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AI and GIS for Urban Biodiversity Monitoring

Tree Census from Location Estimation to Ecosystem Services Assessment

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Research Context

Biodiversity loss is particularly noticeable in **urban** and **peri-urban areas**, where **urbanization processes** exert significant strain on urban biodiversity and urban ecosystem services (ES). As a result, cities are **less sustainable** and **resilient**, with negative consequences for **public health** and **urban environment** quality *[1].*

Urban trees provide several ES that positively impact urban ecosystems *[2]*. Therefore, **accurate urban tree inventories** are effective instruments for **properly estimating the ES**.

Open Challenges

Creating urban tree inventories poses challenges:

- **Temporal** and **spatial resolution** of data acquisition
- **Expensive** and **time-consuming** field data collection campaigns
- A **large amount** of **labeled data** is required to exploit **data-driven approaches** (Deep Learning) to support tree census automation
- The **ongoing** evolution of cities makes public inventories **incomplete** or **outdated**
- **Private green areas** are less accurately mapped

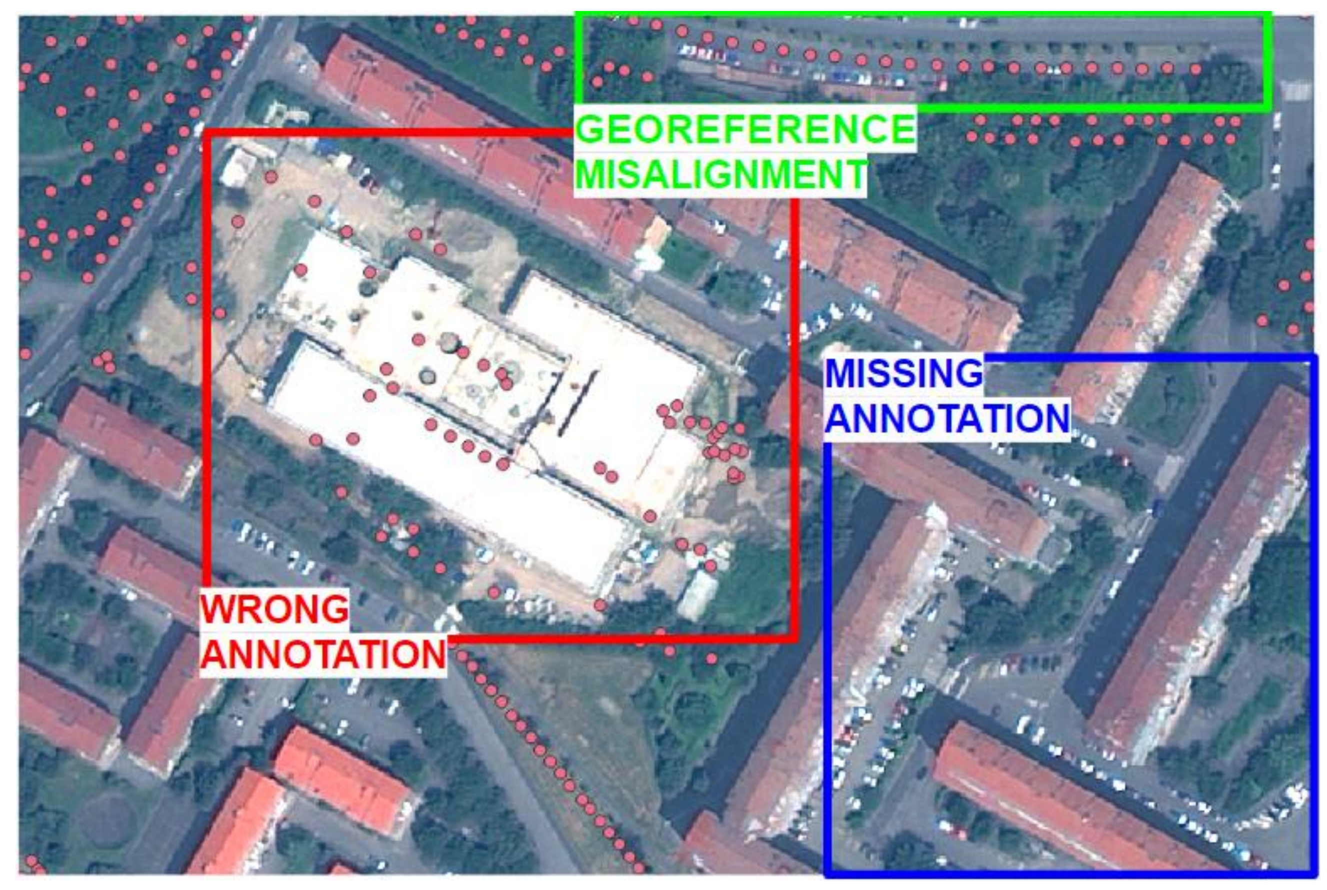

***Figure1**. Satellite images with tree locations (red points) extrapolated from the tree urban inventory of Milan (2023).*

Data

Very **High Spatial** and **Temporal Resolution (VHR) Satellite products** and **GIS data** can be exploited to describe **fragmented** and **dynamic environments** at scale over time.

- Pleiades Neo (**PNEO**) product was considered:
  - Six **multispectral** bands with **1.2 m** as spatial resolution;
  - **Panchromatic** band with **30 cm** as spatial resolution;
- **Tree locations** were collected from the Geoportal of the Lombardy region.

Methods

Deep Learning (DL), combined with Remote Sensing (RS) and GIS data, can be leveraged to **automate operations** for **monitoring urban environments at scale**.

In the early stages of the study, DL models are exploited to **localize** and **count** urban trees within the study area.

Given an image, trees are identified by employing a **binary segmentation** task *[2]*.

Preliminary Results

The original model of *[2]* was evaluated in a study area of the Lombardy region. Annotated images were analysed and **Ground Truth (GT)** was manually corrected. The best results are obtained by **Fine-Tuning (FT)** the model in the study area.

	Training Configuration		Test set Evaluation		
Experiment	**# Images**	**# tree**	**Precision**	**Recall**	**F-Score**
Original Model [2]	1651	95972	0.587	0.451	0.510
FT Model GT Uncorrected	426	24477	0.799	0.420	0.550
FT Model GT corrected	218	17927	**0.670**	**0.660**	**0.665**

***Table1.** Training configuration and the results of the experiments performed, evaluated on the same test set.*

***Figure2.** Confidence Map (model output)*

***Figure3.** Prediction extrapolated from Confidence Map*

Conclusions

DL combined with **VHR Satellite data** can support **tree census** in **urban** environments. However, the **geographical context**, the **tree crown size** and the presence of **dense groups of trees** influence the performance of the models.

Next Steps

New data covering the whole Milan metropolitan area have been acquired to improve and test the performances of DL models at scale.

Other **DL** architectures to **segment** and **detect trees** will be explored.

DL models for **tree species** classification will be investigated.

[1] Yanhua Chen et al; Urban Remote Sensing: Monitoring, Synthesis, and Modeling in the Urban Environment, Chapter 20; (2021)
[2] Ventura et al, Individual tree detection in large-scale urban environments using high-resolution multispectral imagery, (2024)