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EPFL

Underground heating system leak detection using Aerial IR Thermography and advanced data analysis neural algorythms

EPFL Lausanne - 19th May, 2025

Dipl. Ing. Luca Del Nero
DarkWave Thermo Schweiz GmbH

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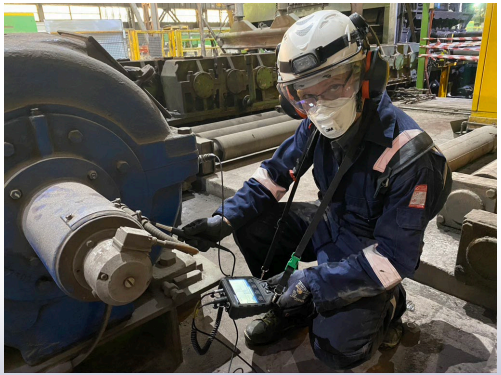

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What is an underground heating system?

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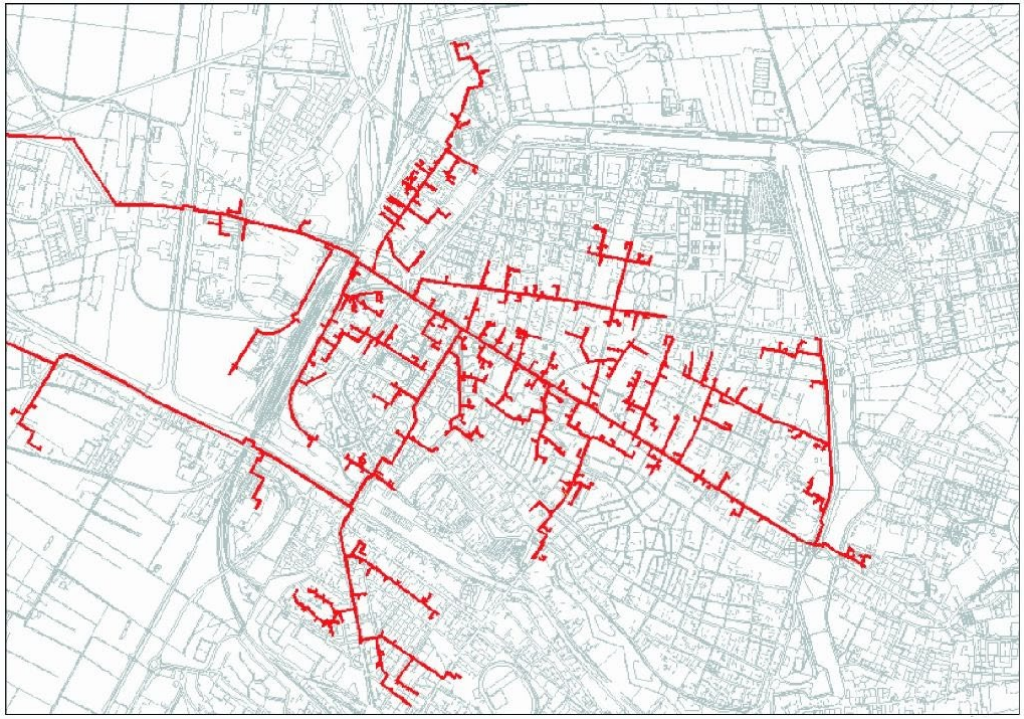
Challenge/Needs:

Multi-utility companies offer services to improve energy efficiency in large urban centers, including building district heating.

The distribution network for heating fluids spans hundreds of kilometers and is subject to losses and leaks.



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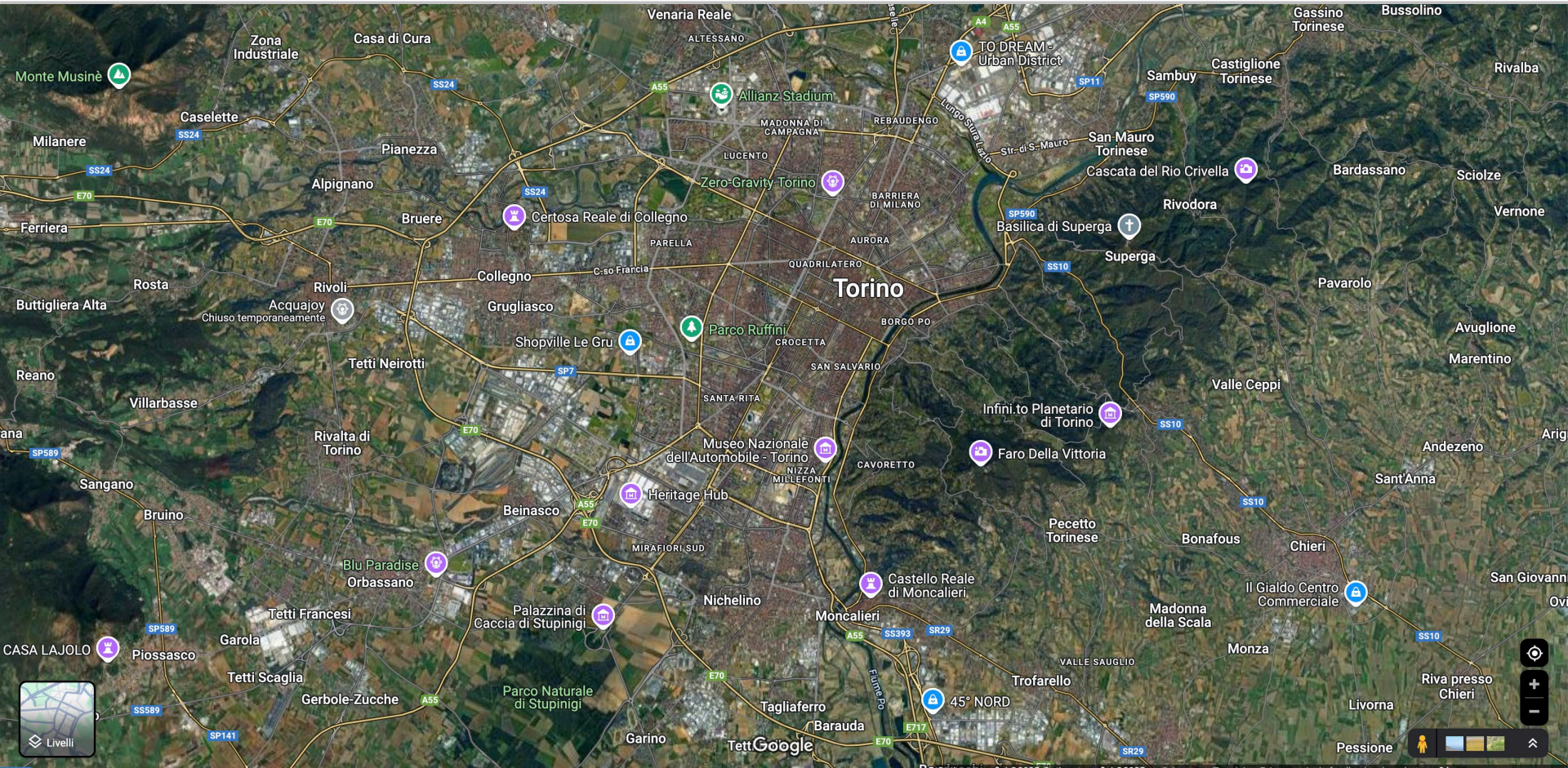
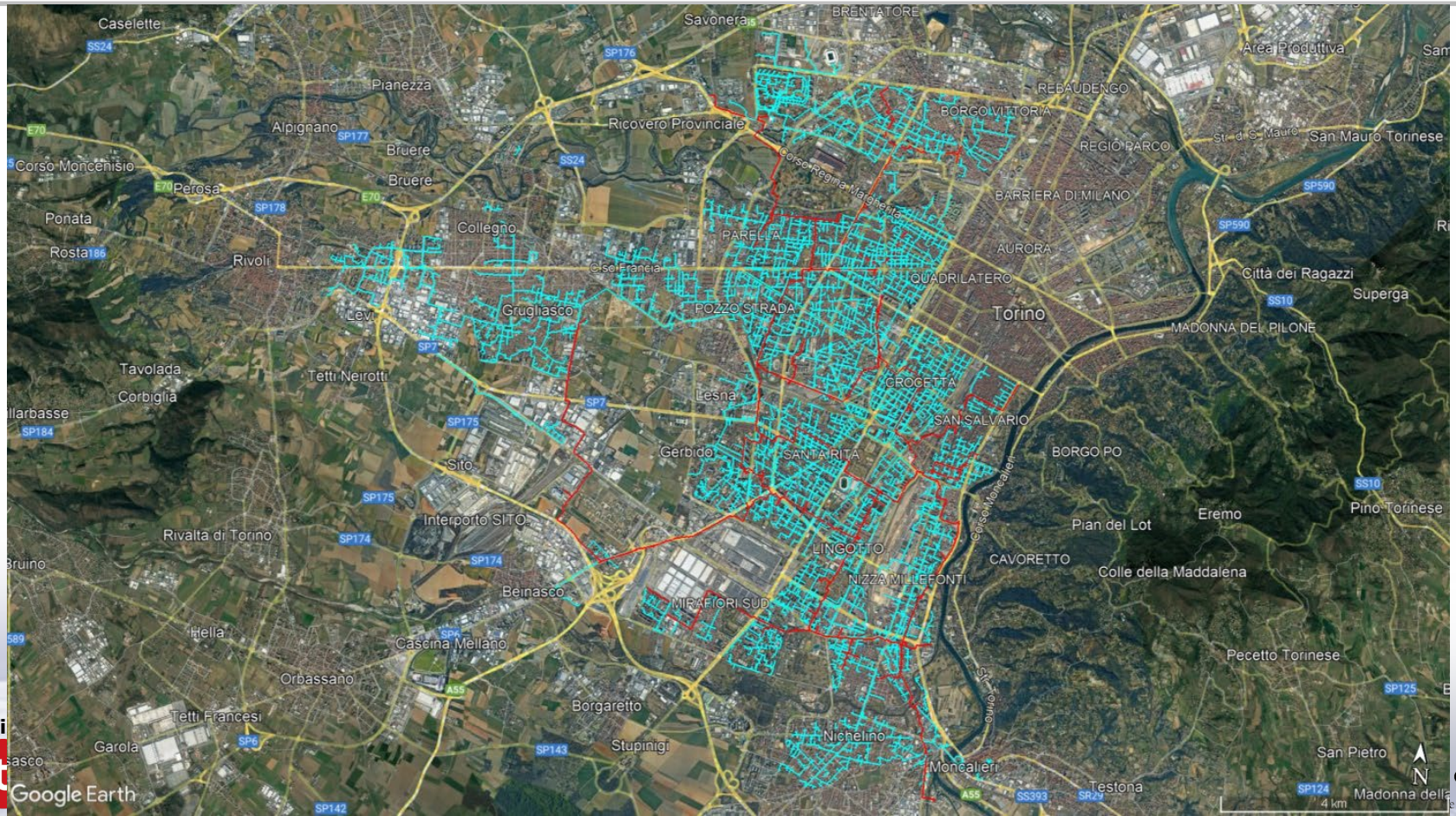


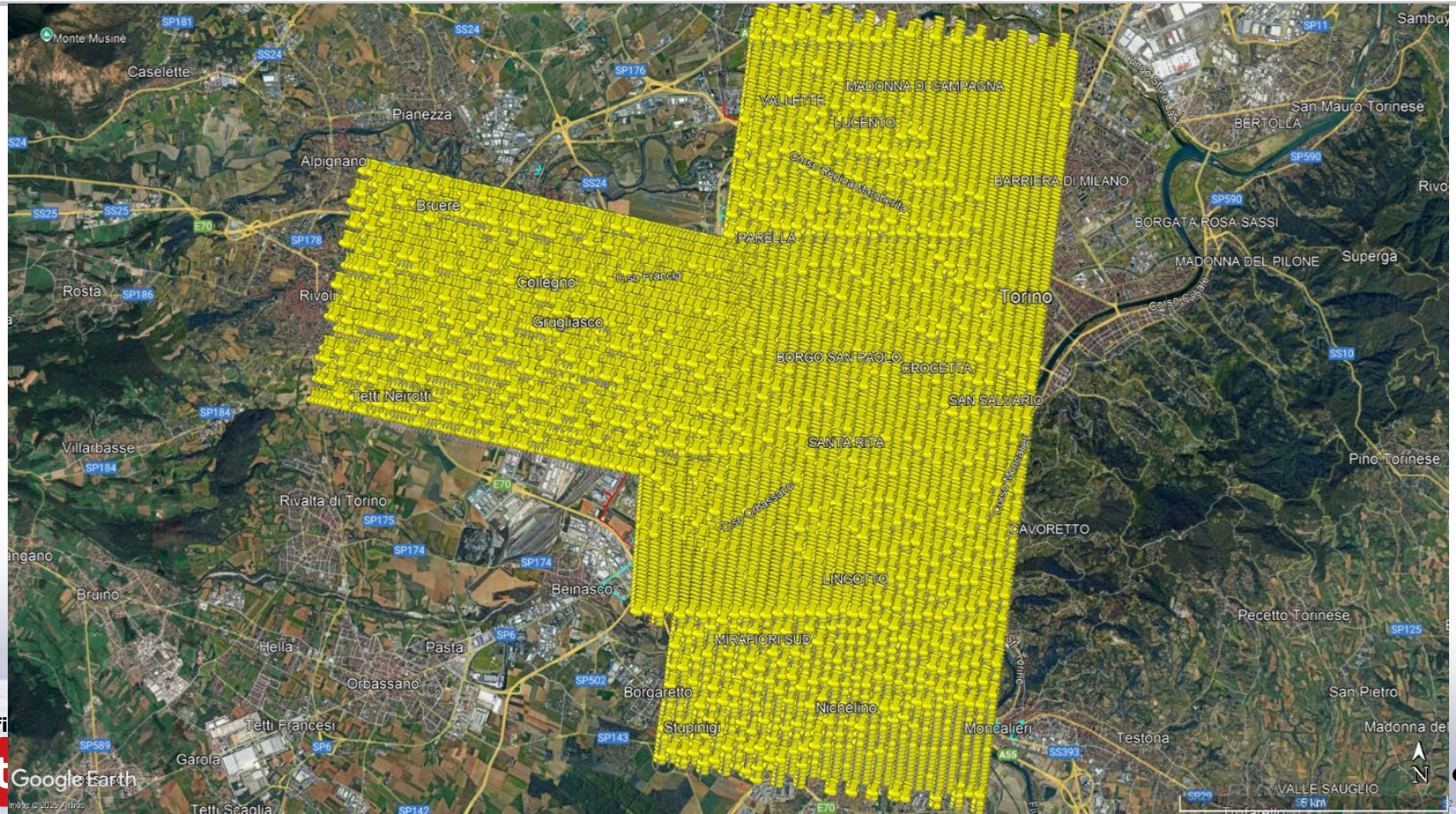

Caselette
SS24
Savonera
BRENTATORE
Area Produttiva
Pianezza
SP176
REBAUDENGO
BORGO VITTORIA
Alpignano
SP177
Ricovero Provinciale
Bruere
REGIO PARCO
San Mauro Torinese
E70
Corso Moncenisio
SS24
Corso Regina Margherita
Perosa
SP178
BARRIERA DI MILANO
SP590
Ponata
Collegno
PARELLA
Rosta
Rivoli
Corso Francia
AURORA
QUADRILATERO
Città dei Ragazzi
Superga
Grugliasco
POZZO STRADA
Torino
SS10
MADONNA DEL PILONE
Tavolada
Tetti Neirotti
Corbiglia
SP7
CROCETTA
Lesna
SP175
SAN SALVARIO
SP184
Gerbido
SANTA RITA
BORGO PO
Sito
SS10
Pino Torinese
Interporto SITO
Eremo
Rivalta di Torino
SP174
Pian del Lot
LINGOTTO
Corso Moncalieri
CAVORETTO
Colle della Maddalena
NIZZA MILLEFONTI
Beinasco
MIRAFIORI SUD
Cascina Mellano
Pecetto Torinese
Orbassano
SP125
Borgaretto
Tetti Francesi
Nichelino
Garola
SP143
Stupinigi
Moncalieri
San Pietro
Testona
SS393
SP124
Madonna della
SP142
4 km
N
Google Earth

DIGISKY

Technological Solution:

Night aerial thermography with high-end MWIR camera allows to obtain accurate maps with a GSD of approximately 15 cm and positional accuracy under one meter, during hours with minimal interference from vehicles on the road.

The map (orthophoto) can be overlaid onto the distribution network to detect thermal "spots" that indicate a network leak.


Monte Musiné
Caselette
Pianezza
Alpignano
Bruere
Collegno
Grugliasco
Rosta
Rivoli
Tetti Neirotti
Villarbasse
Rivalta di Torino
Bruino
Beinasco
Hella
Pasta
Orbassano
Borgaretto
Tetti Francesi
Garola
Stupinigi
Nichelino
Moncalieri
Testona
Torino
VALLETTE
MADONNA DI CAMPAGNA
LUCENTO
BARRIERA DI MILANO
PARELLA
BORGATA ROSA SASSI
MADONNA DEL PILONE
BORGO SAN PAOLO
CROCETTA
SAN SALVARIO
SANTA RITA
CAVORETTO
LINGOTTO
MIRAFIORI SUD
BERTOLLA
San Mauro Torinese
Superga
Pino Torinese
Pecetto Torinese
San Pietro
VALLE SAUGLIO
Corso Regina Margherita
Corso Francia
Corso Orbassano
Corso Casale
Corso Moncalieri
SP181
SS24
SP176
SP590
SP11
SS25
E70
SP178
SP186
SP184
SP175
SP174
SP6
SP502
SP143
SP589
SP142
SS10
SS393
A55
SP29
Google Earth
5 km
N

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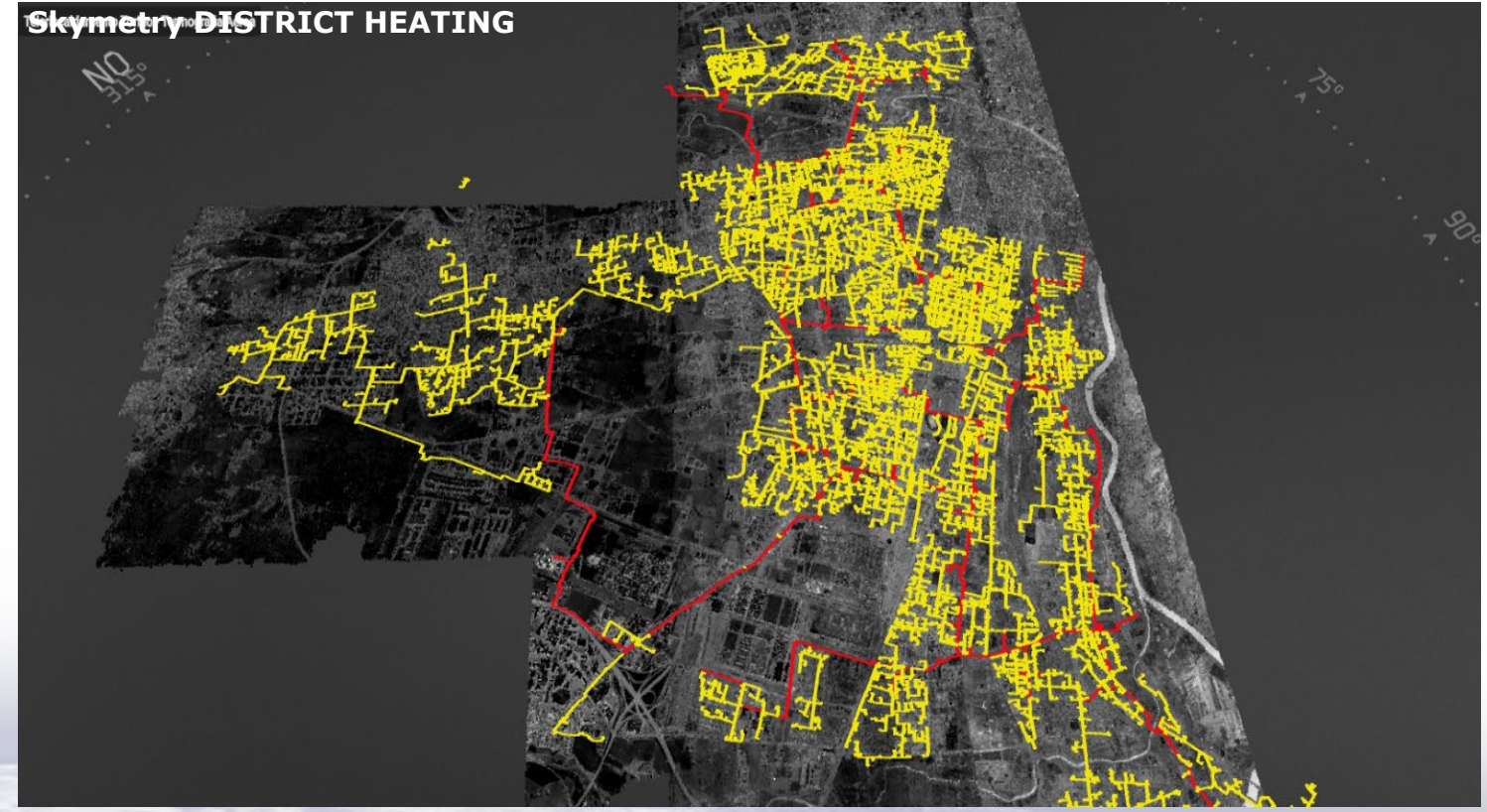
Skymetry DISTRICT HEATING



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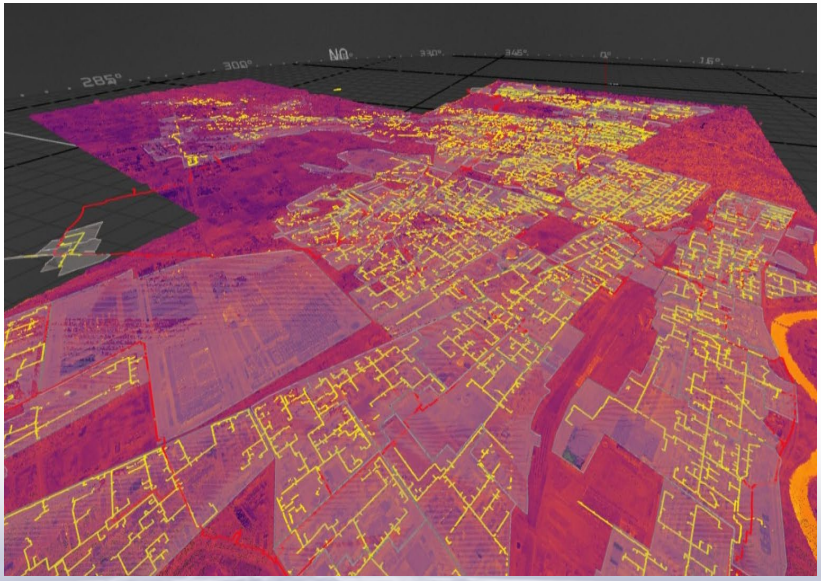
The application of thermal imagery in urban landscapes is highly effective when researching district heating losses.
During the winter months, the thermal response of the environment enables to use InfraRed technology to detect potential hotspots.



Main customers:

IREN/A2A/HERA Group

Target area:

District Heating Management

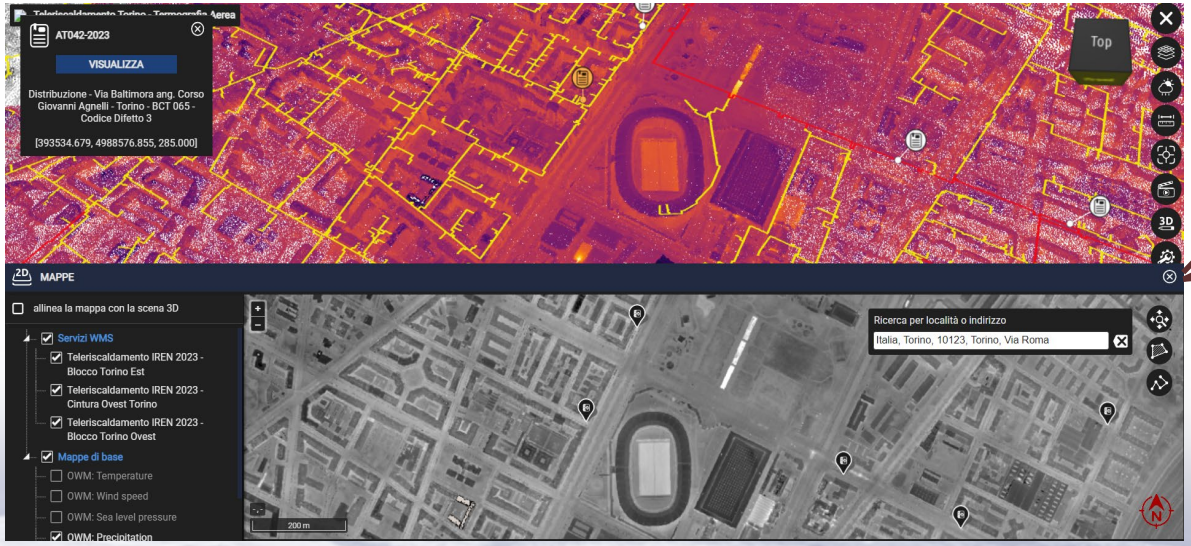
Main Goal:

Heat Leakage detection

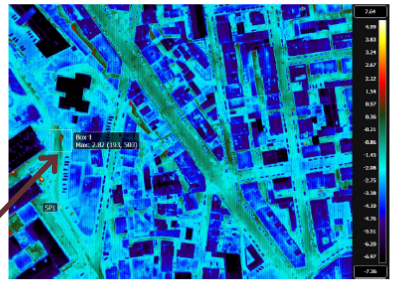
Solution:

Aerial Night-Time Thermographic Mapping

As aerial acquisitions are carried out over the night time, in IFR flight conditions, when the thermal difference is maximized, it is possible to apply analytics and Machine Learning algorithms properly trained to generate reports and classify anomalies fixing criticality threesholds.
The classes will then guide interventions based on the severity of the damage recorded.



DWT	Cliente: IREN S.p.A. - Sede di Torino Località: Torino	Data Ispezione: 12/12/2022



ANALISI	
Emissività	0.95
Temperatura apparente riflessa	-40.0 °C
Box 1 Temperatura massima	2.8 °C
Sp1 Cursore Temperatura	-1.4 °C
Dt1 (Bx1 Max – Sp1)	4.2 °C

RETE TELERISCALDAMENTO	
RETE di DISTRIBUZIONE DN 150	
Indirizzo: Moncalieri - Via Pininfarina - Curva Sala Congressi G. Rota dell'ITIS Pininfarina	
Coordinate GPS: 45.01405014, 7.66231516	
Codice difetto:	AT012-2023
Linea Confine BCT:	007
Sovratemperatura:	4 °C
Classe difetto:	4

COMMENTI

Figura 16 - Via Pininfarina Curva Sala Congressi Sala G. Rota dell'ITIS Pininfarina **- Moncalieri**
[Cod. AT012-2023]

In corrispondenza di Box 1 si rileva una mappa termica lievemente anomala compatibile con una potenziale perdita di isolamento termico della tubazione di rete.
I livelli termici appaiono tuttavia poco rilevanti.

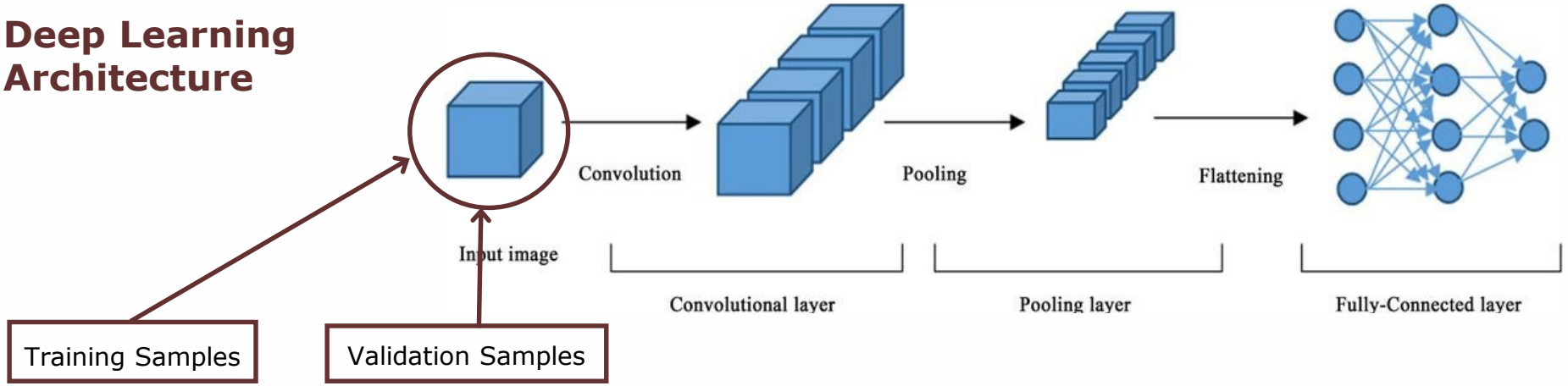
Tenere monitorato con ispezioni periodiche.

Data	12/12/2022	Immagine Ora	03:24:03
Nome file	IR_1570.jpg		

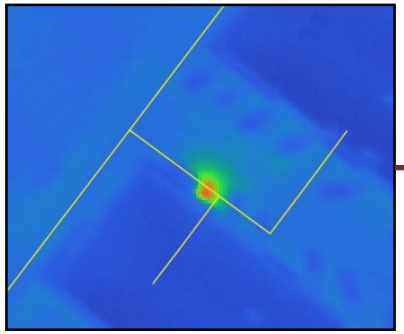
IMMAGINE DEL VISIBILE

Classe 1		ΔT	> 35°C	Verifica urgente
Classe 2	10°C	< ΔT <	35°C	Verifica da programmare
Classe 3	5°C	< ΔT <	10°C	Verifica differibile
Classe 4	< 5°C	ΔT		Non necessita verifica, da rivalutare nelle prossime ispezioni termografiche

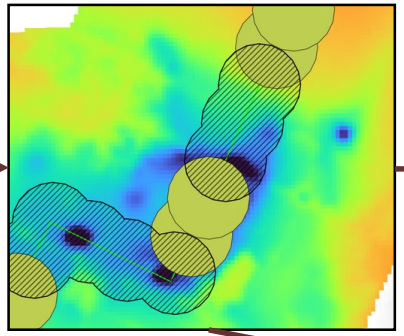
Deep Learning Architecture



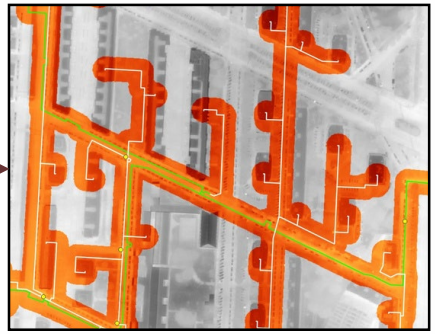
Ratio: Training / Validation / Test Split	Number of training samples	Raster bands	Class balance
Additional information: Texture, Shape, Edge, Statistics, Color	Image resolution	Geometry / Spatial context	Background (True negative)



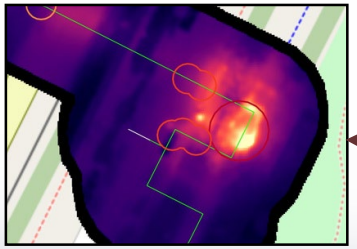
Pipelines



Buffers



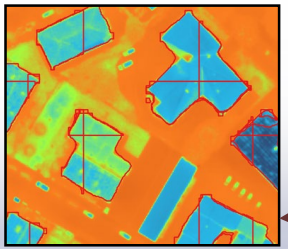
Network extractions



True positive

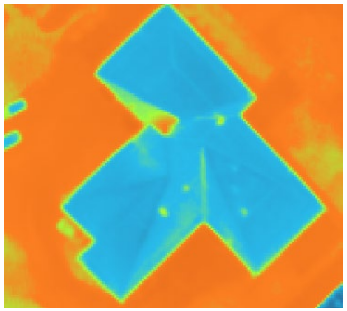
_mean	_median	_stdev	_min
14.3627601097...	14.3721814155...	0.09334762532...	14.0638322830...
13.1205592435...	13.1385641098...	0.10977693563...	12.7375421524...
9.91461795254...	9.92598533630...	0.11642133651...	9.50889968872...
11.9294944366...	11.9538669586...	0.12639188045...	11.4775037765...
12.9091758881...	12.9207887649...	0.10756770745...	12.6254482269...

Zonal statistics

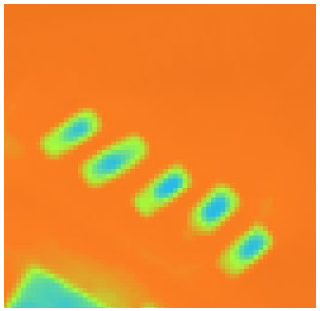


⚠ False positive

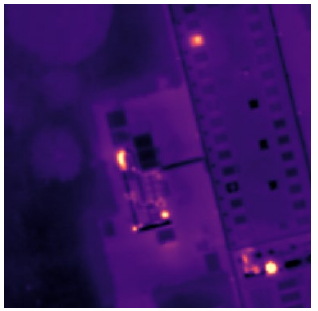
False positive typologies



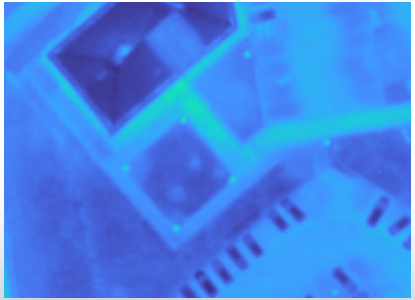
Buildings



Cars

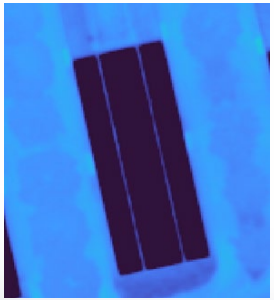


Industries



Street lamps

Spillover effect



Cold objects

False positive prediction DL

Training samples:

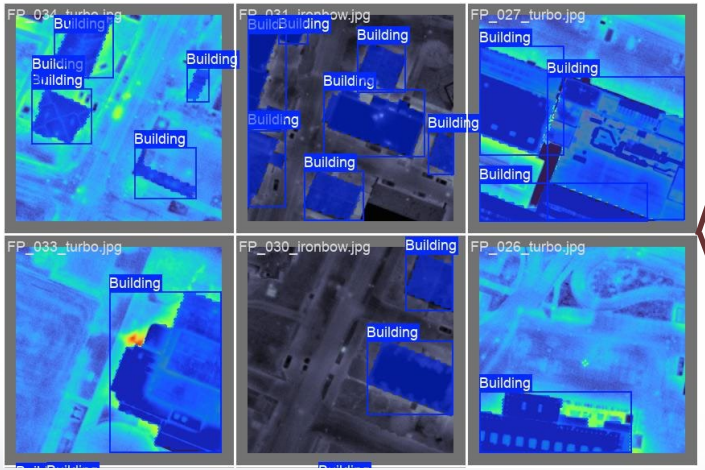
>1000

Deep learning architecture:

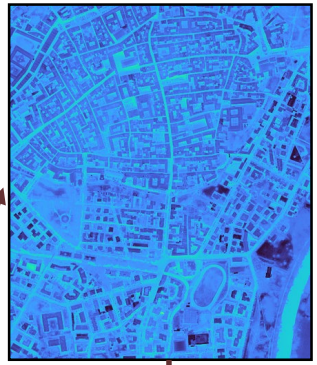
YOLOV8

Bands:

1 (Thermal MWIR)



Raster



YOLOV8
Output

Anomaly prediction DL

Training samples:

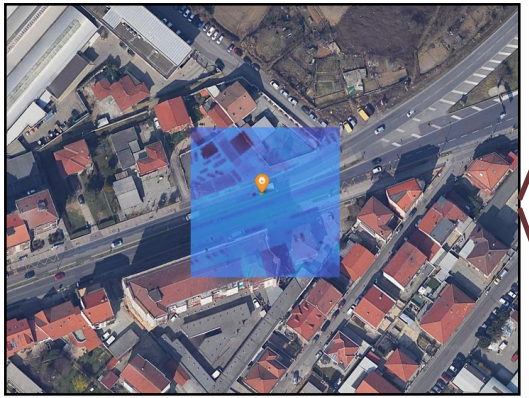
>500 (per class)

Deep learning architecture:

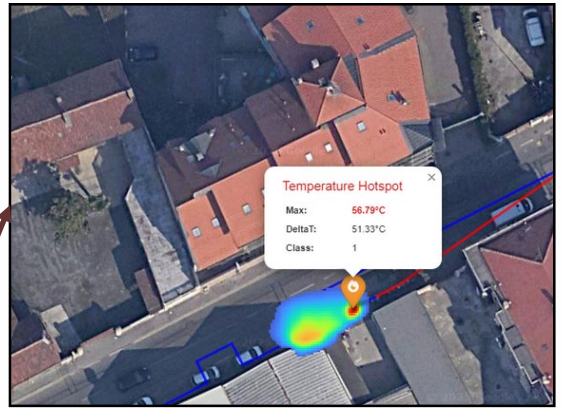
DeepLabV3

Bands:

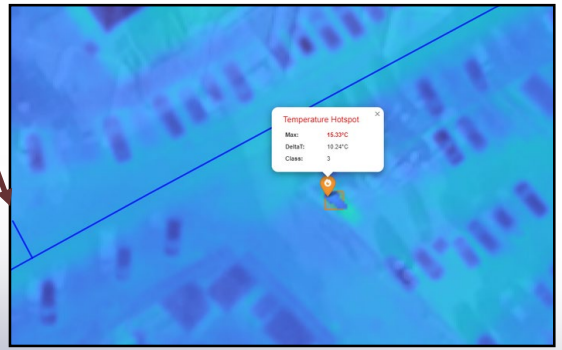
1 (Thermal MWIR)



Class 1 anomaly



Class 3 anomaly



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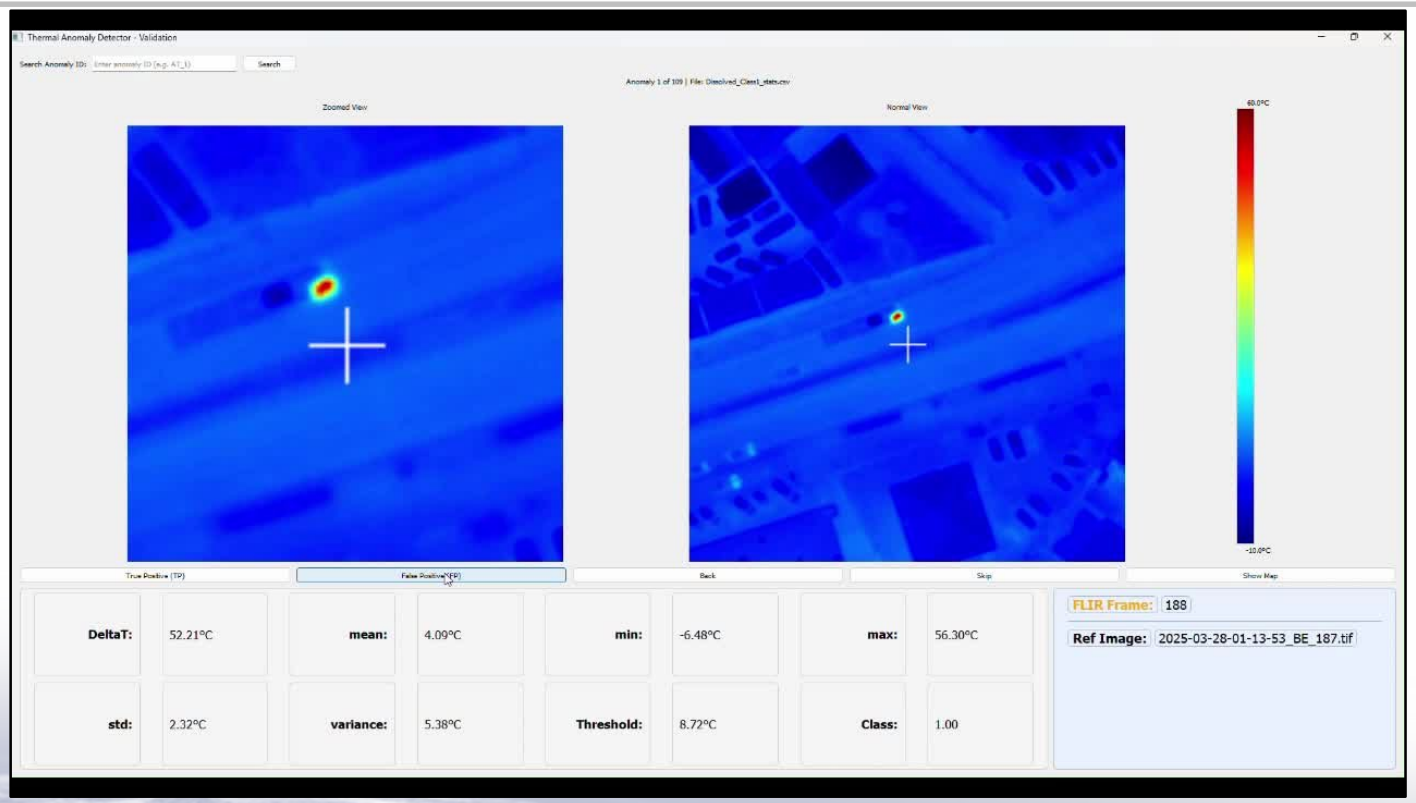
Anomaly detector V03

by

DIGISKY



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