Detecting solar panels and skylights on roofs using machine learning

SDS Business Presentation

23.06.2023

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Meteotest

Hail Damage

Schadensbilanz für 2021

Schweiz verzeichnet grösste Unwetterschäden seit 2007

Rekord: Sommer-Unwetter richten im Kanton Luzern Schäden von 400 Millionen Franken an

2 Milliarden Franken wegen Sturm und Hagel: 2021 wird für die Schweiz eines der teuersten Schadenjahre aller Zeiten

Kanton Di 29.06.2021 - 14:30

Hagel sorgt für grösste Gebäudeschäden seit 15 Jahren

Photo: W. Schmid

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Hail Damage on Buildings

Elementar: Übersicht 2002 - 2021 – Elementarschäden an Gebäuden

|	Elementar Total		Sturm		Hagel		Überschwemmung		Erdrutsch Steinschlag		Lawinen Schneedruck	
	Schadensumme in Mio. CHF	Anzahl Schäden	Schadensumme in Mio. CHF	Anzahl Schäden	Schadensumme in Mio. CHF	Anzahl Schäden	Schadensumme in Mio. CHF	Anzahl Schäden	Schadensumme in Mio. CHF	Anzahl Schäden	Schadensumme in Mio. CHF	Anzahl Schäden
2002	243.1	52'968	30.4	20'247	129.3	23'359	76.5	8'722	6.0	348	0.9	292
2003	139.3	47'757	57.6	31'331	39.7	10'388	37.0	4'546	1.2	239	3.8	1'253
2004	146.2	50'461	28.4	17'632	94.3	26'266	19.9	5'102	1.2	243	2.4	1'218
2005	880.6	58'930	21.2	10'846	142.9	24'525	695.4	18'405	7.9	405	13.2	4'749
2006	128.9	39'357	19.3	11'742	44.2	13'114	33.8	6'296	3.6	431	28.0	7'774
2007	414.9	51'939	35.4	18'837	81.5	14'701	294.2	17'746	2.7	232	1.0	423
2008	68.0	19'622	21.7	10'678	15.7	3'982	23.6	2'587	0.7	103	6.2	2'272
2009	414.8	83'357	47.5	19'576	318.9	55'368	22.5	2'915	1.4	132	24.5	5'366
2010	76.2	21'981	31.5	13'251	16.1	4'506	25.0	3'020	0.8	140	2.9	1'064
2011	307.2	64'451	70.8	25'933	206.5	35'011	27.9	3'060	0.7	79	1.2	368
2012	157.1	39'200	41.1	16'052	72.6	16'225	20.7	2'163	1.0	154	21.8	4'606
2013	250.9	39'354	30.5	10'309	166.4	23'220	46.2	4'022	2.4	225	5.4	1'578
2014	111.2	23'554	33.8	14'988	9.8	2'746	54.5	4'251	5.1	145	7.9	1'424
2015	130.2	28'894	28.2	14'056	31.0	7'153	62.9	5'070	0.9	129	7.2	2'486
2016	98.7	21'299	19.8	9'877	20.0	5'716	54.6	5'222	3.5	166	0.9	318
2017	217.0	40'935	48.6	18'622	74.9	16'363	90.6	5'463	1.7	108	1.2	379
2018	300.6	91'041	187.1	75'906	27.6	6'267	77.4	7'548	2.5	214	5.9	1'106
2019	116.5	33'446	46.9	22'500	21.8	5'510	29.5	2'186	1.1	117	17.2	3'133
2020	150.9	67'031	115.5	60'773	12.2	3'236	20.8	2'455	0.8	119	1.6	448
2021	1'085.0	115'465	69.8	17'234	779.8	74'988	210.2	18'079	3.7	298	21.5	4'866

Source: Schadenstatistik der VKG

→ Where do those damages occur?

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Hail Damage on Buildings

→ For a successful risk assessment, information on **hail** and **roofs** is needed.

Photo: Energie Netzwerk GmbH

Hail Damage
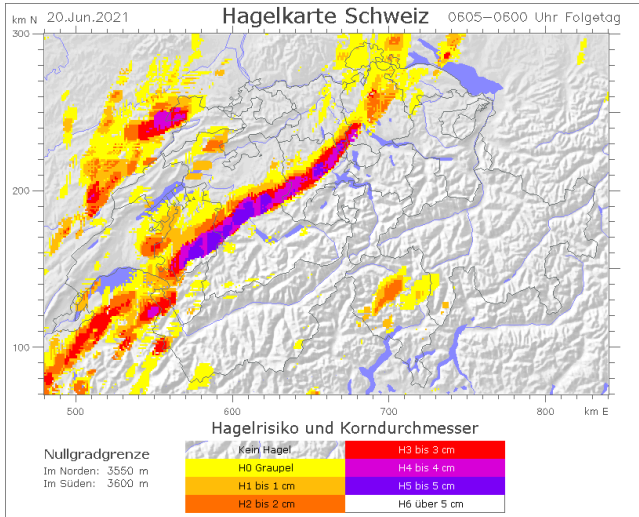
© meteoradar gmbh, Data: MeteoSchweiz

We know where it hails, … but where are the vulnerable roofs?

→ Use machine learning to get information on roofs

Project for the building insurance of the canton Zug

1. Dataset of solar panels

2. Dataset of skylights

Content

– About Meteotest

– Project goals for the *Gebäudeversicherung Zug* (GVZG)

– Data and workflow (for detecting solar panels and skylights)

  – Pre-processing

  – Training data

  – Algorithm training

  – Object detection

– Example of other applications

«Meteo-climate-environment-web Swiss army knife»

Weather Forecasts

Air Quality

Energy & Climate

Measurements

Wind & Ice

Digital Services

Geoinformatics

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About Meteotest

Sonnendach.ch (roof dataset with PV production)
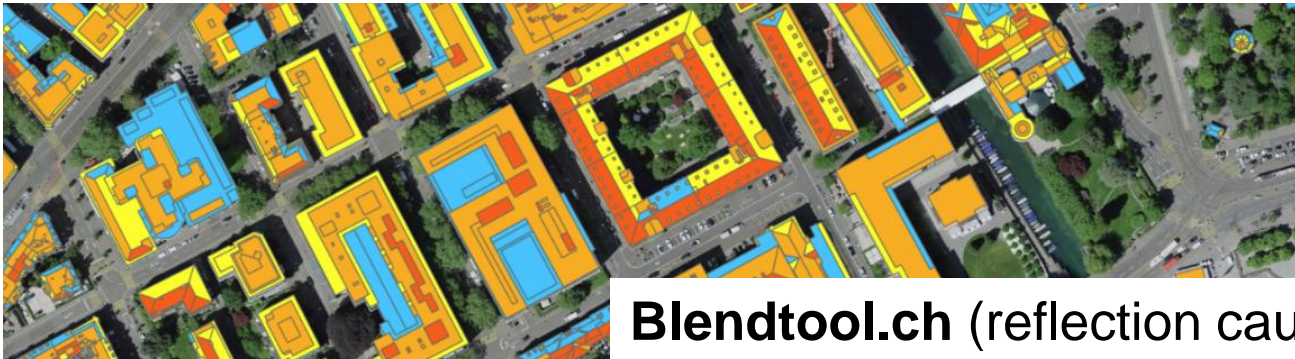
Blendtool.ch (reflection caused by solar panels)

Meteotest and object detection

Detecting roof windows for a client in the construction industry

→ What do you see?

Meteotest and object detection

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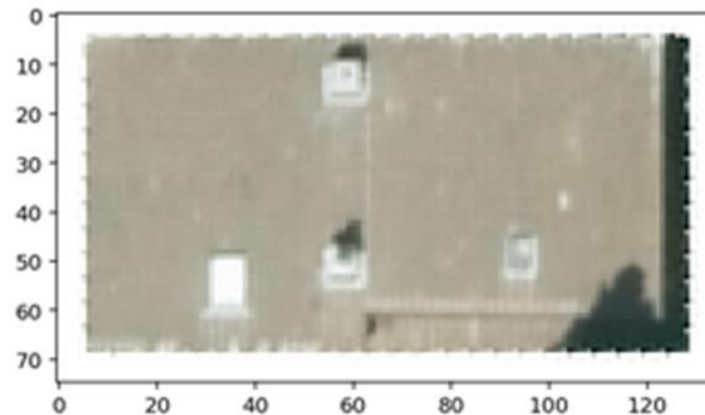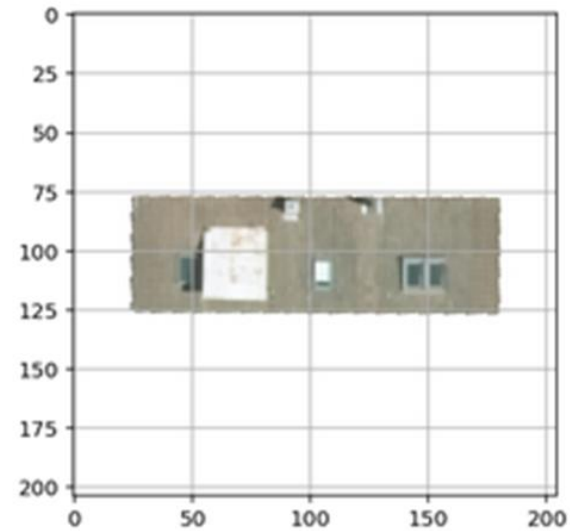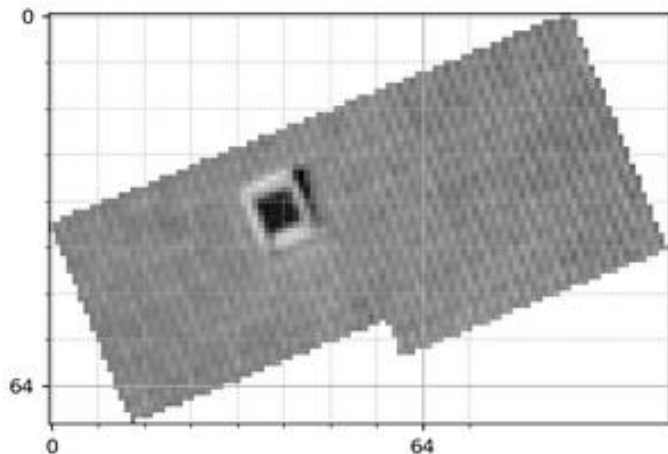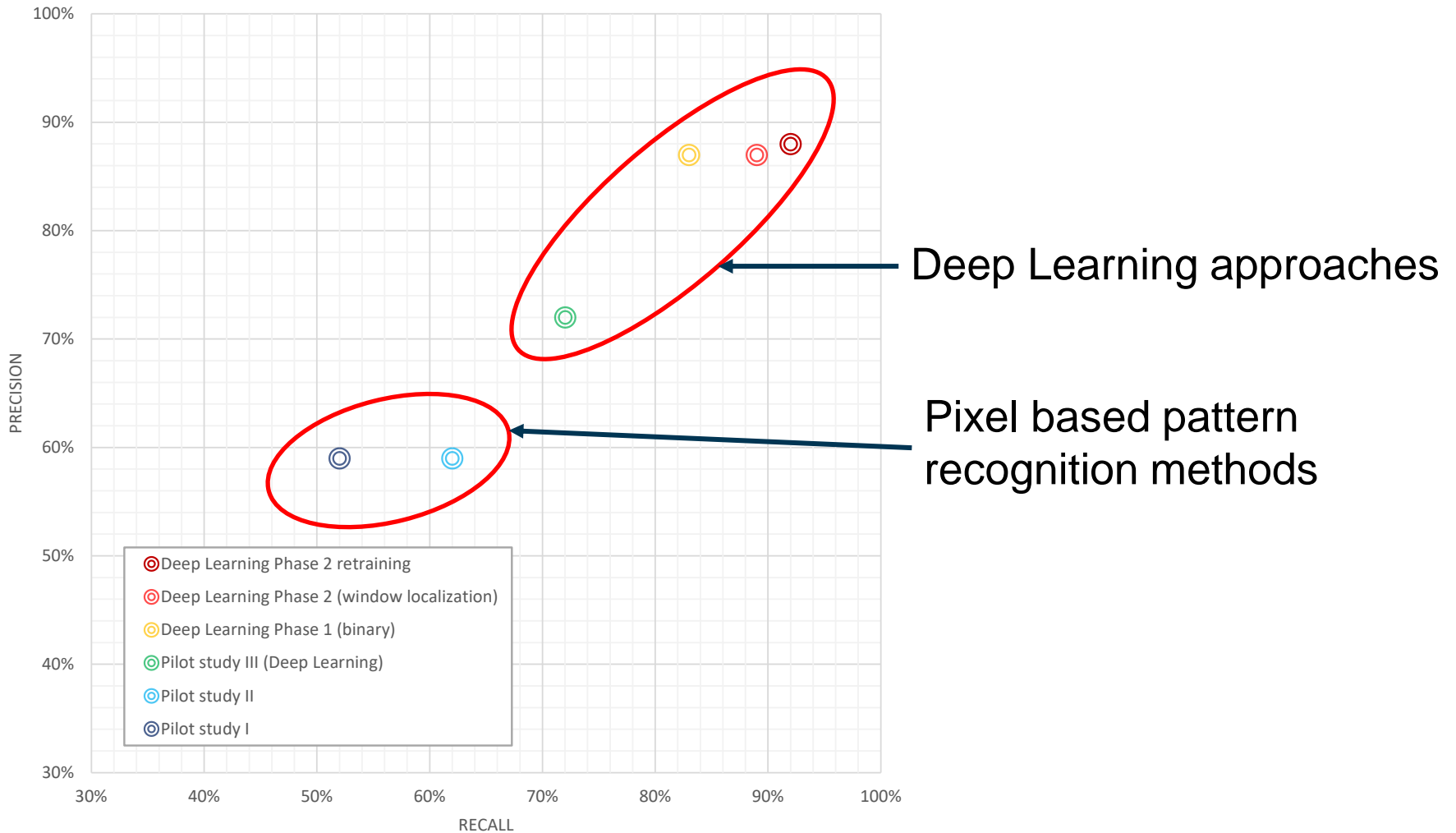
Project Goals

Dataset of solar panels in the canton of Zug
→ Detection of solar panels on roofs with area ≥ 10 m^2

© Christoffer Riemer/AS Solar
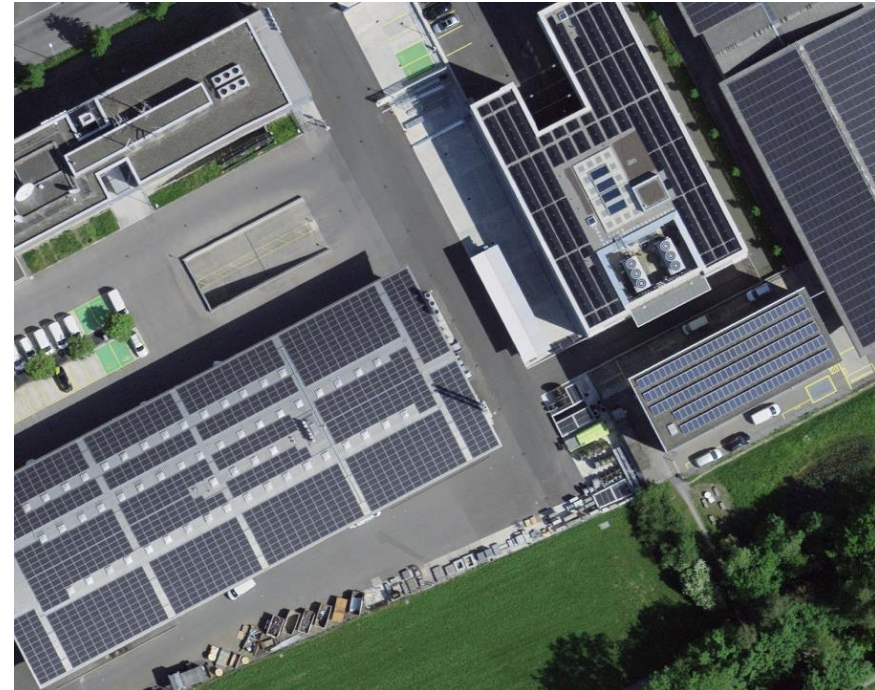
Project Goals

Dataset of skylights in the canton of Zug
→ Detection of skylights on flat roofs (slope ≤ 3°) with area ≥ 10 m^2

Skylights dark

Skylights bright

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Data and Workflow

SWISSIMAGE 10 cm

Manual annotating

swissBUILDINGS3D 2.0

Automatic detection on roofs
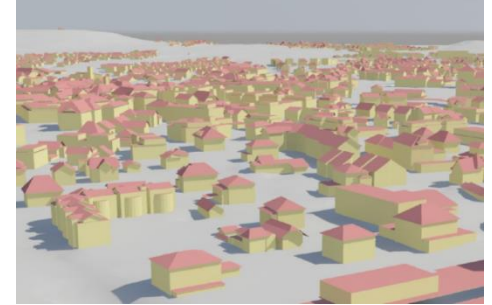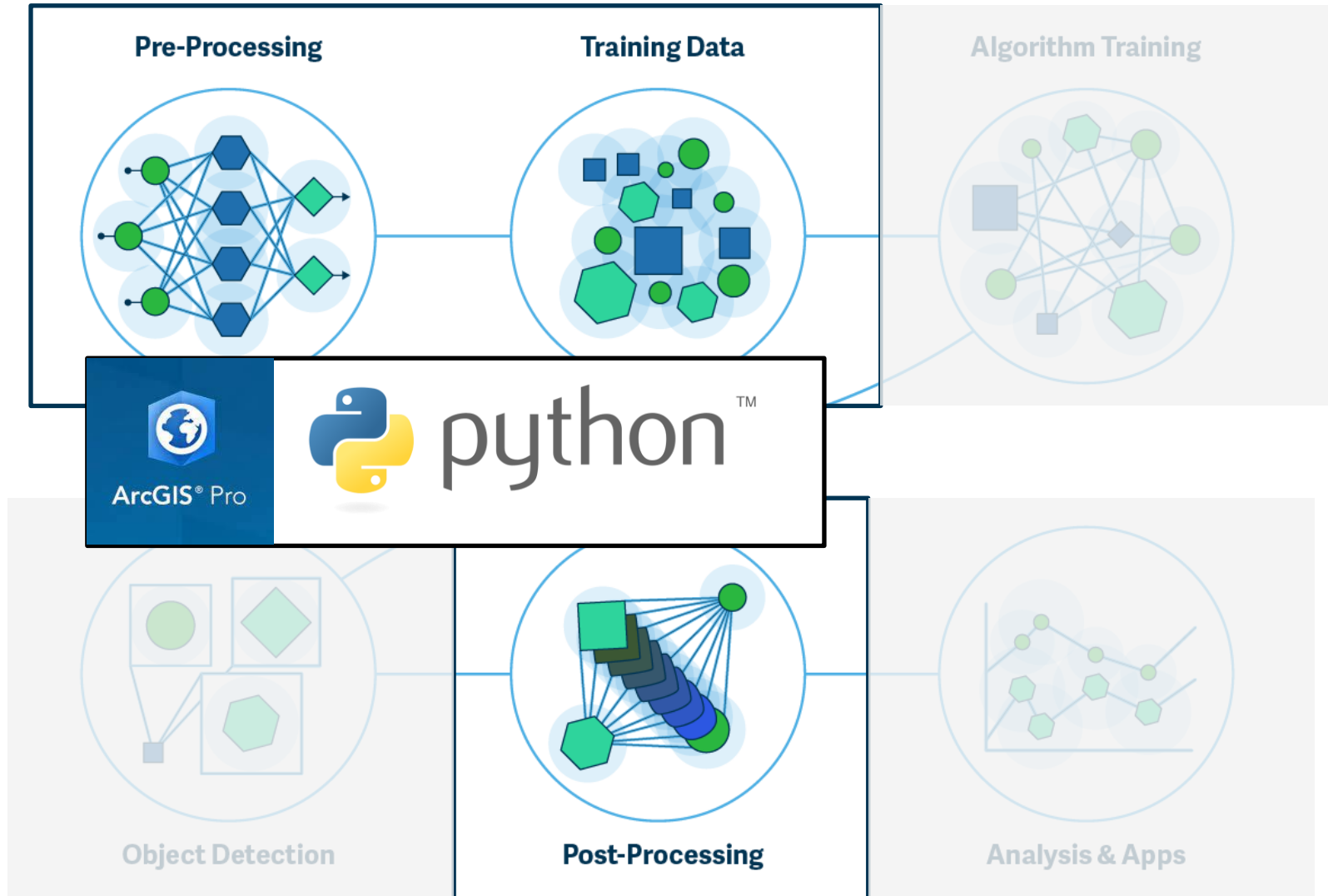
Data and Workflow

Data and Workflow
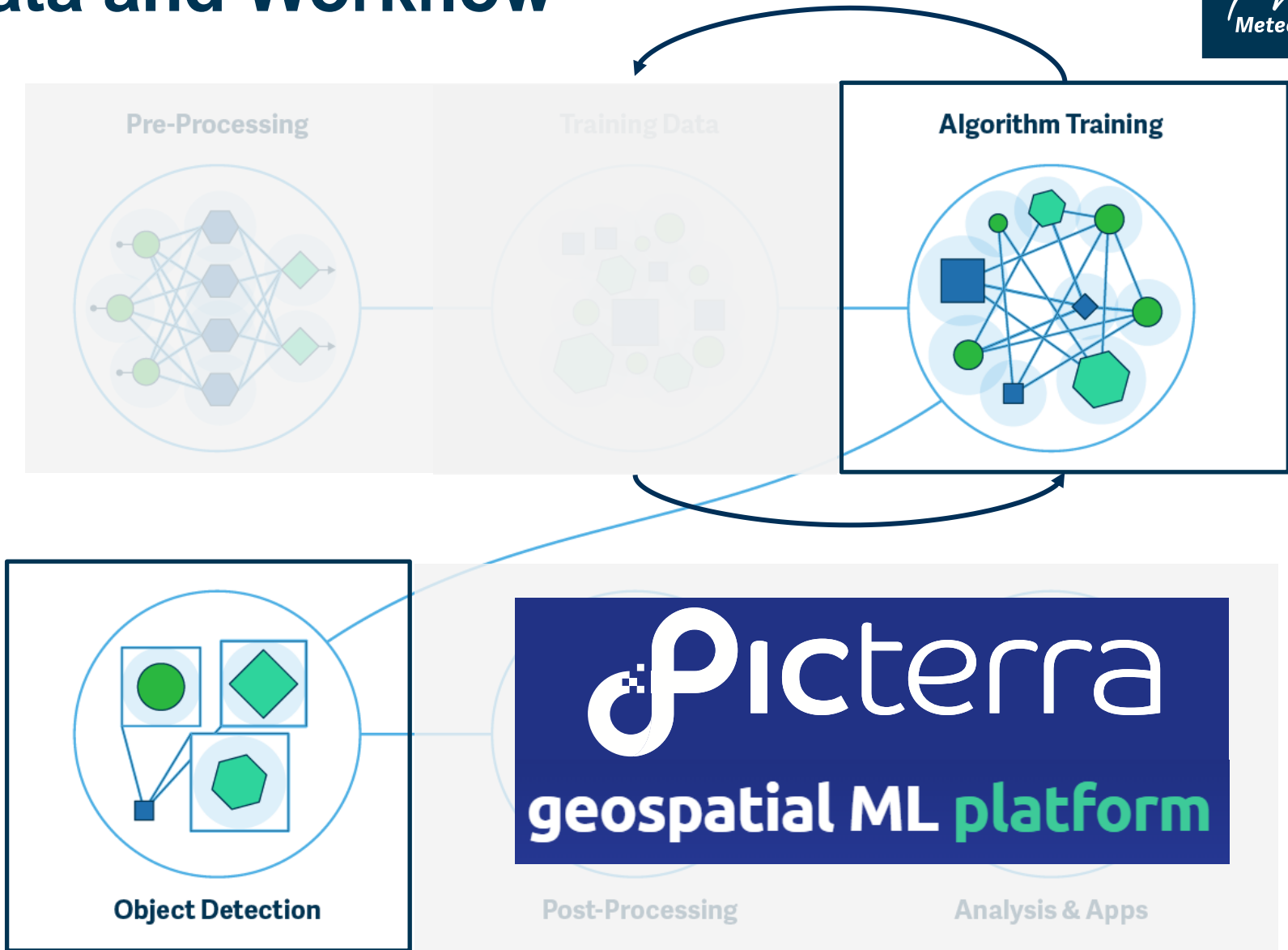
Pre-Processing

- Calculation of roof properties (area, slope)

- Selection of roofs with
  - Area ≥ 10 m^2
  - Slope < 3° (flat roofs for skylights)
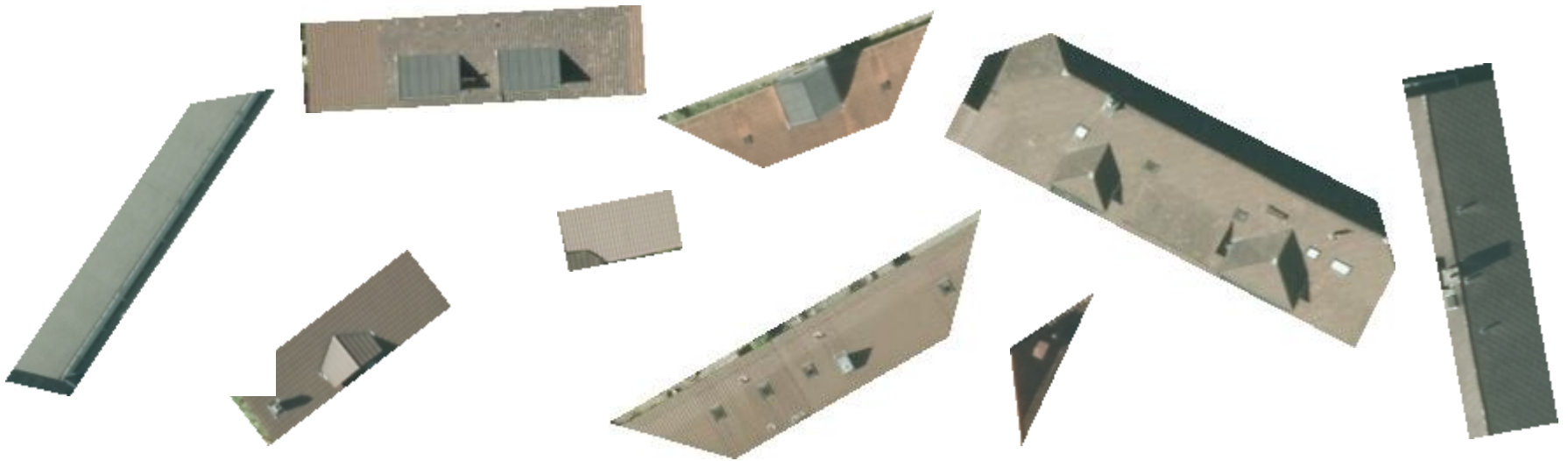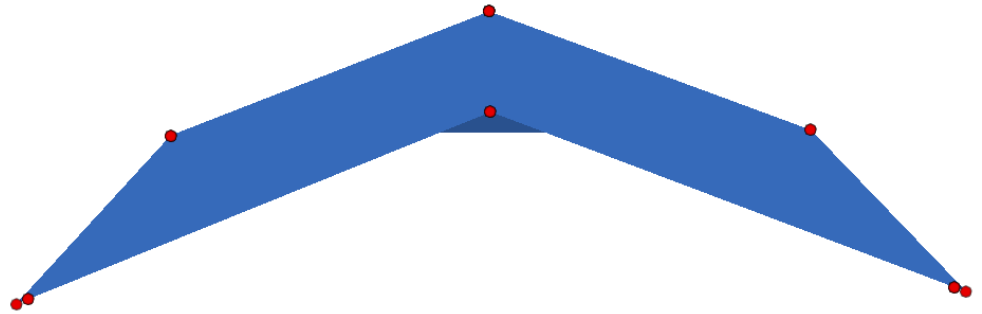
Training Data

Solar panels

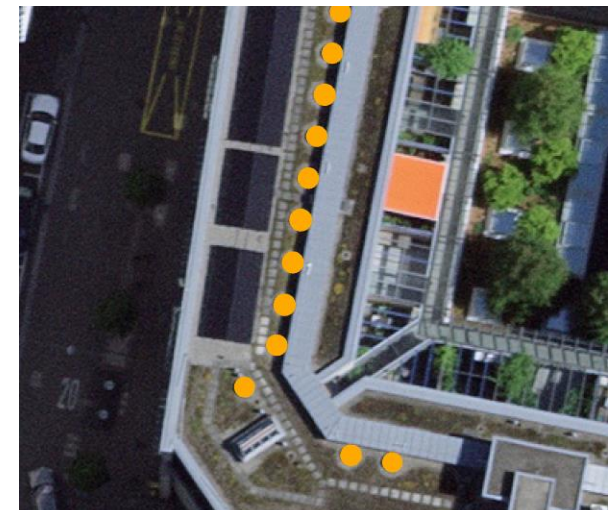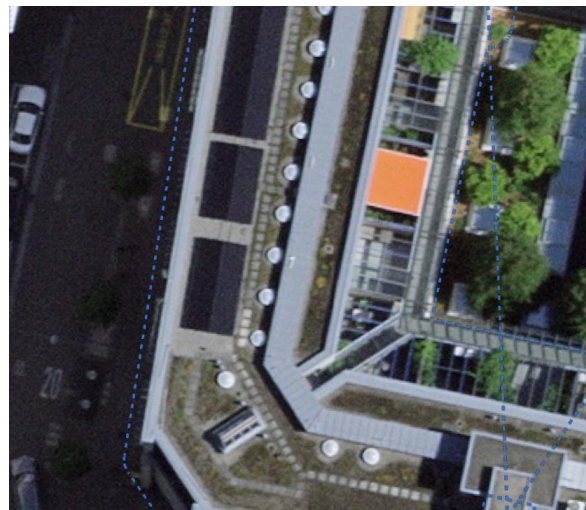- Annotated 1'400 solar panel objects on 450 roof segments
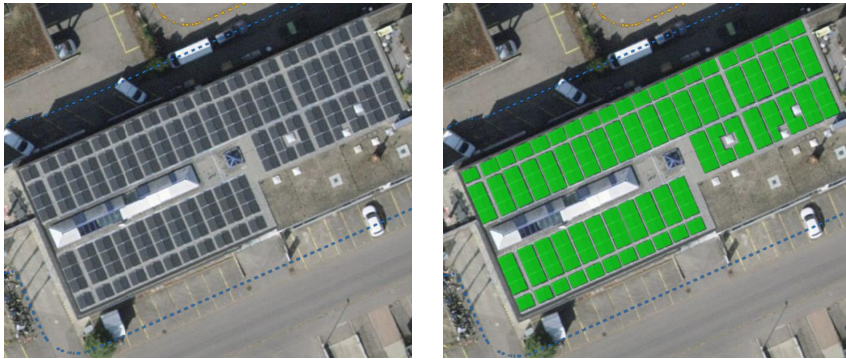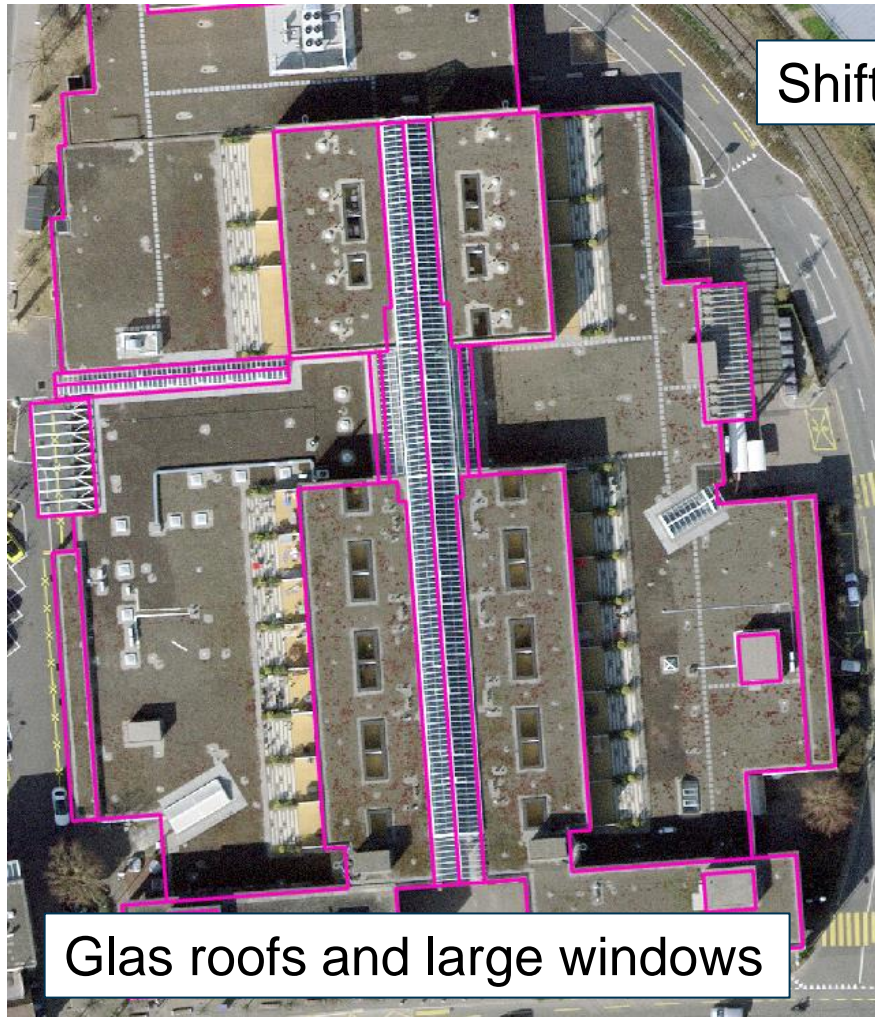

Skylights

- Annotated 2'100 skylights on 600 roof segments

- Seperated into 2 classes

    - Skylights bright (1'300)

    - Skylights dark (700)

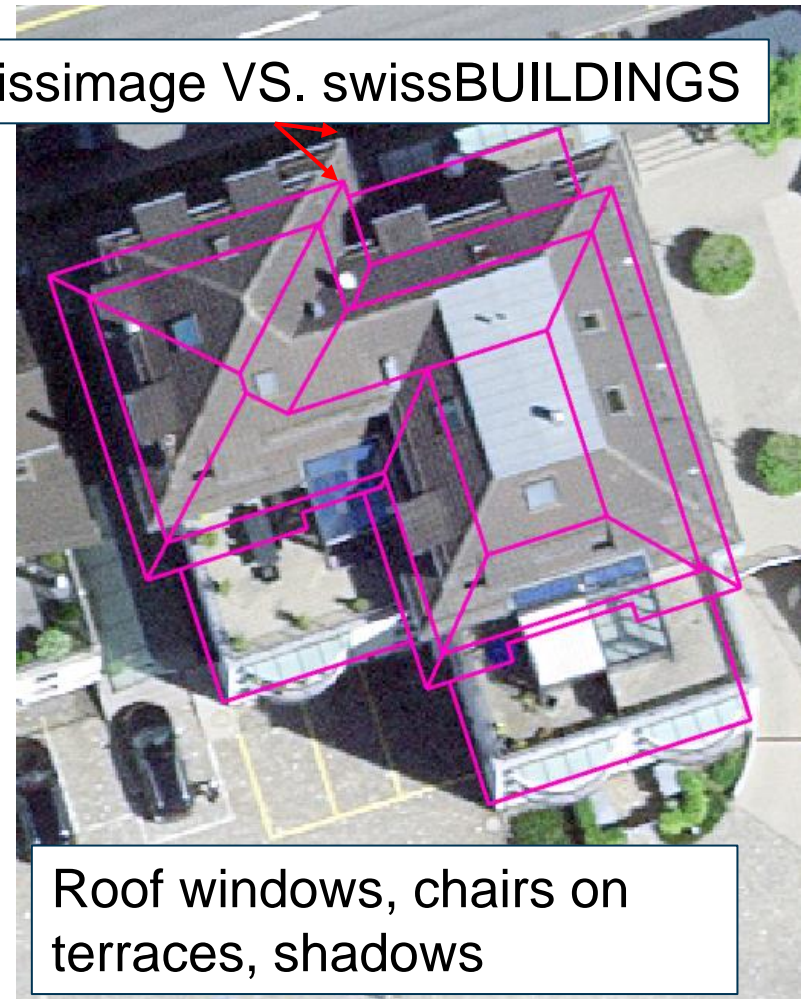Split annotation data into:
a) Training (75%)
b) Validation (25%)

Training Data

Show the algorithm what is NOT a solar panel («negative examples»)

Shift Swissimage VS. swissBUILDINGS

Roof windows, chairs on terraces, shadows

Glas roofs and large windows

Algorithm Training – Example solar panels
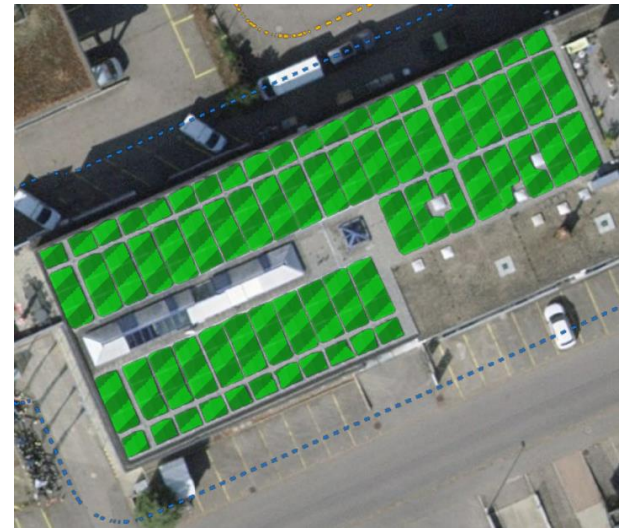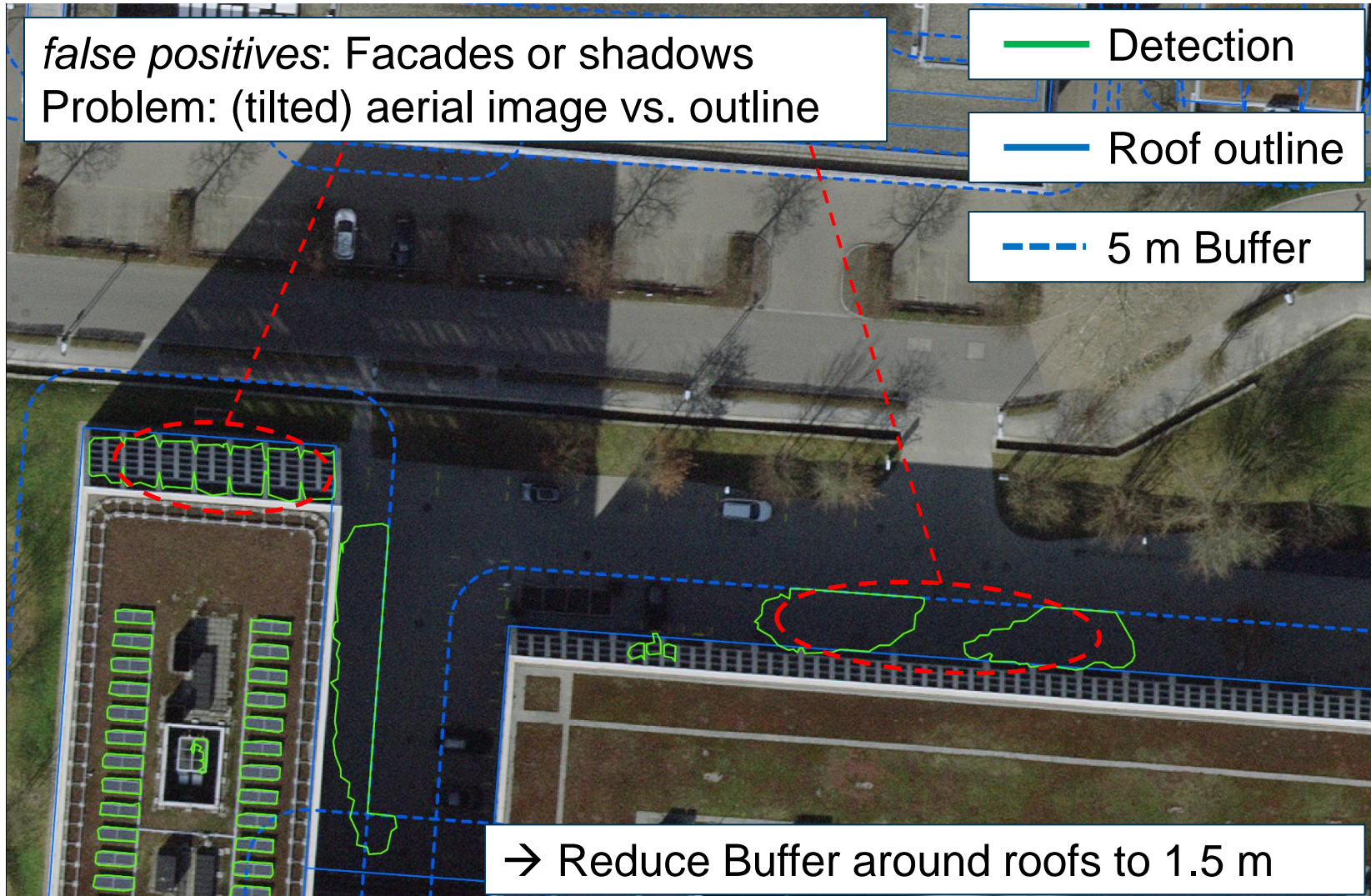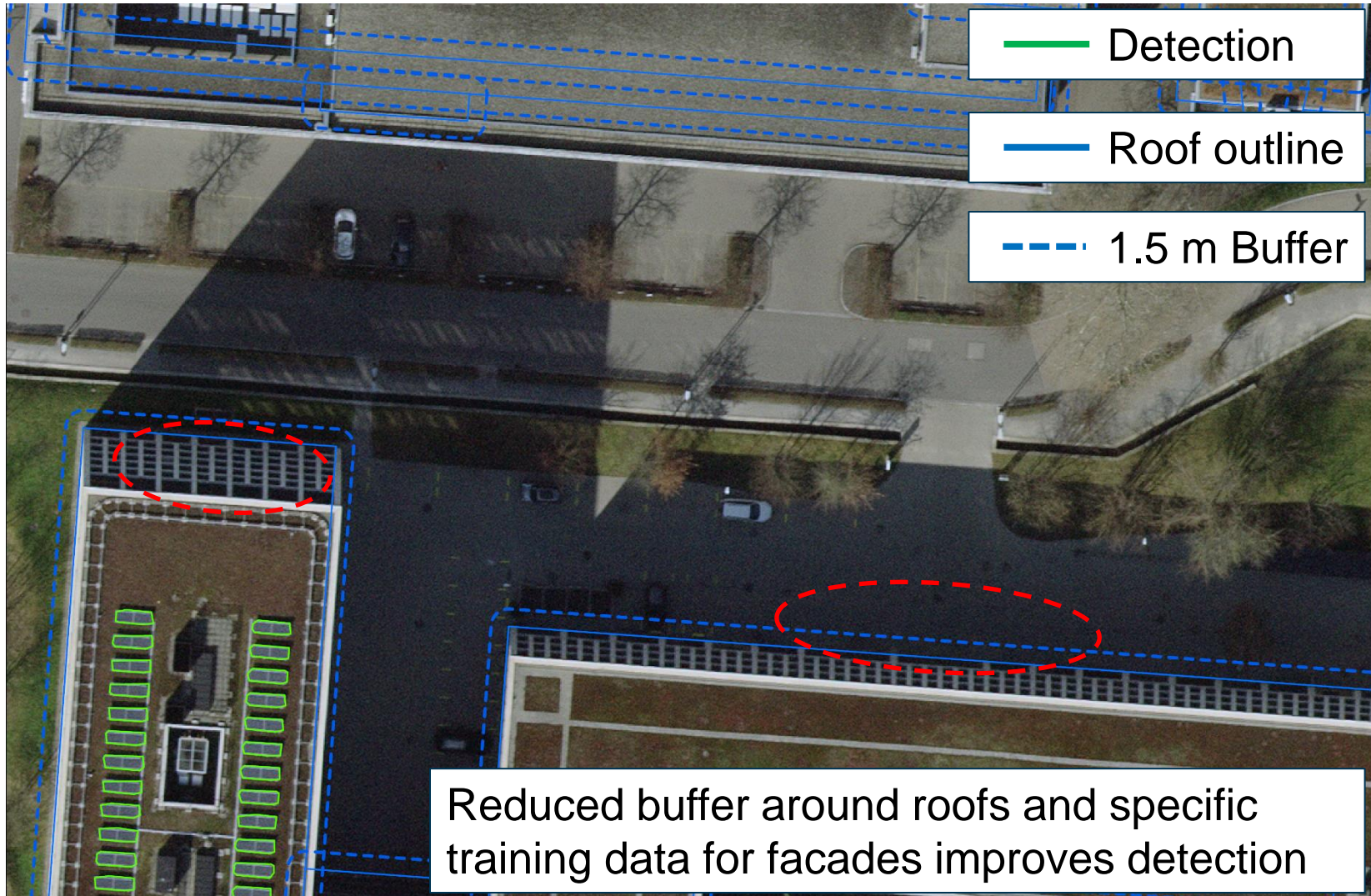
Aerial image

Annotation

Detection

→ Good results early on. Solar panels are recognized and other objects differentiated.

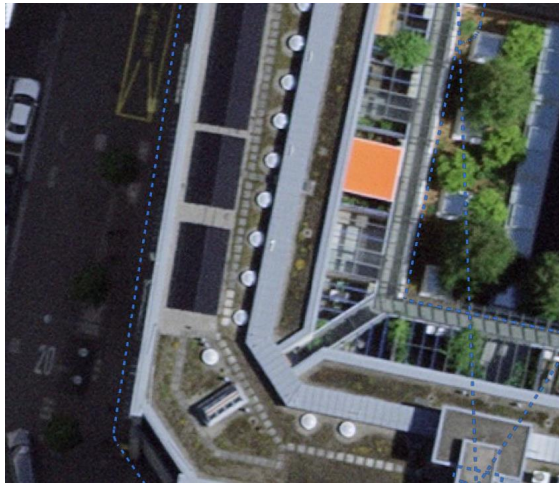23.06.2023

Algorithm Training – Challenges solar panels

false positives: Facades or shadows
Problem: (tilted) aerial image vs. outline

Detection
Roof outline
5 m Buffer

→ Reduce Buffer around roofs to 1.5 m

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Algorithm Training – Challenges solar panels

Legend:
- — Detection
- — Roof outline
- - - - 1.5 m Buffer

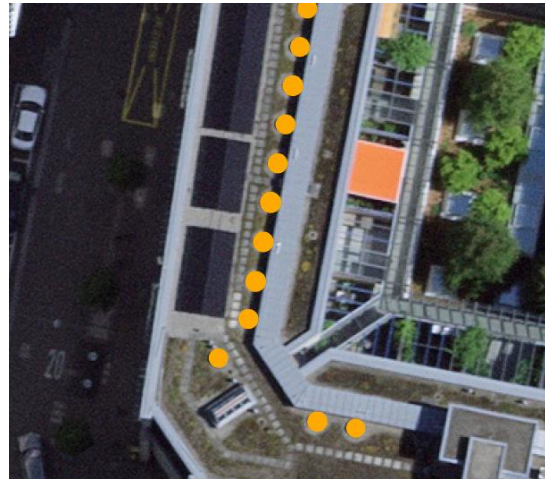Reduced buffer around roofs and specific training data for facades improves detection
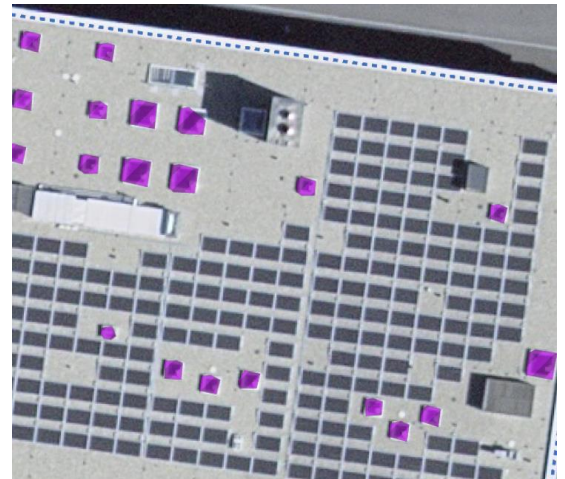
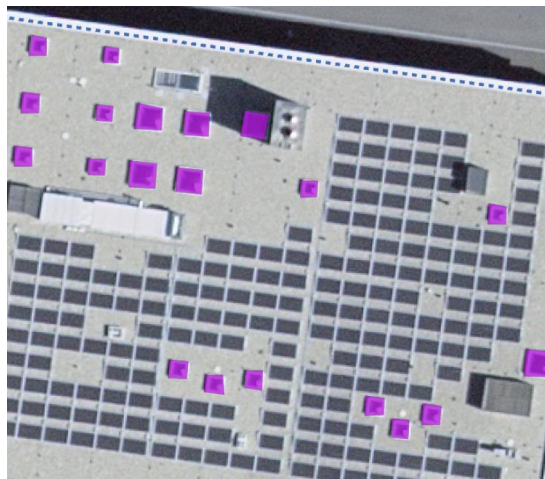23.06.2023

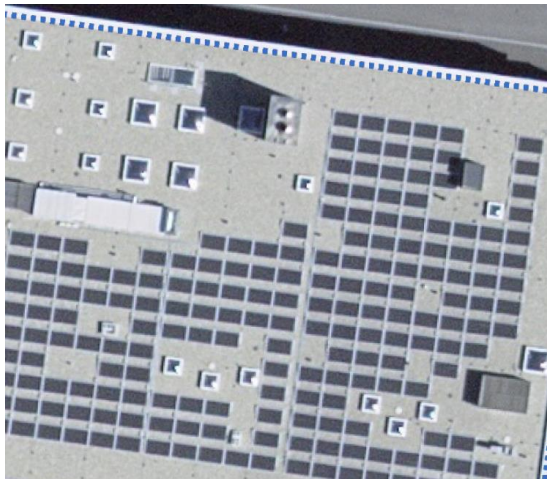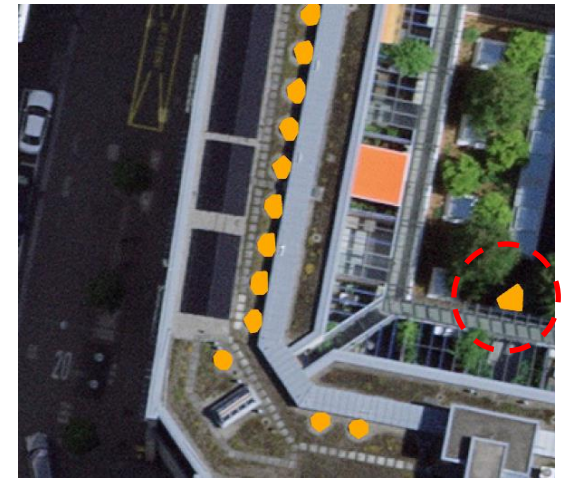# Algorithm Training – Examples skylights
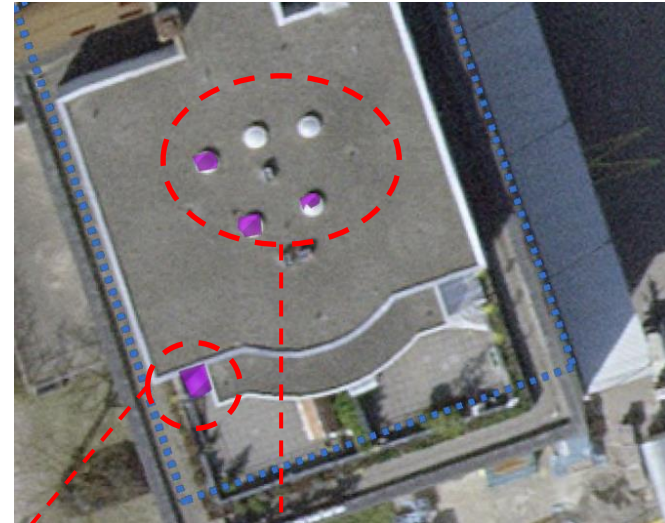
Aerial image

Annotation

Detection

Algorithm Training – Challenges skylights dark

Aerial image

Detection

→ Other dark objects on roofs (small roof windows, antennas, air vents) can be hard to differentiate

→ «*false positives*» on bright skylights lowers precision (only 76%) 43% of «*false positives*» are bright skylights. These should not be considered actual false positives. Overlaps removed in post-processing.

Algorithm Training – Precision and Recall

Object Type	Precision	Recall
Solar panels	89%	93%
Skylights light	95%	95%
Skylights dark	76%	92%

Percentage of detections that matched an outline
(key word: *false positives*)

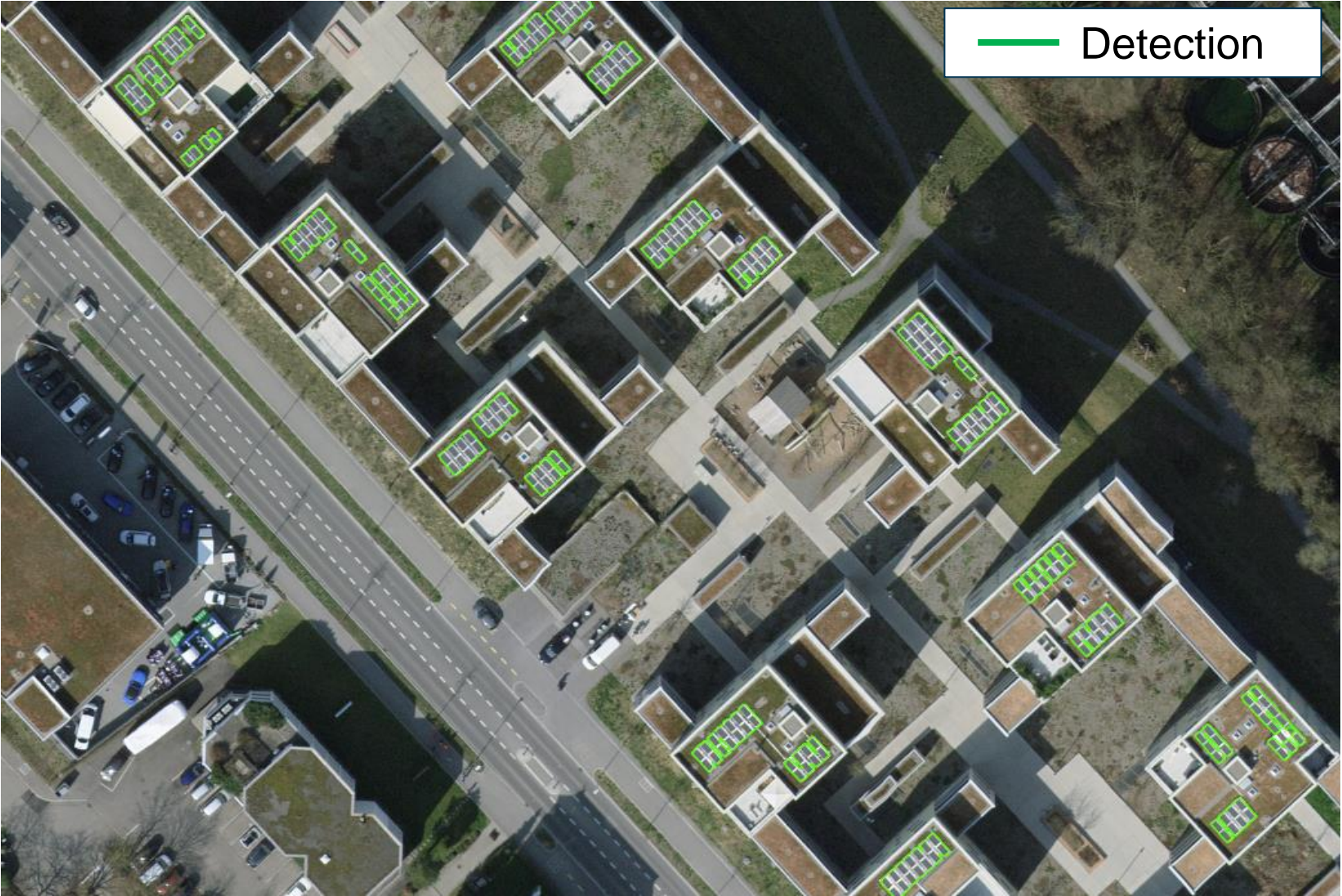Percentage of outlined objects, which are detected

Object Detection – Solar panels

Legend: Training (red), Detection (green)
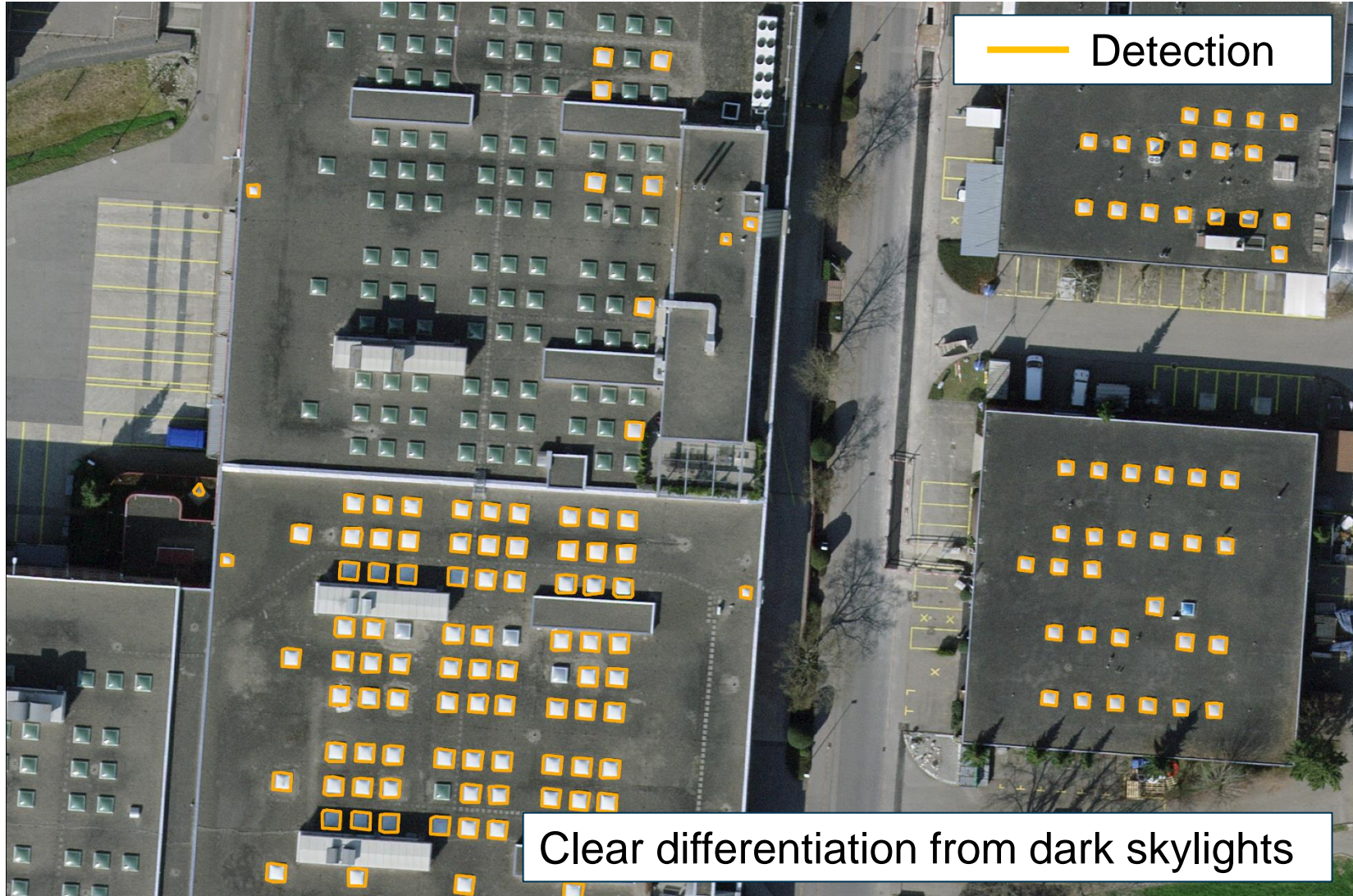
Object Detection – Solar panels

Object Detection – Solar panels

Object Detection – Skylights bright

Training
Detection

Object Detection – Skylights bright

Detection

Clear differentiation from dark skylights

Object Detection – Skylights dark

Detection

Clear differentiation from bright skylights

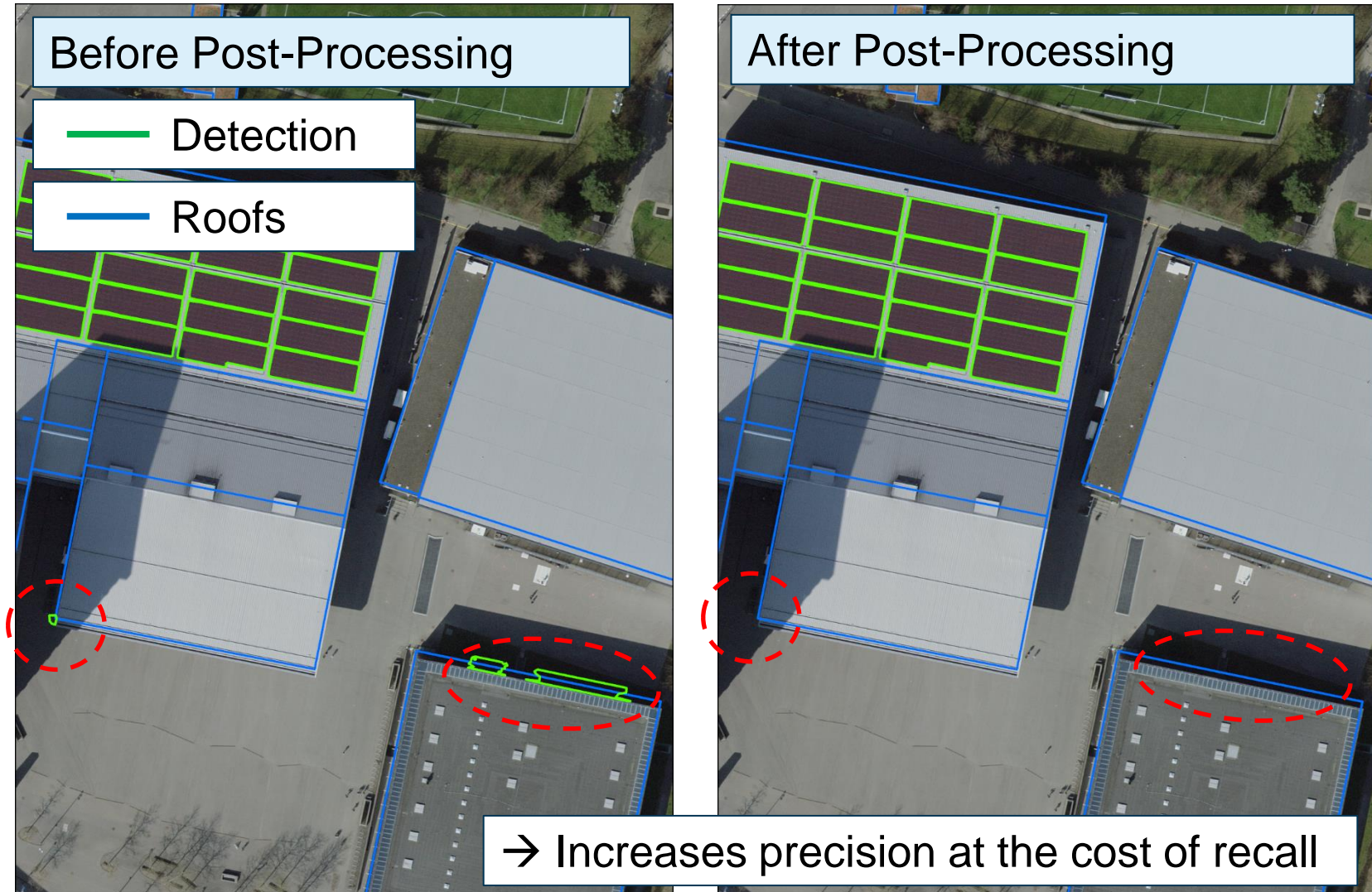23.06.2023

Post-Processing –
Overlaps between Skylight types

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Post-Processing – Overlaps between Skylight types
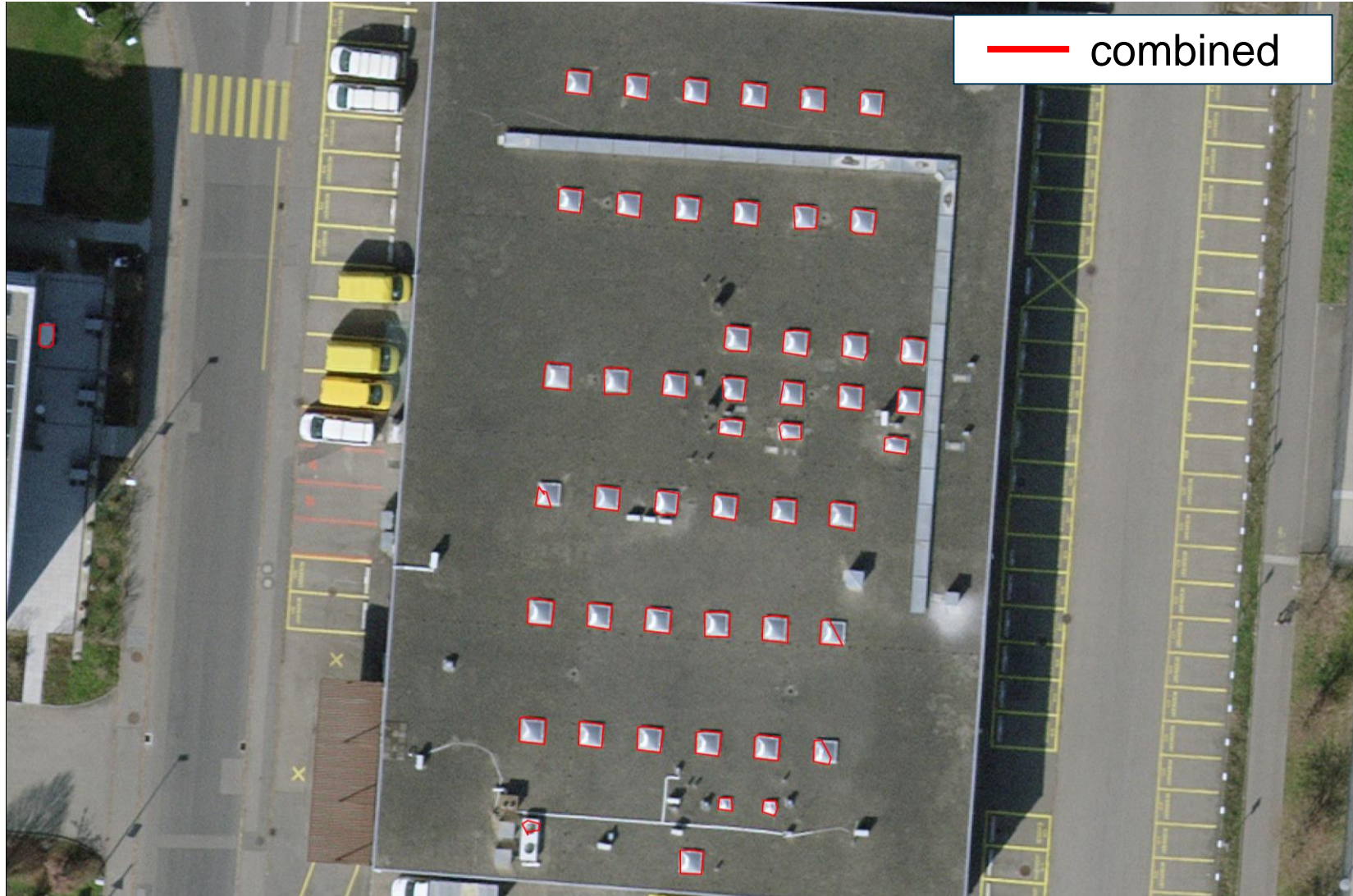
Post-Processing – Solar panels on facades due to buffer

Before Post-Processing

— Detection
— Roofs

After Post-Processing

→ Increases precision at the cost of recall

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Summary

- Successful detection of solar panels and skylights
  in the whole canton of Zug
  → 6'900 solar panels
  → 14'900 skylights (13'000 type light; 1'900 type dark)

- Recall and precision of around 90%

- ~ 4 weeks of work within 6 months

- Cost effective, flexible, and fast approach combining GIS methods and machine learning approaches

- Trained detectors can be scaled to new and much larger areas

- Updates over time are easy and inexpensive

Further Applications –
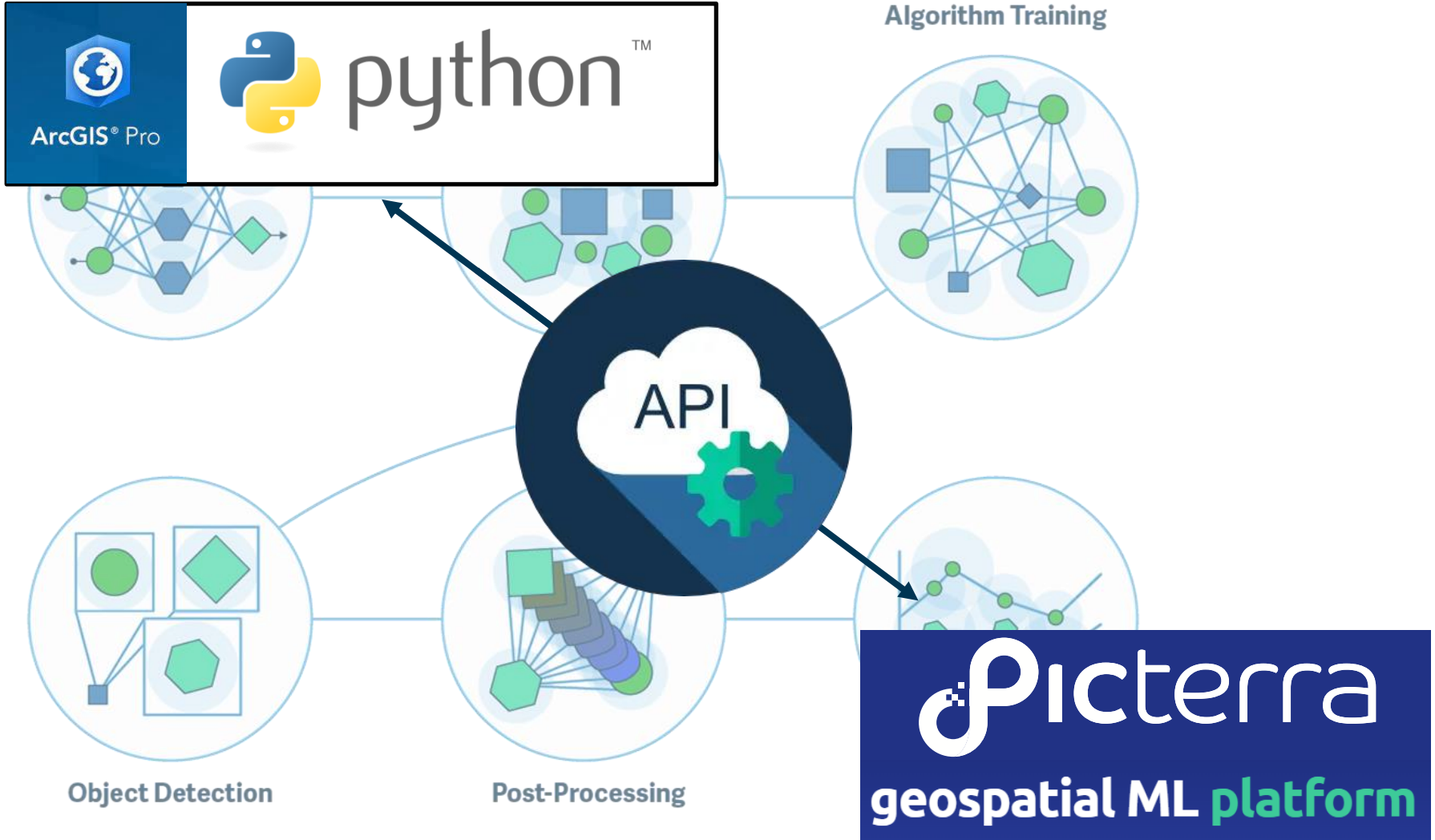# Detecting drainage ditches in bogs

Detection

Aerial image

23.06.2023

Further Applications

Algorithm Training

Object Detection

Post-Processing

Questions & Feedback?

Meteotest

www.meteotest.ch