December 12, 2024

UC BERKELEY
CAPSTONE 210
FALL 2024

SolarScape.AI

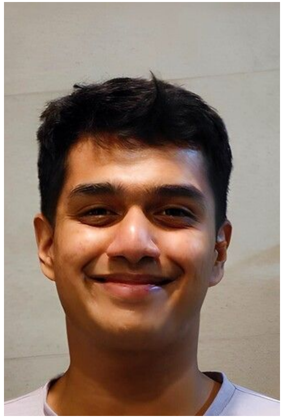
Go for Solar

Luis Cartagena, Alexandra Daniels, Nayan Ganguli, Jacob Jones, & Saurabh Pattarkine

OUR TEAM

Luis Cartagena

Alexandra Daniels



Nayan Ganguli

Jacob Jones

Saurabh Pattarkin
e

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PROBLEM

Solar Potential Uncertainty

Difficulty in accurately assessing solar potential due to factors like roof obstructions and complex property layouts

Limited Scalability

Existing tools like *Google's Project Sunroof* often lack the scalability and accuracy needed for commercial and industrial applications

MARKET OPPORTUNITY

Booming Market

Global solar market is projected to reach USD 436.36 billion by 2032*

Market Gap

Addresses the limitations of existing solutions and expands to commercial and industrial sectors

Enhanced Accuracy

Surpasses Project Sunroof by accurately detecting roof obstructions (e.g. HVAC units), trees, open land, and parking lots

*Source: https://www.fortunebusinessinsights.com/industry-reports/solar-power-market-100764

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INTERVIEWS WITH INDUSTRY EXPERTS

Subject Matter Expert (SME)	Industry/Domain
Nicholas Brown	Utility Scale Solar and Wind Development
Chris Wheat	CEO - Policy & Government Affairs
Eugene Heimann	Large-Scale Solar Development
Matt O’Dell	Large Land Owner
Sanjay Singh	Machine Learning & Amazon Web Services
Emmanuel Bonsu	Software Engineer & Amazon Web Services
Vasha DuTell	UC Berkeley & MIT Computer Vision
Daniel, Katy, Benj, and Kate Jones	Recent Residential Solar Purchasers

OUR TARGET USERS

New Mexico

Ranked 2nd for potential solar-generated electric power production*

Residential

Homeowners interested in installing solar panels on their homes

Businesses

Companies interested in offsetting operating costs and carbon emissions

*Source: https://www.nmstatelands.org/divisions/commercial-resources/renewable-energy/

PRODUCT FEATURES

Accurate Predictions

Calculate the solar energy potential of your commercial business or home

Financial Analysis

Summarize cost savings and break-even point

Rooftop Obstruction Detection

Identify objects that may block sunlight or complicate equipment installation

Viability Assessment

Determine the feasibility of adopting solar

OUR MISSION

Empowering businesses and communities with intelligent solar solutions powered by advanced computer vision.

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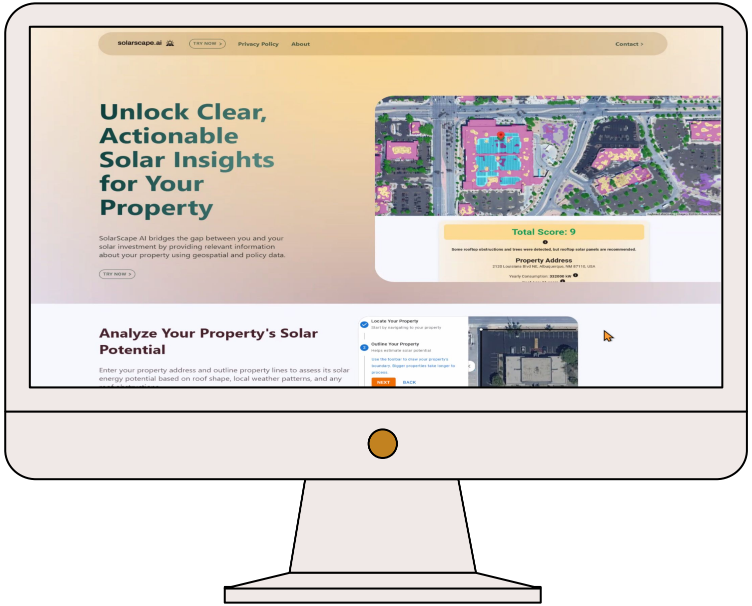
PRODUCT DEMO



DATASETS & APIs

Data

DSIRE
Policy & Incentives

USA Structures
FEMA

Google

Geocoding
API

Solar
API

Maps
API

GOOGLE API

Geocoding API

Converts the address into geographic coordinates

Solar API

Evaluates the roof’s solar potential energy

- LatLngBox
- SolarPotential
- SizeAndSunshineStats
- RoofSegmentSizeAndSunshineStats
- SolarPanel
- SolarPanelOrientation
- SolarPanelConfig
- RoofSegmentSummary
- FinancialAnalysis
- Money
- FinancialDetails

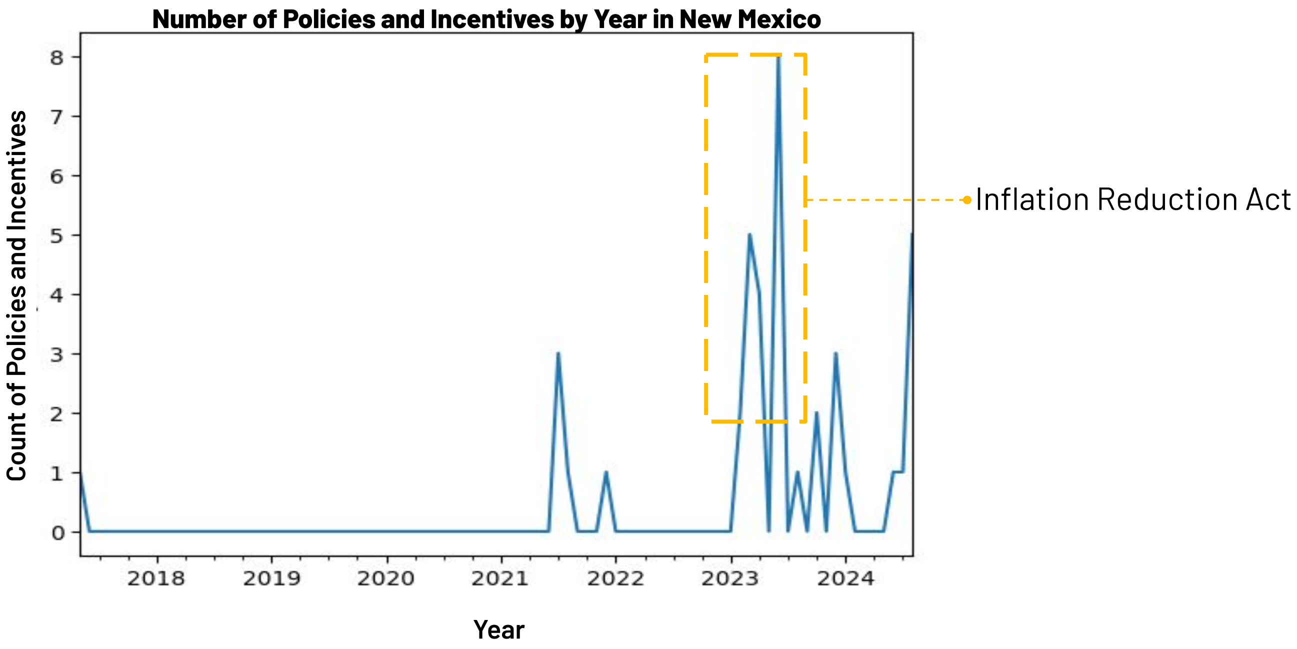
JSON representation

```
{
  "maxArrayPanelsCount": integer,
  "panelCapacityWatts": number,
  "panelHeightMeters": number,
  "panelWidthMeters": number,
  "panelLifetimeYears": integer,
  "maxArrayAreaMeters2": number,
  "maxSunshineHoursPerYear": number,
  "carbonOffsetFactorKgPerMwh": number,
  "wholeRoofStats": {
    object (SizeAndSunshineStats)
  },
  "buildingStats": {
    object (SizeAndSunshineStats)
```

DSIRE

20+ years of incentives and policies that support energy efficiency and renewable energy

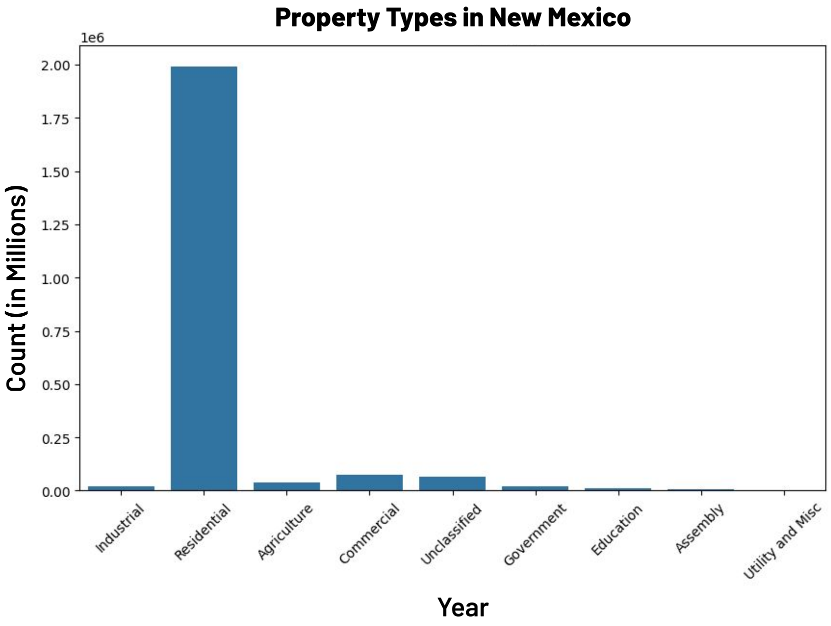
Focused on New Mexico's policy and incentive details



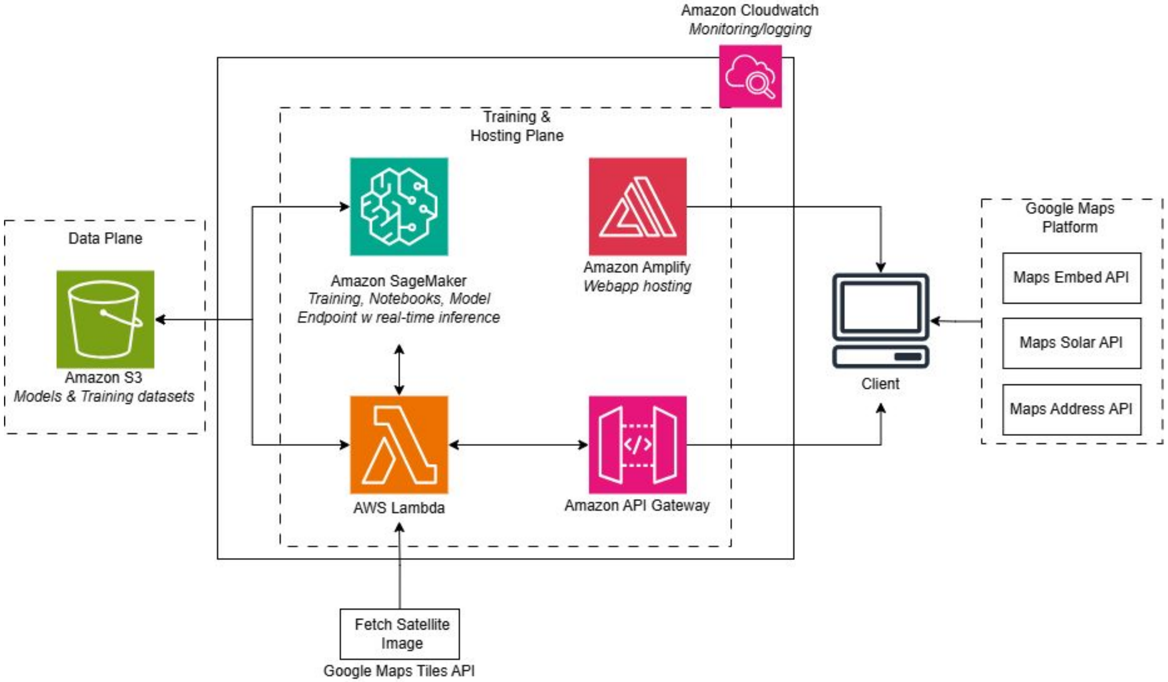
USA STRUCTURES

Footprints for all USA structures larger than 450 square feet; maintained by FEMA

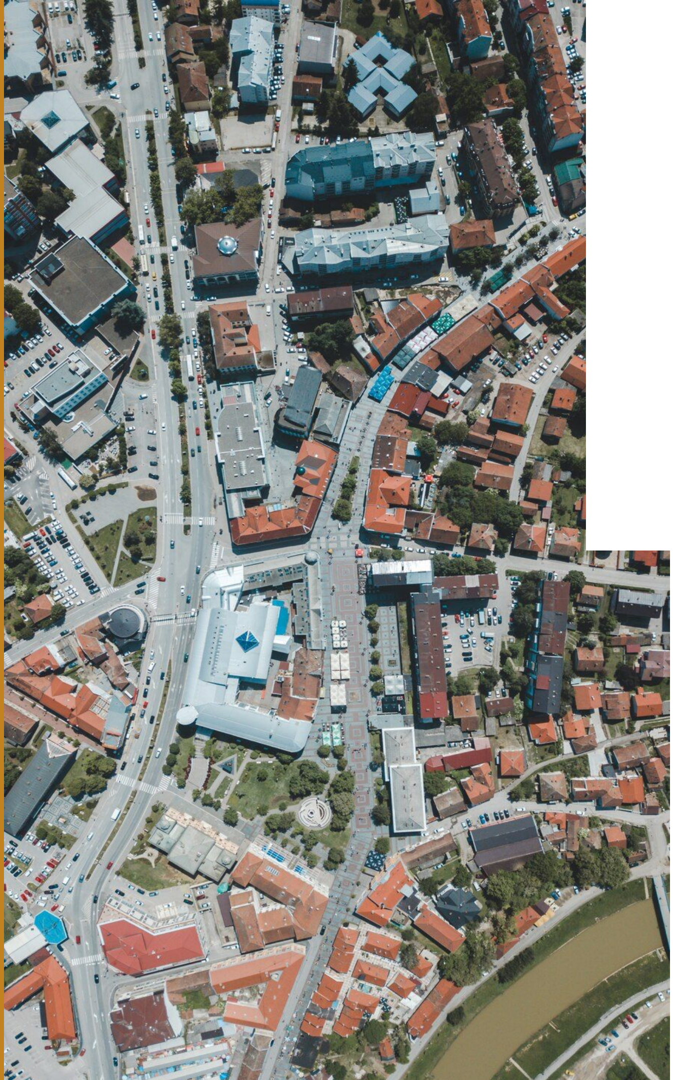
Focused on New Mexico's properties



PRODUCT ARCHITECTURE & PIPELINE



Task	Tool/Service Used	Reason
Web app hosting	*AWS Amplify*	*Ease of use*
Web app (frontend)	*React*	*Integration*
CV model training & hosting	*AWS Sagemaker, Lambda, API Gateway, Google Colab*	*Credits & ease of use*
Data storage	*Amazon S3*	*Credits & ease of use*
Maps embed in browser	*Google*	*Credits & ease of use*



MODELING APPROACH

Examine satellite images at the pixel level to capture fine-grained details and accurately identify rooftop obstructions and property boundaries

GOOGLE MAPS API

Randomly selected images across rural, residential and commercial areas in New Mexico

Example Images

Image Size: 1024x1024 Pixels

Zoom Level: 17

Type: RGB Composite Layers

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LABELBOX

Labeled 25 images for image segmentation

Each image had one labeler and one reviewer

7 classes: Background, Open Land, Parking Lot, Roof, Roof Obstruction, Solar Panel and Trees

Labeled Images

IMAGE AUGMENTATION

Increased images to 150

80% used for model training and 20% used for model validation

Original

Horizontal Flip

Vertical Flip

90° Rotations

MODELS EXPLORED

YOLO

Pros: Fast Inference
Cons: Requires labels to fine-tune
IOU Score: 0.1572
DICE Score: 0.2541

STEGO

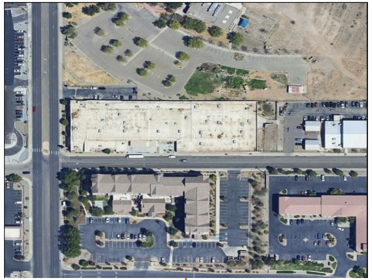
Pros: Self-Supervised Learning; no labels needed
Cons: Unresolvable Dependency Issues
Val: N/A

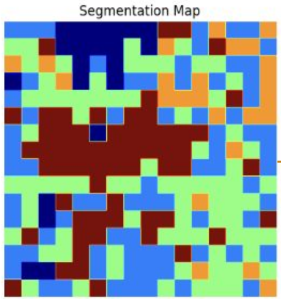
Final Model

DINOv2

Pros: Self-Supervised Learning; not many labels needed to fine-tune; computationally efficient
Cons: Dependency Issues (resolvable!)
IoU Score: 0.4801
DICE Score: 0.5795

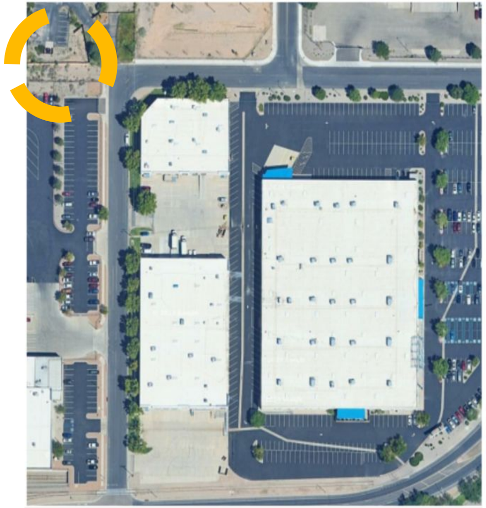
EARLIEST DINOv2 RESULTS



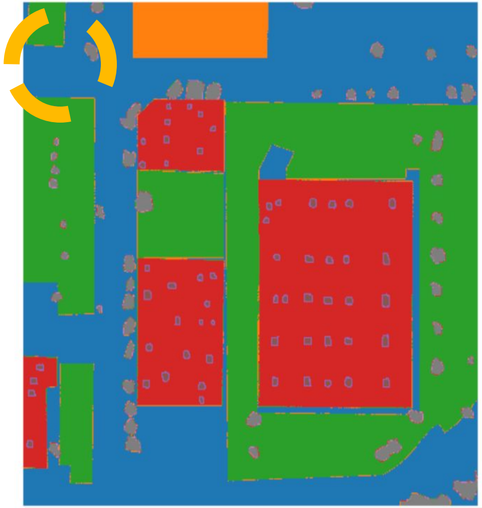


DINOv2 Untrained

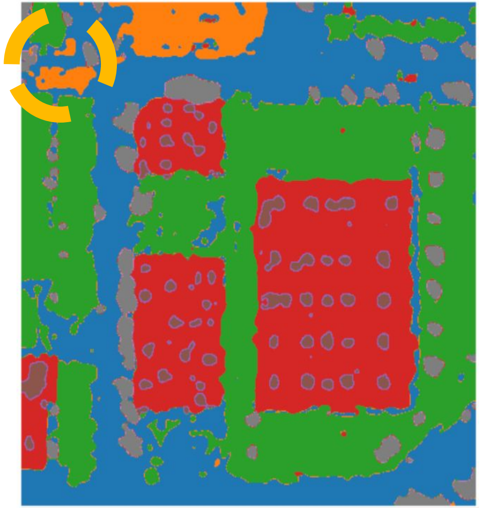
LATEST DINOv2 RESULTS



Original



Training Data



Model Output

Legend:

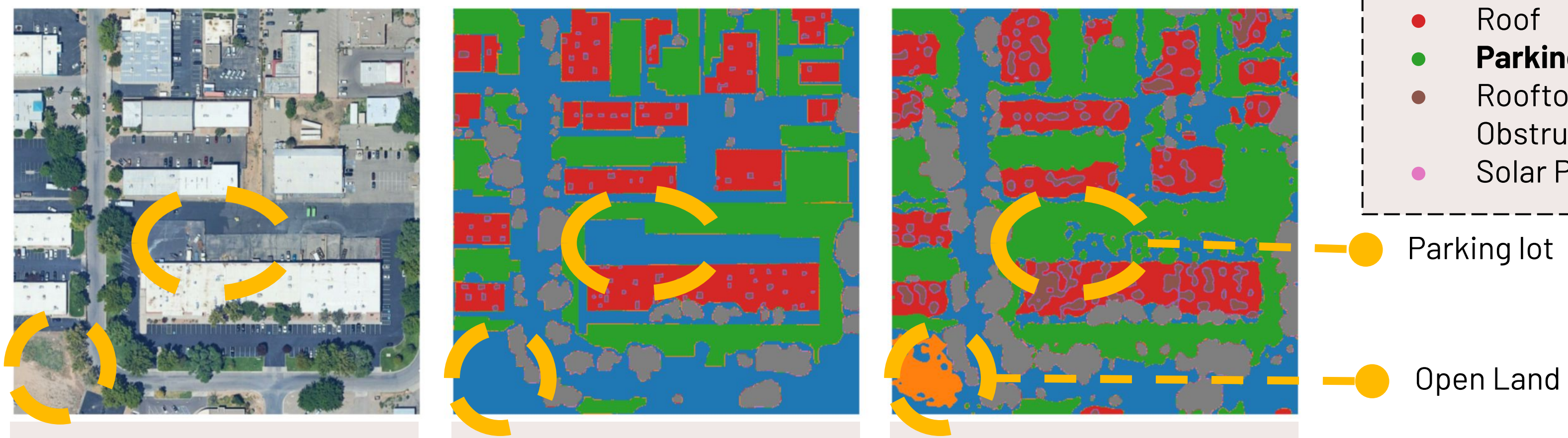
- Background
- Trees
- **Open Land**
- Roof
- Parking Lot
- Rooftop Obstruction
- Solar Panels

DINOv2 LIMITATIONS

Our training data is imperfect

In this case, the model is picking up on potential open land that we did not identify

Legend:
- Background
- Trees
- **Open Land**
- Roof
- **Parking Lot**
- Rooftop Obstruction
- Solar Panels



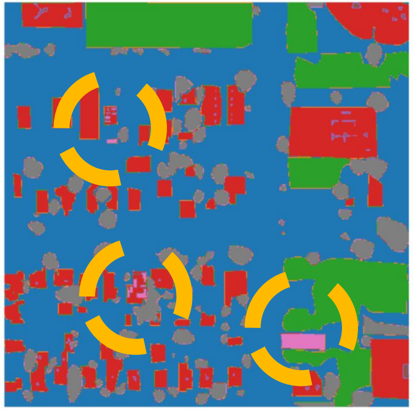
Original | **Training Data** | **Model Output**

DINOv2 LIMITATIONS

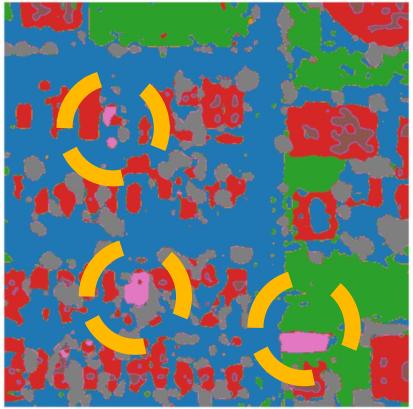
Existing solar panels made up only 0.19% of pixels in our training data (235k pixels)

As a result, despite successful identification of solar panels, the shape can be unreliable

Original



Training Data



Model Output

Legend:

- Background
- Trees
- Open Land
- Roof
- Parking Lot
- Rooftop Obstruction
- **Solar Panels**

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DINOv2 LIMITATIONS

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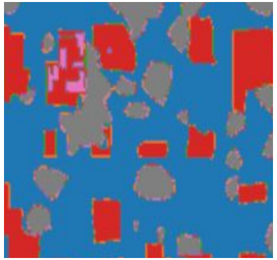
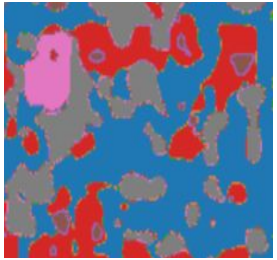


Training Data



Model Output

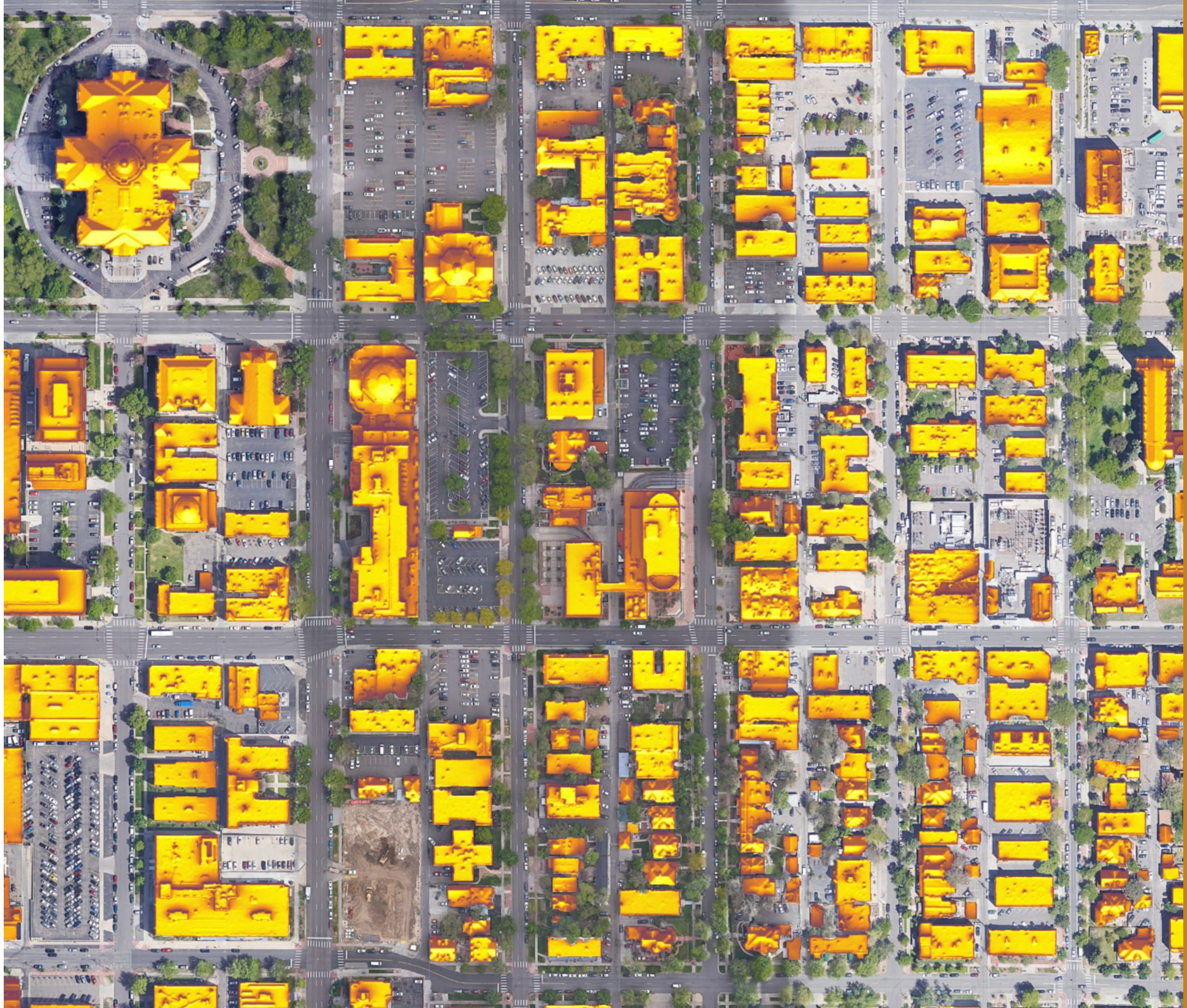
Legend:

- Background
- Trees
- Open Land
- Roof
- Parking Lot
- Rooftop Obstruction
- **Solar Panels**

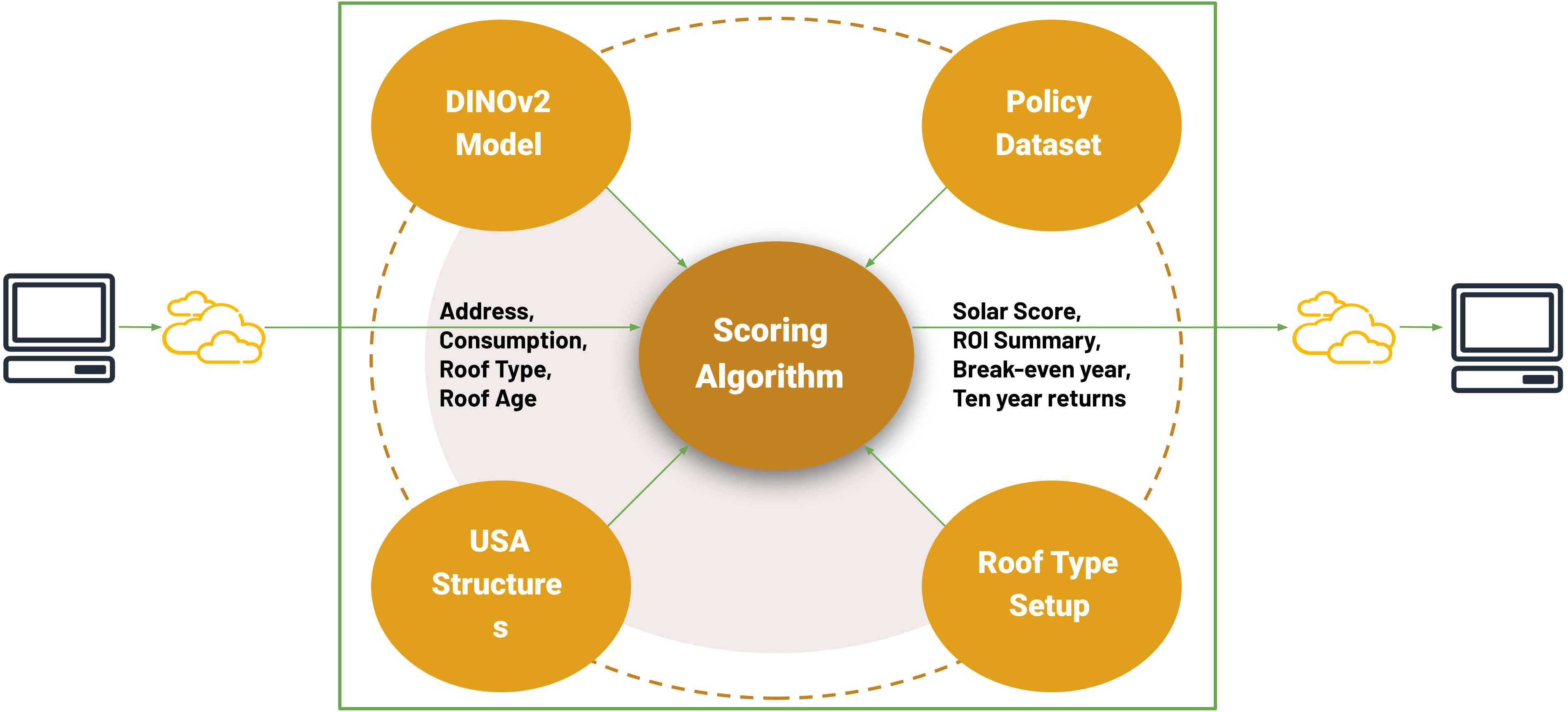
DINOv2 LIMITATION S

Inference time

There is loading time associated with real time inference in the backend

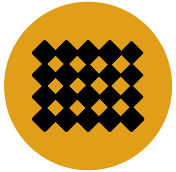


SCORING ALGORITHM



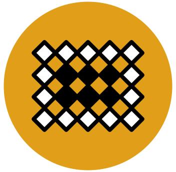
SCORING ALGORITHM

Run Whole Image Through the Model



Whole Image (pixels):
0: 2650342,
1: 186515,
2: 1221964,
3: 1031684,
4: 215823,
5: 29617,
6: 206344,

Limit to Pixels in the Bounding Box

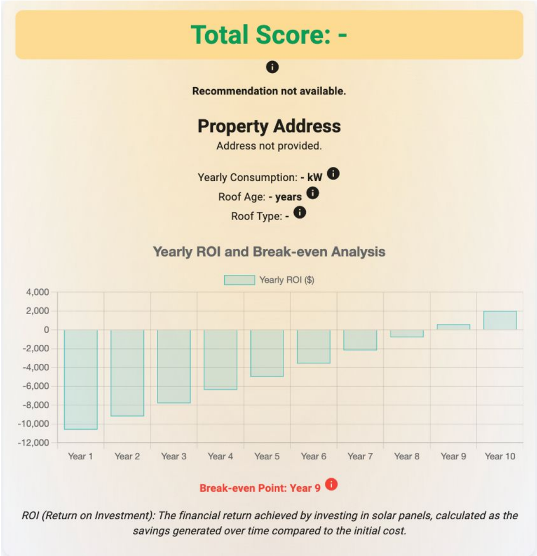


Bounding Box (pixels):
0: 2800,
1: 1860,
Roof: 1200,
Obstruction: 60,
4: 2150,
5: 2960,
6: 2100,

Run Calculations

```
units: "% (Pixels)"
thresholds:
  low:
    min: 0
    max: 10
  moderate:
    min: 11
    max: 25
  high:
    min: 26
    max: 100
simple_score:
  low: 2
  moderate: 1
  high: 0
```

Compute Results



TECHNICAL TAKEAWAYS

01. Obstruction Detection

Image labeling and segmentation

02. Dynamic Property Bounds

Images are selected at zoom level 17 to ensure obstruction are captured

03. Custom Scoring Algorithm

Makes product robust and scalable

04. AWS Architecture

Journey with Sagemaker

OUR NEXT STEPS

- Expand Beyond New Mexico
- Continue Fine-Tuning Model
- Enhance Scoring Algorithm
- Develop Role-based GUIs
- Go to Market!?

"I'd put my money on the sun and solar energy. What a source of power!”

—Thomas Edison

Appendix

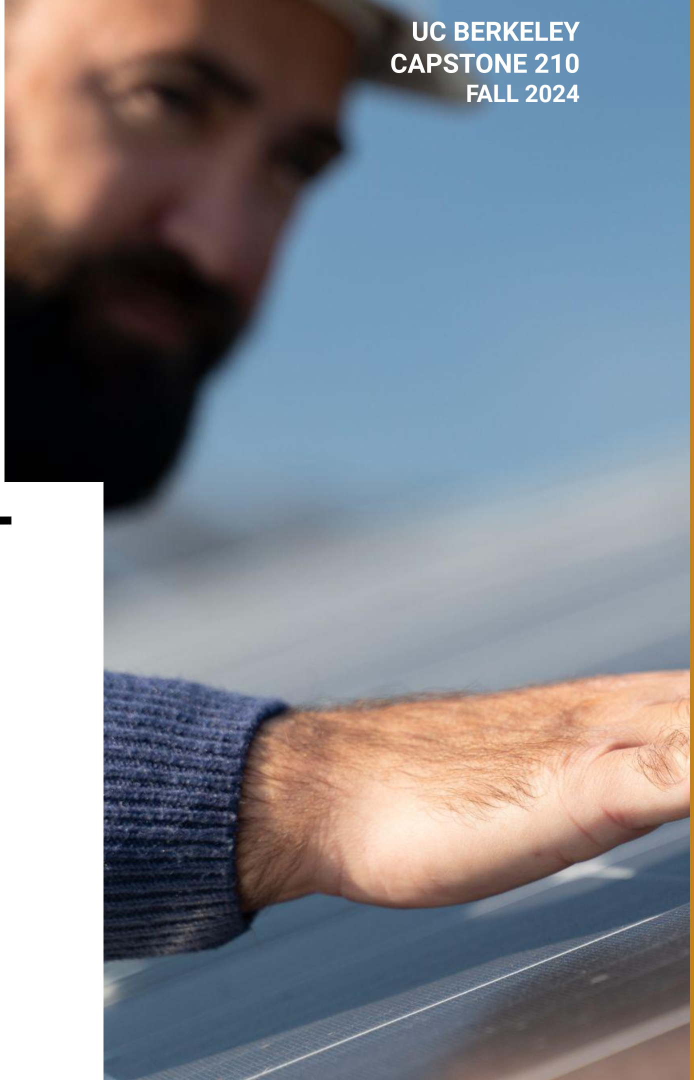
THANK YOU!

Joyce Shen & Korin Reid

Capstone 210 Section 7

SMEs:

- Nicholas Brown
- Chris Wheat
- Eugene Heimann
- Matt O'Dell
- Sanjay Singh
- Emmanuel Bonsu
- Vasha DuTell
- Daniel, Katy, Benj and Kate Jones



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