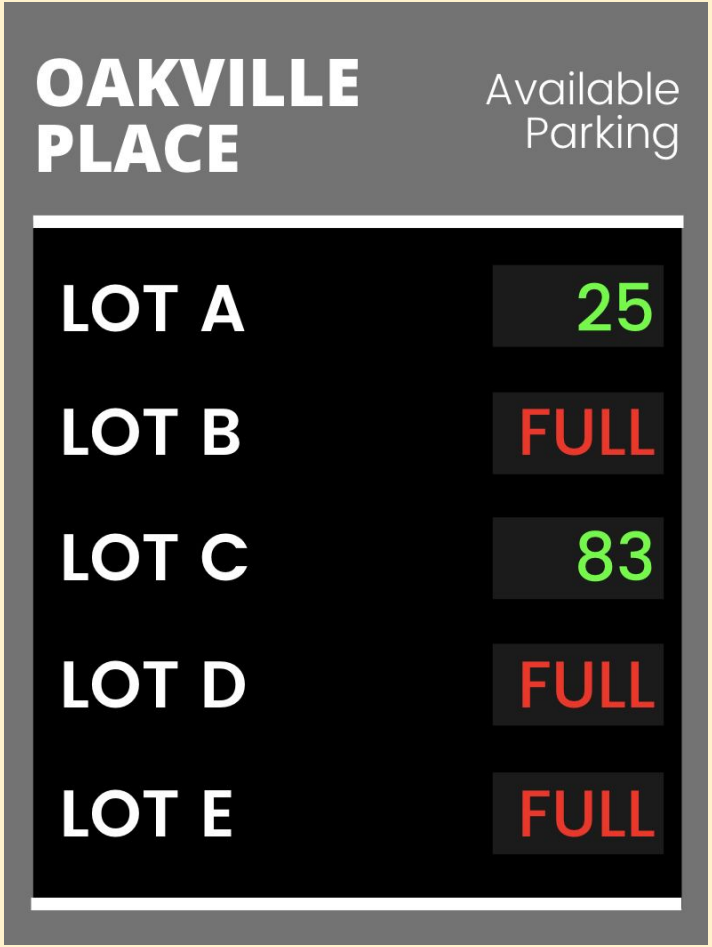
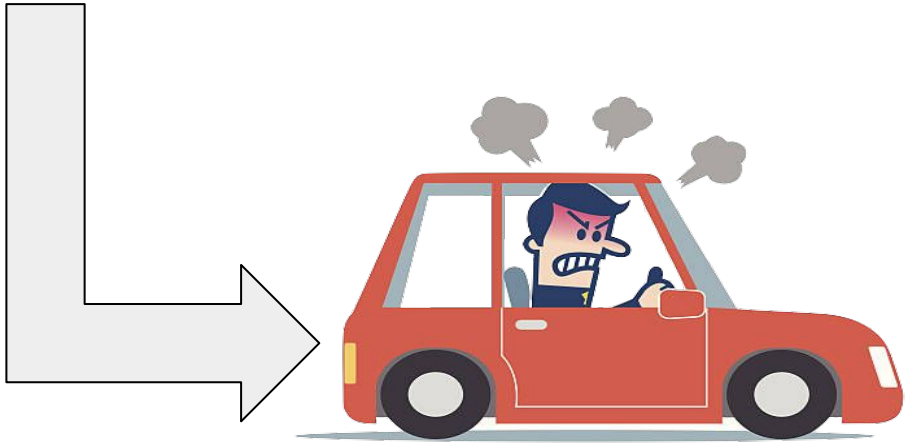
The Parking Lot Predicament

APS360 - Group 21

Michael Boyadjian, Matthew Ing, Scott Oxholm, and Olivia Tracey




OH NO!
Where will I park?



Angry Customers

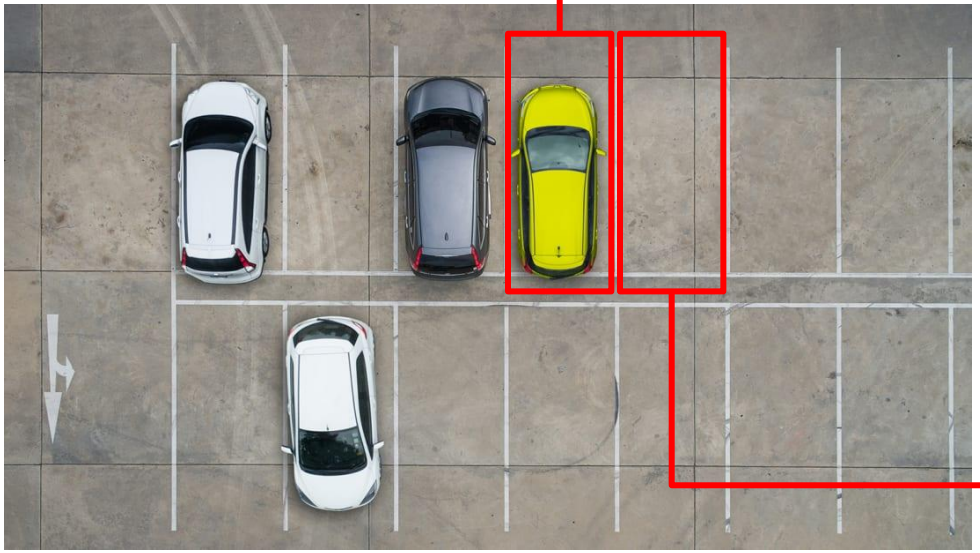
Decreased Profits

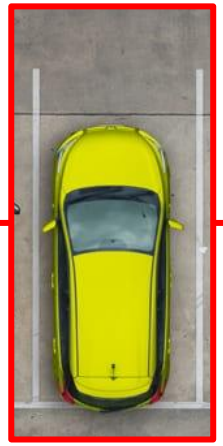
Current Solutions

Current Solutions

The Problem

The Problem



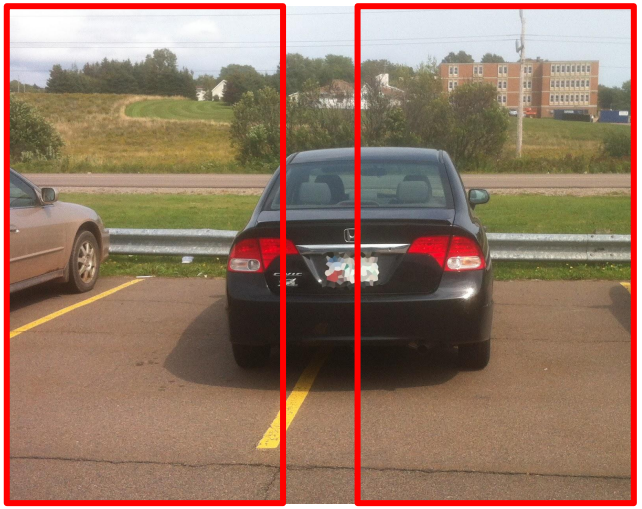


"Occupied"

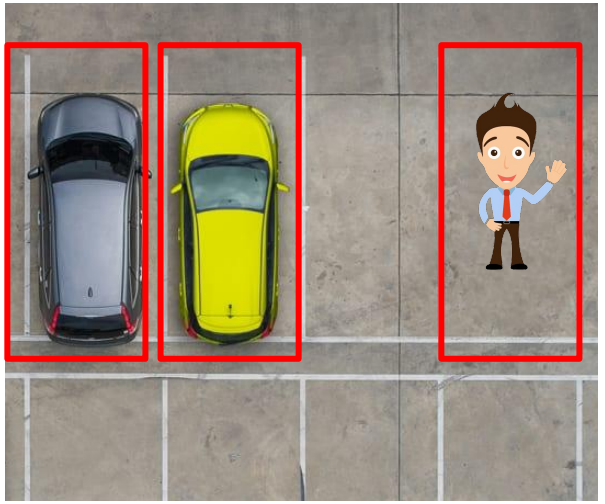
"Empty"

! Possible Roadblocks !

Camera Angle and Image Quality



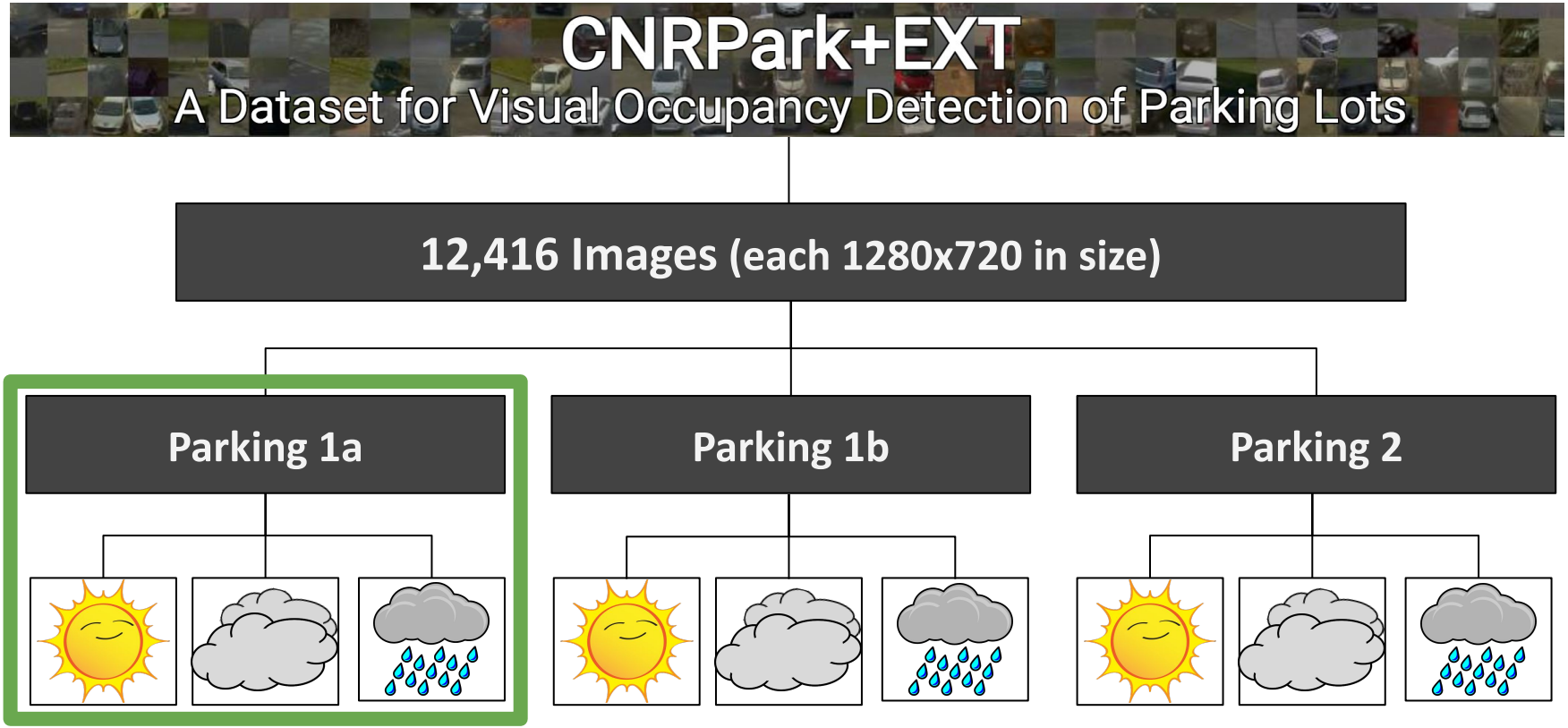
Incorrect Parking
(Double counting of cars)



Interference

SOLUTION: The Data

Source of Data



Segmentation Approaches

XML Files

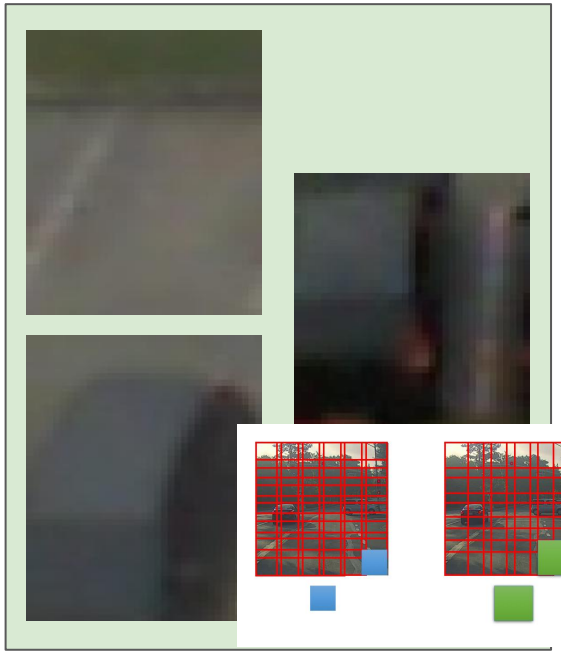
```
<parking id="pucpr">
  <space id="1" occupied="1">
    <rotatedRect>
      <center x="300" y="207" />
      <size w="55" h="32" />
      <angle d="-74" />
    </rotatedRect>
    <contour>
      <point x="278" y="230" />
      <point x="290" y="186" />
      <point x="324" y="185" />
      <point x="308" y="230" />
    </contour>
  </space>
```

SpaceID	Occupied	SizeX	SizeY	SizeW	SizeH	Angle	PointAX	Poin
1	0	300	207	55	32	-74	278	
2	0	332	209	56	33	-77	325	
3	0	366	208	52	32	-77	355	
4	0	398	207	54	36	-79	389	
5	0	430	210	50	31	-75	421	

Segmentation Approaches

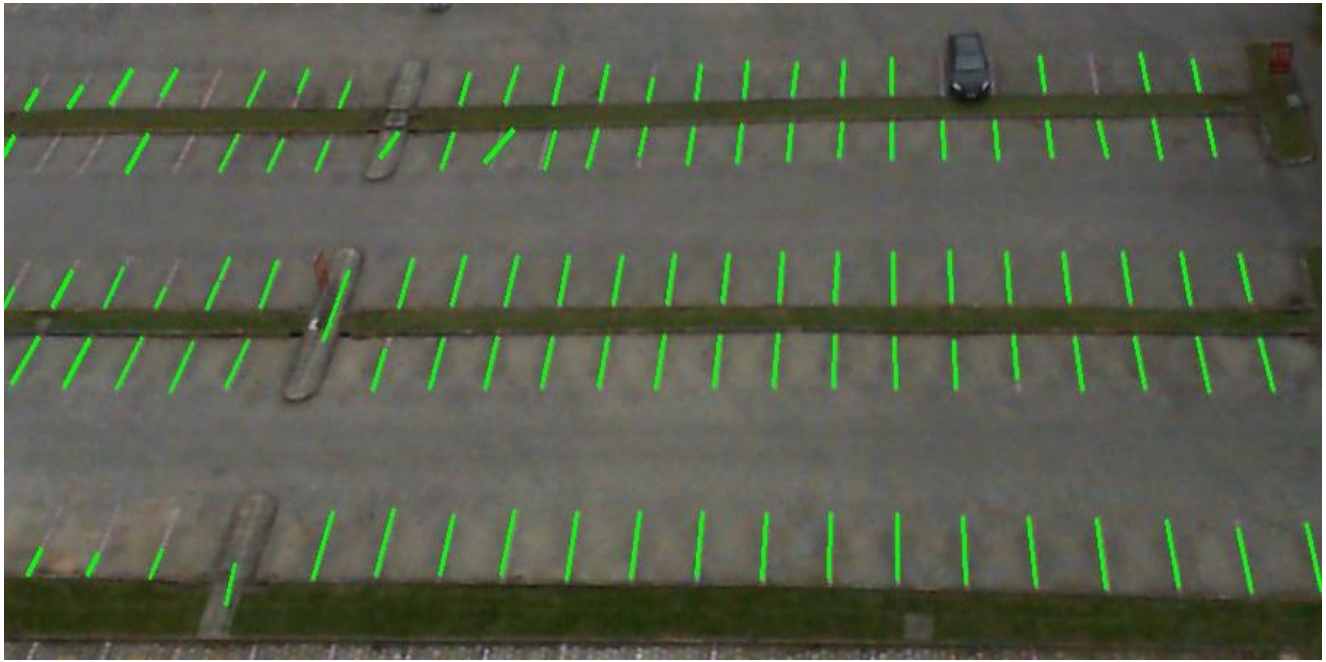
Sliding Window Method

BAD



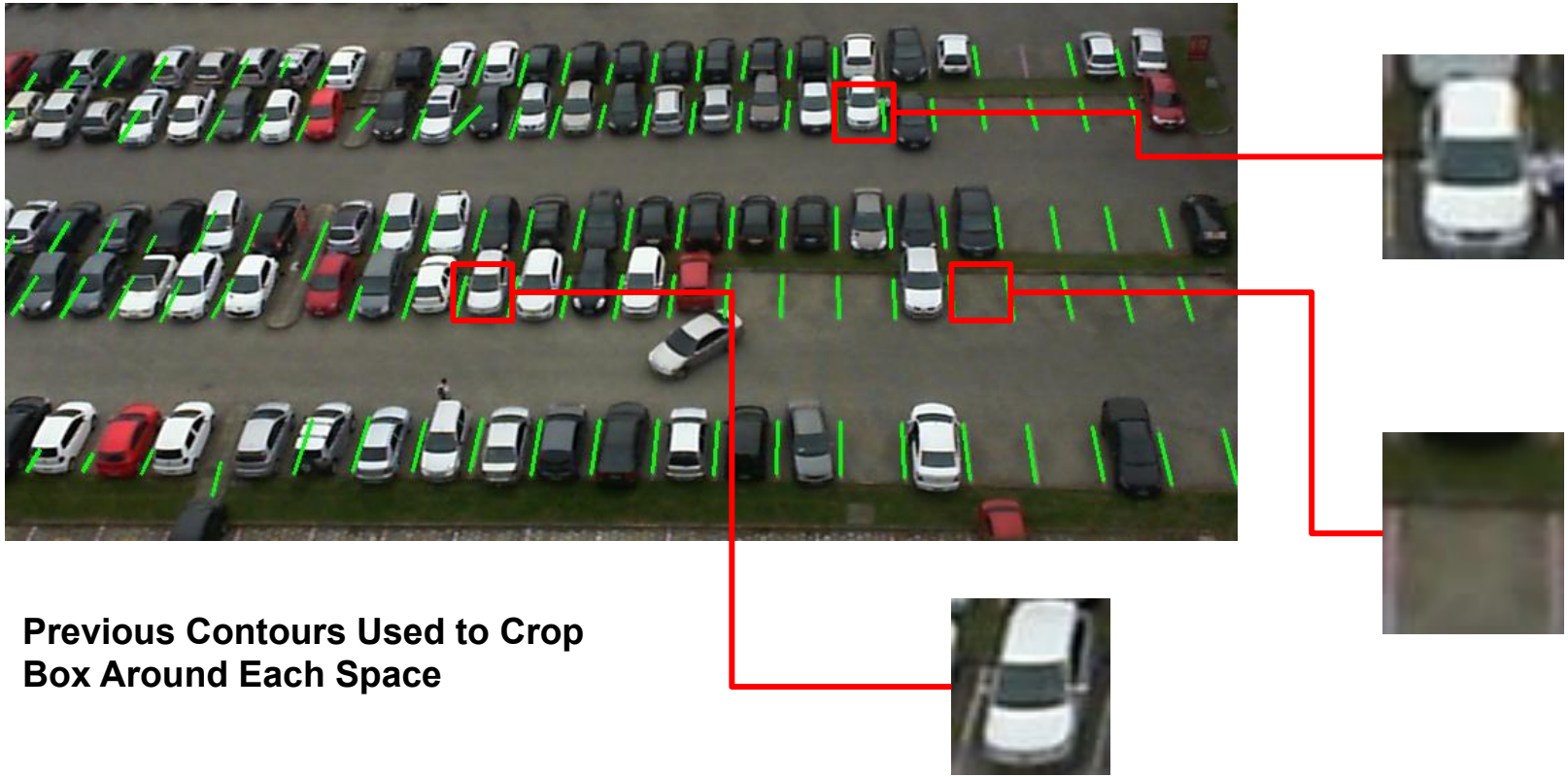
GOOD

Preprocessing the Lot



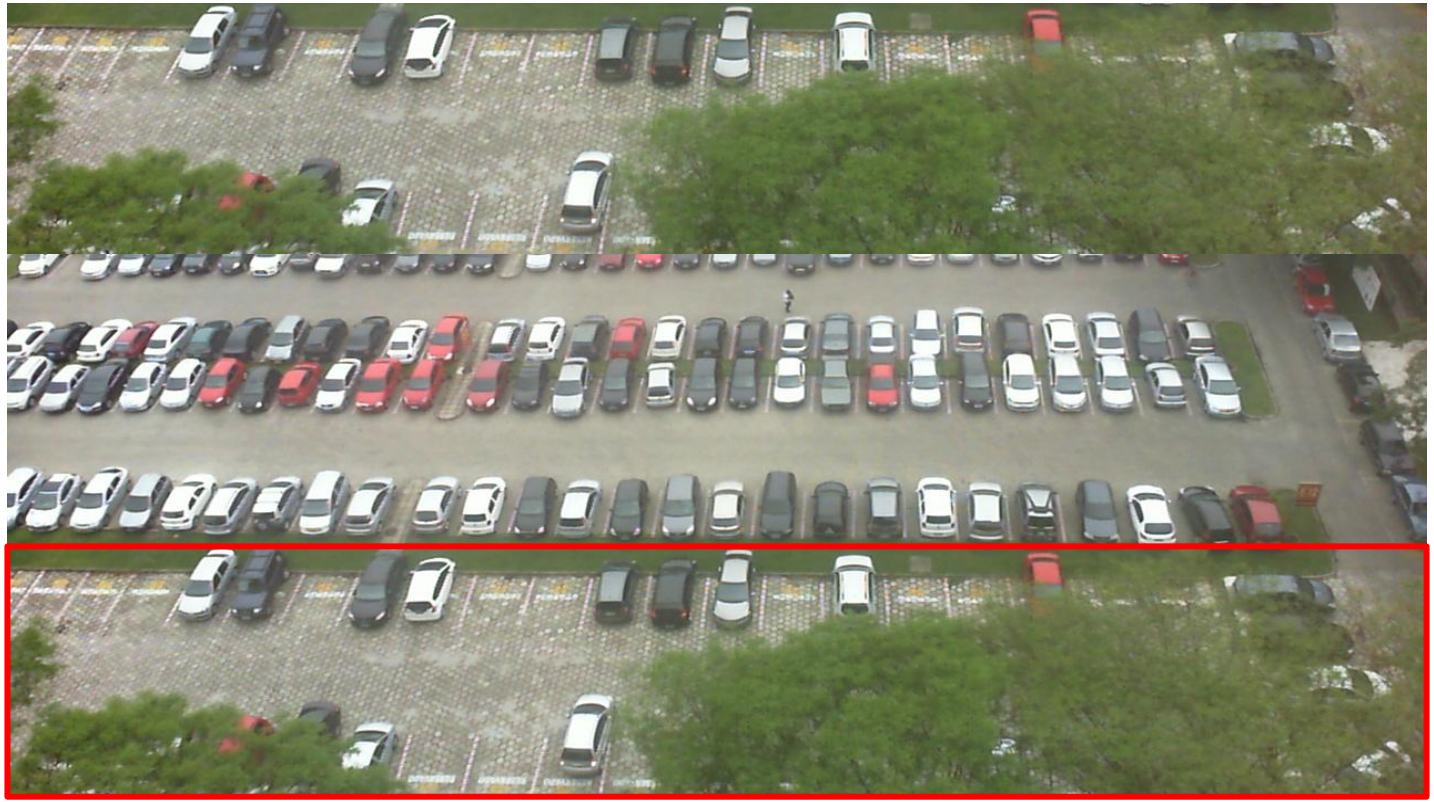
Empty Lot → **Sharpening** → **Thresholding** → **Denoising** → **Contouring**

Preprocessing the Lot



Previous Contours Used to Crop Box Around Each Space

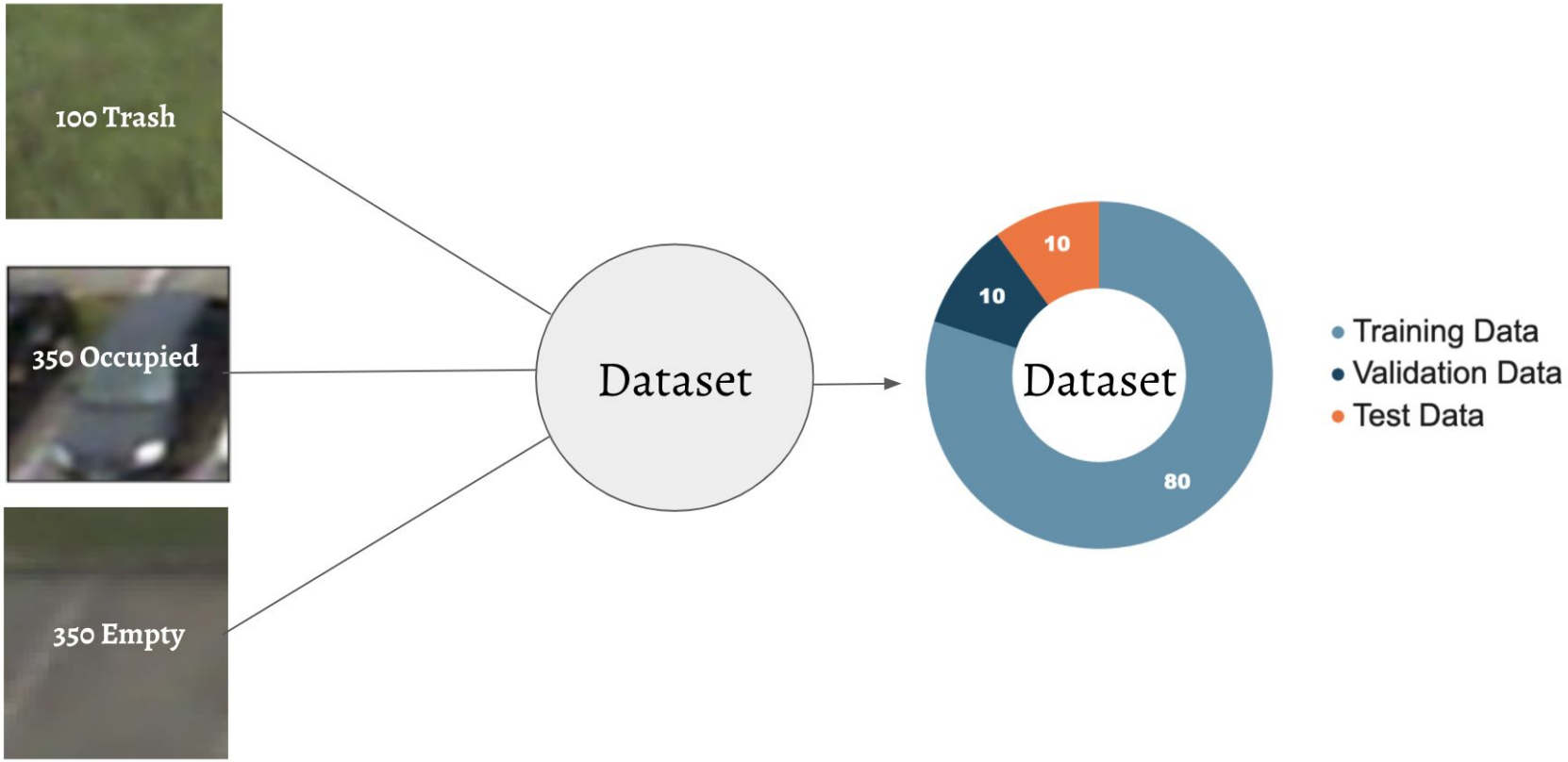
Data Classes



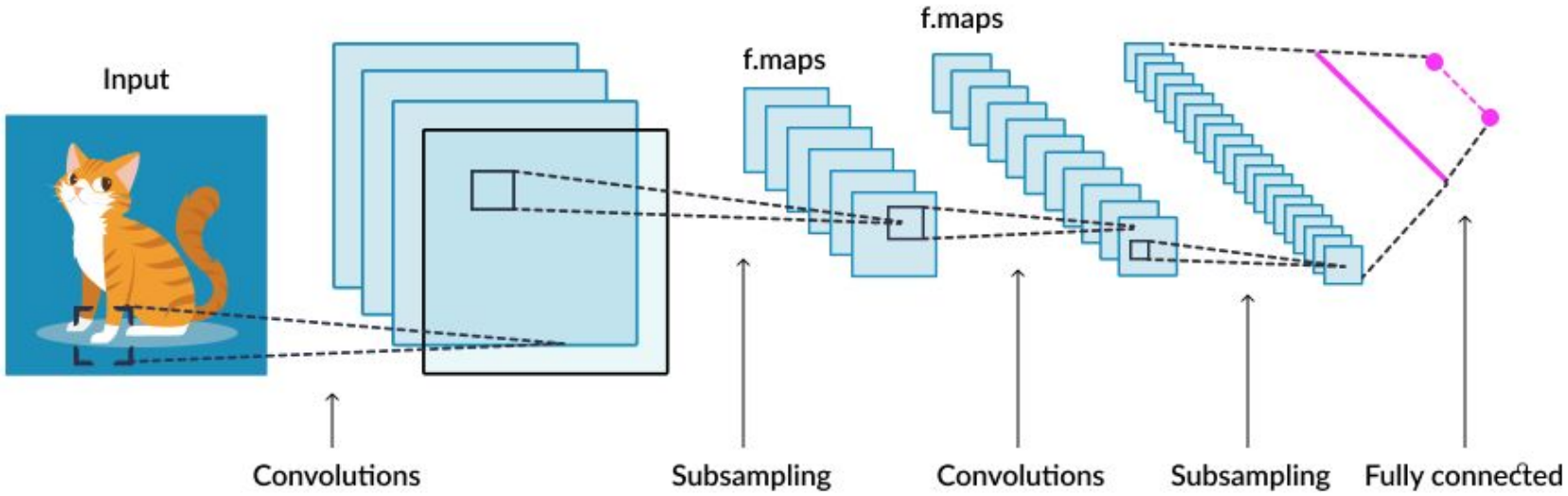
Data Classes

SOLUTION: The Model

Classification Of Parking Spots

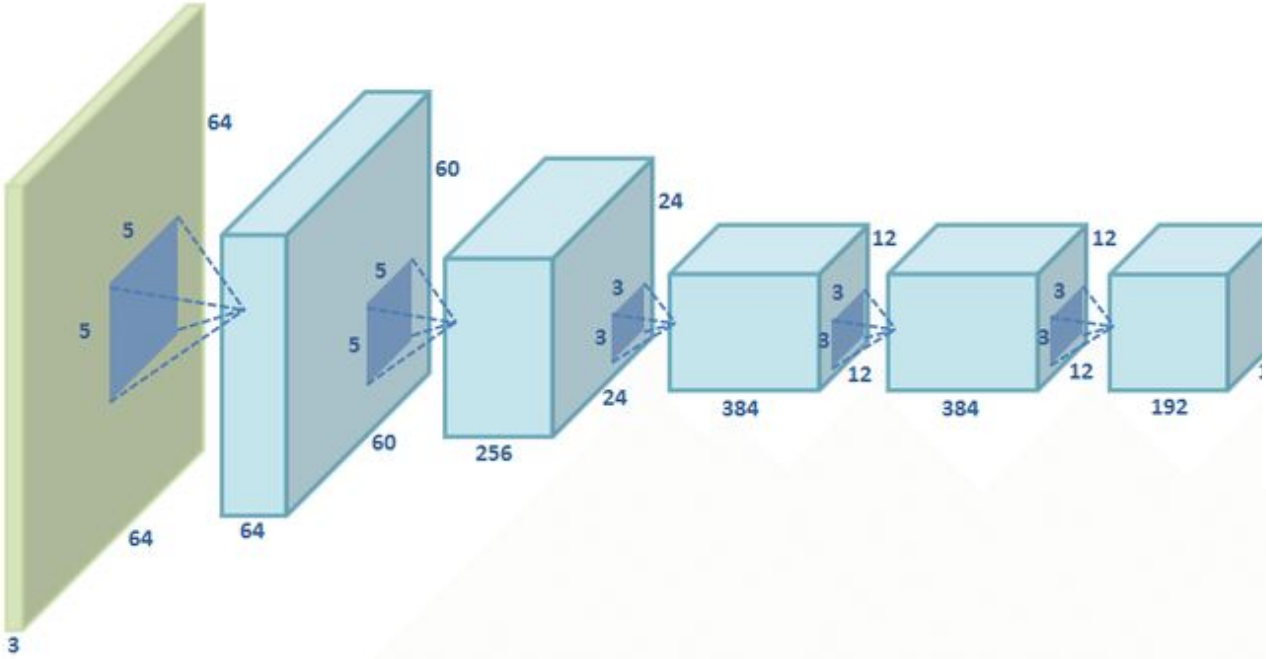


CNN Classification

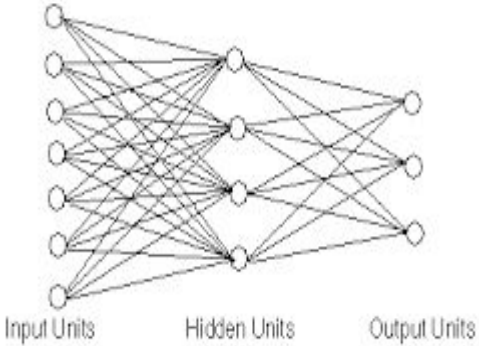


Want Local Features → Weight Sharing During Convolutions → Higher Classification Accuracy → Less Computational Demand → Fewer Hidden Units

AlexNet CNN Classification



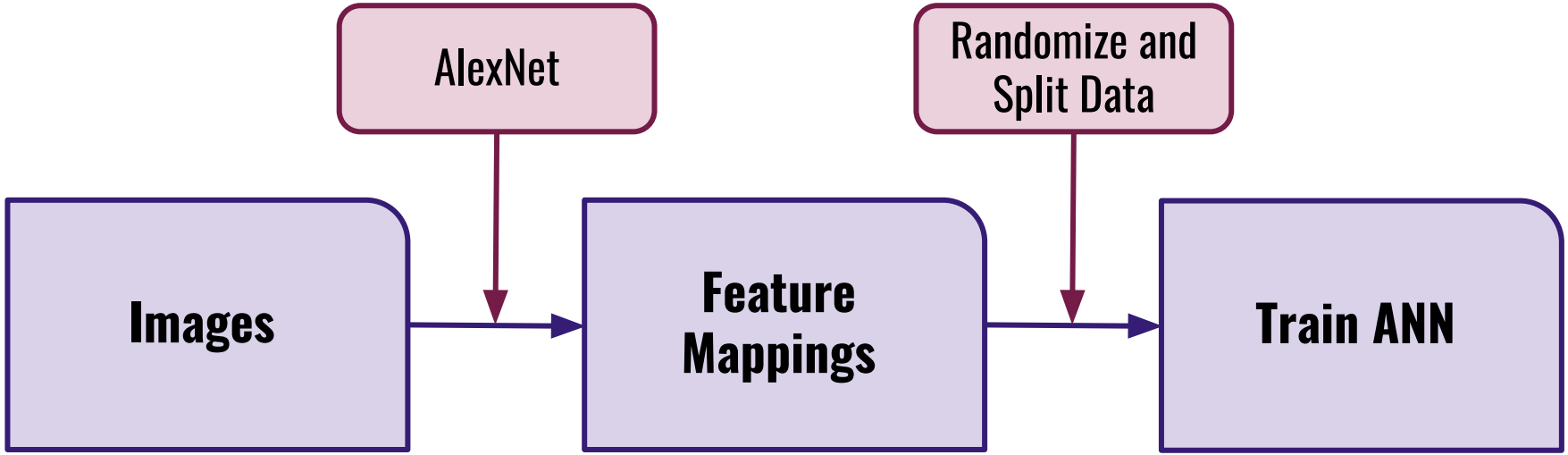
PkLot ANN Classifier



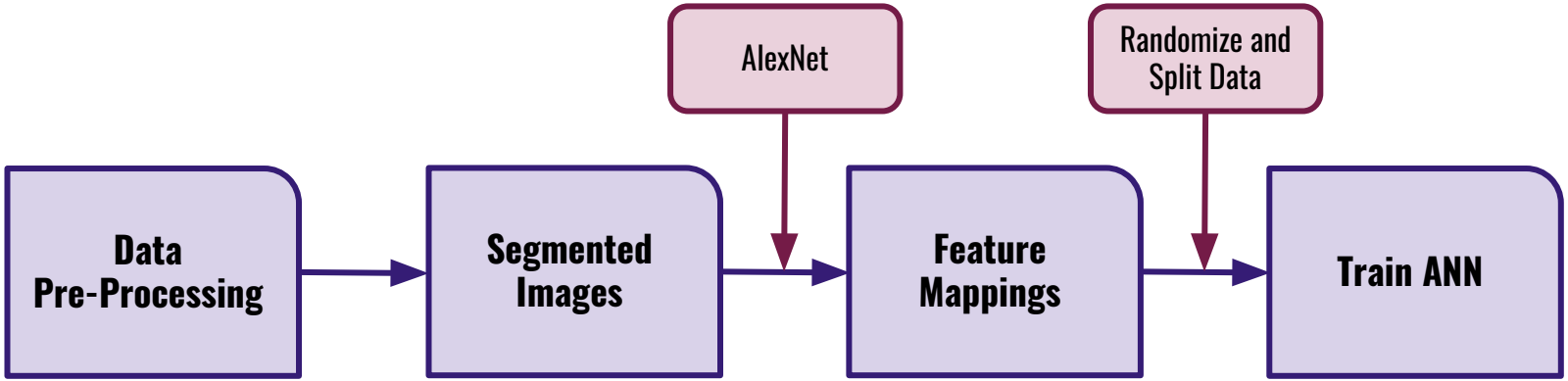
60 Million Parameters — Trained Over 90 Epochs — 6 Days of Training!

Higher Classification Accuracy — Less Computational Demand

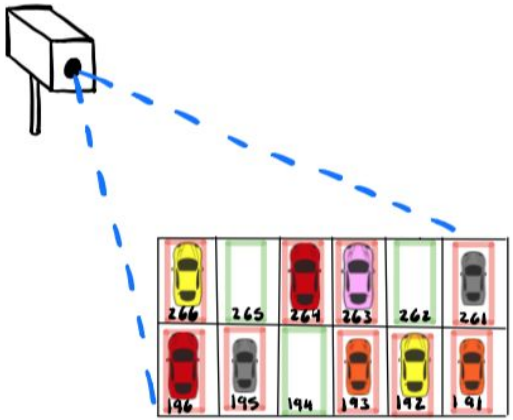
Transfer Learning Process

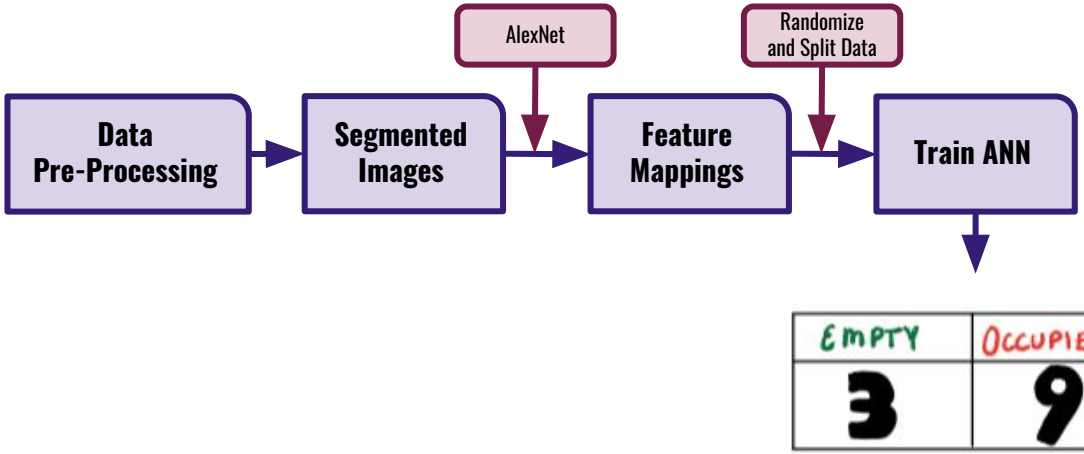


Scott's Thought?

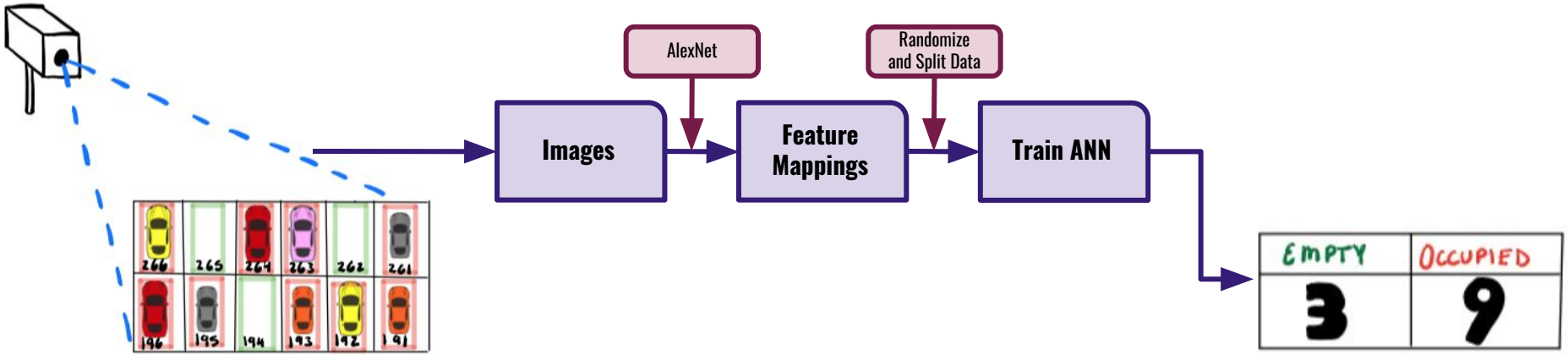


Transfer Learning Process

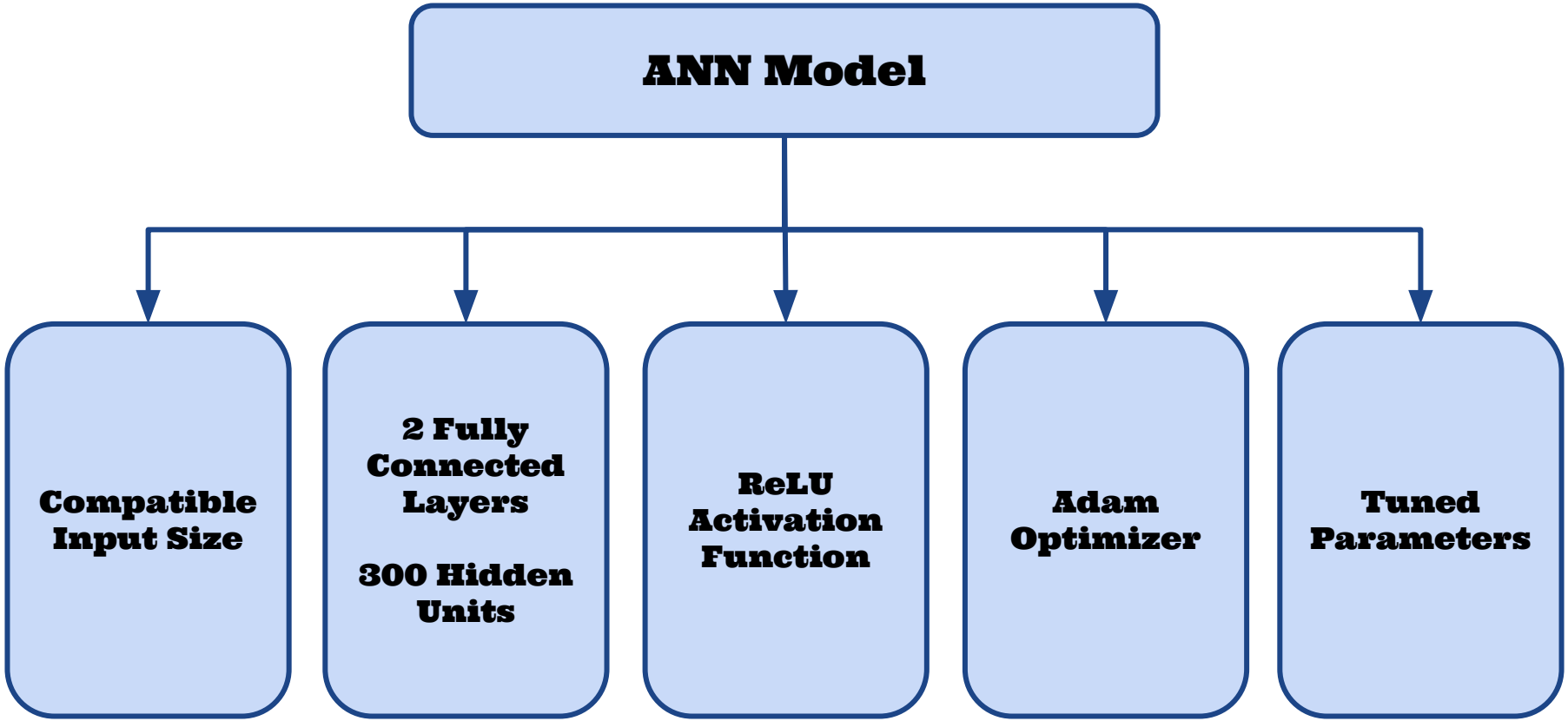




Transfer Learning Process



Details and Choices



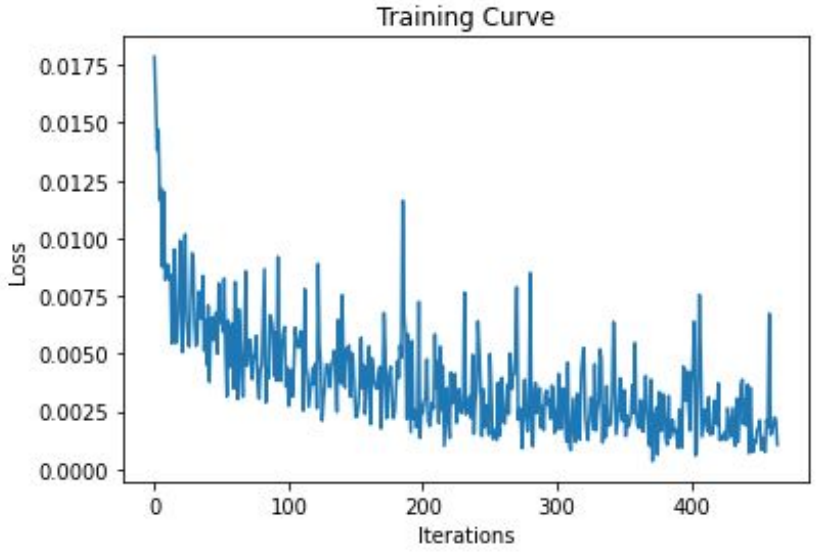
Initial Quantitative Analysis

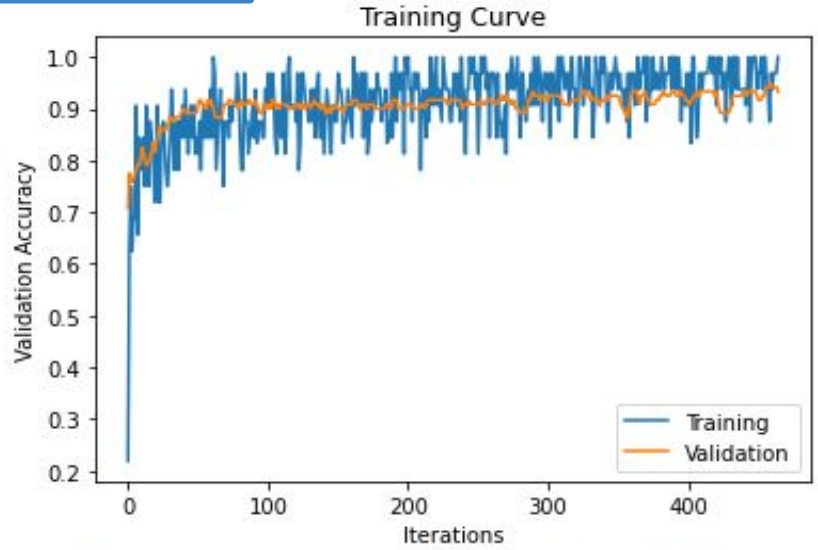
RESULTS

Training Accuracy: 96.48%

Validation Accuracy: 93.33%

Test Accuracy: 93%

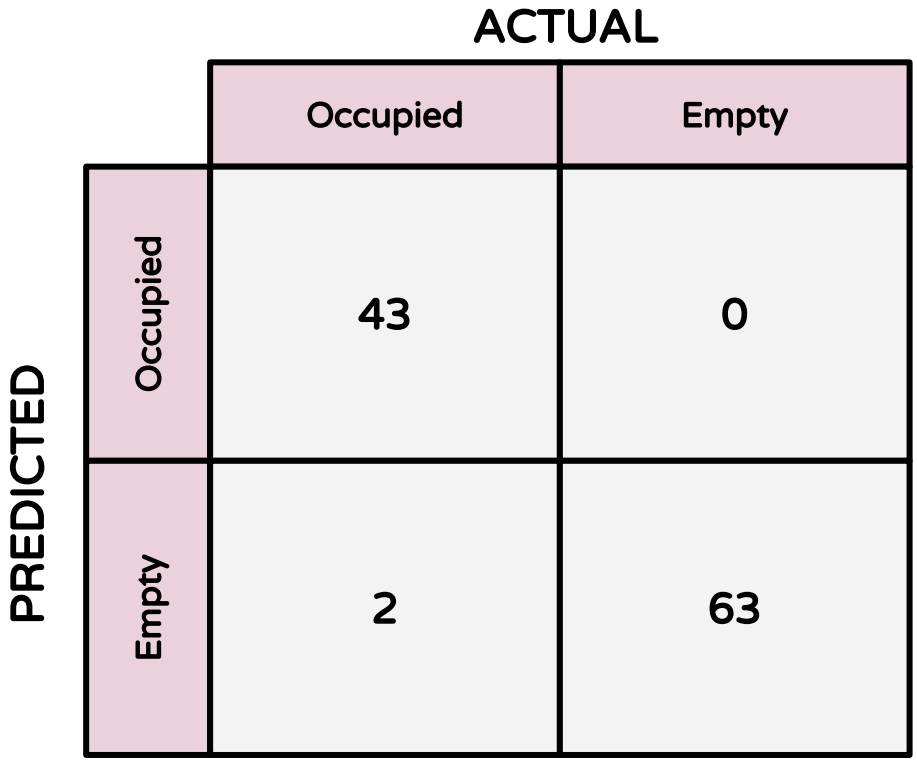




DEMONSTRATION

SOLUTION: The Results

Quantitative Outputs



Sensitivity = 95.56%

Specificity = 100%

Precision = 100%

Accuracy = 98.14%

Qualitative Outputs

1) Total number of cars present
2) Pictures of all cars that are present:

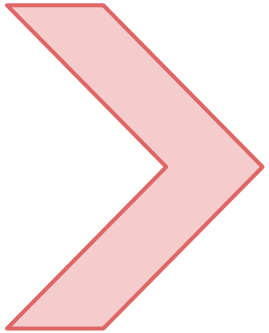
Peculiarities

SOLUTION: Analysis and Discussion

Why was this a success?!?!?

Our Model Accuracy

~98%



SVM Baseline Model Accuracy

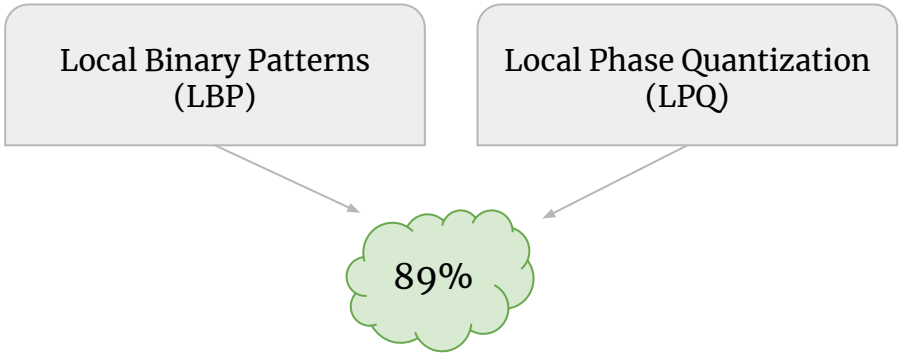
~84%

Extensions

1) Other Possible Applications

Sensor System (Vendor)	Time Accuracy
Radar/Magnetometer (Fybr)	78%
Radar (Sensys)	98%
Infrared (CPT)	92%
Image Recognition (Cysen)	77%
Magnetometer (StreetSmart)	81%

2) Comparison to Related Work
→ Textual Based Classifiers



Outlook on Overall Performance