Bosch's Traffic Sign Recognition

H1_BSC_9

Platform to train DNN architectures

without Code!

Data

Difficulty of Dataset

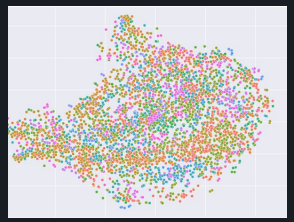
The Benchmark Dataset

German Traffic Sign Recognition Benchmark (GTSRB) Dataset

43
Classes

50,000
images

Large Lifelike dataset



Adding 5 extra classes

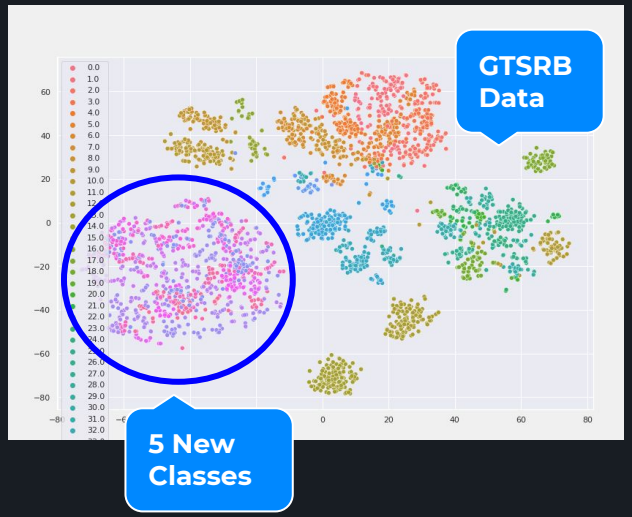
GTSRB + 5 extra classes vs GTSRB Dataset

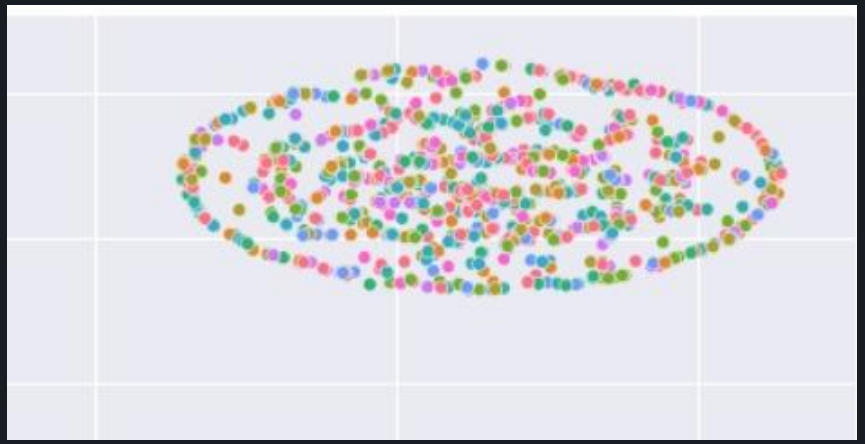
5 extra classes	GTSRB	Num images
No Bicycles	Bicycle crossing	857
No pedestrians	Pedestrian	473
Mandatory minimum speed	Speed limit 30	306
Two-way traffic	Signs featuring forward direction	126
Two way street	Two way traffic, go straight signs	125

Visual similarity between GTSRB and 5 classes

In an attempt to make dataset more difficult

t-SNE plots





5 New classes

Semantic similarity between GTSRB and 5 classes

In an attempt to make dataset more difficult

Benchmark Results

Evaluation Metric drop in GTSRB+5

In attempt to explain difficulty of dataset

	precision	recall	f1-score	support
0	0.967742	1.000000	0.983607	60.000000
1	0.994475	1.000000	0.997230	720.000000
2	0.998665	0.997333	0.997999	750.000000
3	1.000000	0.982222	0.991031	450.000000
4	0.998476	0.992424	0.995441	660.000000
5	0.990566	1.000000	0.995261	630.000000
6	1.000000	0.986667	0.993289	150.000000
7	0.995565	0.997778	0.996670	450.000000
8	0.997783	1.000000	0.998890	450.000000
9	1.000000	1.000000	1.000000	480.000000
10	0.998485	0.998485	0.998485	660.000000
11	0.980488	0.957143	0.968675	420.000000
12	0.968571	0.982609	0.975540	690.000000
13	1.000000	0.997222	0.998609	720.000000
14	1.000000	1.000000	1.000000	270.000000
15	0.972222	1.000000	0.985915	210.000000
16	1.000000	1.000000	1.000000	150.000000
17	0.996979	0.916667	0.955137	360.000000
18	0.997375	0.974359	0.985733	390.000000
19	1.000000	1.000000	1.000000	60.000000
20	0.737705	1.000000	0.849057	90.000000
21	0.909091	1.000000	0.952381	90.000000
22	0.862903	0.891667	0.877049	120.000000
23	0.914634	1.000000	0.955414	150.000000
24	0.988764	0.977778	0.983240	90.000000
25	0.993521	0.958333	0.975610	480.000000
26	0.994475	1.000000	0.997230	180.000000
27	0.842857	0.983333	0.907692	60.000000
28	0.967742	1.000000	0.983607	150.000000
29	1.000000	0.955556	0.977273	90.000000
30	0.983333	0.786667	0.874074	150.000000
31	0.978022	0.988889	0.983425	270.000000
32	1.000000	1.000000	1.000000	60.000000
33	0.967742	1.000000	0.983607	210.000000
34	0.983607	1.000000	0.991736	120.000000
35	0.997409	0.987179	0.992268	390.000000
36	0.983471	0.991667	0.987552	120.000000
37	0.983333	0.983333	0.983333	60.000000
38	0.988406	0.988406	0.988406	690.000000
39	1.000000	1.000000	1.000000	90.000000
40	0.989011	1.000000	0.994475	90.000000
41	0.983607	1.000000	0.991736	60.000000
42	0.989011	1.000000	0.994475	90.000000
accuracy	0.985669	0.985669	0.985669	0.985669
macro avg	0.974326	0.983156	0.977701	12630.000000
weighted avg	0.986679	0.985669	0.985741	12630.000000

Benchmark

	precision	recall	f1-score	support
0	0.967742	1.000000	0.983607	60.000000
1	0.994475	1.000000	0.997230	720.000000
2	0.998665	0.997333	0.997999	750.000000
3	1.000000	0.982222	0.991031	450.000000
4	0.998476	0.992424	0.995441	660.000000
5	0.990566	1.000000	0.995261	630.000000
6	1.000000	0.986667	0.993289	150.000000
7	0.995565	0.997778	0.996670	450.000000
8	0.997783	1.000000	0.998890	450.000000
9	1.000000	1.000000	1.000000	480.000000
10	0.998485	0.998485	0.998485	660.000000
11	0.980488	0.957143	0.968675	420.000000
12	0.968571	0.982609	0.975540	690.000000
13	1.000000	0.997222	0.998609	720.000000
14	1.000000	1.000000	1.000000	270.000000
15	0.972222	1.000000	0.985915	210.000000
16	1.000000	1.000000	1.000000	150.000000
17	0.996979	0.916667	0.955137	360.000000
18	0.997375	0.974359	0.985733	390.000000
19	1.000000	1.000000	1.000000	60.000000
20	0.737705	1.000000	0.849057	90.000000
21	0.909091	1.000000	0.952381	90.000000
22	0.862903	0.891667	0.877049	120.000000
23	0.914634	1.000000	0.955414	150.000000
24	0.988764	0.977778	0.983240	90.000000
25	0.993521	0.958333	0.975610	480.000000
26	0.994475	1.000000	0.997230	180.000000
27	0.842857	0.983333	0.907692	60.000000
28	0.967742	1.000000	0.983607	150.000000
29	1.000000	0.955556	0.977273	90.000000
30	0.983333	0.786667	0.874074	150.000000
31	0.978022	0.988889	0.983425	270.000000
32	1.000000	1.000000	1.000000	60.000000
33	0.967742	1.000000	0.983607	210.000000
34	0.983607	1.000000	0.991736	120.000000
35	0.997409	0.987179	0.992268	390.000000
36	0.983471	0.991667	0.987552	120.000000
37	0.983333	0.983333	0.983333	60.000000
38	0.988406	0.988406	0.988406	690.000000
39	1.000000	1.000000	1.000000	90.000000
40	0.989011	1.000000	0.994475	90.000000
41	0.983607	1.000000	0.991736	60.000000
42	0.989011	1.000000	0.994475	90.000000
accuracy	0.985669	0.985669	0.985669	0.985669
macro avg	0.974326	0.983156	0.977701	12630.000000
weighted avg	0.986679	0.985669	0.985741	12630.000000

Evaluation Metric drop in GTSRB+5:
In attempt to explain difficulty of dataset

	precision	recall	f1-score	support
0	0.62	1.00	0.77	60
1	0.87	1.00	0.93	720
2	0.88	1.00	0.93	750
3	0.88	0.98	0.92	45
4	0.85	0.99	0.92	
5	0.97	0.99	0.98	
6	0.99	0.95	0.97	1
7	0.99	1.00	1.00	4
8	0.99	1.00	0.99	4
9	0.90	1.00	0.95	4
10	0.99	1.00	0.99	6
11	0.97	0.97	0.97	4
12	0.83	0.94	0.89	690
13	0.92	1.00	0.96	720
14	0.87	1.00	0.93	270
15	0.80	1.00	0.89	210
16	0.77	1.00	0.87	150
17	1.00	0.94	0.97	360
18	0.72	0.93	0.81	390
19	0.88	1.00	0.94	60
20	0.98	1.00	0.99	90
21	0.65	1.00	0.79	90
22	0.88	0.82	0.85	120
23	0.72	0.97	0.82	150
24	0.76	0.98	0.85	90
25	0.92	0.98	0.95	480
26	0.69	1.00	0.81	180
27	0.54	0.80	0.64	60
28	0.66	1.00	0.79	150
29	0.39	1.00	0.56	90
30	0.88	0.76	0.81	150
31	0.89	1.00	0.94	270
32	0.81	1.00	0.90	60
33	0.84	1.00	0.91	210
34	0.89	1.00	0.94	120
35	0.78	1.00	0.87	390
36	0.94	1.00	0.97	120
37	0.55	0.98	0.71	60
38	0.89	0.99	0.94	690
39	0.54	0.98	0.69	90
40	0.61	0.98	0.75	90
41	0.42	1.00	0.59	60
42	0.00	0.00	0.00	90
43	0.00	0.00	0.00	857
44	0.00	0.00	0.00	473
45	0.00	0.00	0.00	306
46	0.00	0.00	0.00	126
47	0.00	0.00	0.00	125
accuracy			0.85	14517
macro avg	0.73	0.87	0.78	14517
ghted avg	0.76	0.85	0.80	14517

Noticeable drops in f1 score observed

Zeros as no extra class is present in the model

Evaluation of benchmark network on GTSRB+5

Benchmark

26	0.994475	1.000000	0.997230	180.000000
27	0.842857	0.983333	0.907692	60.000000
28	0.967742	1.000000	0.983607	150.000000
29	1.000000	0.955556	0.977273	90.000000
30	0.983333	0.786667	0.874074	150.000000
36	0.983471	0.991667	0.987552	120.000000
37	0.983333	0.983333	0.983333	60.000000
38	0.988406	0.988406	0.988406	690.000000
39	1.000000	1.000000	1.000000	90.000000
40	0.989011	1.000000	0.994475	90.000000
41	0.983607	1.000000	0.991736	60.000000
42	0.989011	1.000000	0.994475	90.000000

Noticeable drops in f1 score observed

Zeros as no extra class is present in the model

Evaluation of benchmark network on GTSRB+5

26	0.69	1.00	0.81	180
27	0.54	0.80	0.64	60
28	0.66	1.00	0.79	150
29	0.39	1.00	0.56	90
30	[illegible]	0.76	0.81	150
[illegible]	0.89	1.00	0.94	270
32	0.81	1.00	0.90	60
33	0.84	1.00	0.91	210
34	0.89	1.00	0.94	120
35	0.78	1.00	0.87	390
36	0.94	1.00	0.97	120
37	0.55	0.98	0.71	60
38	0.89	0.99	0.94	690
39	0.54	0.98	0.69	90
40	0.61	0.98	0.75	90
41	0.42	1.00	0.59	60
42	0.99	1.00	0.99	90
41	0.42	1.00	0.59	60
42	0.99	1.00	0.99	90
43	0.00	0.00	0.00	857
44	0.00	0.00	0.00	473
45	0.00	0.00	0.00	306
46	0.00	0.00	0.00	126
47	0.00	0.00	0.00	125
accuracy			0.85	14517
macro avg	0.73	0.87	0.78	14517
[illegible]ghted avg	0.76	0.85	0.80	14517

Drop in **average F1 score**
after adding new classes

Drop in **average accuracy**
after adding new classes

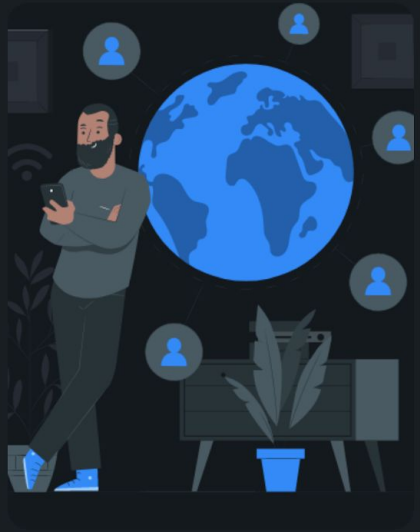
Data

User Interface

The User Interface

Data

Upload, transform and visualise your data with great control and ease.

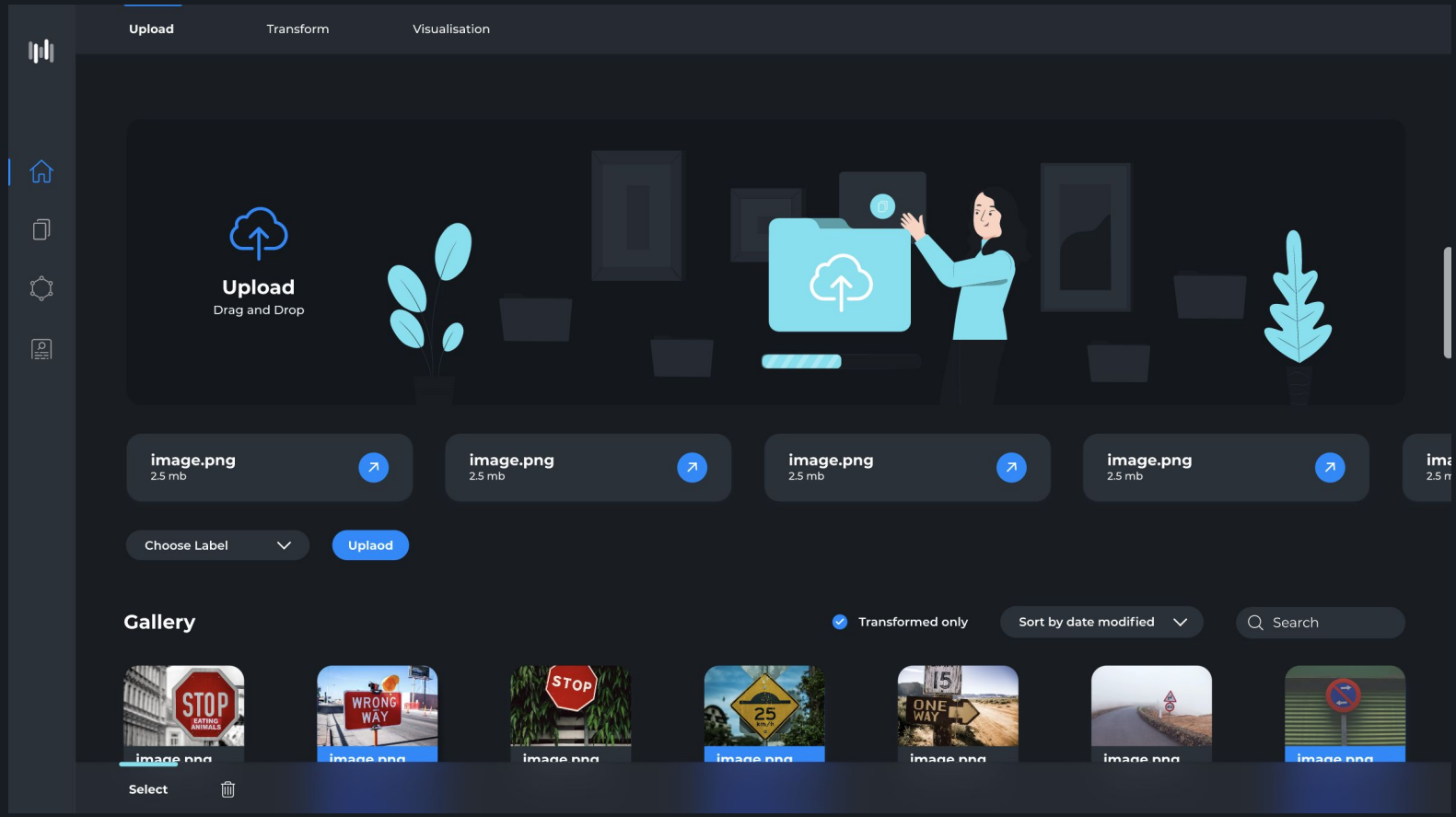


Network

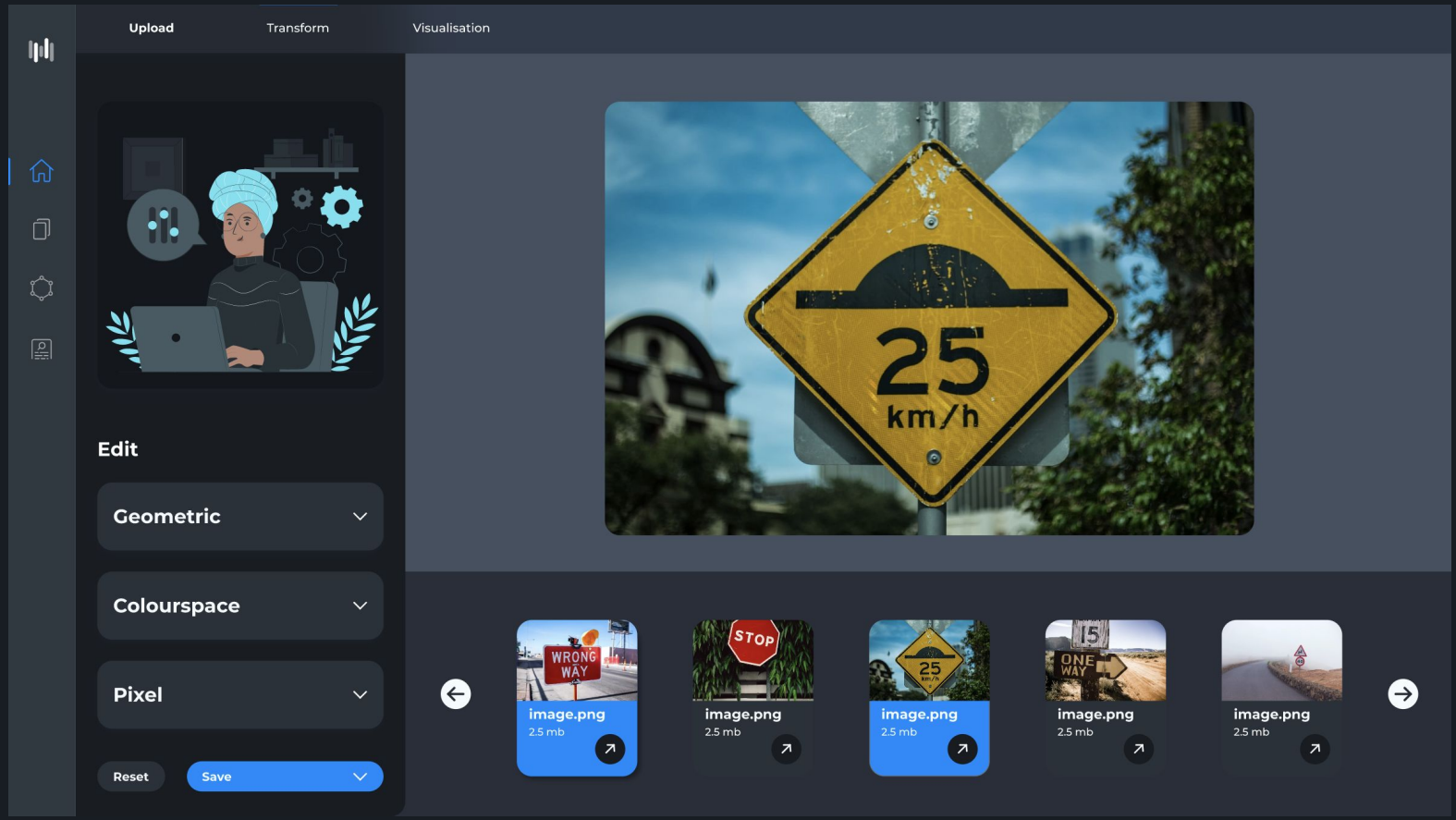
View, Modify and Train your network within a few clicks.

Result

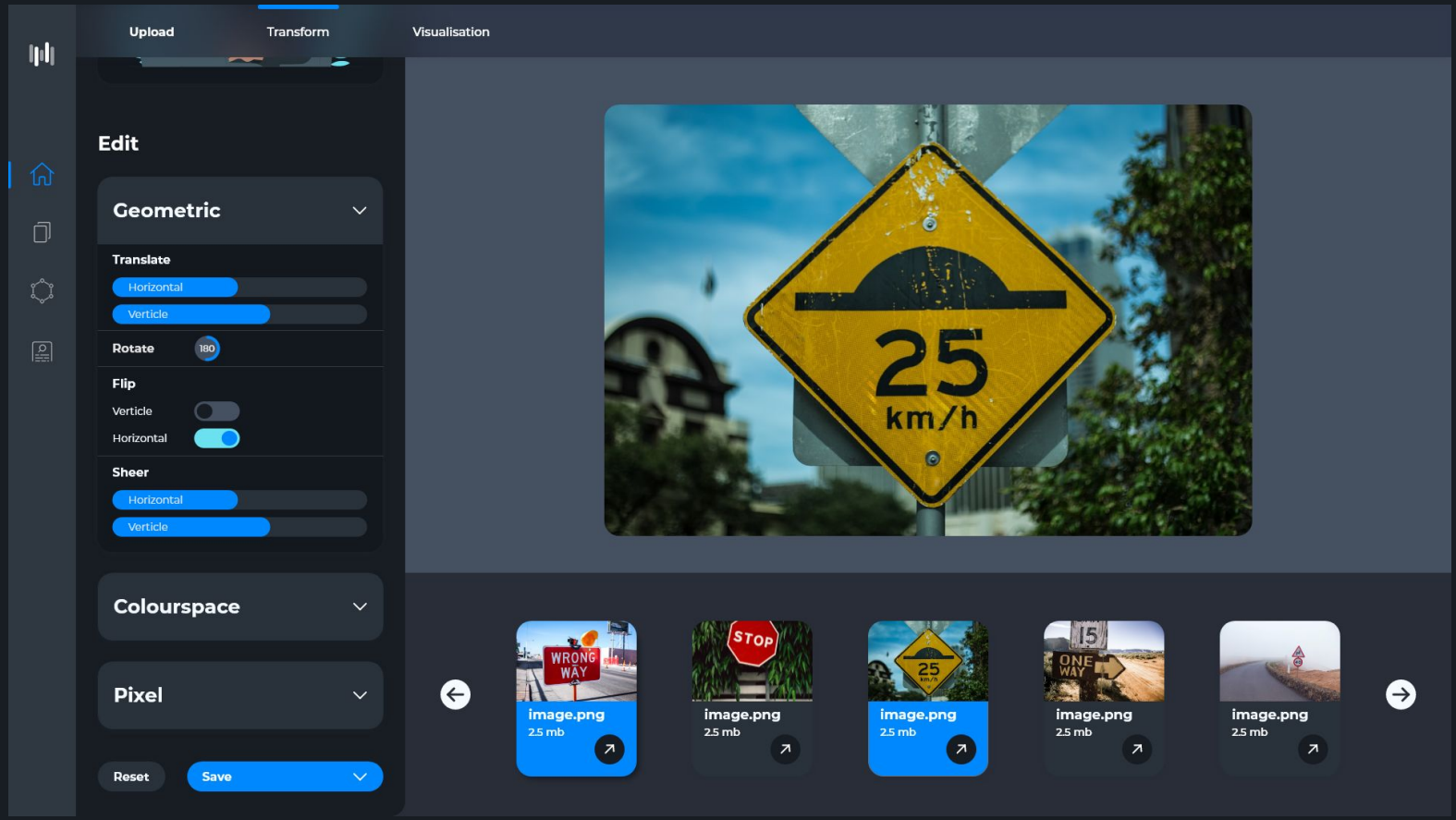
View and analyze your data, network and training results.



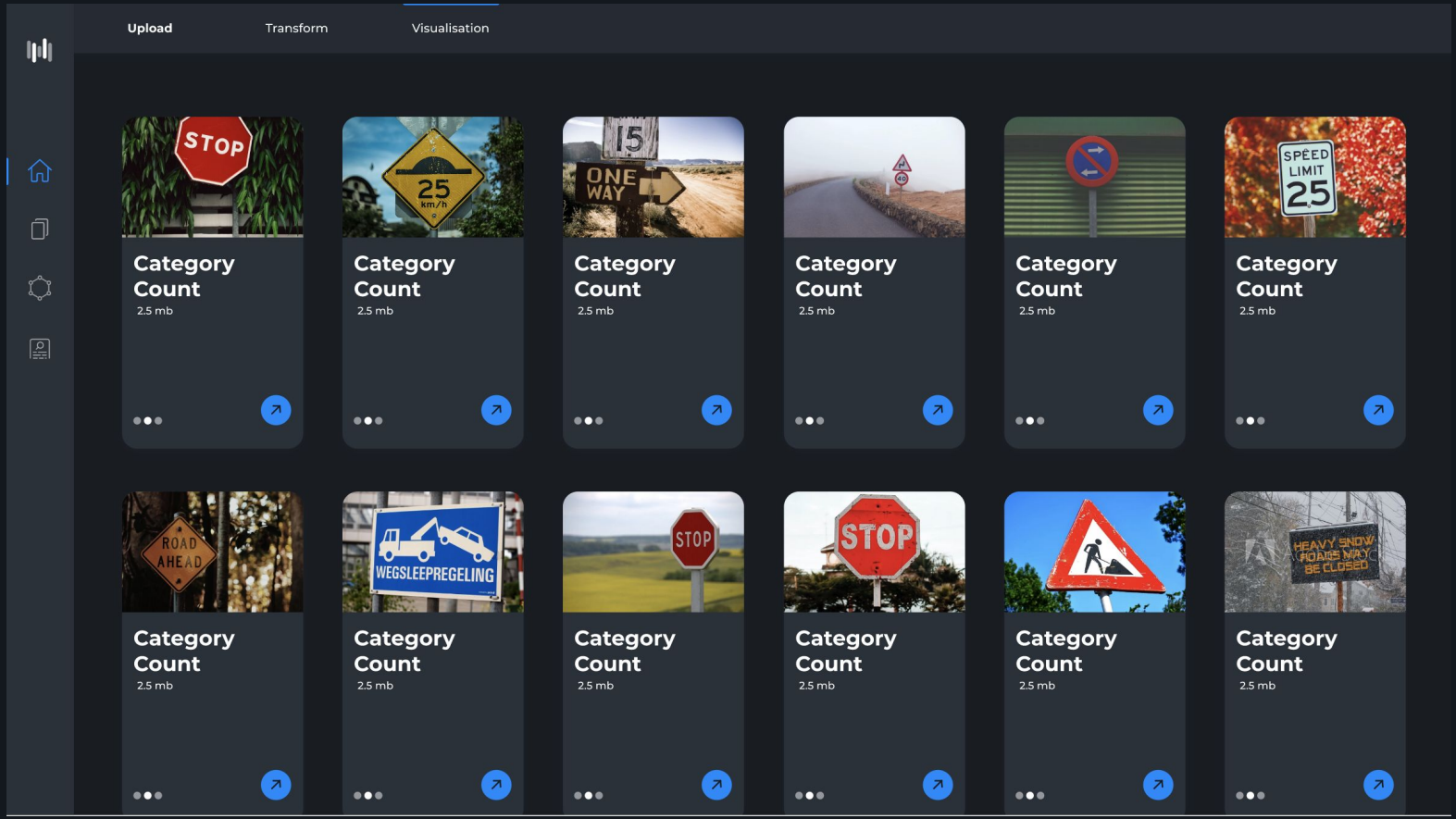
Upload images and apply powerful filters!



Transform images without ever going back to code



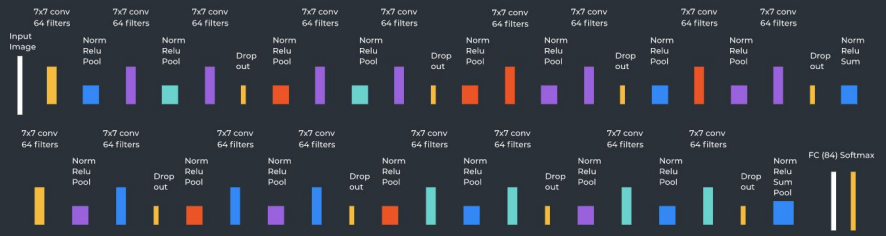
High-fidelity transformations



Visualize your data so you make the right decisions

Display Modify Train

Layers



Hyperparams

Hyp1:	1.1
Hyp2:	1.2
Hyp3:	1.4

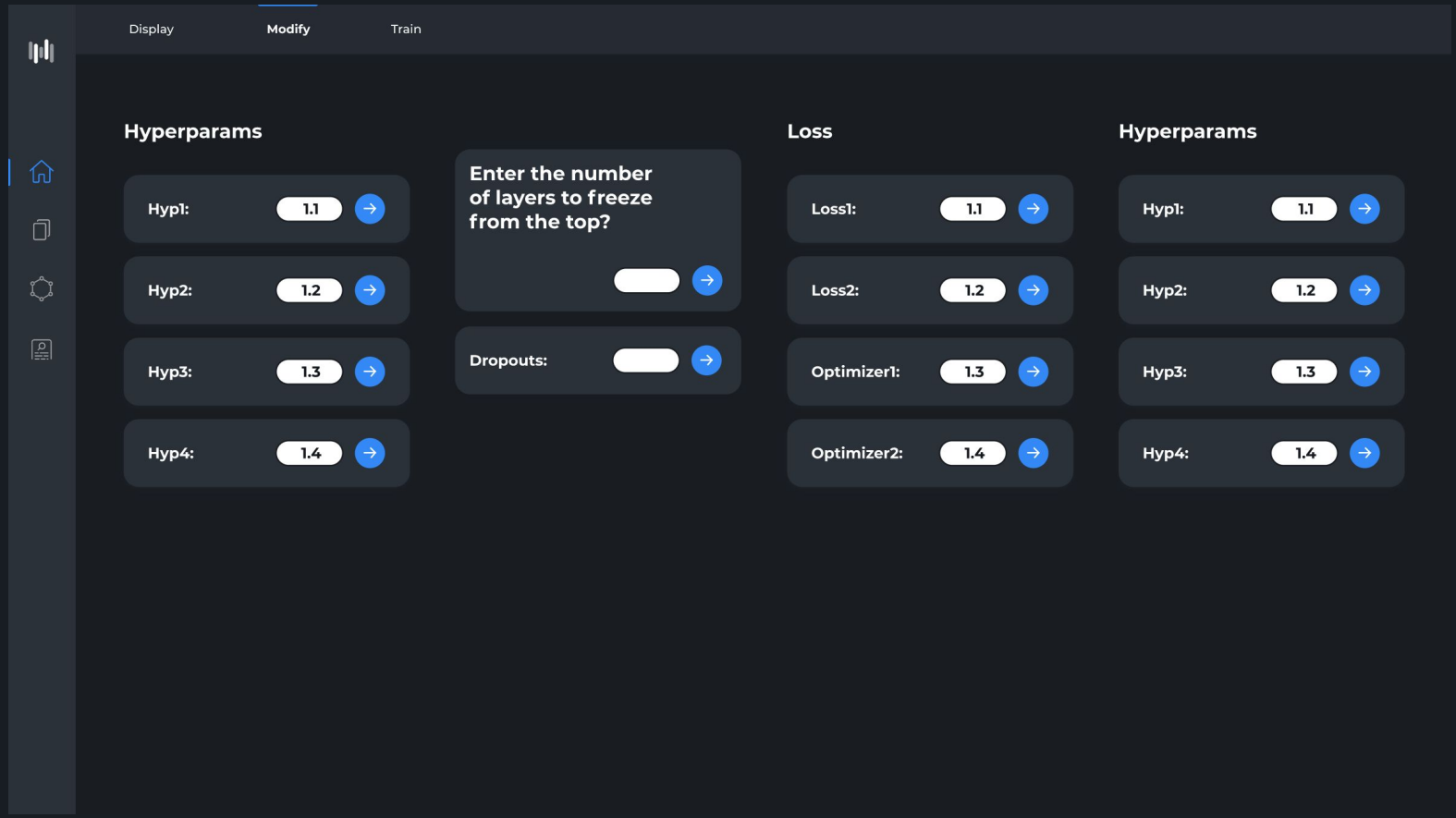
Loss

Loss1:	1.2
Loss1:	1.2
Loss1:	1.2

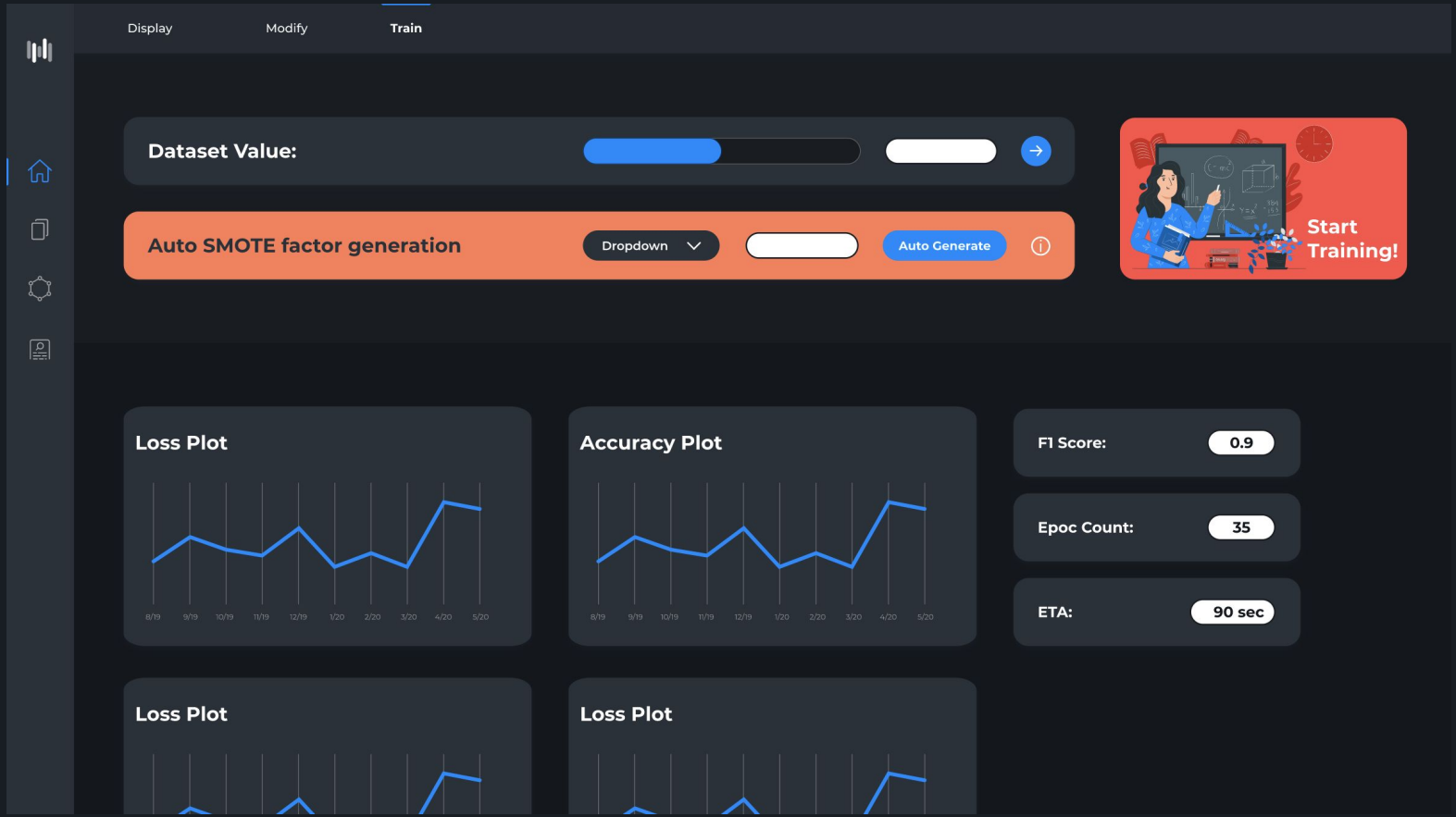
Layer 1

Hyp1:	1.1
Hyp2:	1.2
Hyp3:	1.3

Get all the information you need about your network



Even modify everything from one place!



Finally it's time for your training!

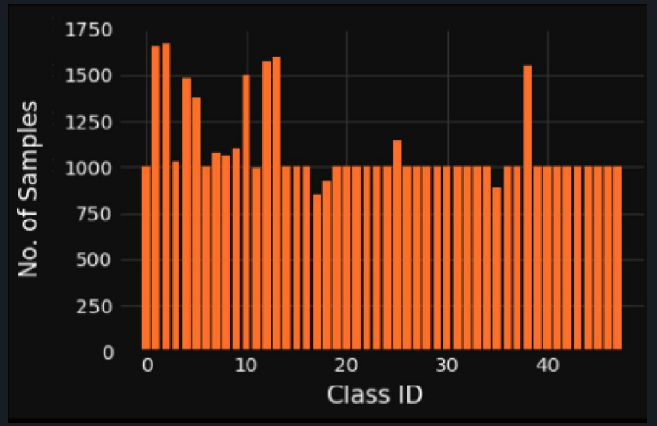
From dataset management to setting up your network to even training, you can do everything right here without writing a single line of code!

But there’s more...

Synthetic Minority Oversampling Technique

It is a statistical oversampling technique used for increasing the no. of samples of the minority classes in a balanced way to counter class imbalance problem.

Before



After applying SMOTE

Dataset Distribution

Synthetic Minority Oversampling Technique

Benefits:

1. Makes the sample distribution in the dataset more general
2. Improves performance on the minority classes
3. Overall classification metrics of the model improve

Results on the minority classes

	Average Precision	Average Recall	Average F1 score
Before	0.88	0.93	0.9
After applying SMOTE	0.96	0.98	0.98

Performance of Network

Multiple models : varying quirks

Baseline

Small custom network focused on the **GTSRB dataset**.

1

Mobilenet

2

Medium deep network focused on **speed of evaluation**.

Googlenet

3

Medium deep network for **balance in speed and accuracy**.

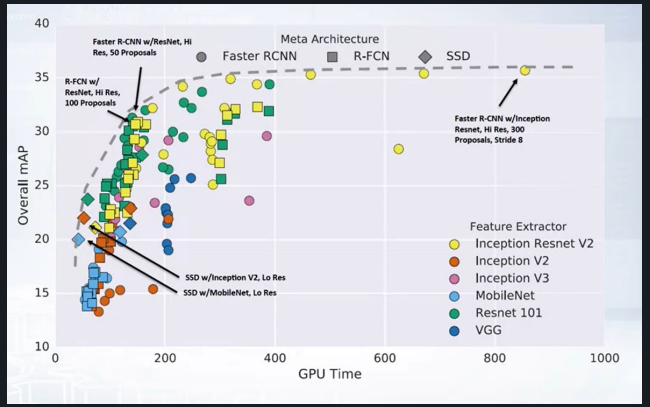
Resnet

4

Deep neural network focused on **accuracy of evaluation**.

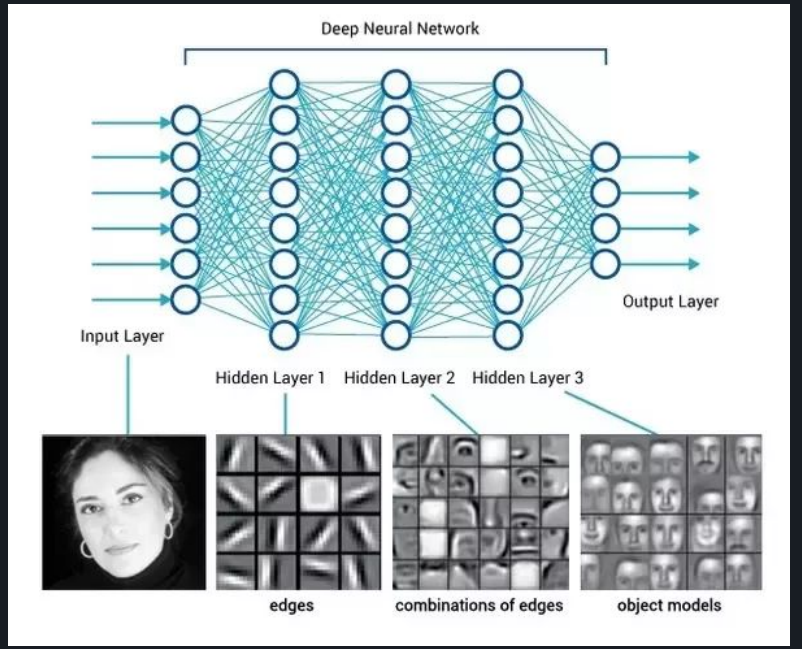
Why multiple models?

1. Speed vs Accuracy
2. Finding the best performing model
3. Validating consistency in results
4. Better understanding of data
5. Ability to choose generalisable models
6. Ensures scalability

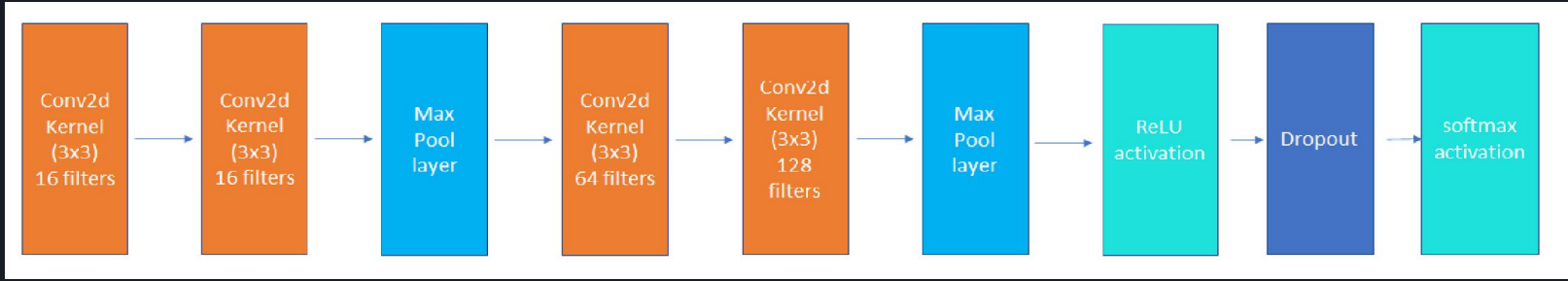


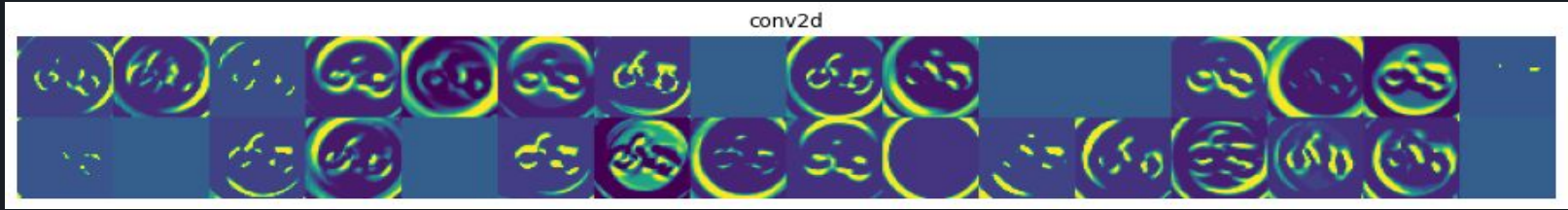
Why visualise networks?

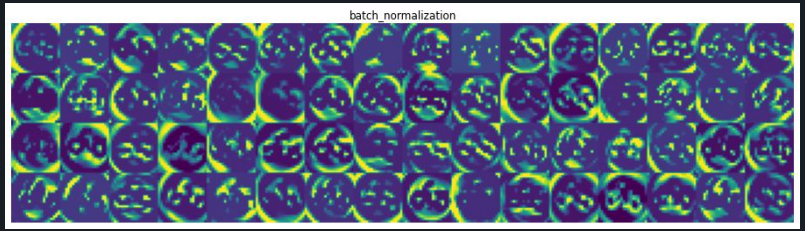
1. First idea of individual convnet filters
2. Understanding transform, their input
3. Less interpretable with depth
4. Redundancy of layers

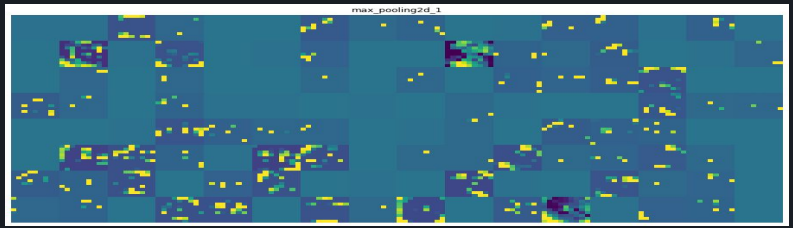


Baseline Network



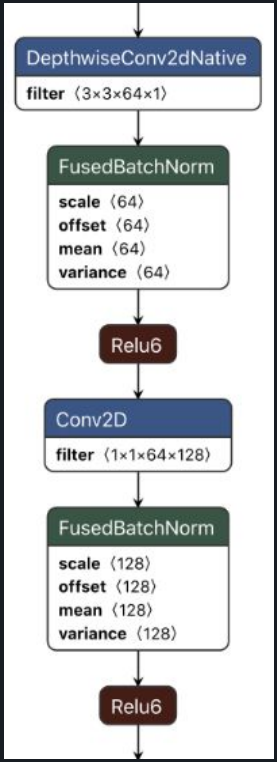


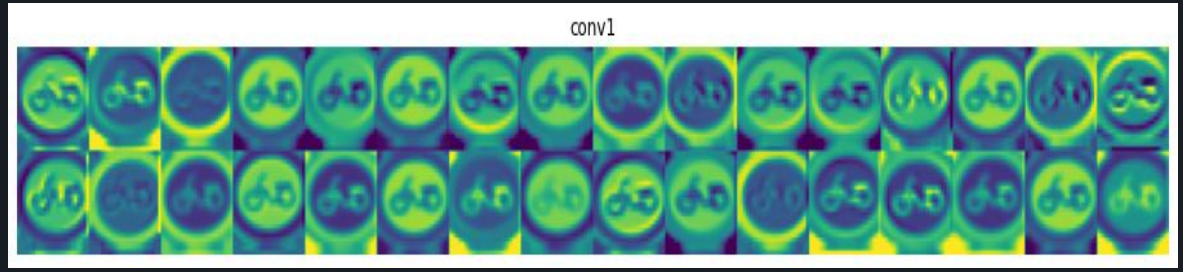


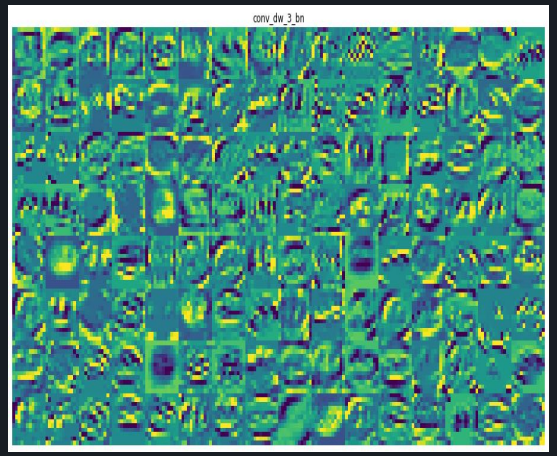


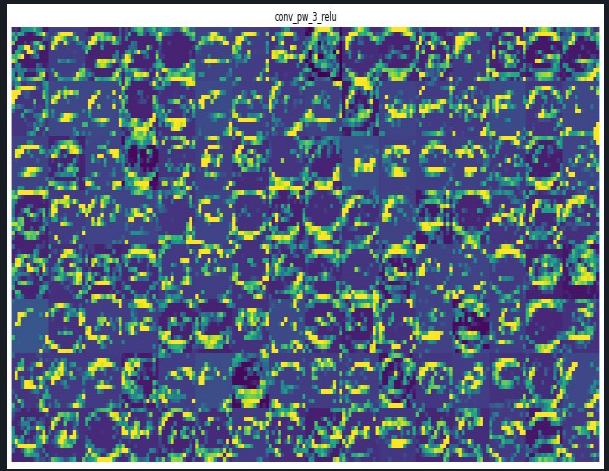
Visualising Baseline Feature maps

Mobilenet-v1 Network



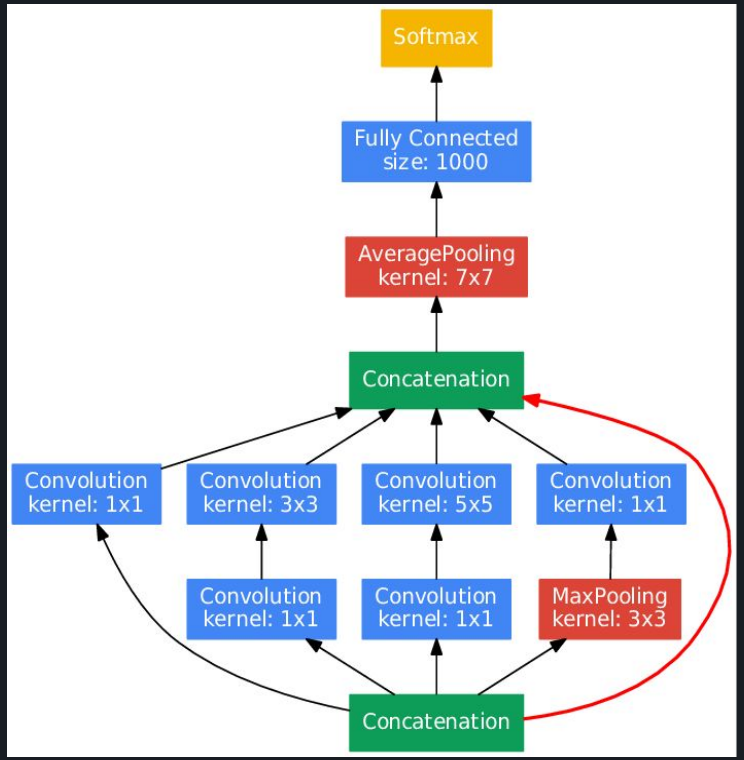


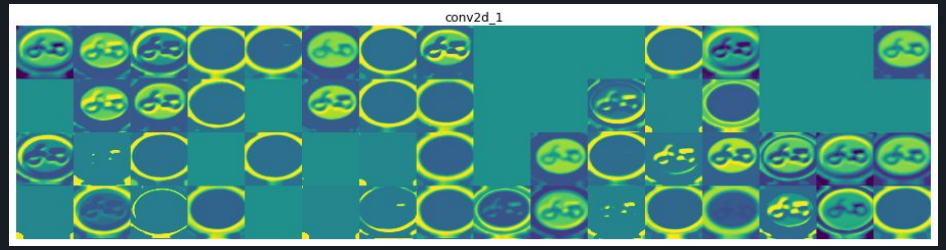


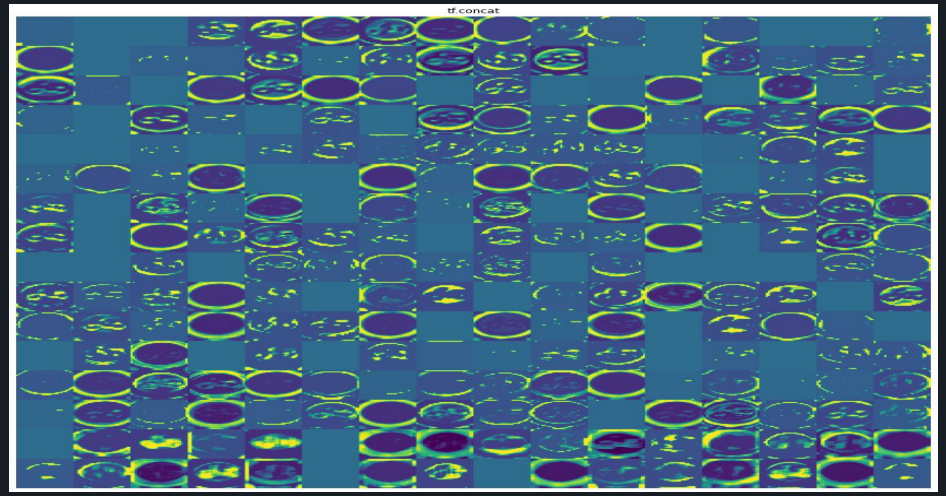


Visualising Mobilenet-v1 feature maps

Googlenet Network

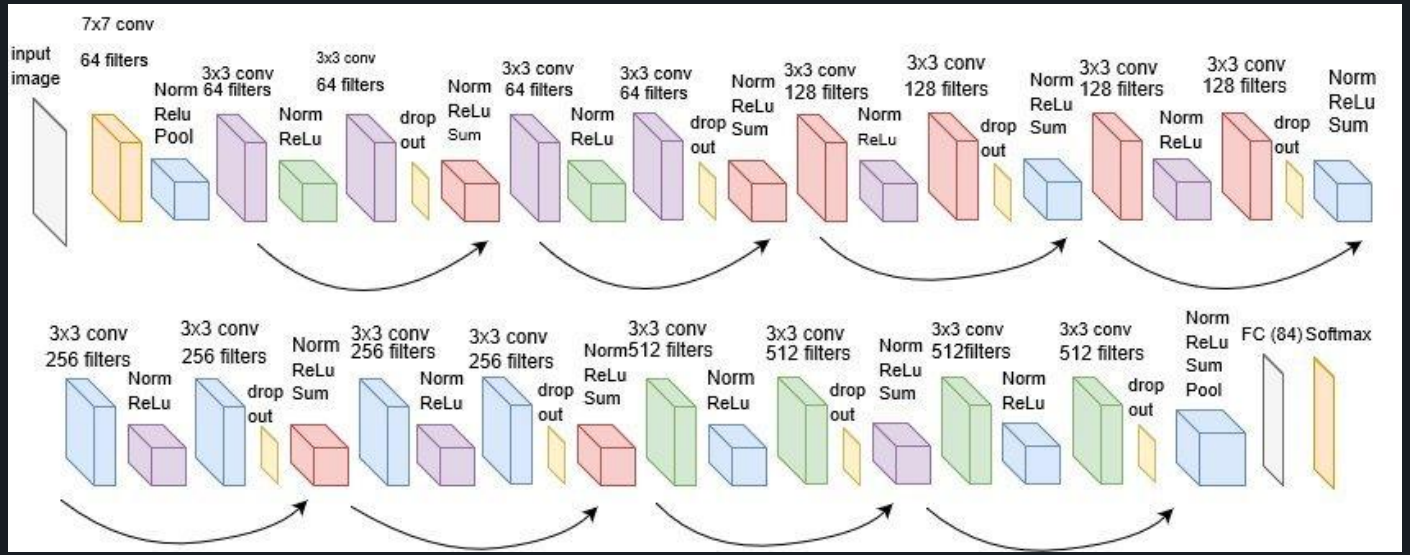


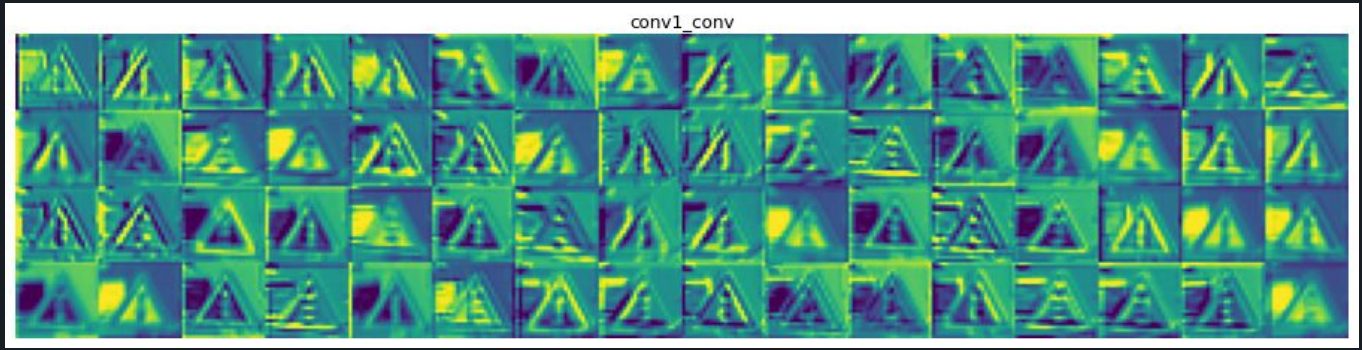


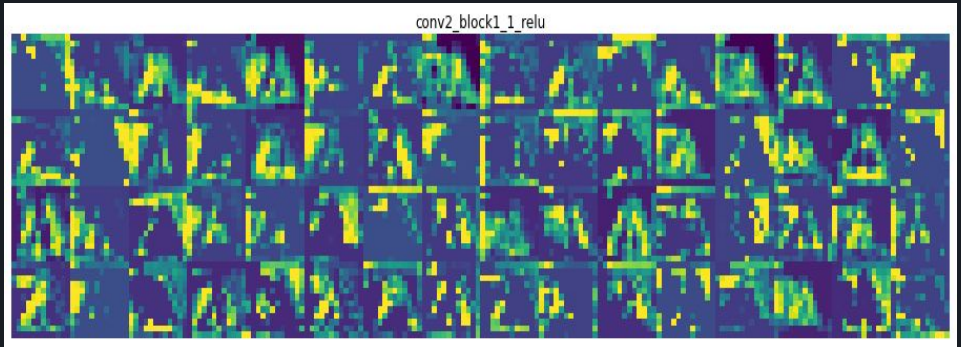


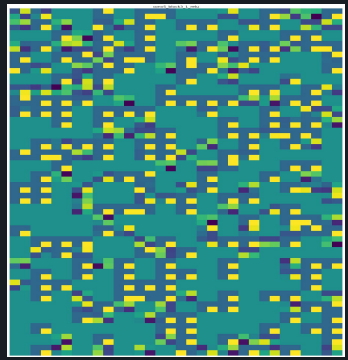
Visualising feature maps of GoogleNet

Resnet Network







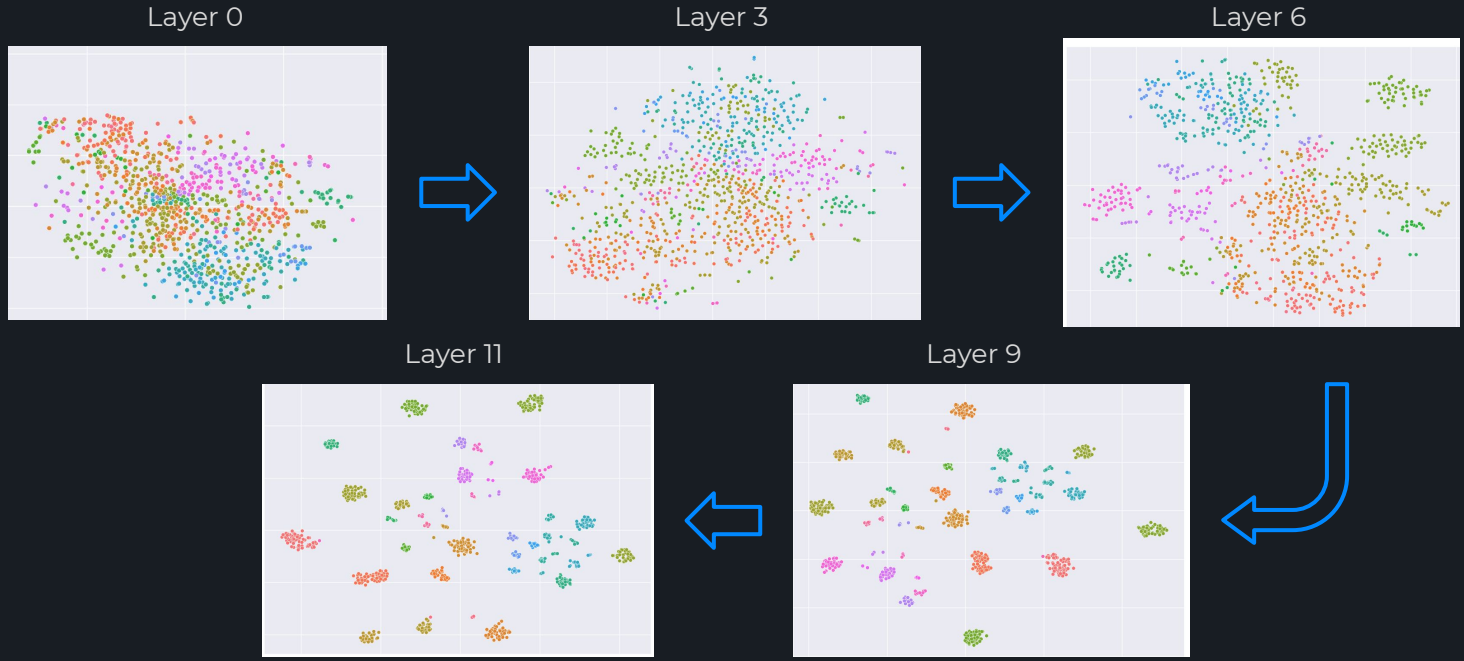


Visualising Resnet feature maps

Post-Experiment User Interface

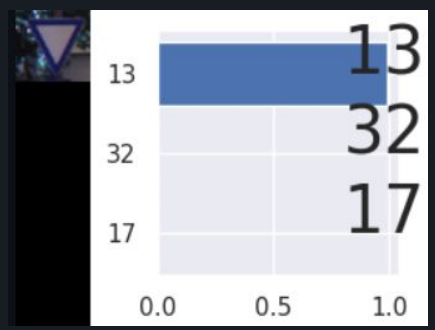
(After Training)

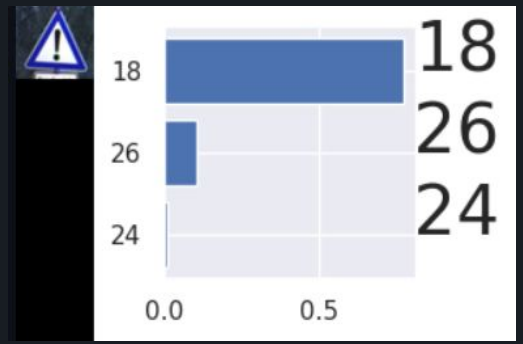
Layerwise evolution of network (Baseline network)

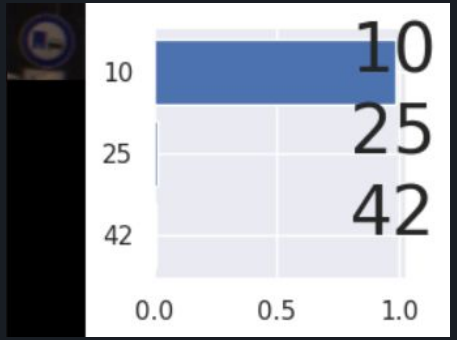


Best 5 classes (according to f1 scores)

We compare top 3 probabilities for the images of the class having high f1-score.

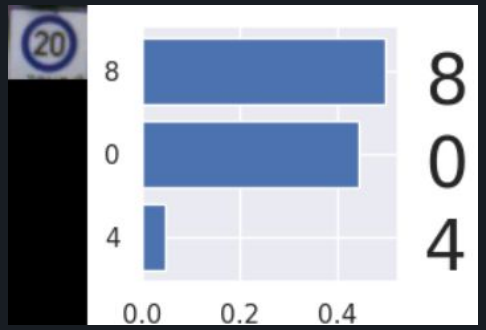


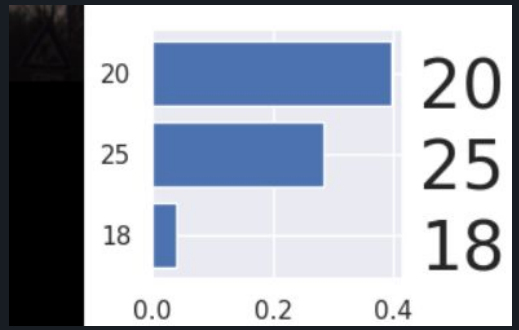


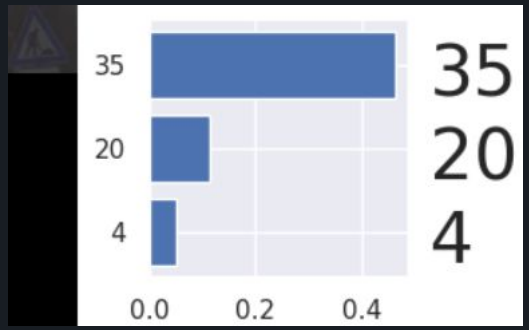


Worst 5 classes (according to f1 scores)

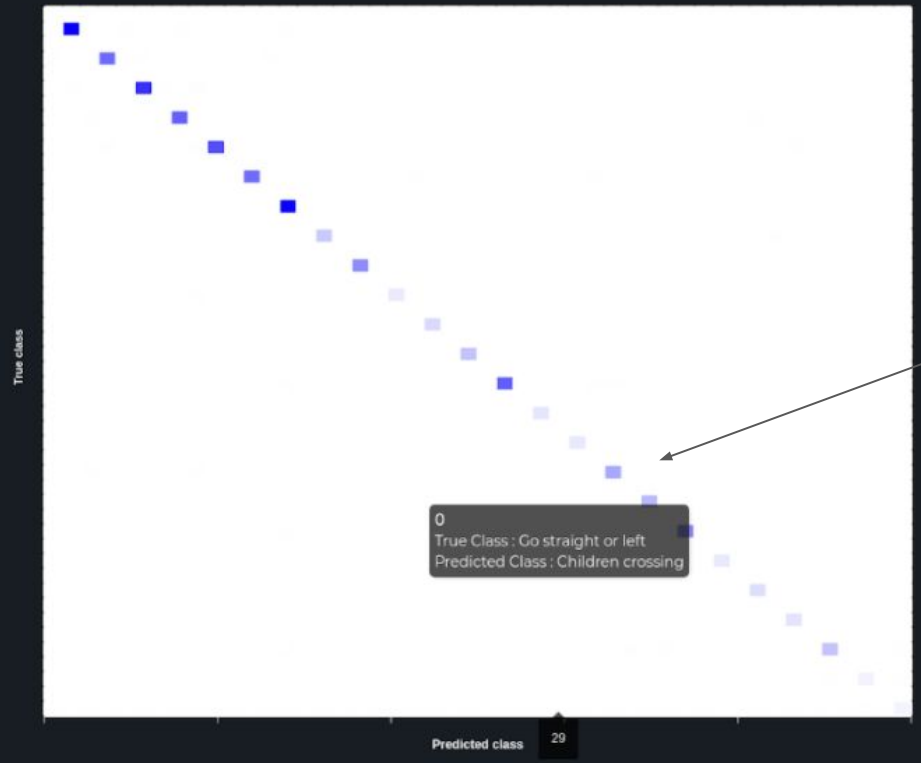
We compare top 3 probabilities for the images of the class having low f1-score to know where the model is getting confused.







Confusion Matrix

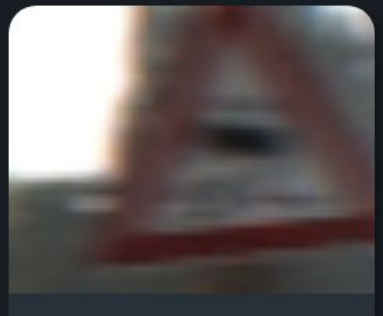


Click on the cell to get corresponding predicted and true class images

Actual VS Predicted class image carousel

True Class: Slippery road

Predicted Class: No passing

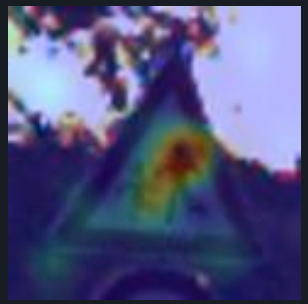


Go to suggestions

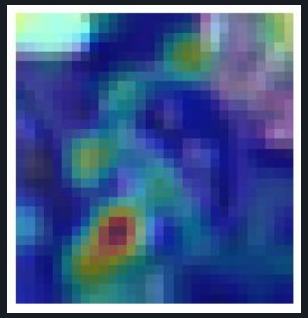
Gradcam++ results

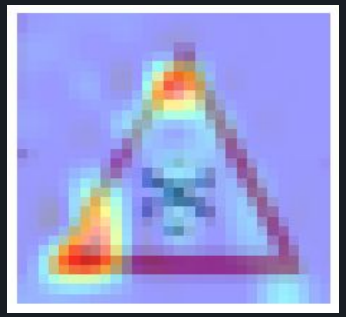
Using gradients to understand regions contributing positively to the classification

On correct predictions



On wrong predictions

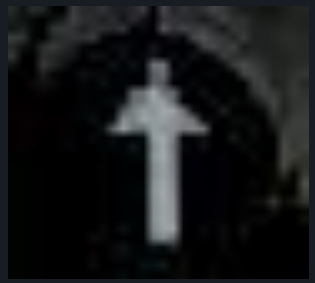




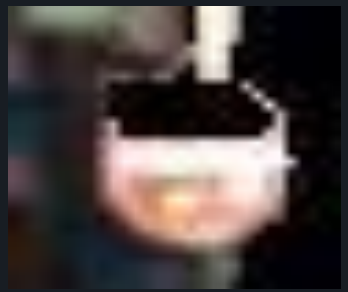
Lime Results

Using local interpretability to understand regions contributing positively to the classification

On correct predictions



On wrong predictions



Explanations and suggestions

	precision	recall	f1-score	support
0	0.97	1.00	0.98	60
1	1.00	1.00	1.00	720
2	0.99	1.00	1.00	750
3	0.99	0.98	0.99	450
4	1.00	0.99	1.00	660
5	0.97	0.99	0.98	630
6	1.00	0.95	0.97	150
7	1.00	1.00	1.00	450
8	1.00	1.00	1.00	450
9	1.00	1.00	1.00	480
10	1.00	1.00	1.00	660
11	0.99	0.99	0.99	420
12	0.99	0.94	0.96	690
13	1.00	1.00	1.00	720
14	1.00	1.00	1.00	270
15	0.95	1.00	0.97	210
16	0.99	1.00	0.99	150
17	1.00	0.91	0.95	360
18	1.00	0.94	0.97	390
19	0.92	1.00	0.96	60
20	0.98	1.00	0.99	90
21	0.88	0.92	0.90	90
22	1.00	0.77	0.87	120
23	0.91	0.97	0.94	150
24	1.00	0.96	0.98	90
25	0.98	0.99	0.98	480
26	0.97	1.00	0.99	180
27	0.86	0.50	0.63	60
28	1.00	1.00	1.00	150
29	0.71	1.00	0.83	90
30	0.94	0.77	0.85	150
31	0.99	0.99	0.99	270
32	0.95	1.00	0.98	60
33	0.90	1.00	0.95	90
34	1.00	1.00	1.00	30
35	0.98	0.99	0.99	300
36	0.99	0.97	0.98	120
37	1.00	1.00	1.00	60
38	0.99	0.99	0.99	690
39	0.99	0.99	0.99	90
40	0.83	0.98	0.90	90
41	1.00	0.98	0.99	60
42	1.00	1.00	1.00	90
43	0.88	0.99	0.93	259
44	0.99	0.99	0.99	130
45	0.89	0.99	0.94	92
46	0.81	0.97	0.88	31

Model is overfitting
Try a smaller network,regularisation, dropouts, augmentations

Class is skewed
Use SMOTE

24	1.00	0.96	0.98	90
25	0.98	0.99	0.98	480
26	0.97	1.00	0.99	180
27	0.86	0.50	0.63	60
28	1.00	1.00	1.00	150
29	0.71	1.00	0.83	90

Thank You!

H1_BSC_9