Detection of Structural Faults in Wastewater Systems

Prof. Zoran Kapelan

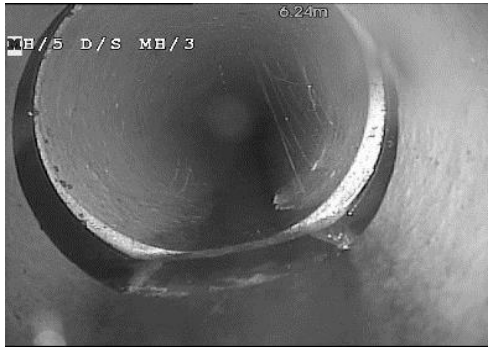
University of Exeter

Introduction

- Analysing CCTV footage is time consuming and costly
- Aim: Automatically detect structural faults using standard CCTV footage
- Work in progress supported by Wessex Water

Deformations

Intruding Roots

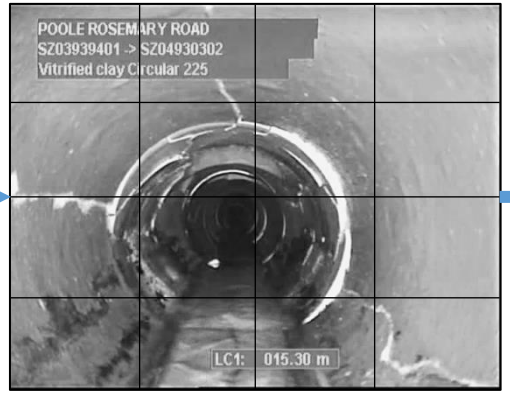


Displaced Joints

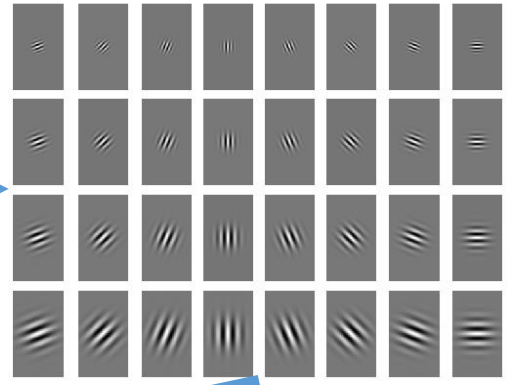
Fault Detection Method

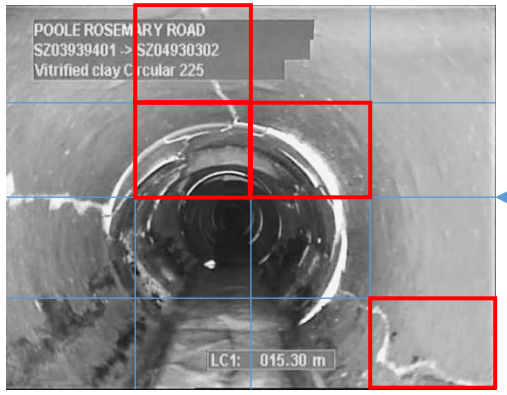
Frame Extraction

Pre-processing

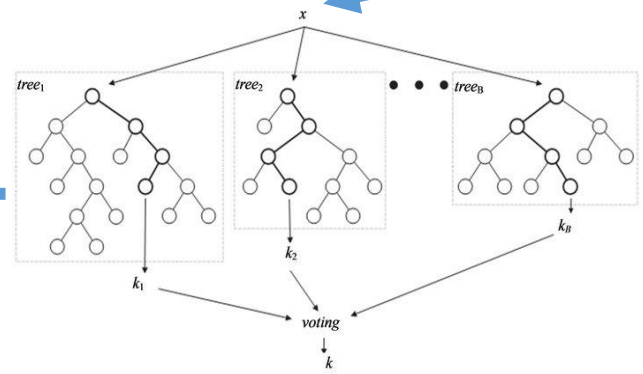


Feature Extraction





Annotate Fault



Random Forest Classification

Application to real-life data

- Wessex Water CCTV: 15 hours of video footage along 5.5km of 200 – 1800mm pipes made of vitrified clay, concrete and brick
- 1500 images, 673 faults

Fault type	Subtypes	Percentage (%)
Deposits	Attached, Settled	**28**
Joint	Displaced, Open	**24**
Obstacles	Intruding junctions, Masonry, Protrusions	**15**
Crack	Longitudinal, Circumferential, Multiple, Spiral	**11**
Hole	-	**11**
Brickwork	Missing mortar, Displaced bricks, Missing bricks	**5**
Roots	Fine, Tap, Mass	**3**
Broken / Collapsed	-	**3**
Infiltration	Running, Gushing	**1**

Detection Results

- Applied to an unseen survey (~30 minutes) with threshold 0.5
- Correctly identified **73%** of frames
- High False Positive rate (due to noisy footage and smoothed annotations)

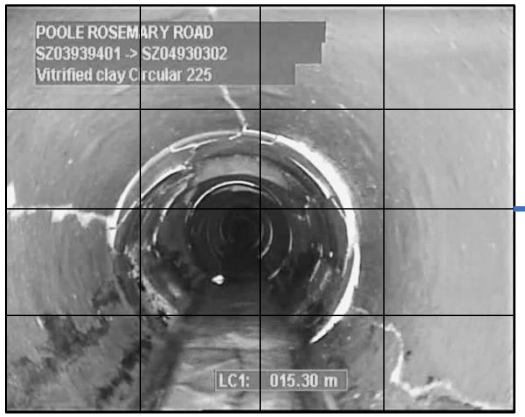
Confusion matrix		Actual	
		Normal	Fault
Predicted	Normal	0.92	0.08
	Fault	**0.47**	0.53

Example

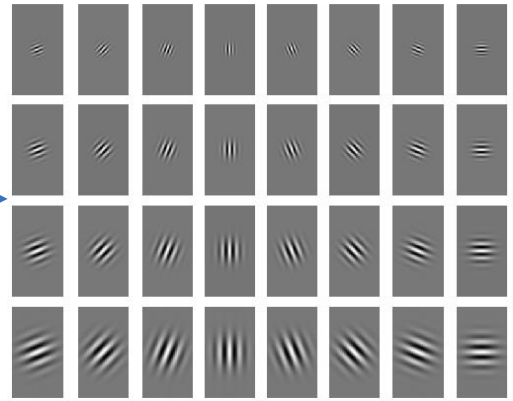

POOLE, SANDBANKS 42 AUSTIN AVENUE
SZ03907307 -> SZ03907301
Vitrified clay Circular 200
23.09.2015
1.02m

Alternative Fault Detection Method

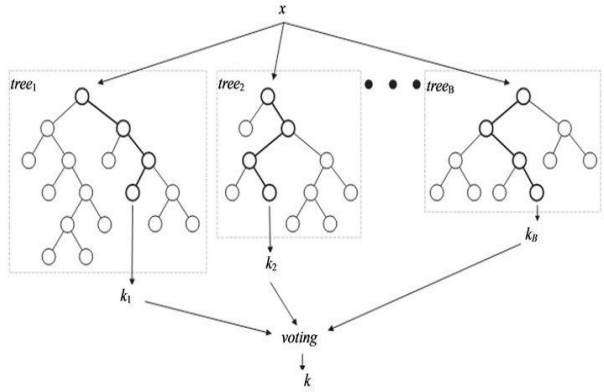
Frame Extraction & Pre-processing

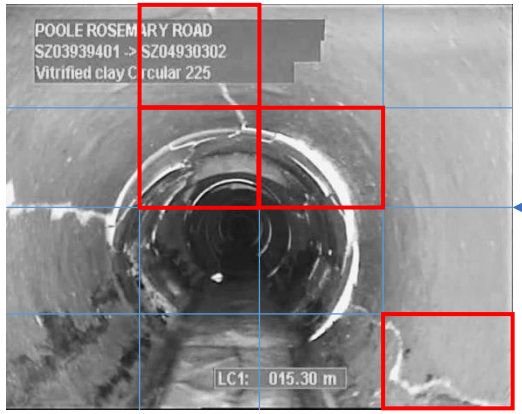


Feature Extraction

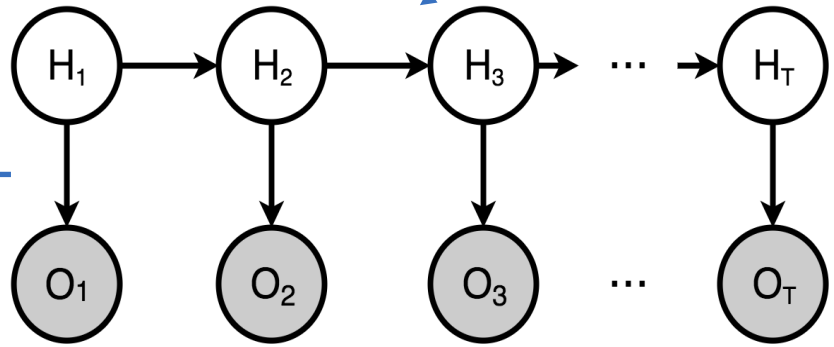


Classification





Annotate Fault



Smoothing

Improved Detection Results

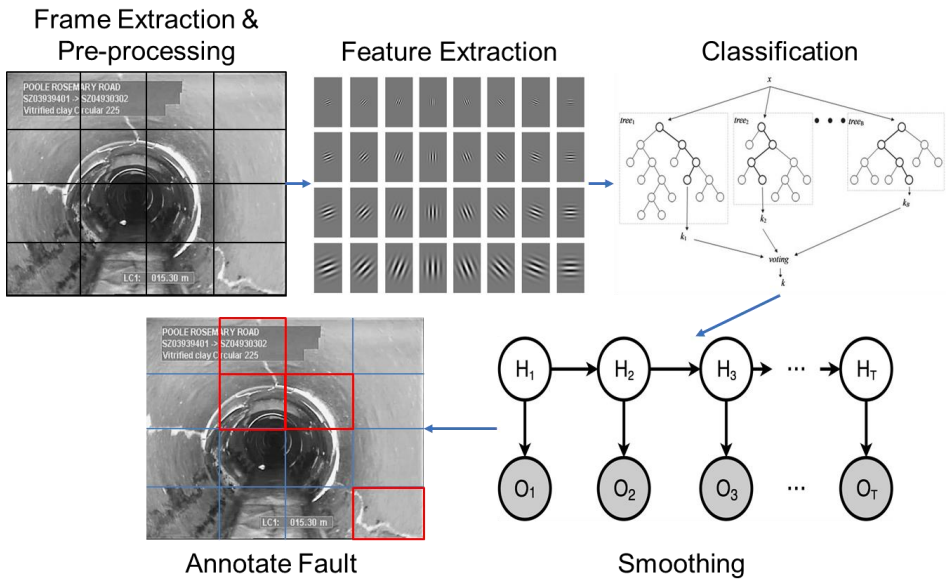
- Applied to same unseen survey (~30 minutes)
- Correctly identified **76%** of frames containing faults
- Minimal impact on execution time
- Much closer to technicians annotations

Confusion matrix		Actual	
		Normal	Fault
Predicted	Normal	0.74	0.23
	Fault	**0.26**	0.77

Comparison of Detection Methods

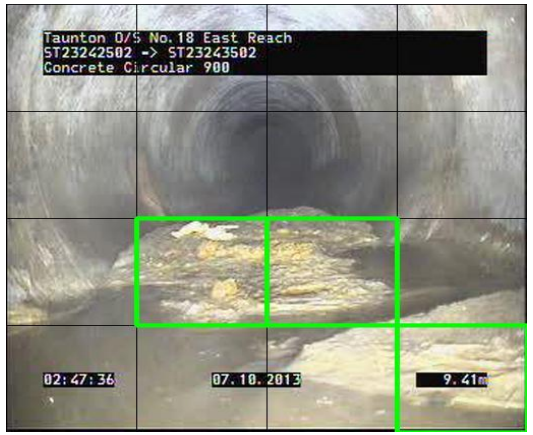
Summary

- Detection of sewer faults based on image processing and AI shown
- Promising results on real world data obtained - faults CAN be automatically detected from standard CCTV footage



More Could be Automated

- Fault type classification
- Fault location within the image
- Determine fault's severity
- Combine everything into a decision support tool



Smart Water Projects

- Ongoing projects:
  - Detection of blockages/collapses in sewer networks (United Utilities)
  - Detection of events at treatment works (United Utilities)
  - Effective operational blockage reduction (Welsh Water)
  - Demand forecasting using smart demand metering data (Wessex Water)
  - Event management and post event response planning (United Utilities)
  - Real-time discolouration risk management (South West Water)
  - Next generation of water mains network modelling tools (Severn Trent Water)
- Completed projects:
  - Burst/event detection system (United Utilities)
  - KTP on blockage detection (Welsh Water)
  - Online (live) modelling of water distribution systems (United Utilities)
  - Smart demand metering (Southern Water)
  - Real-time data validation