Paper-Studium und Umsetzung

Zweite Mini Challenge des Moduls Deep Learning an der FHNW

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Datensatz und Ziel

🎯 Erstellung von Captions für Bilder

📀 Flickr8k
↔️ Unterschiedliche Bilddimensionen, 3 Farbkanäle
🌅 8091 Bilder (70% Train, 15% Val, 15% Test)
💬 5 Captions/Bild

Hauptframeworks

🔦 PyTorch
⚡ PyTorch Lightning
📒 Weights & Biases

Referenzpaper

Show and Tell: A Neural Image Caption Generator

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Abstract

Automatically describing the content of an image is a fundamental problem in artificial intelligence that connects computer vision and natural language processing. In this paper, we present a generative model based on a deep recurrent architecture that combines recent advances in computer vision and machine translation and that can be used to generate natural sentences describing an image. The model is trained to maximize the likelihood of the target description sentence given the training image. Experiments on several datasets show the accuracy of the model and the fluency of the language it learns solely from image descriptions. Our model is often quite accurate, which we verify

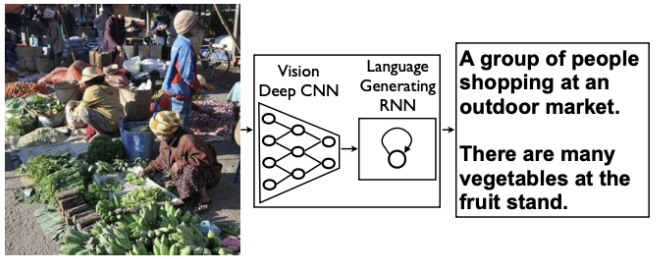
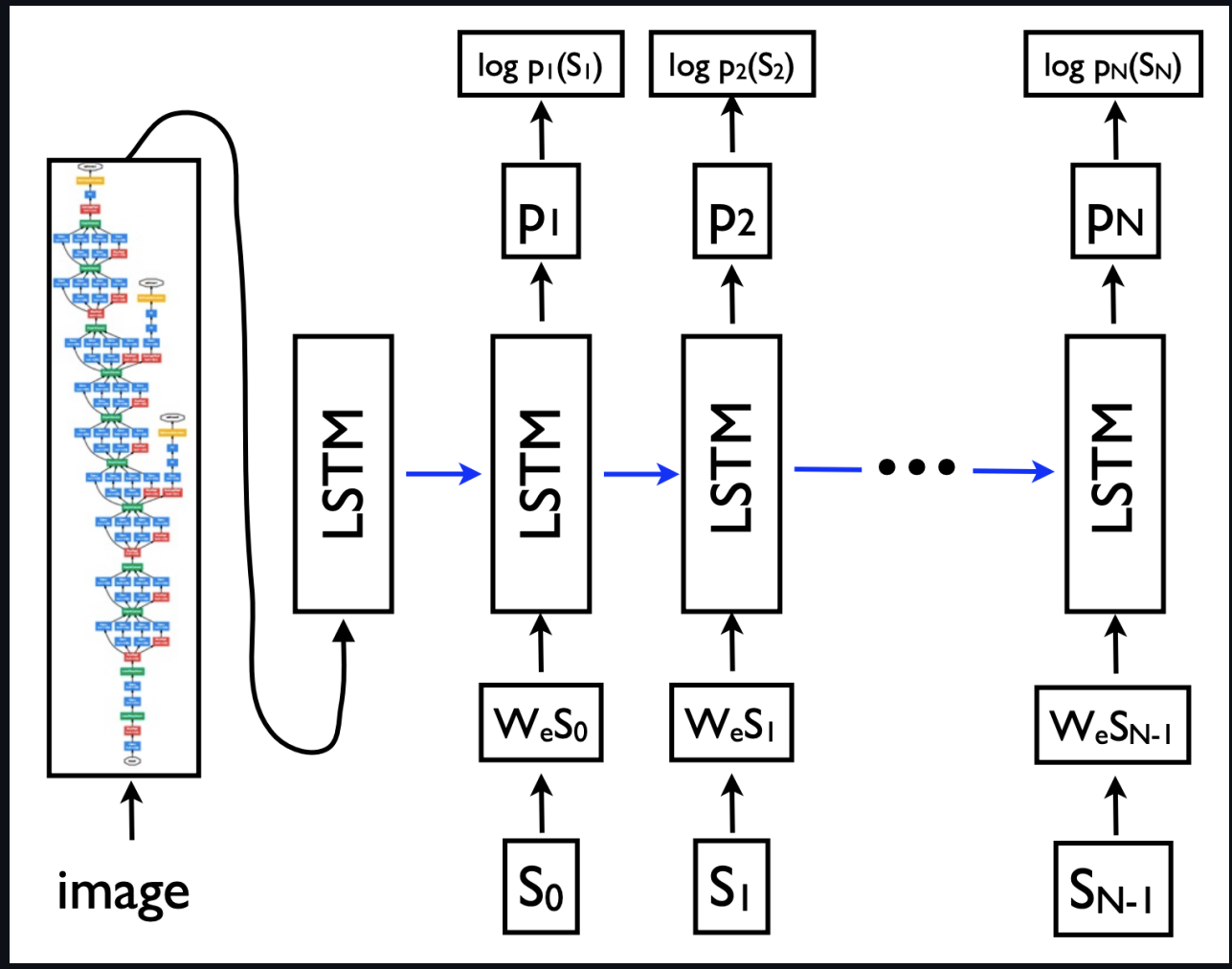


Figure 1. NIC, our model, is based end-to-end on a neural network consisting of a vision CNN followed by a language generating RNN. It generates complete sentences in natural language from an input image, as shown on the example above.

Architektur

- Image Encoder (CNN)
- Caption Encoder (nn.Embedding)
- Captioning Decoder (LSTM)



Verwendete Metriken: BLEU

BLEU-1

- Überprüft Unigramme
- Korrekte Wörter vorhanden?

BLEU-2,3 und 4

- Überprüft Bigramme, Trigramme, Quadrigramme
- Korrekte Wortreihenfolge?

Image Preprocessing

```
transform = transforms.Compose(
    [
        transforms.ToPILImage(),
        transforms.RandomHorizontalFlip(),
        transforms.RandomRotation(10),
        transforms.ColorJitter(brightness=0.2, contrast=0.2,
                               saturation=0.2, hue=0.1),
        transforms.Resize((224, 224)),
        transforms.RandomResizedCrop(224, scale=(0.8, 1.0)),
        transforms.ToTensor(),
    ]
)
```

Text Preprocessing

Example Caption:

```
A child in a pink dress is climbing up a set of stairs in an entry way .
```

Tokenized caption (with nltk word tokenizer):

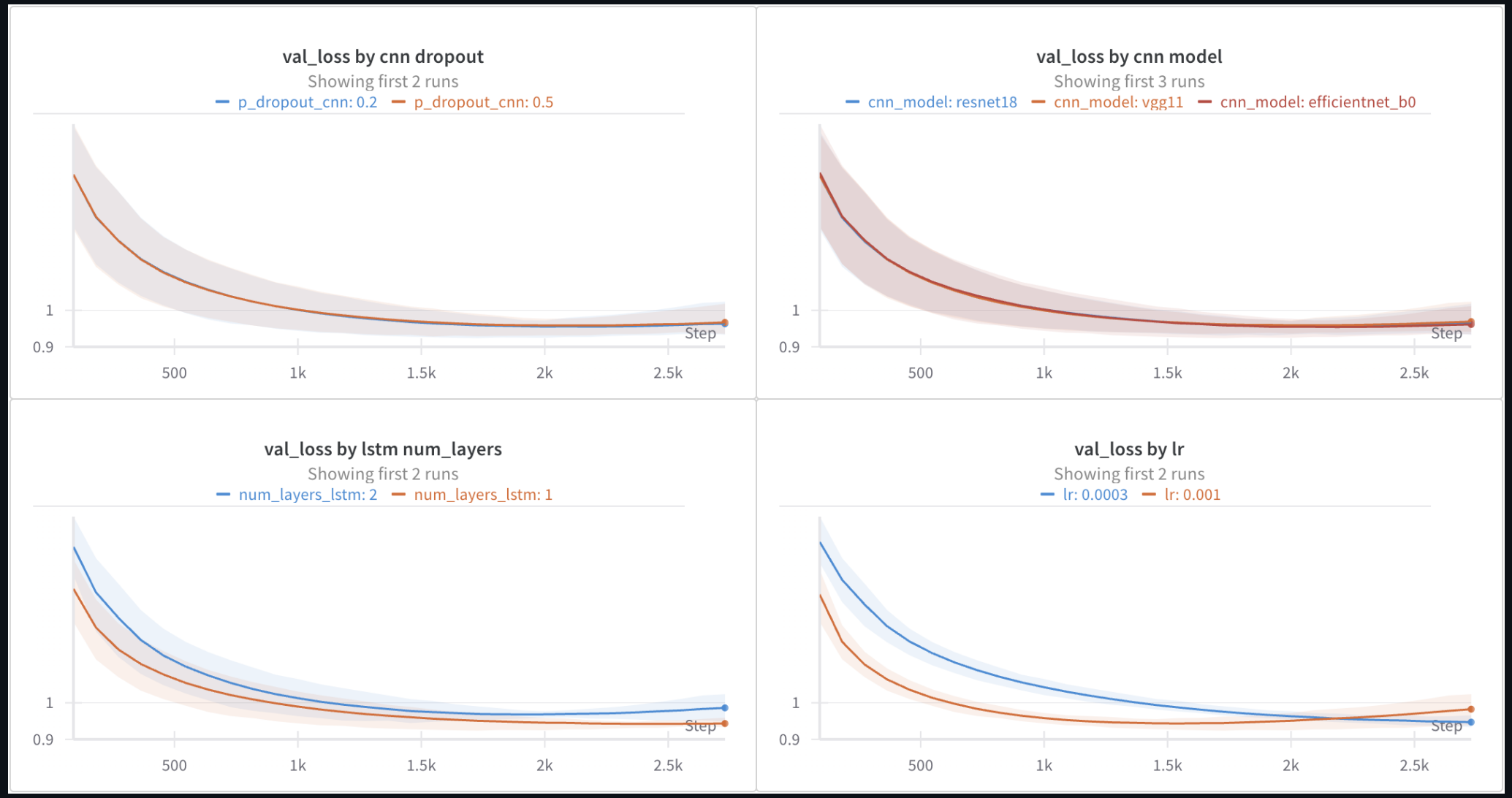
```
['<start>', 'A', 'child', 'in', 'a', 'pink', 'dress', 'is', 'climbing',
'up', 'a', 'set', 'of', 'stairs', 'in', 'an', 'entry', 'way', '.', '<end>',
'<pad>', '<pad>', ...]
```

Tokenized caption (index in dictionary):

```
[9630, 68, 2580, 4910, 1240, 6514, 3457, 4995, 2675, 9105, 1240,
7526, 6030, 8185, 4910, 1411, 3665, 9334, 13, 9631, 9632, 9632, ...]
```

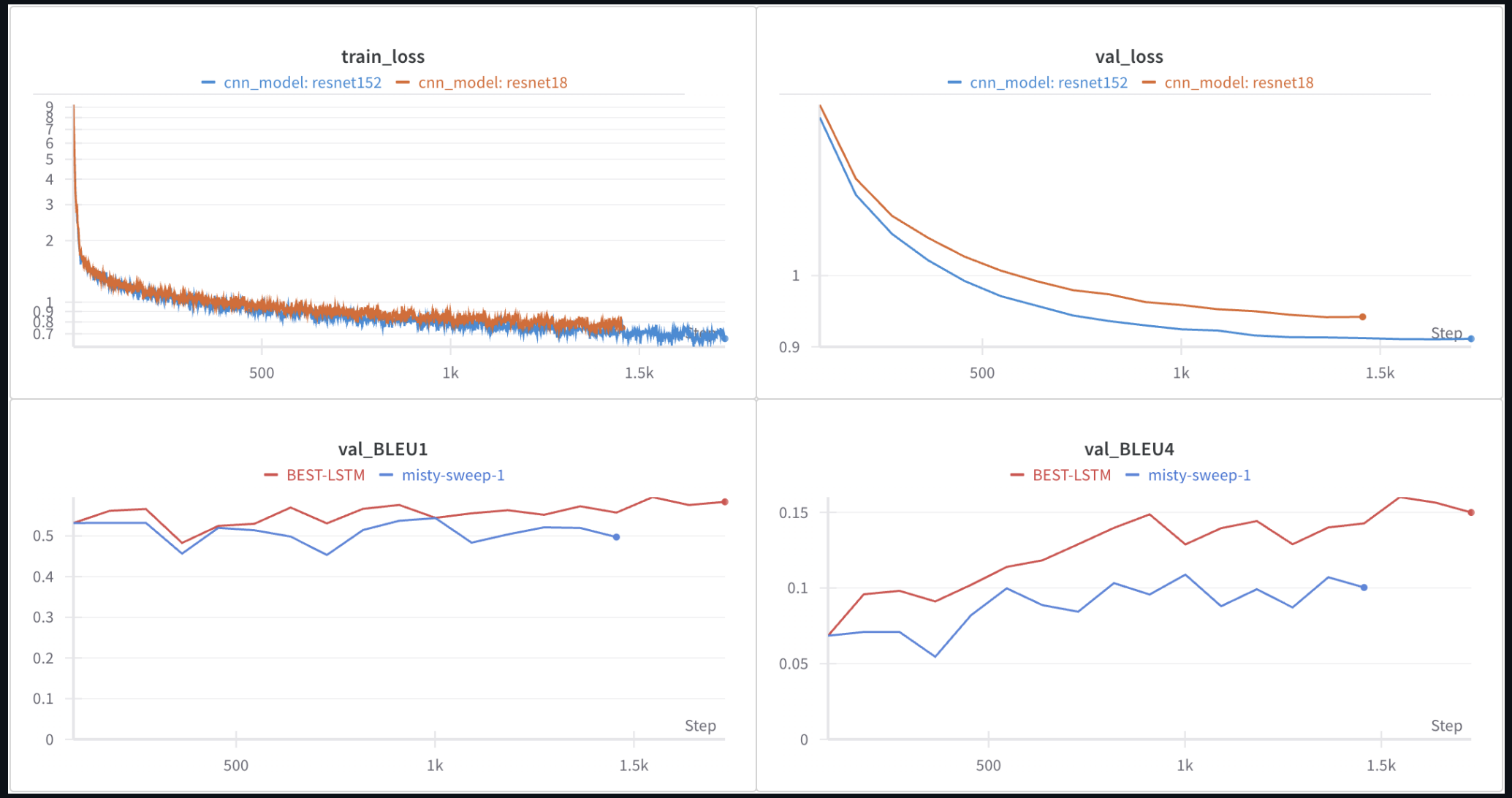
Sweep 1 (Verhalten der Hyperparameter)

```
sweep_config = {
    "method": "grid",
    "name": "ShowAndTell",
    "parameters": {
        "optimizer": {"values": ["Adam"]},
        "lr": {"values": [0.001, 0.0003]},
        "weight_decay": {"values": [0.00001]},
        "cnn_model": {"values": ["efficientnet_b0", "vgg11", "resnet18"]},
        "embed_size": {"values": [512]},
        "p_dropout_cnn": {"values": [0.5, 0.2]},
        "hidden_size_lstm": {"values": [512]},
        "num_layers_lstm": {"values": [1, 2]},
        "n_epochs": {"values": [30]},
    },
}
```


val_loss by cnn dropout
Showing first 2 runs
p_dropout_cnn: 0.2
p_dropout_cnn: 0.5
1
0.9
Step
500
1k
1.5k
2k
2.5k
val_loss by cnn model
Showing first 3 runs
cnn_model: resnet18
cnn_model: vgg11
cnn_model: efficientnet_b0
1
0.9
Step
500
1k
1.5k
2k
2.5k
val_loss by lstm num_layers
Showing first 2 runs
num_layers_lstm: 2
num_layers_lstm: 1
1
0.9
Step
500
1k
1.5k
2k
2.5k
val_loss by lr
Showing first 2 runs
lr: 0.0003
lr: 0.001
1
0.9
Step
500
1k
1.5k
2k
2.5k

Sweep 2 (Vergleich der Modellgrösse)

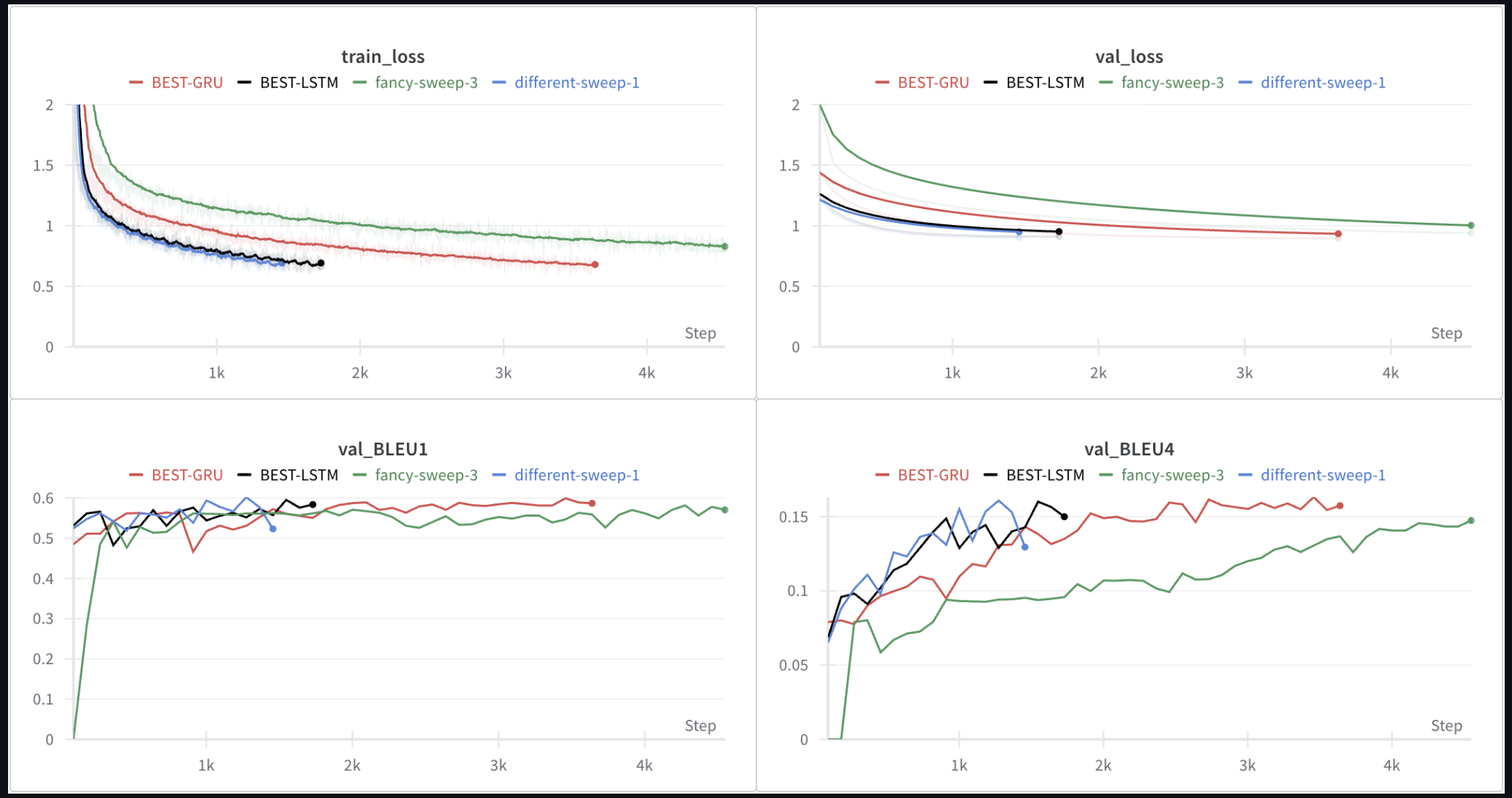
```
sweep_config = {
    "method": "grid",
    "name": "ShowAndTell2", # changed
    "parameters": {
        "optimizer": {"values": ["Adam"]},
        "lr": {"values": [0.001]}, # changed
        "weight_decay": {"values": [0.00001]},
        "cnn_model": {"values": ["resnet18", "resnet152"]}, # changed
        "embed_size": {"values": [512]},
        "p_dropout_cnn": {"values": [0.5]}, # changed
        "hidden_size_lstm": {"values": [512]},
        "num_layers_lstm": {"values": [1]}, # changed
        "n_epochs": {"values": [30]},
    },
}
```


train_loss
cnn_model: resnet152
cnn_model: resnet18
9
8
7
6
5
4
3
2
1
0.9
0.8
0.7
500
1k
1.5k
val_loss
cnn_model: resnet152
cnn_model: resnet18
1
0.9
Step
500
1k
1.5k
val_BLEU1
BEST-LSTM
misty-sweep-1
0.5
0.4
0.3
0.2
0.1
0
Step
500
1k
1.5k
val_BLEU4
BEST-LSTM
misty-sweep-1
0.15
0.1
0.05
0
Step
500
1k
1.5k

epoch	caption	prediction
0	A black and white dog is running in a grassy garden surrounded by a white fence .	scanner bikinis competeition zombie background cheers twos videocameras rustic bullfight rollerblade rainbow plucking consoling smal Riwal ravine moving Greyhound Fawkes plaza gold woody interviewed hoops fan curtsey snowfall Rover lounging Stacks apple kangaroo VW piles opened mouthing featuring pinwheel
9	A black and white dog is running in a grassy garden surrounded by a white fence .	A black and white dog is running through the grass .
19	A black and white dog is running in a grassy garden surrounded by a white fence .	A dog is running through a field .

Sweep 3 (GRU anstatt LSTM)

```
sweep_config = {
    "method": "grid",
    "name": "ShowAndTellGRU", # changed
    "parameters": {
        "optimizer": {"values": ["Adam"]},
        "lr": {"values": [0.001, 0.0003, 0.0001]}, # changed
        "weight_decay": {"values": [0.00001]},
        "cnn_model": {"values": ["resnet152"]},
        "embed_size": {"values": [512]},
        "p_dropout_cnn": {"values": [0.5]},
        "hidden_size_gru": {"values": [512]},
        "num_layers_gru": {"values": [1]},
        "n_epochs": {"values": [50]},
    },
}
```


train_loss
BEST-GRU
BEST-LSTM
fancy-sweep-3
different-sweep-1
2
1.5
1
0.5
0
Step
1k
2k
3k
4k
val_loss
BEST-GRU
BEST-LSTM
fancy-sweep-3
different-sweep-1
2
1.5
1
0.5
0
Step
1k
2k
3k
4k
val_BLEU1
BEST-GRU
BEST-LSTM
fancy-sweep-3
different-sweep-1
0.6
0.5
0.4
0.3
0.2
0.1
0
Step
1k
2k
3k
4k
val_BLEU4
BEST-GRU
BEST-LSTM
fancy-sweep-3
different-sweep-1
0.15
0.1
0.05
0
Step
1k
2k
3k
4k

Metriken (Bestes LSTM)

	Datensatz	Unser Modell	Referenzmodell
BLEU-1	Flickr8k	0.5923	0.63
BLEU-2	Flickr8k	0.3716	:(
BLEU-3	Flickr8k	0.2390	:(
BLEU-4	Flickr8k	0.1555	:(
BLEU-4	MSCOCO (123'287 images)	-	0.277

Gelungenes Beispiel

```
Caption: A brown dog on a leash runs through the white water .
Caption: A soaked dog is playing in the water .
Caption: A tan dog on a leash running in shallow ocean water .
Caption: A wet dog on a leash is running through some water .
Caption: Brown dog running through shallow water .

Prediction: A brown dog is running through the water .
---
```

Ungelungenes Beispiel

```
Caption: A person eats takeout while watching a small television .
Caption: A person sits on the floor and eats in front of a television .
Caption: A television with a picture of a girl on it .
Caption: A young man sits on the floor by the television with a fast food meal in front of him .
Caption: Someone is laying in front of the TV eating food .

Prediction: A man is sitting on a couch .
---
```

Mögliche Verbesserungen

- Tiefere Lernrate, dafür mehr Epochen
- Mehr Daten
- Stärkere Image Encoder (Panoptische Segmentierung?)
- Beam Search

Lessons Learned

❗ Image Encoder wichtig!

🚫 Captioning Decoder eher unwichtig..

👍🏼 Teacher Forcing für Textgeneration

❗ BLEU-1 Metrik ergänzen!