# Multi-Class Classification of Urban Regeneration Using a Siamese Network: An Analysis with Real-World Data from Portland, Oregon

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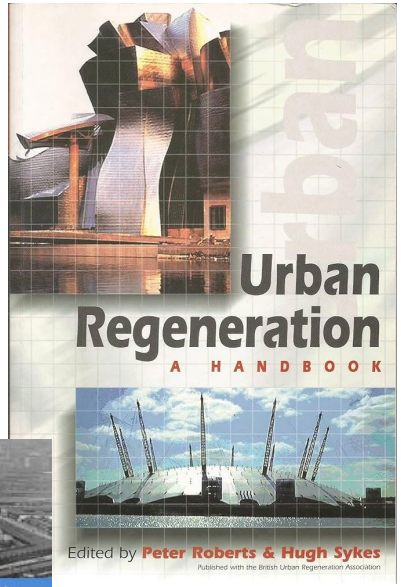
# Global Urban Regeneration Trend

- Urban regeneration is a broad and flexible concept, commonly used to describe the physical and social transformation of a significant portion of a city or a cluster of properties (Lehmann, 2019).

Urban regeneration can take various forms, including:

- smart infill housing,
- development of new infrastructure
- adaptive reuse of historic buildings for workplaces, education, tourism, and cultural initiatives
- Etc



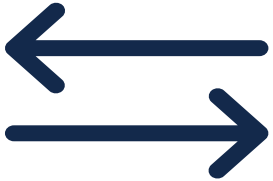

# Detect and Classify Urban Regeneration with AI

## Data Source

Tabular Data

Ground Survey Data

Remote Sensing Data



## AI Method

Tree-based Models (Random Forest, Gradient Boosting)

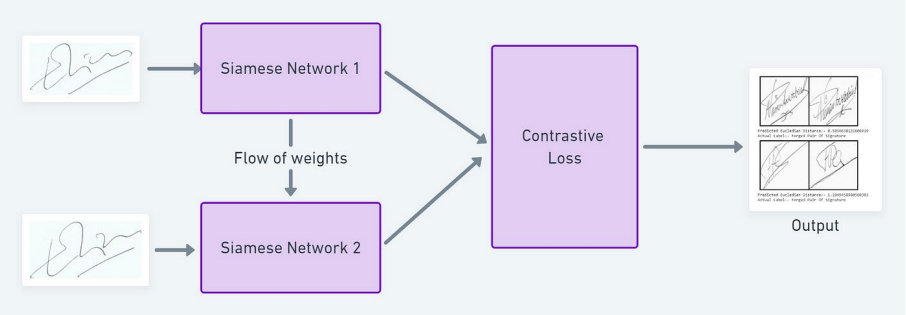
CNNs

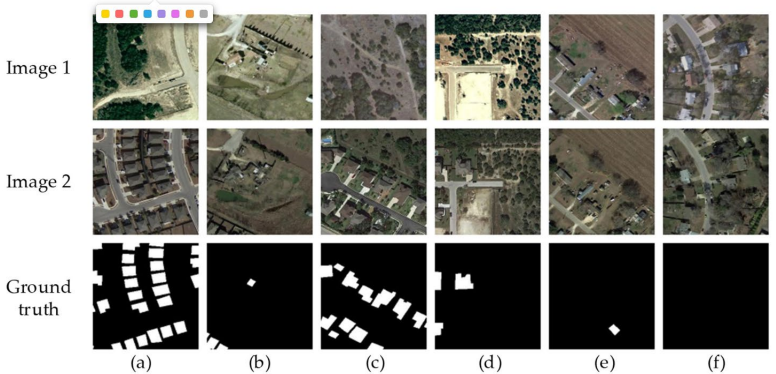
Multimodal LLMs

# The Application of Siamese Network in Urban Regeneration Study

- Originally designed for comparing fingerprint, signatures, and faces.

- Shows great performance in previous study




Haiping Yang, 2023

# Limitation of Current Work

Current Challenge:

1. Reliance on High-Quality Benchmark Datasets.  Does it work well with real-world data - Unstable clarity, little urban change, lots of tree cover

2. Predominance of Binary Classification

3. Urban regeneration should be defined by parcel but not by building

# A Real-World Application Experiment

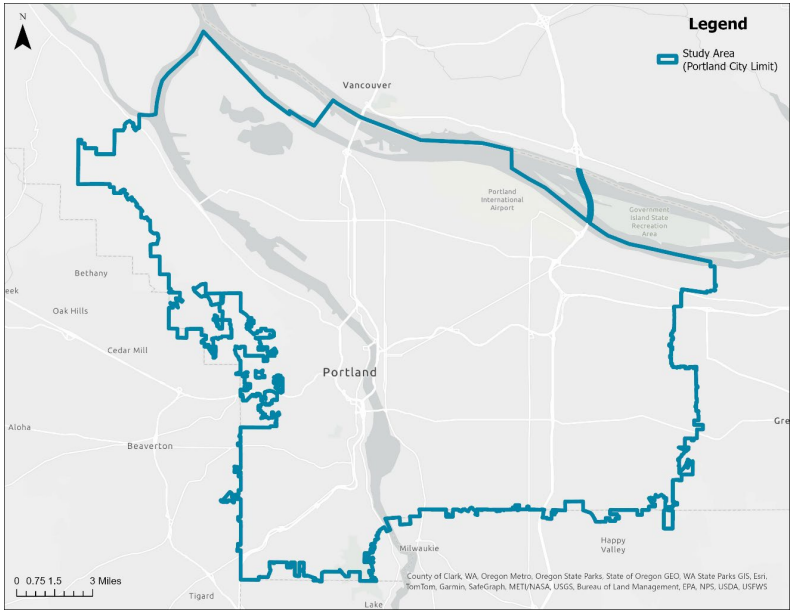
Manually labelled 2000 sample residential parcels from Portland, Oregon with four types of urban changes between 2010 and 2020:

- No Change
- New Development
- Redevelopment
- Demolition

Parcel images are taken from the city orthoimagery program

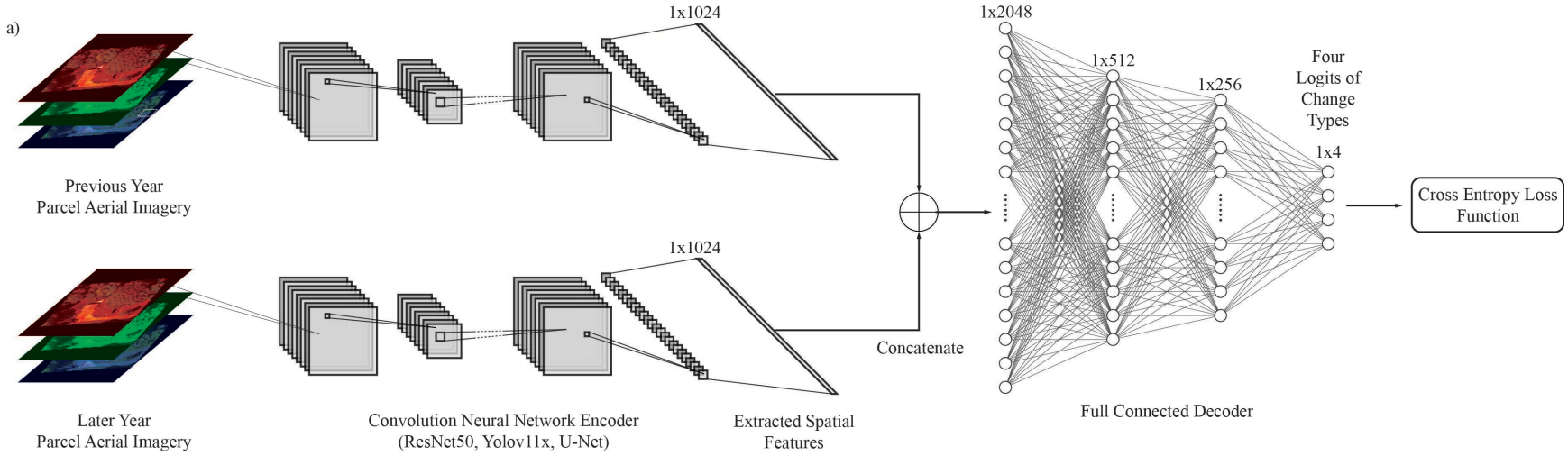
Choose Portland because:

- Different types of regeneration
- Gradual Urban Regeneration
- Different levels of Tree Coverage



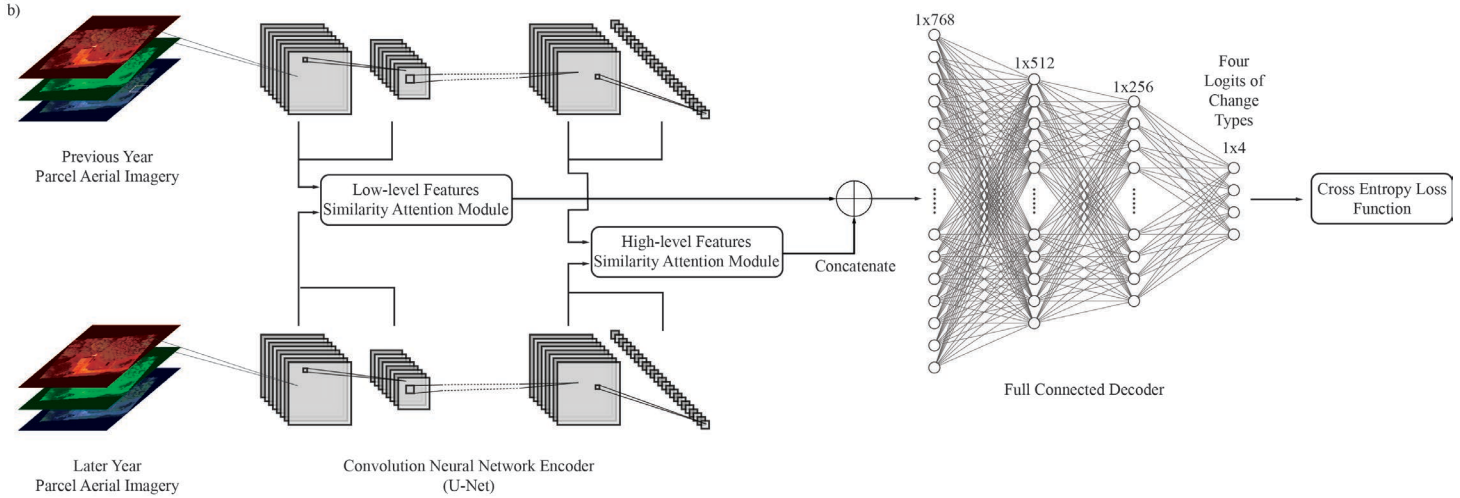
# The Application of Siamese Network in Urban Regeneration Study

- Two Identical CNN Encoders to extract features from Aerial Imagery from previous year and later year
- A Full Connected Decoder to Compare Features and Make Classification Decision
- Optimize by a Cross Entropy Loss Function



# Test if Attention Mechanism Helps to Improve performance

- Many previous studies suggested to use attention mechanism (Lee et al., 2021; J. Li et al., 2022)
- We modified the U-Net model to include a similarity attention mechanism for high-level and low-level features (U-Net was the best among the three backbone)



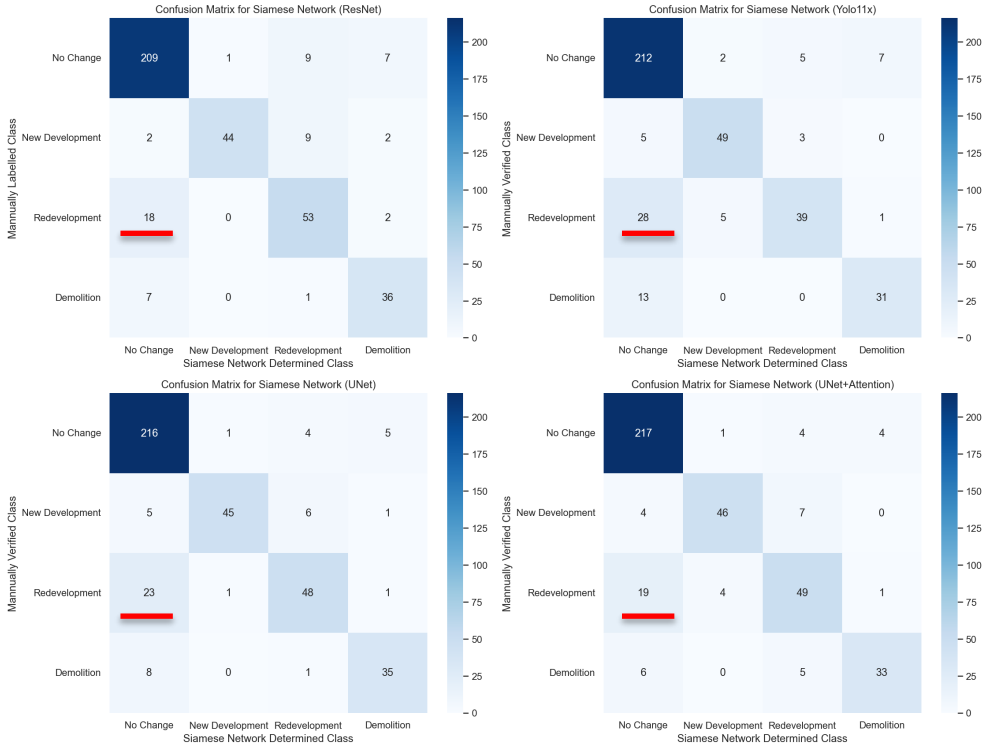
# Model Performance

| Backbone | fold 1 | fold 2 | fold 3 | fold 4 | fold 5 |
|---|---|---|---|---|---|
| ResNet | 85.5 | 85.50 | 81.75 | 84.25 | 84.00 |
| Yolo11x | 80.00 | 80.75 | 80.25 | 82.25 | 82.75 |
| U-Net | 84.25 | **85.75** | 85.50 | **85.75** | 85.50 |
| U-Net + Attention | **86.25** | 84.75 | **86.00** | 84.25 | **86.75** |

U-Net Outperform the other two backbones, but adding attention mechanism did not significantly improve accuracy

# Confusion Matrix

Siamese network can achieve really good accuracy for most classes except
**Redevelopment vs No Change**



# Things that are hard for Computer to “See”


**a) Ground Truth: Redevelopment**
**Siamese Network: No Change**
The main structure did not change; the additional unit location was partially covered by trees in 2010.

**b) Ground Truth: Redevelopment**
**Siamese Network: No Change**
The expansion of the original building is similar in size and texture to the previous hard surface.

**c) Ground Truth: No Change**
**Siamese Network: Demolition**
Part of the original building was covered by tree canopy in 2020.

**d) Ground Truth: No Change**
**Siamese Network: Redevelopment**
The roof of the original building was replaced.

**e) Ground Truth: New Dedevelopment**
**Siamese Network: Redevelopment**
The computer may mistake the car in the upper left corner for a building.

## Advantages of Siamese Network Comparing to Traditional Methods

- Siamese Network has a great potential for Real-World Planning Practice, especially for urban planners operating under budget constraints.

- Only require satellite imagery, which is widely accessible
- More accurate than using building permit records or medium resolution remote sensing data
- Light weight and fast
- Low cost (A Big Problem for the Application of LLM)

## Future Work

- Transfer learning potential
- Local light weight multimodal LLMs (such as llama 3.2-vision)

# Thank you!