Measuring Urban Sprawl with Satellite Imagery

Julia Nguyen

Urban Sprawl: The Negative Effects

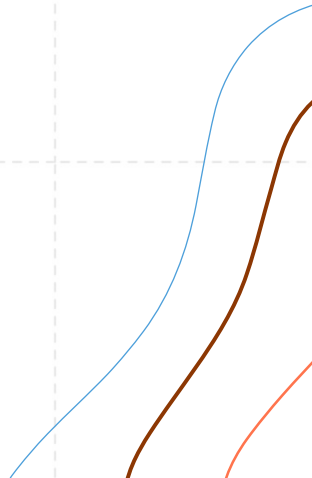Urban Sprawl: Low density, auto-dependent development

Impacts:

- Traffic congestion
- Higher carbon emissions
- Increased air pollution,
- Loss of valuable wildlife habitat
- Negative health impacts: Tied to obesity and respiratory problems

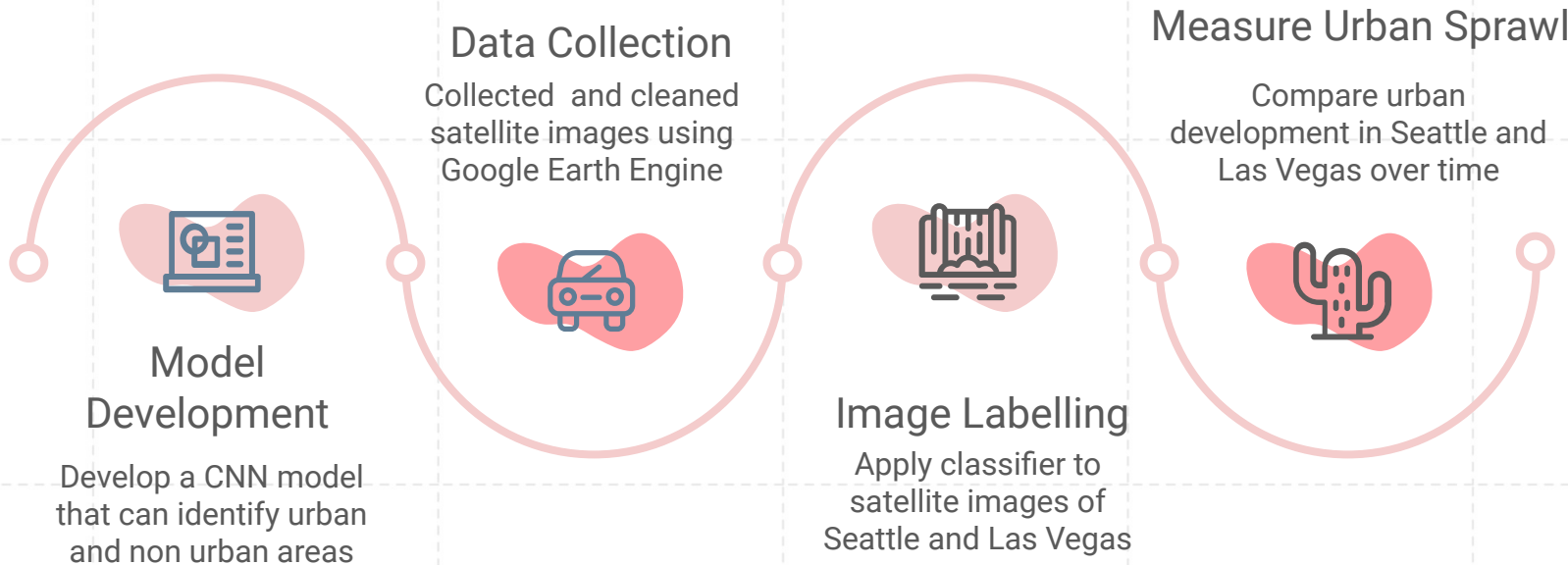# Urban Sprawl: How to Measure

- Land Surveys:
  - Expensive
  - Produced infrequently
  - Subject to measurement problems
- Satellite imagery:
  - High resolution
  - Global scale
  - Flexibility

Project Goal: Develop a model that can detect urban areas using satellite images

Workflow

Data Collection
Collected and cleaned satellite images using Google Earth Engine

Measure Urban Sprawl
Compare urban development in Seattle and Las Vegas over time

Model Development
Develop a CNN model that can identify urban and non urban areas

Image Labelling
Apply classifier to satellite images of Seattle and Las Vegas
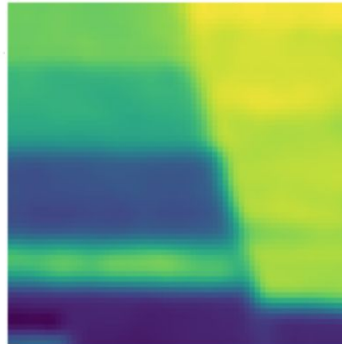
Satellite Data

- Data: 27000 Sentinel-2 labeled satellite images from the German Research Institute of Artificial Intelligence
- Two Overall Categories, 10 subcategories
- **Urban:** Industrial, Residential, Highway
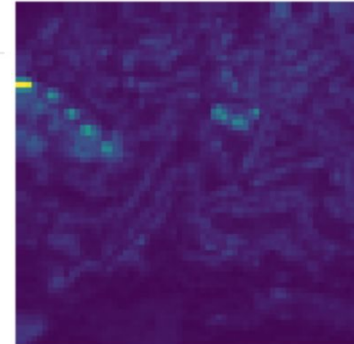- **Non Urban:** Annual Crop, Permanent Crop, River, Sea/Lake, Vegetation, Pasture, Forest.

Pasture
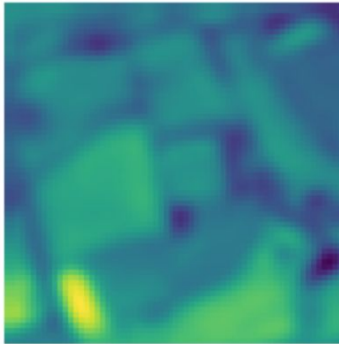
Annual Crop

Residential

Model and Performance

Model: CNN using transfer learning with the fastai library

Predicting 10 Categories Accuracy: 0.94

Examples of Errors:

Predicted: Vegetation
Actual: Permanent Crop

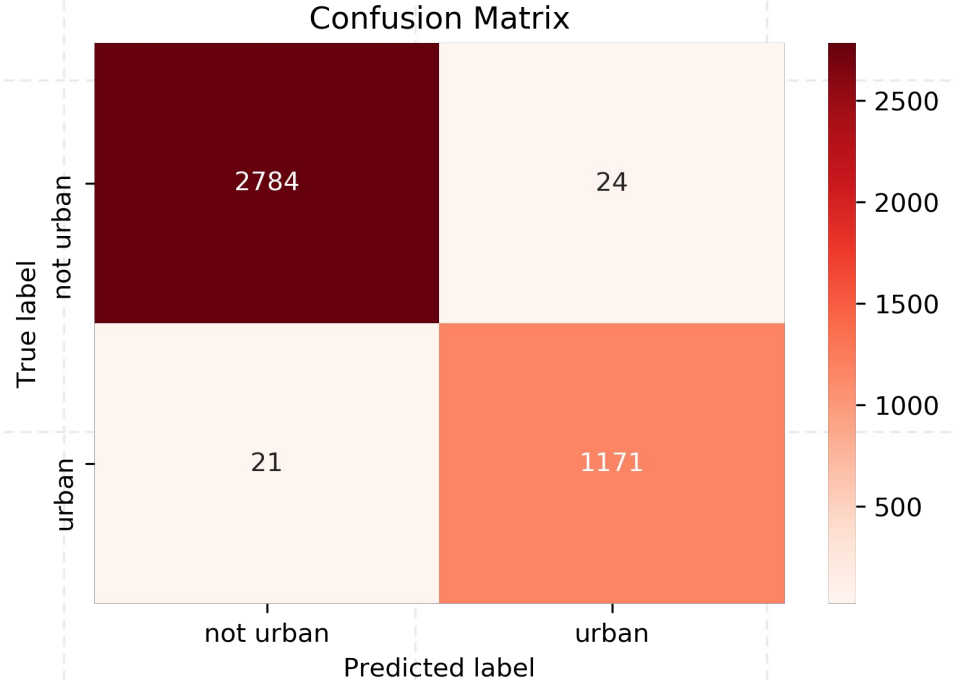Predicted: Pasture
Actual: Annual Crop

Model Performance

Predicting 2 Categories Accuracy
(urban vs not urban): 0.99

Urban Recall: 0.98

Urban Precision: 0.98

Confusion Matrix

	not urban	urban
not urban	2784	24
urban	21	1171

True label / Predicted label
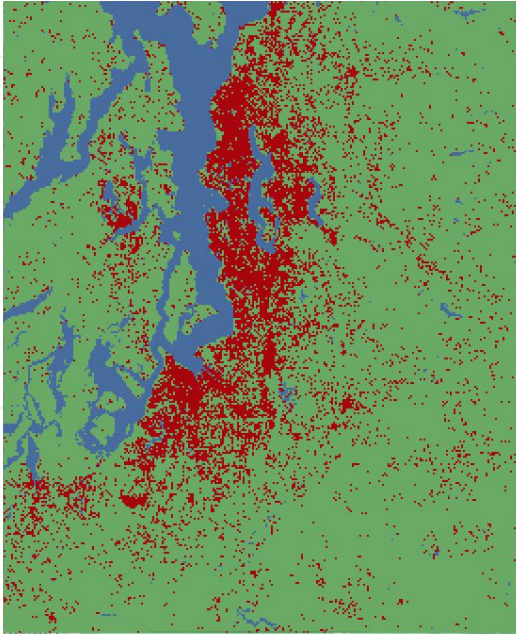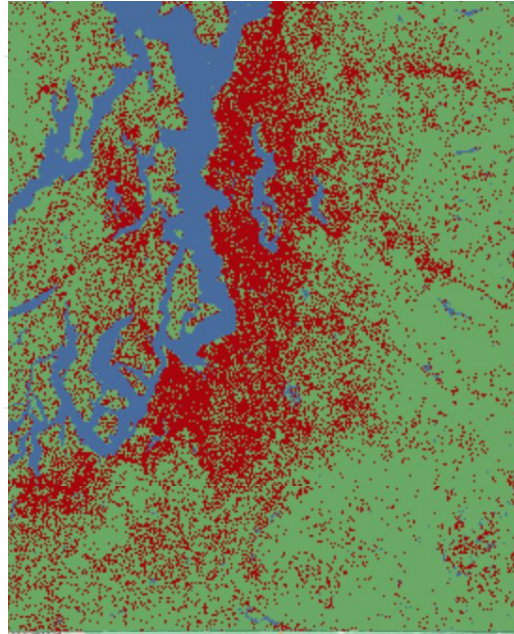
Model Application

Seattle: 2020

Model prediction:
Urban (Residential)
Expect: Urban
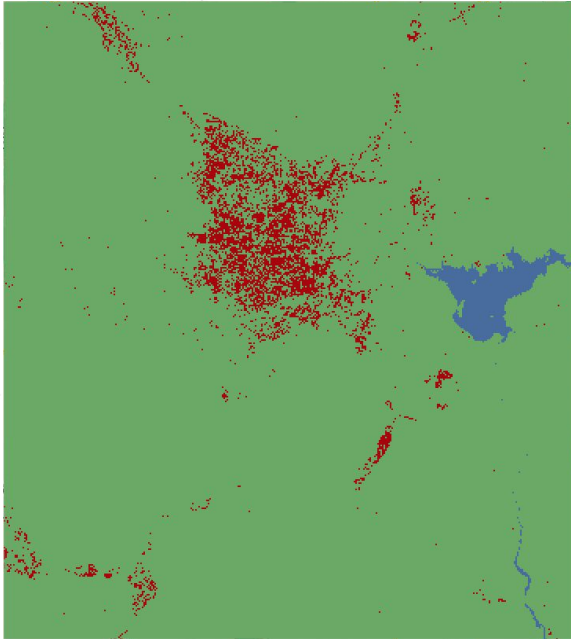
Urban sprawl in Seattle

Seattle: 1984

Seattle: 2020

- 108% growth in developed area
- 77% growth in population
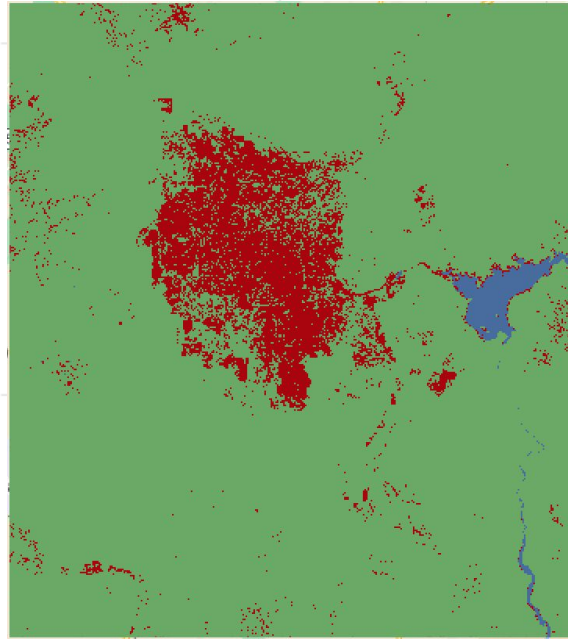- Ratio = 1.4: 1

Legend

water

developed

undeveloped

Urban sprawl in Las Vegas

Las Vegas: 1984

Las Vegas: 2020

- 634% growth in developed area
- 409% growth in population
- Ratio = 1.6:1

Legend
- water
- developed
- undeveloped

Conclusion

- Developed a CNN model that can identify satellite images as urban and not urban with high accuracy.
- Can apply that model to satellite images of Seattle
- Developed a simpler and faster model to look at urban sprawl over time in Seattle and Las Vegas

Thanks!

Questions?

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Future Plans

- Improve visualization of the urban areas in Seattle.

- Look at other cities, like Austin, Las Vegas, etc.

Urban Sprawl: The Negative Effects

Urban Sprawl: Low density, auto-dependent development

- **Economic impacts:** Traffic congestion, increased economic disparity
- Environmental impacts: Higher carbon emissions, increased air pollution, loss of valuable wildlife habitat
- Health impacts: Tied to obesity and respiratory problems

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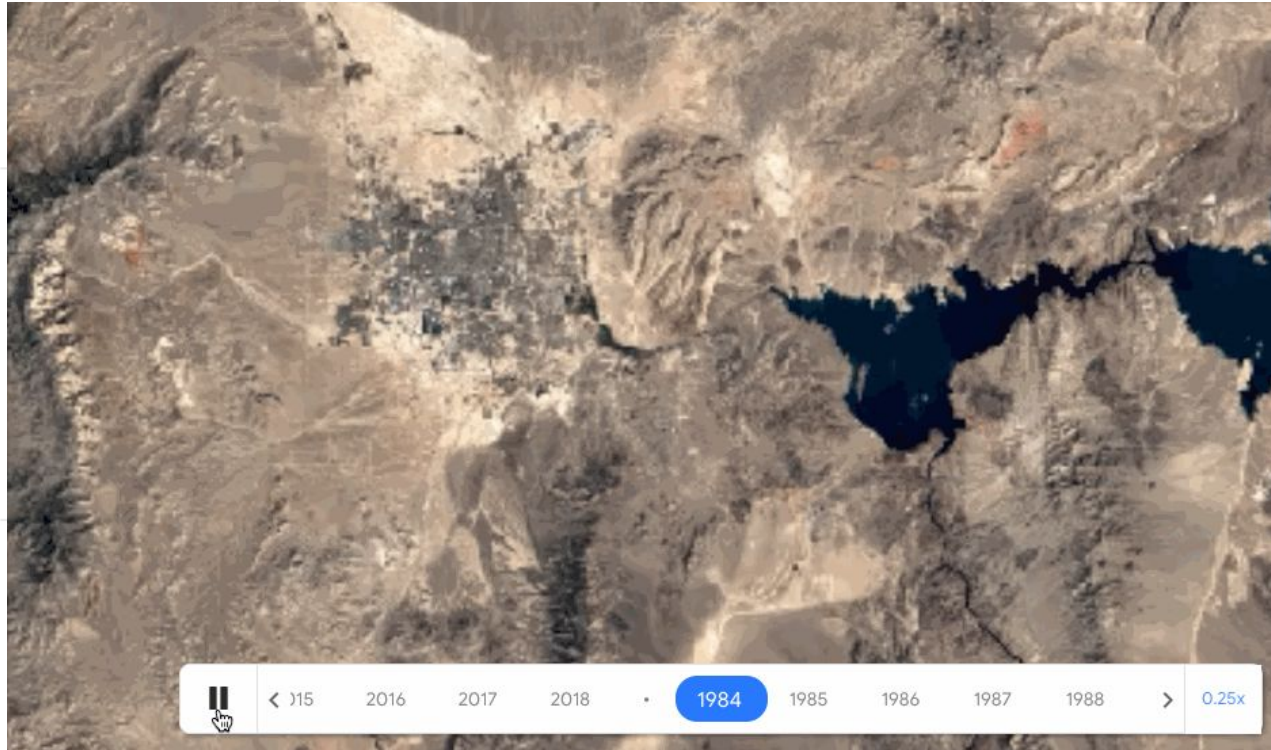
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Seattle Urban Sprawl: 1984-2018
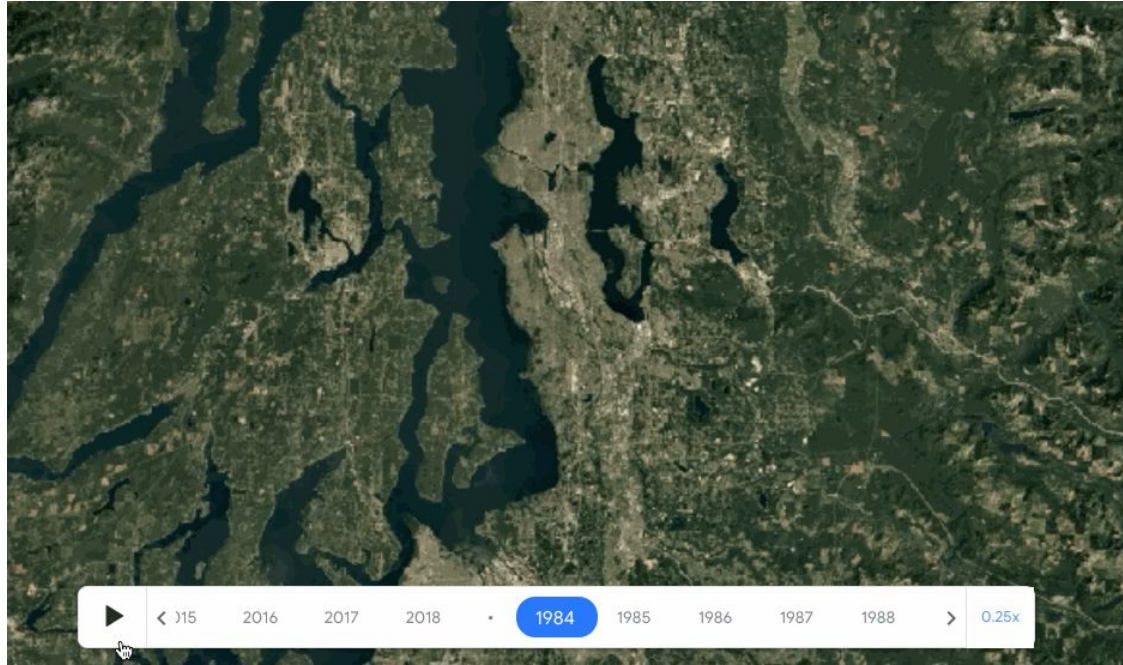
Las Vegas Urban Sprawl: 1984-2018

Satellite Data

Band	Spatial Resolution m	Central Wavelength nm
B01 - Aerosols	60	443
B02 - Blue	10	490
B03 - Green	10	560
B04 - Red	10	665
B05 - Red edge 1	20	705
B06 - Red edge 2	20	740
B07 - Red edge 3	20	783
B08 - NIR	10	842
B08A - Red edge 4	20	865
B09 - Water vapor	60	945
B10 - Cirrus	60	1375
B11 - SWIR 1	20	1610
B12 - SWIR 2	20	2190

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Permanent Crop