Multi-scale approach to estimate land surface temperature (LST)

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Introduction

Low-altitude remote sensing (RS) using unmanned aerial vehicles (UAVs) is a powerful tool in vegetation monitoring. In this context, thermal RS has many potential uses for:

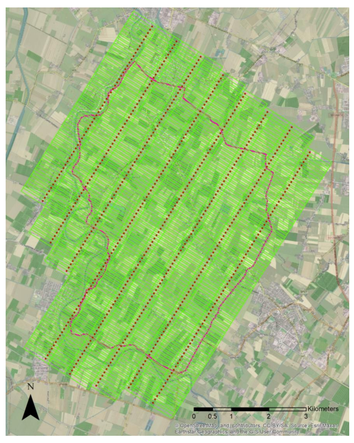
- Land surface temperature (LST) monitoring
- Precision agriculture for water/heat stress monitoring
- Emissivity (e) of different materials
- LST data can be further coupled with atmosphere climate model (evapotranspiration)

Key Challanges

The main challange of the thermal RS is to:
- Accurately estimate the LST
- Data processing chain is quite time consuming
- Required additional primarily field data

Our proposed approach

We have developed a systematic semi-automated data processing chain which overcomes some of the short-comings of conventional data processing chain for estimate LST from different spatial scale (from plot level to large forest coverage)



Instrument at the Plot Level monitoring

Drone DJI M300 RTK

Thermal camera: DJI Zenmuse H20T

D-RTK2 Mobile Station

Instrument at the large field size > 28 sq. km

Survey aircraft: twin engine, open camera hatch

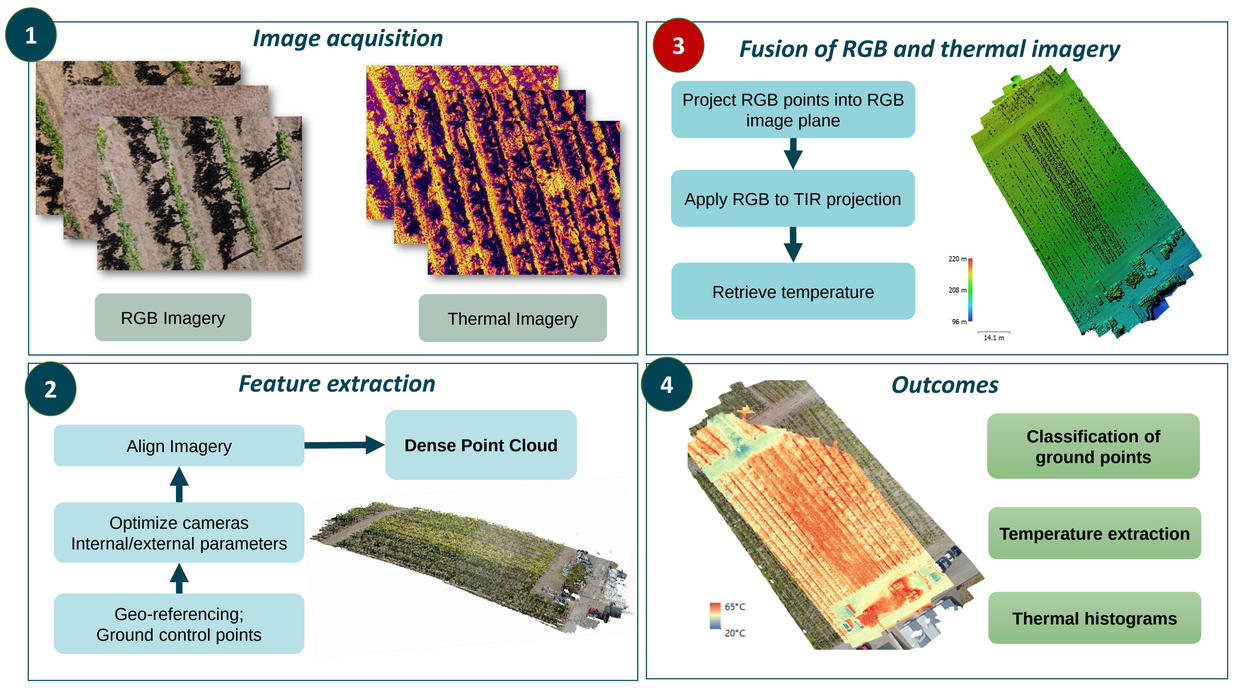
TELOPS Hypercam LW : FTIR hyperspectral thermal imager

Table- 1: Basic specifications and configuration of the Hyper-Cam LW & Zenmuse H20T Sensors

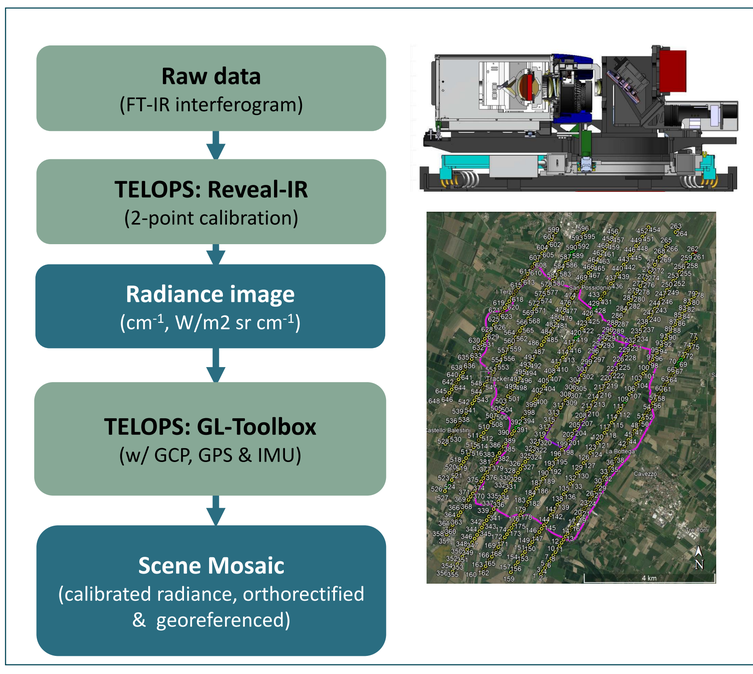
Parameter	Hyper-Cam-LW	Zenmuse H20T
Spectral rang [µm]	7.7 – 12	8 - 14
Spectral resolution [cm^{-1}]	0.25 – 150 (user adjustable)	n/a
Image format [pixels]	320 x 256	640 x 512
Field of view [^{o}]	6.4 x 5.1 (nominal) 25.6 x 20.4 (0.25x telescope)	40.6
Typical NESR [nW/cm^2*srcm^{-1}]	< 20	n/a
Radiometric Accuracy [K]	< 1	< 2
Sensitivity (NETD)	-	≤ 50 mK

Data processing

Several steps are needed to process the thermal RS data. The typical processing steps involved using the Structure from Motion (SfM), which is a common approach to process RGB. However, processing of thermal RS data with SfM does not work flawlessly as it could not align the thermal dataset properly. Therefore, we proposed combining RGB and Thermal data for alignment and projected it to the right geo-referencing using the RTK. This allowed us to perfect the mosaic of the thermal data and have more accurate results.



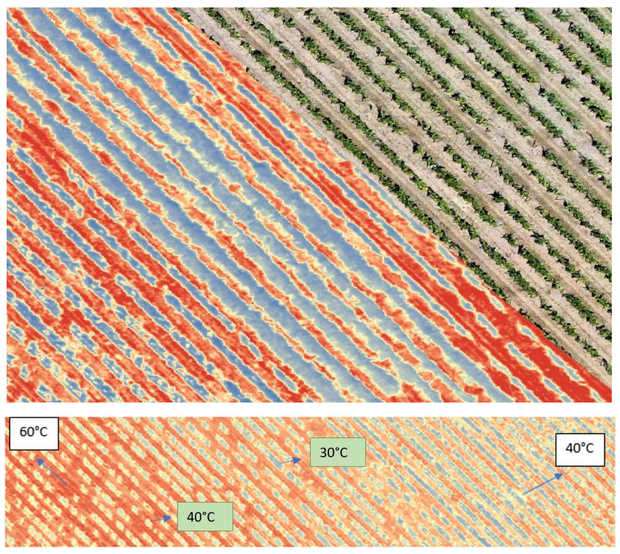
Proposed data processing chain to calculate the thermal orthomosaic image using the Zenmuse H20T sensor at the plot level application (0.25 Hectare)



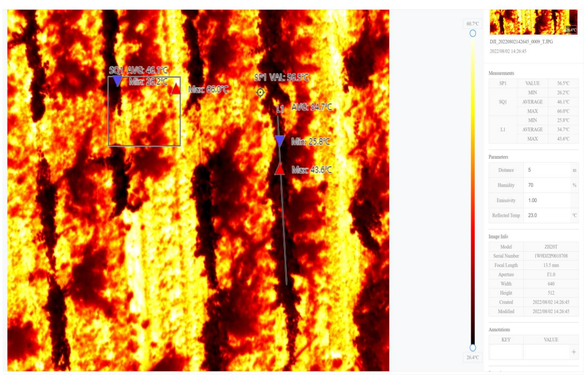
TIR radiance mosaic, July 2022, Lombardy (I).

Proposed data processing chain to calculate the thermal orthomosaic image using the Hyper-Cam sensor at the large field level application (Area: 28.75 km^2)

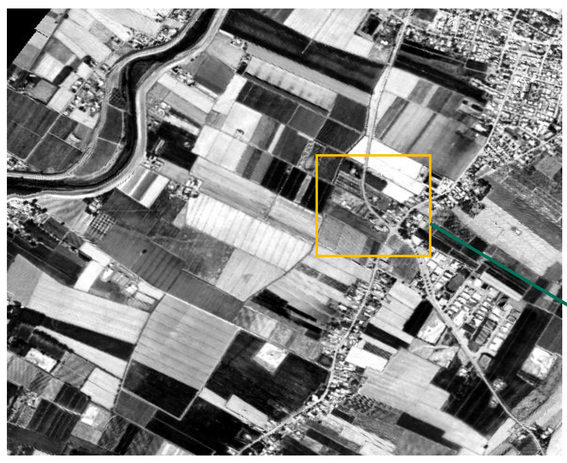
Results & Discussion



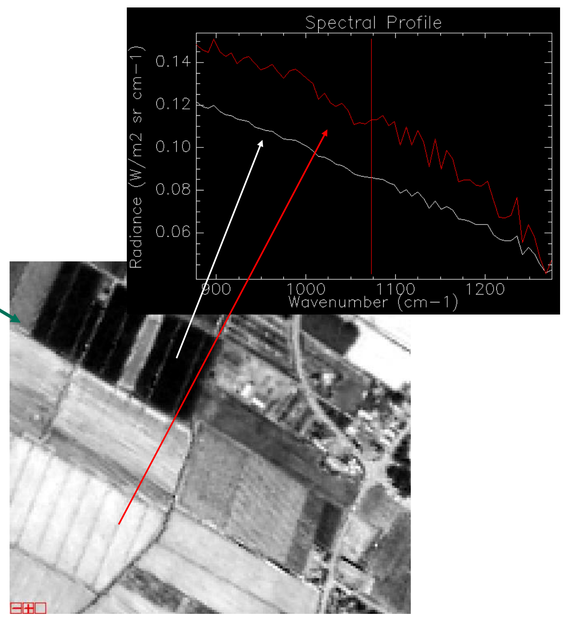
Machwitz, M. (Author) Location: Remich IVV, Luxembourg - 19th July, 2022



The data was acquired on 19th July 2022 from Remich site, Luxembourg (Lat- 49.54456; Lon 6.3539). The distribution of the thermal data is processed with centimer level resolution, it provides detail insight about the vegetation stress during the summer time at the Vineyard at Remich IVV.



Ortho-rectified and georeferenced TIR radiance mosaic.
Spectral resolution: 4 cm-1 or 64 bands
Spectral domain: 7.84 – 11.53 µm
GSD: 4 m



Future outlook

Through the fusion of RGB and Thermal imagery, the precision of thermal data processing output is increasing. It also require some manual intervention, during the processing steps, which is quite time consuming. In parallel with the automation of the processing automation, we aim to increase our technical portfolio with more acquisition methodologies one of them being oblique, this technique allows a more precise offsite visual inspection, providing more stable and more accurate image connections (along track and across track directions);

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