Detection of Structural Faults in Wastewater Systems

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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

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

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
</tr>
<tr>
<td>Predicted</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Fault</td>
</tr>
</tbody>
</table>
Example
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

<table>
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<tbody>
<tr>
<td></td>
<td>Normal</td>
</tr>
<tr>
<td>Predicted</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>0.74</td>
</tr>
<tr>
<td>Fault</td>
<td>0.26</td>
</tr>
</tbody>
</table>
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