# 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

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# Urban Sprawl: How to Measure

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

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

# Workflow

## Model Development

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

## Data Collection

Collected and cleaned satellite images using Google Earth Engine

## Image Labelling

Apply classifier to satellite images of Seattle and Las Vegas

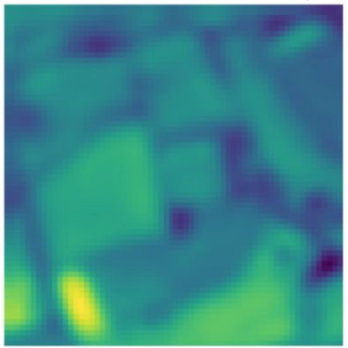
## Measure Urban Sprawl

Compare urban development in Seattle and Las Vegas over time

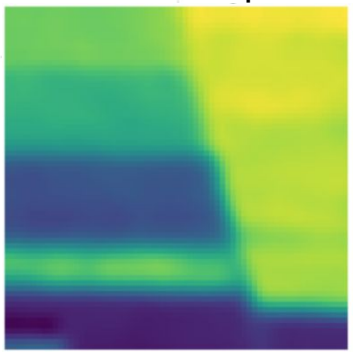
# Satellite Data

- 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.

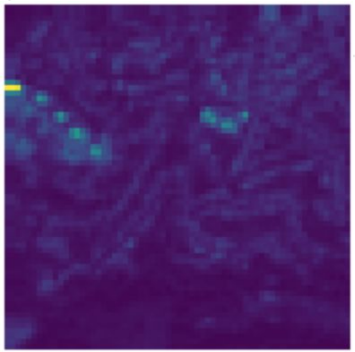
Pasture



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

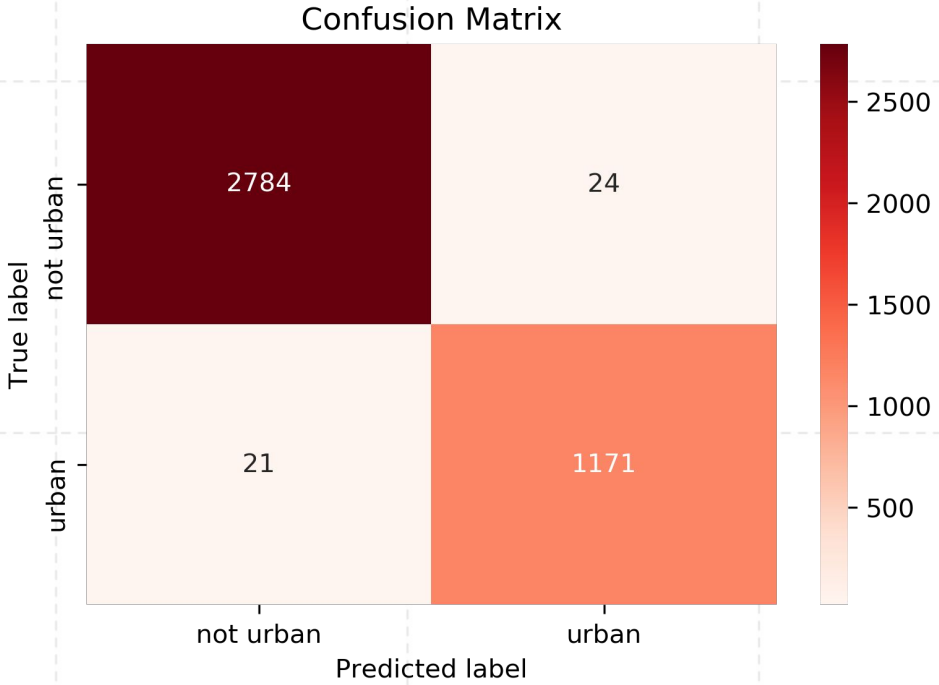
Predicted: Pasture
Actual: Annual Crop

# Model Performance

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

Urban Recall: 0.98

Urban Precision: 0.98



# Model Application

Seattle: 2020

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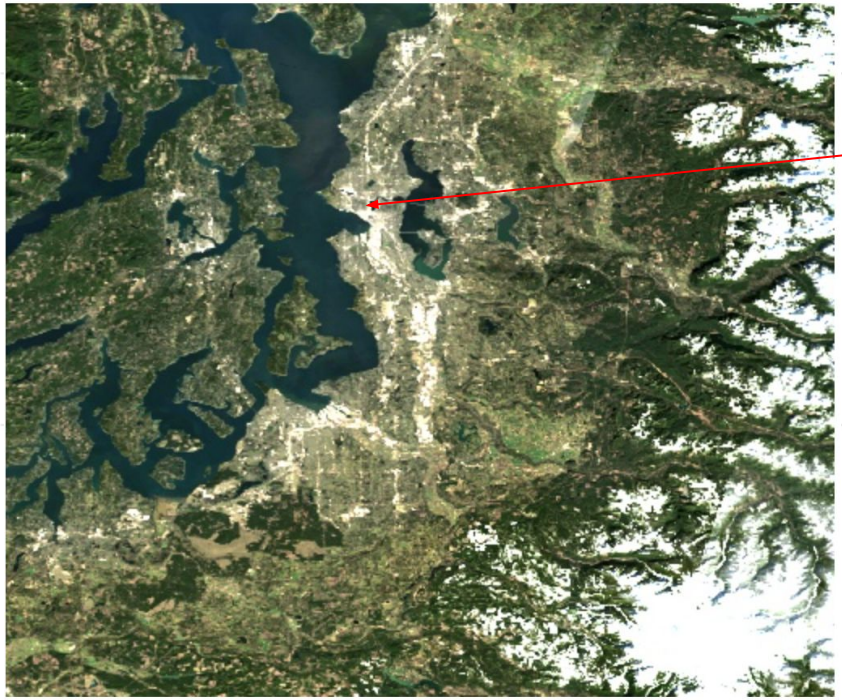

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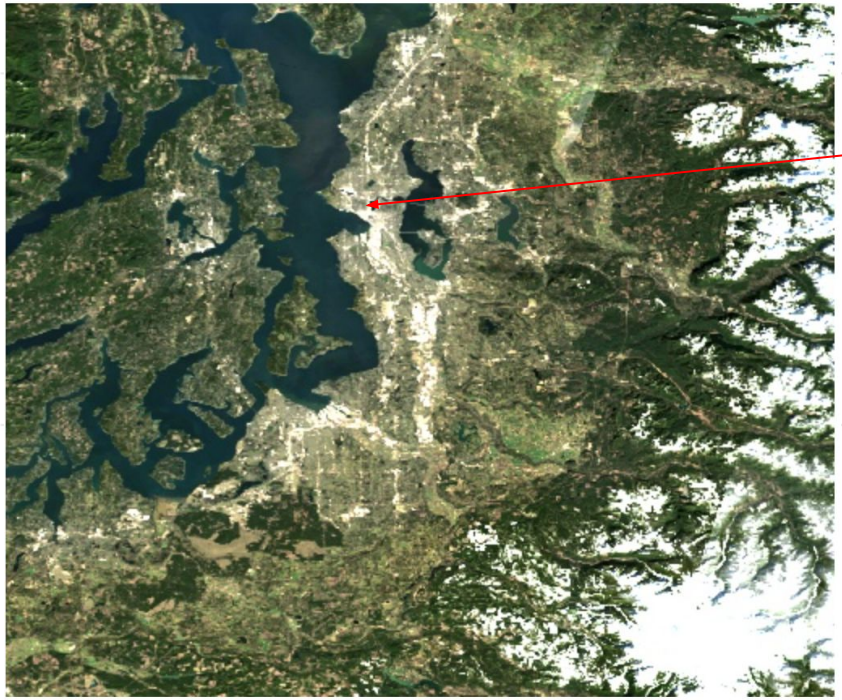
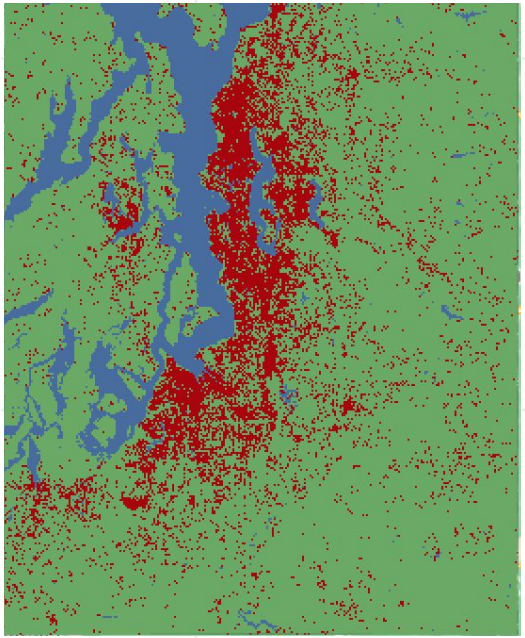


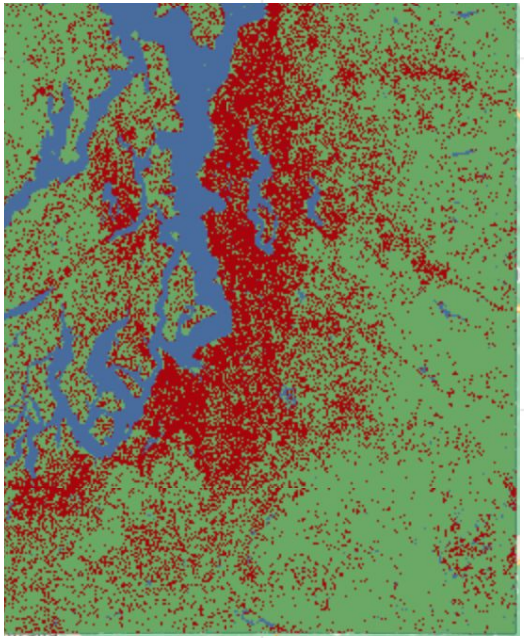
Model prediction:
Urban (Residential)

# Urban sprawl in Seattle

Seattle: 1984



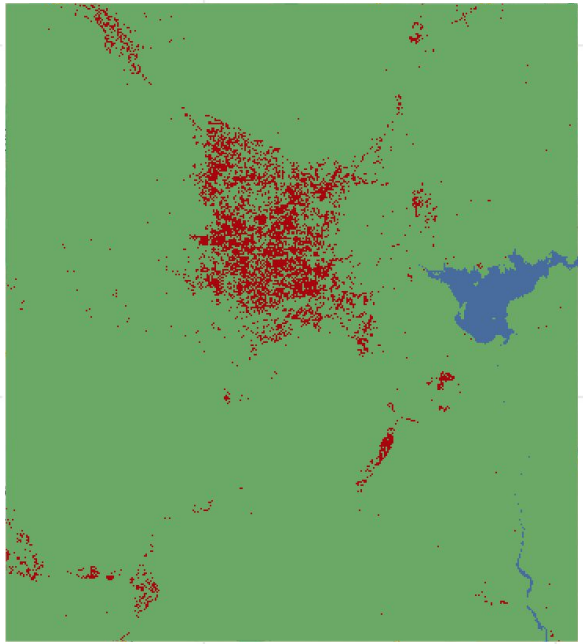
Seattle: 2020



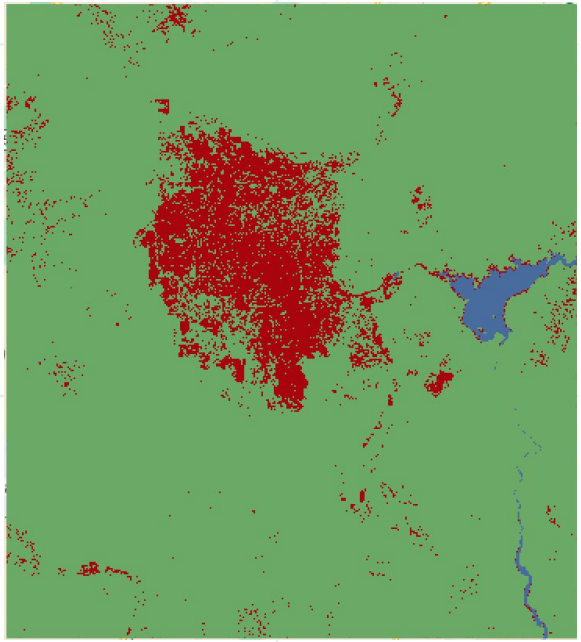
- 108% growth in developed area
- 77% growth in population
- Ratio = 1.4: 1

# Urban sprawl in Las Vegas

Las Vegas: 1984



Las Vegas: 2020



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

# 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

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- 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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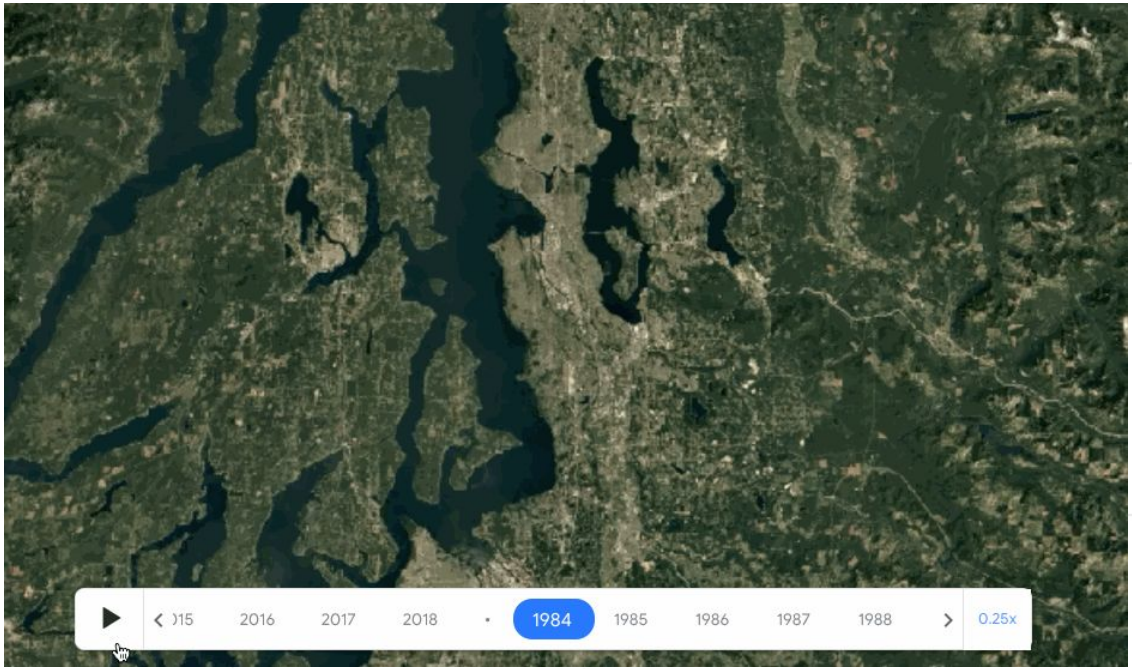
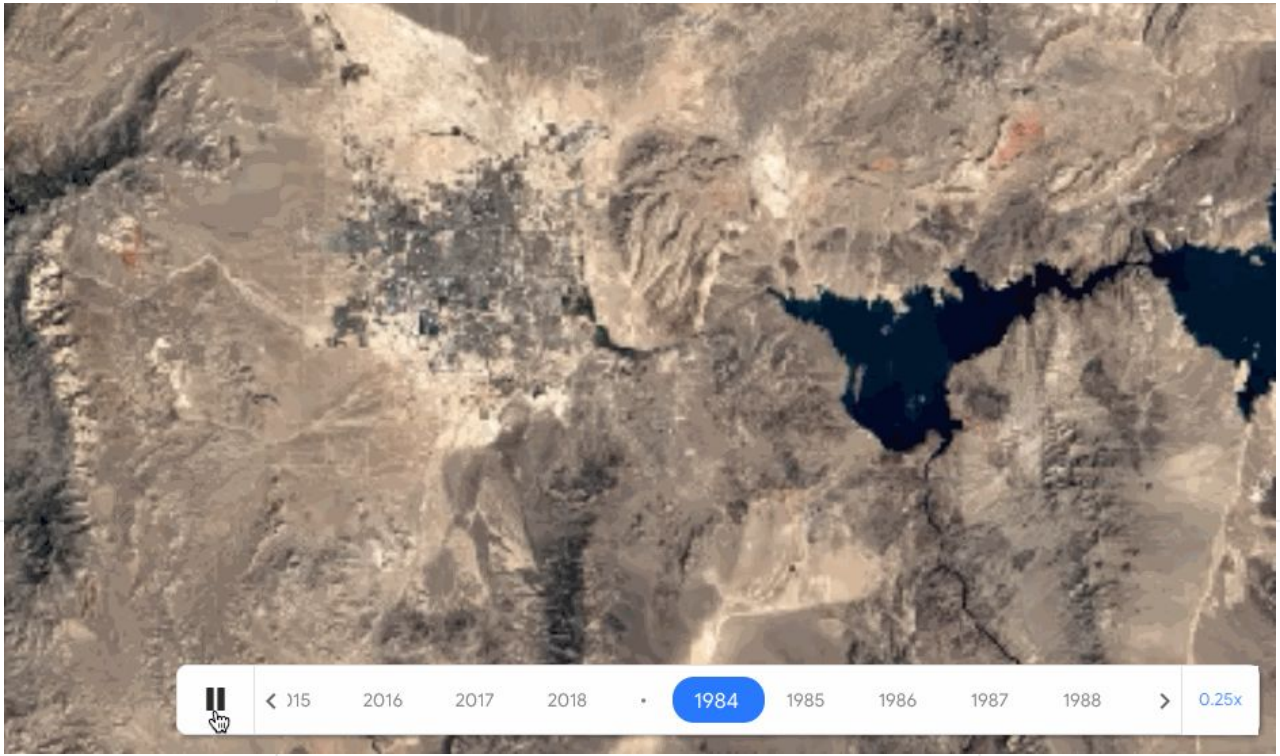
# Seattle Urban Sprawl: 1984-2018



# 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