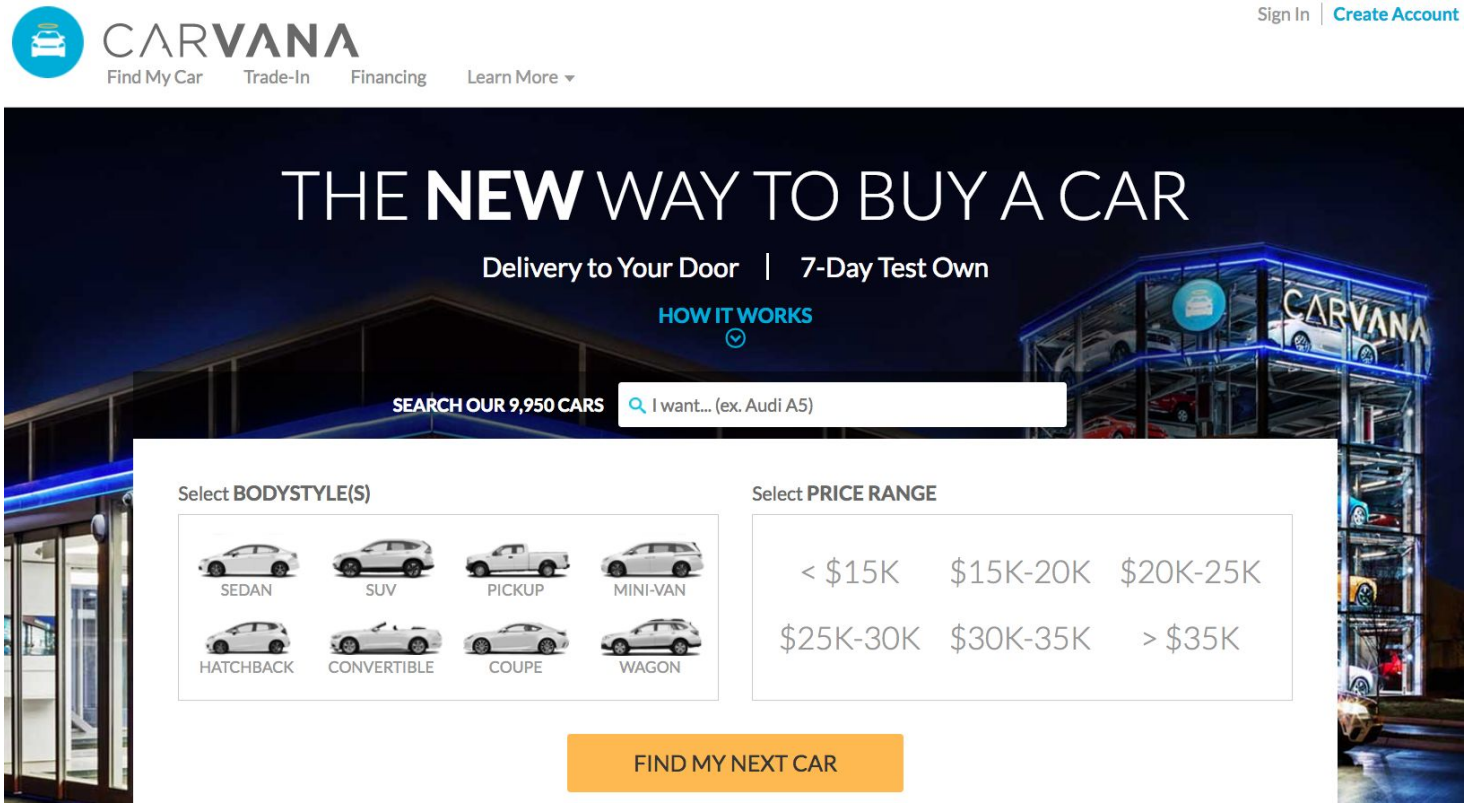
CarMatch

A *singular* car buying solution

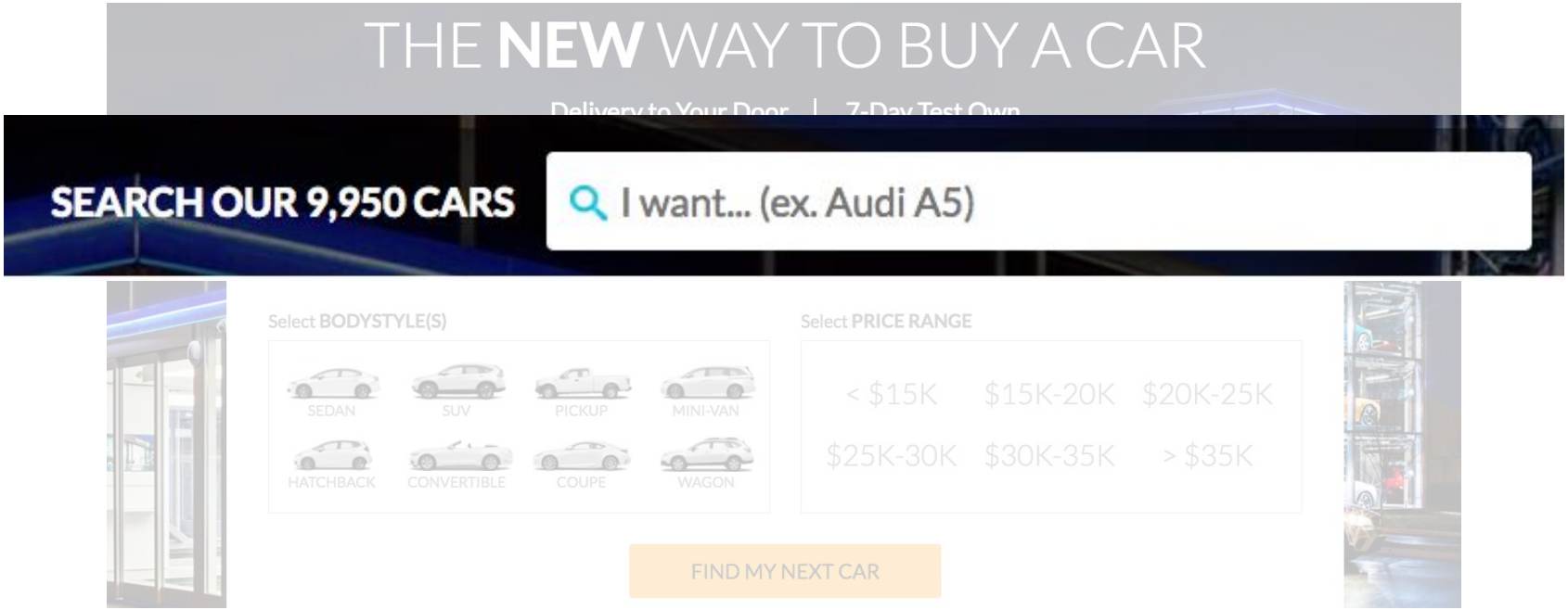
Thomas Noriega

Car Buying is for Experts



Car Buying is for Experts

Need to know exactly what you want



Car Buying is for Experts

Need to know several constraints

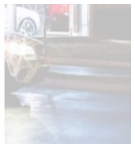
Select **BODYSTYLE(S)**

Select **PRICE RANGE**

< $15K | $15K-20K | $20K-25K

$25K-30K | $30K-35K | > $35K

FIND MY NEXT CAR



CarMatch

Just needs a *single, understandable* input

users don’t need to be experts to browse listings

websites can reduce friction and increase customer conversion

Inception 2D Neural Network

Modified and progressively fine-tuned to classify
196 different car classes

- No feature extraction
- Minimal pre-processing
- Could be trained on a small dataset

Dataset

Each class a unique combination of:

MAKE: Dodge
MODEL: RAM 3500
YEAR: 2009

Approximately 80 photos/class (~16,000 photos total)

http://ai.stanford.edu/~jkrause/cars/car_dataset.html

Multiple Angles

Variable Quality

Validation on Test Set

Top-1 accuracy: 77.1%

Top-5 accuracy: 94.8%

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So if the user just wants to identify the uploaded car they almost certainly will

Validation on Test Set

Top-1 accuracy: 77.1%

Top-5 accuracy: 94.8%

So if the user just wants to identify the uploaded car they almost certainly will

But results are most useful if they also ***look*** **like the submitted photo**

Input: sedan

output: sedans

Input: sedan

output: sedan-like

Similarity Validation

Incorrect ID: 5.2%

Similarity Validation

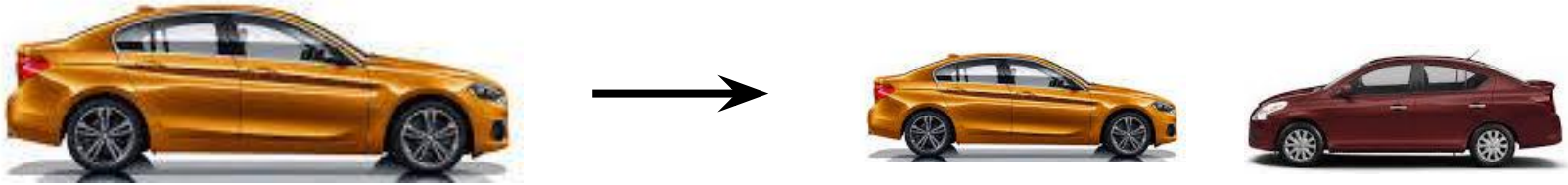
Incorrect ID: 5.2%

Correct ID

Similarity Validation

Incorrect ID: 5.2%

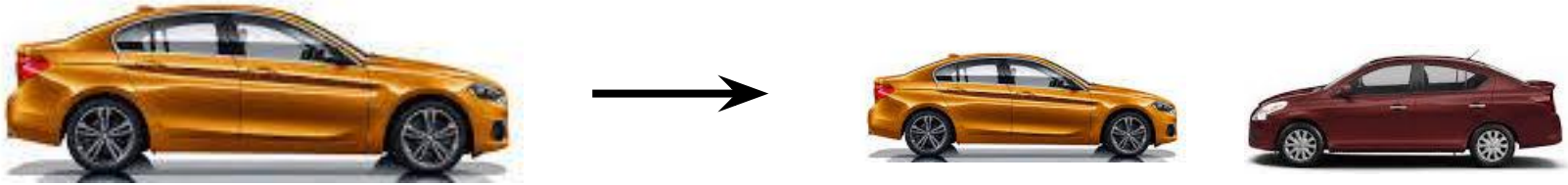
Correct ID AND styles



Similarity Validation

Incorrect ID: 5.2%

Correct ID AND styles: 15.8%

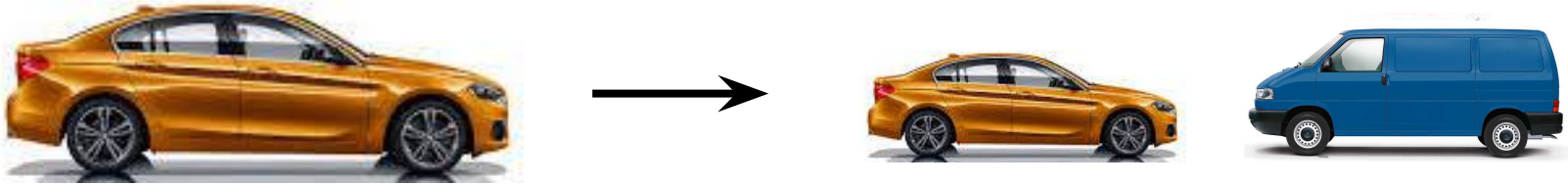


Similarity Validation

Incorrect ID: 5.2%

Correct ID AND styles: 15.8%

Correct ID AND wrong styles: 79.0%



How to improve the results

Instead of absolute top-5 ranking

Algorithm that balances

1) most represented body-styles

and

2) the highest confidence results

Improved results by 4x

Correct ID AND styles:

New algorithm: 71.4% (vs. 15.5%)

Correct ID AND wrong styles:

New algorithm: 21.5% (vs. 79.0%)

4x improvement

Incorrect ID:

New algorithm: 7.1% (vs. 5.2%)

1.4x compromise

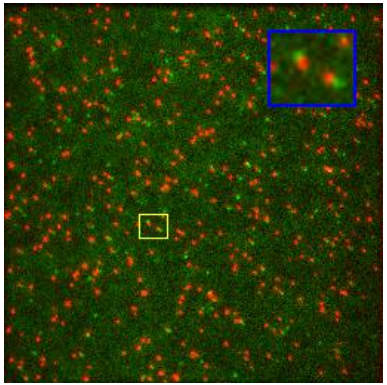
And that’s how CarMatch

gives customers more results, more easily

helps websites sell more cars

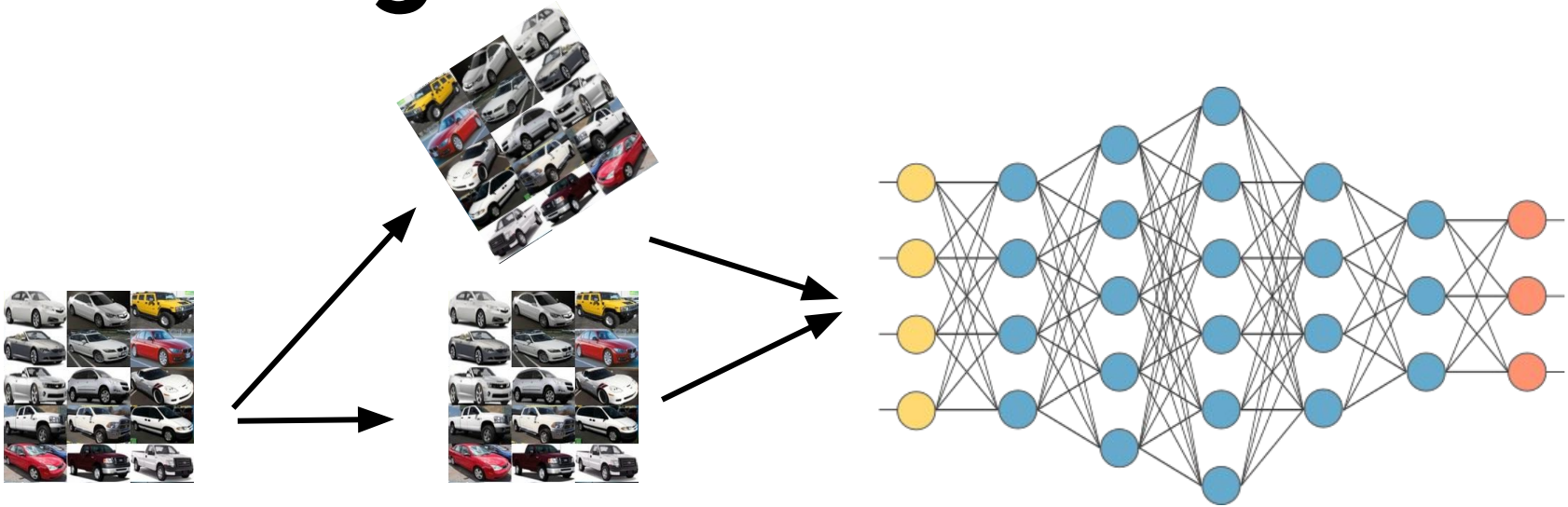
Thomas Noriega

University of California San Francisco



SUPPLEMENTAL SLIDES

Training

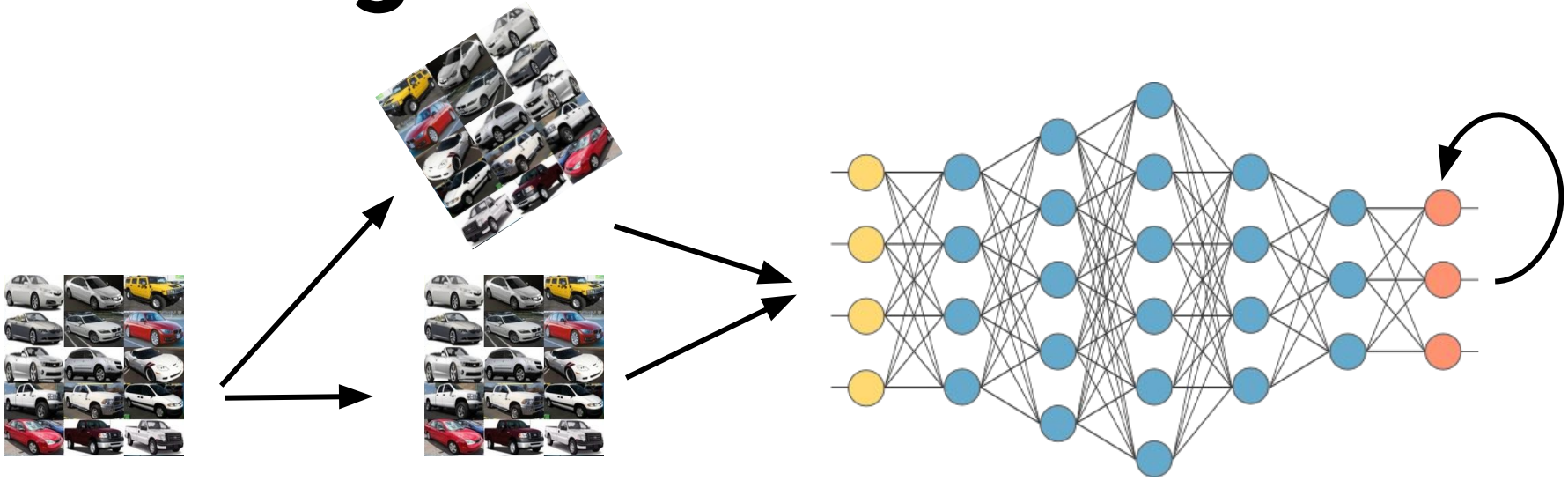


training set

in-memory augmentation

Pre-trained GoogleNet (Inception)
2D convolutional neural network

Training



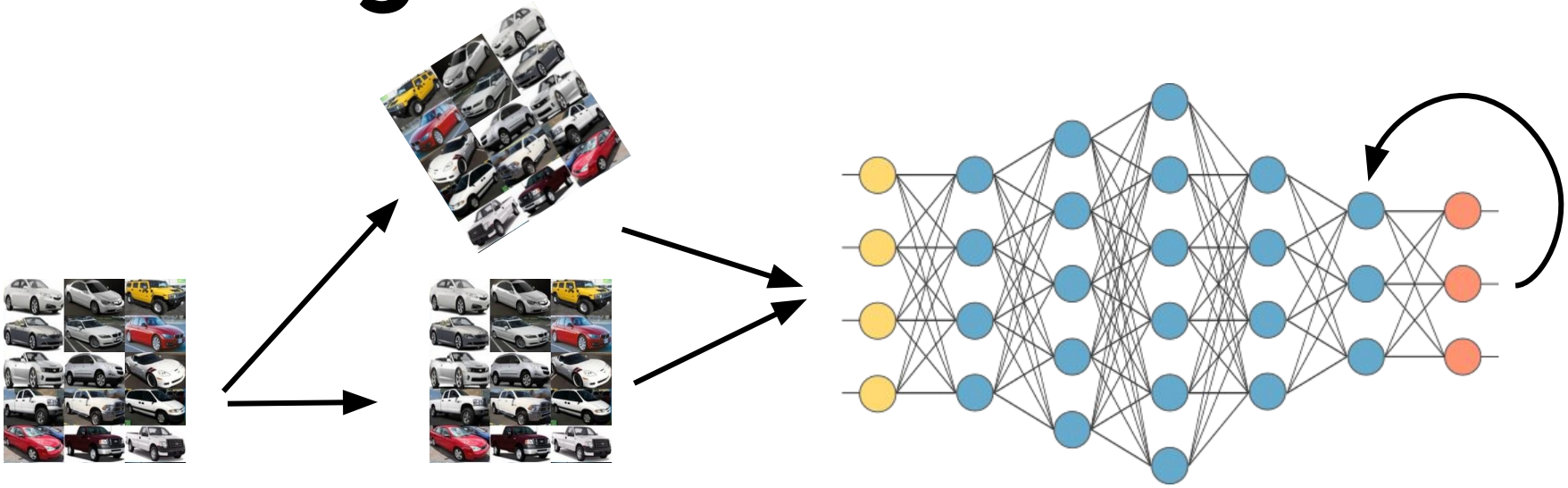
training set

in-memory augmentation

2D convolutional neural network

add/train new prediction layer

Training



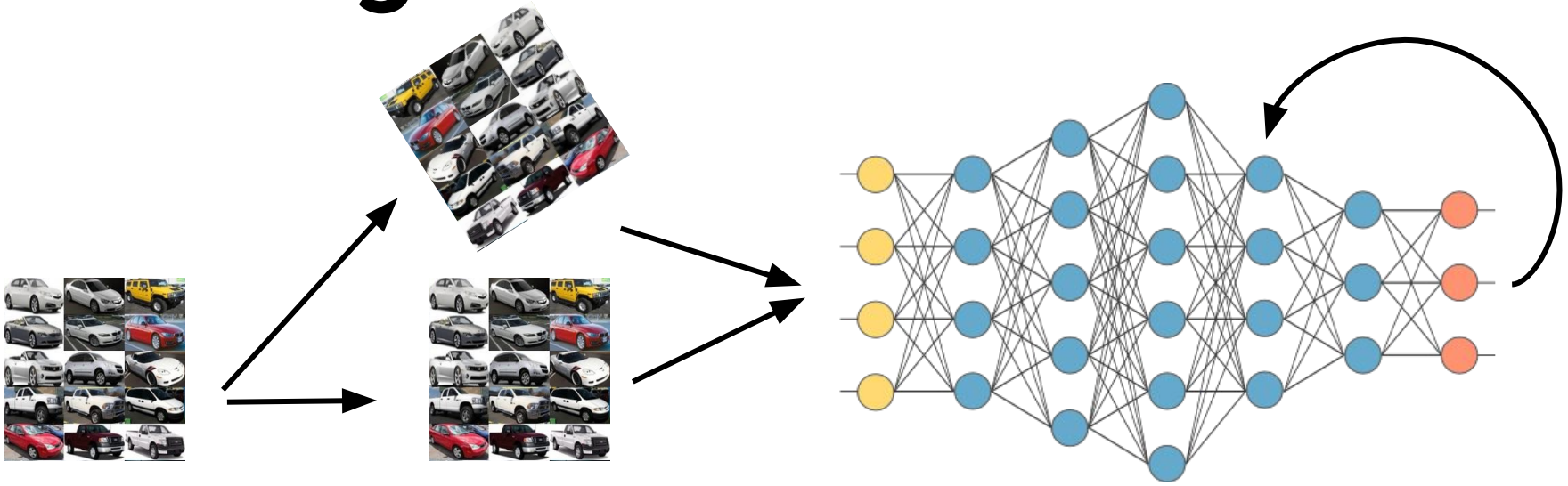
training set

in-memory augmentation

2D convolutional neural network

progressive fine-tuning

Training



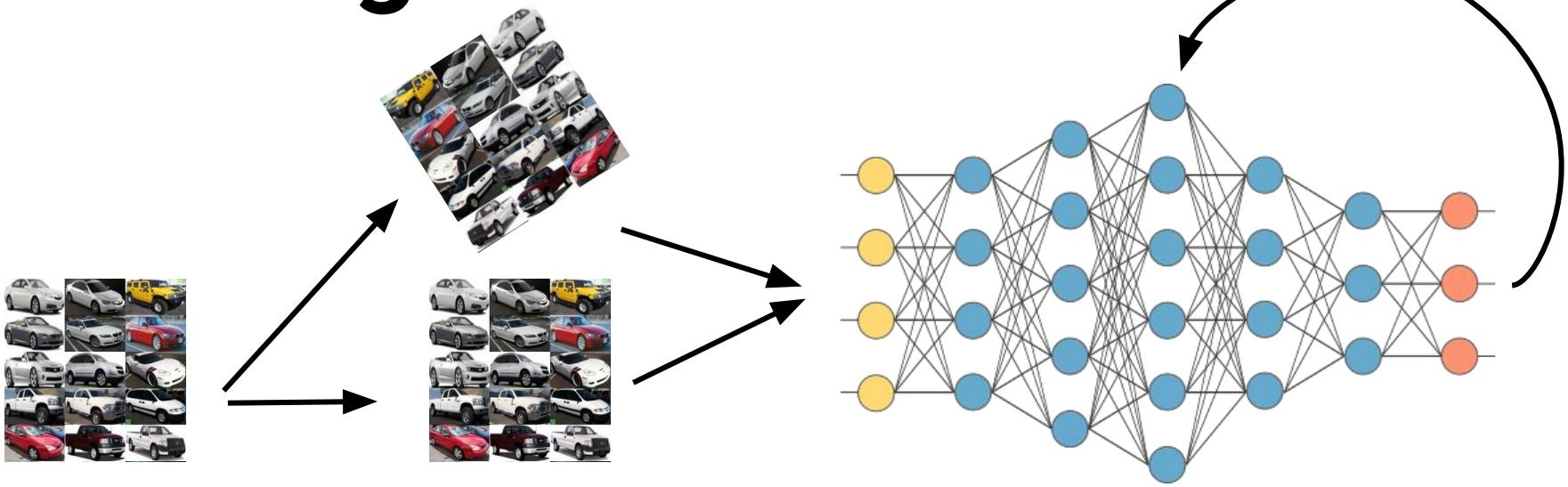
training set

in-memory augmentation

2D convolutional neural network

progressive fine-tuning

Training



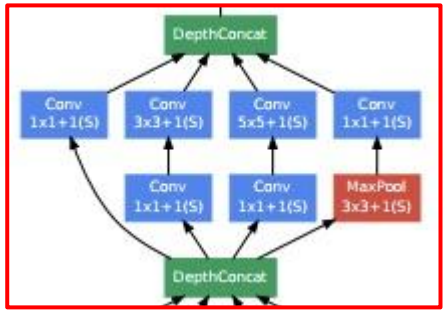
training set

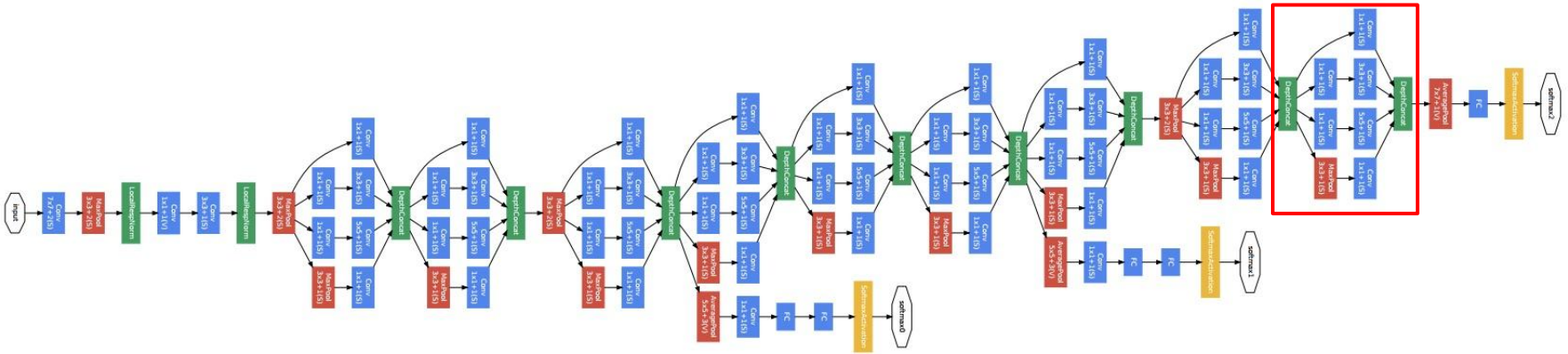
in-memory augmentation

2D convolutional neural network

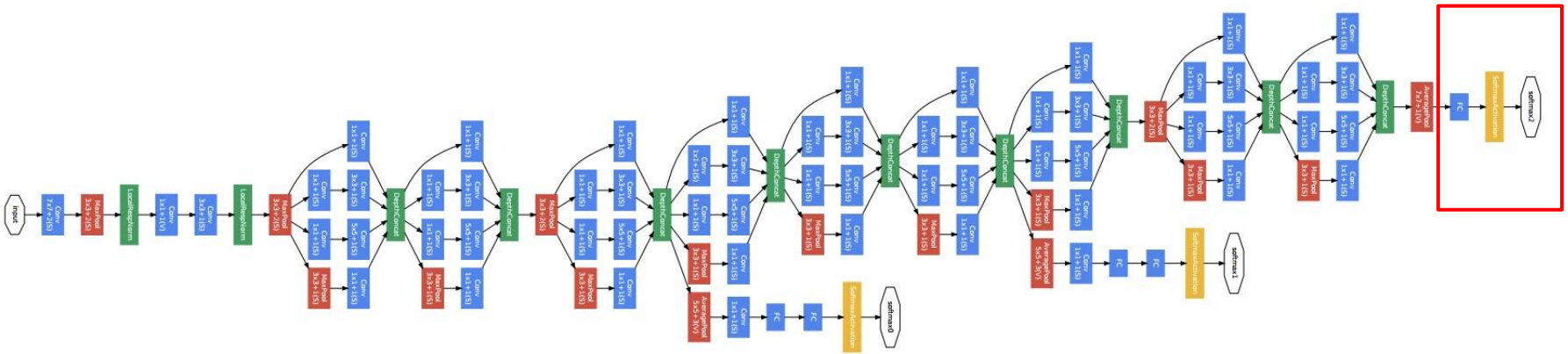
progressive fine-tuning

Inception Model

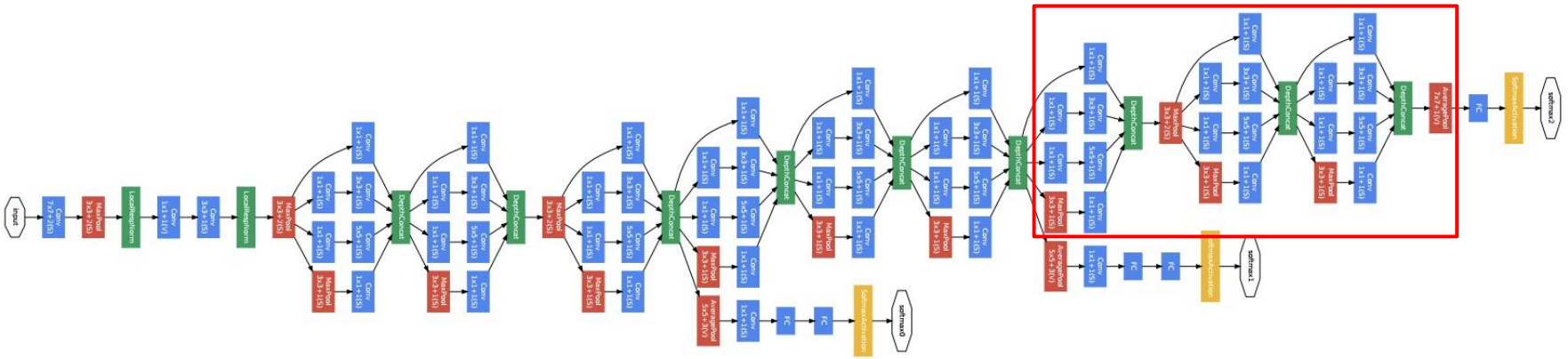




Modify


input
Conv 7x7+2(S)
MaxPool 3x3+2(S)
LocalRespNorm
Conv 1x1+1(V)
Conv 3x3+1(S)
LocalRespNorm
MaxPool 3x3+2(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
MaxPool 3x3+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 3x3+2(S)
MaxPool 3x3+2(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 3x3+2(S)
MaxPool 3x3+2(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 3x3+2(S)
MaxPool 5x5+5(V)
Conv 1x1+1(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 3x3+1(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 3x3+1(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 5x5+3(V)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 3x3+1(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
MaxPool 3x3+1(S)
Conv 1x1+1(S)
Conv 3x3+1(S)
Conv 5x5+1(S)
Conv 1x1+1(S)
DepthConcat
AveragePool 7x7+1(V)
FC
SoftmaxActivation
softmax2
FC
FC
SoftmaxActivation
softmax1
FC
FC
SoftmaxActivation
softmax0

Fine-tune



Why such high wrong style results?

Top-5 ignores probability assignments:

0.85

0.10

0.02

0.02

0.01

Why such high wrong style results?

Top-5 ignores probability assignments:

0.85

0.10

0.02

0.02

0.01

How to improve the results

1) Start with all predictions

0.30

0.10

0.05

0.2

0.10

0.03

0.2

0.10

0.02

How to improve the results

1) Start with all predictions
2) Consider predictions with 95% confidence


0.30


0.10


0.05

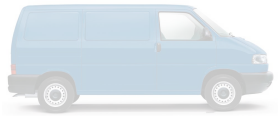

0.2


0.10


0.03


0.2


0.10

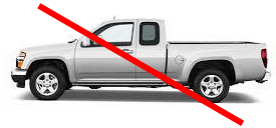

0.02

How to improve the results

1) Start with all predictions
2) Consider predictions with 95% confidence
3) Limit to top-2 body-styles


0.30


0.10


0.05

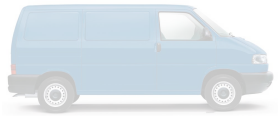

0.2


0.10


0.03


0.2


0.10


0.02

How to improve the results

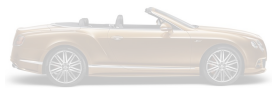
1) Start with all predictions
2) Consider predictions with 95% confidence
3) Limit to top-2 body-styles
4) Present top-5 remaining results

0.30

0.10

0.05

0.2



0.10

0.03

0.2

0.10

0.02