A(I) IS FOR ACCURACY

Artificial intelligence can boost the efficiency of pipeline inspections

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Road collapses, flooding, and sewer backups resulting from pipeline breaks, holes, and fractures are all-too-common occurences. Inspection is critical to repairing defects before they become bigger, more-expensive problems.

However, pipeline inspection, maintenance, and repairs can place a considerable burden on a city's annual budget, especially when available resources are either lacking or applied inefficiently. Pipeline assessment is time-intensive, both in the field and back at the office during quality assurance/quality control (QA/QC) review. Despite an established system for classifying observations and defects within pipe segments, inconsistencies remain a challenge.

Updates to inspection equipment and pipeline defect standards certainly have helped, but the process used to pinpoint problem areas precisely has remained relatively unchanged since the introduction of closed-circuit television (CCTV) in the 1950s. Artifical intelligence (AI) is a game-changer that will vastly improve accuracy in pipeline inspection, significantly reduce costs, and help crews work smarter.

Traditional Pipe Inspection

CCTV was adopted more than 60 years ago to analyze pipe conditions and find line defects. Cameras allow operators to view the inside of pipes, sewer lines, and drains to identify the cause of problems including blockages, cracks, and root intrusion (see Figure 1, p. 41).

The standardization of pipeline observations introduced in the early 2000s by the National Association of Sewer Service Companies (NASSCO; Owings Mills, Maryland) streamlined the process. NASSCO's Pipeline Assessment Certification Program (PACP) provided a system for comparing pipe segments within the collection system, regardless of location and who conducted the assessment.

NASSCO standardization improved the inspection process, but it did not eradicate inconsistencies. Operators are expected to manage and review the video recordings of more than 200 NASSCO codes. Coding is extremely time-consuming, and there are often thousands of feet of pipe and hours of video to review.

AI Benefits

- Time and cost savings
- Reliable data set
- More detailed analysis
- Repeatable results
- Less likelihood of missing a defect
- Reduced burden on the contractor
- No additional training required

The process is not only time-intensive, but also riddled with bias, subjectivity, and variances among levels of experience. Consider the difference between an operator with 30 years of experience and a novice. The two will operate the camera differently, which can significantly affect how long it is in the pipe. They also will document each observation differently, opening coding to a range of interpretations. Aside from years of experience, bias means that five people can examine the same data and interpret defects five different ways.

Subjectivity and bias also come into play when differentiating among cracks, fractures, breaks, and the complexity of root issues. The result? Inconsistent conclusions about a pipe's condition and the decisions to replace, rehabilitate, maintain, or take no action, which adds time during the QA/QC reviews when costly corrections are necessary. Unfortunately, by the time a problem is detected, it can be difficult to respond quickly enough based on the data at hand.

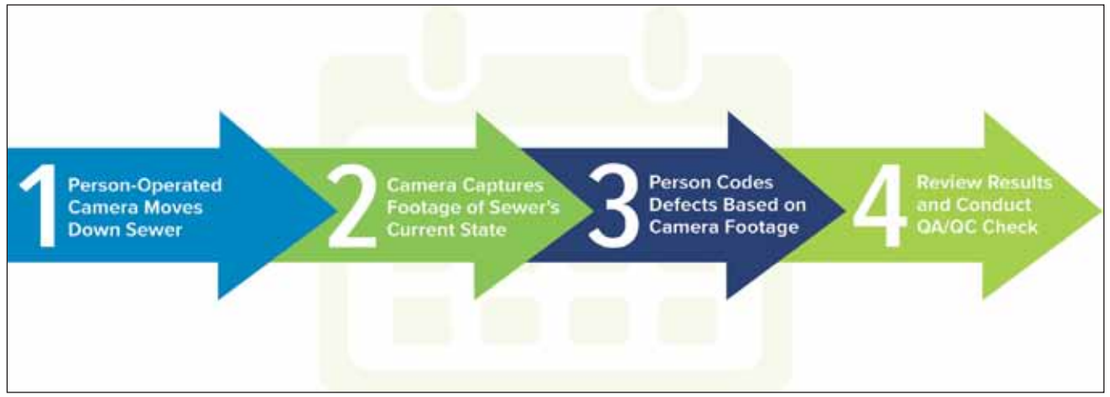
Case Study: Ohio

Need: An Ohio village located near Columbus wanted to ensure its sewer system could withstand future demand anticipated from the construction of a new Intel chip manufacturing plant in Licking County. Village officials also wanted to assess the condition of its entire sewer system proactively so they could fix any deficiencies in the system and provide their customers with a high level of service.

Outcome: Village officials expected the evaluation of its 34,747 m (114,000 ft) of pipe would take 2 to 3 years to complete at a cost of appproximately USD $11.50/m (USD $3.50/ft). Using AI sewer coding, the assessment took less than 1 year to complete at a cost of USD $6.40/m (USD $1.95/ft). Additionally, the contractor was able to be roughly three times more productive by eliminating the need to PACP-code the sewer in the field.

Bonus: Data provided to the village will help it prioritize needs and coordination with other capital improvements. The village also recently undertook the task of creating a geographic information system of village assets and was able to map the condition of each pipe and location of defects and observations accurately to further assist its staff in maintaining the collection system.

Figure 1. Typical CCTV Operation for Pipeline Assessment



AI: Seeing the Bigger Picture

AI responds to the prevailing need for a solution that would help automate video inspections, improve accuracy, and maximize team output.

Most industries have adopted AI to speed processes, boost efficiency, and enhance reliabilty. Contrary to common belief, AI augments rather than replaces human intelligence by spotting patterns the human eye can overlook, enabling teams to work smarter. An unbiased tool significantly mitigates errors in a supervised learning environment.

Leveraging AI for assessing pipeline conditions is a relatively new approach for improving inspection efficiencies. AI removes human subjectivity from inspections by applying machine-learning algorithms paired with computer vision to detect and classify sewer defects. Like the human eye, AI depends on top-quality CCTV to accurately predict what's in the sewer line. Otherwise, mud, water, or other obstructions could obscure the footage.

AI imitates intelligent human behavior and becomes "smarter" the more it is used as it gains a deeper understanding of what each defect looks like, reducing the time required for reviewing sewer inspection data. It provides objective and unbiased condition assessment by coding the same pipe the same way every time, which is essential when comparing two inspections to determine rate of deterioration.

AI also applies the most common NASSCO codes to provide a reliable assessment of pipe conditions. As a result, field staff become more efficient by focusing on cleaning the pipe, capturing quality inspection video, and documenting more complex observations. Utility owners gain greater value from historical inspection data, which can be integrated into current workflows with no additional training needed.

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Leveraging geographic information system (GIS) and mapping data, an AI approach to pipeline assessments delivers a more meaningful visual of pipeline conditions. A quality AI tool will have

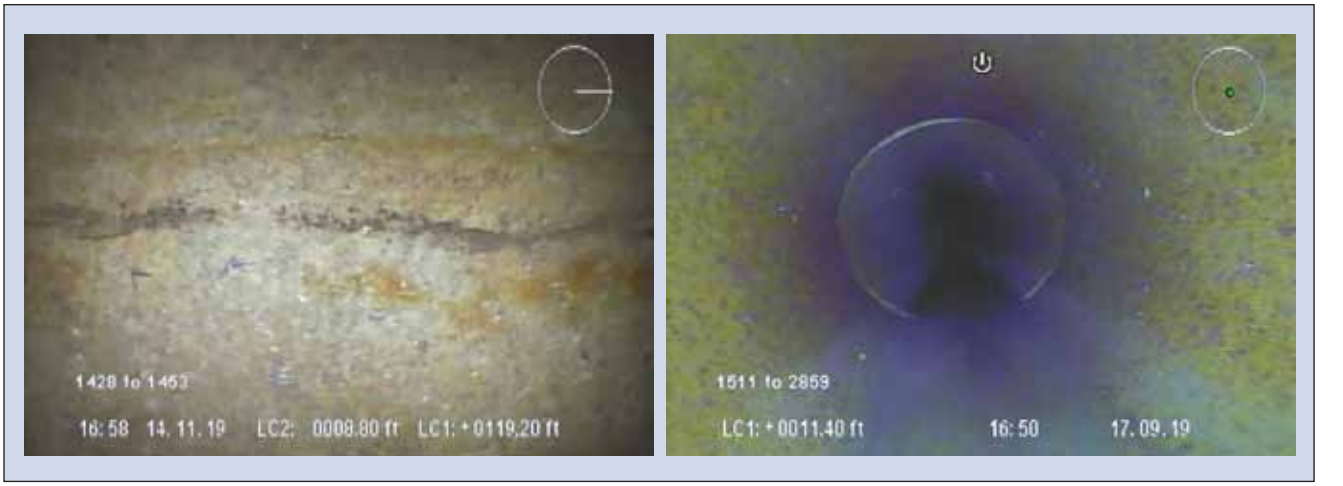
Case Study: Alaska

Need: As part of an asset management contract for a major Alaskan city's water and wastewater utility, AI was used to capture data from CCTV crews and contractors. In total, 34,290 m (112,500 ft) of pipe was processed.

Outcome: The output databases visually display pipe conditions and spatially locate each defect and observation. These data have provided the utility with clear coordinates with the defects, which has made it easier to create a maintenance, rehabilitation, and replacement plan. The outcome was high-quality data and a reduction in overall cost.

Bonus: The utility also is able to save time and money by providing data directly to the contractor, who will perform the work with certainty as to where the defects are located.

Figure 2. AI Approach to Pipeline Assessments



By combining two computer vision AI systems, operators can see whether the inspection camera is in a manhole or a pipe.

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GIS outputs that can be integrated with a city's GIS to show size, material, pipe condition, date of inspection, and location of each defect and observation.

The combination of two computer vision AI systems can reveal whether the inspection camera is in a manhole or a pipe (see Figure 2, above). It will distinguish between a camera looking at the pipe wall or straight down the pipe, spotting voids where there may be breaks or a tap that is open and flowing. AI more accurately determines the exact location of the defect so that it can be rehabilitated, replaced, or simply monitored. For example, it can help crews perform regular maintenance in problem areas, such as cutting tree roots out of pipes.

Accurate and Efficient

By reducing in-pipe time during inspection and the time required to review inspection data, AI alleviates the burden of coding all defects from contractors, allowing them to inspect far more footage each day. The speed with which inspectors can move through existing video to provide a database that shows the condition of the storm and sanitary infrastructure helps them repair defects before they become major repairs.

The mix of CCTV, NASSCO standardization, and AI — combined with human intelligence — gives the water sector a robust set of pipe-inspection tools. In the future, AI efficiencies are expected to cut CCTV review time by more than 50%, driving more informed, data-driven decisions.

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