Sheet 9

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a)

- Sentence Order Prediction (SOP): SOP directly teaches the model to grasp sentence relationships
- Token Boundary Detection (TBD): It can benefit from learning more explicitly where natural word boundaries occur (especially for german)

b)

- Prefix Sequence Reconstruction (PSR): ability to encode earlier parts of a sequence conditioned on later context
- Future Span Prediction (FSP): FSP forces the model to reason about future sequences more holistically instead of predicting token-by-token

2 Under the hood of LLMs: Llama 2.7B

Initilazation of the model

In [ ]:
```
from transformers import AutoTokenizer, AutoModelForCausalLM
import torch

device = torch.device('cuda:0' if torch.cuda.is_available() else 'cpu')

#with open("access_token.txt", "r") as f:
#    access_token = f.read().strip()
access_token = "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"
model = "meta-llama/Llama-2-7b-chat-hf"
tokenizer = AutoTokenizer.from_pretrained(model, token=access_token)
model = AutoModelForCausalLM.from_pretrained(model, token=access_token, torch_dt
print(model)
```

In [2]:
```
for id in range(5100, 5110): #Printing the tokens 5100 up to 5110 for example
    print(f"{id=}, {tokenizer.decode([id])}")

print("\ntokenizer length:", len(tokenizer))  #the whole model contains 32000 to

sun_id = tokenizer.encode("sun", return_tensors="pt")[-1] #find the token number
print(f"\n{sun_id=}")
```

```
print(tokenizer.decode(sun_id))

emb = model.get_input_embeddings()(sun_id.to(device))
print("embedding shape:", emb.shape) #shape of the token
```

```
id=5100, compet
id=5101, pair
id=5102, inglés
id=5103, Response
id=5104, Fig
id=5105, grad
id=5106, documentation
id=5107, cant
id=5108, appreci
id=5109, ån

tokenizer length: 32000

sun_id=tensor([    1, 6575])
<s> sun
embedding shape: torch.Size([2, 4096])
```

In [3]:
```
sequence = "My favorite composer is"
model_inputs = tokenizer(sequence, return_tensors="pt").to(device) #transforms i
print(tokenizer.decode(model_inputs["input_ids"].tolist()[0])) #view decoded tok
with torch.no_grad():
    outputs = model(**model_inputs) #the model gets the input and generates the

logits = outputs['logits'][0, -1, :] #gets unnormalized probability for every to
print("\nlogits shape:", logits.shape)

probabilities = torch.nn.functional.softmax(logits, dim=-1) #normalizes
top_k = 7
top_prob, top_ind = torch.topk(probabilities, top_k)

print("\nOutputs:\n")

for i in range(top_k):
    print(f"{tokenizer.decode(top_ind[i].tolist())}: {top_prob[i]:.2f}") #prints
```

```
<s> My favorite composer is

logits shape: torch.Size([32000])

Outputs:

Moz: 0.25
Ch: 0.11
Be: 0.09
Ludwig: 0.08
Fr: 0.03
Wolfgang: 0.02
Ig: 0.02
```

In [4]:
```
import regex as re

sequence = ""
model_inputs = tokenizer(sequence, return_tensors="pt").to(device) #input is emp

generated_answer = ""
for _ in range(30): #iterative generation of the next 30 tokens
```

```
    with torch.no_grad():
        outputs = model(**model_inputs) #generate output bases on input
        logits = outputs['logits'][0, -1, :] #unnormalized probabilities for the
        probabilities = torch.nn.functional.softmax(logits, dim=-1) #normalizes
        next_token_id = torch.argmax(probabilities).unsqueeze(0) #take the token
        model_inputs["input_ids"] = torch.cat([model_inputs["input_ids"], next_t

    #printing output/generated answer in readable form for every iteration
    next_word = tokenizer.decode(next_token_id.tolist())
    next_word = re.sub(r"[^a-zA-Z0-9.?!]", "", next_word)
    generated_answer += next_word
    generated_answer += " "

    print(generated_answer)
```

```
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Unterscheidung zwischen  K raft  und
Unterscheidung zwischen  K raft  und  K
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Unterscheidung zwischen  K raft  und  K raft werk     K raft  und  K raft werk  s
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Unterscheidung zwischen  K raft  und  K raft werk     K raft  und  K raft werk  s
ind two different
Unterscheidung zwischen  K raft  und  K raft werk     K raft  und  K raft werk  s
ind two different German
Unterscheidung zwischen  K raft  und  K raft werk     K raft  und  K raft werk  s
ind two different German words
Unterscheidung zwischen  K raft  und  K raft werk     K raft  und  K raft werk  s
ind two different German words that
```
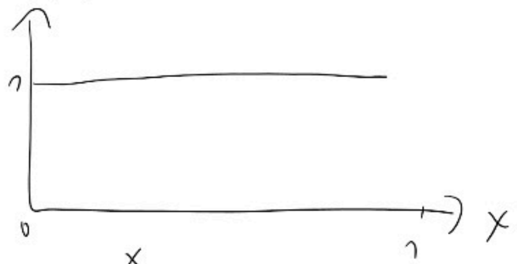

3 Flow-based modeling

Zettel 9

Donnerstag, 19. Dezember 2024
11:25

Nr 3

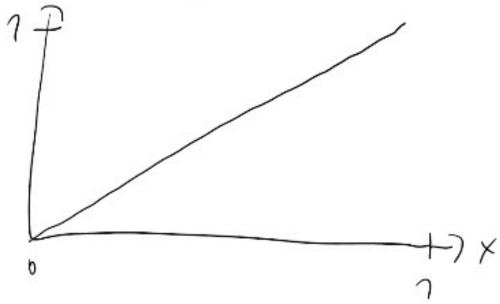
a) $p(x)$



$$y(x) = \int_0^x 1 \, dx' = x$$

$$y'(x) = y^{-1}(x) = x$$

$y'(x) = y(x)$



pdf:

$$pdf(y) = \frac{dy}{dx} = 1$$

$$pdf(y') = \frac{dy'}{dx} = 1$$

b) $p_y(y') = p_x(x) \left| \frac{dx}{dy} \right|$ $\quad x = g^{-1}(y)$

$y = g(x)$

Example:

$$p_x(x) = \frac{1}{2}x \qquad p_y(y) = -\frac{1}{2}y + 1$$

$$g(x): \quad p_x(x) \overset{!}{=} p_y(y) \Rightarrow \frac{1}{2}x = -\frac{1}{2}y + 1 \Rightarrow x = 2 - y$$

$$g(x) = 2 - x \qquad g^{-1}(y) = 2 - y$$

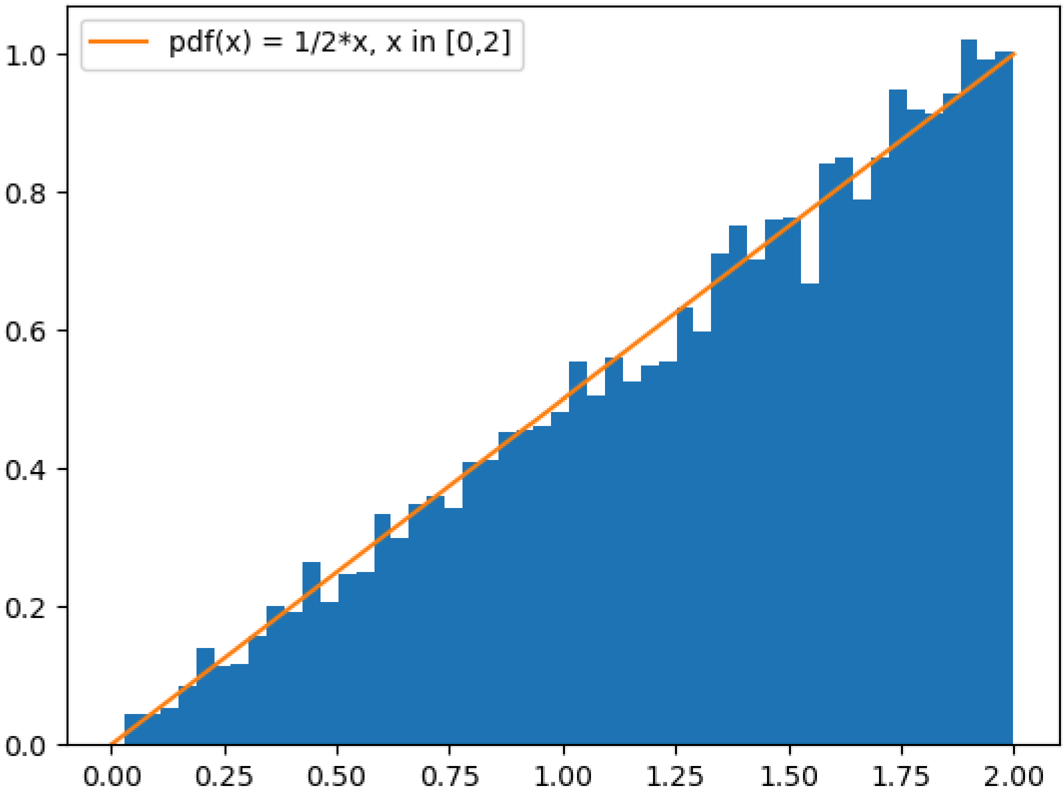
$$p_y(y') = p_x(g^{-1}(x)) \left| \frac{d(g^{-1}(x))}{dy} \right| = \frac{1}{2}(2-y) \left| \frac{d(2-y)}{dy} \right|$$

$= 1 - \frac{1}{2} y \, |-1| = 1 - \frac{1}{2} y$

(b)

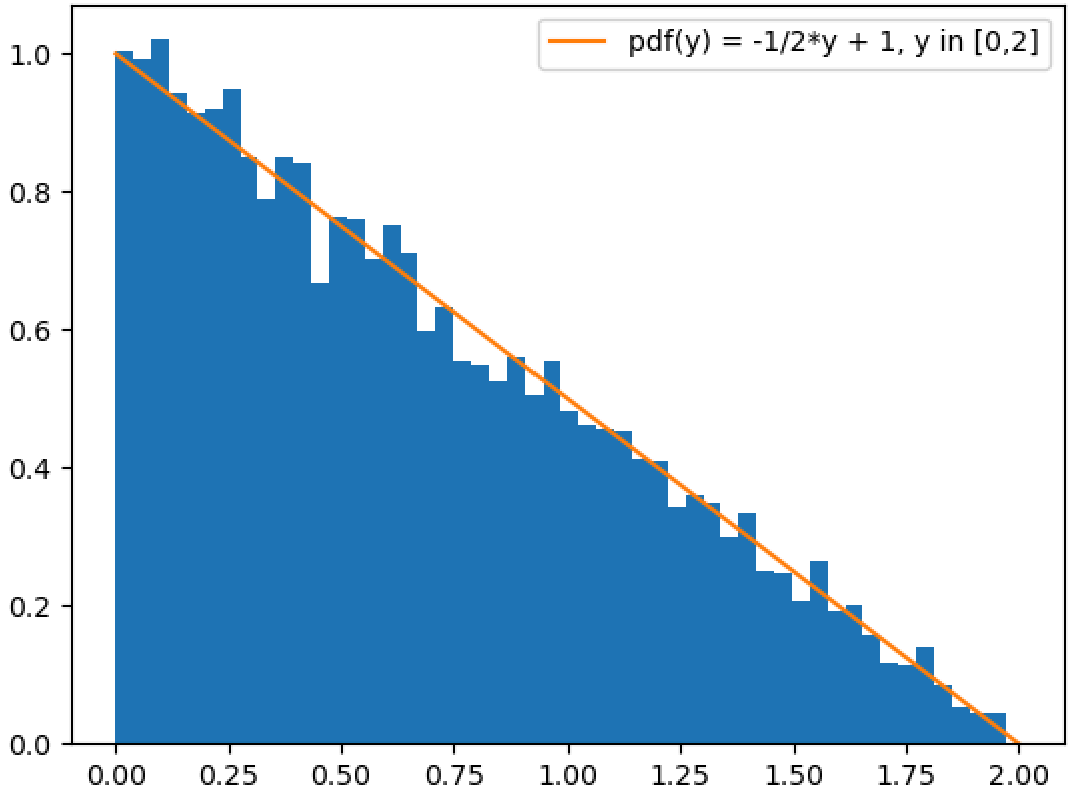
In [7]:

```
import numpy as np
import matplotlib.pyplot as plt

# load the 1d samples:
samples = np.load("data/samples_1d.npy")

x_lin = np.linspace(0, 2, 1000)
plt.hist(samples, bins=50, density=True)
plt.plot(x_lin, 1/2 * x_lin, label="pdf(x) = 1/2*x, x in [0,2]")
plt.legend()
plt.show()
```



In [11]:

```
def g(x):
    return 2-x
samples_trans = g(samples)
x_lin = np.linspace(0, 2, 1000)
plt.hist(samples_trans, bins=50, density=True)
plt.plot(x_lin, -1/2 * x_lin + 1, label="pdf(y) = -1/2*y + 1, y in [0,2]")
plt.legend()
plt.show()
```


pdf(y) = -1/2*y + 1, y in [0,2]
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00