Assessing Car Damage with Convolutional Neural Networks

Objective

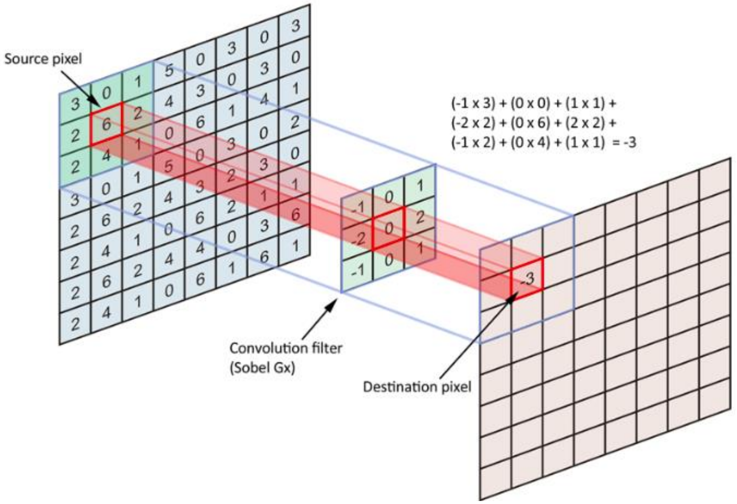
Use computer vision to accurately classify vehicle damage and facilitate claims triage

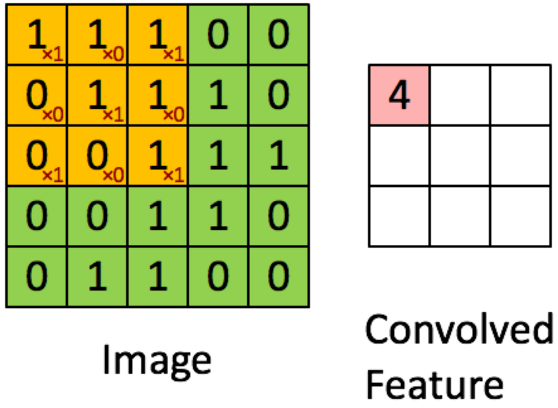
This is a proven use case for ML & multiple vendors provide range of similar tools: Altoros, Nanonets to name a few.

Can we make computer “see” Car Damage?

- Convolutional Neural Networks (CNNs)
  - Neural networks for Vision tasks
  - Special Layers performing an operation called “Convolution”

- What is Convolution?
  - is performed on the input data with the use of a filter or kernel
  - extract features by maintaining relationship between the pixels (spatial)


Source pixel
(-1 x 3) + (0 x 0) + (1 x 1) +
(-2 x 2) + (0 x 6) + (2 x 2) +
(-1 x 2) + (0 x 4) + (1 x 1) = -3
Convolution filter
(Sobel Gx)
Destination pixel



$1_{\times 1}$	$1_{\times 0}$	$1_{\times 1}$	0	0
$0_{\times 0}$	$1_{\times 1}$	$1_{\times 0}$	1	0
$0_{\times 1}$	$0_{\times 0}$	$1_{\times 1}$	1	1
0	0	1	1	0
0	1	1	0	0

Image

4		

Convolved Feature

Image Credits: https://towardsdatascience.com/applied-deep-learning-part-4-convolutional-neural-networks-584bc134c1e2

What is Transfer Learning & Why should we know about it?

- Transfer learning refer to the situation where what has been learned in one setting … is exploited to improve generalization in another setting.
- Models trained on huge datasets; efficiently learn to extract features from photographs in order to perform well on the problem.
- Transfer Learning approach:
  - Take layers from a previous model
  - Freeze them, and add new layers on top
  - Train new layers on ”our” dataset
- Fine-tuning (optional): unfreezing a part of model (few layers/whole model), retrain on new dataset with very slow learning rate. This adapts the pretrained model to the new dataset and could achieve improvements.

*Photo by Mike's Birds, some rights reserved.

ImageNet & VGG16

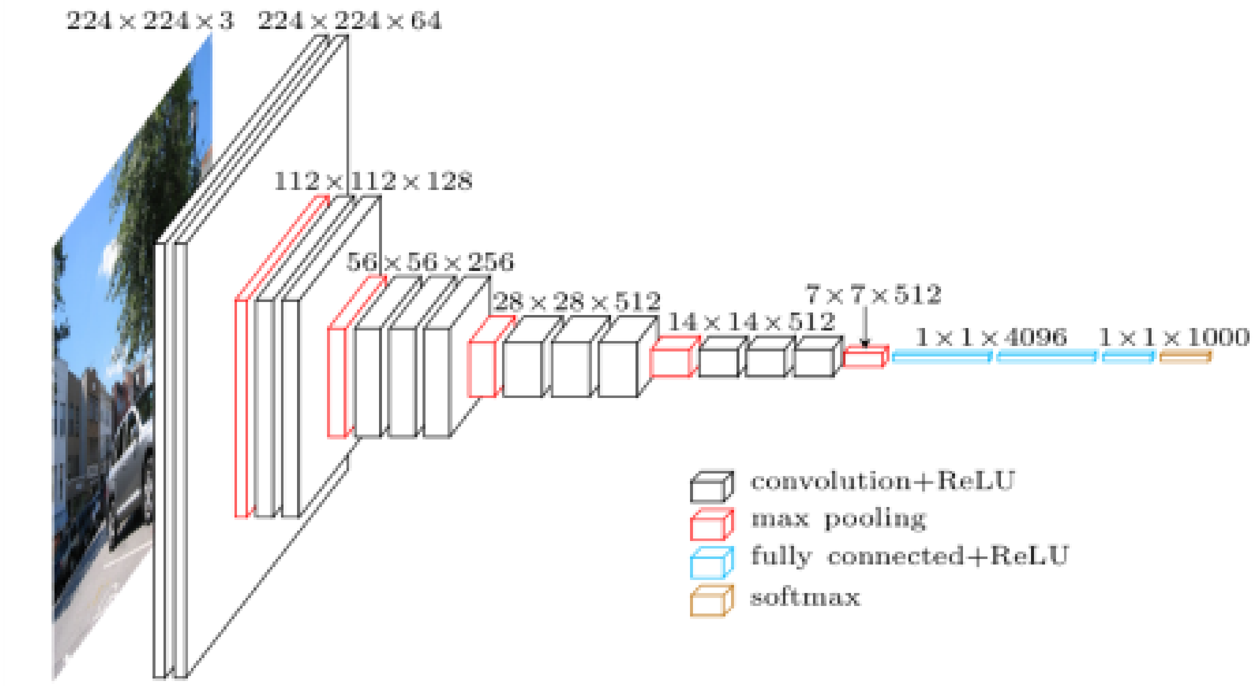
❑ ImageNet

- ImageNet is a set of ~15 million images belonging to ~22000 image categories.
- The images were collected from the web and labelled by human labellers using Amazon's Mechanical Turk crowd-sourcing tool.
- There is an annual competition using this Dataset called "ImageNet Large-Scale Visual Recognition Challenge" (ILSVRC), using 14 million images and 1000 classes.

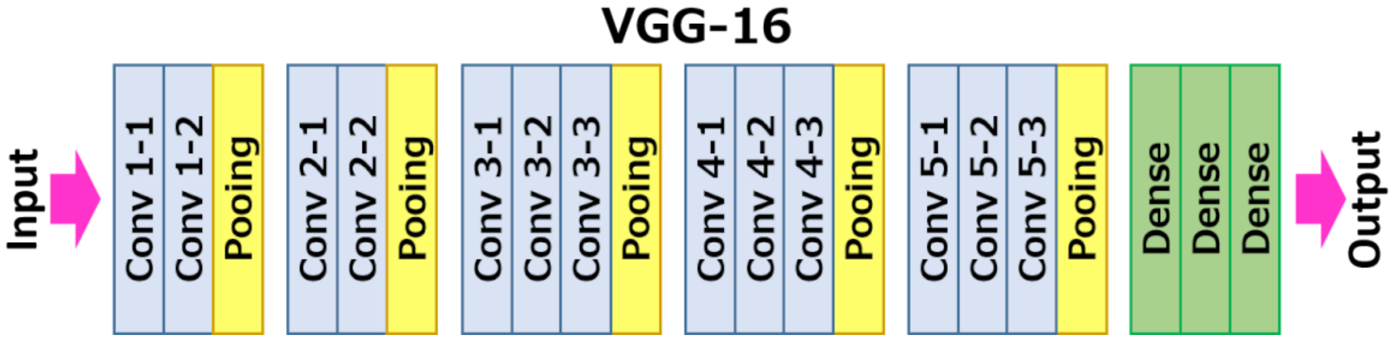
❑ VGG 16

- submitted to ILSVRC in 2014,
- achieved 92.7% top-5 accuracy on ImageNet
- trained for weeks using NVIDIA Titan Black GPU's

VGG16 architecture



- convolution layers of 3x3 filter with a stride 1, using “same” padding
- maxpool layer of 2x2 filter of stride 2
- 2 FC(fully connected layers) followed by a SoftMax for output
- the 16 in VGG16 refers to it has 16 layers that have weights



How did we make computer “see” Car Damage?

- Convolutional Neural Networks (CNNs)

❑ VGG16 trained on ImageNet (14M images, 2200 classes)

Transfer Learning

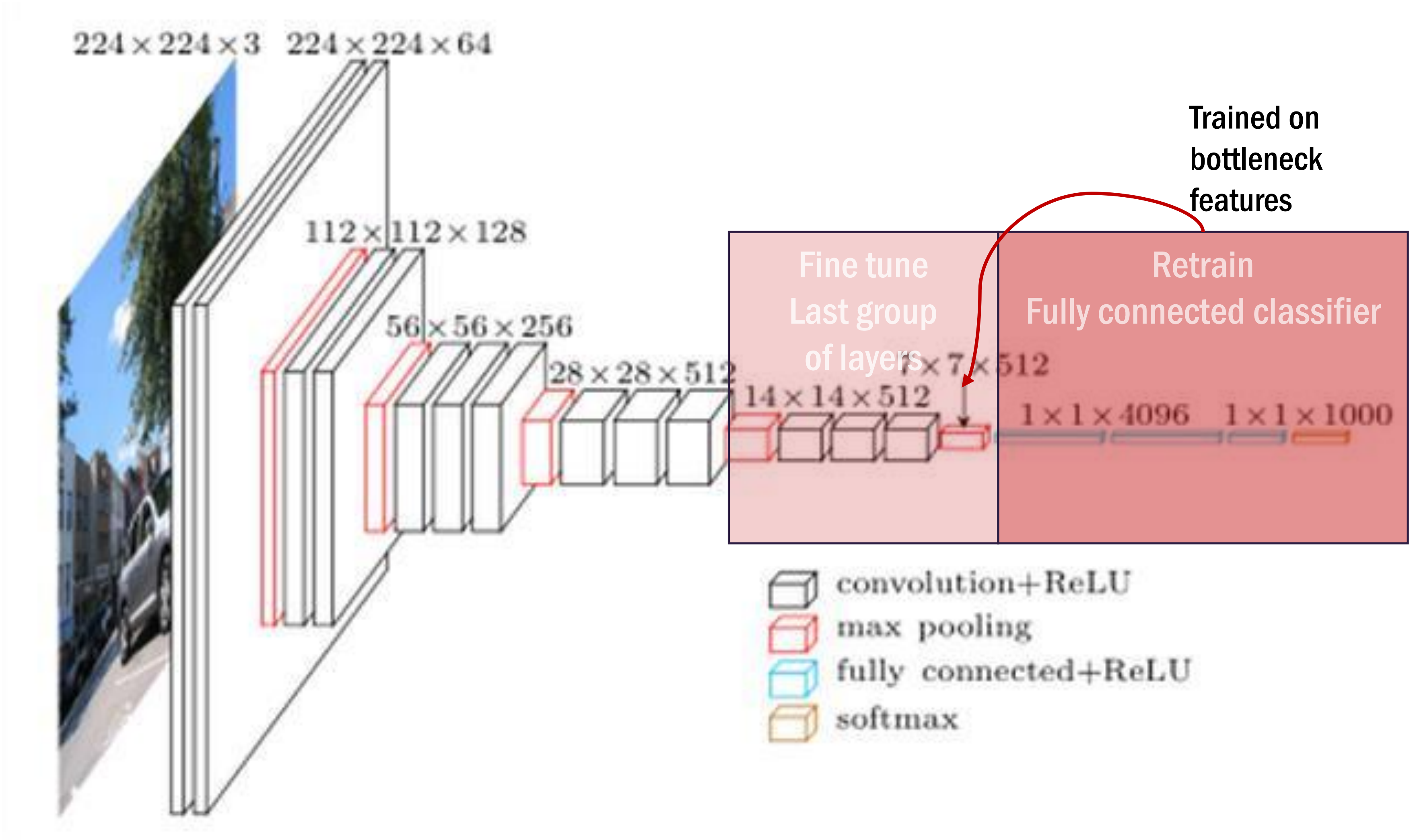
❑ Train a fully-connected classifier on top of a pre-trained CNN

- Allows training a CNN with as little as ~300 images per class

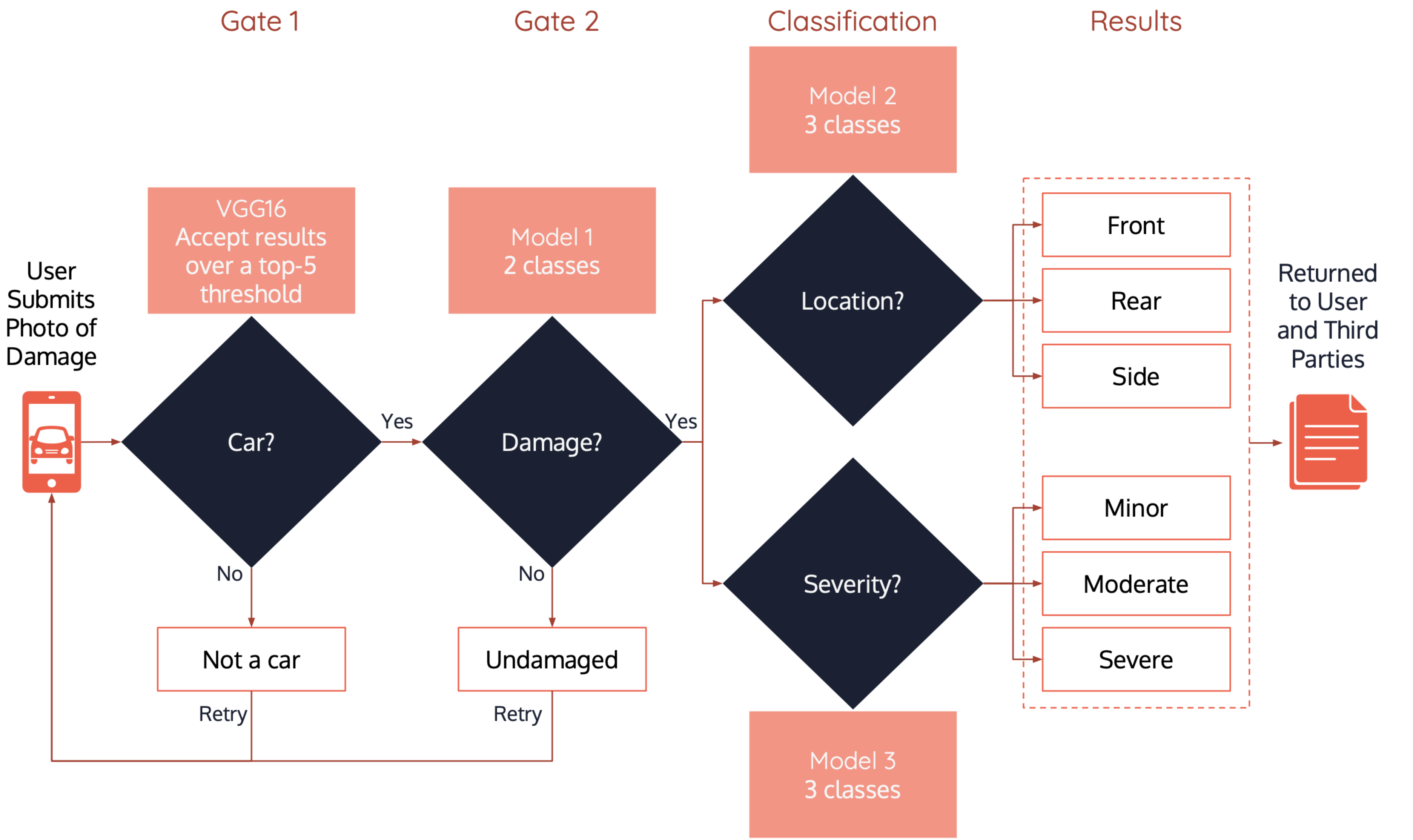
❑ Fine-tuning

- Tweaking the last convolutional block and retraining fully connected classifier with a very slow learning

VGG16 finetuned architecture

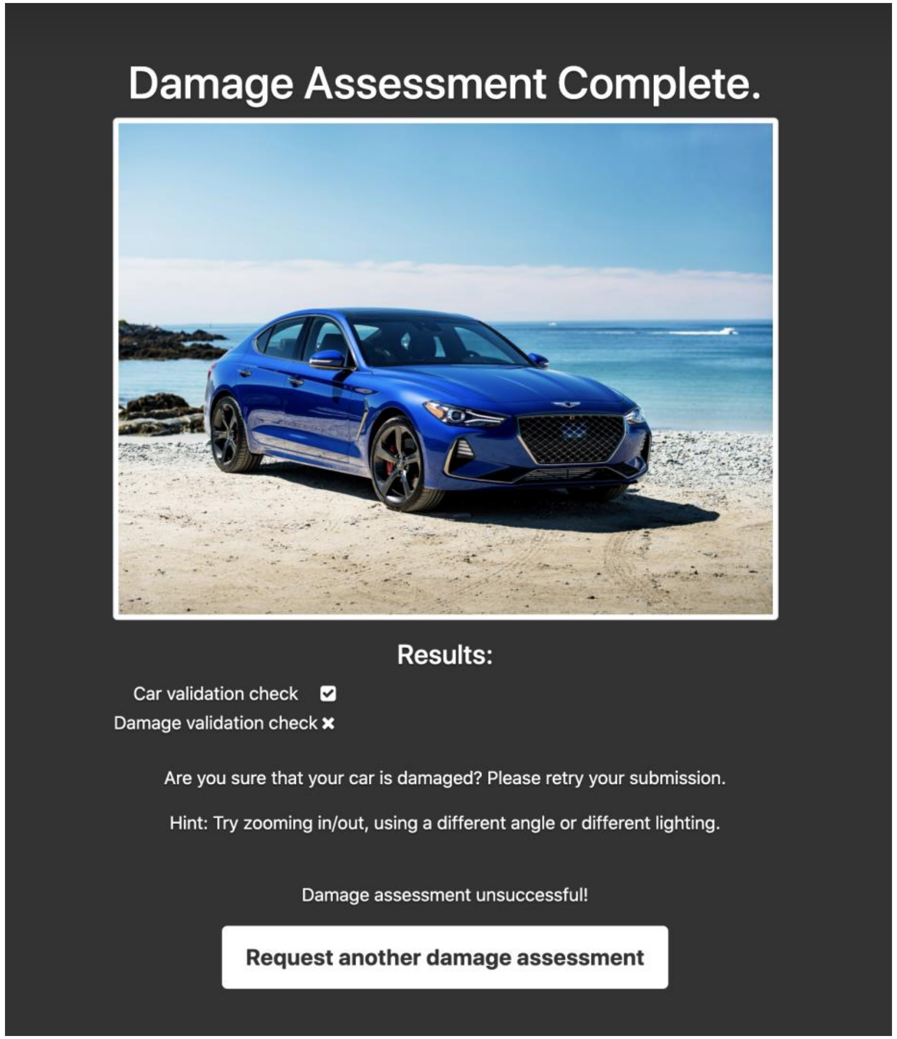


Developing a pipeline



See it live!

Output from the tool



Damage Assessment Complete.

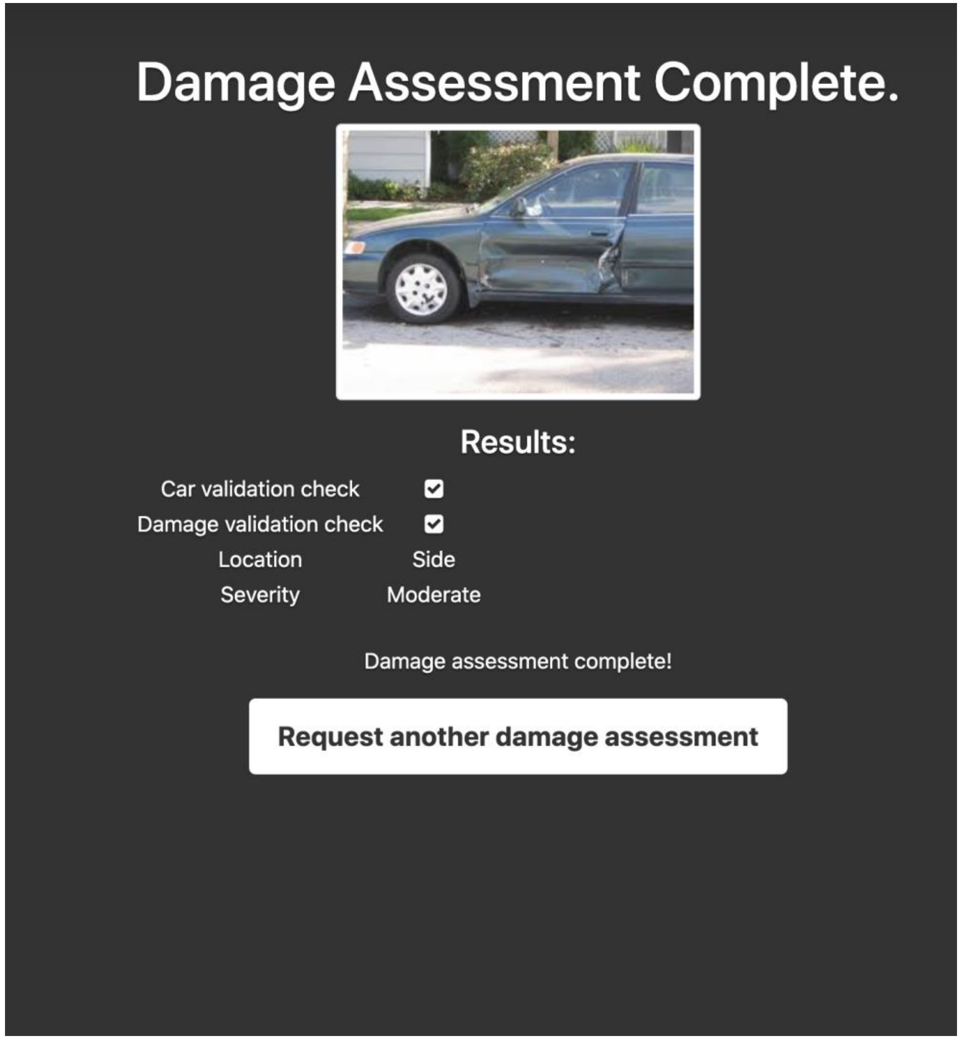
Results:

Car validation check	☑
Damage validation check	✖

Are you sure that your car is damaged? Please retry your submission.

Hint: Try zooming in/out, using a different angle or different lighting.

Damage assessment unsuccessful!



Damage Assessment Complete.

Results:

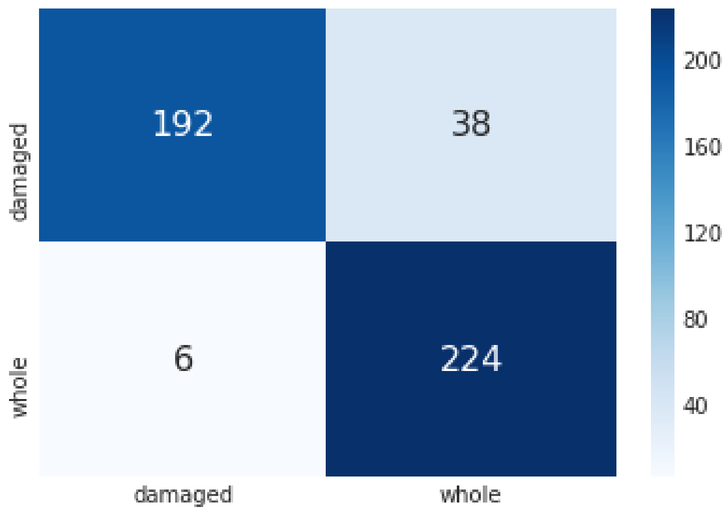
Car validation check	☑
Damage validation check	☑
Location	Side
Severity	Moderate

Damage assessment complete!

Evaluating the effort!

Model 1
Damaged or Whole?

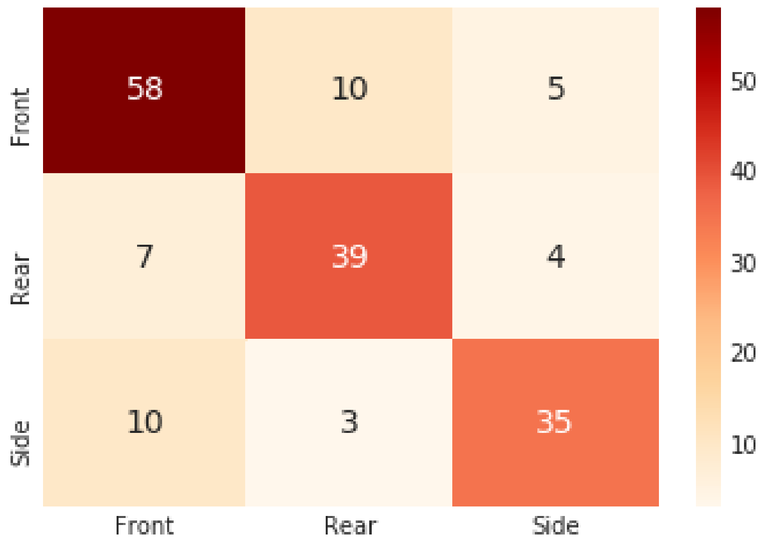
Accuracy: 90%
Precision: 91%
Recall: 90%



	damaged	whole
damaged	192	38
whole	6	224

Model 2
Damage Location

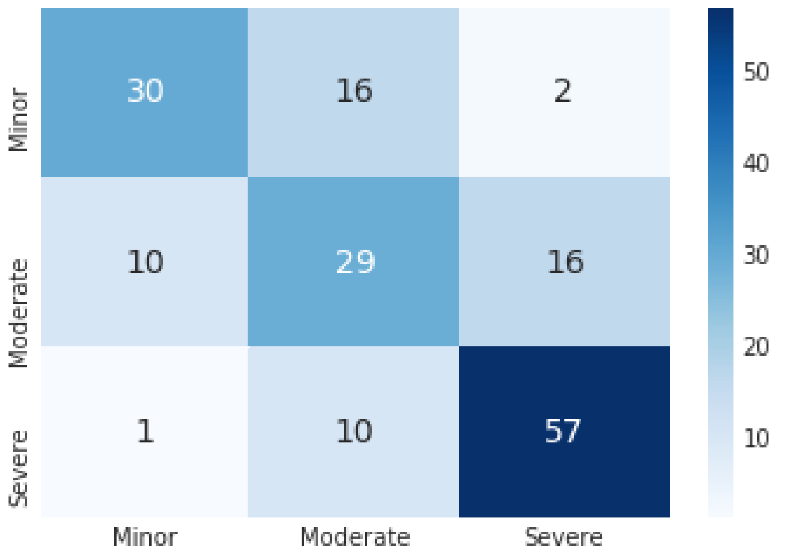
Accuracy: 77%
Precision: 77%
Recall: 76%



	Front	Rear	Side
Front	58	10	5
Rear	7	39	4
Side	10	3	35

Model 3
Damage Severity

Accuracy: 67%
Precision: 67%
Recall: 67%



	Minor	Moderate	Severe
Minor	30	16	2
Moderate	10	29	16
Severe	1	10	57

Choice of precision-recall threshold depends on perspective!

Dataset & Toolset

- Scrapped by using “import.io” from Google Images
    - Could be provided if needed (~1000 damaged, ~1000 whole cars)
- TensorFlow & Keras - Deep Learning Library
- Flask - Web Framework for Python
- Jupyter notebooks & VS Code
- Anaconda Distribution

Conclusion & Future Work

- Convolutional neural networks are accurate at evaluating car damage - even trained on only 1,150 damaged car images.

- With a wider range of data set featuring multiple components of the car, the model can also be trained to identify what components are damaged, also classifying the varying degree of damage of each.

- With a highly expansive dataset containing the make, model, year of the car and the possible cost estimates for the varying degrees of damage, the model can also predict the value for the user, before he submits the more advanced and detailed assessment for evaluation.

References and further reads

- Credit for the Google Images scraper goes to Ian London's fantastic General Image Classifier project.
- What are Bottleneck Features?
- More about CNNs!!