Traffic Signs Classification

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Intro

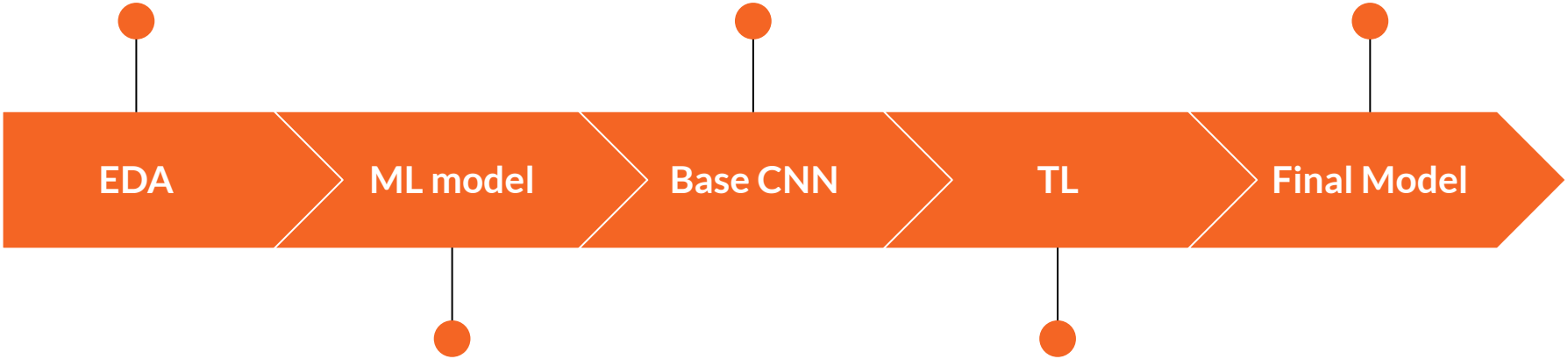
Autonomous vehicles are becoming a part of our reality.

In the foreseeable future, they will have to understand the traffic signs around them.

Visualization of images and classes

Starting point for the Deep Learning route

Choosing the best model and generate predictions



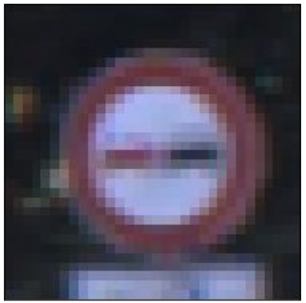
Building a RF classifier

Transfer learning, aiming for better performance

Example images

Wild animals crossing

No passing


No passing

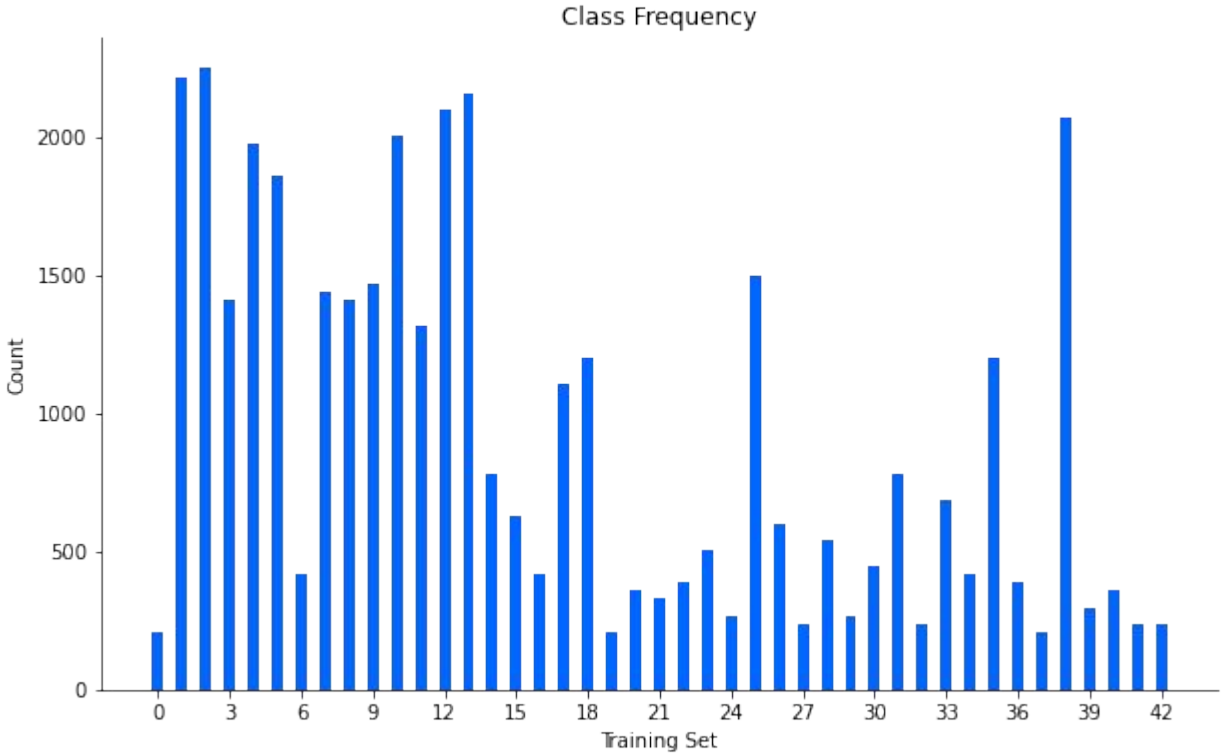
Speed limit (120km/h)

No passing

Priority road

Traffic signals

General caution


Class Frequency
Count
2000
1500
1000
500
0
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
Training Set

ML approach - Random Forest

Initial steps:

- **Reshape input data**
  (n, height*width*channels)
- **Train-test split**
- **RandomSearch to find optimal parameters.**

Results:

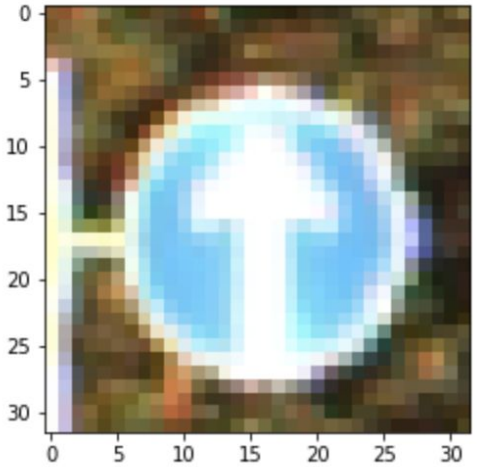
- Acc on test 0.713

With optimal parameters

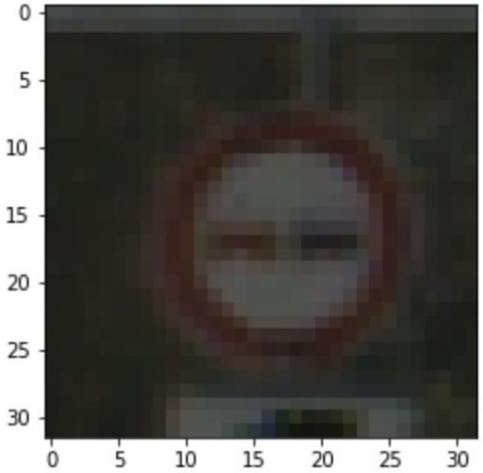
- Acc on test 0.776

Predictions by the RF

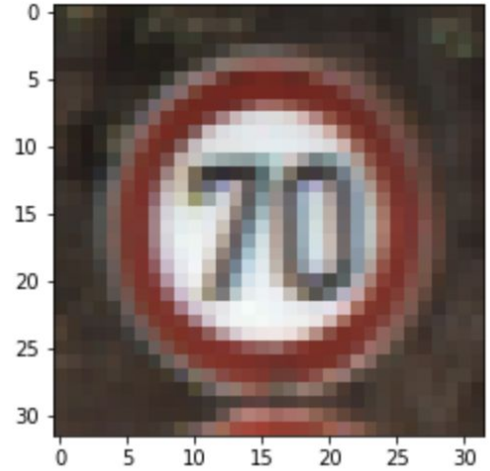
'Ahead only'



'No passing'

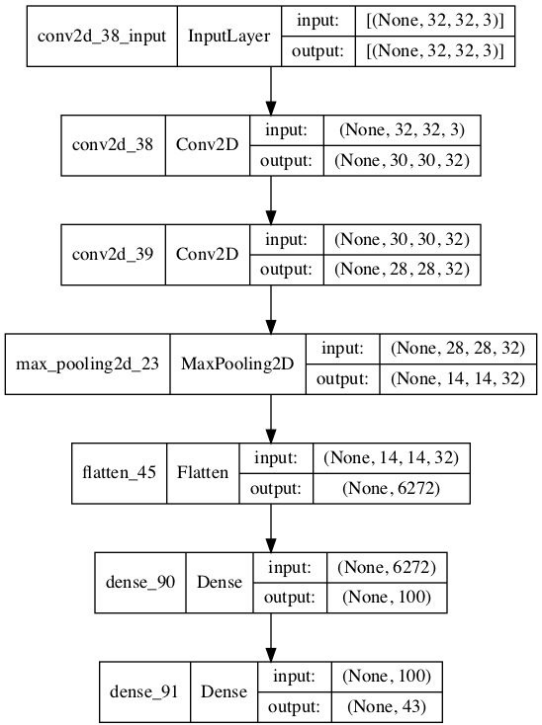


'Speed limit (30km/h)'



Deep Learning

Baseline CNN



Results

accuracy			0.88	12630
macro avg	0.94	0.85	0.88	12630
weighted avg	0.90	0.88	0.89	12630

After...

Creating different architecture models, changing batch size, applying grayscale and histogram equalization to the inputs.

Transfer Learning

ResNet-50

- Use their preprocessing module for the inputs.
- Build on top of the model, dropping top layer.
- Steps LR decrease

- Results = Acc on val < 0.47

VGG16

- Input shape corresponds to the model's input shape.

- Results = Acc on val < 0.67

nope.

Final model

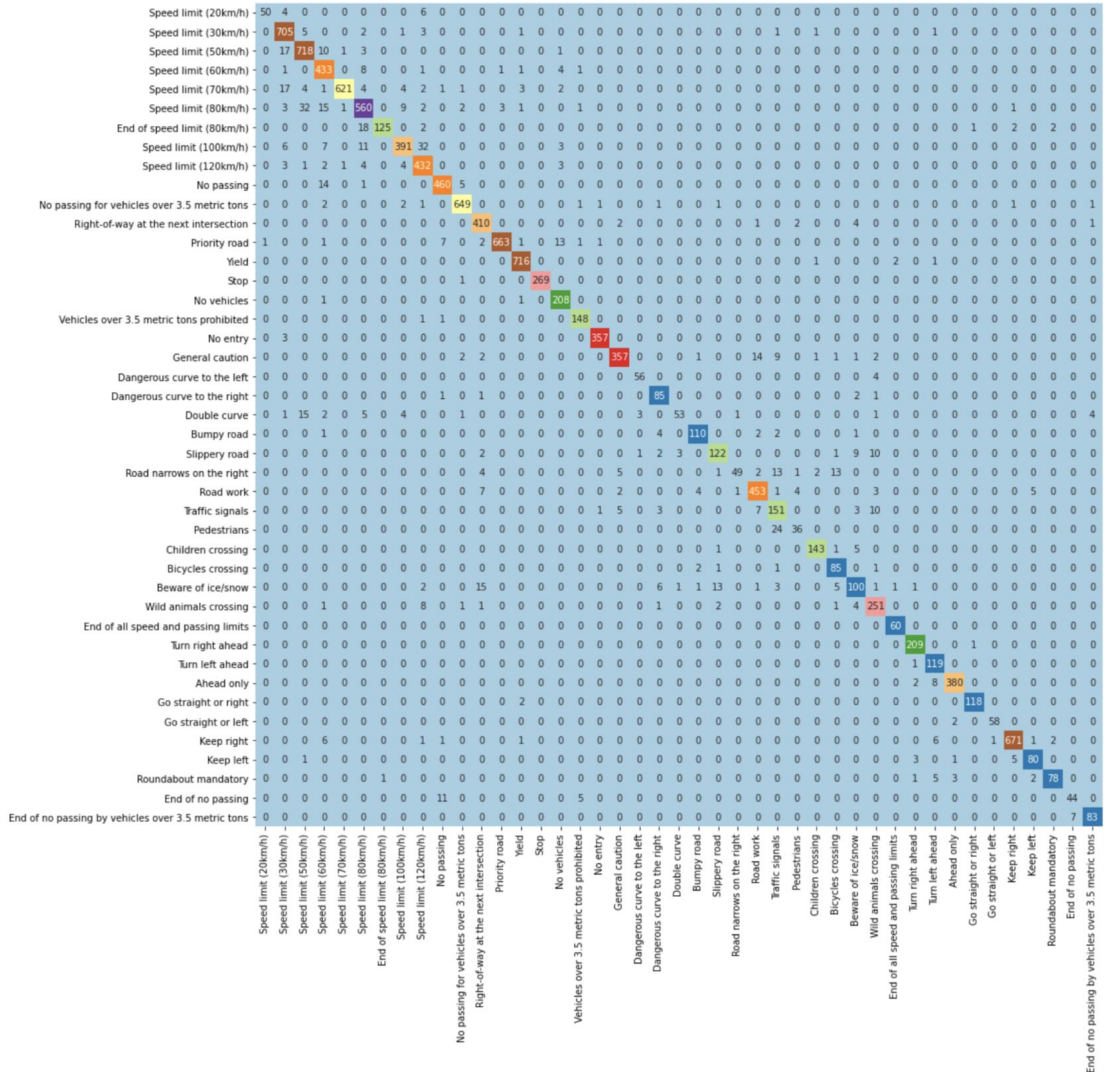
- Added dropout layers to the base model
- Implemented drop learning rate on plateau
- Saved and loaded the best model to make predictions.

Accuracy score on test = 0.94

Model accuracy by class

Class_Label	Accuracy
Speed limit (20km/h)	83.33
Speed limit (30km/h)	97.92
Speed limit (50km/h)	95.73
Speed limit (60km/h)	96.22
Speed limit (70km/h)	94.09
Speed limit (80km/h)	88.89
End of speed limit (80km/h)	83.33
Speed limit (100km/h)	86.89
Speed limit (120km/h)	96.00
No passing	95.83
No passing for vehicles over 3.5 metric tons	98.33
Right-of-way at the next intersection	97.62
Priority road	96.09
Yield	99.44
Stop	99.63
No vehicles	99.05
Vehicles over 3.5 metric tons prohibited	98.67
No entry	99.17
General caution	91.54
Dangerous curve to the left	93.33
Dangerous curve to the right	94.44
Double curve	58.89
Bumpy road	91.67
Slippery road	81.33
Road narrows on the right	54.44
Road work	94.38
Traffic signals	83.89
Pedestrians	60.00
Children crossing	95.33
Bicycles crossing	94.44
Beware of ice/snow	66.67
Wild animals crossing	92.96
End of all speed and passing limits	100.00
Turn right ahead	99.52
Turn left ahead	99.17
Ahead only	97.44
Go straight or right	98.33
Go straight or left	96.67
Keep right	97.25
Keep left	88.89
Roundabout mandatory	86.67
End of no passing	73.33
End of no passing by vehicles over 3.5 metric tons	92.22

CM


Speed limit (20km/h)
Speed limit (30km/h)
Speed limit (50km/h)
Speed limit (60km/h)
Speed limit (70km/h)
Speed limit (80km/h)
End of speed limit (80km/h)
Speed limit (100km/h)
Speed limit (120km/h)
No passing
No passing for vehicles over 3.5 metric tons
Right-of-way at the next intersection
Priority road
Yield
Stop
No vehicles
Vehicles over 3.5 metric tons prohibited
No entry
General caution
Dangerous curve to the left
Dangerous curve to the right
Double curve
Bumpy road
Slippery road
Road narrows on the right
Road work
Traffic signals
Pedestrians
Children crossing
Bicycles crossing
Beware of ice/snow
Wild animals crossing
End of all speed and passing limits
Turn right ahead
Turn left ahead
Ahead only
Go straight or right
Go straight or left
Keep right
Keep left
Roundabout mandatory
End of no passing
End of no passing by vehicles over 3.5 metric tons

Predictions

```
1 signs[16]
```

```
'Vehicles over 3.5 metric tons prohibited'
```

```
1 signs[8]
```

```
'Speed limit (120km/h)'
```

```
1 signs[25]
```

```
'Road work'
```

```
1 signs[11]
```

```
'Right-of-way at the next intersection'
```

Conclusions

- A simple model can perform better that more complex setups depending on the field of application.
- Model improvement over epochs must be measured in order to avoid overtraining and expenses in computational resources.
- The external shape of the traffic signs is the main factor for the misclassifications.

Future Work

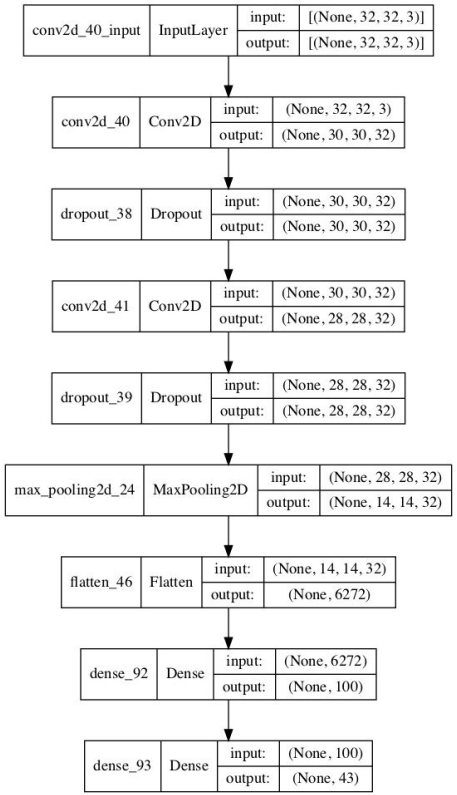
- Using data augmentation
- Implementing hierarchical convolutional neural networks to identify subgroups within the traffic signs.

Appendix

Classification report

	precision	recall	f1-score	support
Speed limit (20km/h)	0.98	0.83	0.90	60
Speed limit (30km/h)	0.93	0.98	0.95	720
Speed limit (50km/h)	0.93	0.96	0.94	750
Speed limit (60km/h)	0.87	0.96	0.92	450
Speed limit (70km/h)	1.00	0.94	0.97	660
Speed limit (80km/h)	0.91	0.89	0.90	630
End of speed limit (80km/h)	0.99	0.83	0.91	150
Speed limit (100km/h)	0.94	0.87	0.90	450
Speed limit (120km/h)	0.88	0.96	0.92	450
No passing	0.95	0.96	0.96	480
No passing for vehicles over 3.5 metric tons	0.98	0.98	0.98	660
Right-of-way at the next intersection	0.92	0.98	0.95	420
Priority road	0.99	0.96	0.98	690
Yield	0.98	0.99	0.99	720
Stop	1.00	1.00	1.00	270
No vehicles	0.89	0.99	0.94	210
Vehicles over 3.5 metric tons prohibited	0.94	0.99	0.96	150
No entry	0.99	0.99	0.99	360
General caution	0.96	0.92	0.94	390
Dangerous curve to the left	0.93	0.93	0.93	60
Dangerous curve to the right	0.83	0.94	0.89	90
Double curve	0.93	0.59	0.72	90
Bumpy road	0.93	0.92	0.92	120
Slippery road	0.87	0.81	0.84	150
Road narrows on the right	0.96	0.54	0.70	90
Road work	0.94	0.94	0.94	480
Traffic signals	0.74	0.84	0.78	180
Pedestrians	0.84	0.60	0.70	60
Children crossing	0.97	0.95	0.96	150
Bicycles crossing	0.79	0.94	0.86	90
Beware of ice/snow	0.78	0.67	0.72	150
Wild animals crossing	0.88	0.93	0.91	270
End of all speed and passing limits	0.95	1.00	0.98	60
Turn right ahead	0.96	1.00	0.98	210
Turn left ahead	0.85	0.99	0.92	120
Ahead only	0.98	0.97	0.98	390
Go straight or right	0.98	0.98	0.98	120
Go straight or left	0.98	0.97	0.97	60
Keep right	0.99	0.97	0.98	690
Keep left	0.91	0.89	0.90	90
Roundabout mandatory	0.95	0.87	0.91	90
End of no passing	0.86	0.73	0.79	60
End of no passing by vehicles over 3.5 metric tons	0.93	0.92	0.93	90
accuracy			0.94	12630
macro avg	0.93	0.90	0.91	12630
weighted avg	0.94	0.94	0.94	12630

Final model architecture



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