents/km²
Workplaces (2012)	617 000	719 000

Fig. 1 Helsinki Metropolitan Area and Uusimaa, Finland.

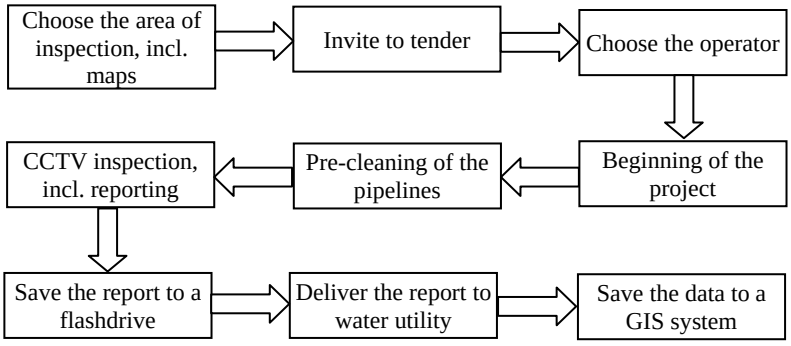

Fig. 2 The CCTV process currently used in Finland.

2. Material and Methods

SmartWater-project in HSY started in the beginning of the year 2015. One of the recognized main goals was to find new possibilities to interpret CCTV inspections with an automatic machine learning technique. This would lead to a more homogeneous and more objective interpretation of sewer inspections. We do not currently know of other studies to automatically interpret CCTV inspections.

Two proofs of concept (POC) were made to study the possibility to interpret digitally filmed sewer inspection data automatically with machine learning techniques. Both POCs proved that the method can be developed further for the use of water utilities all over the world.

During the SmartWater project, HSY organized two seminars on the subject, in which experts in the field and engineering companies' representatives discussed the topic of the challenge, and whether it is necessary to change the instructions for CCTV inspections. With digital imaging and automated interpretation, the results of the CCTV process will be more accurate, homogeneous and faster, resulting in considerable

savings in the cost of the pipelines' condition assessment (Fig. 3 and Fig. 4).

The screening method was tested using a Envirosight ® camera system with a software solution developed by Underground City (UC). Envirosight provides an Android application to control the camera and to store inspection videos locally in the Android device's memory. An Android application developed by UC was used to transfer inspection videos automatically to UC's cloud service. The cloud service associates inspection videos to correct pipes ensuring that inspection results are readily available and can be found later on. A web application developed by UC can then be used to view inspection videos, to evaluate the condition of a pipe and to visualize the condition of the sewer network overlaid on a background map.

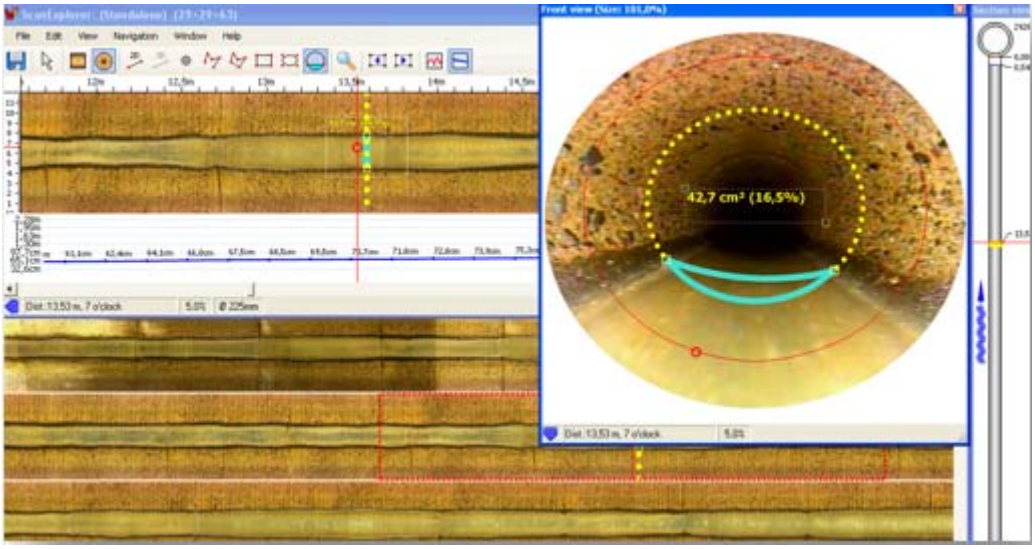

Fig. 3 Result figures of a DigiSewer® inspection.

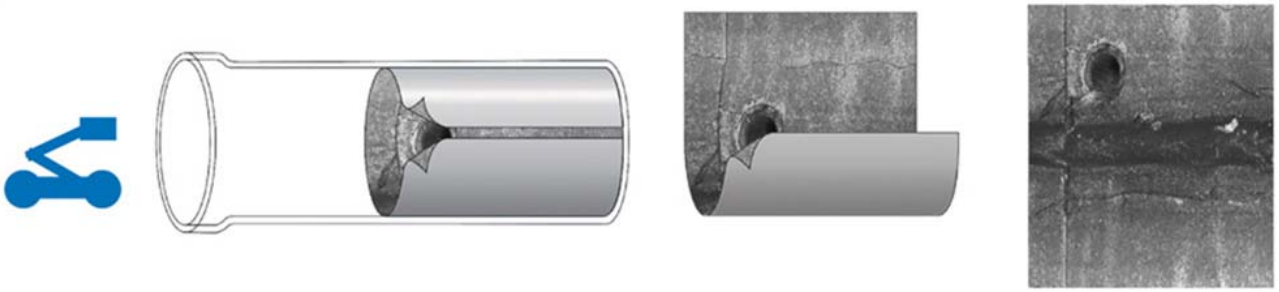

Fig. 4 The figure (from the DigiSewer®) of the pipe section is formed as shown here.

3. Results and Discussion

3.1 Data Transfer from the Field to the Utility

A method was developed to manage the sewer inspection through a cloud service. The cloud service has a map of the sewer pipelines (data from a GIS system from the utility), where real-time observations of the sewer are added and color codes are used to illustrate the condition of pipelines in the area investigated, showing also possible renovation and reparation needs. It is possible to transfer the information obtained to the network data system (GIS) (Fig. 5). This will provide a more accurate foundation for the engineering of sewer renovations and a more cost-effective way to manage and maintain pipelines.

3.2 Digitalizing the Sewer Filming Process

The traditional CCTV inspection process is done with a robot crawler and a pan-and-tilt camera. The operator runs the robot through the pipe section, and

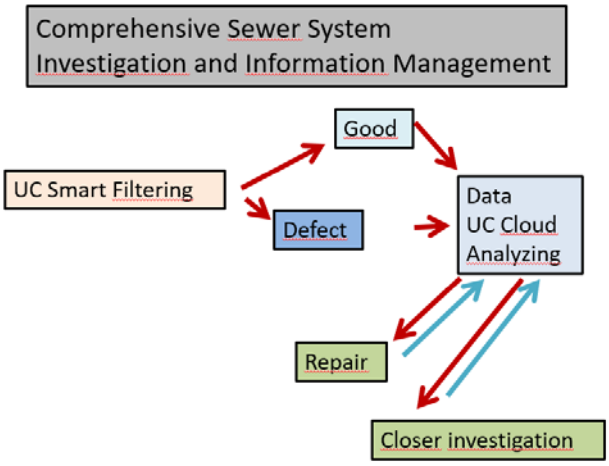

Fig. 5 A schematic presentation of data transfer, and data analyses (©Underground City Oy).

stops and turns the camera head towards possible breakages and problems he/she observes during the inspection. From the inspections, a video recording results, with the notification of the operator. The inspection and analyses of the observations is based on national or international standards (such as EN 13508-2). The observations and their severity are very dependent on the operator, and very unreliable and incomparable results.

Digital filming techniques, such as DigiSewer® used here, provide homogeneous information from the inner wall of the pipelines resulting in a single picture. The digital filming proceeds through the pipeline section without separate interceptions and zoom-ins as is the case with the traditional CCTV inspection. In the DigiSewer® system is possible to include, e.g. laser beams, with which a very accurate knowledge of the inner wall is obtained.

3.3 Use of the Screening Method in Sewer Inspections

The screening method with an Envirosight® zooming camera and the cloud-based information transfer system by the UC were found to increase the the amount of inspected sewer pipelines annually. This method is very useful for its fast turnaround time and results, and it can be used with less money to get a better tool for asset management and planning of the renovations etc. (Table 1).

Table 1 Comparison of traditional CCTV inspection (including pre-cleaning process) and screening method for a time span of 4 years.

	CCTV with pre-cleaning	Screening method
Length of inspected pipelines	150 km/a	600 km/a
Working time	12 months	5 months
Costs	900 000 €	900 000 €
€/km	6	1.5
Length of inspected pipelines	600 km	2,400 km

The screening method is faster than the traditional CCTV inspection, and it does not require pre-cleaning as the traditional CCTV inspection method. The screening method gives also information about the operational condition of the pipelines, which can then be used further to estimate remaining life time of a pipe section, and to prioritize the network for more accurate inspection methods.

With the screening method, the utility can obtain more detailed and comprehensive data and knowledge of their network system.

3.4 Further Development of the Digital Filming and Automated Image Learning Processes

The methods presented here enable new business opportunities and possibilities for both the operators and other fields, such as engineering companies. If digital filming is used together with the screening method and faster and more reliable data transfer processes, the data would be objective and readily available for all the sides working with urban drainage, asset management and planning.

4. Conclusion

Water companies globally are in need for the development of digital pipeline condition inspection methods to meet today’s demands for more efficient ways to manage the maintenance and rehabilitation of pipeline networks. Digitizing and measuring more accurately and objectively the pipelines, automatizing the interpretation of the data obtained, combined with modern data storage and transfer methods through cloud service answers to this challenge.

References

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