SewerSense

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Outline

- Project Overview
- Recent Work
- Upcoming Steps
- Conclusion

Project Overview

Project Overview

- Sewer CCTV inspections are lacking in objectivity and reliability (up to 25% of defects missed according to Dirksen J. et al, 2013)
- Decision Making process relies on flawed inspection reports
- Recent advances in Machine Learning provide opportunities
- Plenty of data is available: CCTV footage and reports
- Investigate possibility of more sophisticated sensors

Project Overview

- Given large amounts of such data,

  Can we learn by example?
- How much data is enough?
- What other sensory data is interesting?

  (3D camera, laser profile scanner, etc.)
- To what degree do more reliable defect

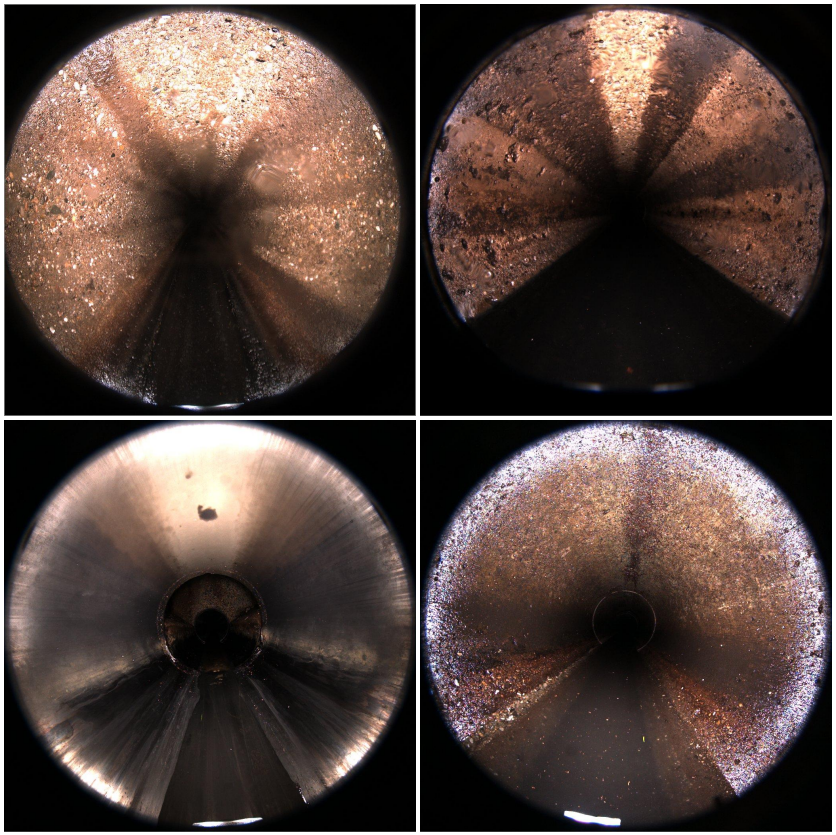
  classifications lead to better decision making?

Recent Work:

A defect classification methodology for sewer image sets with convolutional neural networks

Recent Work - Data

Image data (~2.2 million)



Reports (30 in 12 municipalities)

Rijdende camera

Algemene strenggegevens en waarnemingen

Rapportnummer : [redacted]
Opdrachtgever [AAM] : [redacted]
Plaats [AAN] : [redacted]

Riool-ID [AAA] : 001

ALGEMENE GEGEVENS

Wijk/kern	[AAO]	: [redacted]
Straat	[AAJ]	: [redacted]
Tekening		: [redacted]
Bemal.gebied		:
Rioolstelsel	[ACK]	: Alleen afgestroomd hemelwater
Soort riool	[ACJ]	: Vrij verval afvoerleiding of riool
Datum	[ABF]	: 5-5-2014
Soort locatie	[AAL]	: In weg
Verharding		: Klinkers
Gereinigd	[ACM]	: Gereinigd
Vloeistofstr.	[ADC]	: Geen
Neerslag	[ADA]	: Geen
Temperatuur	[ADB]	: Boven vriespunt
Grondeigend.	[AAQ]	: Publiek
Operator	[ABH]	: MB/70.017

STRENGGEGEVENS

Insp. richting	[AAK]	: Stroomopwaarts
Beginput	[AAD]	: R15
Eindput	[AAF]	: R17
Bodemhoogte beginput		: m (t.o.v. putrand)
Bodemhoogte eindput		: m (t.o.v. putrand)
Axial ref.punt	[ABC]	: Midden van beginput
Strenglengte	[ABQ]	: 71.50 m
Geïnsp. Lengte		: 71.50 m
Jaar in gebruikn.	[ACN]	: 2014

BUISGEGEVENS

Breedte	[ACC]	: 300 mm
Hoogte	[ACB]	: 300 mm
Vorm	[ACA]	: Cirkelvormig
Materiaal	[ACD]	: Beton
Lengte	[ACG]	: 2.40 m
Verbinding		: Mof/spie
Liningmat.	[ACF]	:
Soort lining	[ACE]	:

VIDEOGEGEVENS

1e Videobestandsnaam		: USB01
1e Begintelling		: 000000
1e Eindtelling		: 000020
2e Videobestandsnaam		:
2e Begintelling		:
2e Eindtelling		:
Videomedium	[ABK]	: Anders (=> in algemene opmerking !)
Fotomedium	[ABL]	: Stilstaand beeld op de computer

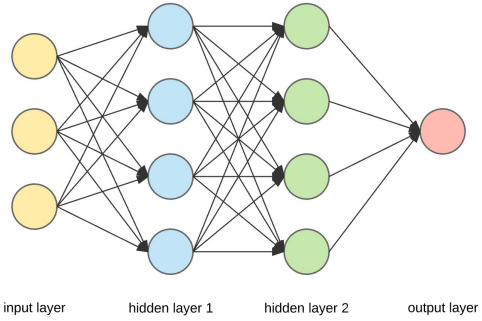
INLATEN/COMMENTAAR

Aantal inlaten : 5
Commentaar :

Alg. Opm. [ADE] : "ABK: Panoramo"

Foto nr.	Afst. [m]	Code	K1	K2	K3	KLS	V	Waarneming	Klok
	0.0	BCD	A					Beginknooppunt, rioolput, R15	
	0.0	BDD	A		E	1		(0)Begin >Waterpeil, helder afvalwater, waterdiepte in cm:, h <= 10%	
	19.6	BCA	A	A				Aansluiting, samenkomst, open, hoogte = 0mm, breedte = 0mm	12-00
001	24.1	BDA						Algemene foto	
	24.5	BCA	A	A				Aansluiting, samenkomst, open, hoogte = 0mm, breedte = 0mm	12-00
002	41.1	BDA						Algemene foto	
	41.6	BCA	A	A				Aansluiting, samenkomst, open, hoogte = 0mm, breedte = 0mm	12-00
	58.6	BCA	A	A				Aansluiting, samenkomst, open, hoogte = 0mm, breedte = 0mm	12-00
	68.3	BCA	A	A				Aansluiting, samenkomst, open, hoogte = 0mm, breedte = 0mm	12-00
	71.5	BDD	A		E	1		(0)Eind >Waterpeil, helder afvalwater, waterdiepte in cm:, h <= 10%	
	71.5	BCE	A					Eindknooppunt, rioolput, R17	

Recent Work - Challenges



- We train a Neural Network to classify footage
- Some methodological groundwork was needed first
  - Classifiers were often trained and tested on 50/50 datasets
  - Quality metrics used (accuracy) do not translate to operational impact
  - Division into training and test set can lead to data leakage
  - Use of human-operated camera footage biases classifier

Recent Work - Solutions

- Classifiers **must** be **tested** on realistic ratios (~1% defects)

  (**Training** on realistic ratios **might** improve performance)
- Because of high costs of false negatives,

  It makes more sense to report FP at **set** FN rates.
- Dividing dataset into inspections prevents the same pipe

  Appearing in both training and test set
- Footage of zooming, panning, rotating, by a human

  operator is not part of our dataset

Recent Work - Conclusions

- The usefulness of a classifier depends largely on interpretability of its output.
- Our validation methodology translates directly into operational impact.
- Fully-automated classification is not possible yet, but our work pushes that boundary.
- The proposed classifier can reduce the images that require review by 60.5%.

Upcoming Steps

Upcoming Steps

- Multi-Sensor measurements
  - Stereo Vision/RGB-D
  - Laser Profiler
- Linking Defects to Performance
- Quantify Improvement in Data Quality
- Link data quality to better Decision Making

Conclusion

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- SewerSense aims to automate (parts of) sewer inspections
- Groundwork for automated classification of defects in sewer pipes has been prepared
- Investigation into Multi-Sensor Data is starting
- Implications on a higher level than operational require more research

Thank you.