Underground Infrastructures Detection by Analyzing Thermal Anomalies

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1. Introduction

Locating underground objects is essential for infrastructure works such as area development for construction, road pavement, installation of utility lines and more.
In this work, we present a method for locating subsurface objects that is based on periodic observation of the surface with a thermal camera. Analysis by model-based image processing algorithms enables detection of thermal anomalies which represent underground objects . The end-product is a georeferenced map of the detected subsurface objects.

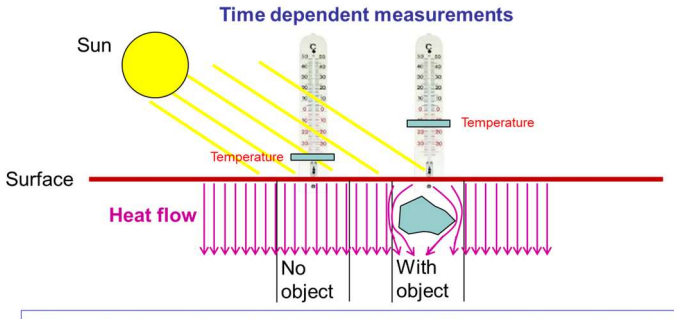
Method Advantages

- ✓ Non-invasive
- ✓ Enables scanning of large areas
- ✓ Detection of various materials
- ✓ Low cost

2. Detection Method

Thermal Anomalies Detection

Time dependent measurements



The surface temperature of soil with object\void is different from temperature of soil without object\void

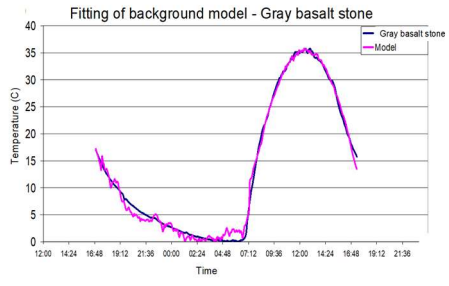
Generally it is hard to detect this difference because of background clutter

Clutter reduction by thermal dynamic measurements – increases anomalies detection capability

Methodology of Detection Algorithm

1. The basis for the detection algorithm is a semi empirical connection between the time dependent temperature of the surface and the meteorological conditions.
2. An example of a semi empirical model:
   $T(t) = a_1 \cdot R_{solar}(t) + a_2 * R_{sky}(t) + a_3 \cdot T_{air}(t) + a_4 * T_{air}(t) * V_{wind}(t)$
3. Generating coefficients map and anomalies detection.
4. Multispectral analysis for false alarm reduction.
5. Morphological classification.

Example of semi-empirical thermal model



3. Product R&D

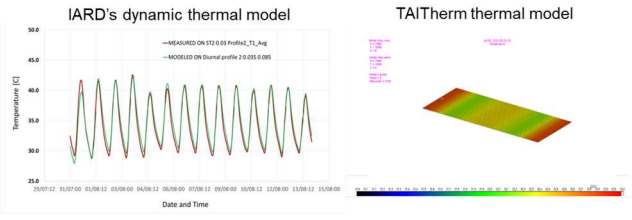
Research and Test Field

- ✓ A variety of buried objects
- ✓ Ground temperature and environmental data are collected continuously along the year

Thermal model for Detection Ability Evaluation

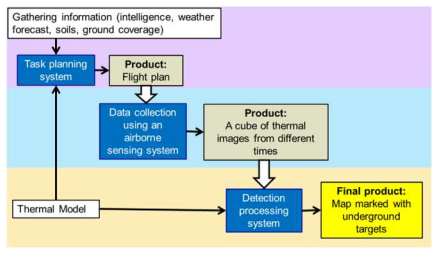
IARD's dynamic thermal model

TAITherm thermal model



Detection System

Detection Process – Flowchart



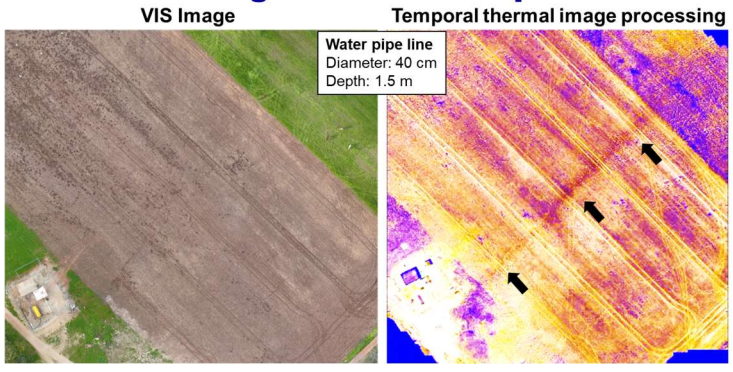
The Measurement System

1. MWIR thermal camera
2. The thermal camera is mounted on a drone

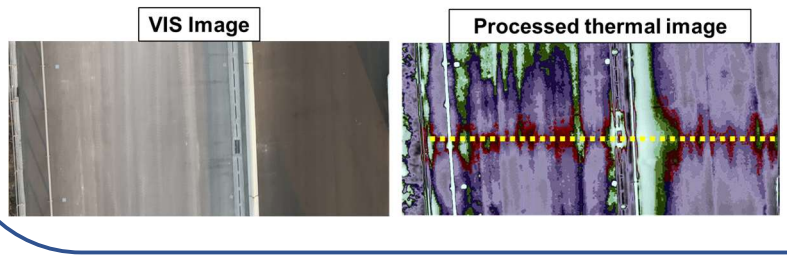
4. Examples of Underground Object Detection

Underground Water Pipeline

VIS Image — Temporal thermal image processing

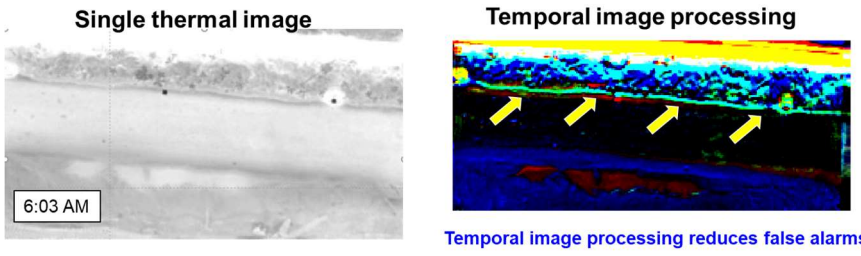


Drain-pipe Under a Road



Buried Electric Line

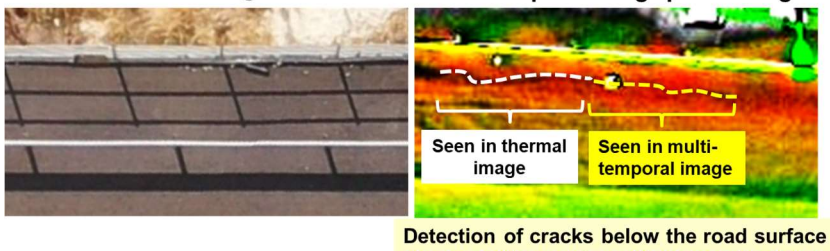
Single thermal image — Temporal image processing



Temporal image processing reduces false alarms

Detection of Underground Cracks In a Road

VIS Image — Multi-temporal image processing



Detection of cracks below the road surface
Seen on the surface three weeks later

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