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Sequence-based Recognition of License Plates with Severe Out-of-Distribution Degradations

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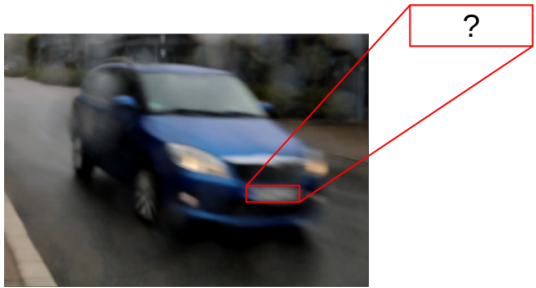
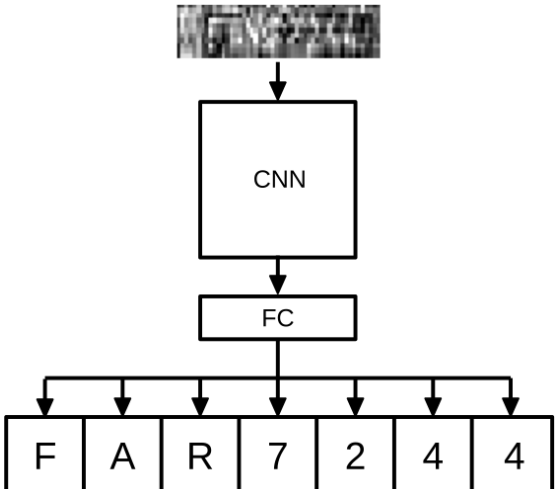
Challenges for Recognizing License Plates (LPs)

- **Goal**: Automatically deciphering LPs subjected to unknown degradations
- **Problem**: Digital image quality can heavily be impacted in practice
  - Images can be degraded beyond human recognition
  - Information may still be available for reconstruction



Prior Work and Research Questions

- Prior work: CNNs are applied to recognize severely degraded LPs



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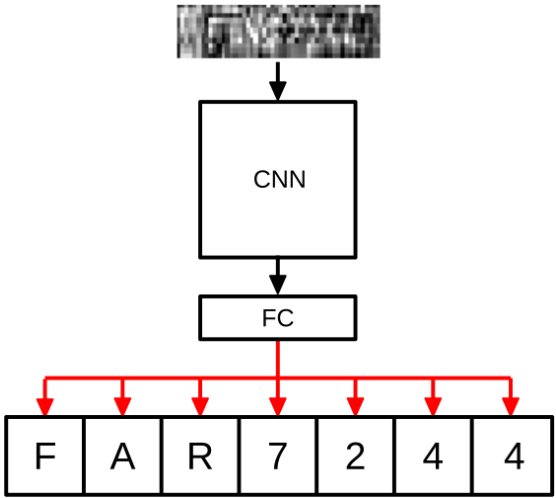
  - **Sequential context information?**
    - LP caption = sequence
    - Prior work on recognizing high-quality LPs profit from CNN-RNN combinations
    - Top-n sequence predictions



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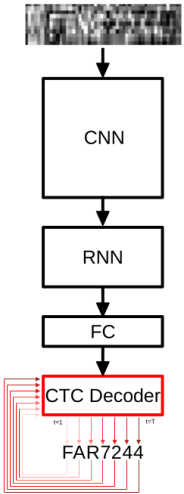

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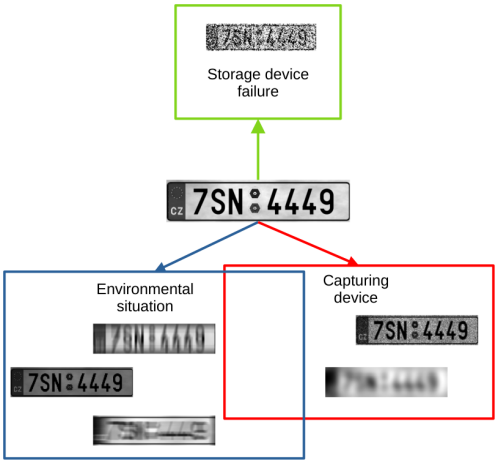
  - **Robustness?**
    - Footage stems from uncontrolled sources
    - Degradation phenomena not covered in training data usually appear

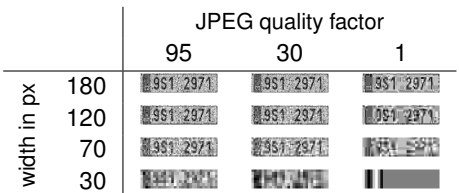


Contributions

1. Adaptation of a sequence based approach for recognizing severely degraded license plates
2. Robustness evaluation on out-of-distribution data
3. Evaluation of top-n sequence predictions
4. Evaluation on in-distribution-data and real world data set (ReId [1])

Generation of Training Data

- Generation pipeline as described by Kaiser [3]
  - Synthetic LPs of Czech format
  - Degradation factors and strength controlled
  - Training set of 10 Mio samples
- Common degradation factors modeled by ...
  - Gaussian noise
  - Low resolution
  - JPEG-compression



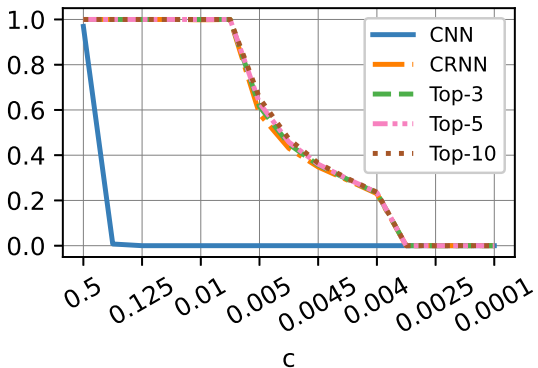
Evaluation

- Test data for robustness evaluation
  - Includes six degradation factors not occurring in the training set
  - strength of each factor ranges from low to high
  - Per test set: 10 000 samples of one degradation factor of one strength
- Metrics
  - Top-1 LP accuracies of CNN by Lorch *et al.* [4] and CRNN
  - CRNN top-n with $n \in \{3, 5, 10\}$ predictions from beam search decoding

Results - Underexposure

- Implementation
  - Linear pixel shift by multiplicative constant *c*

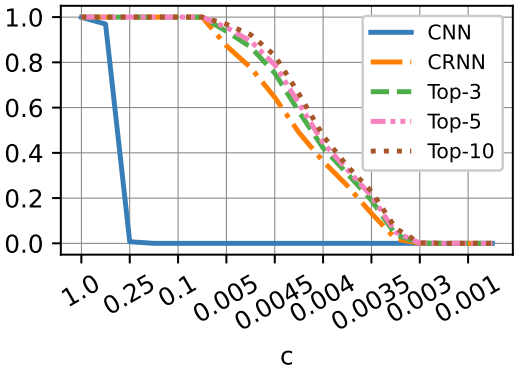
- Remarks
  - No. degradation levels: 15
  - Beam search: hardly improves performance



Results - Shot Noise

- Implementation
  - Scaling by Poisson distribution $P_\lambda(n^p)$

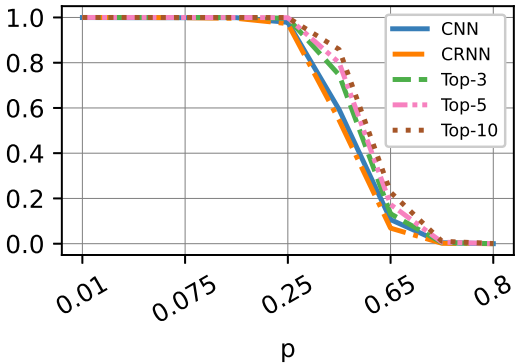
- Remarks
  - No. degradation levels: 18
  - Beam search: more rewarding than for underexposure



Results - Salt and Pepper Noise

- Implementation
  - Randomly set pixels to min. or max. value

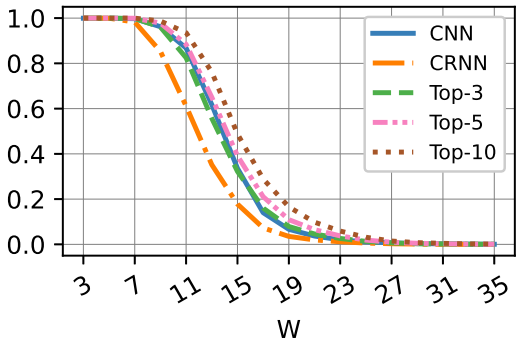
- Remarks
  - No. degradation levels: 9
  - Beam search: $n = 3$ needed to surpass CNN



Results - Horizontal Motion Blur

- Implementation
  - Convolution with box kernel in horizontal direction

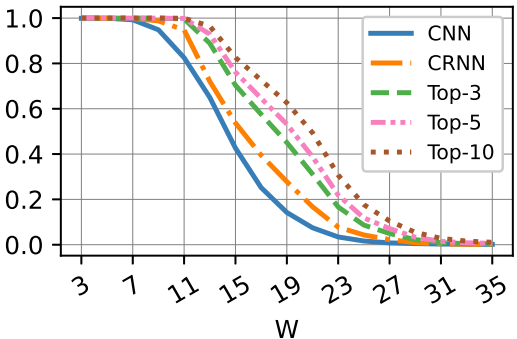
- Remarks
  - No. degradation levels: 17
  - Sequential processing disadvantageous for horizontally ‘smeared’ features
  - Beam search: $n = 5$ needed to surpass CNN



Results - Vertical Motion Blur

- Implementation
  - Convolution with box kernel in vertical direction

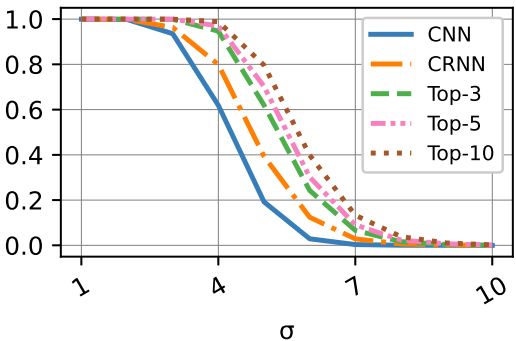
- Remarks
  - No. degradation levels: 17
  - Beam search: vast performance increase



Results - Defocus Blur

- Implementation
  - Convolution with Gaussian kernel of width σ

- Remarks
  - No. degradation levels: 10
  - Beam search: exploits most information for $\sigma \in [4, 6]$



Conclusion and Future Work

- CRNN outperforms CNN on most out-of-distribution degradation factors
- Degradations in sequence direction are problematic (e.g. horizontal motion blur)
- Top-n sequence predictions pose an advantage for identifying LPs

- Future Work
  - Various additional degradation types remain to be investigated
  - Acquiring labeled real world data sets with controlled degradation types
  - Aim for more robustness towards degradation along the sequence dimension
  - Explore performance on LP formats with more syntactic sequence rules (e.g. German license plates)

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Thank you for listening.
Any questions?

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References

References I

[1] Jakub Špaňhel *et al.* “Holistic recognition of low quality license plates by CNN using track annotated data”. In: *2017 14th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS)*. IEEE. 2017, pp. 1–6.

[2] Baoguang Shi, Xiang Bai, and Cong Yao. “An End-to-End Trainable Neural Network for Image-Based Sequence Recognition and Its Application to Scene Text Recognition”. In: *IEEE Transactions on Pattern Analysis and Machine Intelligence* 39.11 (Nov. 2017). Conference Name: IEEE Transactions on Pattern Analysis and Machine Intelligence, pp. 2298–2304. ISSN: 1939-3539. DOI: 10.1109/TPAMI.2016.2646371.

[3] Paula Kaiser. “Learning to Decipher License Plates in Severely Degraded Images”. MA thesis. Friedrich-Alexander-UniversitÃ¤t Erlangen-NÃ¼rnberg, Nov. 2019.

[4] Benedikt Lorch, Shruti Agarwal, and Hany Farid. “Forensic reconstruction of severely degraded license plates”. In: *Electronic Imaging* 2019.5 (2019), pp. 529–1.