Third Arab Land Conference

Troisième Conférence Arabe sur le Foncier

المؤتمرالعربي الثالث للأراضي

18-20 FEBRUARY 2025 • RABAT, MOROCCO

Geospatial Artificial Intelligence for MPC-Driven NSDIs

[PARTNERS-LED SESSION: FROM FIT-FOR-PURPOSE TO GEOAI: THE CADASTRAL MODERNIZATION JOURNEY]

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المملكة المغربية

ROYAUME DU MAROC

وزارة إعداد التراب الوطني والتعمير والإسكان وسياسة المدينة

MINISTERE DE L'AMENAGEMENT DU TERRITOIRE NATIONAL DE L'URBANISME, DE L'HABITAT ET DE LA POLITIQUE DE LA VILLE

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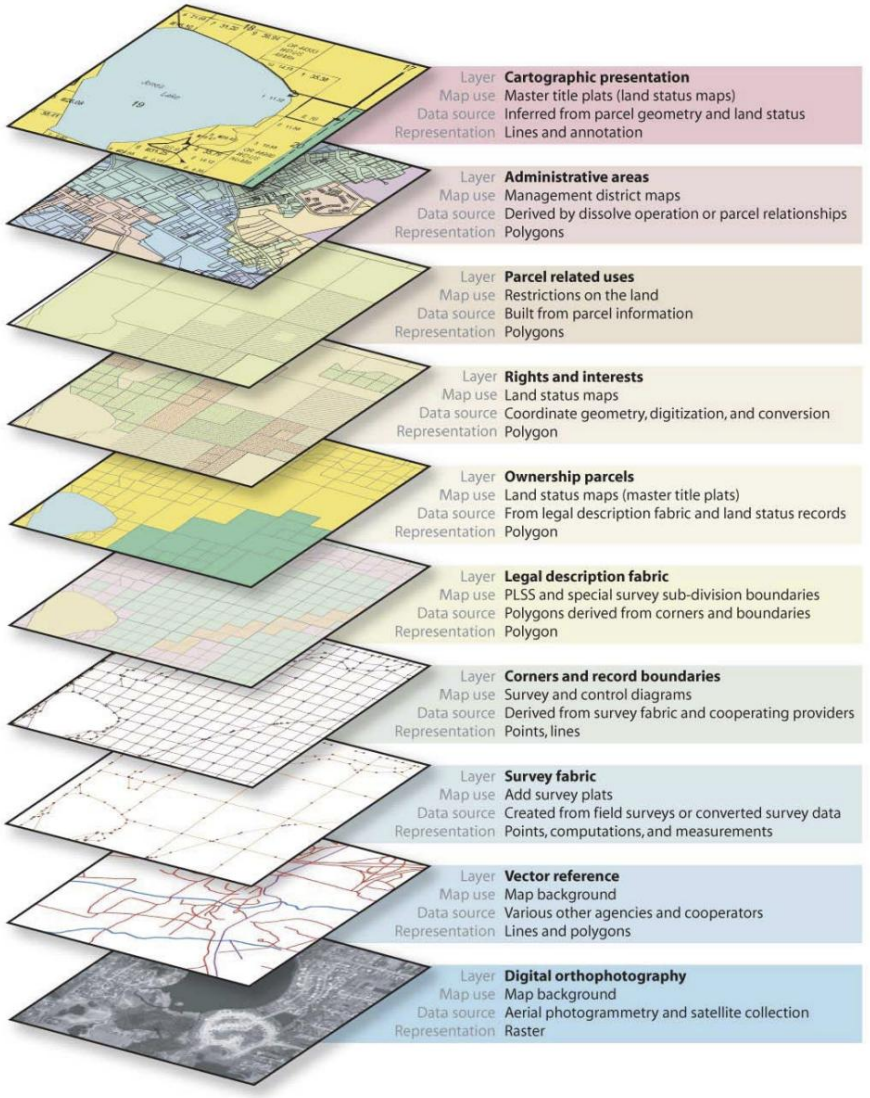
INTRODUCTION

Multi-Purpose Cadaster may be defined **as Integrated land information system** containing legal information related to land that may include ownership records, physical information such as topography, man-made features, and cultural features such as zoning, land use, demographics information in a common and accurate geospatial reference framework.

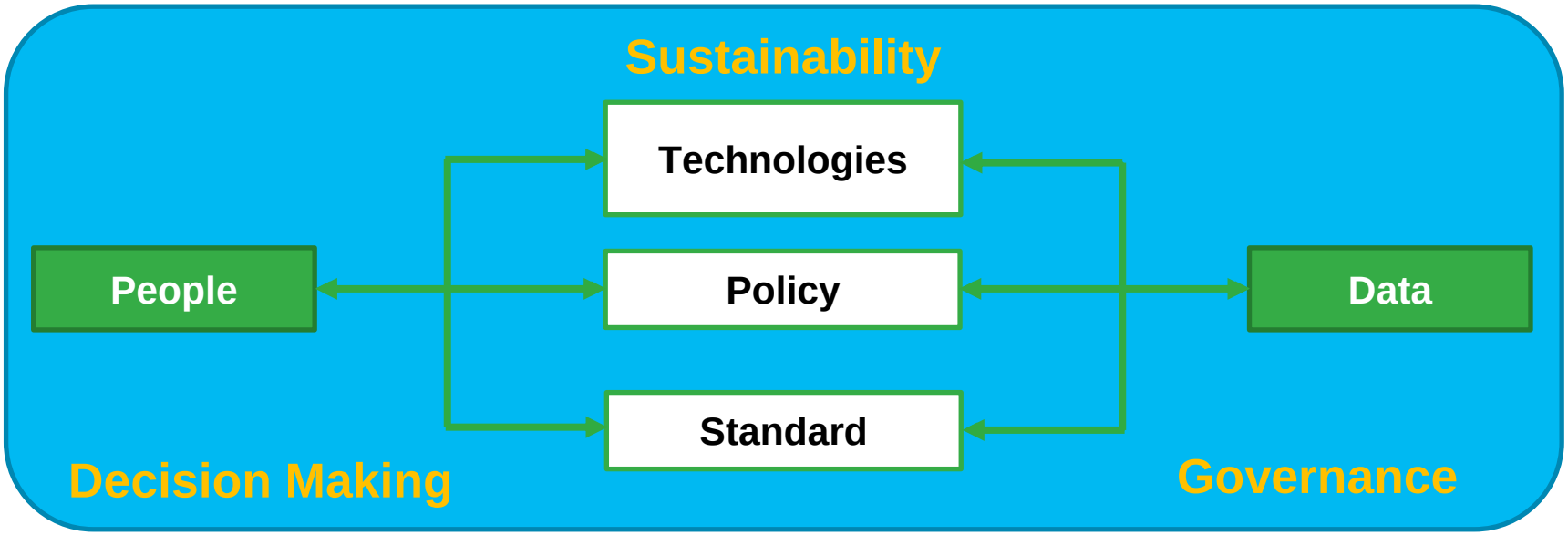
(United Nations. Economic Commission for Europe. (1996). Land Administration Guidelines: with special reference to countries in transition)



INTRODUCTION

MPC data is considered as a foundational dataset within a National Spatial Data Infrastructure **(NSDI) ecosystem**.

An NSDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general.



INTRODUCTION

Applying **Geospatial Artificial Intelligence (GeoAI)** methods to **MPC** data could provide **valuable insights to support decision making**, while **enriching the NSDI** by integrating additional information.

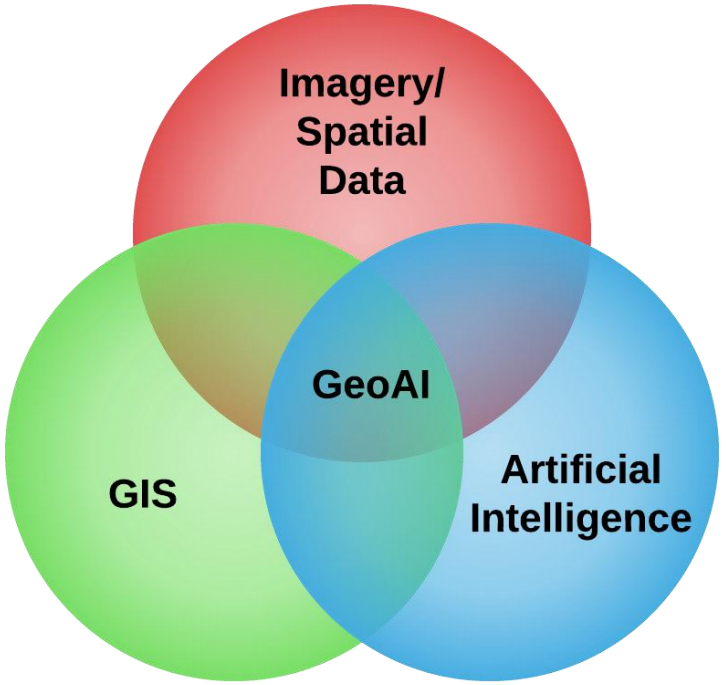
Three use cases will be presented:

- **Parcel delineation.**
- **Forecasting of the urban growth.**
- **Data extraction from 360 images.**

GEOSPATIAL ARTIFICIAL INTELLIGENCE

GeoAI is an emerging scientific field that **combines methods and techniques** from **Artificial Intelligence**, particularly **ML** and **DL**, with **GIS** to analyze and interpret geospatial data.

GeoAI aims to extract information and insights from **various sources of Geospatial Data** (Satellite images, LiDAR, IoT, etc.).



GeoAI = GIS + Artificial Intelligence

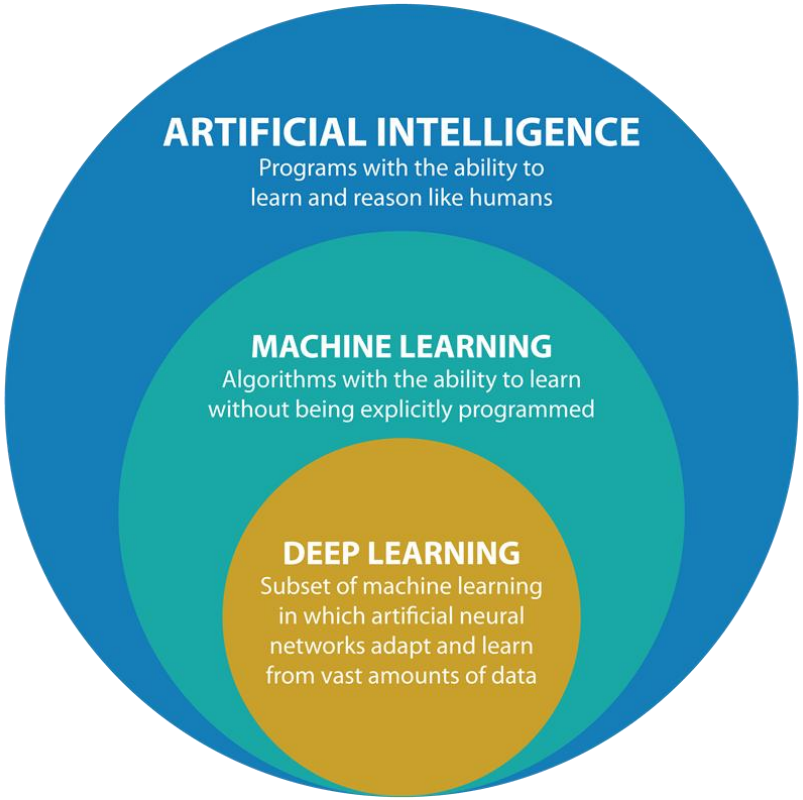
GEOSPATIAL ARTIFICIAL INTELLIGENCE

Some Concepts:

Artificial Intelligence refers to the ability to **perform intelligent tasks** like **those carried out by humans** through computer systems to solve specific problems.

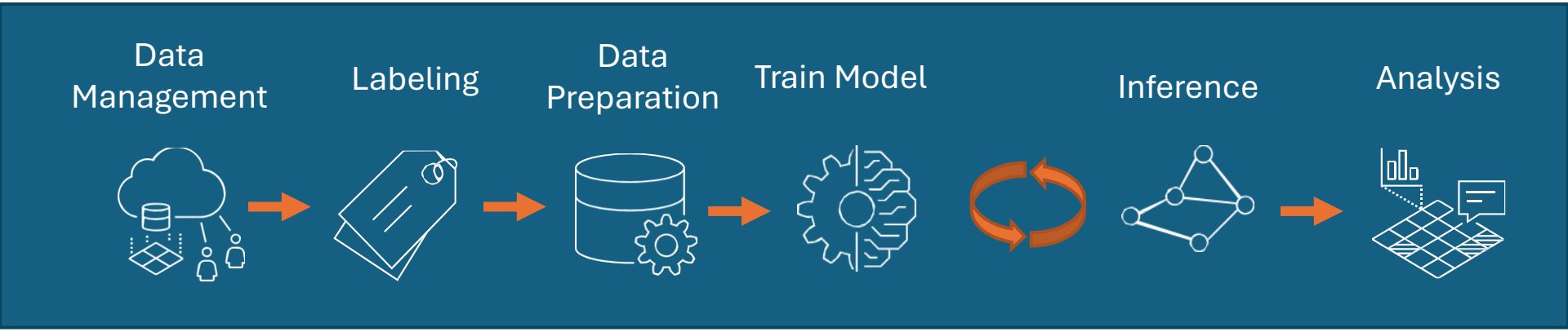
ML algorithms allow computer systems to **learn from data** to solve specific tasks, **without being explicitly programmed**.

DL algorithms is a branch of ML methods based on **Deep Artificial Neural Networks** (ANN).



GEOSPATIAL ARTIFICIAL INTELLIGENCE

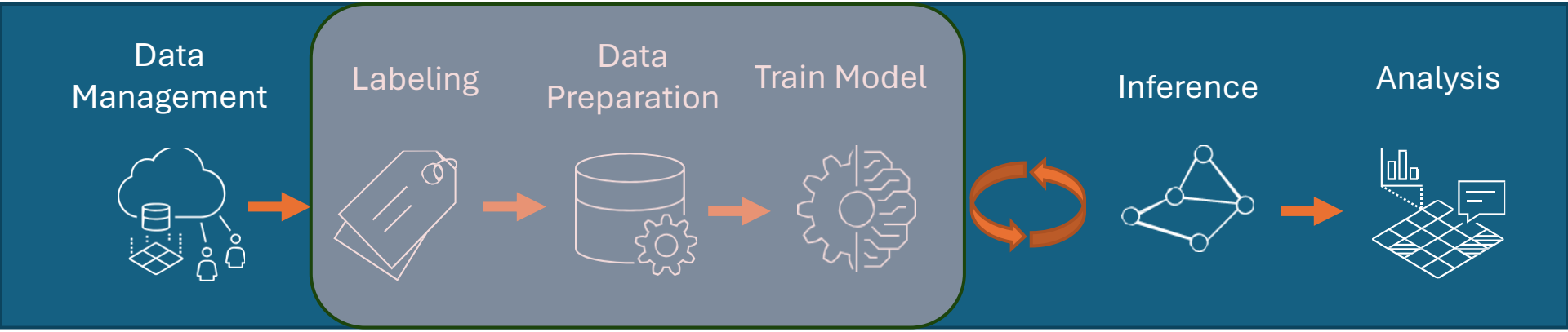
DL workflow in GeoAI :



Example of DL Workflow in GeoAI :
Building Detection

GEOSPATIAL ARTIFICIAL INTELLIGENCE

DL Workflow in GeoAI – Using Pretrained Model:

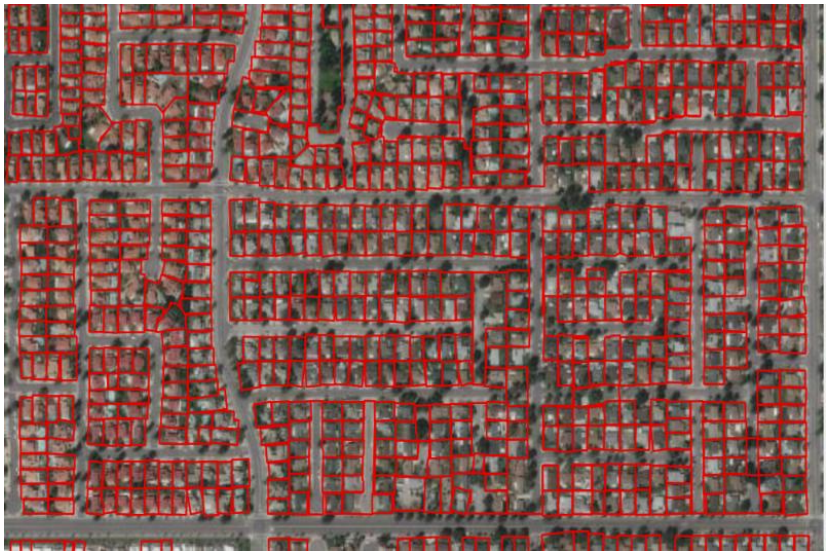


Pretrained models are DL models that **have been previously trained on a large dataset**. These models **can be used directly**, or **fine-tuned using Transfer Learning**, for a specific tasks in GeoAI.

GEOAI FOR PARCEL DELINEATION

Parcel delineation is crucial for MPC as it establishes, **clear and accurate parcel boundaries**, that are the **foundation for integrating various land-related data**.

This data supports various application such as Urban planning, Agriculture, Environmental Management, etc.



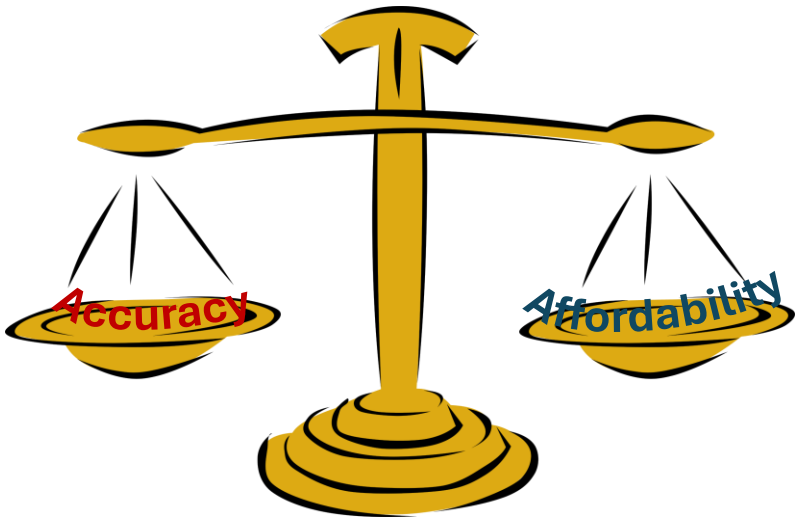
GEOAI FOR PARCEL DELINEATION

While **manual parcel delineation** offers precision, **it is a slow and costly process**, which may face scalability issues for large areas.

It is important to choose **cost-effective methods for Parcel Delineation** to ensure that the **MPC** remains **adaptable** to **evolving needs**.

A cost-effective method should **balance affordability and accuracy** to maximize **efficiency**, **scalability** and **usability**.

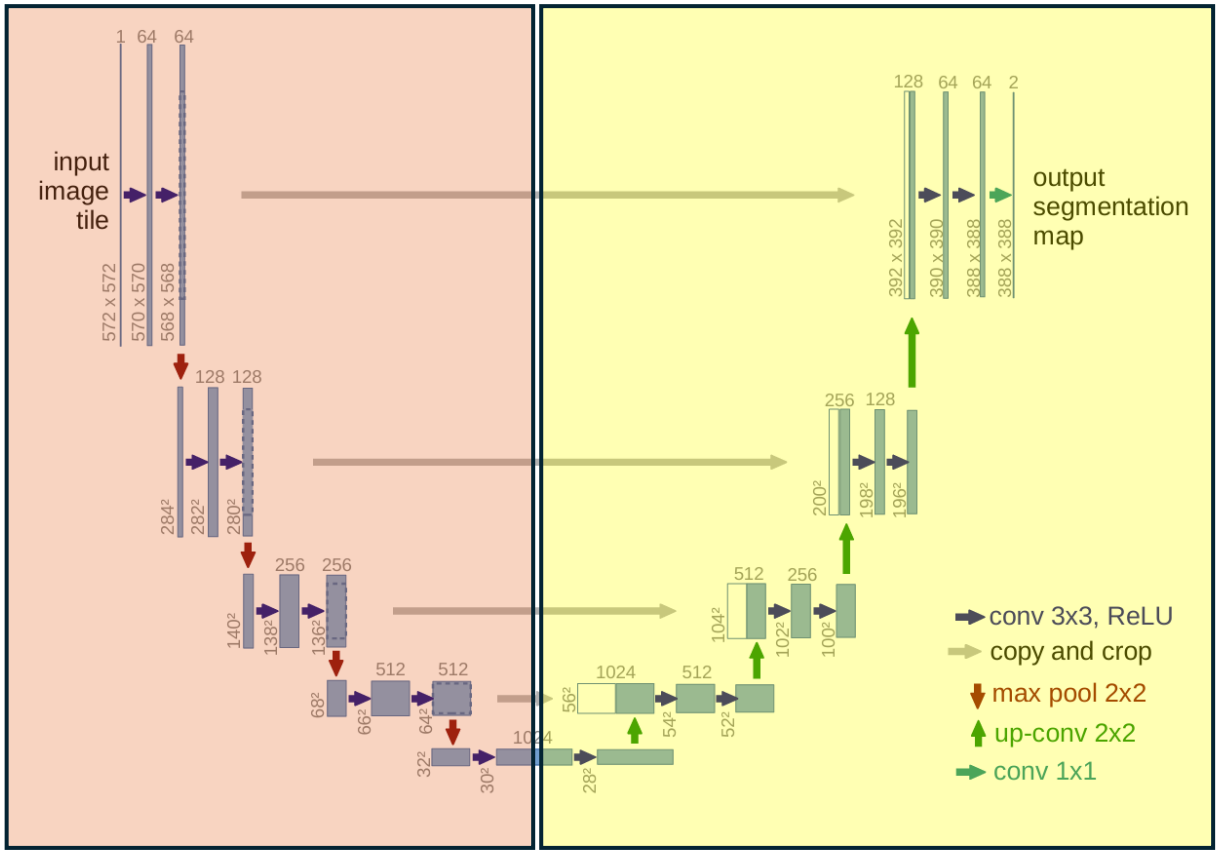
GeoAI



GEOAI FOR PARCEL DELINEATION

Deep Learning Models:

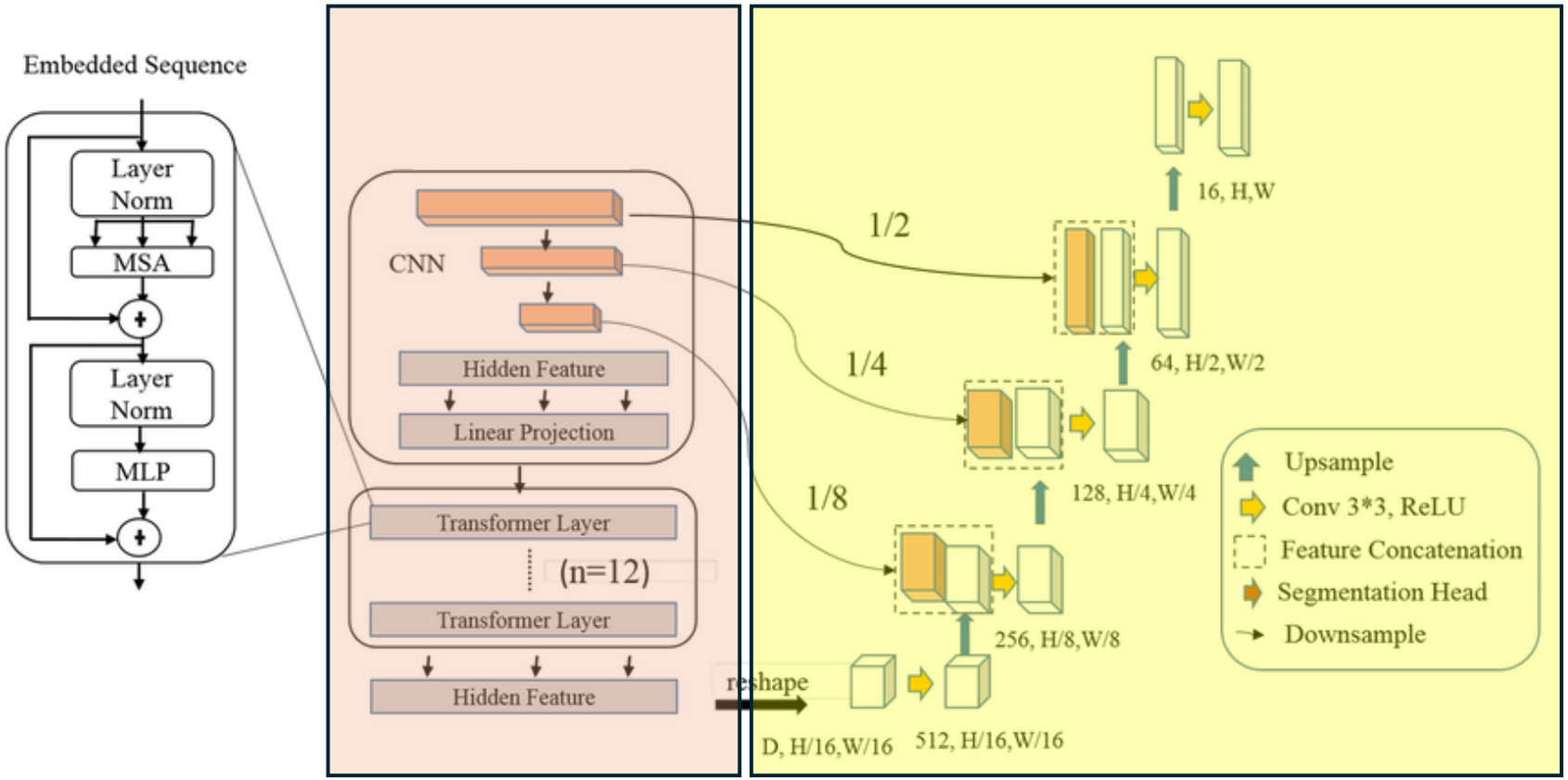
UNet Model:



GEOAI FOR PARCEL DELINEATION

Deep Learning Models :

TransUNet Model:

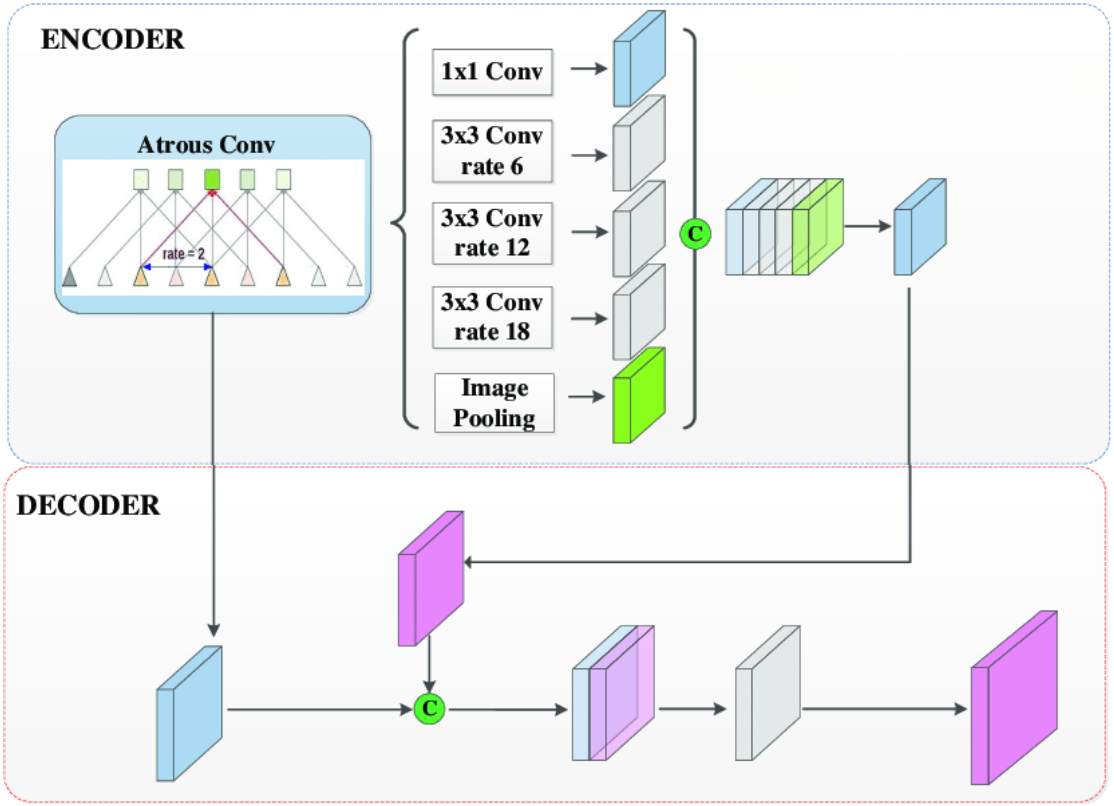


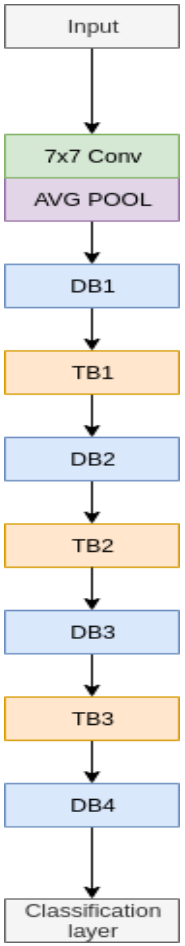
ViT-Encoder Decoder

GEOAI FOR PARCEL DELINEATION

Deep Learning Models

DeepLabV3+ with DenseNet-121 as backbone:



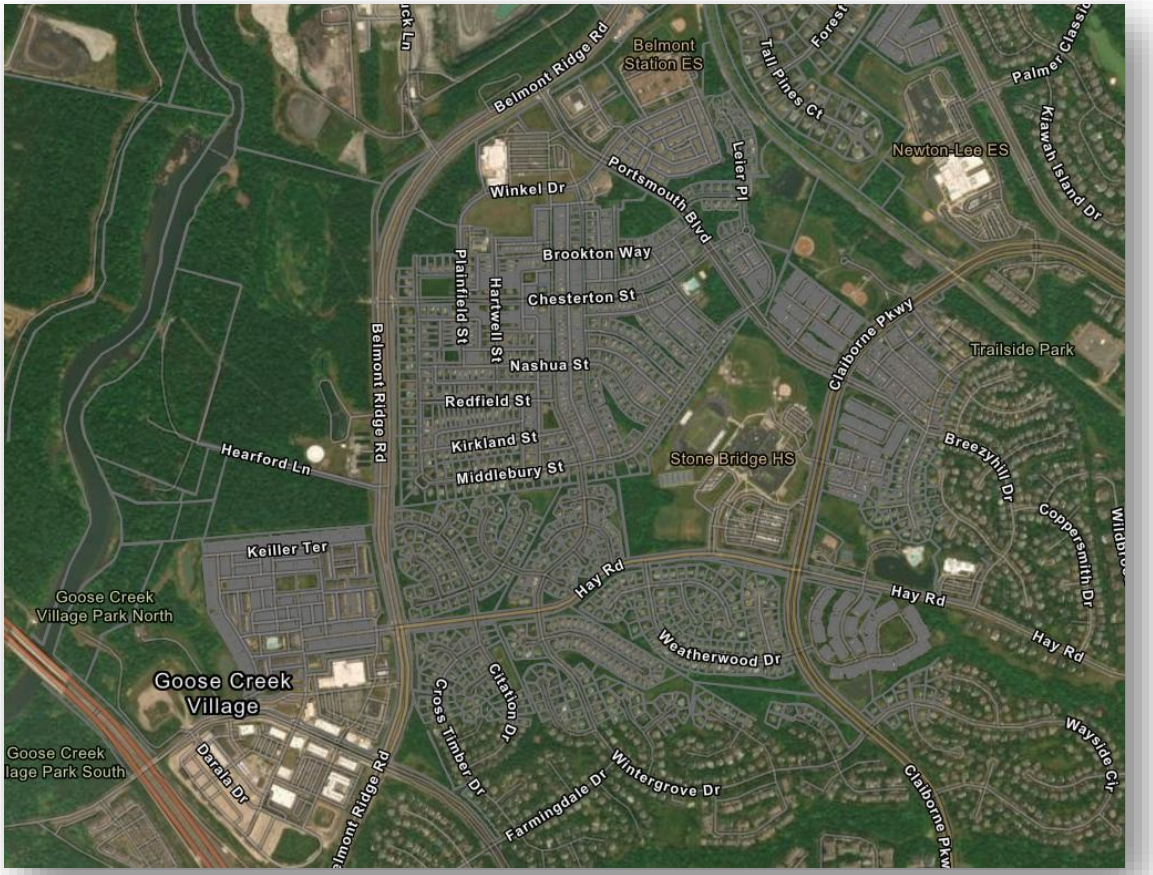


DenseNet-121

GEOAI FOR PARCEL DELINEATION

Urban Area:

- Location : Goose Creek Village
- Country : United State
- Area : 10 kilometers square



Graduation Project
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GEOAI FOR PARCEL DELINEATION

Urban Area:

Data Preparation :

Parcel Data

Ortho-imagery Data: 1m RGB+NIR

Graduation Project
Elmoussaoui & Rachidi, 2024

GEOAI FOR PARCEL DELINEATION

Rural Area:

- Location : Middelkoop
- Country : Netherlands
- Area : 80 kilometers square

Graduation Project
Elmoussaoui & Rachidi, 2024

GEOAI FOR PARCEL DELINEATION

Rural Area:

Data Preparation :

AI4Boundaries

Parcel Data

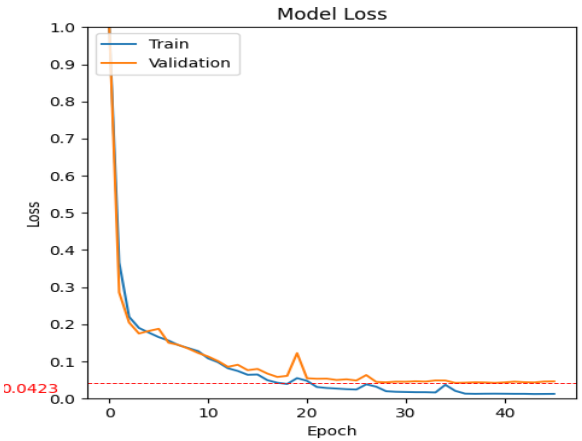
Ortho-imagery Data: 1m RGB+NIR

Graduation Project
Elmoussaoui & Rachidi, 2024

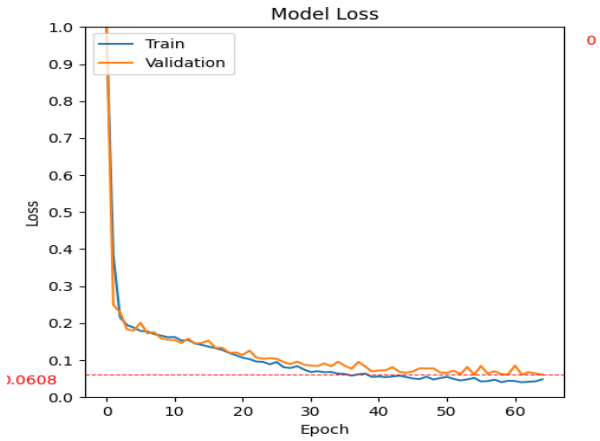
GEOAI FOR PARCEL DELINEATION

Deep Learning Models

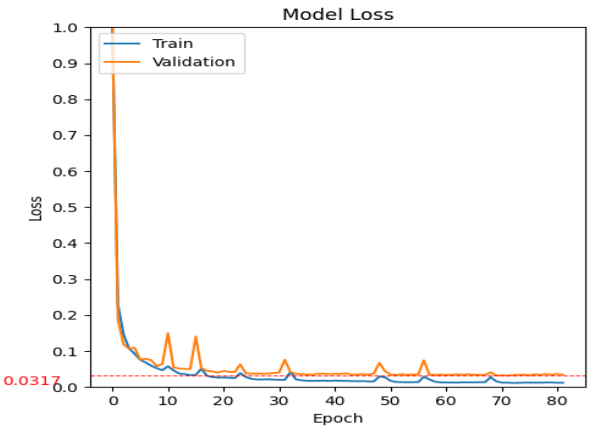
Learning Curves for the Rural area :



UNet



TransUNet



DeepLabV3+

Metrics	Loss	Accuracy	Precision	Recall	F1 Score	IoU
UNet	0.03	0.99	0.99	0.99	0.99	0.97
DeeplabV3+	0.03	0.99	0.99	0.99	0.99	0.97
TransUNet	0.06	0.98	0.98	0.99	0.98	0.96

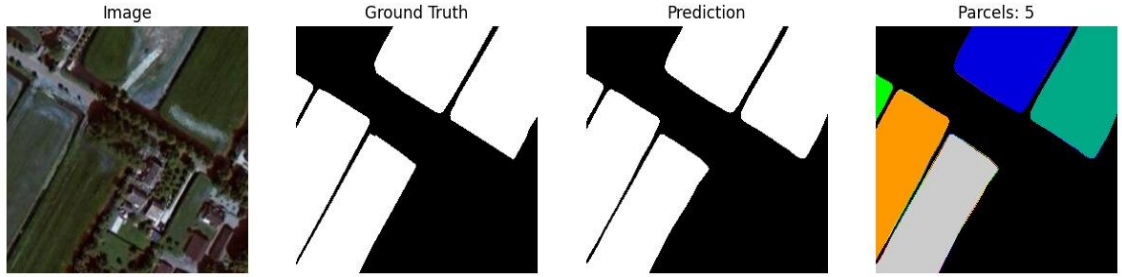
* Metrics based on the number of instances

GEOAI FOR PARCEL DELINEATION

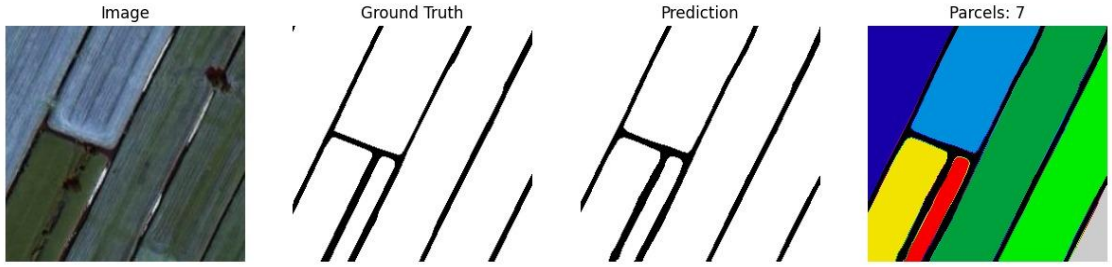
Deep Learning Models

Results for the Rural area :

UNet



DeeplabV3+

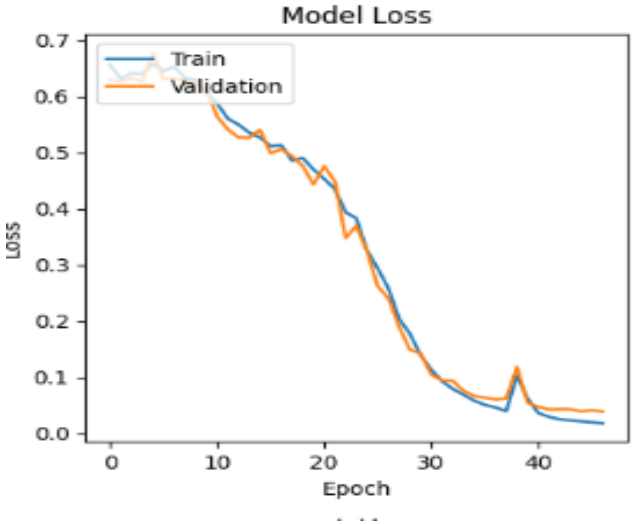


TransUnet

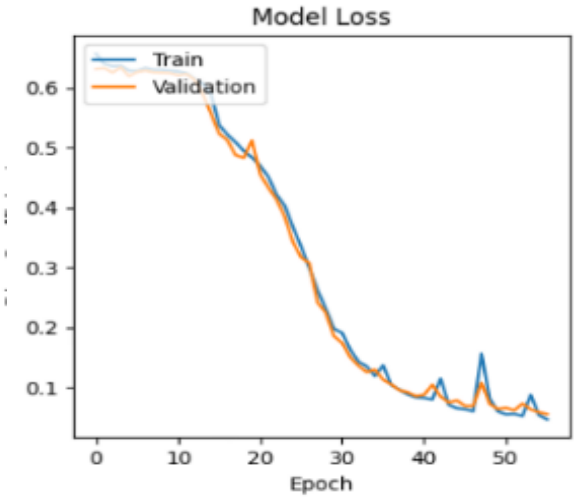
GEOAI FOR PARCEL DELINEATION

Deep Learning Models

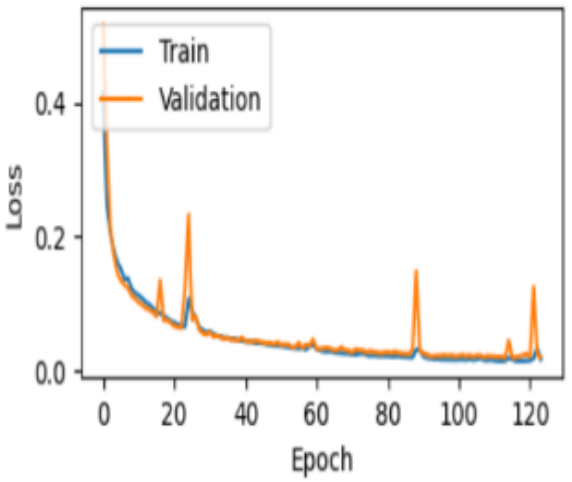
Learning Curves for the Urban area :



UNet



TransUNet



DeepLabV3+

Metrics	Loss	Accuracy	Precision	Recall	F1 Score	IoU
UNet	0.05	0.99	0.98	0.99	0.98	0.96
DeeplabV3+	0.02	0.99	0.99	0.99	0.99	0.95
TransUNet	0.07	0.98	0.96	0.98	0.97	0.92

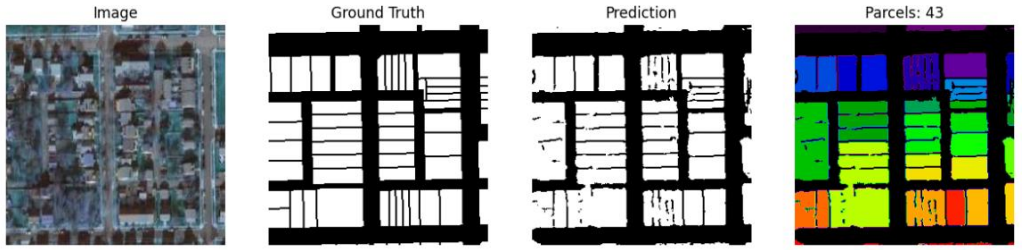
* Metrics based on the number of instances

GEOAI FOR PARCEL DELINEATION

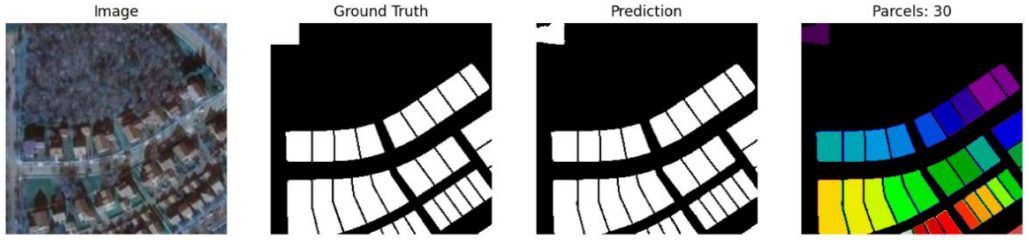
Deep Learning Models

Results for the Rural area :

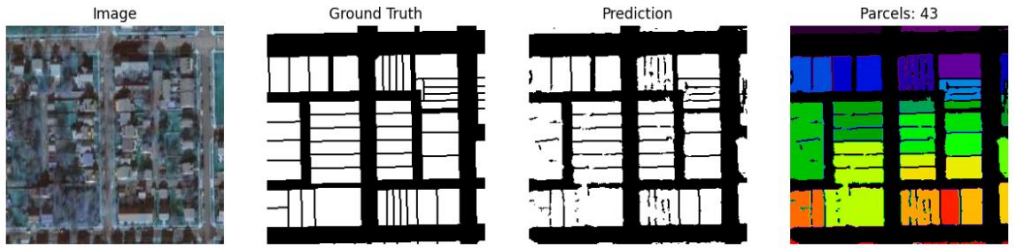
UNet



DeeplabV3+

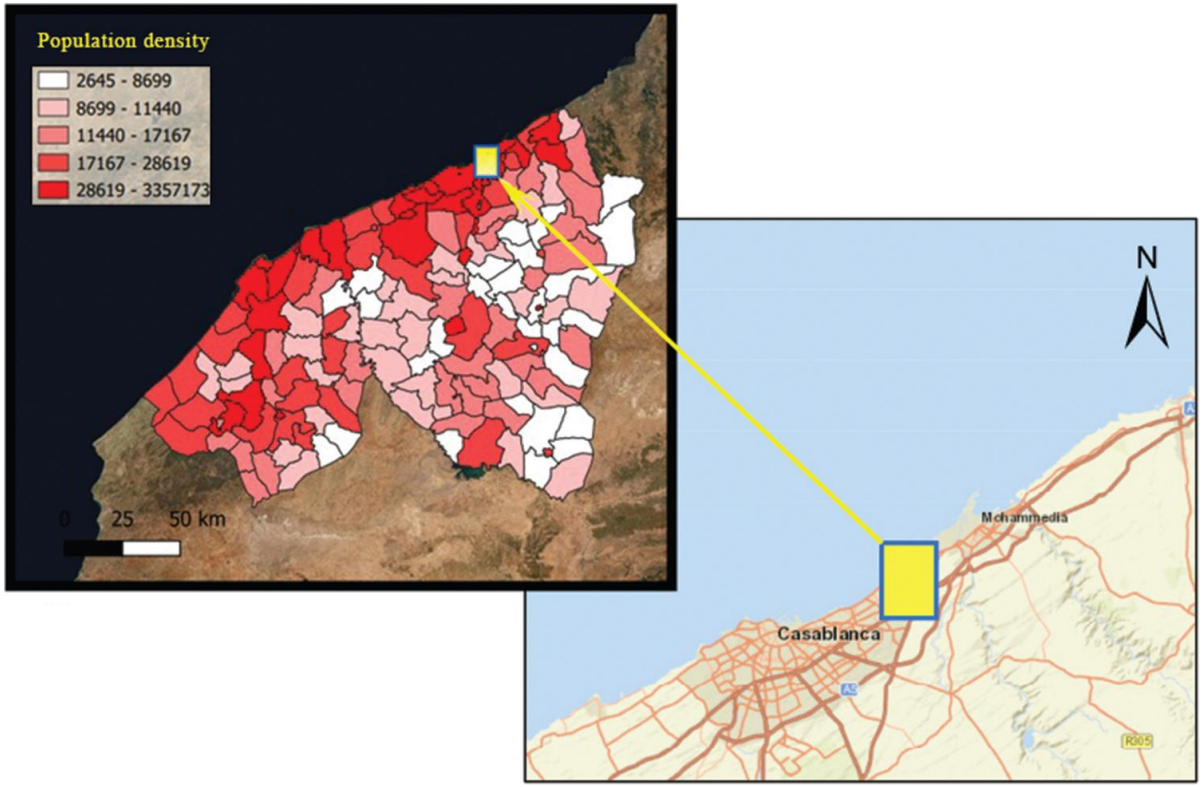


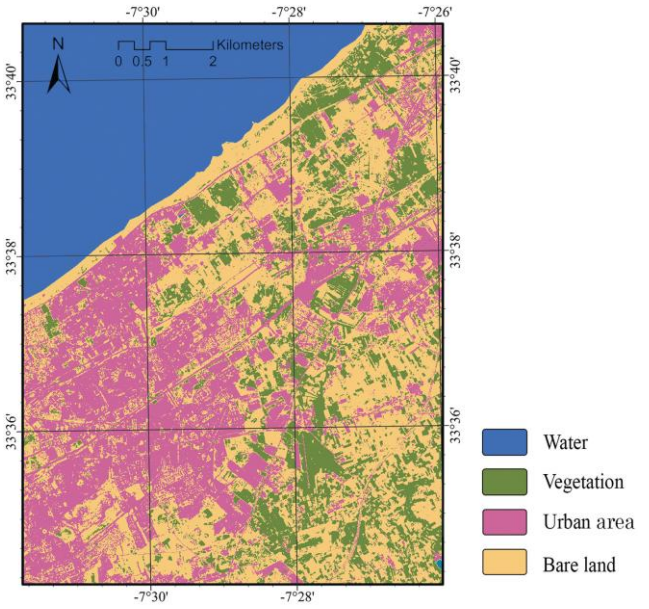
TransUnet



GEOAI FOR URBAN GROWTH

Urban growth forecasting is very important for **optimizing Land Use Planning and Zoning**. In addition, a precise forecasting of urban expansion, planners and decision makers can **anticipate challenges to ensure a sustainable development** of urban landscapes.



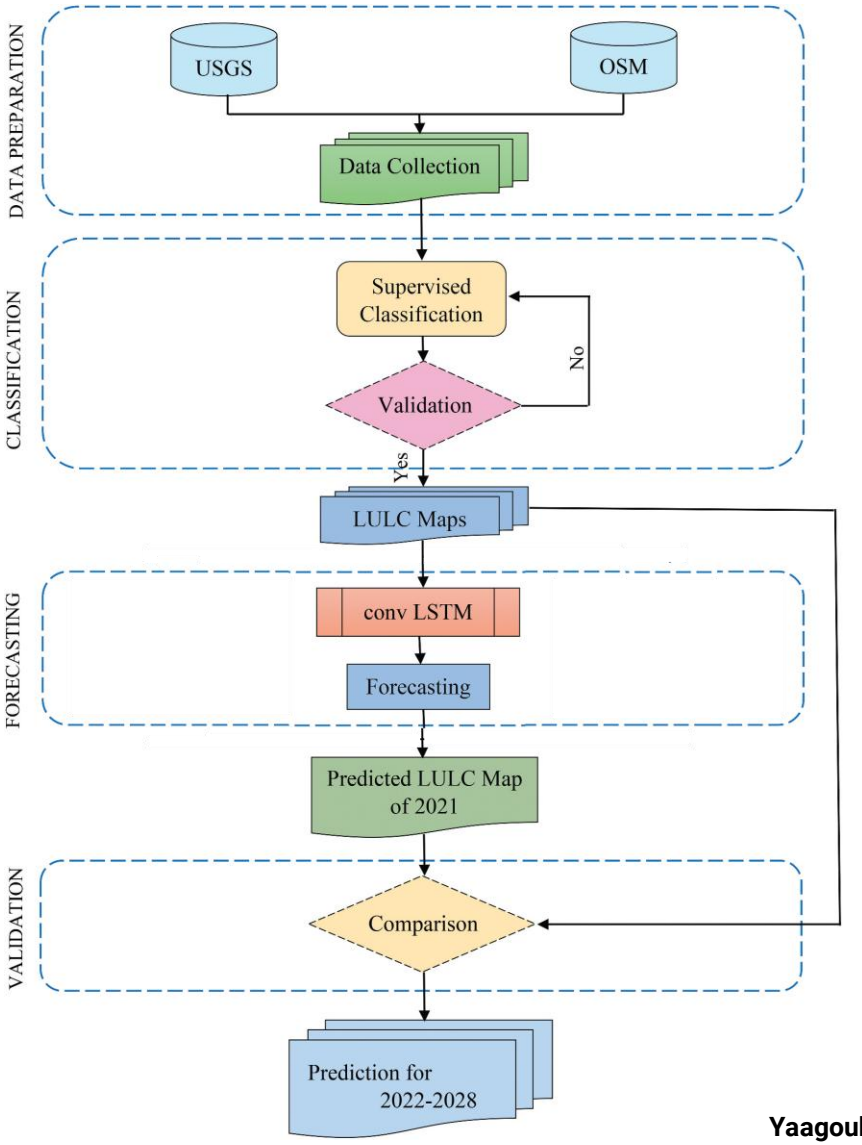


LULC obtained from the sentinel 2A image acquired on 21/05/2021

GEOAI FOR URBAN GROWTH

Methodology

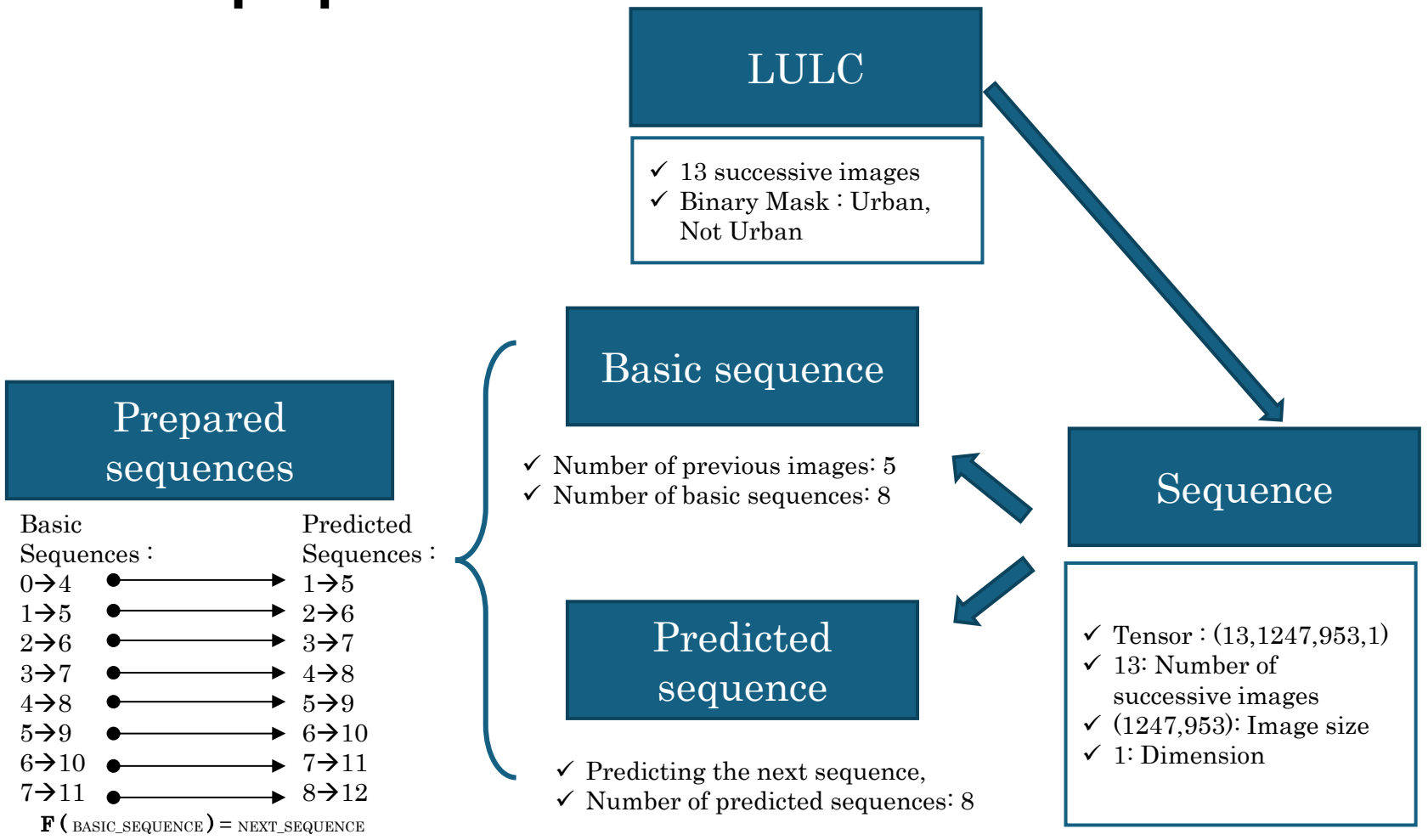
Mission	Date	Resolution	Tile
Sentinel-2	07/12/2015	10 m	T29SPT
	08/01/2016		
	06/06/2016		
	02/01/2017		
	21/06/2017		
	02/01/2018		
	17/05/2018		
	07/01/2019		
	11/07/2019		
	18/01/2020		
	05/06/2020		
	22/12/2020		
	21/05/2021		



Yaagoubi et al., 2024

GEOAI FOR URBAN GROWTH

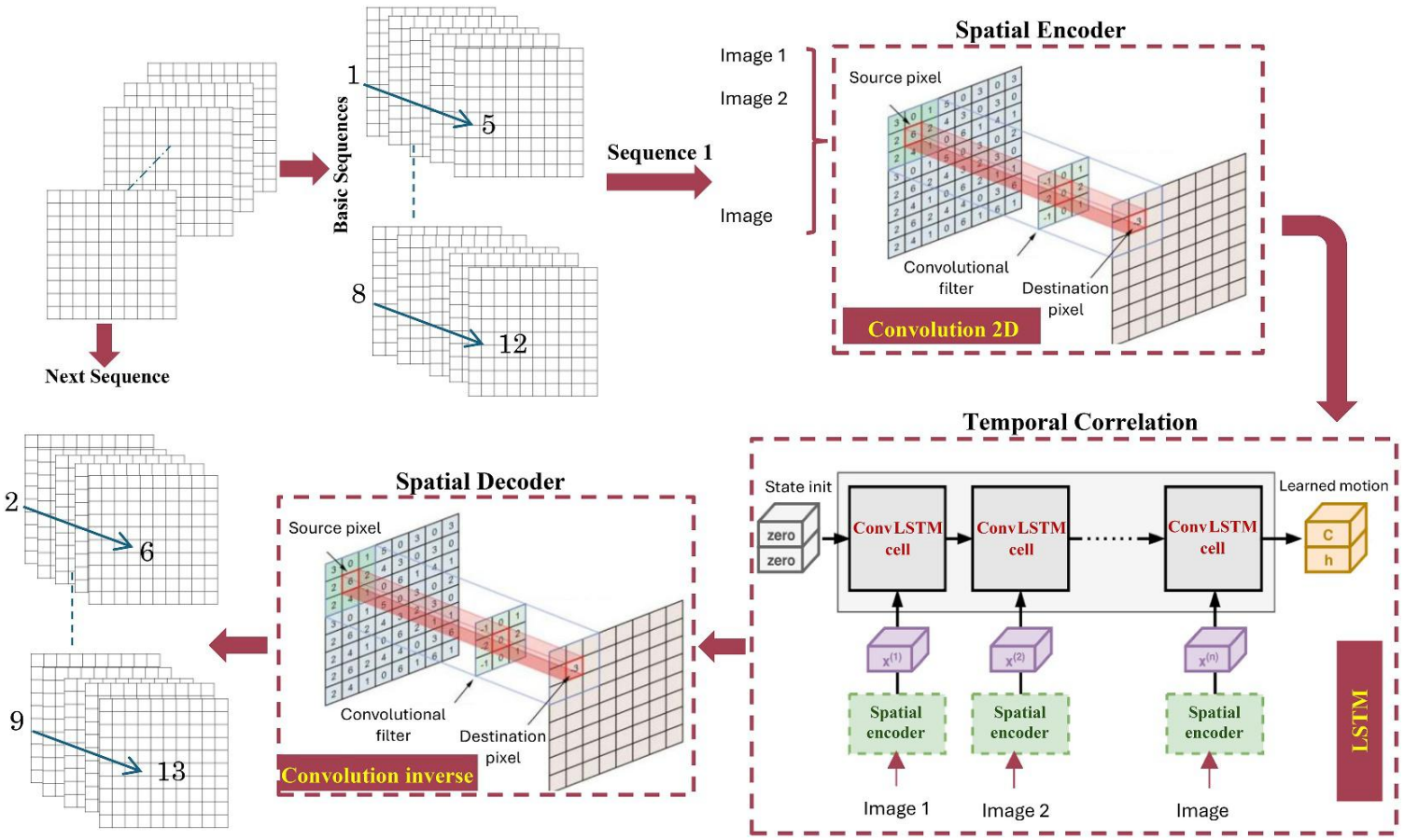
Data preparation



Yaagoubi et al., 2024

GEOAI FOR URBAN GROWTH

ConvLSTM model



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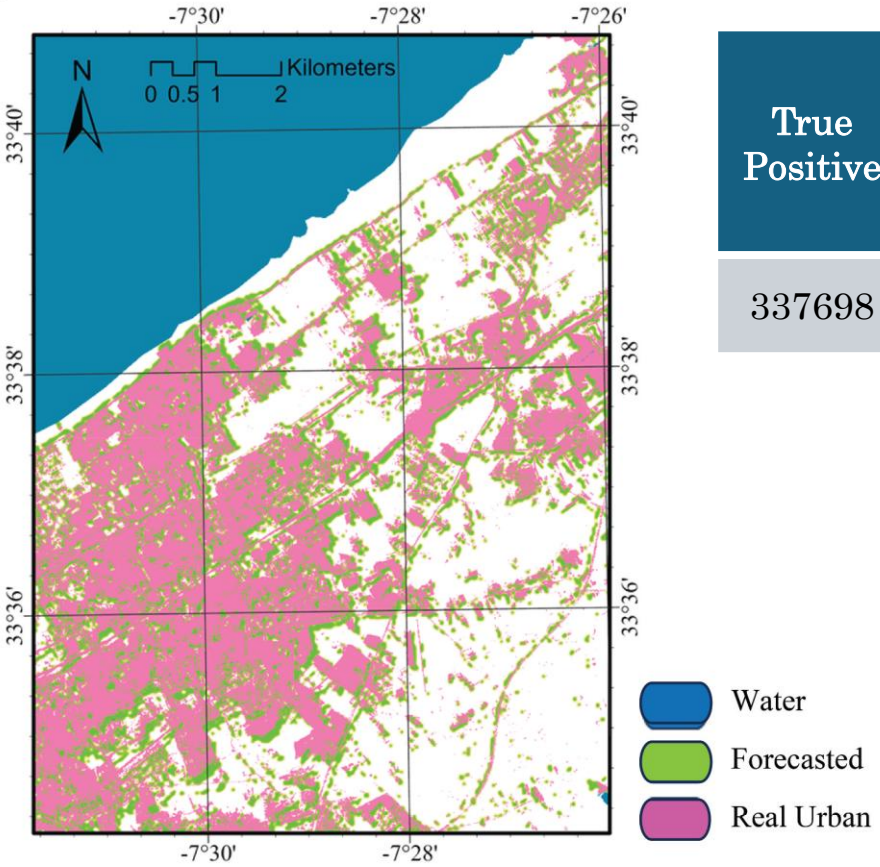
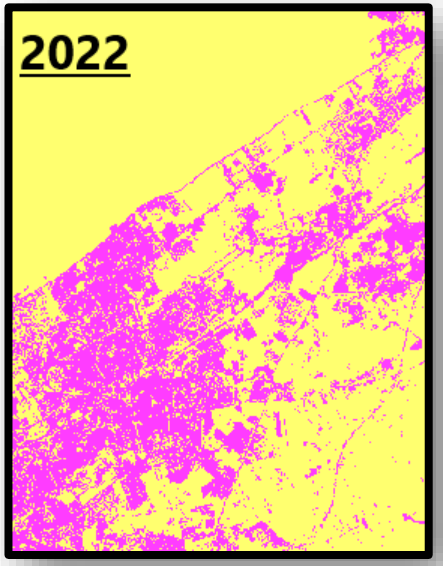
GEOAI FOR URBAN GROWTH

Forecasting urban growth



True Positive	False Negative	False Positive	True Negative	Kappa Coefficient
337698	3499	22442	824752	94,75%



Comparing the real urbanization map 2021 and the predicted one (ConvLSTM).

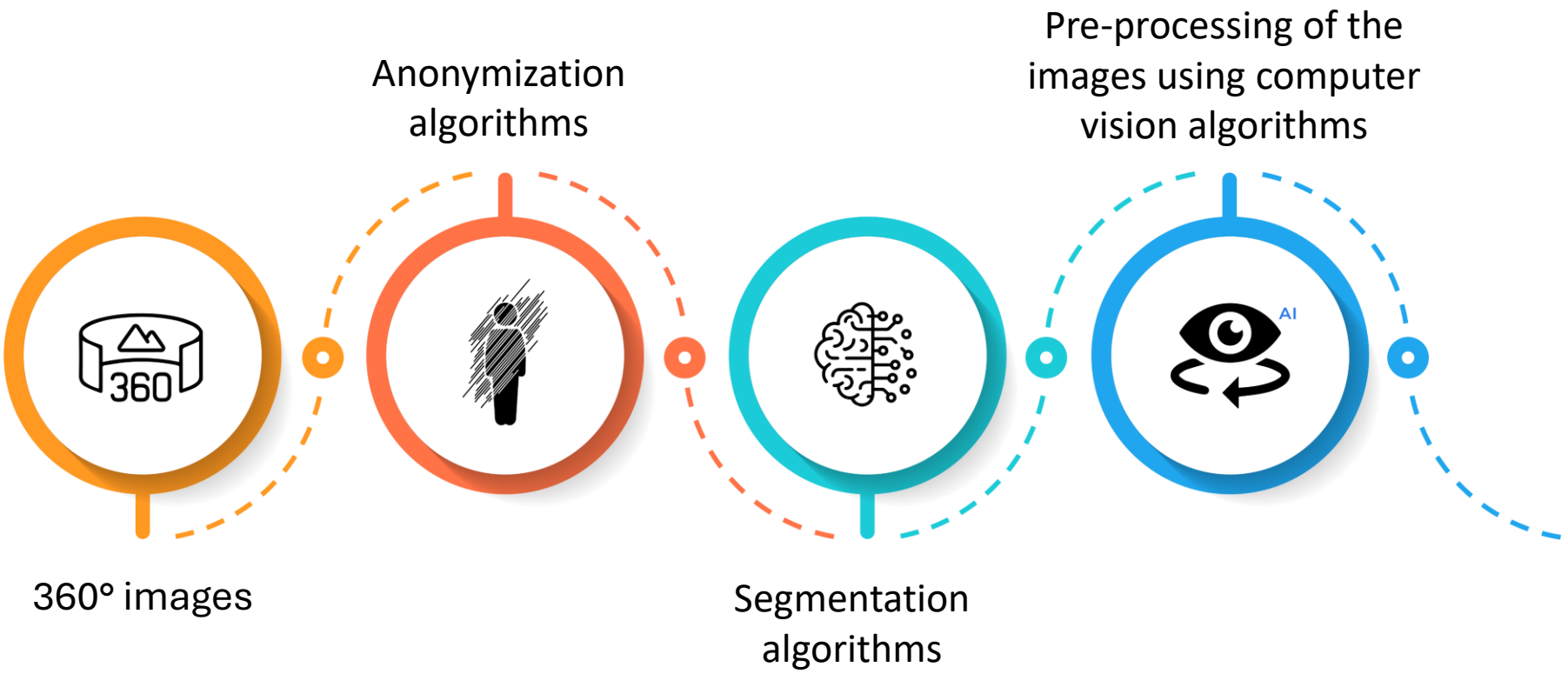
Yaagoubi et al., 2024

GEOAI FOR DATA EXTRACTION FROM 360 IMAGES

GeoAI and computer vision offer efficient techniques for **extracting geospatial data from 360-degree images**, enhancing land-related datasets. Specifically, these methods enable the extraction of valuable information from **large-scale street-level imagery with greater scalability**.

GEOAI FOR DATA EXTRACTION FROM 360 IMAGES

Turning Images into Insights: 360° Imagery to Land-related datasets



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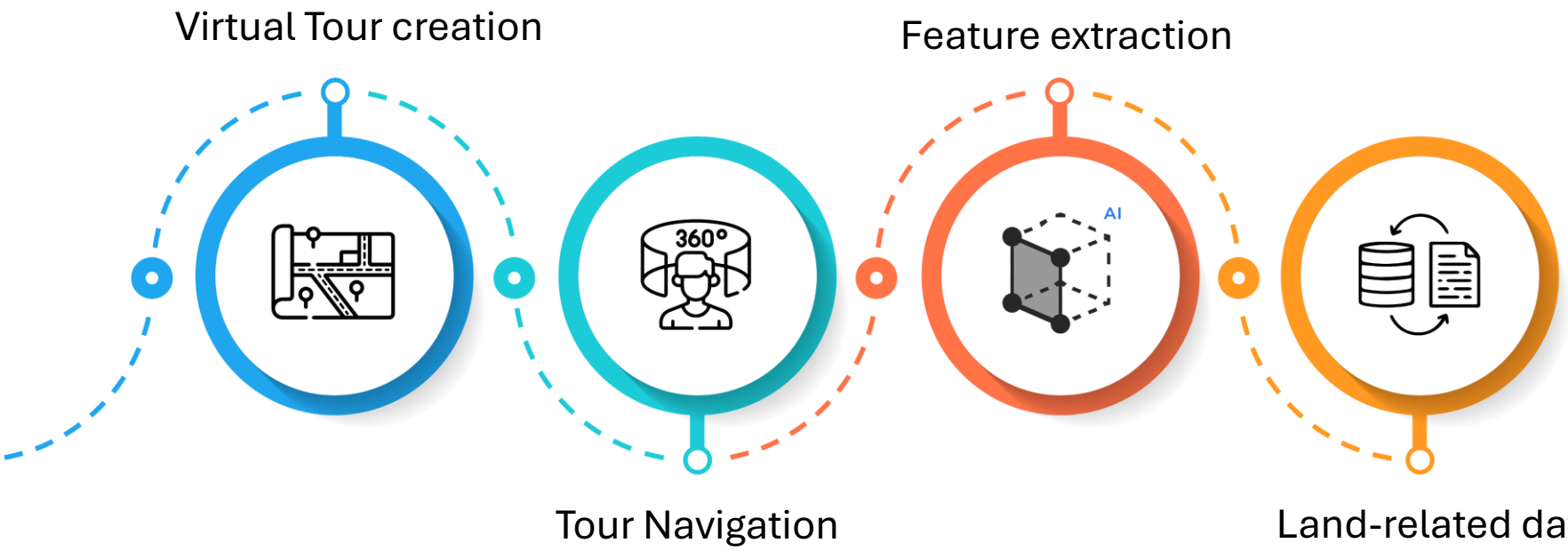

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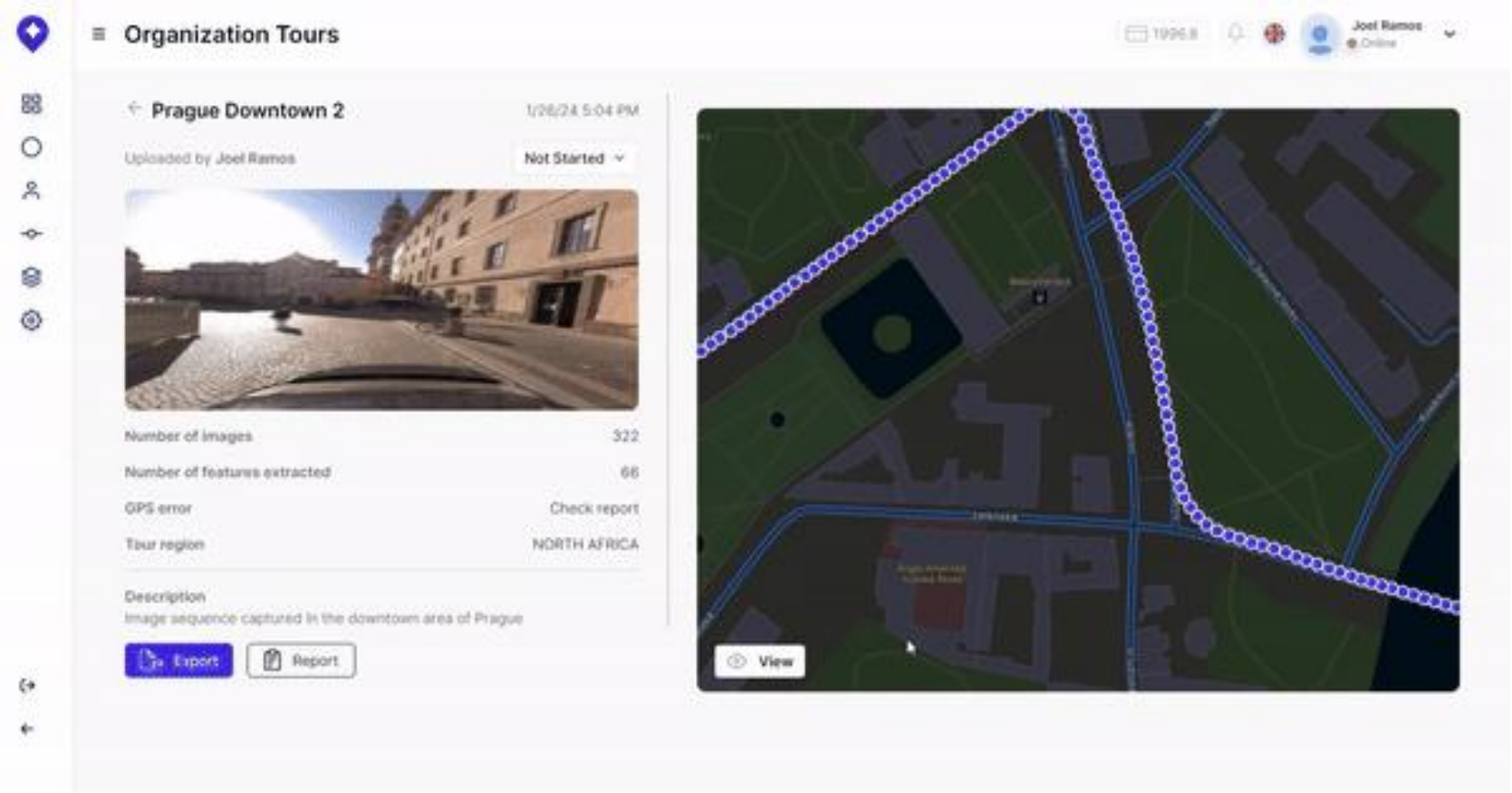
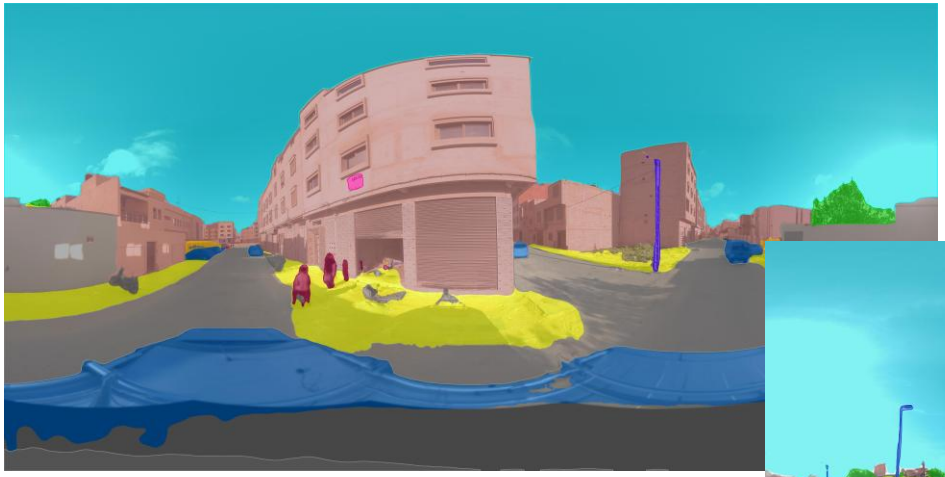
Turning Images into Insights: 360° Imagery to Land-related datasets

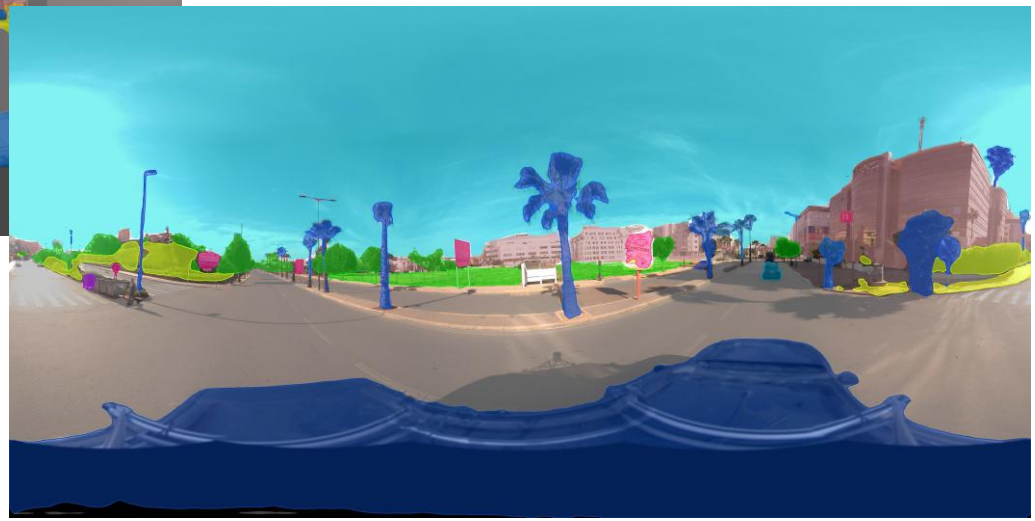


GEOAI FOR DATA EXTRACTION FROM 360 IMAGES

Turning Images into Insights: 360° Imagery to Land-related datasets

Panoptic Segmentation of 360 images:

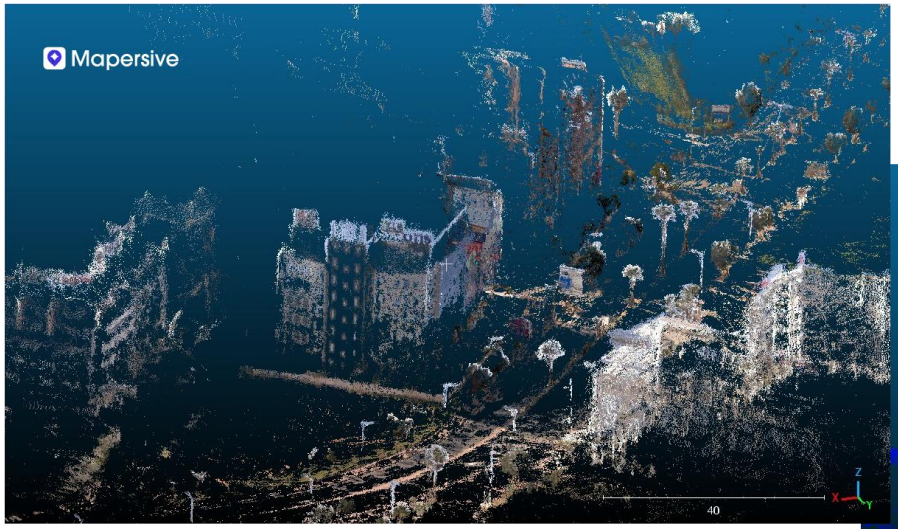


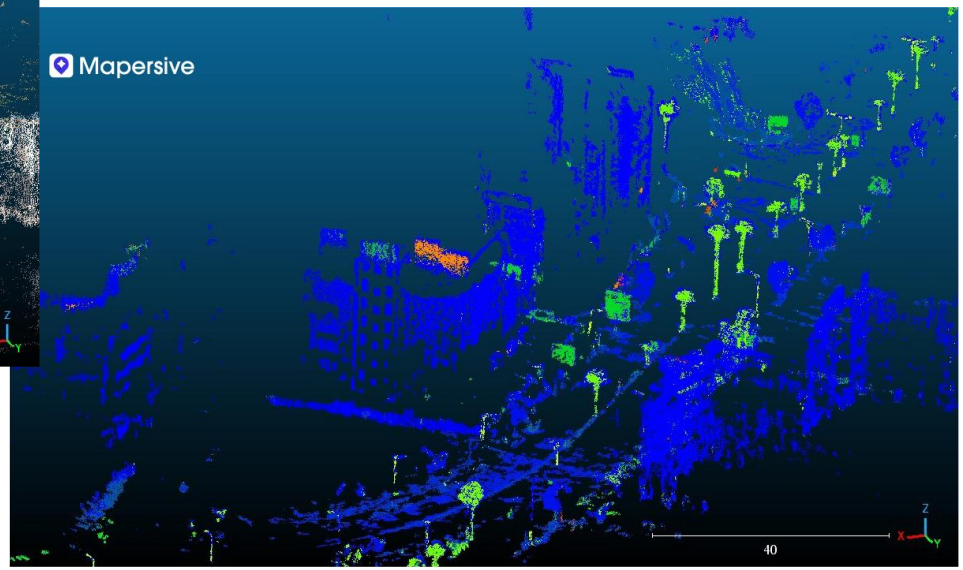


GEOAI FOR DATA EXTRACTION FROM 360 IMAGES

Turning Images into Insights: 360° Imagery to Land-related datasets

Point cloud generation and Segmentation from 360 images:





THANK YOU!

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