GehirnWagen

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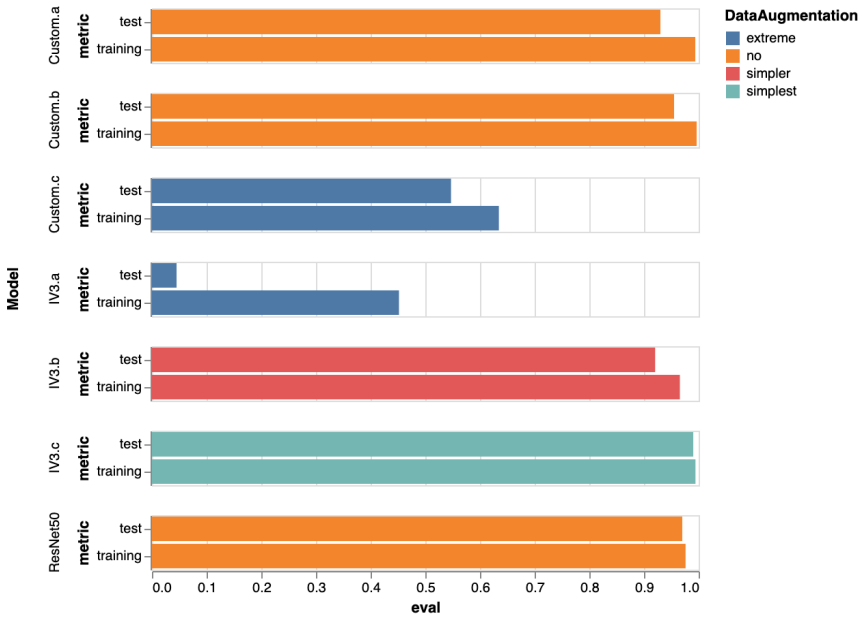
Machine Learning Model Summary

To help GehirnWagen with their self-driving car initiative, we decided that it would be most appropriate to build a convolutional neural network classification model in order to identify road signs that a car will encounter in Germany. Using 31,368 images of German road signs and their labels, we were able to train various models with different modifications to come out with one final model that performed with 99% accuracy on our partial holdout set (data that it had never seen before). We anticipate similar results on its real-life application.

Different Models



Displayed are the accuracies of our different models that we experimented with. Ultimately, our InceptionV3 model performed the best on our partial holdout data, leading us to choose it as our finalized model. The graph is included to display the improvements made across different models, as well as how data augmentation affected our results. They are arranged in the order that they were developed, from top to bottom. The exact numbers are shown in the table below.

	Model	DataAugmentation	training	test
0	Custom VGG16	no	0.9938	0.93000
1	Deeper VGG16	no	0.9963	0.95500
2	Custom Model	extreme	0.6345	0.54700
3	InceptionV3	extreme	0.4518	0.04500
4	InceptionV3	simpler	0.9656	0.92039
5	InceptionV3	simplest	0.9941	0.99005
6	ResNet50	no	0.9760	0.97000

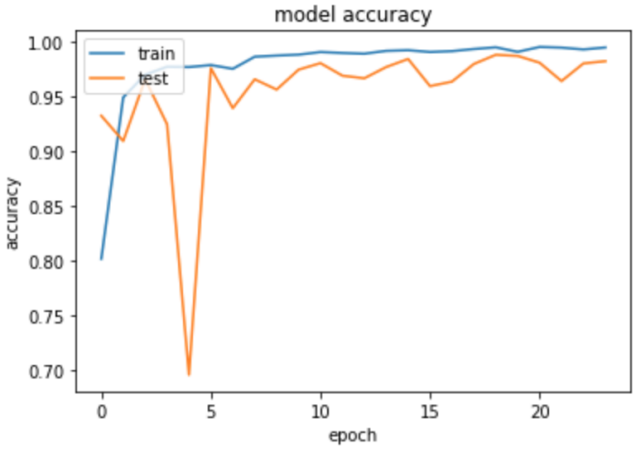
Data Augmentation

Our only pre-processing that we did to our data was image augmentation. This is the idea that the training data that we had was too clear and easy to recognize, while in real life, it may not be this easy. To prepare for this, the images from the training data that we had were augmented by attempting to simulate real-life scenarios.

Out of all of our tuning, this seemed to have the biggest effect on the performance of our models. At first, we took the approach of attempting to train our model in the most extreme conditions possible, such as flipping the signs upside down and having a range of brightness from 0 (being no light) to 1 (maximum brightness). Our puzzling result was, however, our simple non-augmented trained models were performing better on the partial holdout set than our augmented trained models. With further thought, we realized that some of our "extreme" images must be "confusing" our model and were also unrealistic. We decided that the best approach was to use the augmentation to match real-life scenarios as closely as possible by using our own logic. This approach was able to give us our best results. The final parameters that we used on our image augmentation function are as follows:

- Image rotation up to 30 degrees
- horizontal shifts
- vertical shifts
- Brightness in a range of .2 - .8
- Rescaling (Zooming out) up to 1/255 of the original size

Training the Model



In order to prevent overfitting we made sure to augment the data in a way that would challenge the model without making it impossible for the model to learn. The

Model needed more Epochs to train itself, however it was able to, over time, train itself on more difficult images, allowing it to have a wider variety and skill level for identifying images.

Model Performance

Here is a classification report for the Custom.b model. The left is a report on classification metrics for each of the individual signs. The right side is the key stating which road sign corresponds to each class on the left.

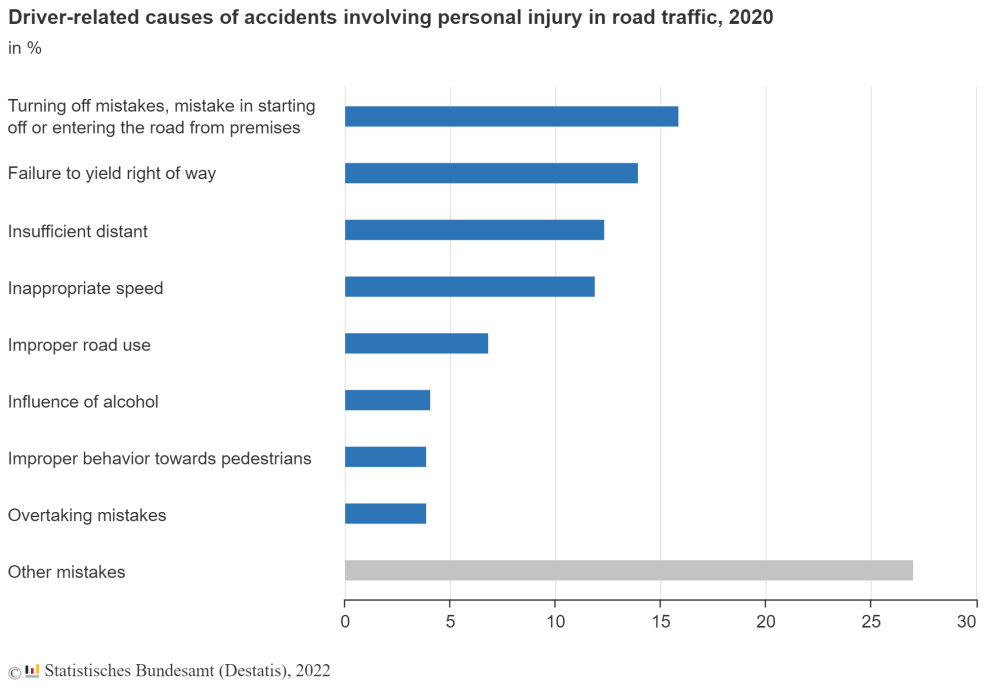
	precision	recall	f1-score	support
1	0.83	0.91	0.87	11
2	0.89	1.00	0.94	8
3	1.00	0.90	0.95	10
4	0.90	1.00	0.95	9
5	0.80	0.80	0.80	5
6	1.00	1.00	1.00	3
7	1.00	1.00	1.00	8
8	1.00	0.83	0.91	6
9	1.00	1.00	1.00	10
10	1.00	1.00	1.00	12
11	0.89	1.00	0.94	8
12	1.00	0.86	0.92	7
13	1.00	1.00	1.00	10
14	1.00	1.00	1.00	4
15	1.00	1.00	1.00	2
16	1.00	1.00	1.00	5
17	1.00	1.00	1.00	7
18	1.00	0.88	0.93	8
20	1.00	1.00	1.00	2
21	0.75	1.00	0.86	3
22	1.00	1.00	1.00	1
23	1.00	1.00	1.00	2
24	1.00	1.00	1.00	2
25	1.00	0.93	0.96	14
26	1.00	1.00	1.00	3
27	1.00	1.00	1.00	2
28	0.67	1.00	0.80	2
29	1.00	0.33	0.50	3
30	0.67	0.50	0.57	4
31	0.33	1.00	0.50	1
32	1.00	1.00	1.00	1
33	1.00	1.00	1.00	7
34	1.00	1.00	1.00	2
35	0.80	1.00	0.89	4
36	1.00	1.00	1.00	2
38	1.00	1.00	1.00	9
40	1.00	0.50	0.67	2
41	1.00	1.00	1.00	2
accuracy			0.94	201
macro avg	0.93	0.93	0.92	201
weighted avg	0.95	0.94	0.94	201

0. Max speed 20
1. Max speed 30
2. Max speed 50
3. Max speed 60
4. Max speed 70
5. Max speed 80
6. End of 30 Zone. The speed limit is now 50 km/h. Which is a normal speed limit inside city limits, unless another speed limit is specifically mentioned.
7. Max speed 100
8. Max speed 120
9. No Passing (overtaking) for any vehicle type except one line (track) transport (like motorcycles and mopeds)
10. No passing for vehicles with a total weight of over 3.5 t.
11. Indicates priority, only at the upcoming intersection or crossing.
12. Priority Road starts. This sign indicates a priority at all upcoming intersections and crossings till sign 307. Oncoming traffic must yield.
13. Yield right of way
14. Stop Sign
15. No entry for any type of vehicle
16. No entry for motor vehicles with a maximum authorized mass of more than 3.5 t.
17. Do not enter
18. General Warning Sign
19. A single curve approaching in the left

	direction 20. A single curve is approaching in the right direction 21. Approaching double curve- first to the left 22. Rough road ahead 23. Danger of skidding or slipping 24. Road narrows from the right 25. Work in process/be aware of workers on the road 26. Traffic Signal ahead 27. Pedestrians may cross 28. Pay attention to children? 29. Be aware of cyclists 30. Beware of icy road 31. Wild animals may cross road 32. End of all previously set passing and speed restrictions. 33. Turn right 34. Turn left 35. The mandatory direction of travel is straight ahead. No turns are permitted. 36. Go straight or turn right 37. Go straight or turn left 38. Prescribed drive direction around the obstacle. Drive from the right of the obstacle 39. Prescribed drive direction around the obstacle. Drive from the left of the obstacle. 40. Indicates entrance to a traffic circle (roundabout) 41. End of the no-passing zone for vehicles under 3.5 t 42. End of all passing

Safety Measures

The accident rate in Germany has fallen by 60% between 2000 and 2019, sitting at 3.7 per 100,000 inhabitants. The graph below shows the main reasons of driver related causes of accidents. According to the graph, turning mistakes, failure to yield right of way, insufficient distance and inappropriate speed are the leading causes. Based on the available information an accuracy of 85% on warning signs and 98% or above all other prohibitions and traffic signs would be the best option. Because the majority of accidents seem to be due to a misinterpretation of traffic signs.



Colab Notebooks

https://colab.research.google.com/drive/1qQB3DLwHlp_UPbxfYeCjekjVcJqxhVbe#scrollTo=VN1VcmblcQh4

https://colab.research.google.com/drive/1l0YU3F6XM7Jwu_-0pUqAdikYS9vNiIwJ?usp=sharing#scrollTo=gtE4i_EWljYF

https://colab.research.google.com/drive/1ysf9fiKqmhX-CTThVsrbvefc2iBc5_GJ?usp=sharing