Learning to Decipher License Plates in Severely Degraded Images

MultiMedia FORensics in the WILD (MMForWILD) 2020

Paula Kaiser, **Franziska Schirrmacher**, Benedikt Lorch, Christian Riess
IT Security Infrastructures Lab, Computer Science, University of Erlangen-Nürnberg

License Plate Recognition in the Wild: Challenges

- Uncontrolled environment
- Unknown image degradation
- Low image quality
- Compression

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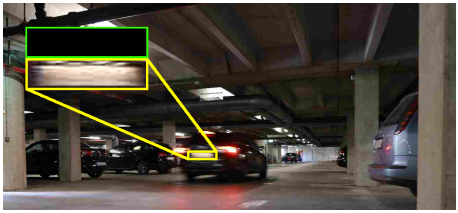

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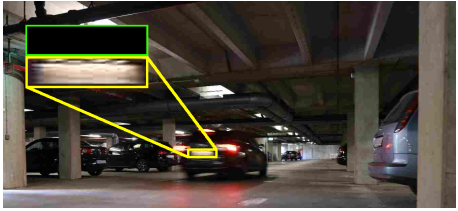

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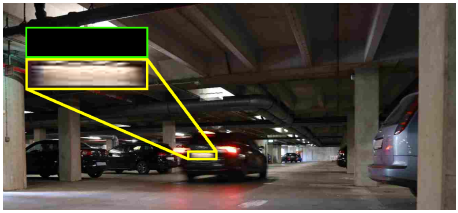

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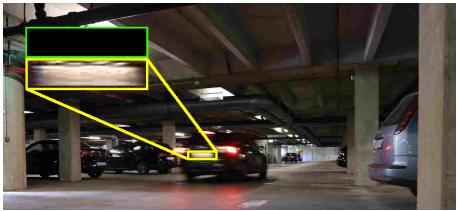

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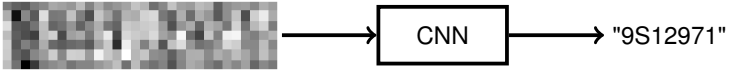
Prior Art and Research Question

- CNNs can in principle decipher unreadable license plates



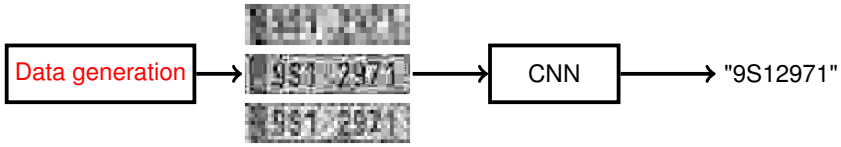
- Previous art models only low resolution and added Gaussian noise

- Reseach question: Can we also reconstruct license plates under strong compression?

B. Lorch, S. Agarwal, and H. Farid, "Forensic reconstruction of severely degraded license plates," in *Electronic Imaging*, Jan. 2019.

Contributions

- Generating synthetic Czech license plates according to Czech regulations
- Top-1 detection accuracy under compression
- Influence of similarity and position of characters



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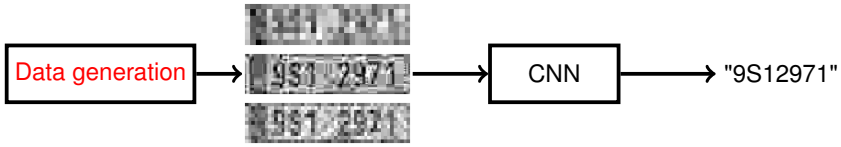

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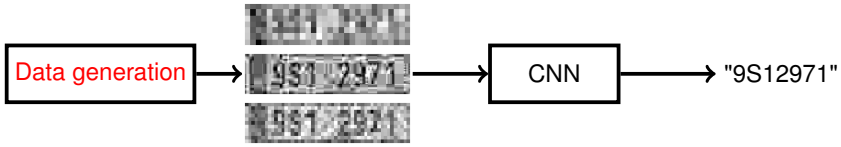

Data Generation Pipeline

- Allows to generate large number ($\approx$ 10M) training examples
- Randomly drawn characters (following Czech regulations)
- Forms of degradation
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  - Gaussian noise
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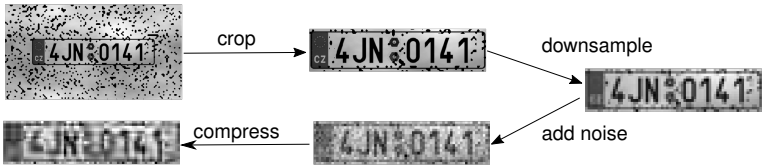

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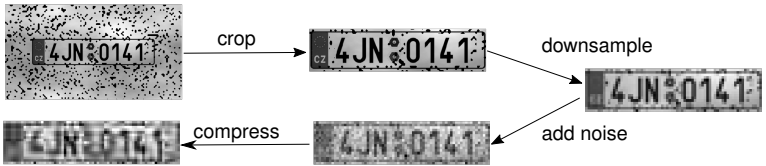

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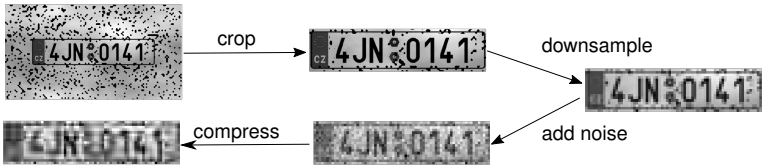

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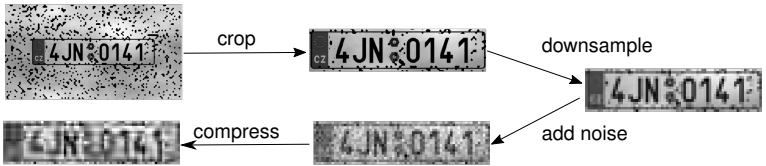
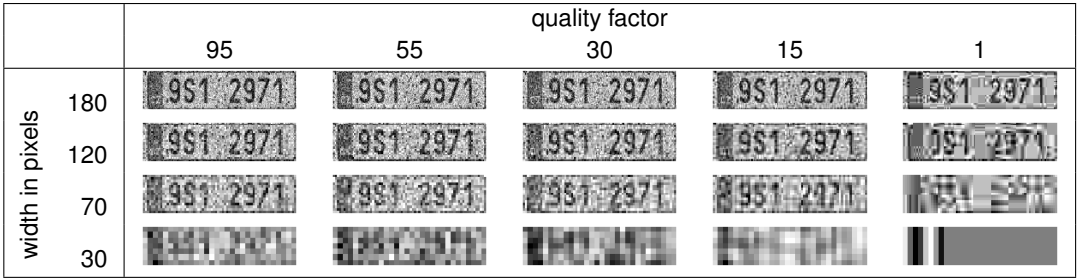
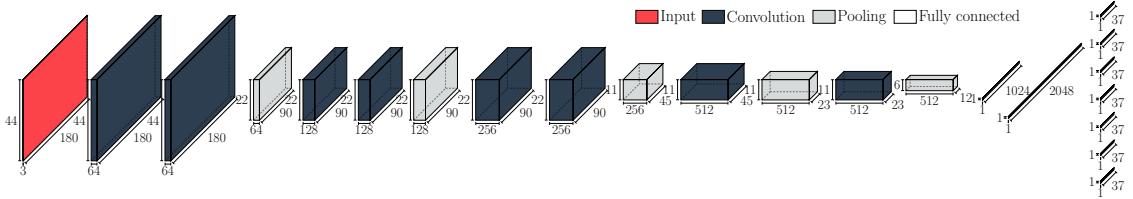


Example Images with an SNR of 3 dB



CNN Architecture

- We study an existing feedforward convolutional neural network
- Convolutional and pooling layers extract features
- One output layer per position for character prediction



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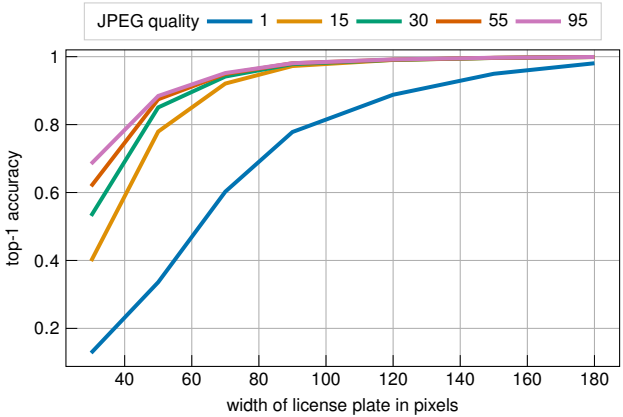
Results: JPEG Compression relative to License Plate Resolution

- Width ≤ 70 pixels: stronly impacted by JPEG quality
- Width ≥ 50 pixels: JPEG qualities ≥ 55 similarly well detectable



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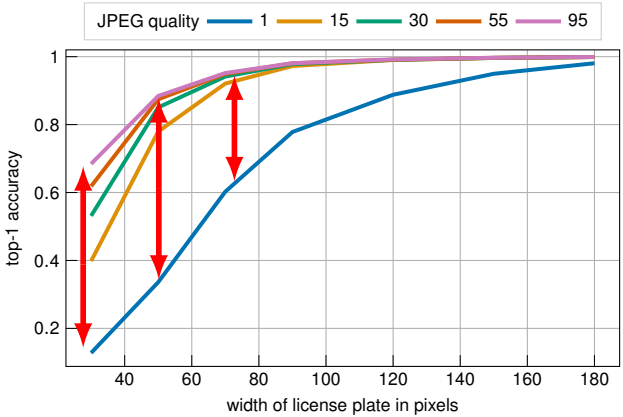

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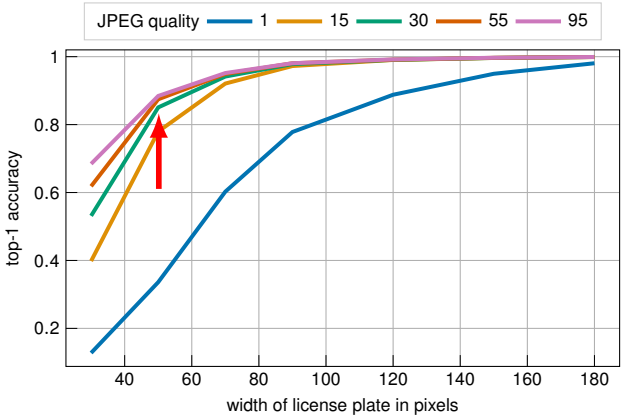
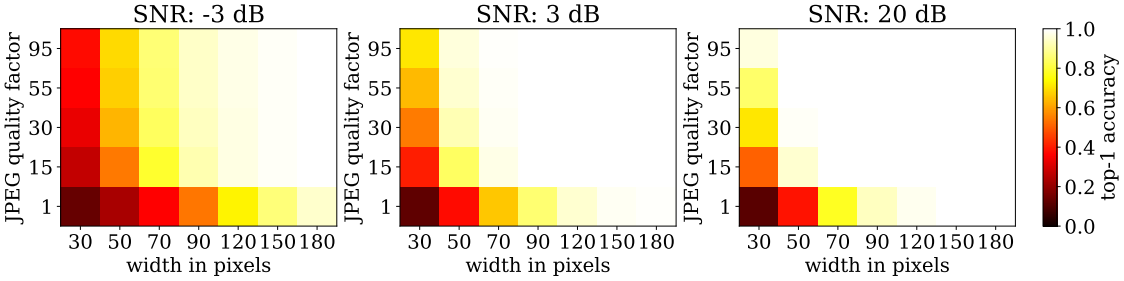


Results: Impact of Added Noise, Resolution and Compression on Top-1 Accuracy

- Width $\geq$ 30 pixels typically suffices for detection, even under strong compression and high noise
- Compression irrelevant for high-resolution images



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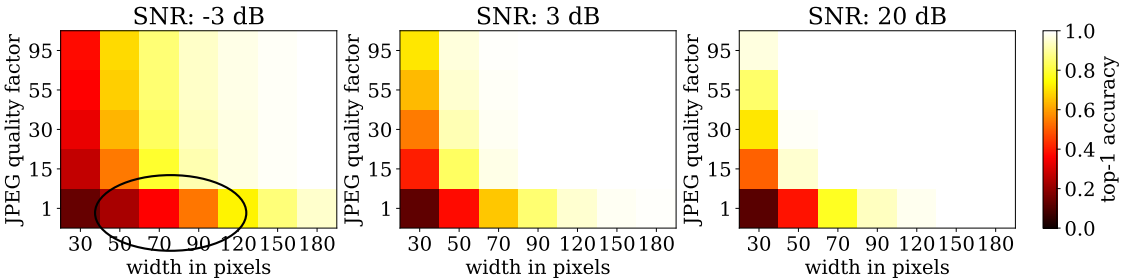

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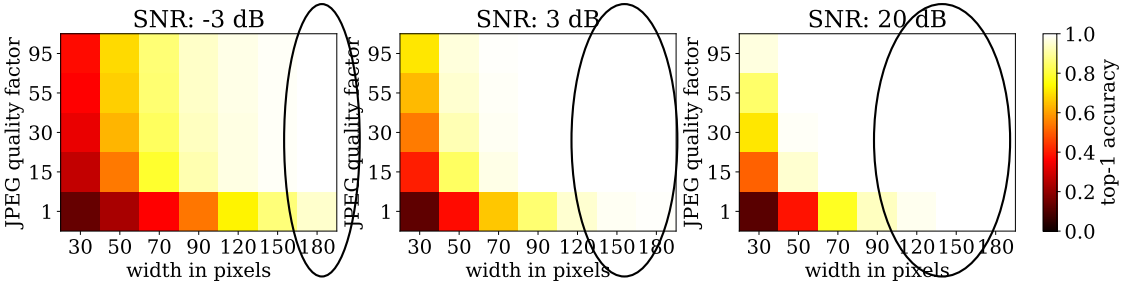
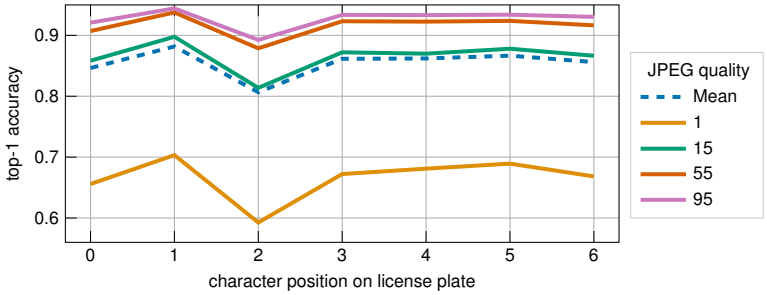


In-depth Analysis of the Influence of the Position of Characters

- Position 2 is particularly difficult to recognize
  → number of possible characters
- Drop at the first and last positions
  → image cropping
- Quality factor of 1 leads to a drastic decrease
- Overall high accuracy for low quality images



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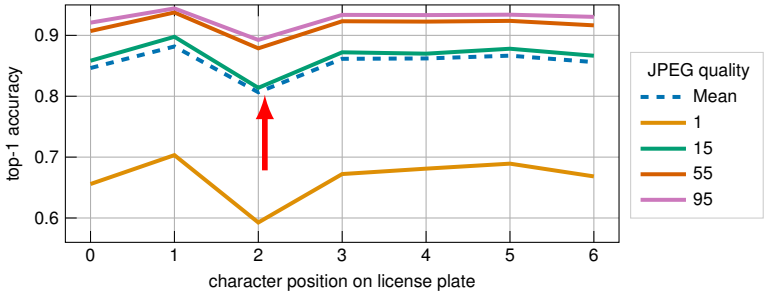

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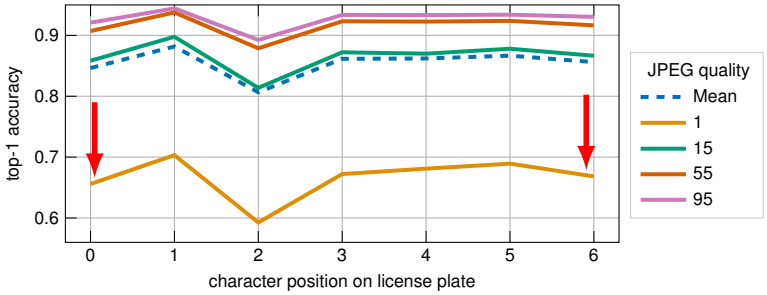

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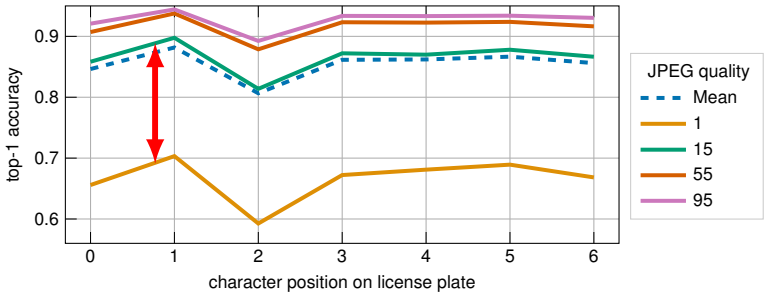

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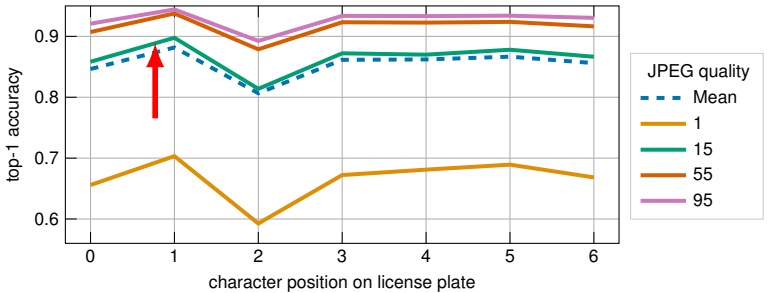

In-depth Analysis of the Influence of Similarity of Characters

- Network learns which characters are possible at a certain position
- Position four to seven: no letters are predicted
- Recognition rates of similar characters are lower
- Possible similarity features for characters:
  - Direction and position of strokes: B ↔ 8
  - Horizontal projections: H ↔ M ↔ U

position	possible characters
0	1, 2 ,3 ,4 ,5 ,6 ,7 ,8 ,9
1	A, B, C, E, H, J, K, L, M, P, S, T, U, Z
2	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, H, I, J, K, L, M, N, P, R, S, T, U, V, X, Y, Z
3-6	0, 1, 2, 3, 4, 5, 6, 7, 8, 9

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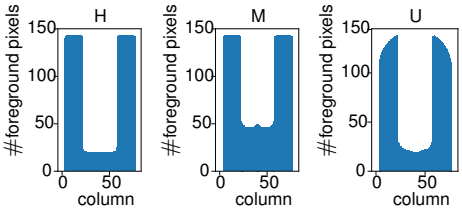

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quality factor	char	p1	p2	p3	c1	c2	c3
1		P	E	H	0.62	0.04	0.03
15		P	M	F	0.87	0.02	0.01
95		P	F	E	0.92	0.01	0.01

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- Hence, forensic triage on license plates can benefits from conditioning on compression strength

Conclusion

- Investigate the recognition of license plates in JPEG-compressed images
- Synthetic Czech dataset is created with low-resolution, noisy, and compressed images
- Trained CNN predicts the characters of the license plate
- Reliable recognition for images with
  - Width $\geq$ 30 pixels
  - SNR $\geq$ -3 dB
  - JPEG quality factor $\geq$ 15
- Top-*n* accuracy is a non-trivial function of
  - compression strength
  - character position
  - inter-character similarity
- Character confusion matrix depends on compression strength,
  hence forensic triage can benefit from compression-dependent confusion matrices

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