Road Surface Condition Monitoring System

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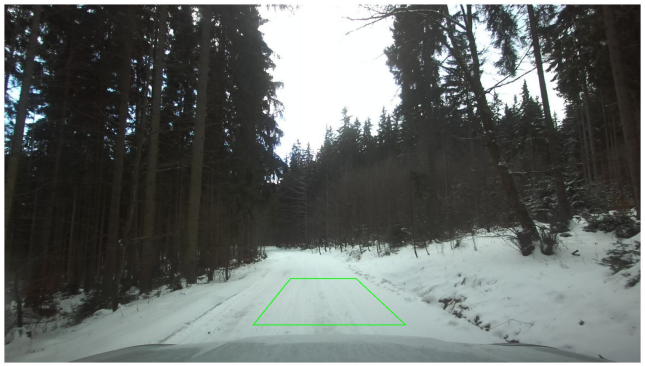
FJFI ČVUT

Motivation

Motivation

- Enhancing active safety and autonomous driving
- Benefits of camera-based detection



Motivation

- Real-world application and project focus

Computer Vision Methods

Computer Vision Methods

- Convolutional neural networks
- Fast and accurate predictions
- MobilenetV3, EfficientnetB0

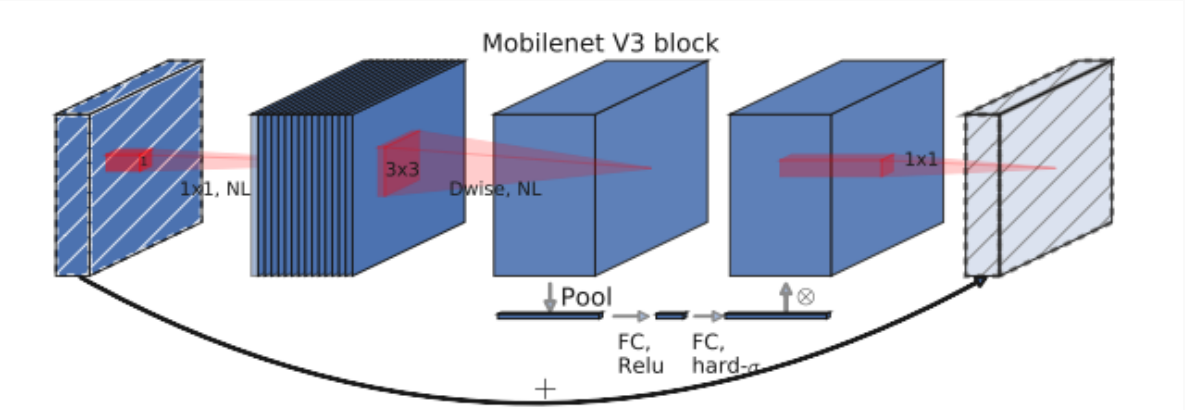


Figure 2: Inverted residual block [2].

[2] Howard, Andrew, et al. "Searching for mobilenetv3." Proceedings of the IEEE/CVF international conference on computer vision. 2019.

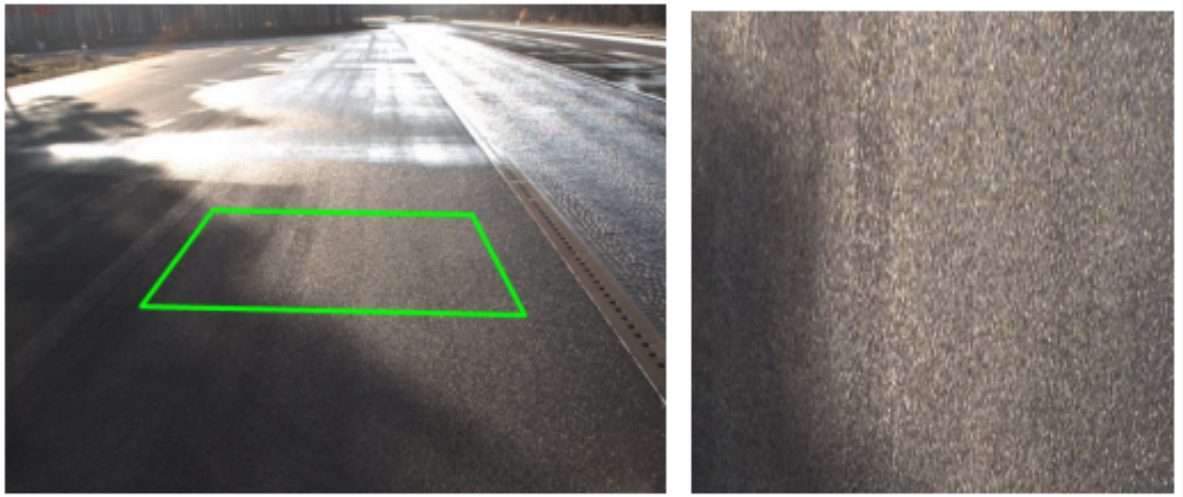
Datasets

- Autonomous driving datasets

Dataset	Images	Sequences	Diverse RSC	Diverse Location
BDD100K	12 000 000	100 000	✓	✓
KITTI	14 999	22	N/A	✓
RobotCar	N/A	>100	✓	×
CityScapes	5 000 (+2 000)	50	×	✓
Ithaca365	>680 000	40	✓	×
ACDC	8 012	N/A	✓	✓
RoadSaW	20 244	>250	✓	×
RSCD	1 000 000	N/A	✓	✓
Created	54 952	1 854	✓	✓

Datasets

- Autonomous driving datasets
- RoadSaW [1]



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- Autonomous driving datasets
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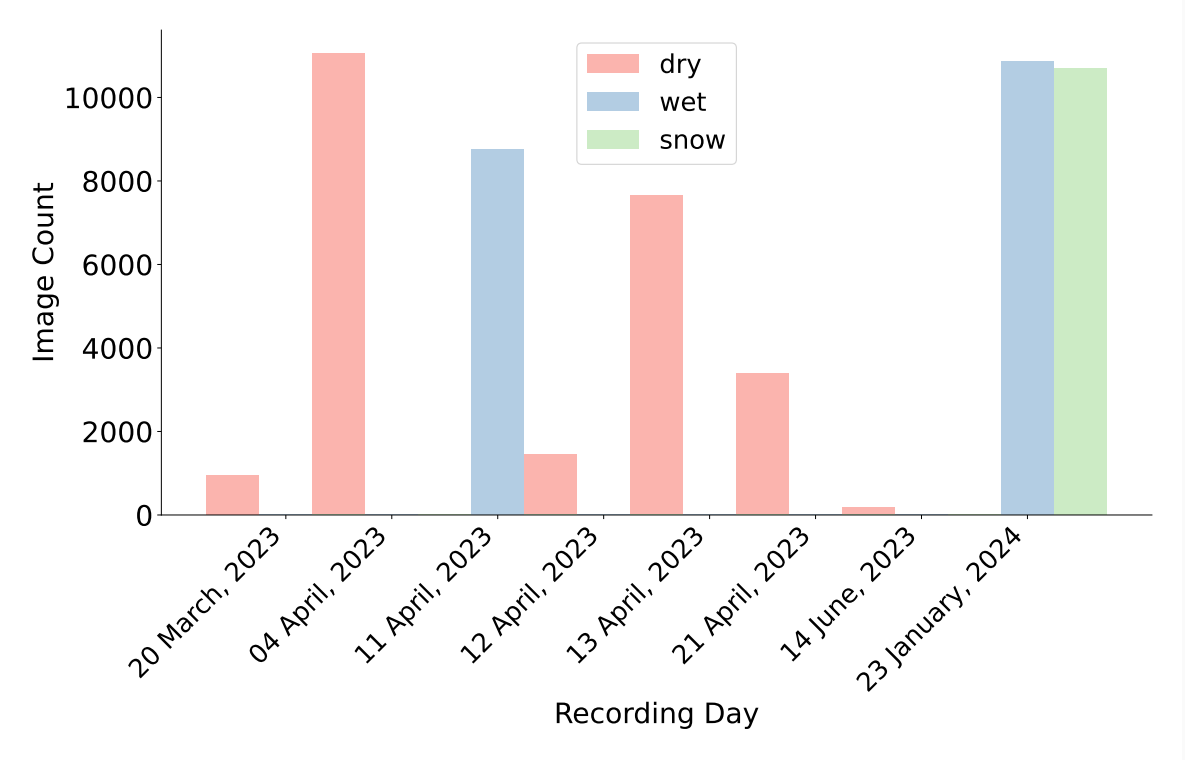
- Created dataset



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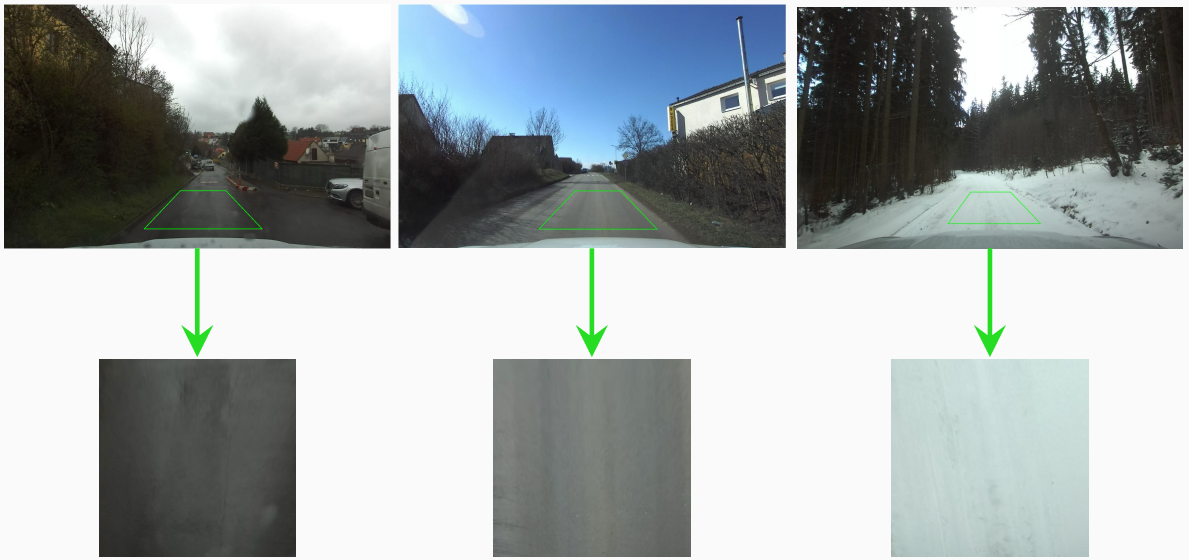
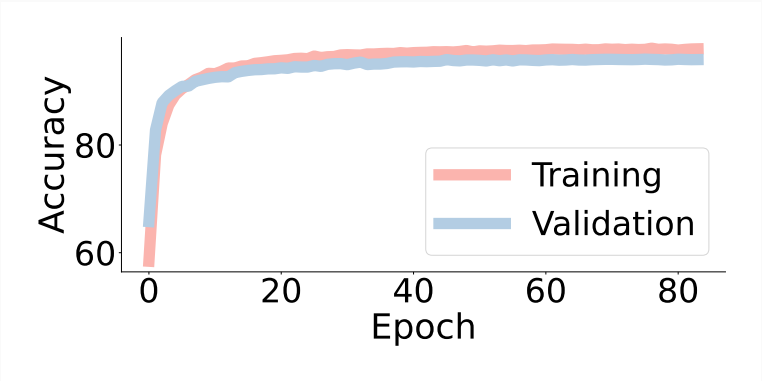
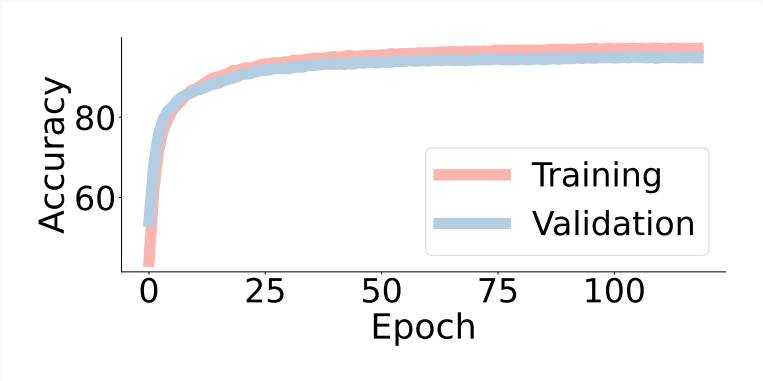


Experiments and Evaluation



(a) Training and validation accuracy with epochs MobileNet.



(b) Training and validation accuracy with epochs EfficientNet.

Model	*Training Accuracy [%]*	*Validation Accuracy [%]*
MobileNet	98.88	95.88
EfficientNet	97.94	94.99

Table 1: Training and Validation Accuracy of MobileNet and EfficientNet

RoadSaW - MobileNet

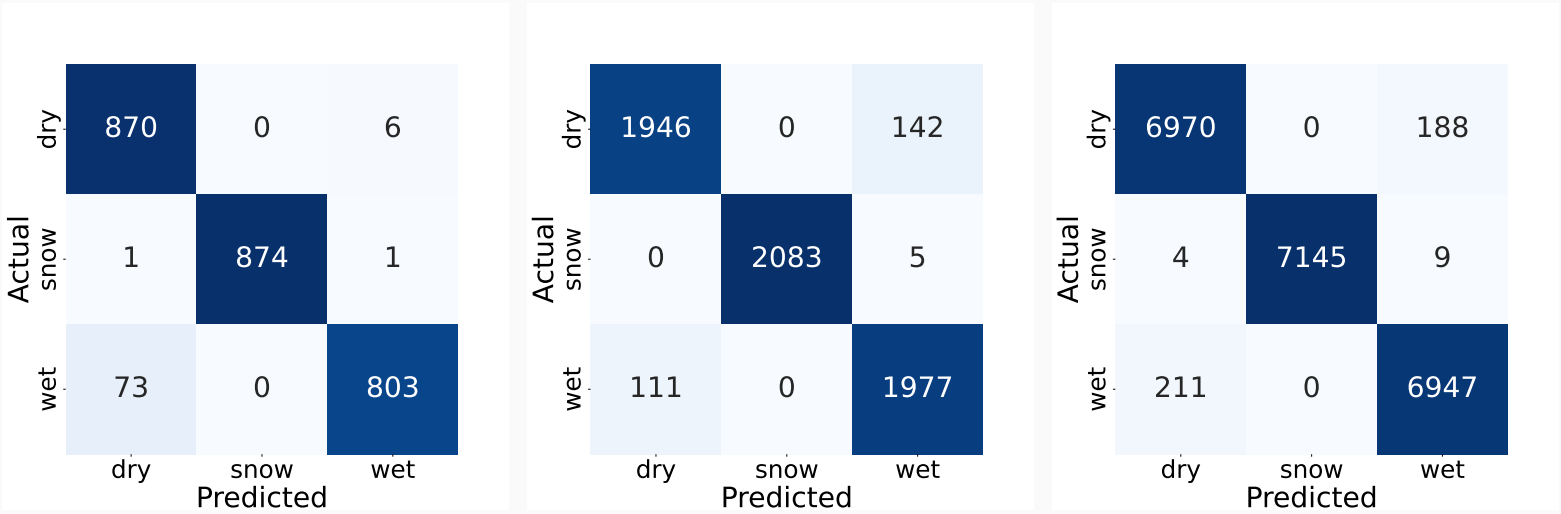


Figure 4: Confusion matrices for MobileNet on the RoadSaW dataset. Matrix (a) shows the classification results for test dataset, (b) for validation and (c) for the train set

RoadSaW - EfficientNet

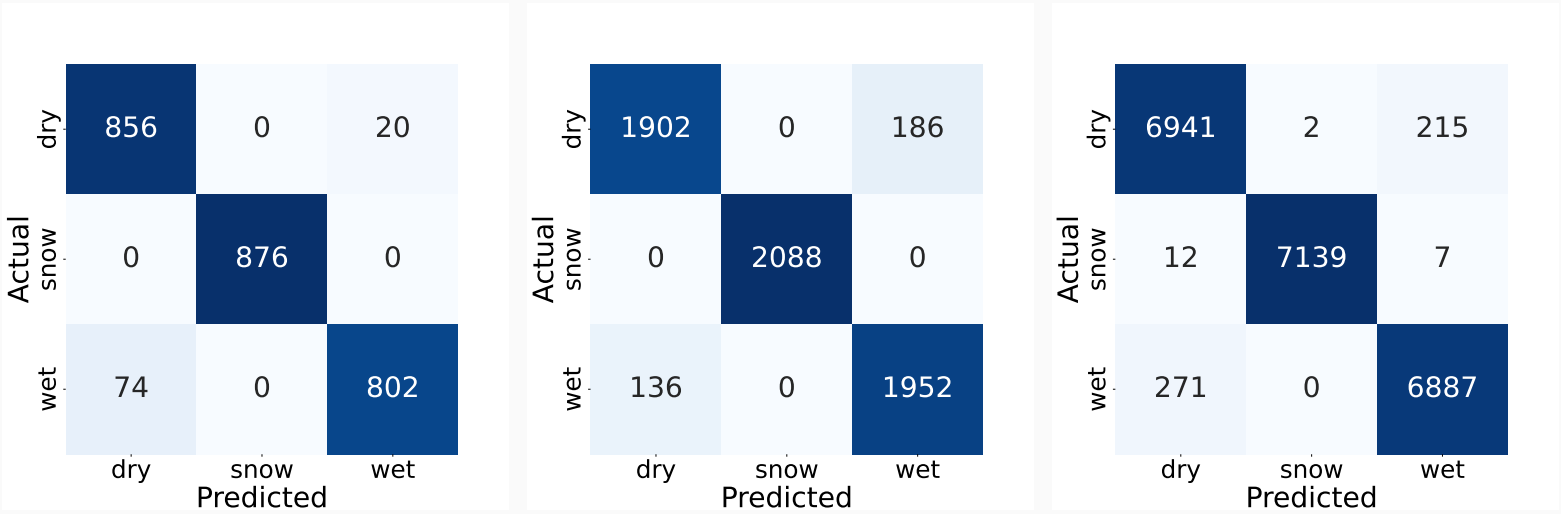


Figure 5: Confusion matrices for EfficientNet on the RoadSaW dataset. Matrix (a) shows the classification results for test dataset, (b) for validation and (c) for the train set.

RoadSaW

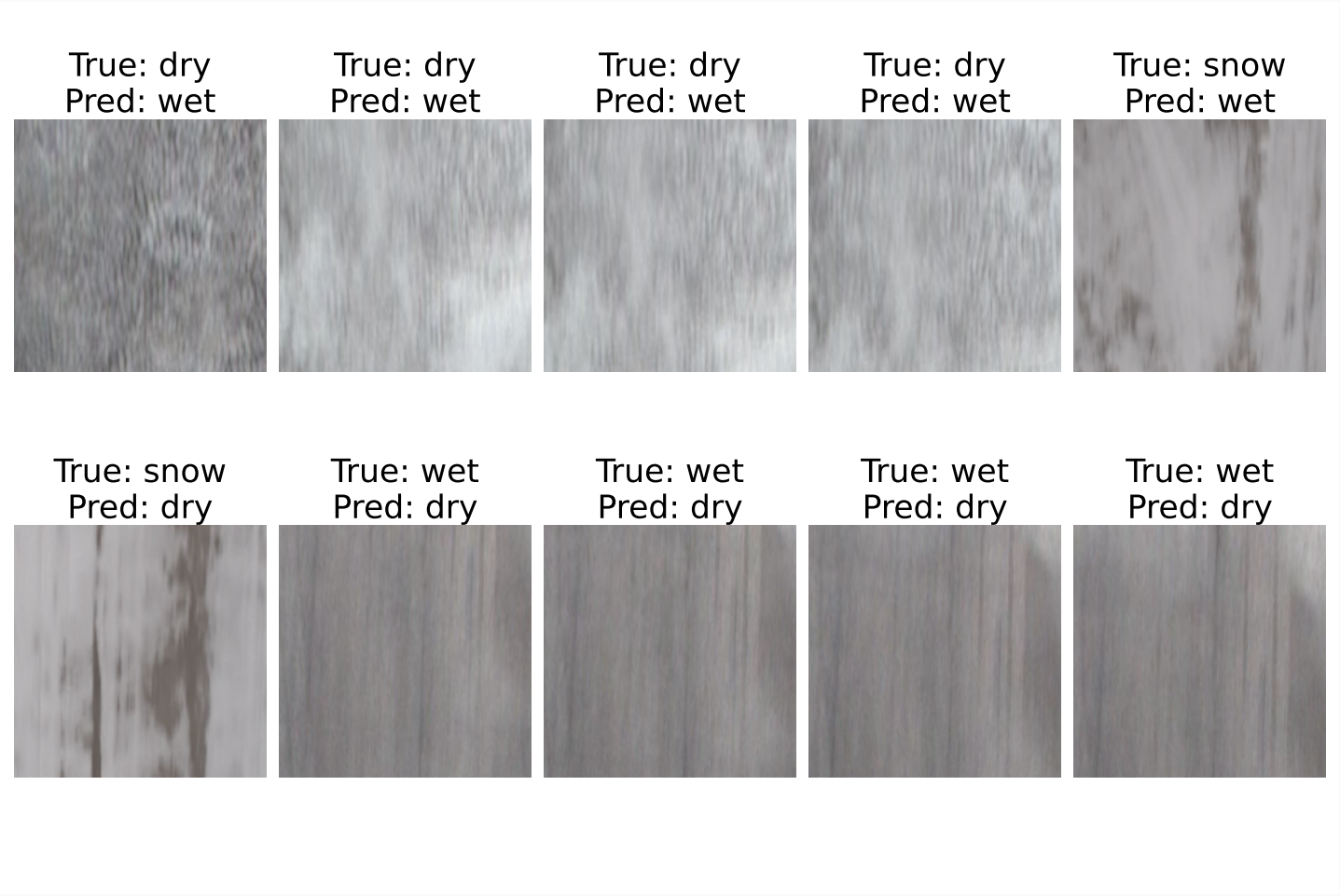


Figure 6: Examples of misclassified images from test set of RoadSaW by trained MobileNet architecture.

RoadSaW - Window Aggregation

Table 2: Metrics of the final trained MobileNet on the test set of RoadSaW for prediction using window aggregation approach.

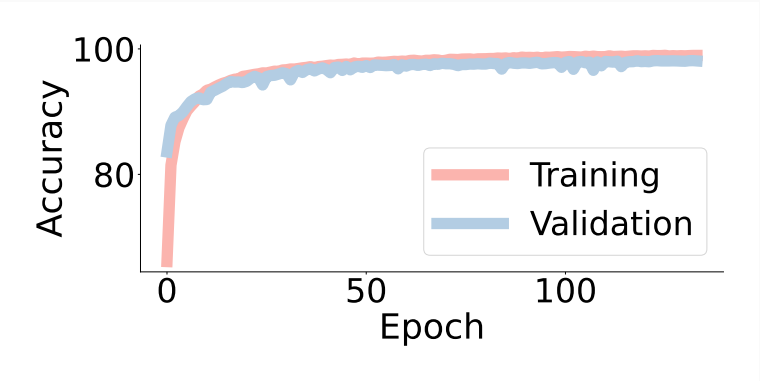
Subset	Accuracy [%]	Precision [%]	Recall [%]	F1 Score [%]
Test	97.72	97.85	97.72	97.71
Train	98.43	98.43	98.43	98.43
Validation	96.41	96.41	96.41	96.41

Table 3: Metrics of the final trained EfficientNet for prediction on RoadSaW using window aggregation approach.

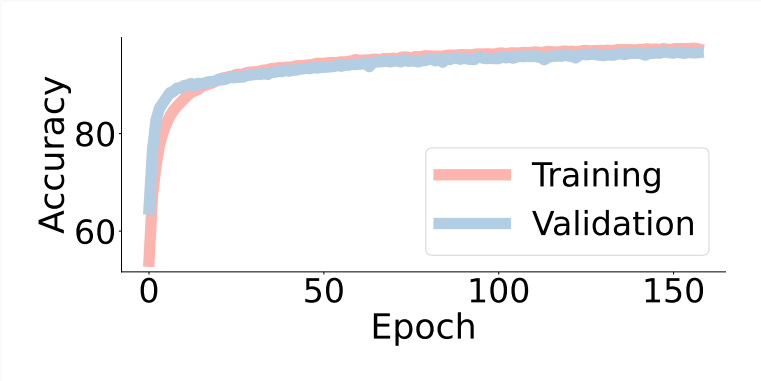
Subset	Accuracy [%]	Precision [%]	Recall [%]	F1 Score [%]
Test	97.49	97.65	97.49	97.57
Train	98.27	98.27	98.27	98.26
Validation	95.21	95.23	95.21	95.22

Created Dataset

Created Dataset



(a) Training and validation accuracy with epochs MobileNet.



(b) Training and validation accuracy with epochs EfficientNet.

Model	*Training Accuracy [%]*	*Validation Accuracy [%]*
MobileNet	98.24	96.60
EfficientNet	97.41	95.88

Table 4: Training and Validation Accuracy of MobileNet and EfficientNet

Created Dataset - MobileNet

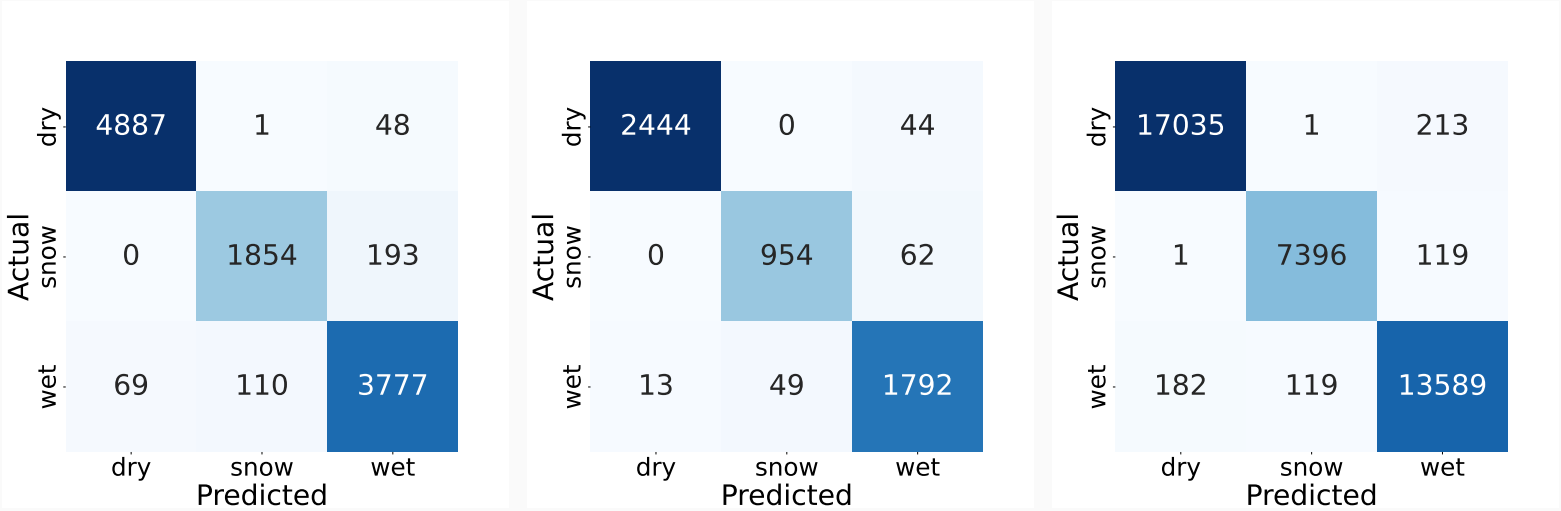


Figure 8: Confusion matrices for MobileNet on the created dataset. Matrix (a) shows the classification results for test dataset, (b) for validation and (c) for the train set.

Created Dataset - EfficientNet

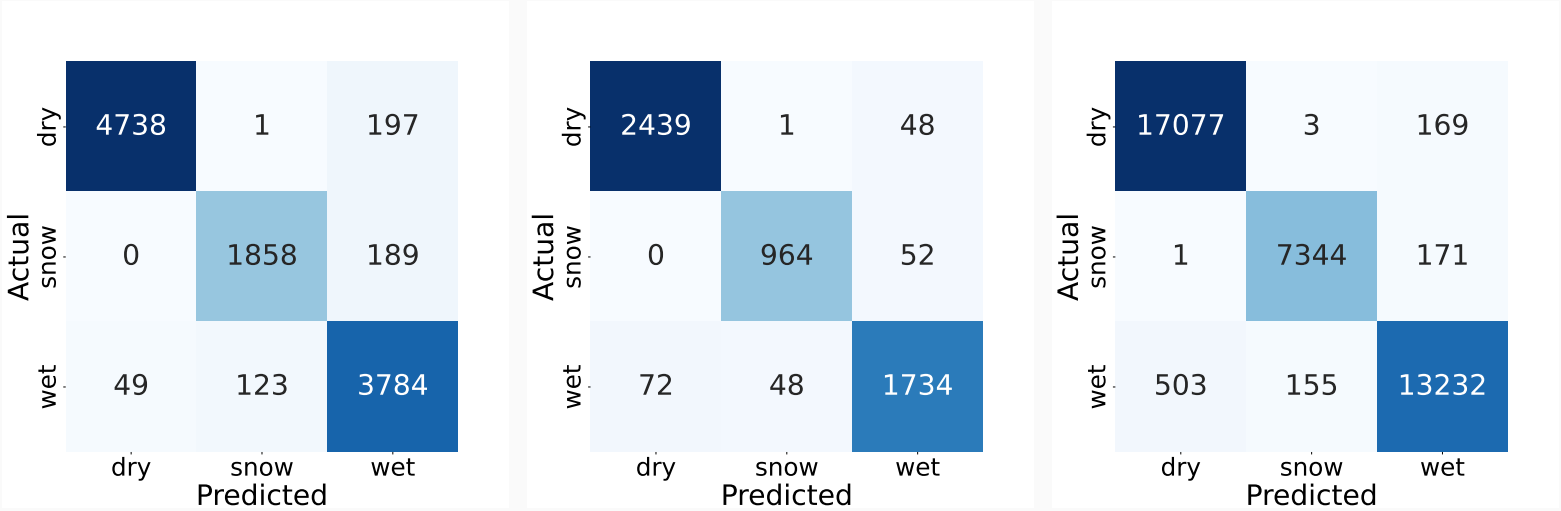
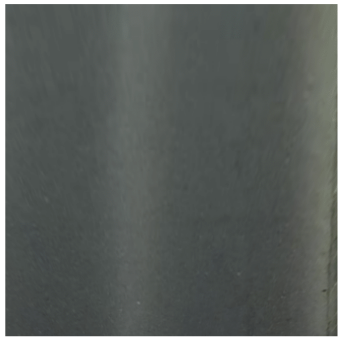


Figure 9: Confusion matrices for EfficientNet on the creted dataset. Matrix (a) shows the classification results for test dataset, (b) for validation and (c) for the train set.

Created Dataset

Road patch
True: dry
Pred: wet

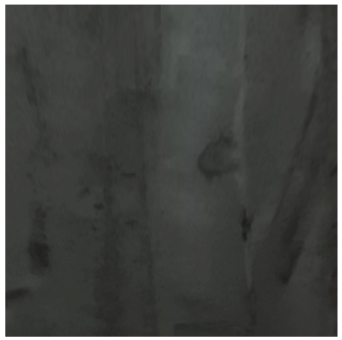


Original

Road patch
True: dry
Pred: wet

Original

Road patch
True: snow
Pred: wet



Original

Created Dataset - Window Aggregation

Table 5: Metrics of the final trained MobileNet on the created dataset using the aggregation technique.

Subset	Accuracy [%]	Precision [%]	Recall [%]	F1 Score [%]
Test	96.54	95.98	95.29	95.62
Validation	97.31	96.84	96.60	96.70
Train	98.81	98.81	98.75	98.78

Table 6: Metrics of the final trained EfficientNet on the created dataset for prediction using the aggregation technique.

Subset	Accuracy [%]	Precision [%]	Recall [%]	F1 Score [%]
Test	95.93	95.44	94.92	95.18
Validation	96.55	96.28	96.28	96.28
Train	98.05	98.08	98.10	98.09

Prediction Speed

- Laptop GPU NVIDIA GeForce RTX 3050 Ti and a CPU AMD Ryzen 7 5800U

Table 7: Prediction speed on GPU and CPU for both networks given as a mean of 200 prediction times.

Network	GPU [ms]	CPU [ms]
EfficientNet	35.53	55.54
MobileNet	23.20	40.00

Summary

Summary

Table 8: Results of both models on the train and validation sets of the two datasets.

Trained Architecture	Dataset	Subset	Accuracy [%]
MobileNet	RoadSaW	Train	98.08
		Validation	95.88
	Recorded	Train	98.24
		Validation	96.60
EfficientNet	RoadSaW	Train	97.64
		Validation	94.86
	Recorded	Train	97.41
		Validation	95.88

Thank you.

References i

K. Cordes, C. Reinders, P. Hindricks, J. Lammers, B. Rosenhahn, and H. Broszio.
Roadsaw: A large-scale dataset for camera-based road surface and wetness estimation.
In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pages 4440–4449, 2022.

A. Howard, M. Sandler, G. Chu, L.-C. Chen, B. Chen, M. Tan, W. Wang, Y. Zhu, R. Pang, V. Vasudevan, Q. V. Le, and H. Adam.
Searching for mobilenetv3, 2019.

- Zdá se, že klasifikátor dělá chyby při snímání ve vyšší rychlosti, kvůli motion blur. Je nějaká možnost zvýšit přesnost v těchto případech?
- Jak je možné využít apriorní informaci? Například mám teploměr, předpověď počasí, znám GPS polohu.