DCGAN-Based Data Augmentation for Enhanced Performance of Convolution Neural Networks

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Presenter resume

Christian Reser

- M.Sc degree in Computer Science from Furtwangen University of Applied Science received in 2018
- Since then, research assistant at the Institute for Data Science, Cloud Computing and IT-Security at Hochschule Furtwangen.
- Research Fields: Machine Learning, Computer Vision

Institute for Data Science, Cloud Computing and IT-Security

Facts:

- Since 2009 research in Cloud Computing and IT-Security
- Head: Prof. Dr. Christoph Reich
- Faculty: Computer Science
- Currently: 5 PhDs, 4 Masters, 6 Bachelors

Area of Research:

- Distributed Systems
- Cloud Computing
- IT-Security, Blockchain
- IoT/Industry 4.0 (Data Analysis)

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Content

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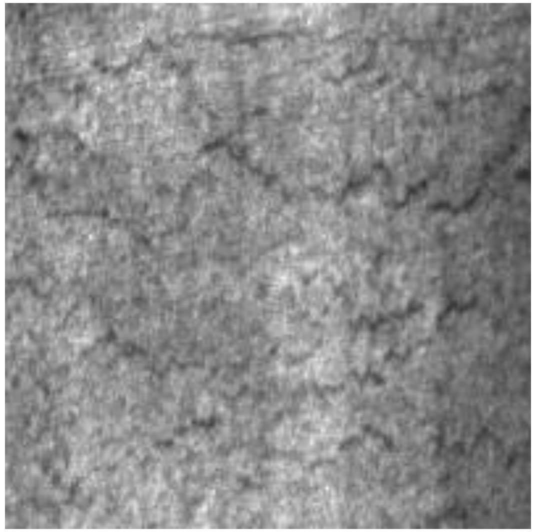
Introduction

- Convolutional Neural Networks for image classification
- Common problem is small data set for specific use cases
- Using image augmentation to expand the data set
  - Common basic augmentation
  - Augmentation with DCGAN model
- Deep Convolutional Generative Adversarial Network (DCGAN)
  - Generates artificial images that look like real ones
- Goal:
  - How much can a data set improve with DCGAN augmentations
  - Compare performance of models trained with:
    - Full data set
    - Sub sets with different augmentation techniques

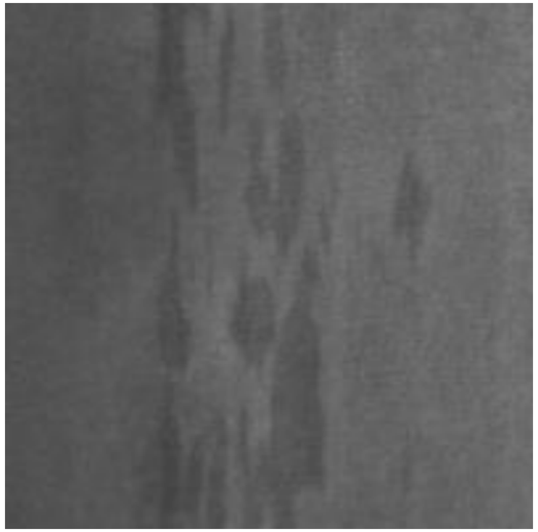
Data Set (NEU Surface Defect Database)

- Available from https://www.kaggle.com/kaustubhdikshit/neu-surface-defect-database
- 900 Images with steel surface defects
- 300 for each class (crazing, inclusion, patches)
- 128x128 pixel

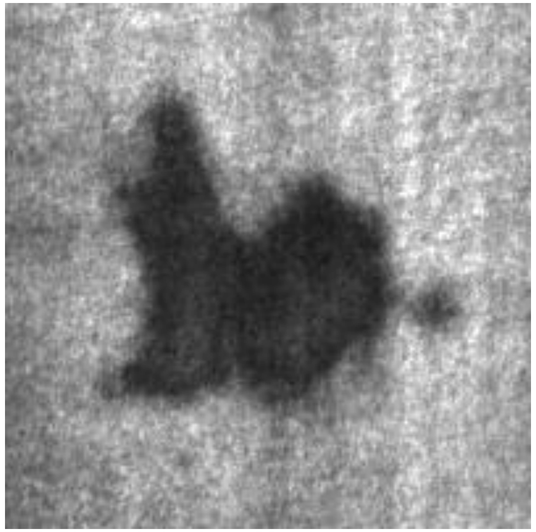
crazing



inclusion



patches



Training with Convolutional Neural Network

Hyperparameter:

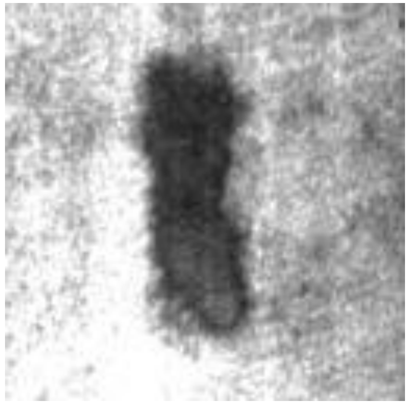
- 100 epochs
- 150 images per epoch
  - 120 training
  - 30 validation
- Adaptive Moment Estimation (Adam)
- Learning rate: 0.001

CNN-Architecture

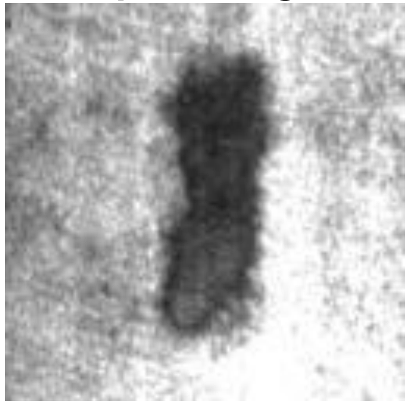
LAYER	FILTERS	OUTPUT SHAPE	ACTIVATION
Input Layer	-	(128, 128, 3)	-
Conv2D	64	(128, 128, 64)	relu
MaxPooling2D	-	(64, 64, 64)	-
Flatten	-	262144	-
Dense	64	(64, 64, 64)	relu
Output Layer	-	3	softmax

Common Augmentations

Original

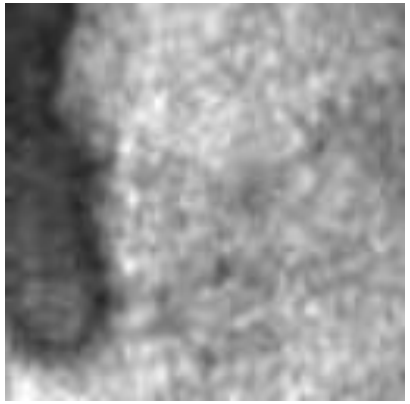


Flip Left Right

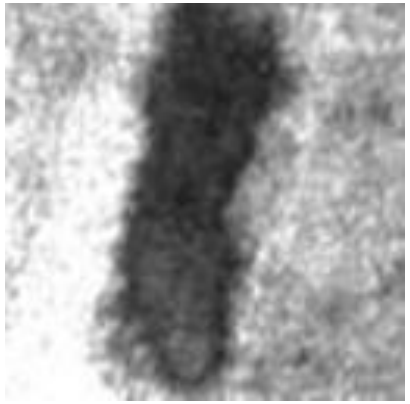


Flip Top Bottom

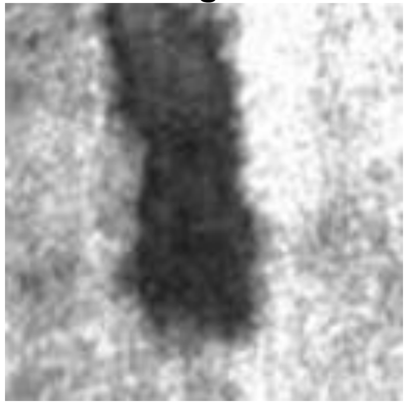
Random Zoom



Random Rotate



All Together



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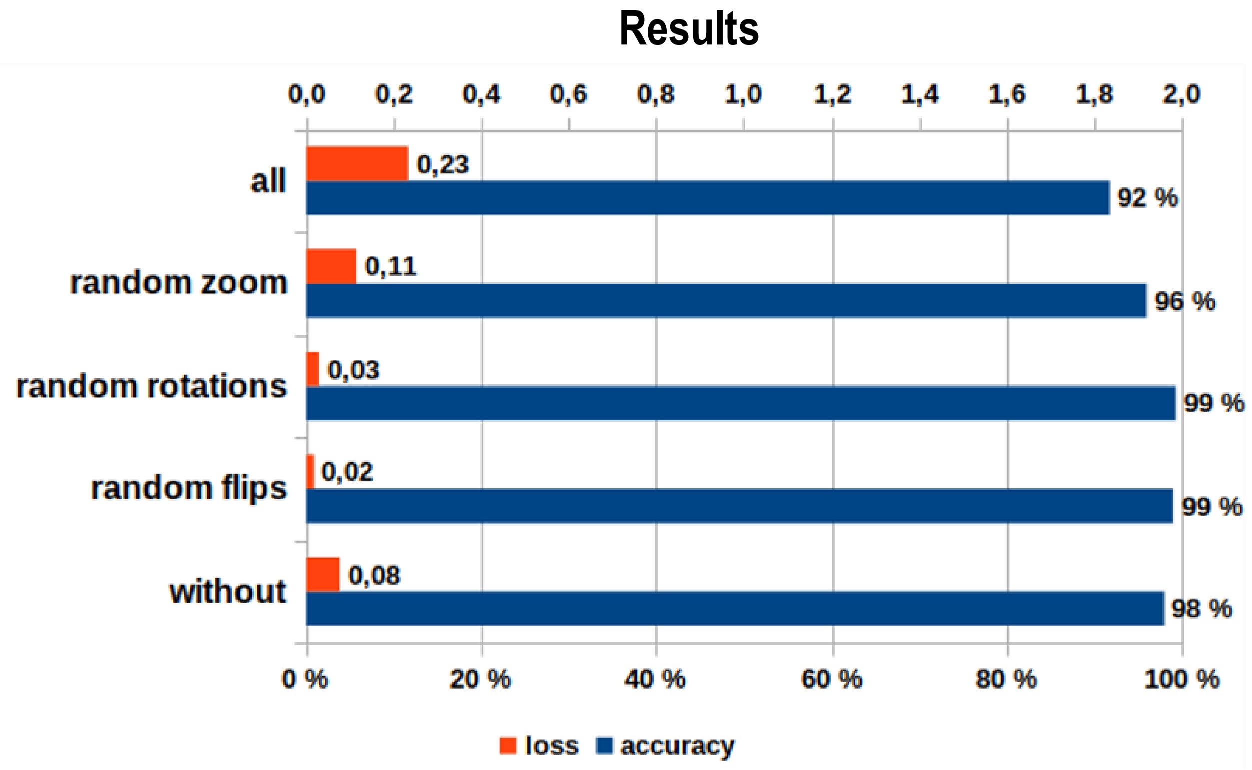
Experiment 1: Full Data Set

- Train models with the full data set
- Using different common augmentations
- Best model was trained with random flips augmentations
- Without was better than with random zoom augmentations
- All augmentations together made the model even worse

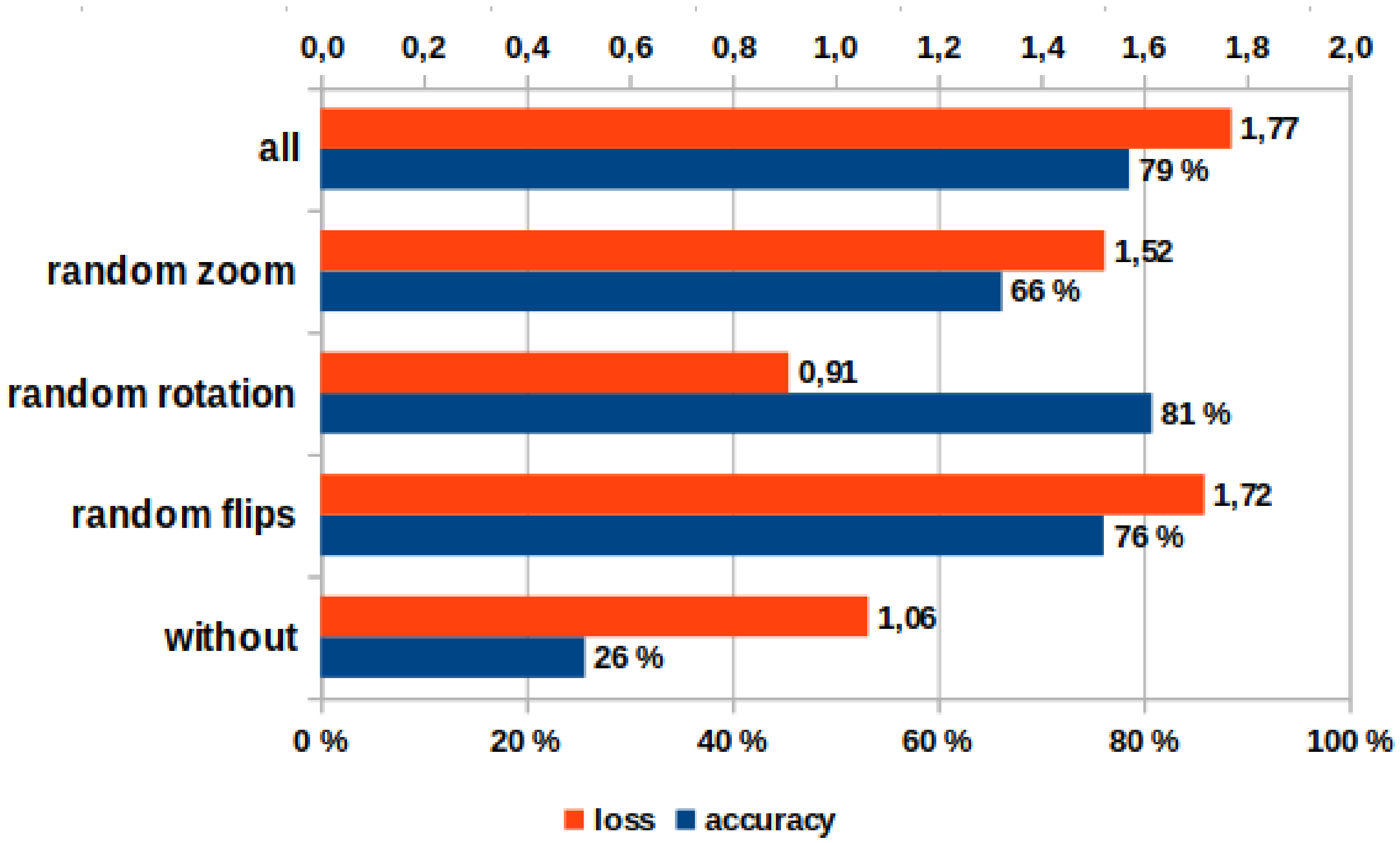


Experiment 2: Small Data Set expanded by Common Augmentations

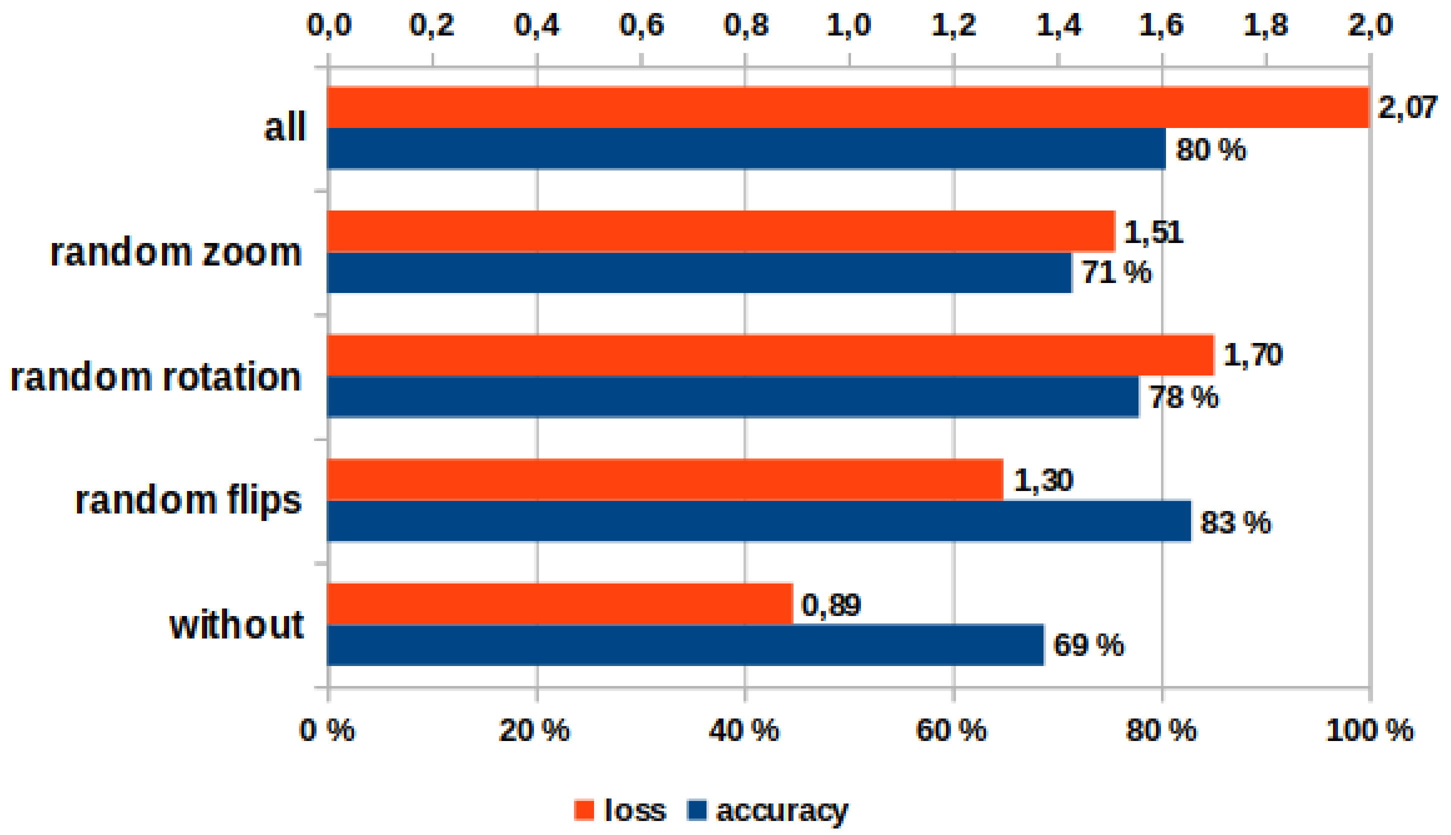
Comparing models trained on different subsets and with different augmentations

1. Created 5 sub sets out of the full data set through random selection
    - 10 images per class
    - 20 images per class
    - 30 images per class
    - 40 images per class
    - 50 images per class
2. Total number of images augmented to 150 per class
3. Trained with same hyperparameters and CNN-Architecture than experiment 1
4. Trained models got evaluated on the full data set

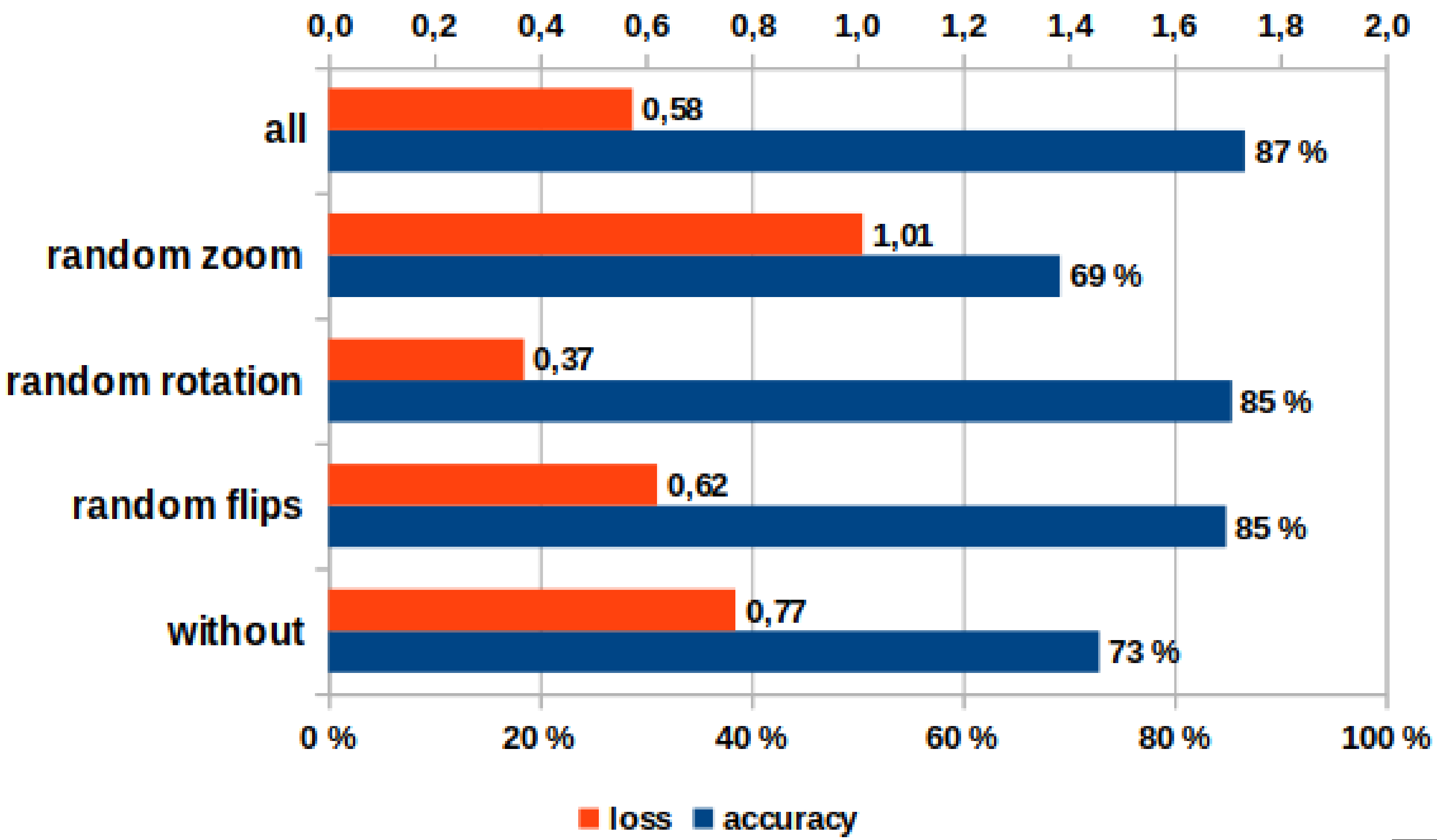
Results: 10 samples per class



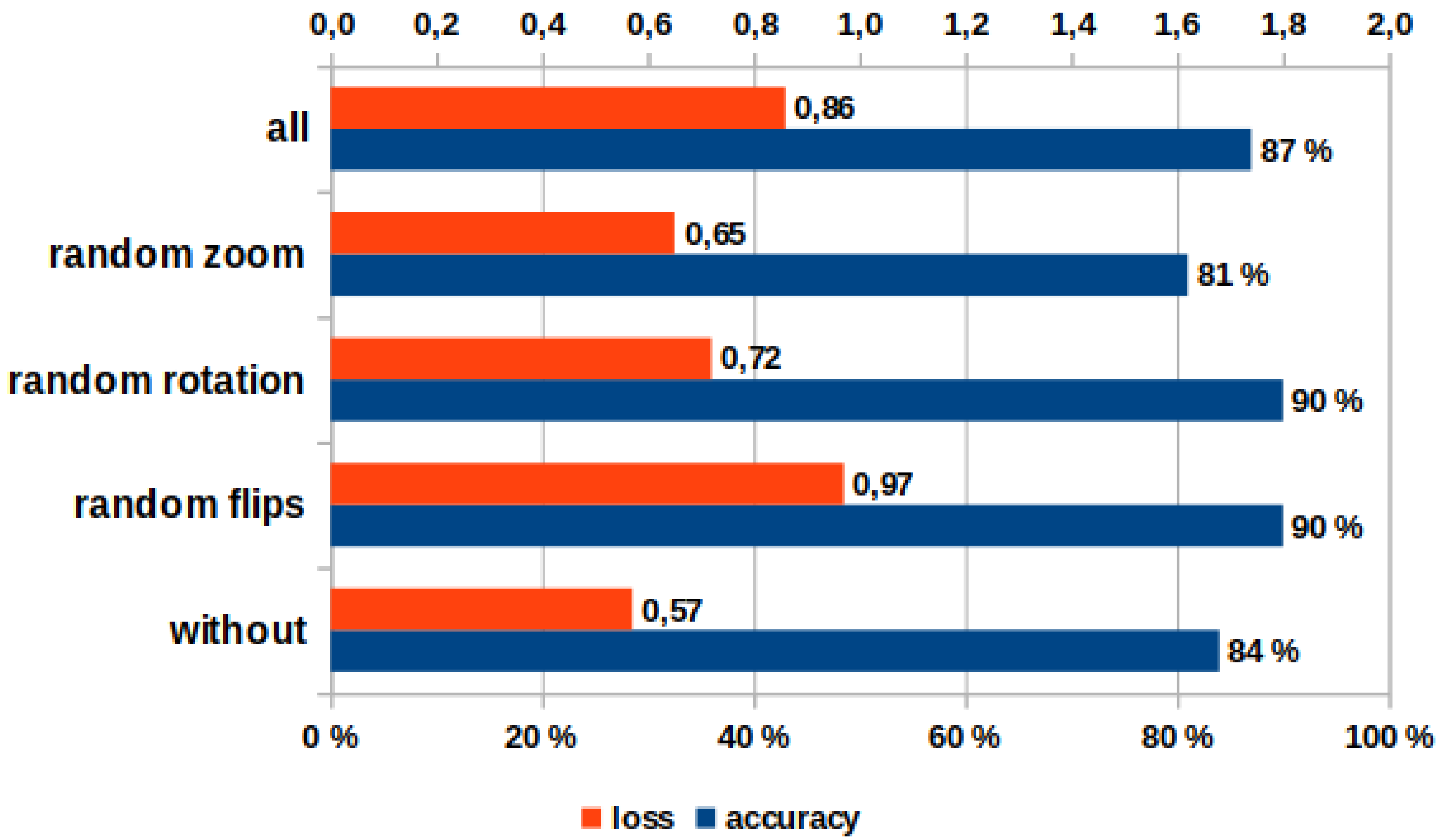
Results: 20 samples per class



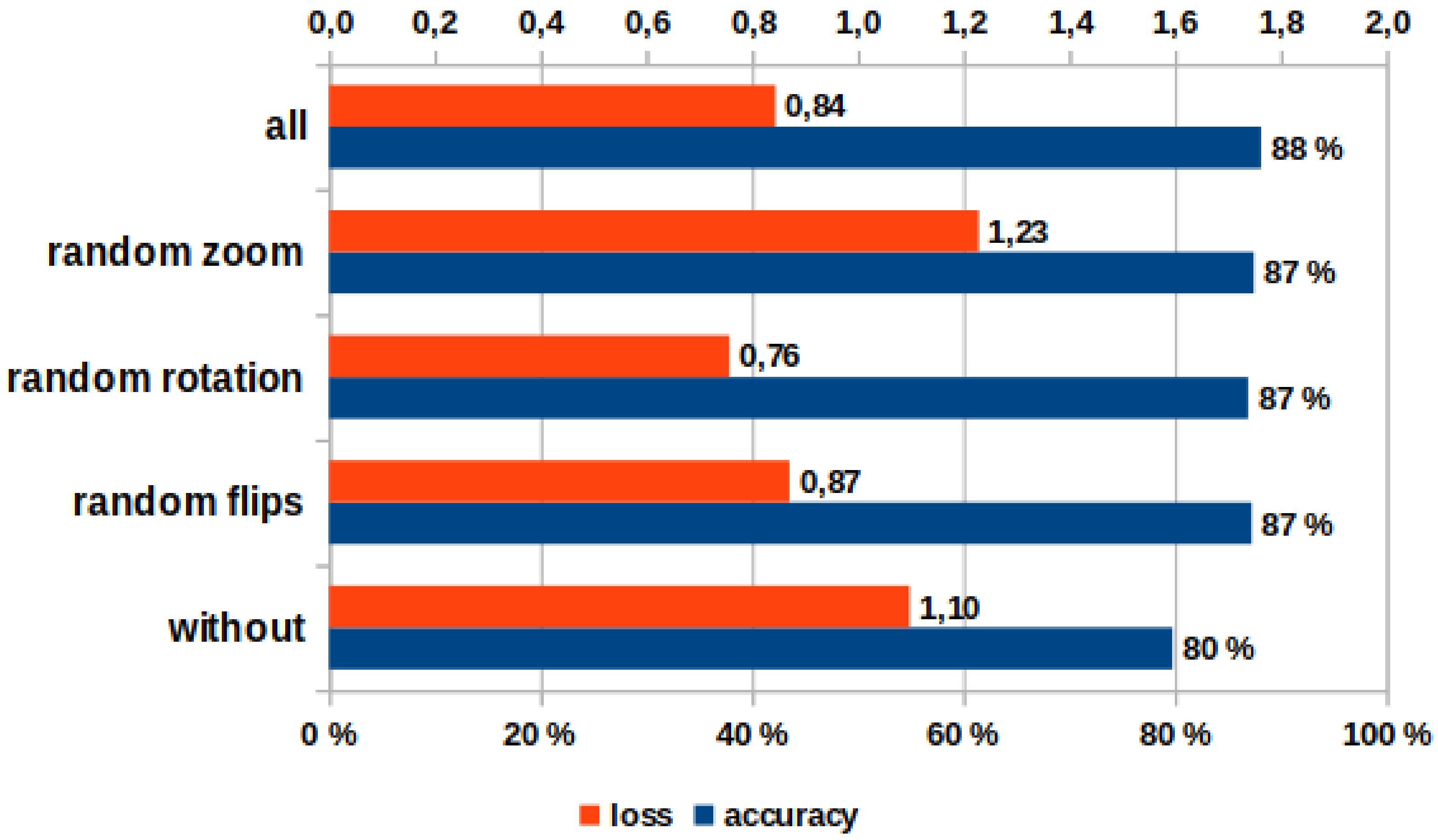
Results: 30 samples per class



Results: 40 samples per class



Results: 50 samples per class

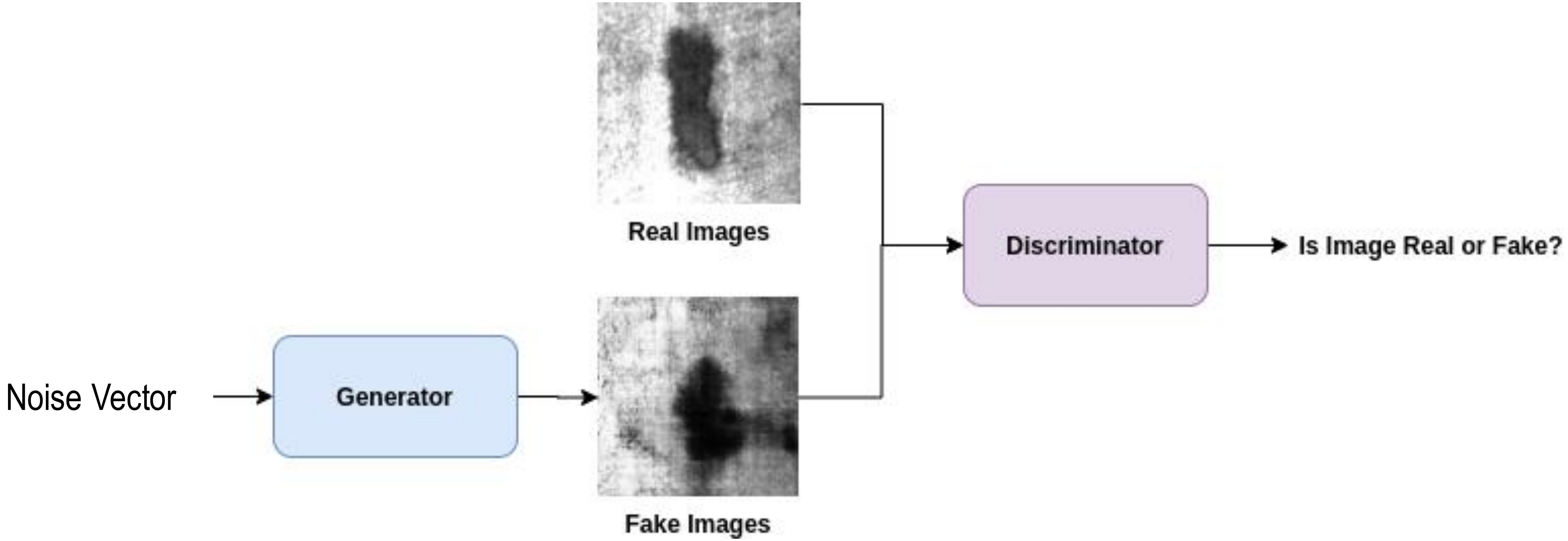


Experiment 2: Summary

- Best loss: 0.37 (with 30 samples per class and random rotation)
- Best accuracy: 90% (with 40 samples per class and random flips)

Experiment 3: Expand Small Data Sets with DCGAN Generated Images

1. Train DCGAN models for each sub set and class (10,20,30,40,50 from experiment 2)
2. Generate 300 images from the trained DCGAN models for each subset



3. Train CNN Model on generated data sets

DCGAN Training Hyperparameters

Hyperparameters:

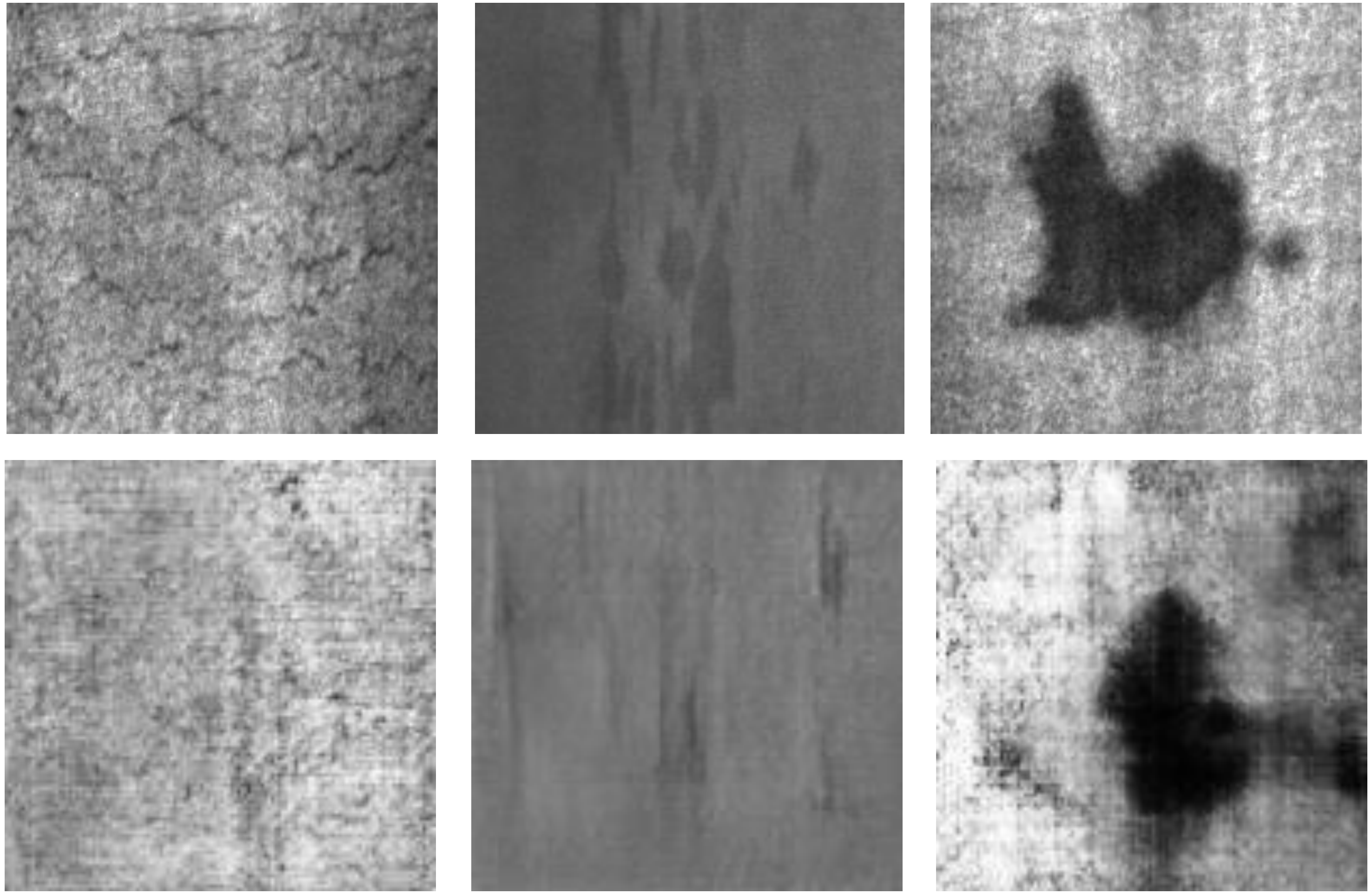
- Noise vector dimension: 100
- Generator generates 128x128 pixel images
- One DCGAN model per sub set per class
- 3000 epochs
- Saved weights after 600, 1200, 1800, 2400 and last epoch

DCGAN generated images

crazing | inclusion | patches

Real images

Generated images



Results: DCGAN Augmentation

Samples per Class + 300 generated	Epoch	Accuracy	Loss
10	600	80%	0.87
10	1200	73%	1.13
10	1800	67%	2.13
10	2400	75%	1.12
10	3000	71%	2.19
20	600	78%	0.62
20	1200	74%	0.72
20	1800	61%	1.17
20	2400	74%	0.77
20	3000	71%	1.03
30	600	88%	0.49
30	1200	86%	0.38
30	1800	86%	0.47
30	2400	82%	0.61
30	3000	84%	0.56
40	600	88%	0.32
40	**1200**	**92%**	**0.23**
40	1800	88%	0.31
40	2400	89%	0.32
40	3000	88%	0.30
50	600	87%	0.47
50	1200	87%	0.55
50	1800	85%	0.35
50	2400	87%	0.40
50	3000	84%	0.56

- From each DCGAN model we generated 300 images per class
- Models were trained on the expanded datasets the same way as in experiment 1 and 2
- Trained models were evaluated in the full original data set
- Experiment 3: Best performing data set was the one with 40 randomly chosen images from the full data set plus 300 images per class generated from the DCGAN model trained for 1200 epochs

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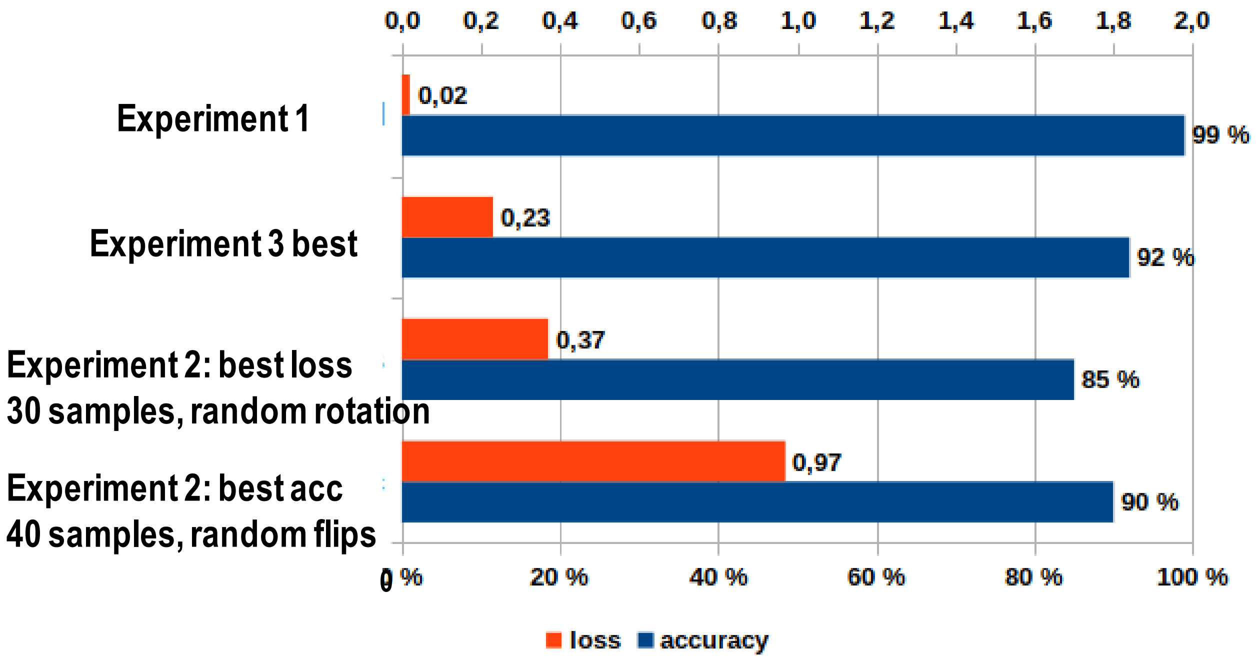
Evaluation: Comparison of the Experiments

- Full data set is (of course) still the best
- DCGAN generated data set performed better on the small data set
- DCGAN generated data set (experiment 3) improved
  - 0.14 in loss and
  - 2% in accuracy

  compared to common augmentations (experiment 2)



Conclusion

DCGAN augmentation improved a small data set, but it can not replace a big real data set

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Thank you very much for your attention!

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