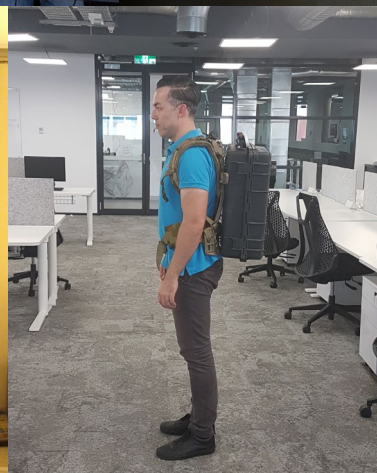
Subterra.ai

How advances in Computer Vision, Robotics & Artificial Intelligence are helping municipals to inspect underground assets

Disclaimer

Background

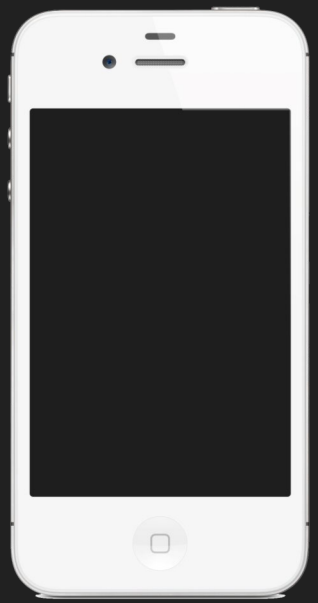


Advances in tech in the last 10 years

2007

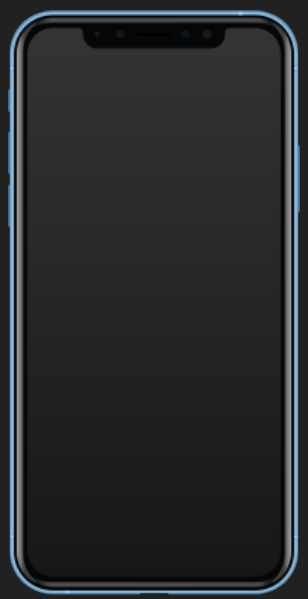
iPhone
2MP Rear Camera
Up to 16GB Storage

2013



iPhone 5S
8 MP Camera
1080 Video
Up to 64GB Storage

2018



iPhone X
12 MP Camera
4K Video
Up to 256GB Storage
Depth Sensing using AI

2020

Real time ToF camera
8K Video
1TB Storage
5G Connectivity

Subterra.ai

iPhone 5S

2013
iPhone 5S

8 MP Camera
1080 Video
Up to 64GB
Storage

iPhone X

2018
iPhone X

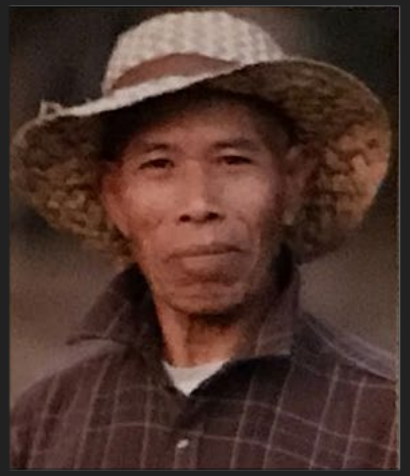
12 MP Camera
4K Video
Up to 256GB
Storage
Depth Sensing
using AI

Subterra.ai

iPhone Image Evolution

iPhone 5s

iPhone 6

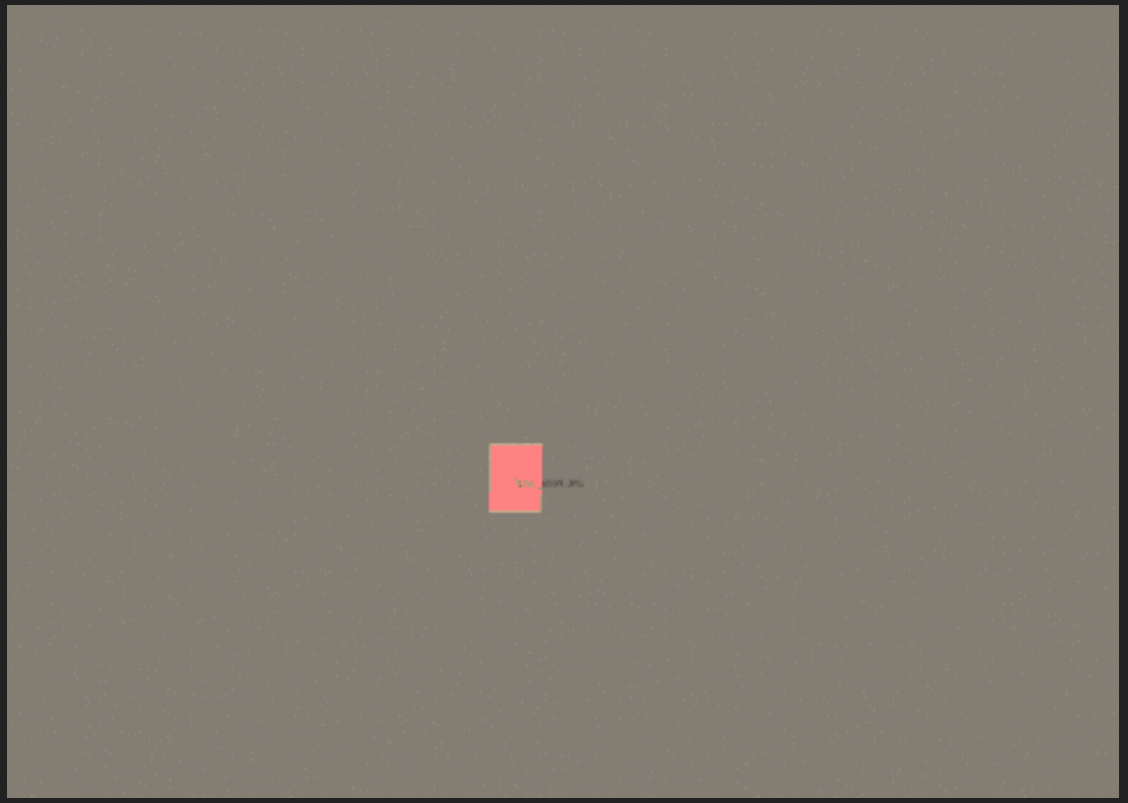


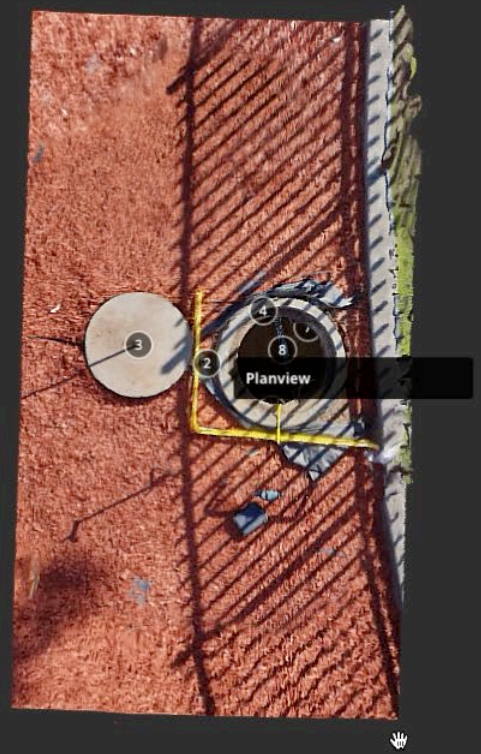
iPhone 7 plus

iPhone X

Subterra.ai

Photogrammetry – Close Range Photogrammetry




4
8
3
2
Planview

Subterra.ai

Each year the US spends

$30B on O&M

with 10% being spent on inspections

But only 9%

of sewers are inspected

800,000 - 1.2M miles estimated

Subterra.ai

Why are we not inspecting more?

1. High cost with current methods & technologies;
2. Slow speed of inspection and reporting;
3. Difficult to access many sewers that need to be inspected.

Subterra.ai

Why are we not inspecting more?

High cost with current methods & technologies;

- Manhole systems: $10,000 - $125,000
- Walkabouts: Cost of people
- CCTV systems: $25,000 - $500,000

Current Inspection Techniques - People

Current Inspection Techniques - People

Subterra.ai

Why are we not inspecting more?

Slow speed of inspection and reporting;

- People traverse (Walkabouts): 3 miles or 16,000ft. Per day
- CCTV systems: 1000 – 2000ft. Per day
- Do not exceed 30ft. in a minute (NASSCO PACP)

Current Inspection Techniques - CCTV

Subterra.ai

Why are we not inspecting more?

Difficult to access many sewers that need to be inspected.

How can advances in technology help

- Lower cost of electronics > lower cost to purchase inspection systems
- Using software instead of hardware
- 360 camera’s > allow for faster inspections
- CV & AI will increase efficiencies in coding, reporting and reviewing
- This should all then lower the cost of inspection per foot
- Asset optimization through ongoing and frequent inspections

Subterra.ai

Terminology

- Computer Vision
- Robotics
- Artificial Intelligence

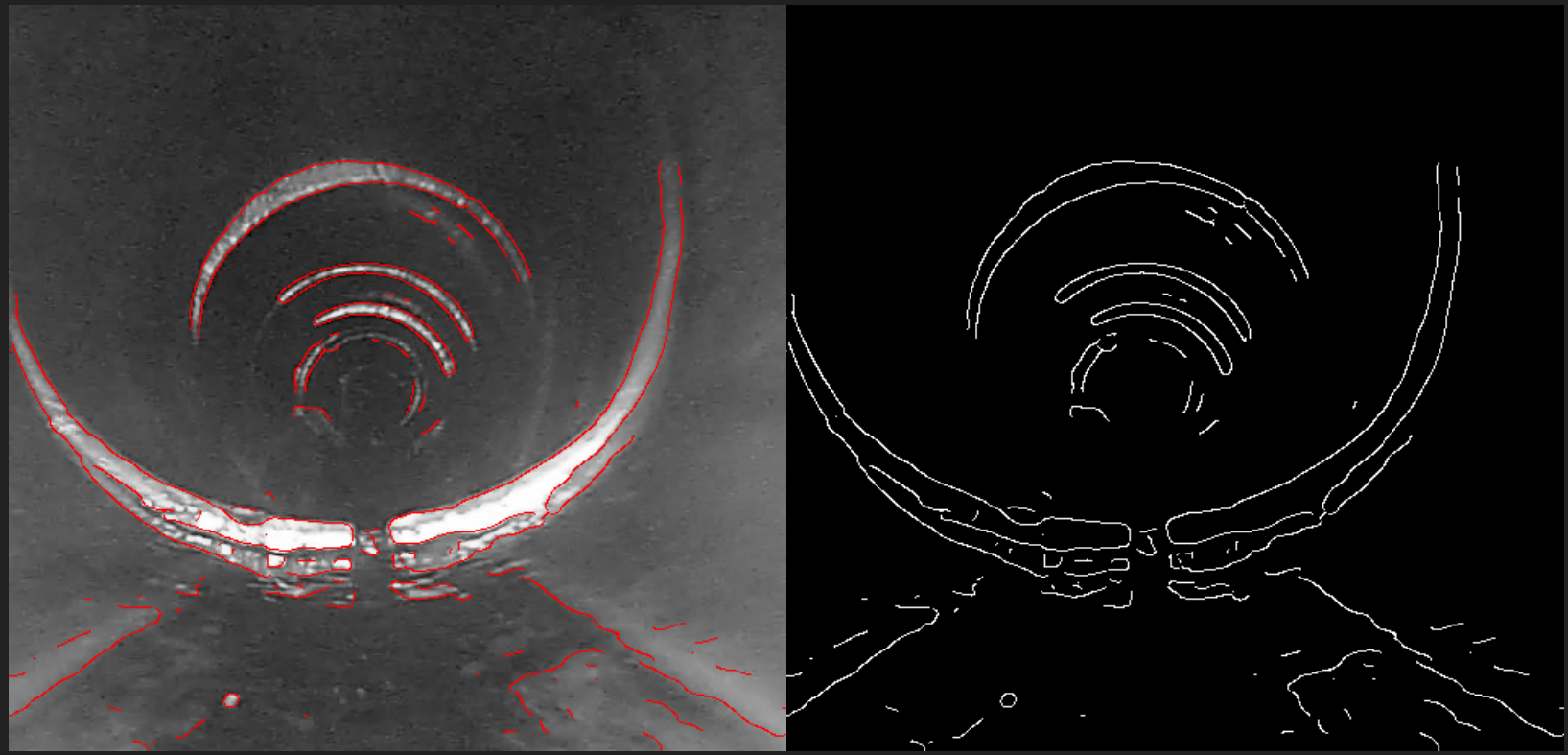
Subterra.ai

Image Processing – Computer Vision (CV)

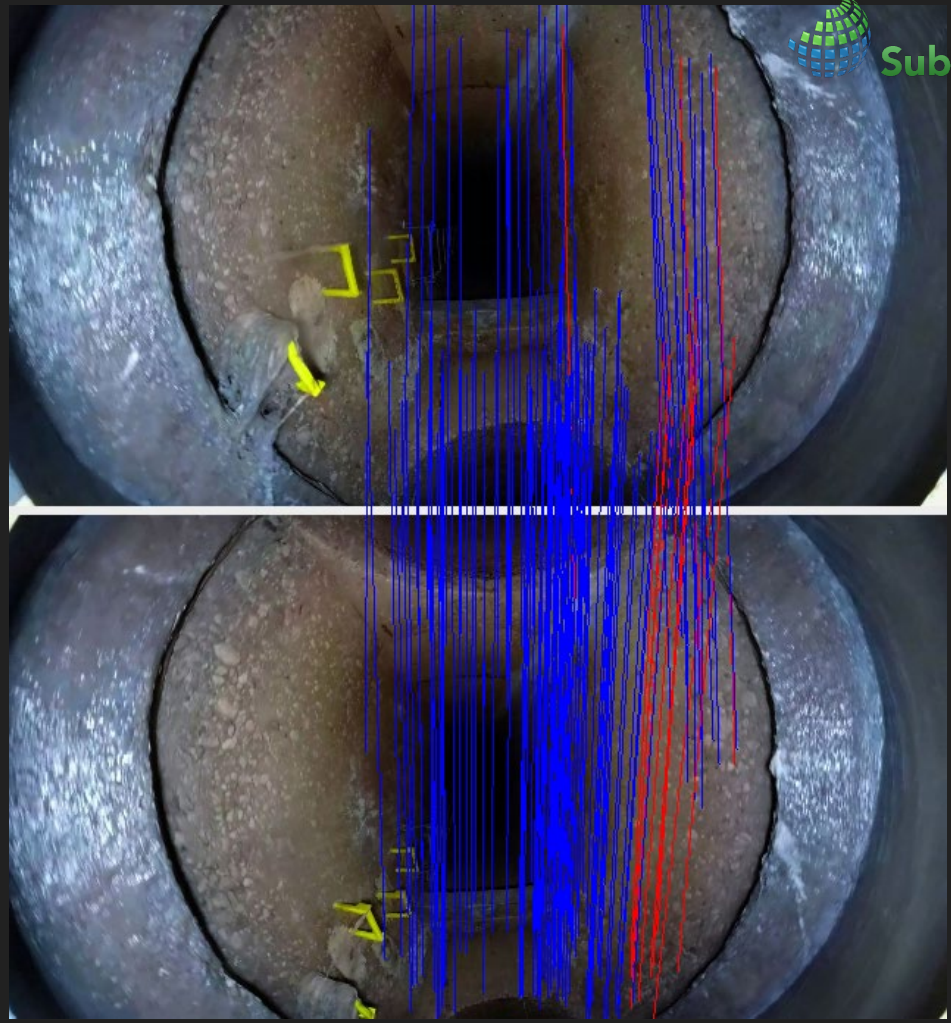
Image processing - Manipulating an image to be clearer or more detailed

Subterra.ai

Computer Vision - Feature Detection

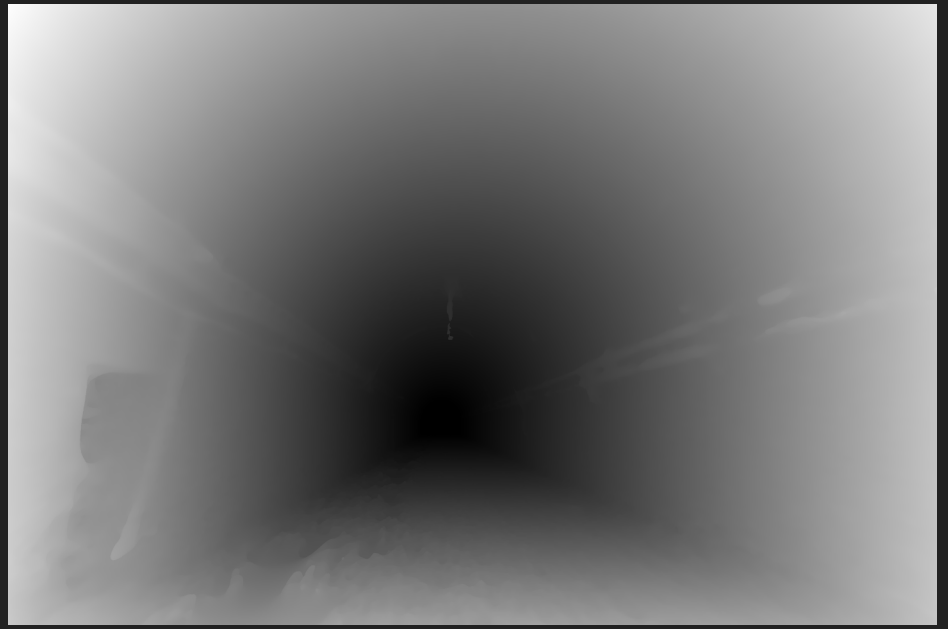


Computer Vision Feature Tracking



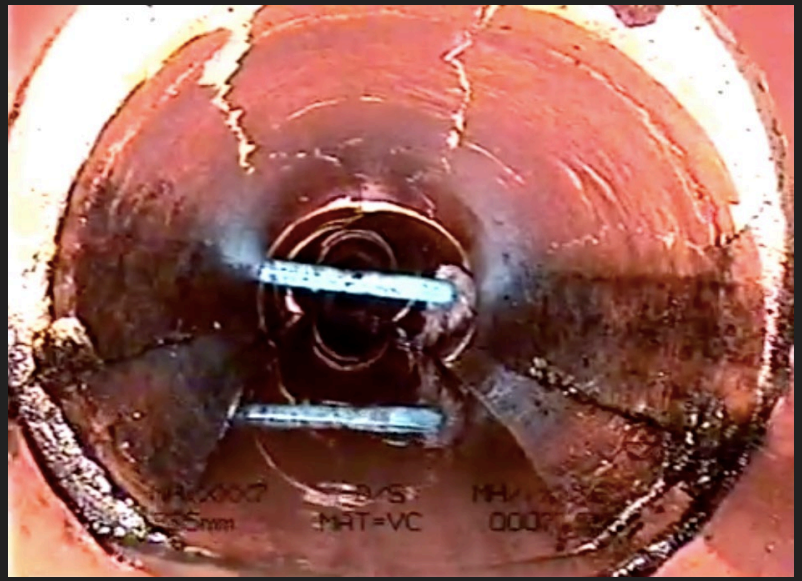
Subterra.ai

Computer Vision - Depth Perception

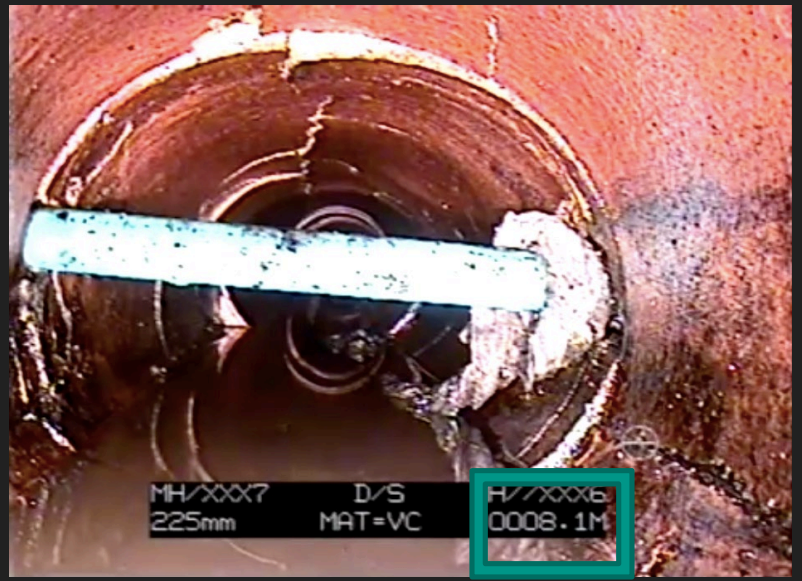


Computer Vision – 3D

Computer Vision – Optical Character Recognition OCR



Bad example for OCR



Better example for OCR
= 8.1m

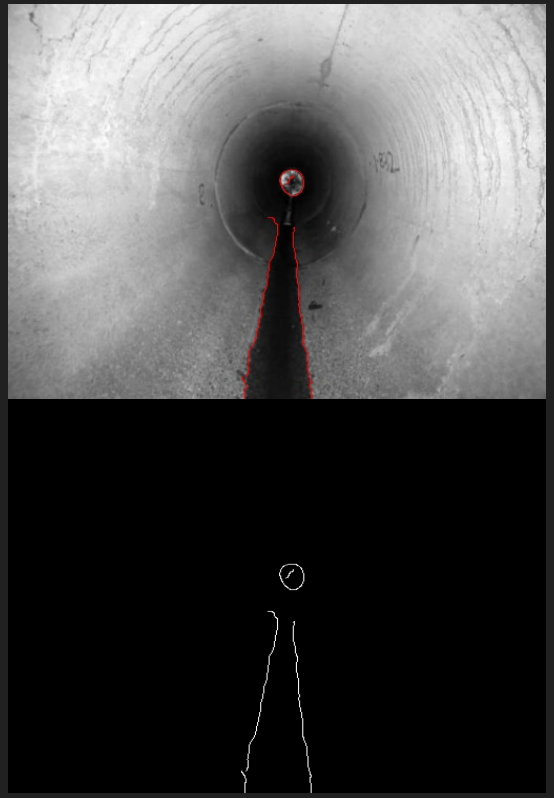
Subterra.ai

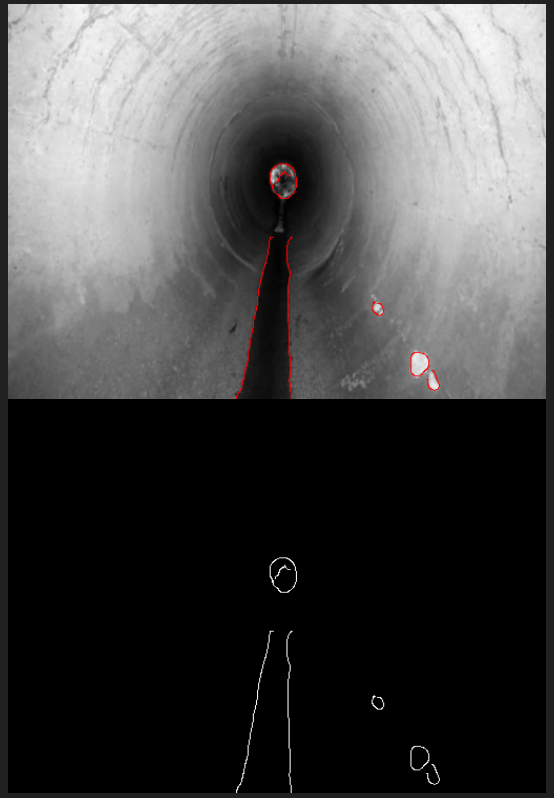
Benefits using Computer Vision

- Automatically detect features
- Track & geolocate images underground
- Measure features of interest
- Compare change over time
- Build a training data set for AI

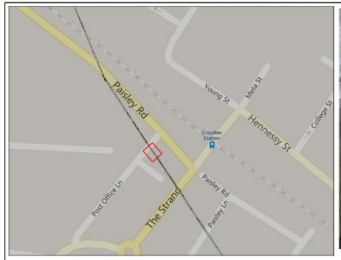
How feature detection & tracking can be used

Comparative analysis





Detailed investigations



Location

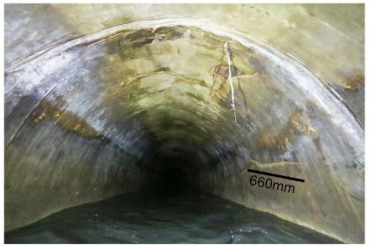


Figure 1: Feature - Debonded epoxy coating next to step

Figure 2: Feature - Closeup of debonded epoxy coating

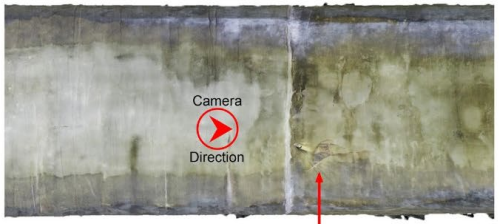


Figure 3: Approximately126m from MH12

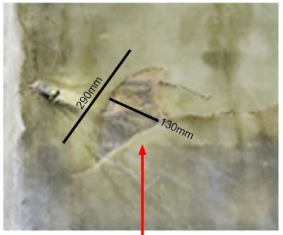


Figure 4: Dimensions of debonded epoxy section

Planview Section

REVISION NOTE	REV	CLIENT	DRAWN:		TITLE:
			DATE:		
			CHECKED:		
			DATE:	SHEET: A3	DWG No:
			PROJECT No:		

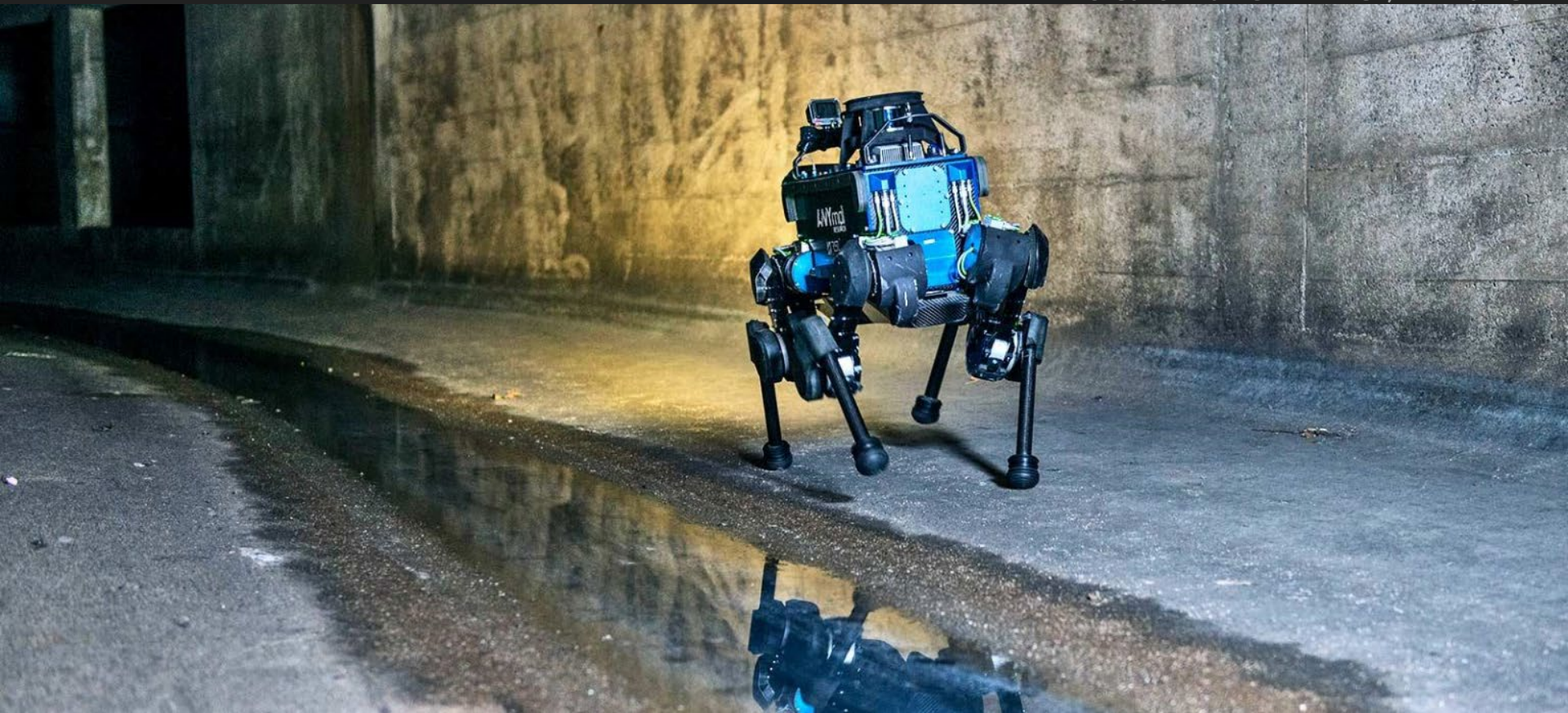
Repair estimation


Subterra.ai

Subterra.ai

Robotics

Credit: Daniel Winkler/ETH Zurich



Robotics

Robotics

Simple Robot or drones


Subterra.ai

Subterra.ai

Terminology

- Artificial Intelligence or AI – To mimic human intelligence
- Machine Learning - The ability for the computer to learn from teaching it.
- Deep Learning - Mimicking the human brain to solve more complex problems through the development of neural networks and interconnectivity.
- Neural networks – As in brains neural networks that work connectively to come up with an output.

Subterra.ai

Machine learning

- The goal = Computers learning on their own
- Identify patterns from observed data
- Build models that explain the world

Data sets




Data sets


Randstad Drainage Services
225 V.C

Subterra AI Example

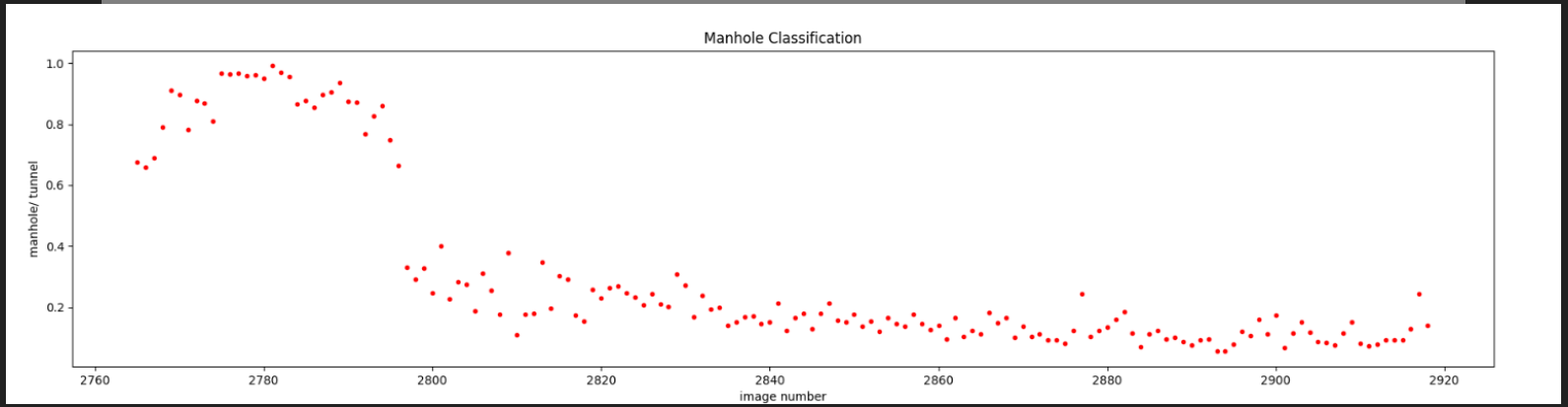
Training sets

- 10,000 images of sewer with chambers and other features.

Training sets

- Specified what to look for and where to find it.

Subterra.ai


Manhole Classification
manhole/ tunnel
1.0
0.8
0.6
0.4
0.2
2760
2780
2800
2820
2840
2860
2880
2900
2920
image number

Subterra.ai

Our vision for the future

- Field data collection - fully autonomous
- Real time streaming of inspection to control room
- Robot swarms with different sensors for underground assets
- On-board CV, AI and ML for immediate notification, cleaning or repair
- Going from reactive -> Proactive and preventative

Robert Lee
robert@subterra.ai