AI-BASED COMPUTER VISION PROVIDES INNOVATION TO OPTIMIZE SEWER REHAB AND ASSET MANAGEMENT DECISION MAKING

The Sewer Network

A Sanitary Sewer Collection System is a series of pipes, manholes, and lift stations that convey wastewater from homes and businesses to a treatment plant. In the US, there are over 875,000 miles of public sewers and 500,000 miles of private laterals. Over one third of US wastewater utilities are unable to engage in proactive asset management and instead find themselves reacting to sewer overflows, sinkholes, pipe collapses, and storm events of increasing severity.

This deterioration of critical wastewater infrastructure contributes to over 800 billion gallons (or 120,000 Olympic-size swimming pools) of overflowing sewage annually in the US, polluting our oceans, rivers, and lakes. Solutions have proven expensive, with the American Society of Civil Engineers (ASCE) estimating an $80 billion annual funding gap for US water utilities between capital needs and actual capital spending.

Sewer operators have a critical role in managing the public health and the affordability of wastewater services for the community. One area of innovation making a difference in overcoming this challenge is in the recent application of emerging capabilities in Automated Defect Recognition (ADR) (commonly referred to as Artificial Intelligence, or AI) and Cloud Computing to NASSCO's Pipeline Assessment Certification Program (PACP™) data, driving optimization in the design and implementation of trenchless rehabilitation projects.

Operator assisted sewer AI allows the sewer operator to focus on prioritizing maintenance activities like the type and frequency of cleanings, the timing and location of point repairs, determining the need of additional condition assessment or remaining useful life (RUL) and replacement cost efforts, the evaluation of lining or other rehab trenchless technologies, and the development of the replacement capital plan.

The maintenance goals and objectives for municipal sewer utilities include:

Goal: Maintain sanitary sewer system and related infrastructure to ensure uninterrupted service.

Objective 1: Annual closed-circuit CCTV" inspection of existing sanitary sewer lines and all new collection systems.

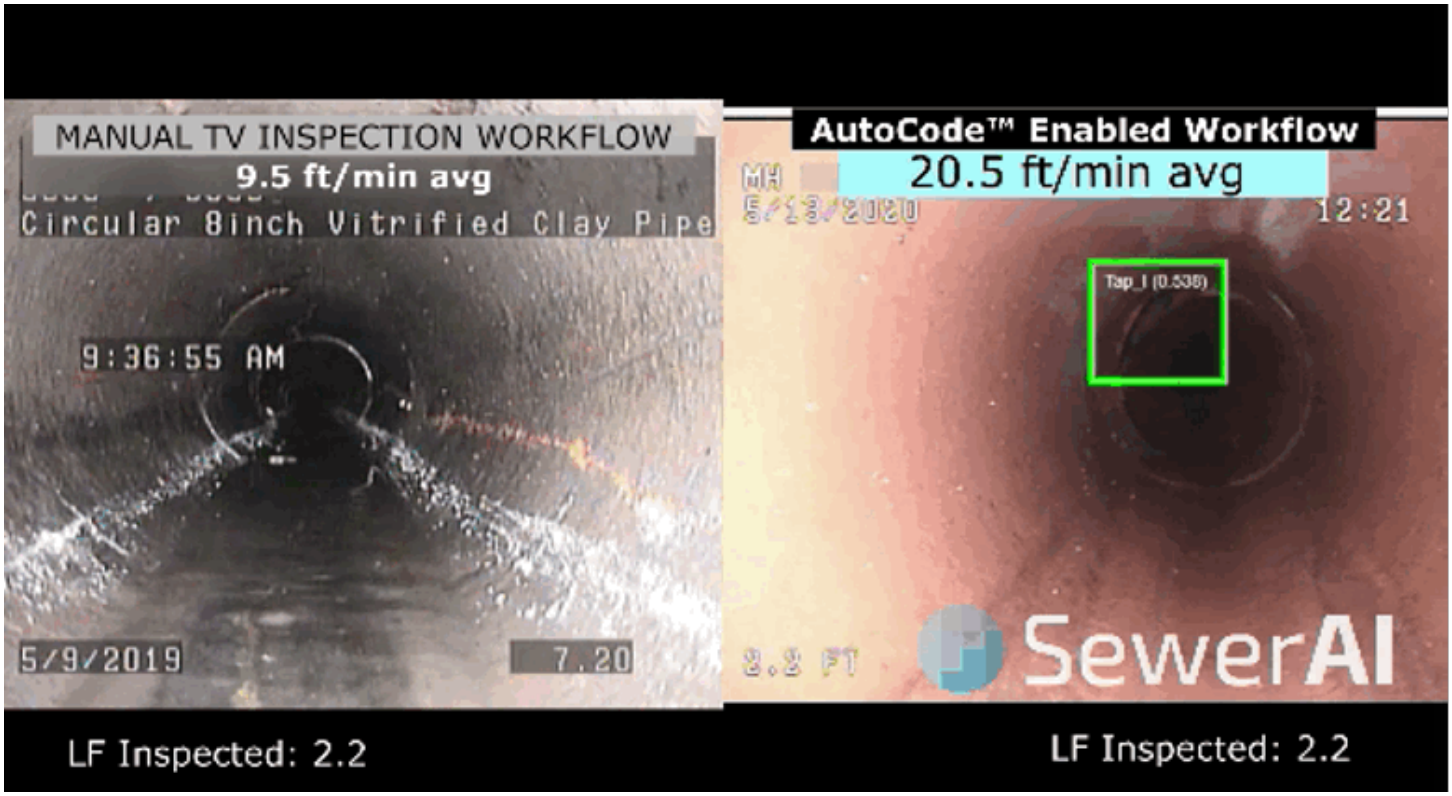
Objective 2: Annually clean the sanitary sewer system.

Objective 3: Conduct monthly sand/grease interceptor inspections.

Objective 4: Conduct root cutting for service connections.

Computer Vision

Human assisted task automation is called computer vision, which is when an AI gains



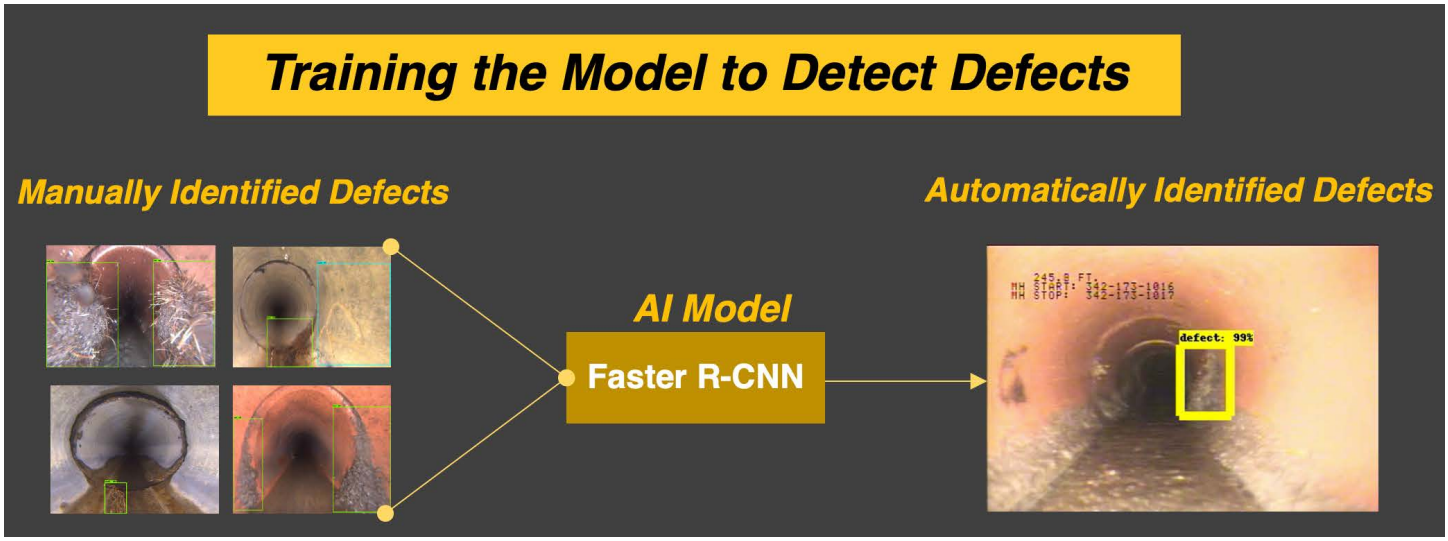
a high-level understanding of objects and/or conditions from digital images or videos, such as CCTV data collected from sewer and storm pipeline inspections. Software engineers use machine learning as a way of training an algorithm so that it learns for itself how to fulfill a specific objective, and this happens by exposing the algorithm to various (and numerous) examples that enable it to adjust itself to make improvements over time.

Pipe Condition Assessment Standardization

Developed by NASSCO in partnership with the Water Research Center (WRc), PACP, with 226 distinct condition codes, is the North American licensed adaptation of the United Kingdom's TV inspection coding system developed by the WRc. This coding system is the recognized standard in the United Kingdom and much of Europe and Asia.

Since 2001, PACP guidelines, created by NASSCO, have been widely used in condition assessment of buried drainage infrastructure. Its catalogue of observations enables one to describe a feature quantitatively and with a 1 to 5 severity grade. After two decades of use, our industry now possesses an abundance of PACP data, in the form of electronic databases and media files from countless inspections, stored on local servers, in external hard drives, and now, increasingly, stored and streamed on the Web, for use in Cloud-based applications. This increased access to large amounts of PACP data, combined with emerging capabilities in Machine Learning (ML) has enabled advanced analytics for support of predictive and prescriptive decision-making. This includes Computer Vision models for ADR, enabling descriptive condition assessments with more consistency, rigor, and efficiency, provides ample opportunity to improve outdated data management and asset planning practices.

NASSCO's PACP-Based Asset Management Objectives of Asset Management is to maintain function or level of service as cost effectively as possible while maintaining individual components (assets) at lowest life cycle cost possible. Each sewer asset has a life cycle from design, construction/installation, operations, maintenance, repair/rehab to replacement or disposal. Asset management seeks to continuously identify cost savings and efficiencies in each of the life cycle phases to improve the financial areas of current revenues and expenses for operations and maintenance and capital expenditures typically funded with long term debt. Good asset management is always integrated with long-term financial planning and rate funding setting scenarios.



Standardization provides accuracy, consistency and cost savings when it comes to data management and analytics. While defect coding standardization does not yet exist for water pipes, standardization does exist for sewer pipe condition assessments. The National Association of Sewer Service Companies (NASSCO) trains and certifies technicians and engineers. PACP (Pipeline Assessment Certification Program) is the North American Standard for pipeline defect identification and assessment, providing standardization and consistency to the methods in which pipeline conditions are identified, evaluated and managed. The goal of PACP is to have pipeline system owners create a comprehensive database to properly identify, plan, prioritize, manage, and renovate their pipelines based on sound condition evaluations.

- PACP asset management seeks answers for the following questions:
- What pipes, manholes, and laterals do we own?
- Where are these assets located?
- What are their materials, dimensions, depth, and ground cover?
- What is the condition of each asset?
- What other community assets would be affected by failure of a particular asset?
- Which assets are critical to sustained performance?

- What are my best O&M and CIP investment strategies?
- What will be the rehabilitation cost?
- What effect will this have upon the utility budget?
- How should all of this be communicated to stake holders?

PACP can assist in developing an asset management plan by collecting asset information including:

- Pipe segment length
- Relative location details
- Pipe size
- Pipe shape
- Pipe material
- Upstream manhole data
- Pipe segment lateral data
- Consequence of failure
- Defect codes (Structural and O&M)
- Condition grades

AI Supports Workforce Retention and Training

Wastewater Collections Operators perform skilled construction, repair, and maintenance of wastewater system facilities. They operate a variety of power equipment and ensure public health by preventing sewage overflows and blockages. They inspect, clean, maintain, construct, and repair wastewater collection systems including sanitary sewers, storm drains, pump stations, pipes, manholes, and catch basins (access points). https://www.workforwater.org/

AI does not replace the operator or take away the need for certification. AI can accelerate the training for new recruits and leverage the trained operator applying their skills to more value added and meaningful duties. Computer vision software automatically recognizes defects and features in pipes assists in generating condition assessment reports, at a significantly faster rate (~4X) than if performed manually, and with a higher degree of accuracy (95-100%) and consistency. This allows the sewer utility, engineers, and contractors to save time and money, and complete more pipe inspections.

CCTV Direct Assessments

Human assisted computer vision using AI/machine learning applied to CCTV data of sewer pipes sits at the top of the sewer network condition assessment and asset management pyramid. These direct condition assessments coded with defect catalogs can quickly, accurately, and effectively provide the basis for all other asset management program decision making. Based on this low-cost AI approach of coding the condition of each sewer pipe, the decision can be made as to where and when additional resources and funding should be allocated for asset work order maintenance and asset management activities moving a utility from a reactive (high cost) mode to a planned and predictive (lower cost) strategic operation. This is especially true for compliance mitigation strategies for consent decrees, the management of sanitary overflows (SSO) and the reduction of the Inflow and Infiltration (I&I) responsible for increased flows to the treatment plant (as high as 45%) resulting in higher water treatment costs passed onto rate payers, causing community equity and affordability issues.

Conclusion

Sewer condition assessment and asset management also integrates with the sustainability elements of a triple bottom line (TBL) approach evaluating the social, environmental, and both tangible and intangible economic costs. All these efforts build resiliency into the sewer network from risk mitigation to recovery, from climate events or man-made malevolent acts. AI and machine learning will continue to enhance our understanding and operational experiences when it comes to our drinking water, clean water, and reuse infrastructure networks and treatment operations. Public and private utilities, operators, engineers, and contractors each can benefit through the inevitable adoption and acceptance of new technologies like computer vision which better protects our quality of life from the potential threat of service failures, contamination, and higher costs.

ABOUT THE AUTHOR

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Eric is an underground construction professional who specializes in solutions for infrastructure condition assessment and trenchless technologies. Working with water and sewer utilities, consulting engineers, and contractors, Eric has fulfilled a variety of accountabilities in his 15 years in the industry as an operations manager, business development manager, professional certification trainer, CCTV operator, inspection system and vacuum truck technical sales rep, and sewer services project manager. Eric has been a NASSCO Trainer since early 2012, and has led NASSCO programs throughout the US and Canada to TV operators, asset managers, and consulting engineers.

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