EEL 6935: Safe Autonomous Systems

Risk Bounds for Distracted Driver Detection

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Outline

- Background
- Methods
- Results
- Future Directions
- Questions!

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Background

Dangers of Distracted Drivers

- 3,142 fatalities and 324,652 injuries in 2020[1]
- 1 in 8 police-reported motor vehicle accidents
- Drivers of ages between 15 and 20 are most at risk

Detecting Distracted Drivers

- Provided 2D images or video stream, classifying drivers as distracted or alert is a viable approach
- Models can then be integrated into a larger driver alert system

Methods

State Farm Distracted Driver Detection Dataset

- Approximately 100,000 640x840 resolution images
- Training set is imbalanced, about 9-to-1 with a larger representation of alert drivers

Previous work

- Deep learning networks have shown promise, obtaining prediction accuracies of 99%
- Machine learning has been applied with lesser success
- Other approaches, like the one proposed here, involve transfer learning techniques

Methods

Alert Drivers

Distracted Drivers

Methods

Performance Evaluation

- Main Objective is to identify distracted drivers
- Must minimize false positives - distracted drivers labeled as alert
- Precision is then a favorable metric to track
- F1-score is also considered

$$\text{Precision} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}}$$

$$\text{Recall} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}}$$

$$\text{F1} = 2 \times \frac{\text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

Images from: Shung, Koo Ping. “Accuracy, Precision, Recall or F1?” *Medium*, Towards Data Science, 10 Apr. 2020, https://towardsdatascience.com/accuracy-precision-recall-or-f1-331fb37c5cb9.

Methods

Binomial Proportion Confidence Intervals

- Quantifying uncertainty estimate in false positives
- Gaussian assumptions do not always hold
- Analogous to providing a confidence interval around a binomial distribution

Clopper-Pearson interval

- Often called the exact interval because it is based on the cumulative probabilities of the binomial distribution[3]
- Provided an observation, the bounds can be determined by:

$$\sum_{k=X}^{n} \binom{n}{k} p_L^k (1-p_L)^{n-k} = \alpha/2 \qquad \sum_{k=0}^{X} \binom{n}{k} p_U^k (1-p_U)^{n-k} = \alpha/2.$$

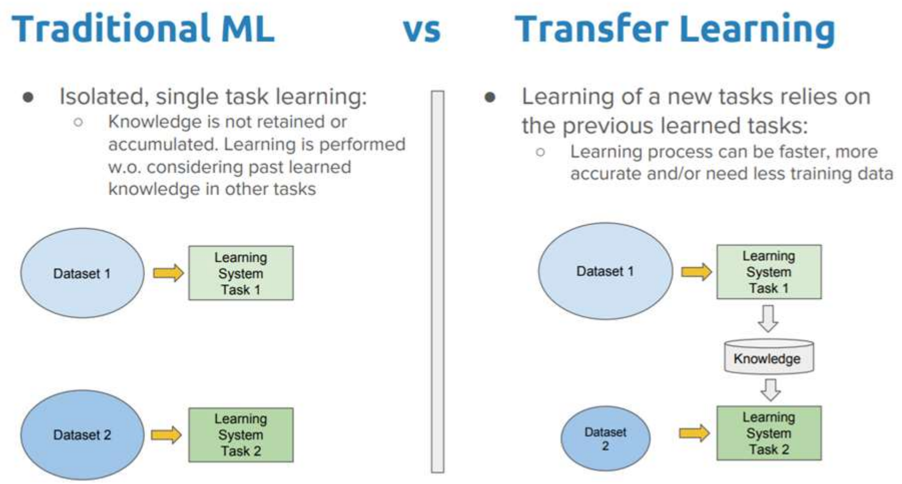
Image provided by Stephanie. "Clopper-Pearson Exact Method." *Statistics How To*, 28 May 2022, https://www.statisticshowto.com/clopper-pearson-exact-method/.

Methods

Tested Frameworks

Framework 1	Framework 2
Input (150x150x3)	Input (150x150x3)
Convolution layer, 32 kernels, 3x3	Xception base model
Max-pooling 2x2	Convolution layer, 32 kernels, 5x5
Convolution layer, 64 kernels, 3x3	Max-pooling 2x2
Convolution layer, 64 kernels, 3x3	Convolution layer, 64 kernels, 5x5
Max-pooling 2x2	Convolution layer, 64 kernels, 5x5
Full connection 1024	Max-pooling 2x2
Full connection 512	Full connection 256, dropout 0.25
Sigmoid 1	Sigmoid 1

Table 1: Frameworks of the two Convolutional Neural Networks (CNN) that were trained and tested.



Images from: https://www.v7labs.com/blog/transfer-learning-guide#:~:text=In%20other%20words%2C%20transfer%20learning,when%20modeling%20the%20second%20task.

Results

Metric	**Dataset**	**Model**	
		Framework 1	Framework 2
F1-Score	Train	0.95	1
	Test	0.95	0.98
BPCI	Train	8.4 – 11.7%	0.1 – 0.9%
	Test	6.5 – 14.8%	1.1 – 6.2%

Future Directions

- Investigate differences in performance amongst various age groups – focus on most at risk population
- Perform multiclass classification in order to classify degree of distraction
- Integrate model into larger driver alert system

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Summary

- Discussed the dangers of distracted driving
- Proposed a method for classifying distracted drivers
- Introduced methods for obtaining risk bounds
- Compared two convolutional neural networks, one involving transfer learning techniques
- Discussed possible future directions

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References

[1] N. Highway Traffic Safety Administration and U. Department of Transportation, “Distracted Driving 2020,” 2020.
[2] F Chollet. “Xception: Deep Learning with Depthwise Separable Convolutions” 2017
[3] “Binomial Proportion Confidence Interval.” Wikipedia, Wikimedia Foundation, 16 Nov. 2022, https://en.wikipedia.org/wiki/Binomial_proportion_confidence_interval#Clopper%E2%80%93Pearson_interval.

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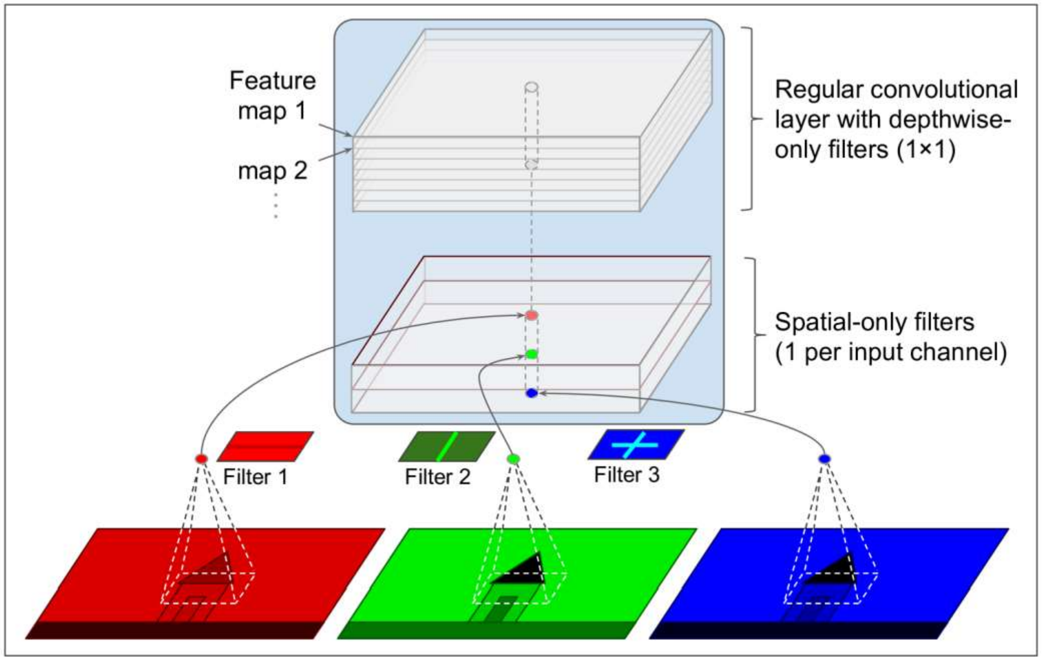
Questions?

Bonus slide!

Xception[2]



- Significantly outperformed its predecessor on a huge vision task (350 million images and 17,000 classes)
- Makes assumption that spatial patters and cross-channel patterns can be modeled separately
- Uses depth-wise separable convolution layer or separable convolution layer for short
- First applies single spatial filters to each channel, then second part looks for cross-channel patterns