Royal Military Academy - 4D Perception Lab
Darius Couchard

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TaMaCare: Integrating multi-spectral sensing and 3D mapping for battlefield casualty care.

darius.couchard@mil.be

Agenda

1. Introduction and objectives
2. Used technologies
3. Simultaneous Localization and Mapping
4. Hyperspectral Imaging
5. Ultra wideband positioning

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1. Introduction – Context

Traditional methods of casualty care rely on limited information:

- Lack of a comprehensive picture of the battlefield
- Limited ability to locate and prioritise casualties
- Limited ability to minimize exposure to threats

We will build **a real-time digital twin** of the frontline including location of **casualties & threats** using **passive portable/wearable systems** (<3kg)

→ Better situational awareness
→ Better decision making

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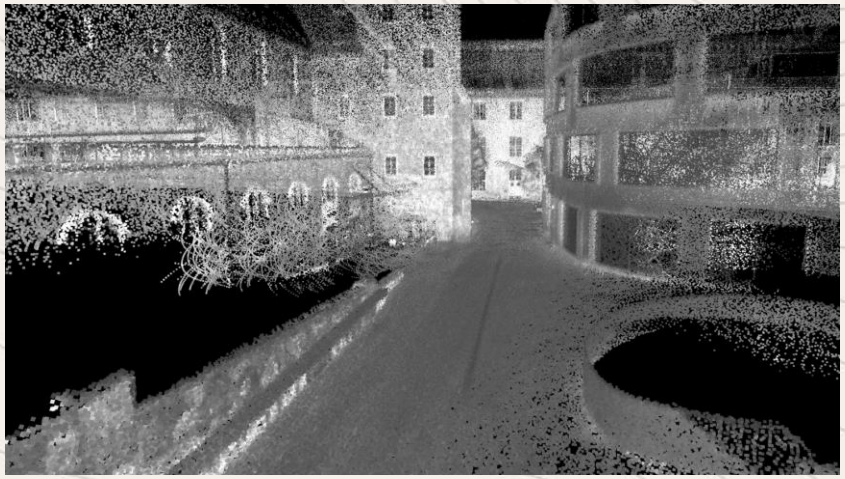
1. Objectives

Objective 1: develop a robotic or wearable 3D mapping system using SLAM techniques

- Pose accuracy of 1m in 1km x 1km test area
- Real-time on embedded system:
  - First: IMU, cameras and LiDAR
  - Then: IMU and cameras only (passive)
- Hand-held or UGV system: cover a 500m x 500m area in 2 hours
- Combination of VIS and IR camera: robustness to day / night and DVE (SotA: day)



Sample 3D mapping rig (ongoing project)

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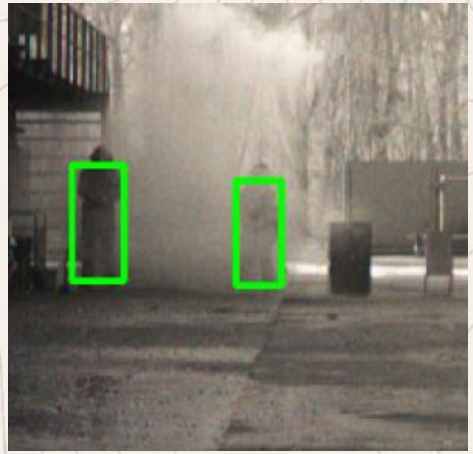
1. Objectives

Objective 2: develop robust sensor fusion algorithms to detect and classify casualties and threats

- Accuracy with F1-score› 0.8 for day & night + degraded visual environment (DVE).
  (SotA: day + under good visibility conditions)
- Increase robustness using sensor fusion.
- Combination of LWIR & HSI (VIS/NIR/SWIR).
- Casualty detection: research focus on context modeling and sensor fusion.
- Threat detection: start from anomaly detection (large-scale exploration) towards target detection (detailed spectral analysis)

PFM-1 replica



Person detection in DVE

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1. Objectives

Final objective: Create a Digital Twin of the Battlefield

- User-friendly visualization of results of sub-objectives.

Point cloud to be colorized with VIS or IR information
Markers updating in real-time

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2. Used Technologies

- Simultaneous Localization and Mapping (SLAM).
- Hyperspectral Imaging (HSI).
- Ultra wideband for casualty monitoring (UWB).

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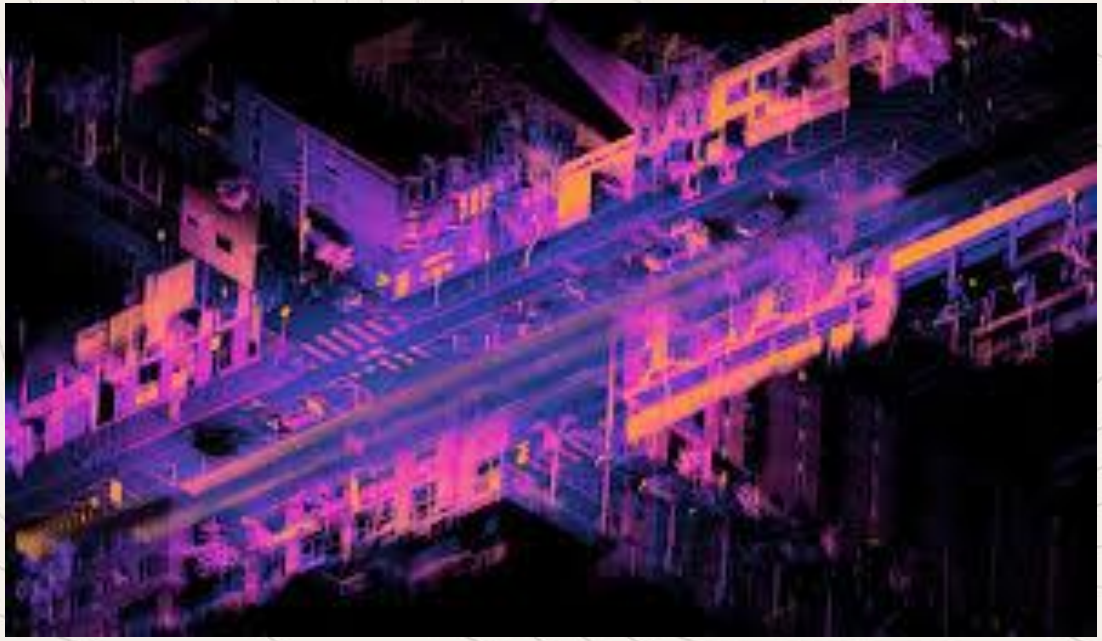
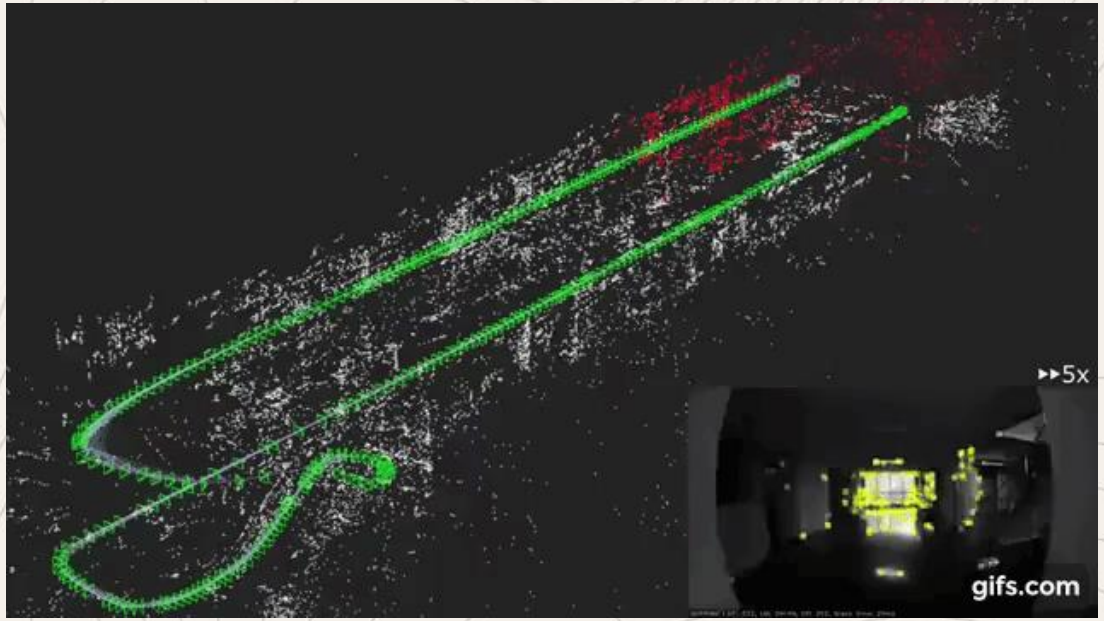
3. SLAM





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3. SLAM

- Creation of a point cloud and navigation.
- Hypothesis of jammed GPS signals.
- Basic systems use LiDAR.
  - With inertial measurement units.
- We want to transfer to visual SLAM.
  - Passive system for stealth.
  - **However:** Challenges with precision.

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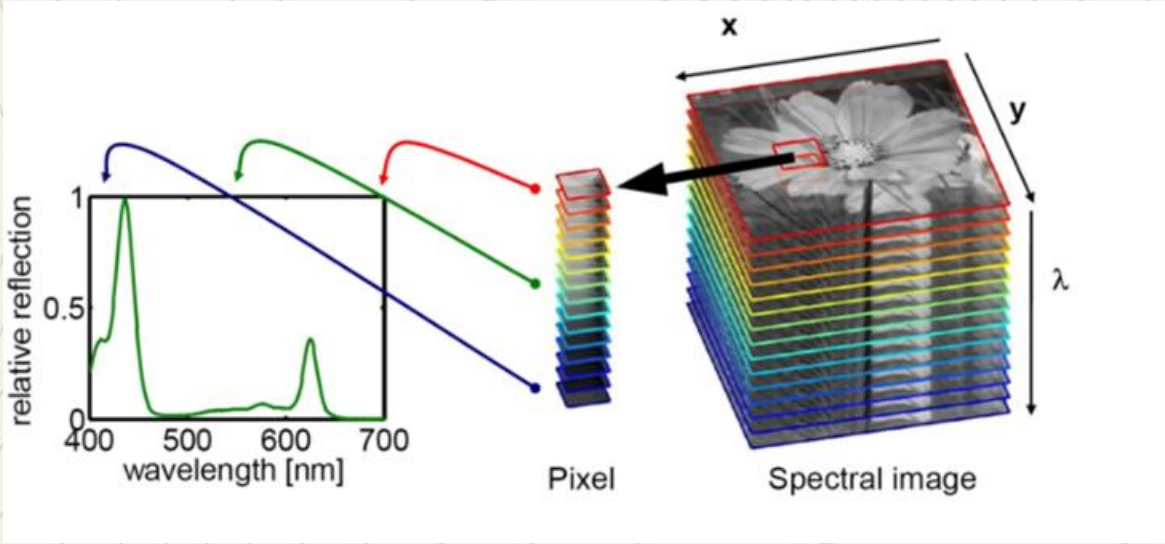
4. Hyperspectral Imaging

Traditional imaging techniques focus on few, broad bands.

- RGB in visible (3 bands).
- Panchromatic (1 band).
- Multispectral (~10-20 bands).

HSI captures many consecutive narrow bands:

- Detailed spectral signature of objects.
- Camouflaged object detection.



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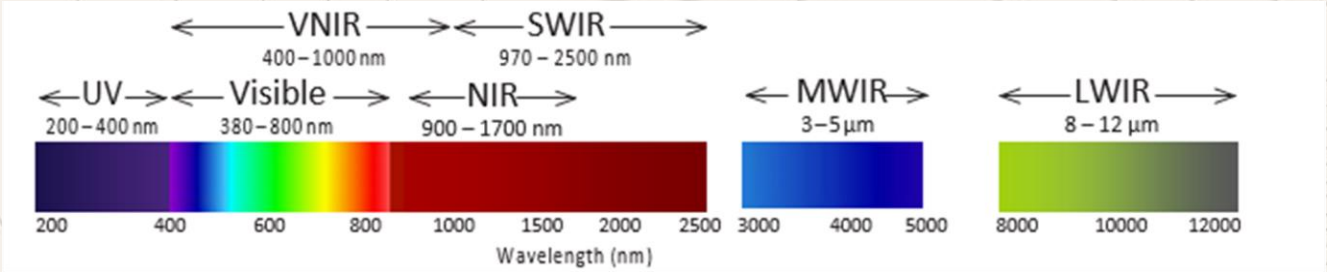
4. Hyperspectral Imaging



HSI has shown potential in detecting landmines:

- Mostly Visible + NIR spectrum (0.4 – 1 µm).
- SWIR can also help (1 - 2.5 µm).
- Laid on ground/partially buried.
- Detection of painted, metallic or plastic materials as anomalies.

Buried mines:

- Thermal imaging to detect anomalies in soil.
- LWIR cameras (8 – 12 µm).

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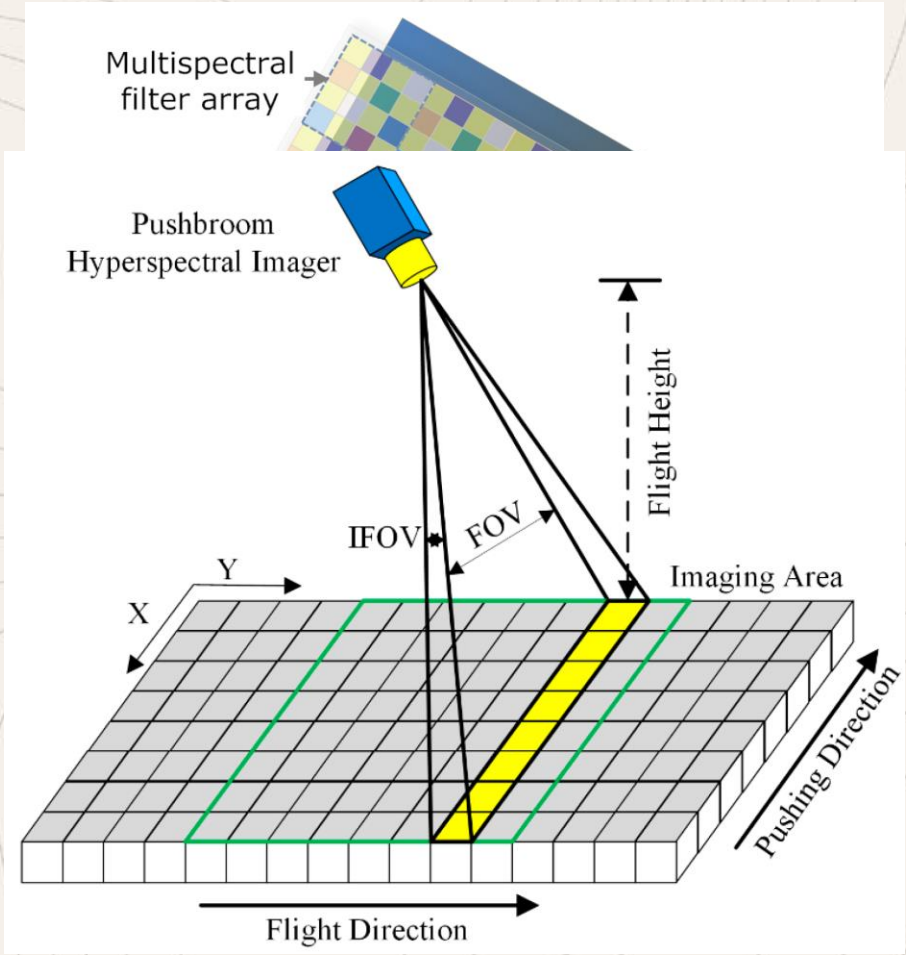
4. HSI Limitations

HSI suffers from limitations:

- Spatial/spectral resolution tradeoff due to filter arrays.
- High volume of data to capture.

Custom multispectral cameras:

- Pushbroom cameras are not suited for dynamic environments.
- Do a measurement campaign with pushbroom.
- Peform band selection.
- Design multispectral filter array for mine detection.



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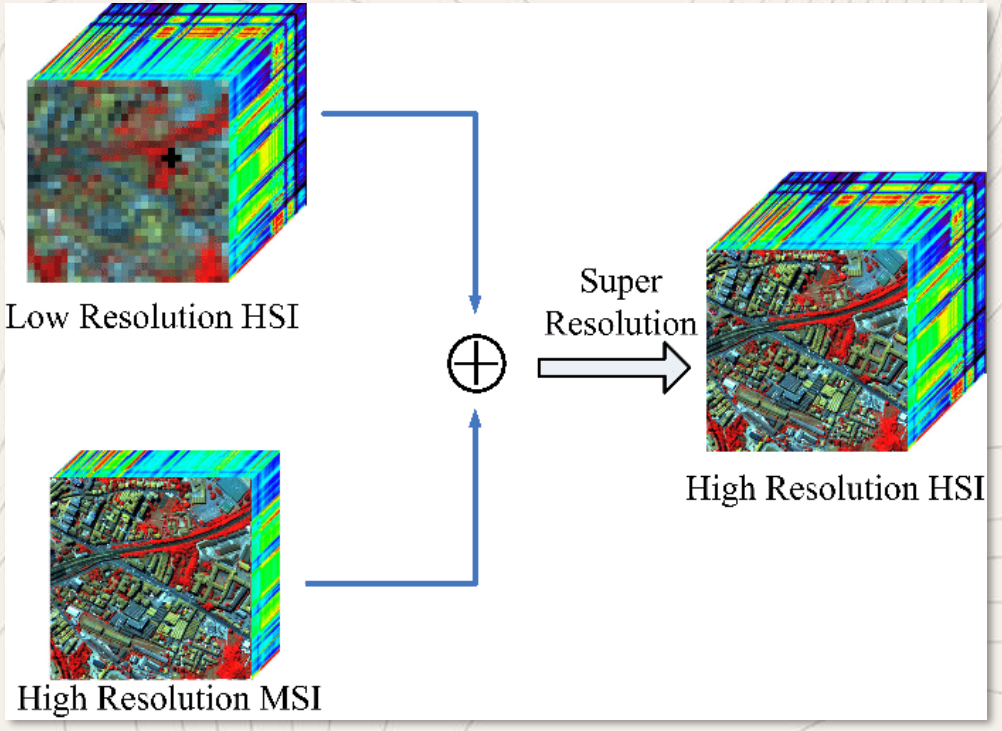
4. HSI Limitations

Additional sensors:

- Visual SLAM RGB sensors.
- Panchromatic LWIR.
- Multispectral VNIR/SWIR.

Sensor fusion:

- Low-resolution spatial HSI sensor.
- High-resolution spatial RGB/Pan. sensor.
- Sensor fusion for High-resolution HSI.



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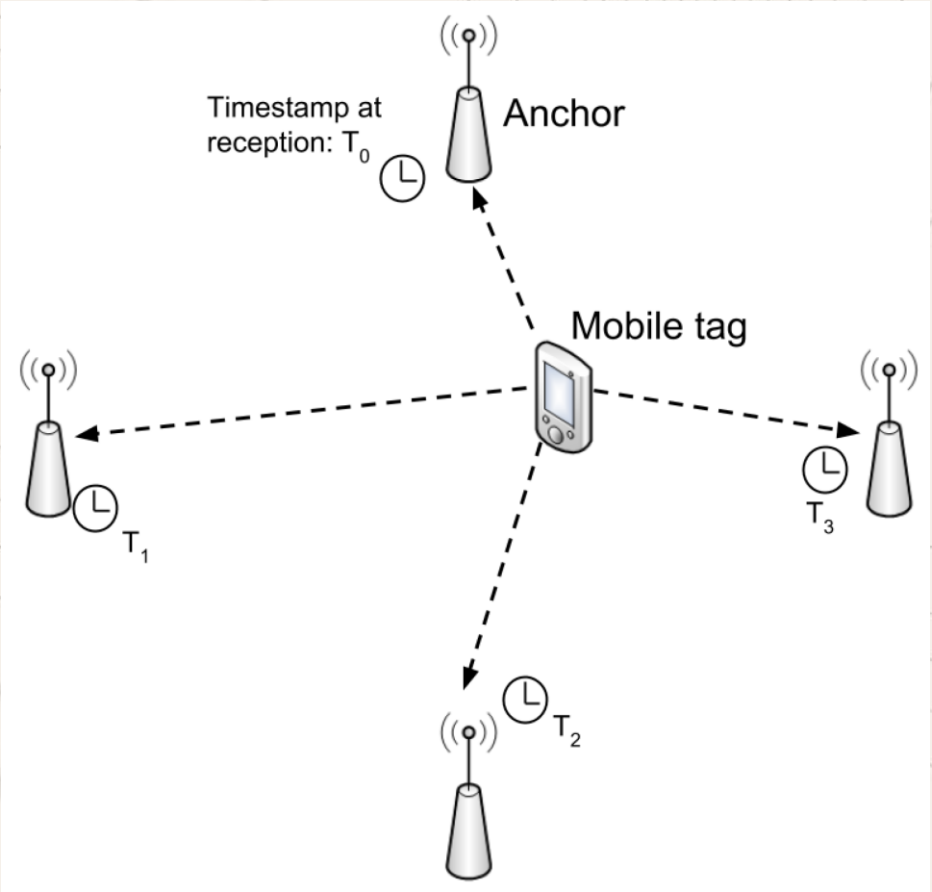
5. Ultra Wideband

- Short impulses (few nanoseconds) on a very wide range in the spectrum.
- Allow to determine position from triangulation.
  - Live tracking of moving casualties.
- Wide range → Harder to jam the signal than GPS



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Thank you for listening!