MoeBIOS

IMPROVING WASTE MANAGEMENT OF BIOBASED PLASTICS AND THE UPCYCLING IN PACKAGING, TEXTILE AND AGRICULTURE SECTOR

Bioplastic Recycling Webinar
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LEITAT

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MOEBIOS

- Project Overview
- Sorting Technologies: Hyperspectral vision
- Sorting Technologies: Robotics

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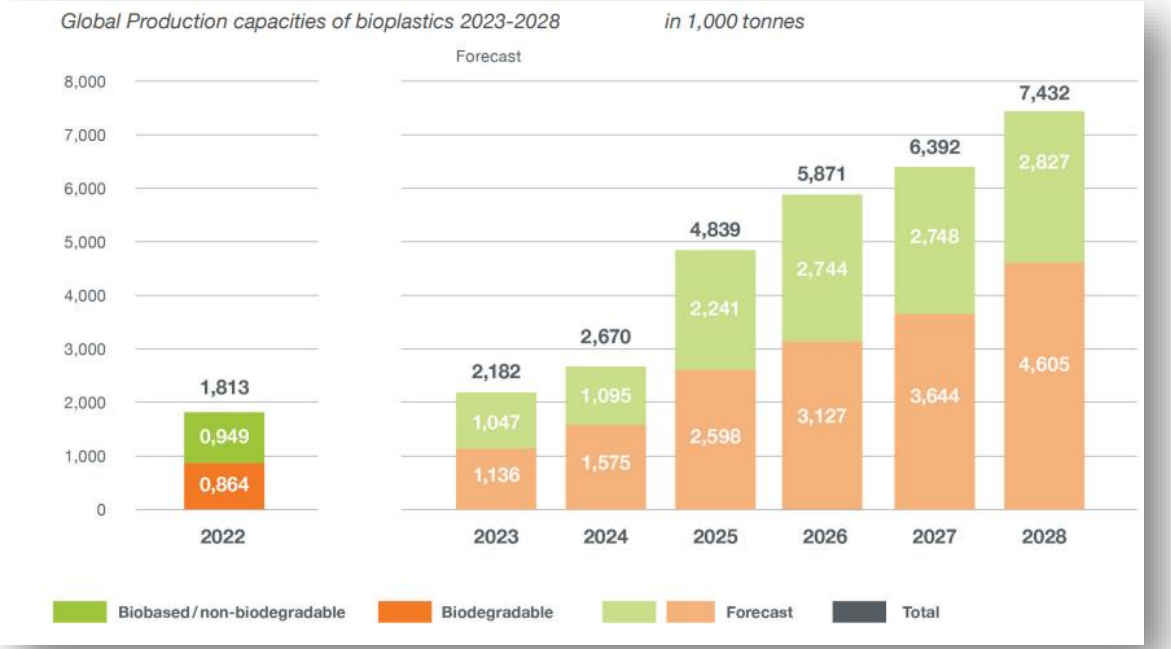
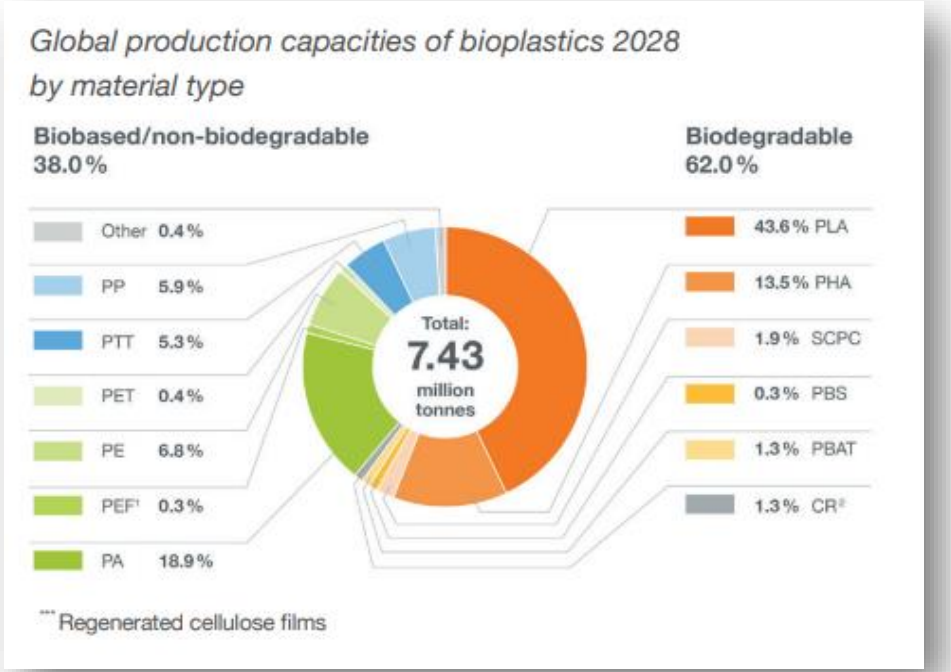
Project overview: Context

- Global BIOS production (2023-2028) by European Bioplastics





- Bioplastic (**BIO**s) presence in the waste streams is expected to dramatically grow
- Non-effective value chain has been currently implemented for the **BIO**s EoL (including collection, sorting, recycling and upcycling)
- **BIO**s have a promising potential for recycling

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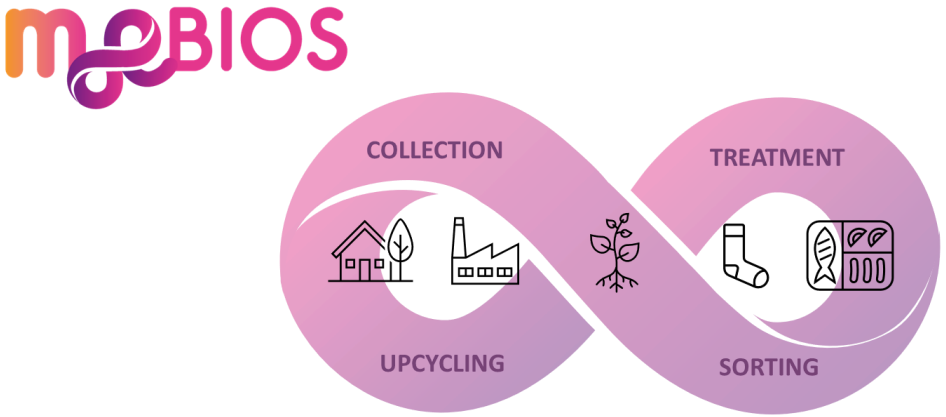
Project overview: OBJECTIVE

The MoeBIOs concept :Closing the loop of the BIOs End of Life

The overall objective of MoeBIOS is to demonstrate novel recycling routes for bioplastics waste streams (BIOs) along the EoL within 3 value chains, towards new upcycled high-value products

Value chains

- Packaging
- Textile
- Agriculture



- Decision Support System (DSS)
- Multiactor approach (MAA)
- Safe and Sustainable by Design (SSbD)

Multiactor approach → Waste Managers | Industry | Citizens | Brand-owners | Policy makers | Research

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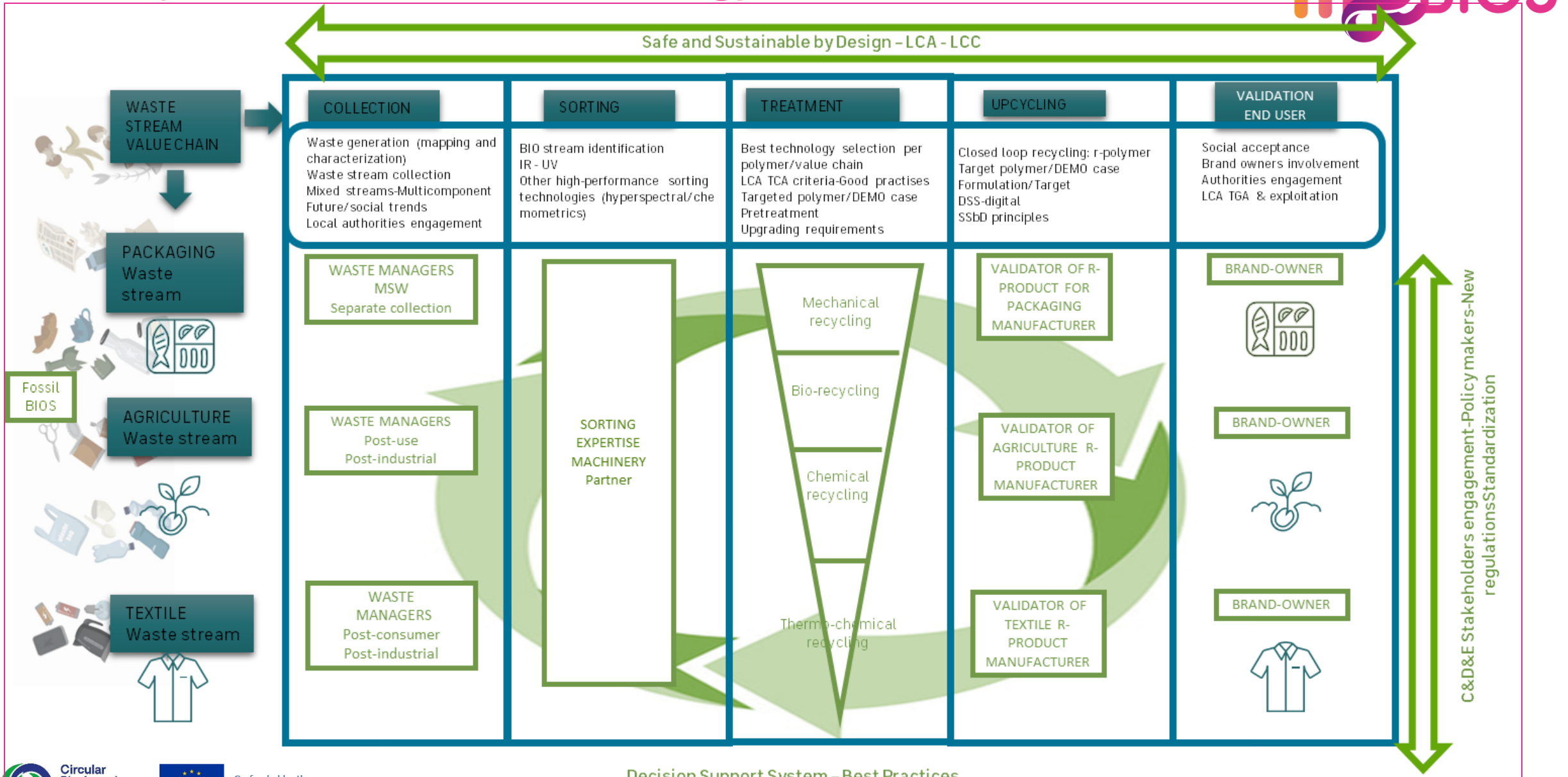
Project overview: Methodology



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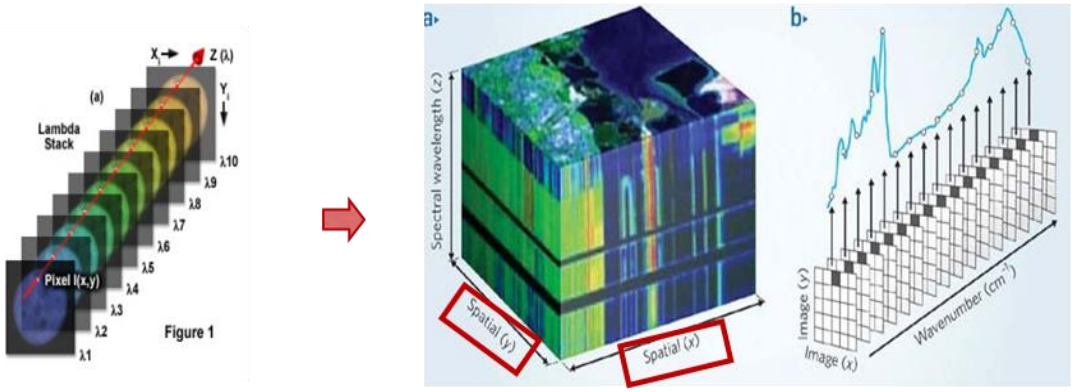
Sorting technologies: Hyperspectral

Hyperspectral Imaging (HIS): The concept

Hyperspectral Imaging (HSI) captures a series of images at different wavelengths, creating a data structure known as a **hypercube**. Every pixel in the image contains a spectrum, so every point of the sample has a **unique spectral fingerprint**, enabling precise **identification** and **location** of materials or **compounds**.

The hypercube can be analyzed in two ways:

- **Spectrally Analysis:** Intensity vs. Wavelength
- **Spatially Analysis:** Pixel location and distribution



Set of images | Hypercube | 1 pixel's spectrum

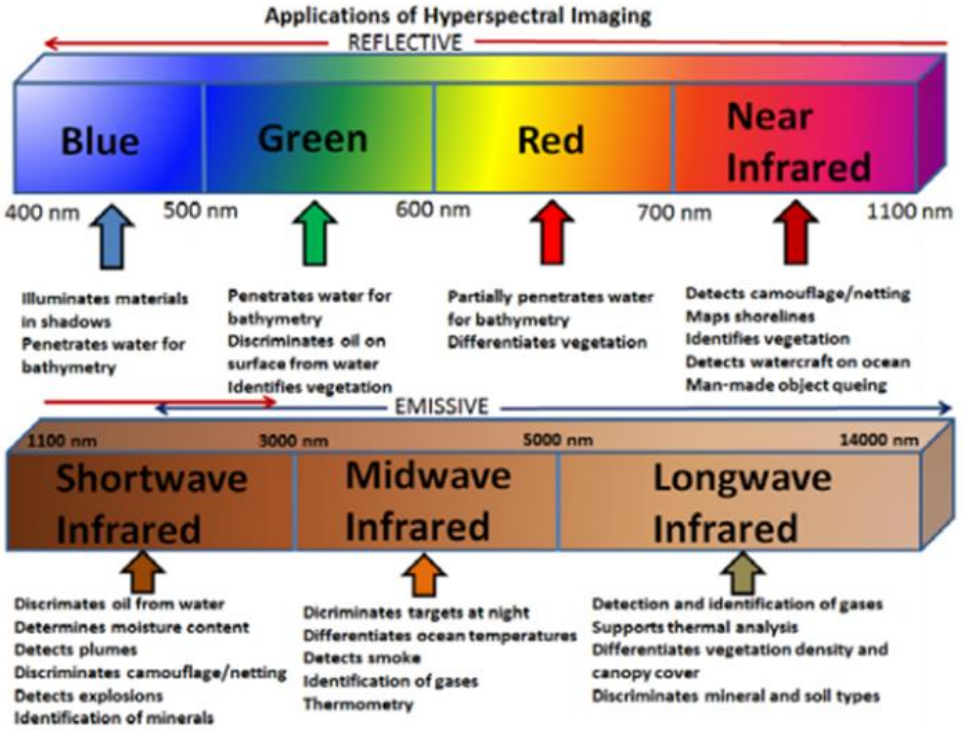
Sorting technologies: Hyperspectral

Advantages of HSI

Regarding:

- *Conventional spectroscopy*: HSI not only allows **identifying** the presence of determined **compounds**, but **also locating them in the images.**

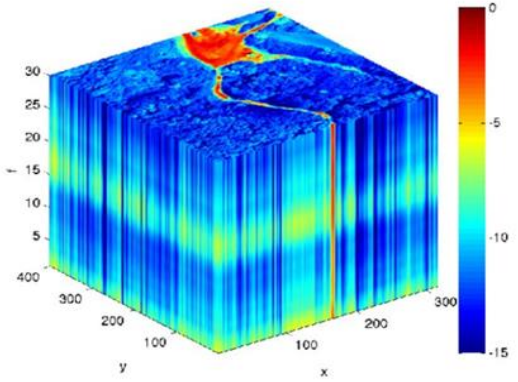
- *Conventional RGB cameras*: analyses a **wide range of wavelength** so it reveals features that in RGB are invisible, as it only analyses three wavelengths.



Sorting technologies: Hyperspectral

HSI's value

- **Non-invasive** tecnhique
- **2D spatial & spectral information** of the compounds present in the scene where the images are taken.
- Images can range from MICRO- to MACRO- scales, allowing remote scenes' **characterization**:
  - → **Quantification:** determines abundance of materials
  - → **Discrimination:** between determined materials/compunds/particles/molecules
  - → **Classification:** separates materials into spectrally similar groups
  - → **Detection:** determines presence of materials, objects, activities of interest
  - → **Measurement:** compound's size

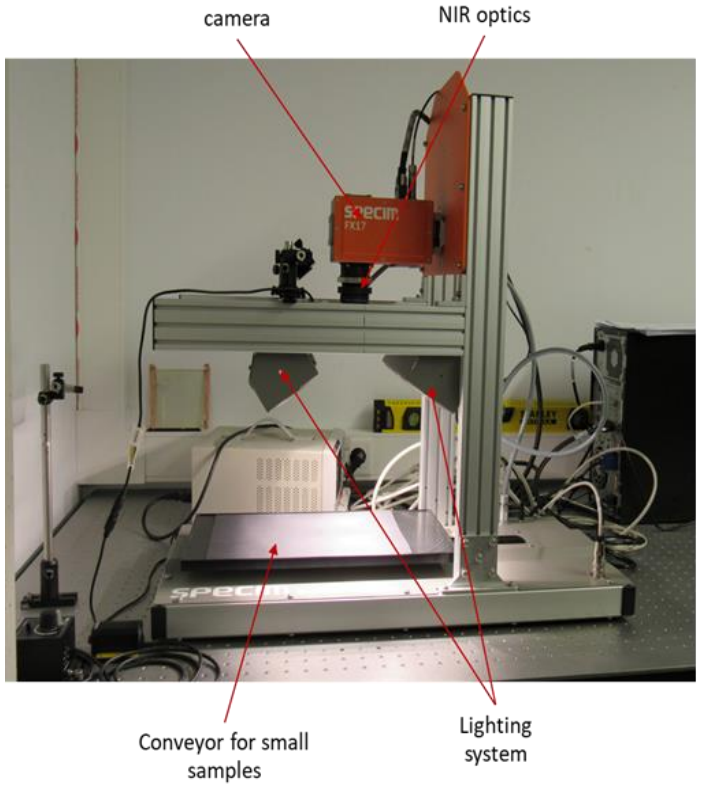


Sorting technologies: Hyperspectral

LEITAT's HSI approach

- **Customized Setups:** Controlled lighting and tailored configurations to **maximize data quality** and **reading efficiency**.
- **Hypespectral camera** captures images in:
  - → **Near-infrarred (NIR):** 900- 1700 nm
  - → Free wavelength selection from **224 bands**
  - → High **spatial resolution** of **640 pixels**
- Image analysis:
  - → **Custom algorithms** for accurate **compound identification**
  - → **Predictive models** to support informed decision-making

NIR hyperspectral camera



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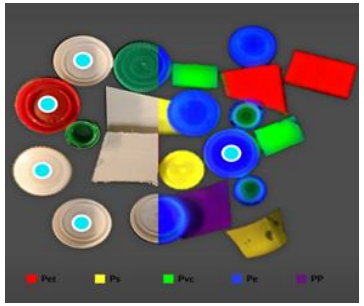
Sorting technologies: Hyperspectral

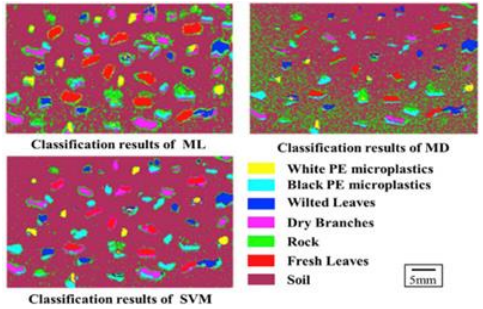
HSI applications

Recycling



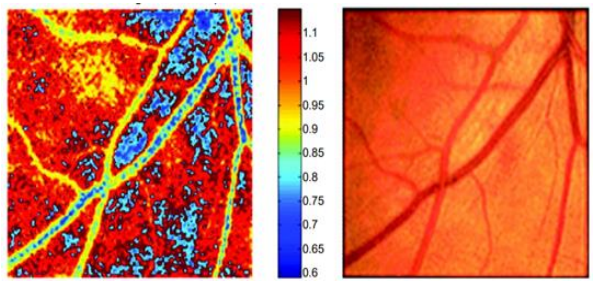
Identification and classification of plastic types for efficient sorting and recycling

Microplastics - polution



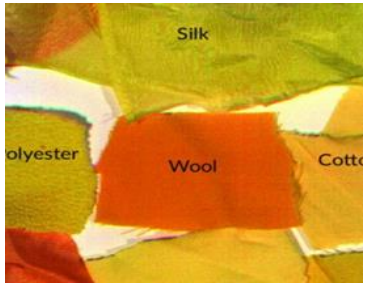
Detection and classification of microplastics based on spectral characteristics

Biomedical applications



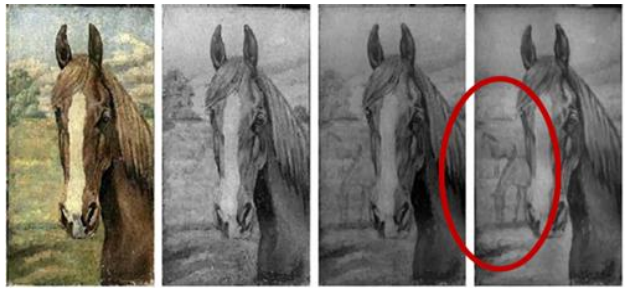
Visualization of spatial oxygen saturation to assess retinal health and vascular function

Textil industry



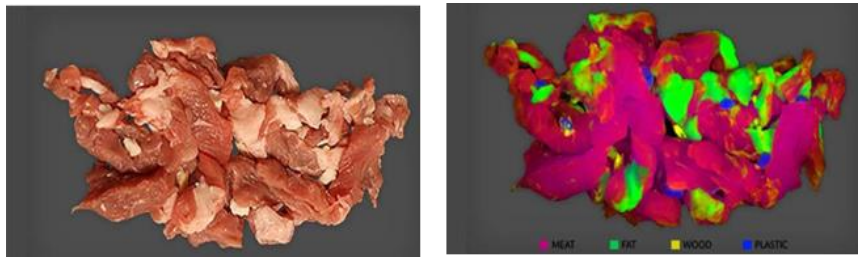
Detection of material types, contaminants, or defects in textile products

Authentification domains



Revealing underdrawings and hidden layers in artworks

Food quality control



Detection of meat composition and foreign materials

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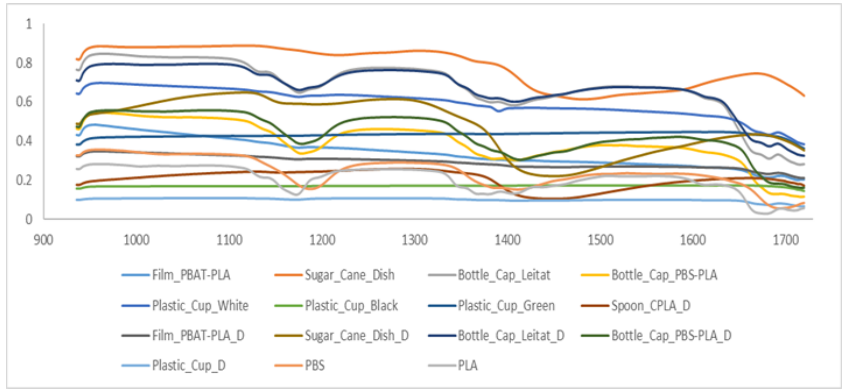
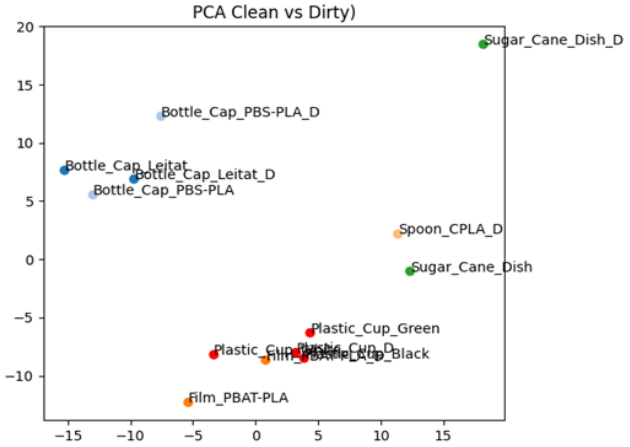
Sorting technologies: Hyperspectral

Definition and characterization of biobased plastic packaging

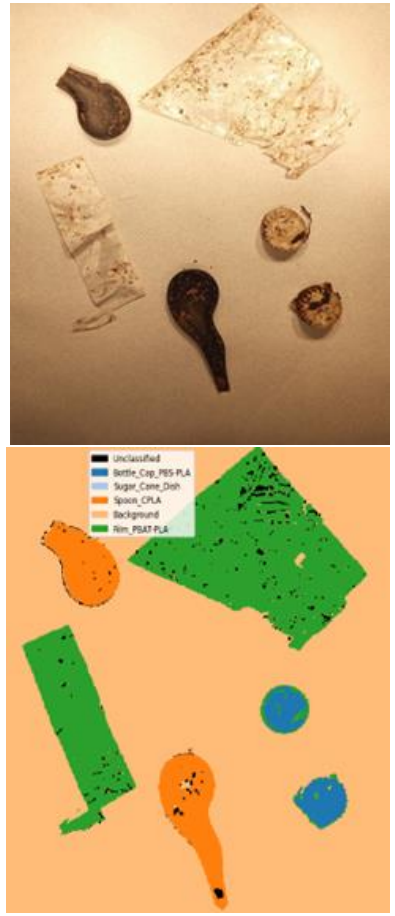
- Samples received and measured with HSI camera
- **PCA (clean VS dirty samples)** to check the contamination impact on the spectrum
- **PoC** on **PLA** and **PBS classification**



Spectra reflectance of packaging samples



PCA analysis of bioplastic packaging. Suffix "_D" in sample tag indicate that the sample is contaminated (dirty)



RGB image of the contaminated samples (top) classified contaminated samples from their NIR reflectance (bottom)

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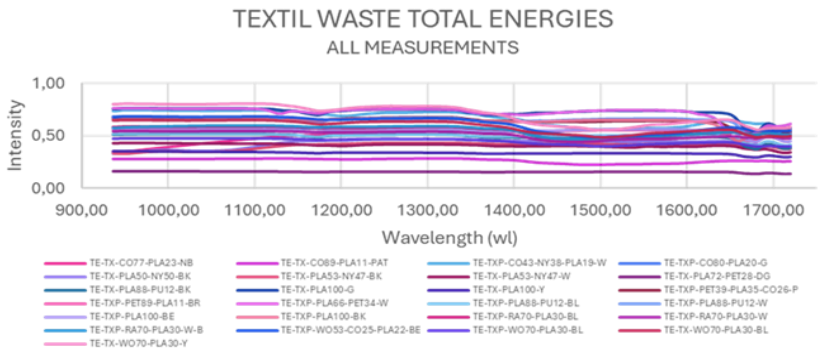
Sorting technologies: Hyperspectral

Definition and characterization of biobased textile samples

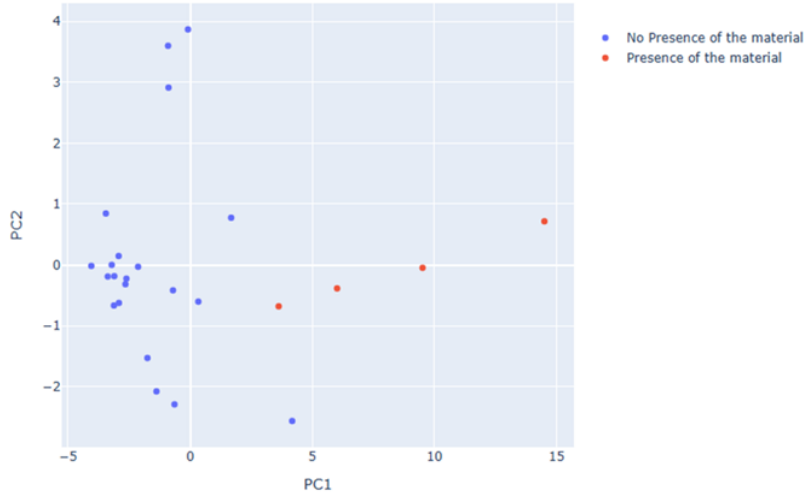
- Samples received and measured with HSI camera

Wool detection analysis example:

- **PCA:** wool VS non-wool textile samples
- **Binary model:** Detects if the garnement has or not Wool
- **PoC classification** by materials



Spectra reflectance of textile samples



PCA analysis with the NIR reflectance at the wavelengths selected

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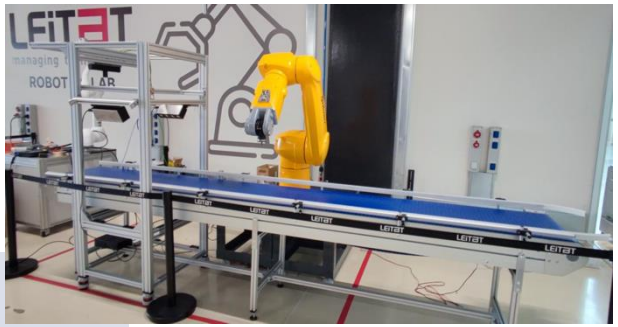
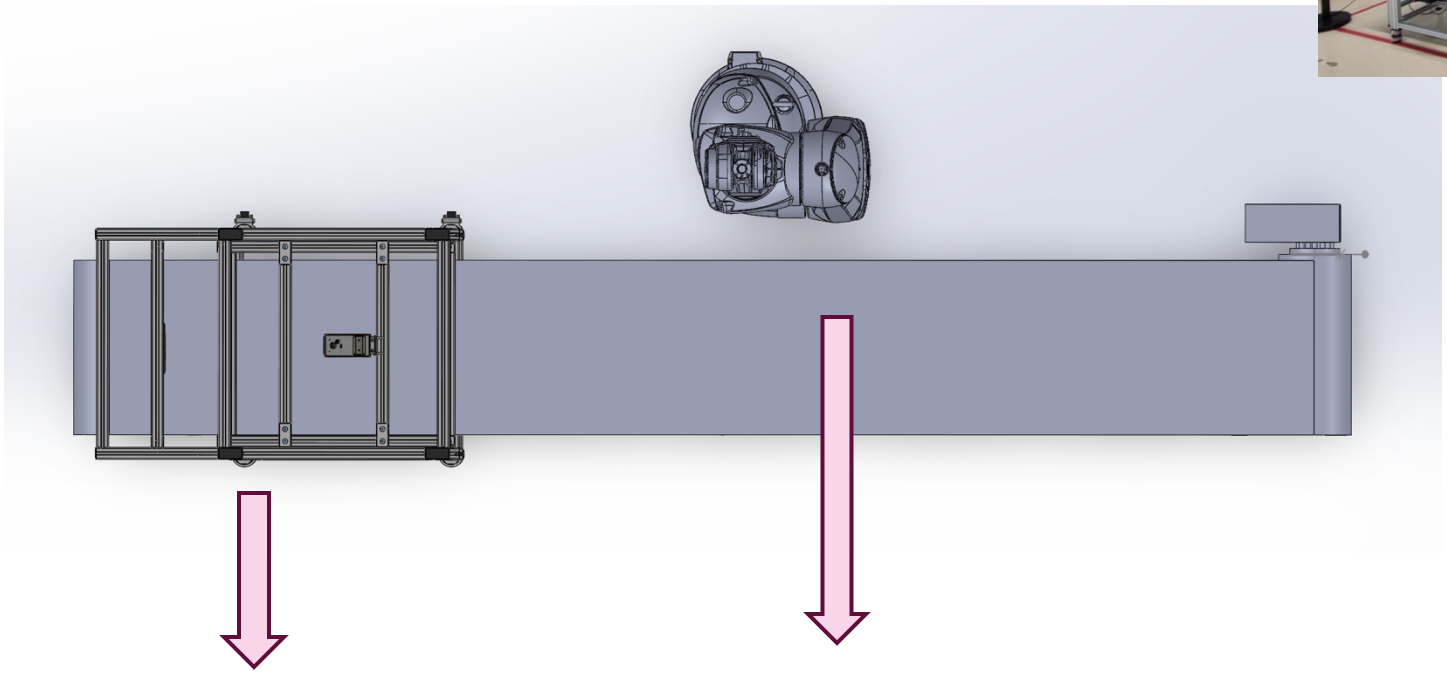
Sorting technologies: Robotics

Pilot sorting line





- Hyperspectral camera
- 3D camera

- Automatic picking algorithm

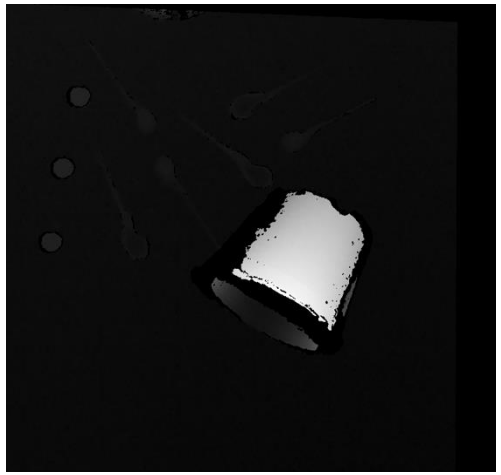
Characteristics:

- 3D camera to detect and segmentate objects
- Hyperspectral camera to perform chemical analysis of samples
- Tracking system to be able to pick objects while moving on the conveyor
- Study and testing of robotic grippers will be performed according to the characteristics of the waste stream. For example vacuum, parallel grippers or needle grippers for picking textile parts.

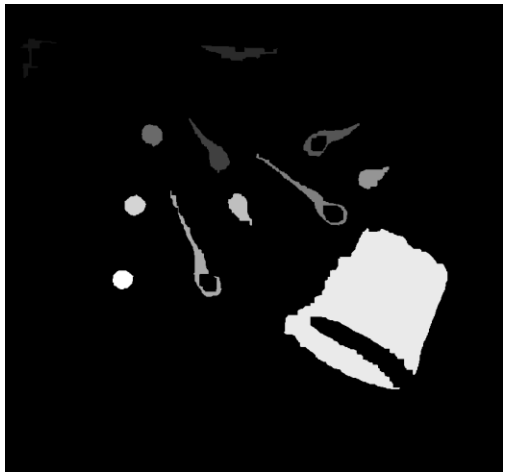
Sorting technologies: Robotics

Vision algorithm

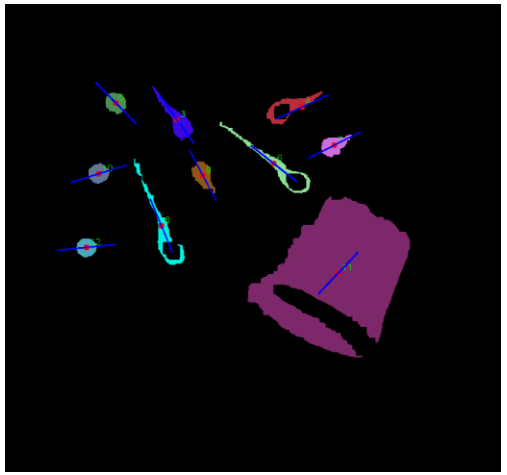
Segmentation pipeline process:



Depth map



Segmentation



Identification, labelling and removal of edge touching objects

Next steps:

- Compute picking pose
- Calibrate 3D camera with HIS

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