Non-ferrous scrap metals classification by hyperspectral and multi-energy X-ray transmission imaging

PICKIT Project

Braibant, L. ; Barnabé, P. ; Leroy, S. ; Dislaire, G. ; Pirard, E.

Speaker – Lorraine Braibant

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Reverse Metallurgy

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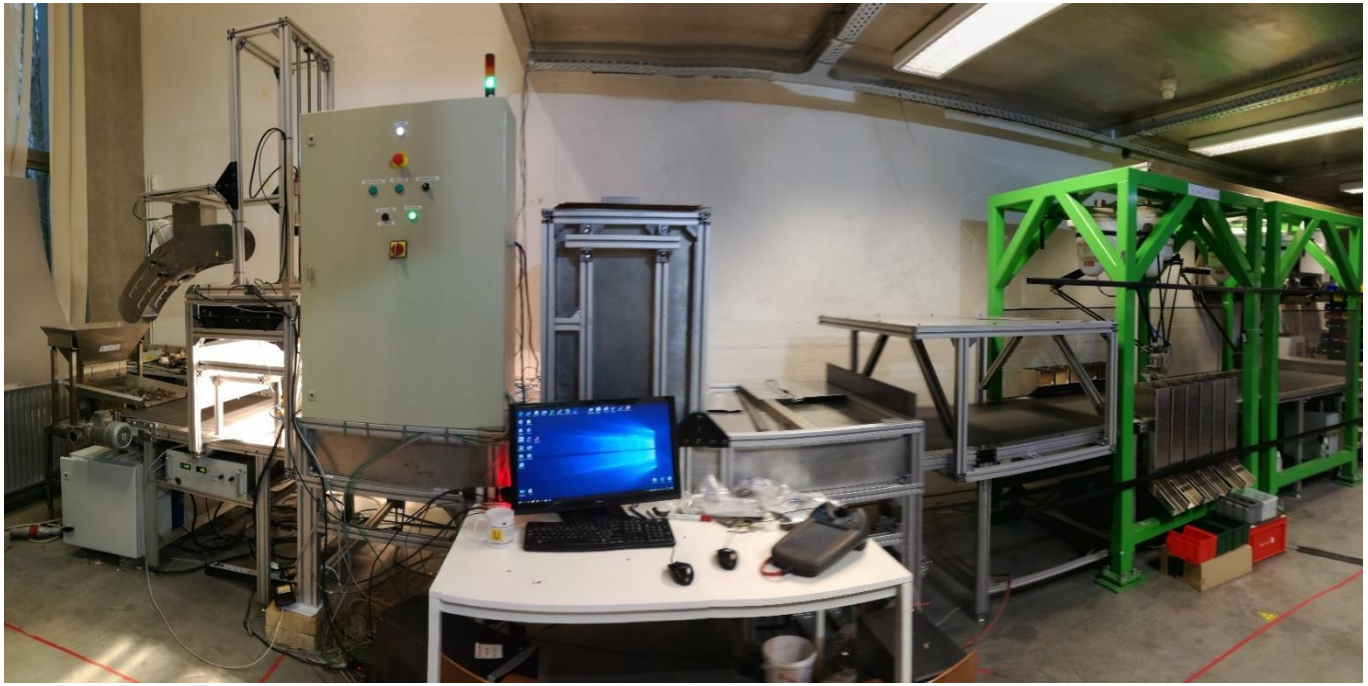
Non-ferrous scrap metals : input stream

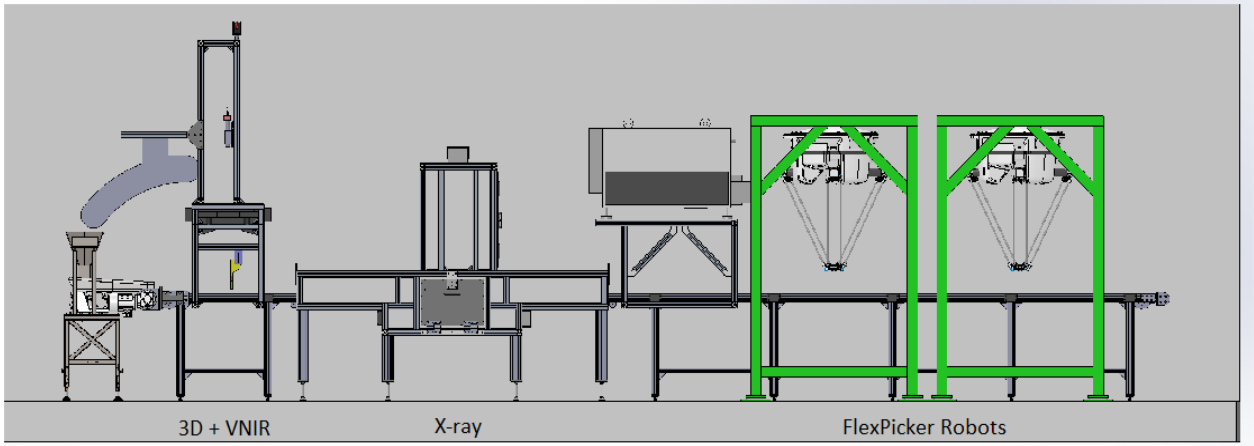
Nickeled Brass	Aluminum	Zinc	Brass	Copper
24 pieces	58 pieces	49 pieces	53 pieces	50 pieces

PICKIT : multi-sensor approach

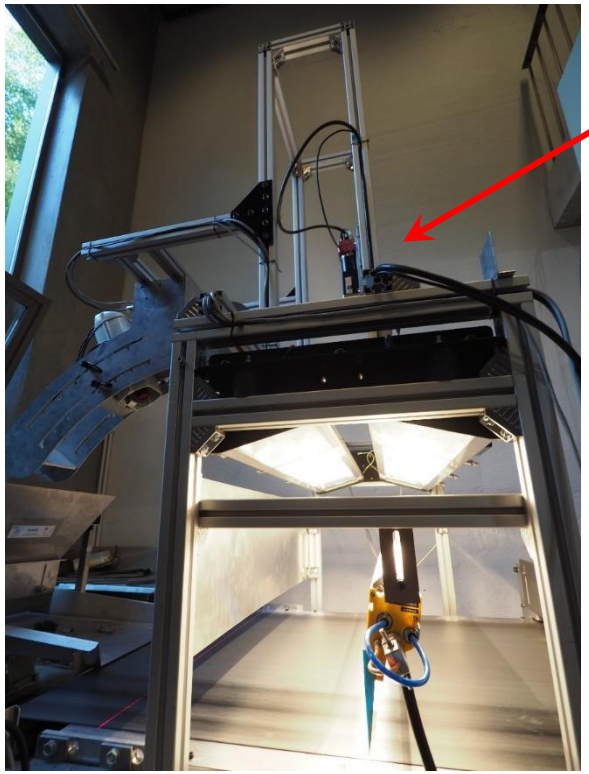


Reverse Metallurgy

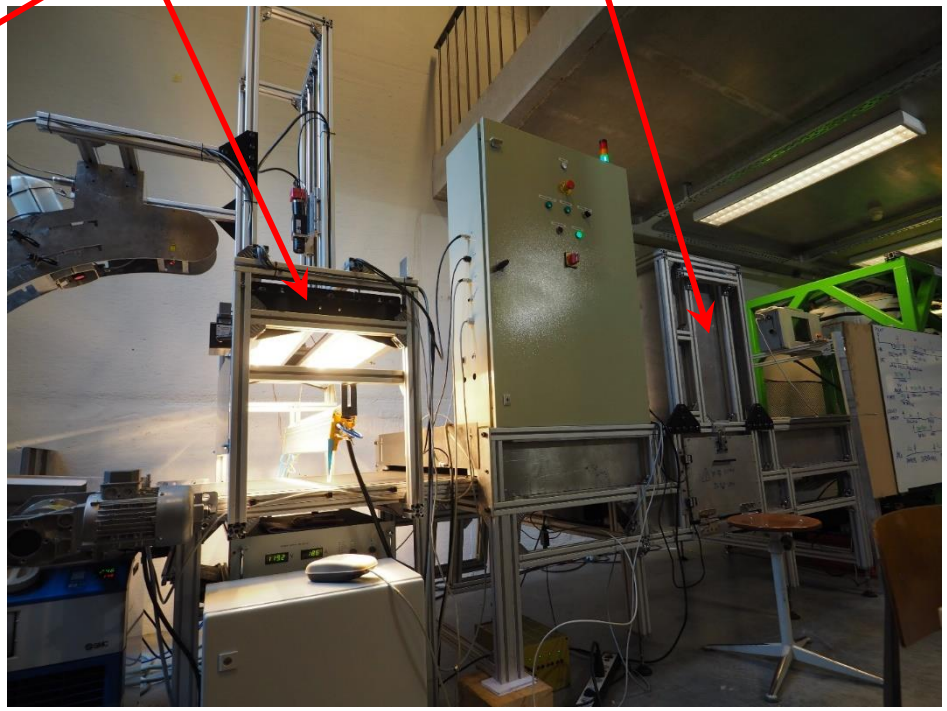
Wallonie



PICKIT : multi-sensor approach



3D + VNIR sensors + X-ray multi-energy sensor



Classification using perClass toolbox

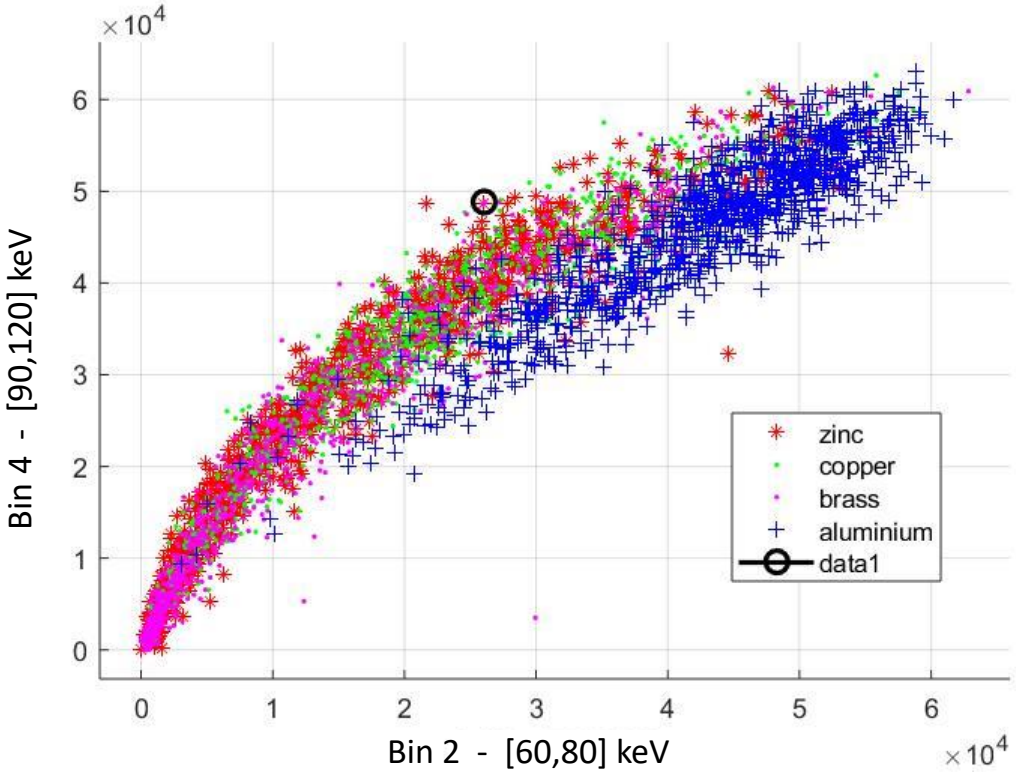
Classification based only on visible-NIR spectra in a limited sample of 234 pieces of zinc (20.9%), copper (21.4%), aluminum (24.8%), brass (22.6%), and nickeled brass (10.2%) alloys

		VNIR decisions, pixel level				
		Aluminum	Copper	Zinc	Brass	Brass Ni
True labels	Aluminum	74%	1%	15%	5%	6%
	Copper	3%	82%	0%	12%	2%
	Zinc	6%	0%	89%	1%	4%
	Brass	8%	21%	2%	61%	7%
	Brass Ni	20%	4%	15%	9%	52%

		VNIR decisions, object level				
		Aluminum	Copper	Zinc	Brass	Brass Ni
True labels	Aluminum	91%	0%	4%	0%	4%
	Copper	0%	100%	0%	0%	0%
	Zinc	3%	0%	97%	0%	0%
	Brass	5%	5%	0%	85%	5%
	Brass Ni	8%	0%	8%	17%	67%

Classification using perClass toolbox

X-ray transmission (XRT) measurements in 5 energy bins in the [40,160] keV range



- Virtually impossible to discriminate zinc, copper, brass based on XRT
- Problematic overlap between the XRT measurements of aluminum alloys and zinc/copper/brass alloys despite their different atomic number (Z)

		Decisions XRT	
		Heavy	Light
True labels	Heavy	95%	5%
	Light	8%	92%

Classification using perClass toolbox

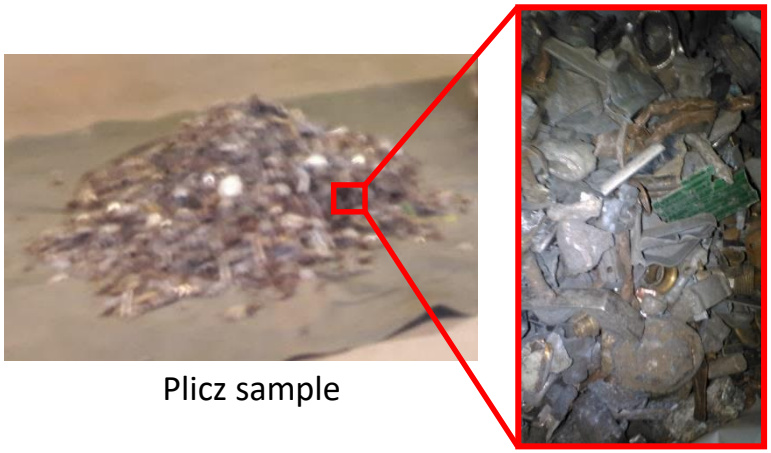
Cascade classification : (i) separation between low-Z aluminum alloys and higher-Z alloys based on XRT, (ii) classification of high-Z zinc, copper, and brass alloys based on visible-NIR spectra.

		Cascade decisions, pixel level				
		Aluminum	Copper	Zinc	Brass	Brass Ni
True labels	Aluminum	96%	0%	2%	1%	2%
	Copper	8%	79%	1%	12%	1%
	Zinc	8%	0%	88%	2%	1%
	Brass	9%	24%	4%	64%	3%
	Brass Ni	4%	3%	17%	13%	62%

		Cascade decisions, object level				
		Aluminum	Copper	Zinc	Brass	Brass Ni
True labels	Aluminum	100%	0%	0%	0%	0%
	Copper	3%	97%	0%	0%	0%
	Zinc	0%	0%	100%	0%	0%
	Brass	2%	5%	2%	90%	0%
	Brass Ni	0%	0%	8%	25%	67%

Challenges & perspectives

- Multi-class sorting in a larger and more complex sample representative of the non-ferrous metal fraction of shredder output



Plicz sample

Alloys	Fragments	Mass (kg)
Grey zinc	414 (24.2%)	7.82 (26%)
Dark zinc	46 (2.7%)	1.36 (4.5%)
Iridescent zinc	55 (3.2%)	1.04 (3.4%)
Cast aluminum	227 (13,2%)	2.72 (9.1%)
Wrought aluminum	79 (4.6%)	0.44 (1.5%)
Copper	165 (9.6%)	1.2 (4%)
Brass	216 (12.6%)	5.30 (17.7%)
Nickeled brass	186 (10.9%)	3.01 (10%)
Stainless Steel	3 (0.2%)	0.12 (0.4%)
Heavies (Pb, Sn, Ag)	13 (0.8%)	0.765 (2.5%)
Magnesium	2 (0.1%)	0.025 (0.1%)
Waste + PCB	17 (1%)	0.282 (0.9%)
Coated	109 (6.4%)	1.32 (4.4%)
Alloy mixture	157 (9.2%)	4.27 (14.2%)
Soldered copper	25 (1.5%)	0.34 (1.1%)

Total = 30 kg

Challenges & perspectives

- Multi-class sorting in a larger and more complex sample representative of the non-ferrous metal fraction of shredder output

- Optimize classification to produce purified streams for classes of interest

Challenges & perspectives

- Multi-class sorting in a larger and more complex sample representative of the non-ferrous metal fraction of shredder output
- Optimize classification to produce purified streams for classes of interest
- Detect imperfectly shredded scraps, composed of several alloys

I thank you for your attention.

Any questions?

We acknowledge the financial support from the Region Wallonne (Belgium) and we thank our industrial partner, Comet Traitements.