MONASH University CSIRO DATA 61

NEURAL INFORMATION PROCESSING SYSTEMS IARAI institute of advanced research in artificial intelligence

Large-scale Traffic Prediction using 3DResNet and Sparse-UNet

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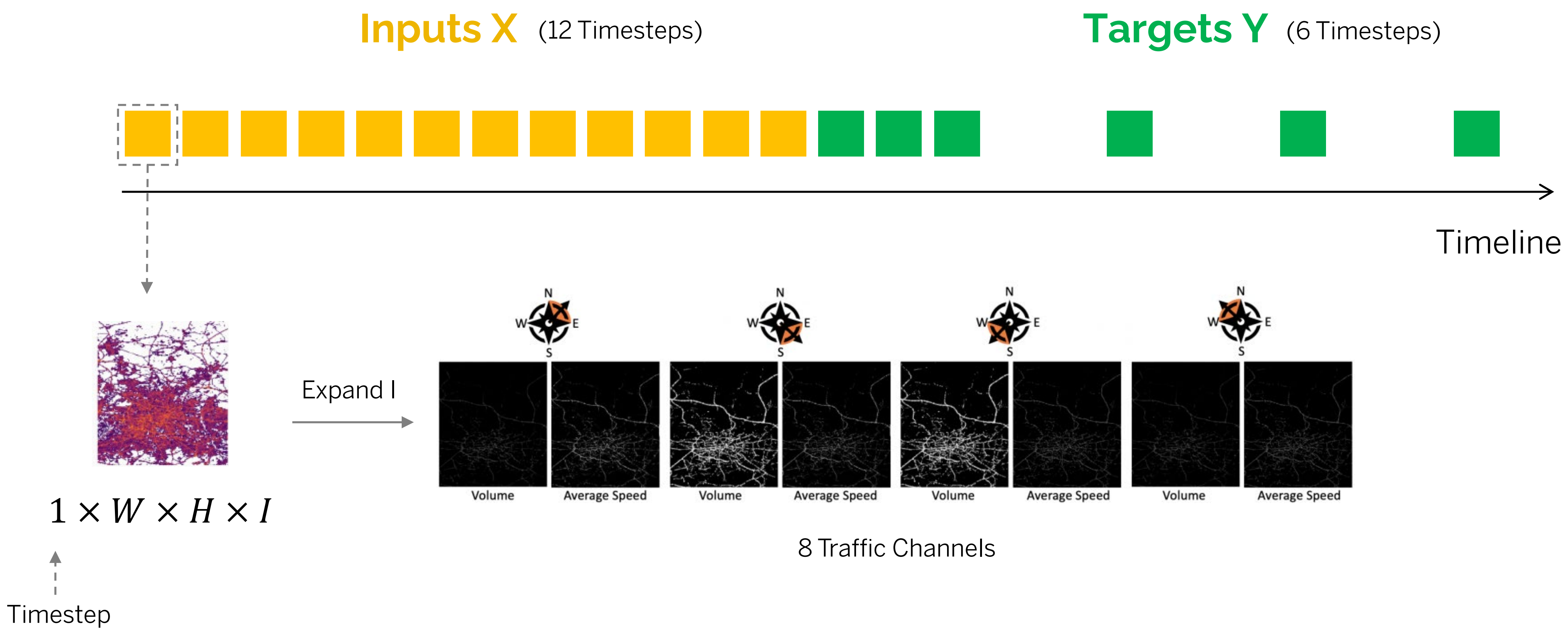
Presenter: Bo Wang

10th Dec 2021

Outline

1. Background
2. Methodology
3. Conclusion

Background



Inputs X (12 Timesteps)

Targets Y (6 Timesteps)

Timeline

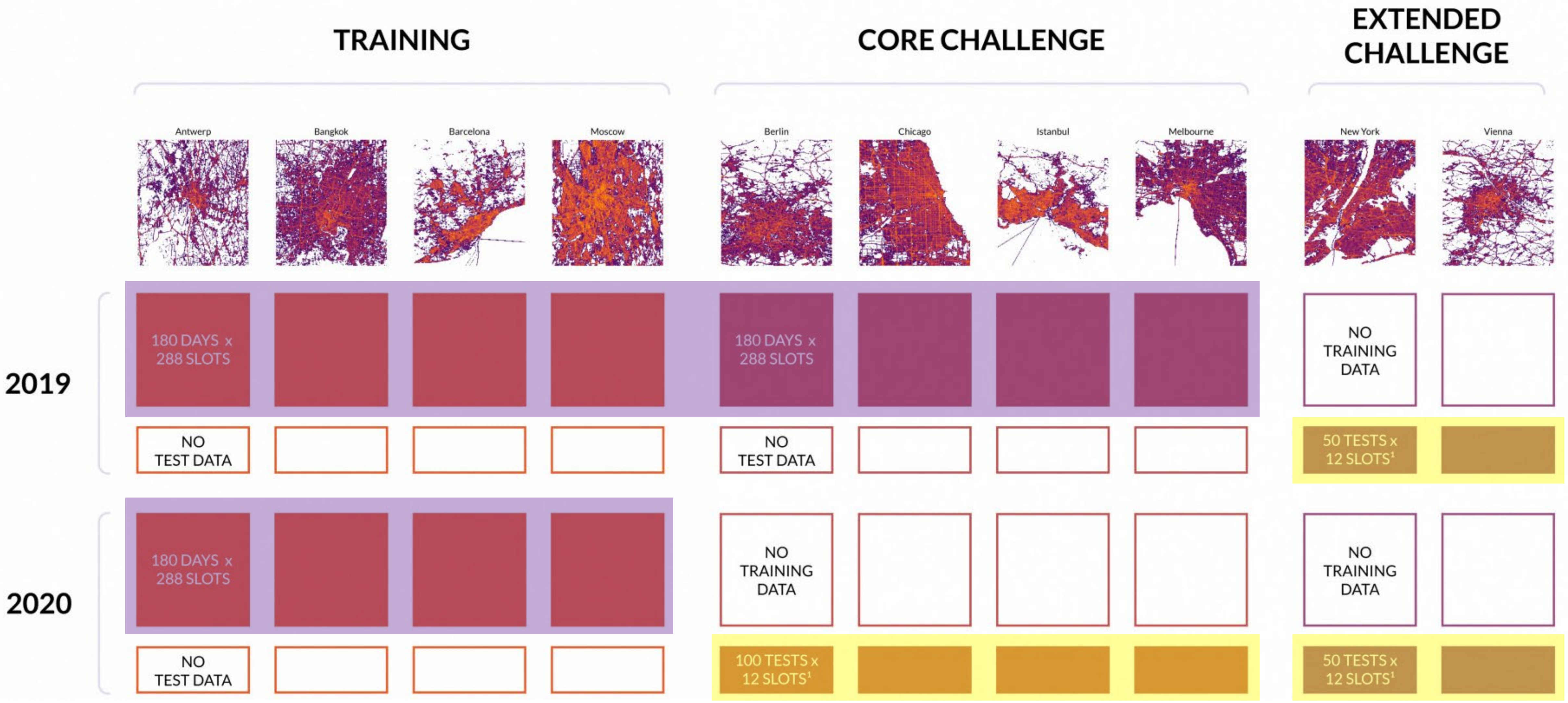
Expand I

$1 \times W \times H \times I$

Timestep

8 Traffic Channels

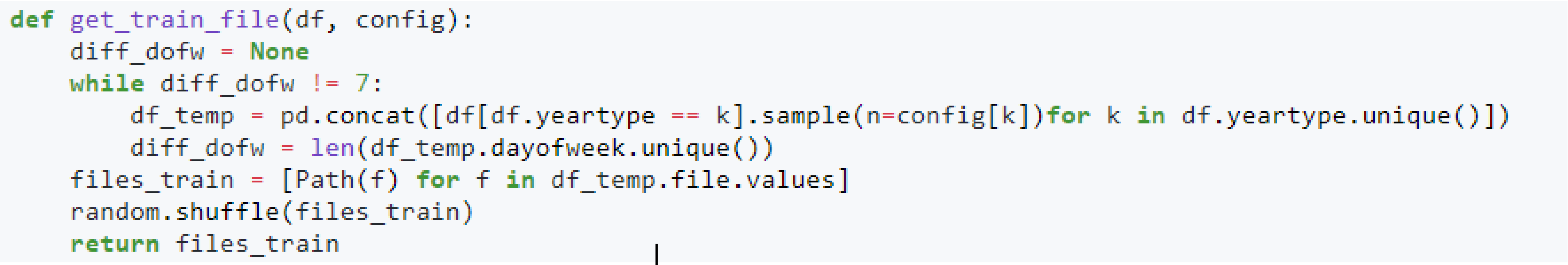
Background



	TRAINING				CORE CHALLENGE				EXTENDED CHALLENGE	
	Antwerp	Bangkok	Barcelona	Moscow	Berlin	Chicago	Istanbul	Melbourne	New York	Vienna
2019	180 DAYS x 288 SLOTS				180 DAYS x 288 SLOTS				NO TRAINING DATA	
	NO TEST DATA				NO TEST DATA				50 TESTS x 12 SLOTS[1]	
2020	180 DAYS x 288 SLOTS				NO TRAINING DATA				NO TRAINING DATA	
	NO TEST DATA				100 TESTS x 12 SLOTS[1]				50 TESTS x 12 SLOTS[1]	

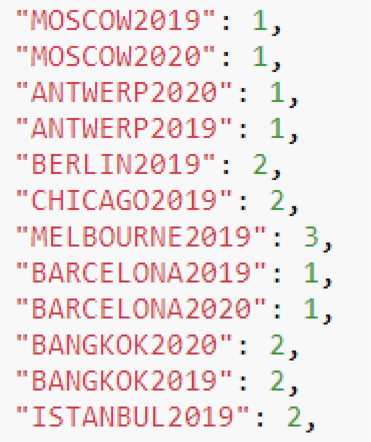
Methodology – Data Loader

Select days from Monday to Sunday

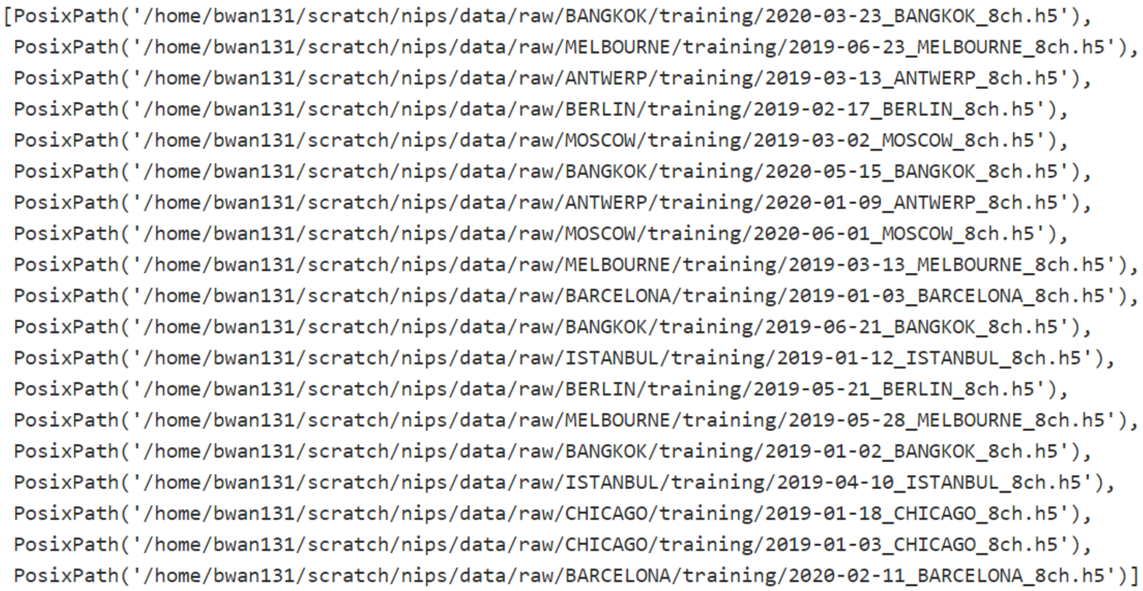


```python
def get_train_file(df, config):
    diff_dofw = None
    while diff_dofw != 7:
        df_temp = pd.concat([df[df.yeartype == k].sample(n=config[k])for k in df.yeartype.unique()])
        diff_dofw = len(df_temp.dayofweek.unique())
    files_train = [Path(f) for f in df_temp.file.values]
    random.shuffle(files_train)
    return files_train
```

Select all cities



```
"MOSCOW2019": 1,
"MOSCOW2020": 1,
"ANTWERP2020": 1,
"ANTWERP2019": 1,
"BERLIN2019": 2,
"CHICAGO2019": 2,
"MELBOURNE2019": 3,
"BARCELONA2019": 1,
"BARCELONA2020": 1,
"BANGKOK2020": 2,
"BANGKOK2019": 2,
"ISTANBUL2019": 2,
```



```
[PosixPath('/home/bwan131/scratch/nips/data/raw/BANGKOK/training/2020-03-23_BANGKOK_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/MELBOURNE/training/2019-06-23_MELBOURNE_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/ANTWERP/training/2019-03-13_ANTWERP_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/BERLIN/training/2019-02-17_BERLIN_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/MOSCOW/training/2019-03-02_MOSCOW_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/BANGKOK/training/2020-05-15_BANGKOK_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/ANTWERP/training/2020-01-09_ANTWERP_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/MOSCOW/training/2020-06-01_MOSCOW_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/MELBOURNE/training/2019-03-13_MELBOURNE_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/BARCELONA/training/2019-01-03_BARCELONA_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/BANGKOK/training/2019-06-21_BANGKOK_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/ISTANBUL/training/2019-01-12_ISTANBUL_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/BERLIN/training/2019-05-21_BERLIN_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/MELBOURNE/training/2019-05-28_MELBOURNE_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/BANGKOK/training/2019-01-02_BANGKOK_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/ISTANBUL/training/2019-04-10_ISTANBUL_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/CHICAGO/training/2019-01-18_CHICAGO_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/CHICAGO/training/2019-01-03_CHICAGO_8ch.h5'),
 PosixPath('/home/bwan131/scratch/nips/data/raw/BARCELONA/training/2020-02-11_BARCELONA_8ch.h5')]
```

DataLoader -> input and output batches

X (batch size, 12, 495, 436, 8)
Y (batch size, 6, 495, 436, 8)

Methodology – Data Loader

File 1	0, 1, 2, 3, 4
File 2	5, 6, 7, 8, 9
File 3	10, 11, 12, 13, 14

```
Dataloader(dataset, batch_size=3, shuffle=True)
```

Shuffle all index first
Get batch index -> (1, 7, 13)

If the indies are coming from multiple files, it will need multiple IO operations.

From 1.89 batches/s

File 1	12, 13, 11, 14, 15
File 2	2, 3, 1, 4, 0
File 3	9, 6, 5, 7, 10, 8

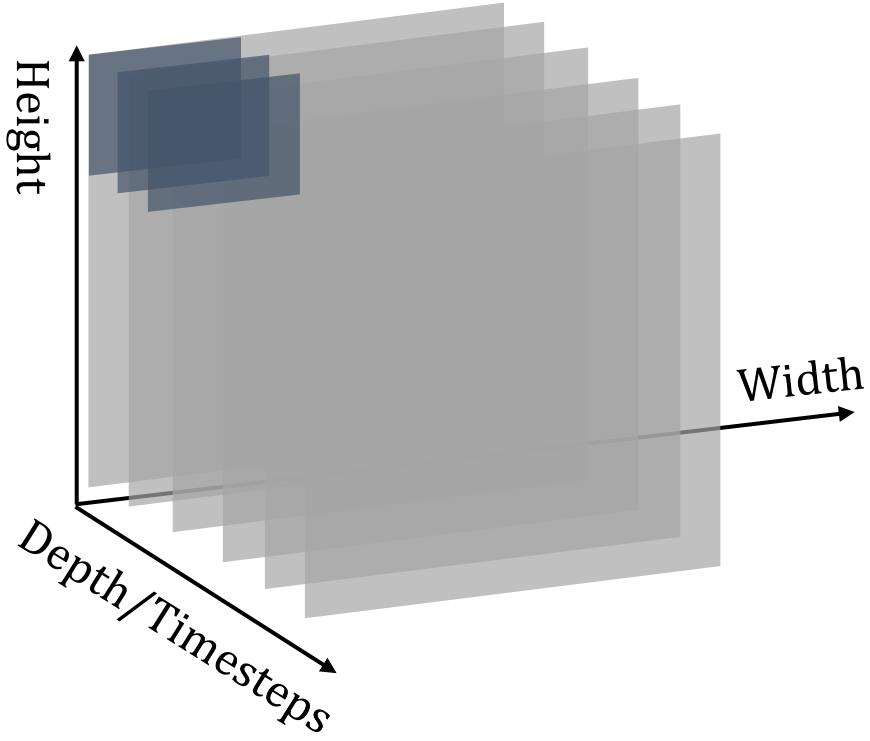
→ Custom Sampler + File Cache

Up to 60 batches/s

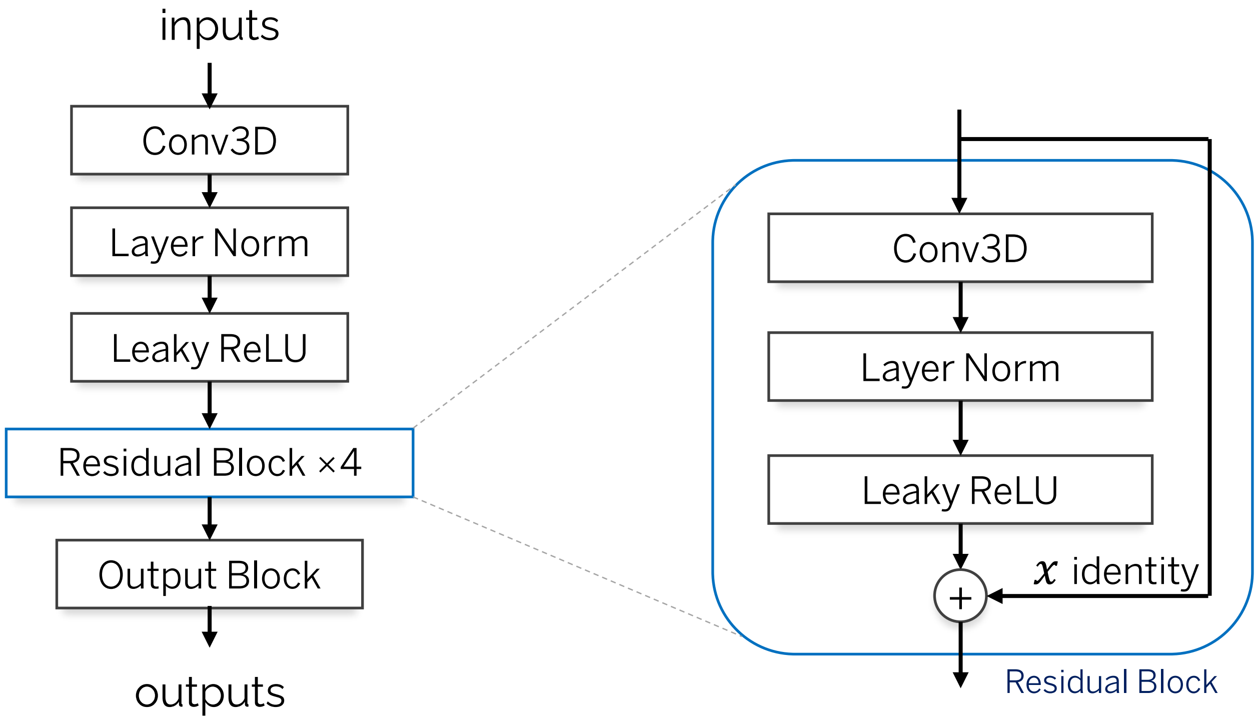
30X faster

Methodology – 3DResNets

3DResNets



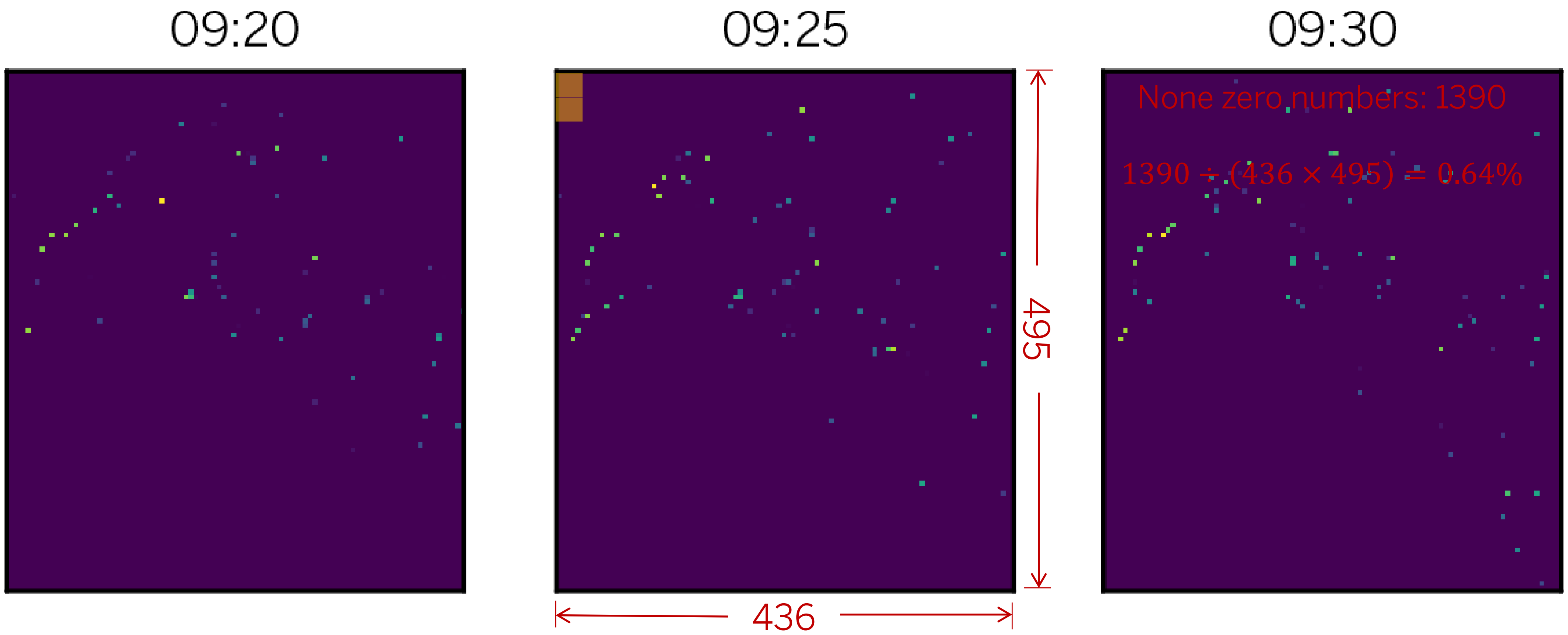
3D Convolution



MSE 50.219 (5th place) on the Core Challenge

Methodology – Sparse-UNet

Motivation



09:20

09:25

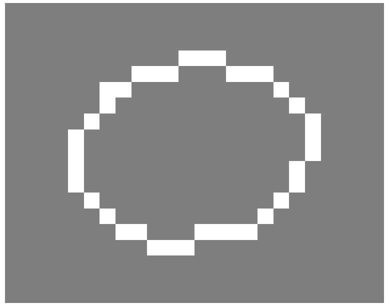
09:30

None zero numbers: 1390

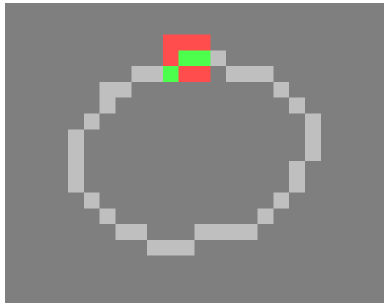
$1390 \div (436 \times 495) = 0.64\%$

Methodology – Sparse-UNet

Sparse Convolution



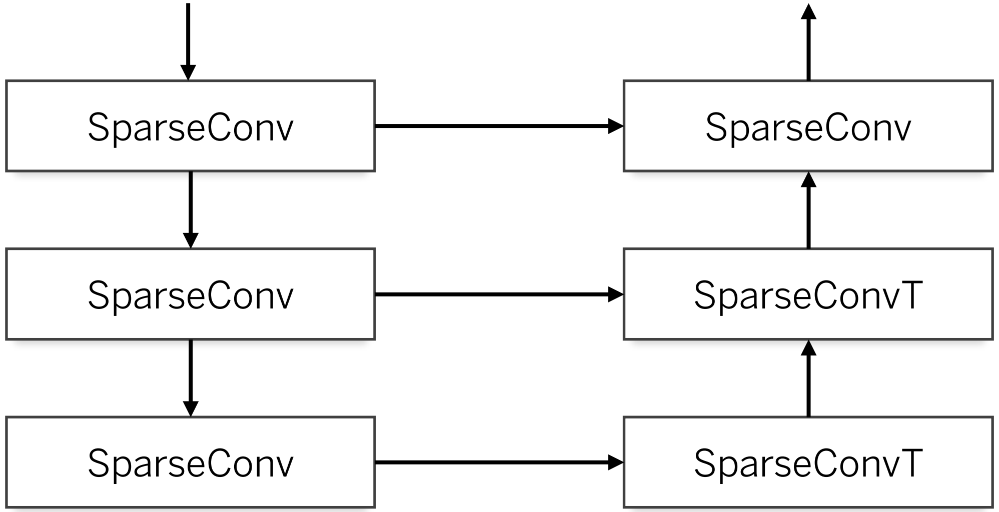
Regular Convolution



Sparse Convolution

Source:
https://github.com/facebookresearch/SparseConvNet
https://github.com/NVIDIA/MinkowskiEngine

Sparse-UNet



Methodology – Sparse-UNet

Speed Comparison

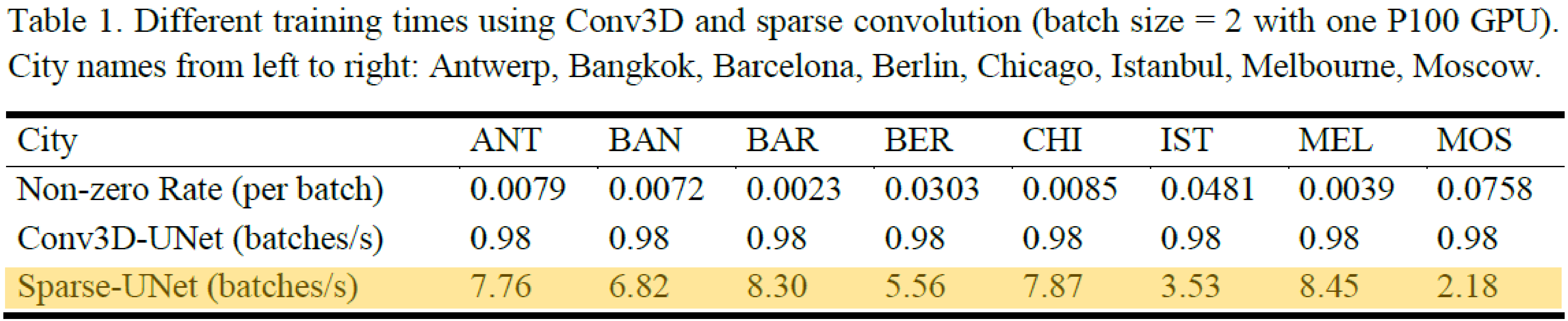
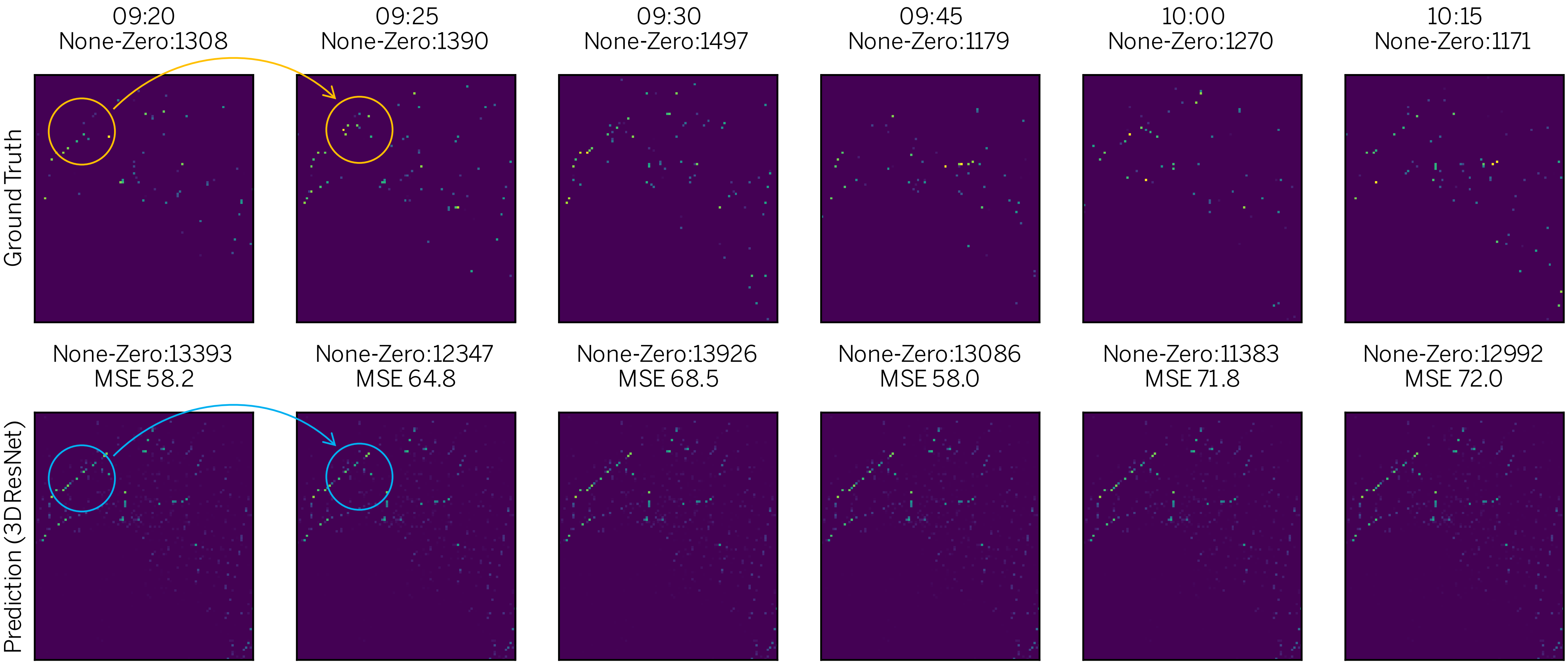


Table 1. Different training times using Conv3D and sparse convolution (batch size = 2 with one P100 GPU). City names from left to right: Antwerp, Bangkok, Barcelona, Berlin, Chicago, Istanbul, Melbourne, Moscow.

City	ANT	BAN	BAR	BER	CHI	IST	MEL	MOS
Non-zero Rate (per batch)	0.0079	0.0072	0.0023	0.0303	0.0085	0.0481	0.0039	0.0758
Conv3D-UNet (batches/s)	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Sparse-UNet (batches/s)	7.76	6.82	8.30	5.56	7.87	3.53	8.45	2.18

MSE 61.59 for Extended Challenge

Performance Bottleneck



09:20
None-Zero:1308

09:25
None-Zero:1390

09:30
None-Zero:1497

09:45
None-Zero:1179

10:00
None-Zero:1270

10:15
None-Zero:1171

None-Zero:13393
MSE 58.2

None-Zero:12347
MSE 64.8

None-Zero:13926
MSE 68.5

None-Zero:13086
MSE 58.0

None-Zero:11383
MSE 71.8

None-Zero:12992
MSE 72.0

Conclusion

We have proposed two new approaches, **3DResNet** (more accurate than 2D Convolution) and **Sparse-UNet** (much faster in modelling), for the challenges in traffic4cast 2021.

In the future:

(1) Study further on sparse convolution in regression problems

(2) Combine different feature learning approaches together

(3) Consider the transport domain knowledge in designing neural networks

(4) Improve the spatial accuracy in local area.

Thank you!

Large-scale Traffic Prediction using 3DResNet and Sparse-UNet

Authors: Bo Wang, Reza Mohajerpoor, Chen Cai, Inhi Kim, Hai Vu

Presenter: Bo Wang

Paper: https://arxiv.org/abs/2111.05990

Code: https://github.com/resuly/Traffic4Cast-2021

10th Dec 2021