BUILDING A TRANSFORMER BASED LANGUAGE MODEL

CUATRO

DATASETS

Shakespeare Dataset
Huggingface

1,115,394
characters

QnA Dataset
Huggingface

31,985,086
characters

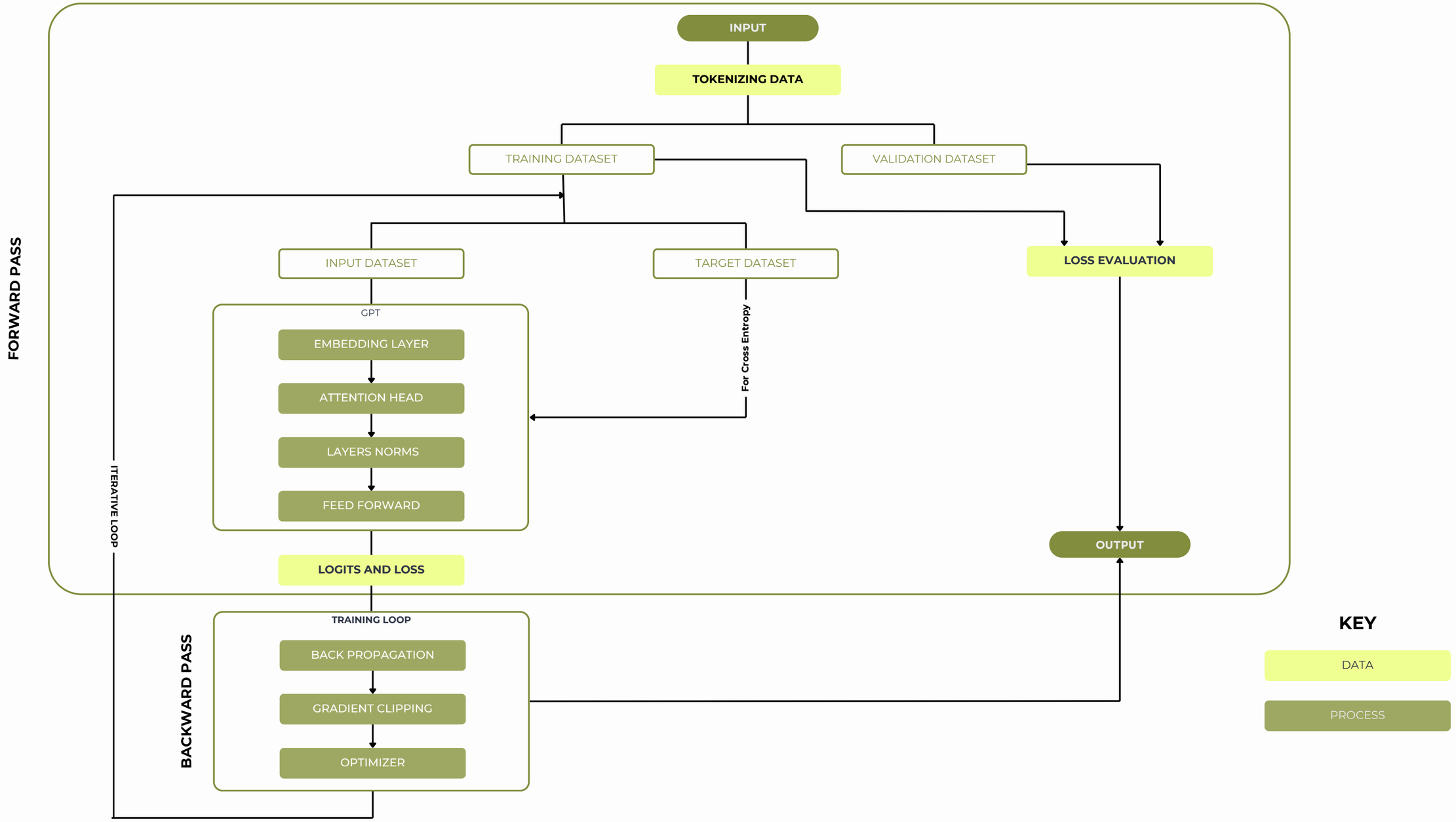
Harry Potter Dataset
Dialogues from all the movies

683,693
characters

Thamizh Dataset
Ponniyin Selvan Book

1,661,635
characters

FLOW OF THE MODEL


FORWARD PASS
INPUT
TOKENIZING DATA
TRAINING DATASET
VALIDATION DATASET
INPUT DATASET
TARGET DATASET
LOSS EVALUATION
GPT
EMBEDDING LAYER
ATTENTION HEAD
LAYERS NORMS
FEED FORWARD
For Cross Entropy
OUTPUT
LOGITS AND LOSS
ITERATIVE LOOP
TRAINING LOOP
BACKWARD PASS
BACK PROPAGATION
GRADIENT CLIPPING
OPTIMIZER
KEY
DATA
PROCESS

MILESTONES

MILESTONE 1

```
C:\Users\karthee\Desktop\CSULB\Project\LLM Project>py rough.py

Size of the dataset: 683693 Characters

Vocabulary Size: 85

Unique Characters in the dataset - Tokens

 !"#&'()*,-./0123456789:;?ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz—‘’“”

First 100 encoded characterd in the dataset

[35, 28, 45, 45, 52, 2, 43, 42, 47, 47, 32, 45, 2, 28, 41, 31, 2, 47, 35, 32, 2, 46, 42, 45, 30,
32, 45, 32, 45, 7, 46, 2, 46, 47, 42, 41, 32, 1, 1, 31, 48, 40, 29, 39, 32, 31, 42, 45, 32, 25, 1
, 36, 2, 72, 61, 68, 74, 65, 57, 2, 61, 54, 75, 58, 2, 64, 67, 68, 76, 67, 2, 78, 68, 74, 7, 57,
2, 55, 58, 2, 61, 58, 71, 58, 11, 2, 43, 71, 68, 59, 58, 72, 72, 68, 71, 2, 40, 56, 34, 68]
```

Import Libraries

Hyperparameters

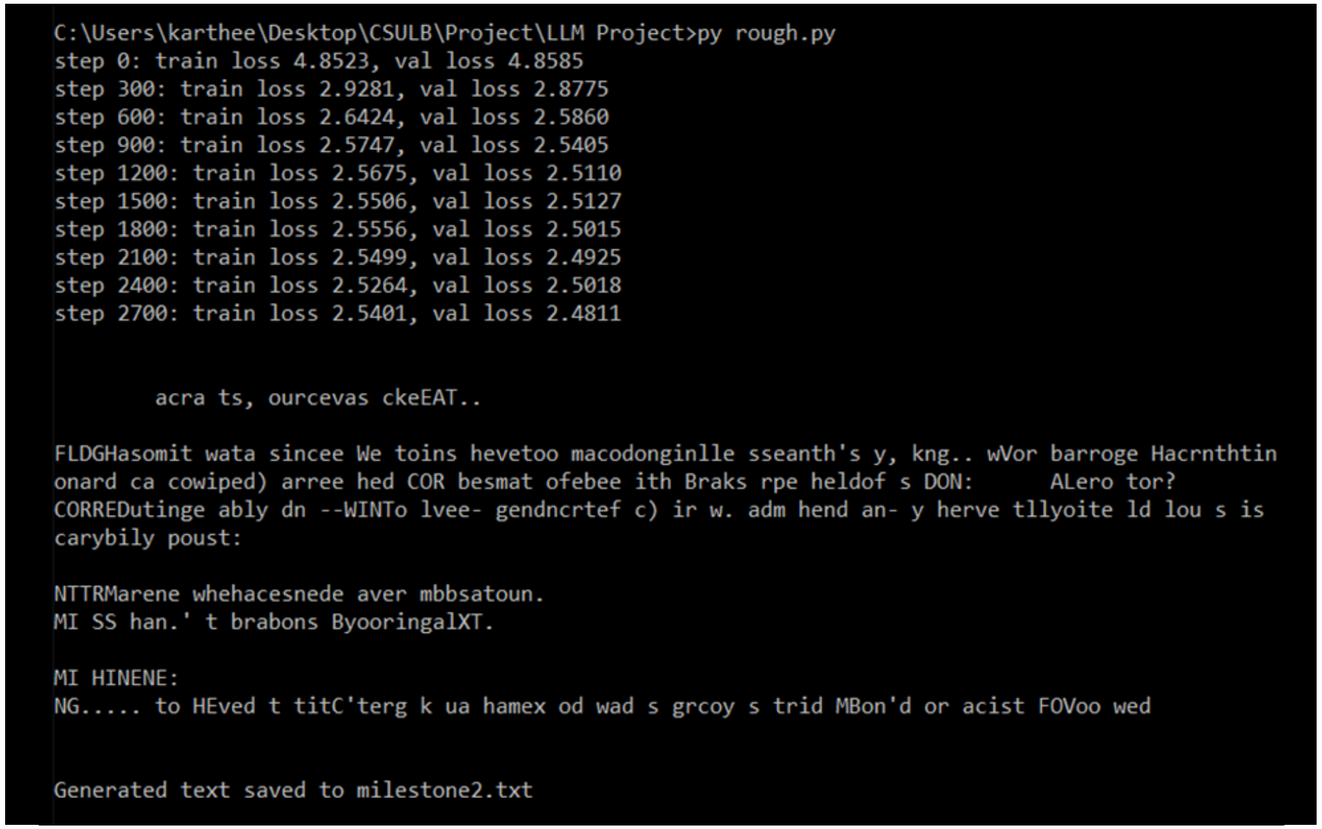
Tokenizing Text

Encoding Text

IMPACT

Characters of the Dataset are Encoded into Integers.

MILESTONE 2



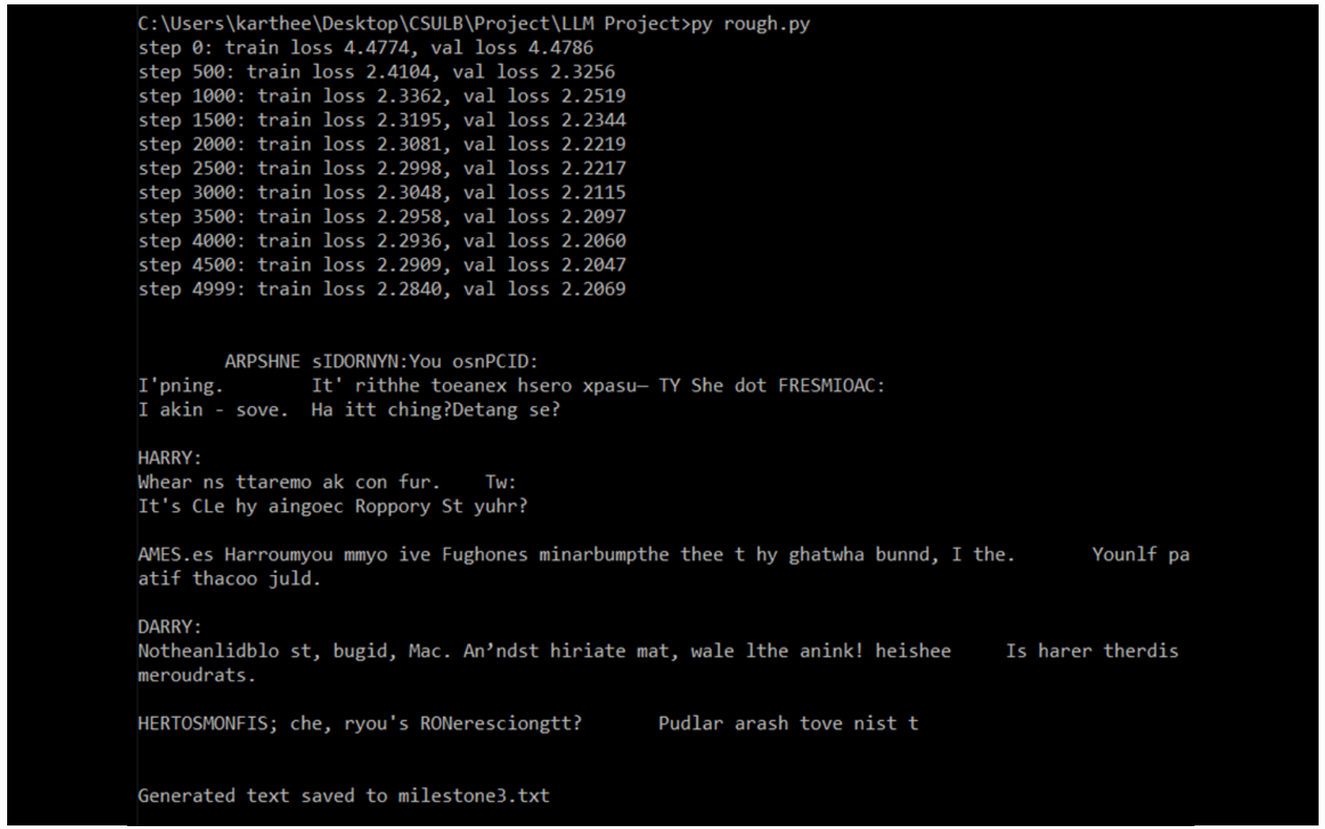
```
C:\Users\karthee\Desktop\CSULB\Project\LLM Project>py rough.py
step 0: train loss 4.8523, val loss 4.8585
step 300: train loss 2.9281, val loss 2.8775
step 600: train loss 2.6424, val loss 2.5860
step 900: train loss 2.5747, val loss 2.5405
step 1200: train loss 2.5675, val loss 2.5110
step 1500: train loss 2.5506, val loss 2.5127
step 1800: train loss 2.5556, val loss 2.5015
step 2100: train loss 2.5499, val loss 2.4925
step 2400: train loss 2.5264, val loss 2.5018
step 2700: train loss 2.5401, val loss 2.4811


       acra ts, ourcevas ckeEAT..

FLDGHasomit wata sincee We toins hevetoo macodonginlle sseanth's y, kng.. wVor barroge Hacrnthtin
onard ca cowiped) arree hed COR besmat ofebee ith Braks rpe heldof s DON:      ALero tor?
CORREDutinge ably dn --WINTo lvee- gendncrtef c) ir w. adm hend an- y herve tllyoite ld lou s is
carybily poust:

NTTRMarene whehacesnede aver mbbsatoun.
MI SS han.' t brabons ByooringalXT.

MI HINENE:
NG..... to HEved t titC'terg k ua hamex od wad s grcoy s trid MBon'd or acist FOVoo wed


Generated text saved to milestone2.txt
```

IMPACT

Model performs text prediction with the construction of a Basic Bigram Language class.

- Import Libraries
- Hyperparameters
- Tokenizing Text
- Data Loading
- Bigram model
- Loss Estimation
- Training Loop
- Generate Text

MILESTONE 3



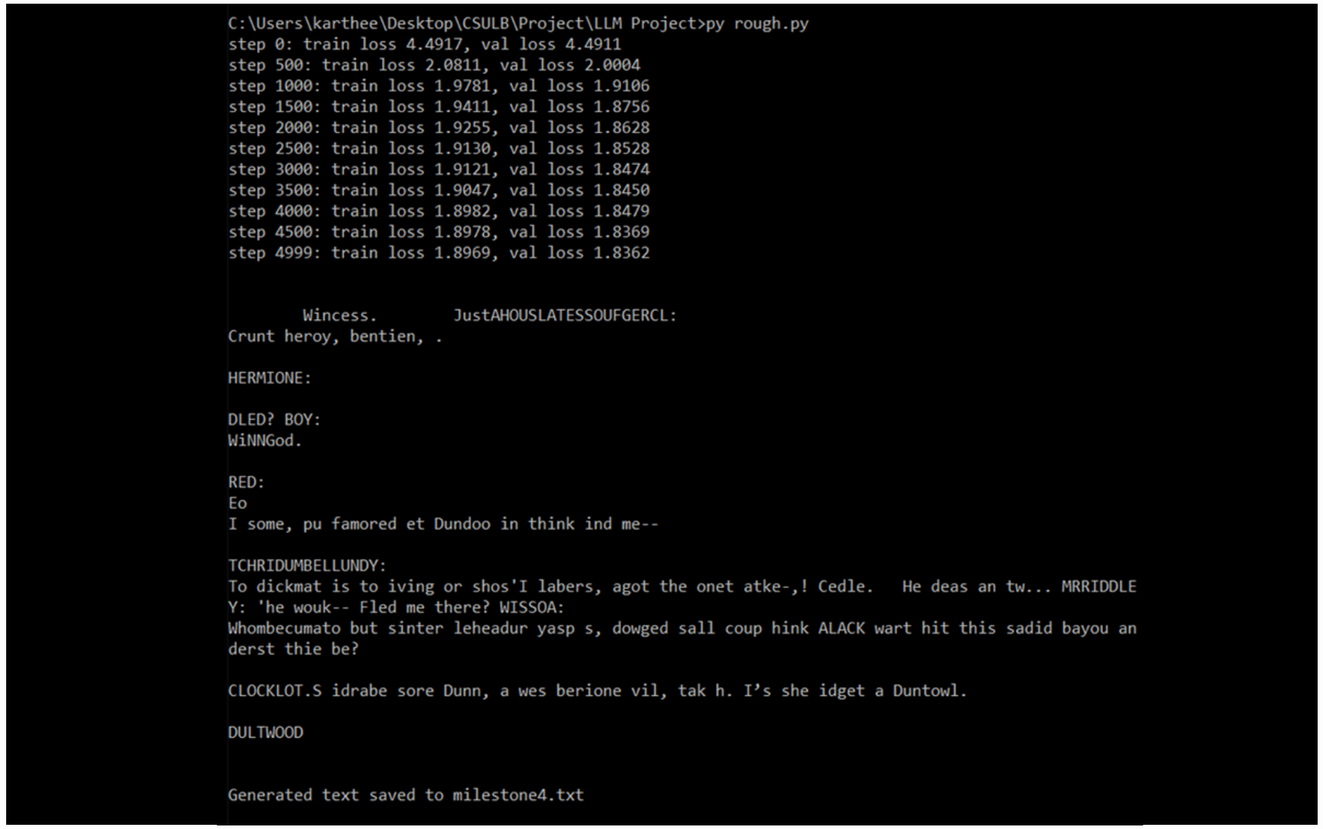
```
C:\Users\karthee\Desktop\CSULB\Project\LLM Project>py rough.py
step 0: train loss 4.4774, val loss 4.4786
step 500: train loss 2.4104, val loss 2.3256
step 1000: train loss 2.3362, val loss 2.2519
step 1500: train loss 2.3195, val loss 2.2344
step 2000: train loss 2.3081, val loss 2.2219
step 2500: train loss 2.2998, val loss 2.2217
step 3000: train loss 2.3048, val loss 2.2115
step 3500: train loss 2.2958, val loss 2.2097
step 4000: train loss 2.2936, val loss 2.2060
step 4500: train loss 2.2909, val loss 2.2047
step 4999: train loss 2.2840, val loss 2.2069


       ARPSHNE sIDORNYN:You osnPCID:
I'pning.        It' rithhe toeanex hsero xpasu— TY She dot FRESMIOAC:
I akin - sove.  Ha itt ching?Detang se?

HARRY:
Whear ns ttaremo ak con fur.    Tw:
It's CLe hy aingoec Roppory St yuhr?

AMES.es Harroumyou mmyo ive Fughones minarbumpthe thee t hy ghatwha bunnd, I the.       Younlf pa
atif thacoo juld.

DARRY:
Notheanlidblo st, bugid, Mac. An’ndst hiriate mat, wale lthe anink! heishee     Is harer therdis
meroudrats.

HERTOSMONFIS; che, ryou's RONerescionggtt?       Pudlar arash tove nist t


Generated text saved to milestone3.txt
```

IMPACT

Text prediction significantly improves because history of preceding tokens is considered in the model.

- Import Libraries
- Hyperparameters
- Tokenizing Text
- Data Loading
- Self Attention
- GPT model
- Loss Estimation
- Training Loop
- Generate Text

MILESTONE 4

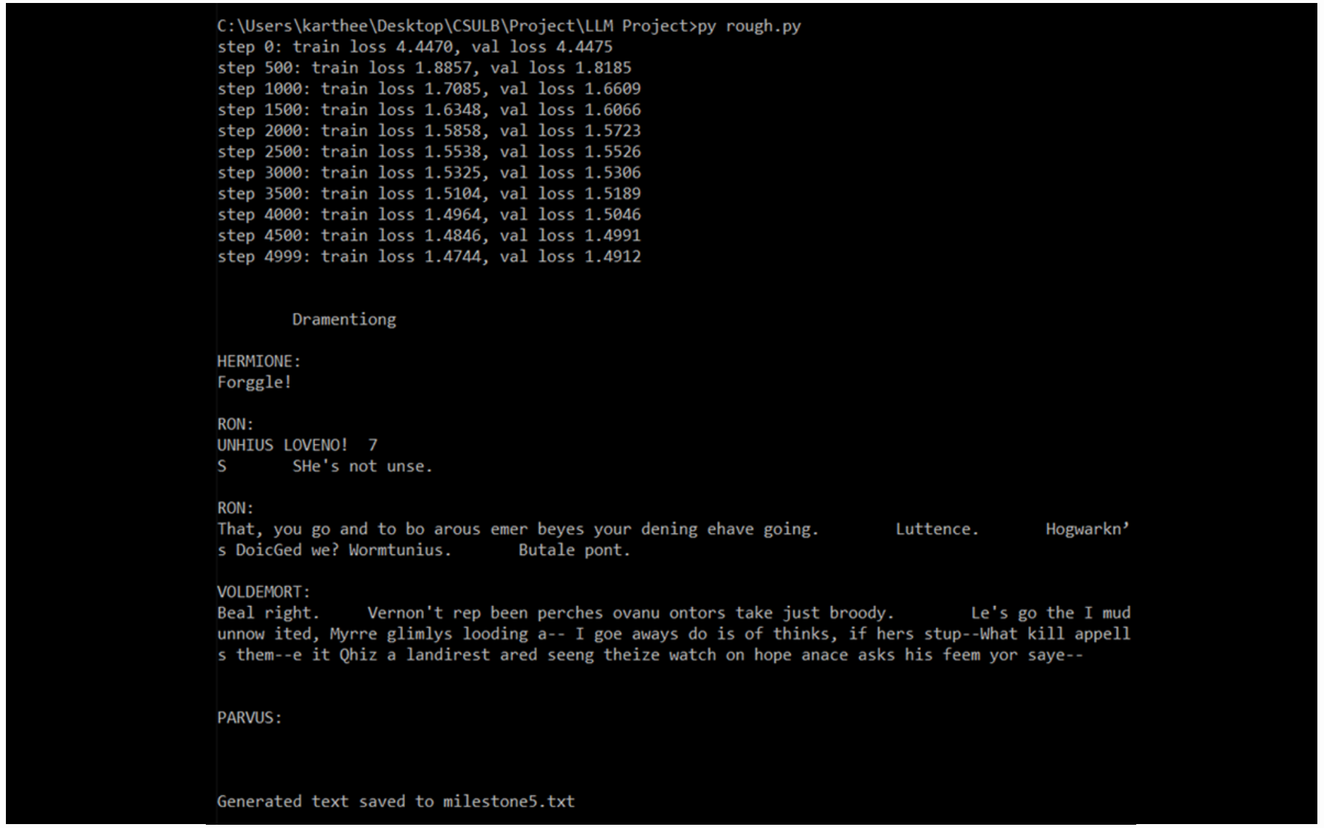


IMPACT

Much more data is gathered by the model given multiple communication channels.

- Import Libraries
- Hyperparameters
- Tokenizing Text
- Data Loading
- Self Attention
- Multi-Head Attention
- GPT model
- Loss Estimation
- Training Loop
- Generate Text

MILESTONE 5



IMPACT

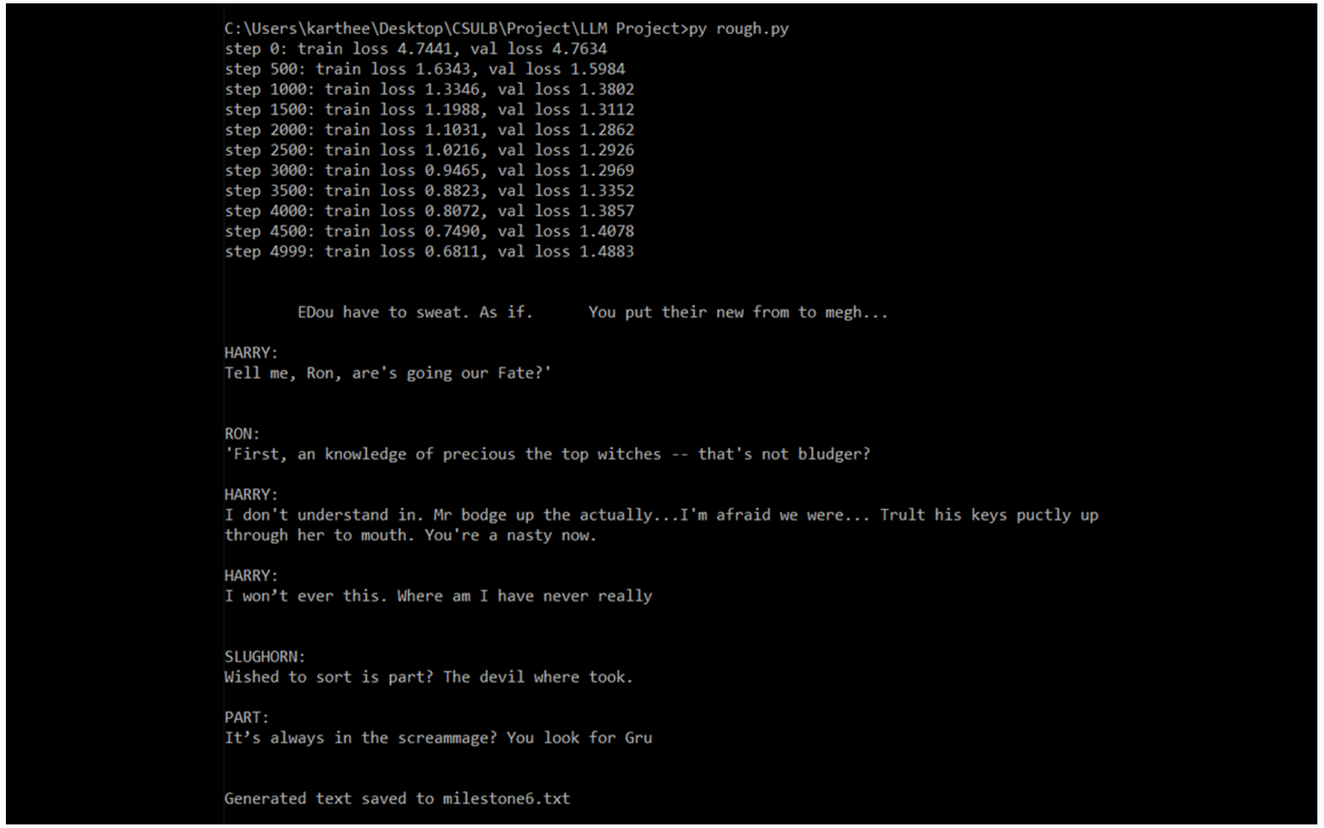
Regularize the model

Expand the model's capacity

Refine the output of the self-attention mechanism

- Import Libraries
- Hyperparameters
- Tokenizing Text
- Data Loading
- Self Attention
- Multi-Head Attention
- **Feed Forward Layer**
- GPT model
- Loss Estimation
- Training Loop
- Generate Text

MILESTONE 6



```
C:\Users\karthee\Desktop\CSULB\Project\LLM Project>py rough.py
step 0: train loss 4.7441, val loss 4.7634
step 500: train loss 1.6343, val loss 1.5984
step 1000: train loss 1.3346, val loss 1.3802
step 1500: train loss 1.1988, val loss 1.3112
step 2000: train loss 1.1031, val loss 1.2862
step 2500: train loss 1.0216, val loss 1.2926
step 3000: train loss 0.9465, val loss 1.2969
step 3500: train loss 0.8823, val loss 1.3352
step 4000: train loss 0.8072, val loss 1.3857
step 4500: train loss 0.7490, val loss 1.4078
step 4999: train loss 0.6811, val loss 1.4883


       EDou have to sweat. As if.      You put their new from to megh...

HARRY:
Tell me, Ron, are's going our Fate?'


RON:
'First, an knowledge of precious the top witches -- that's not bludger?

HARRY:
I don't understand in. Mr bodge up the actually...I'm afraid we were... Trult his keys puctly up
through her to mouth. You're a nasty now.

HARRY:
I won’t ever this. Where am I have never really


SLUGHORN:
Wished to sort is part? The devil where took.

PART:
It’s always in the screammage? You look for Gru


Generated text saved to milestone6.txt
```

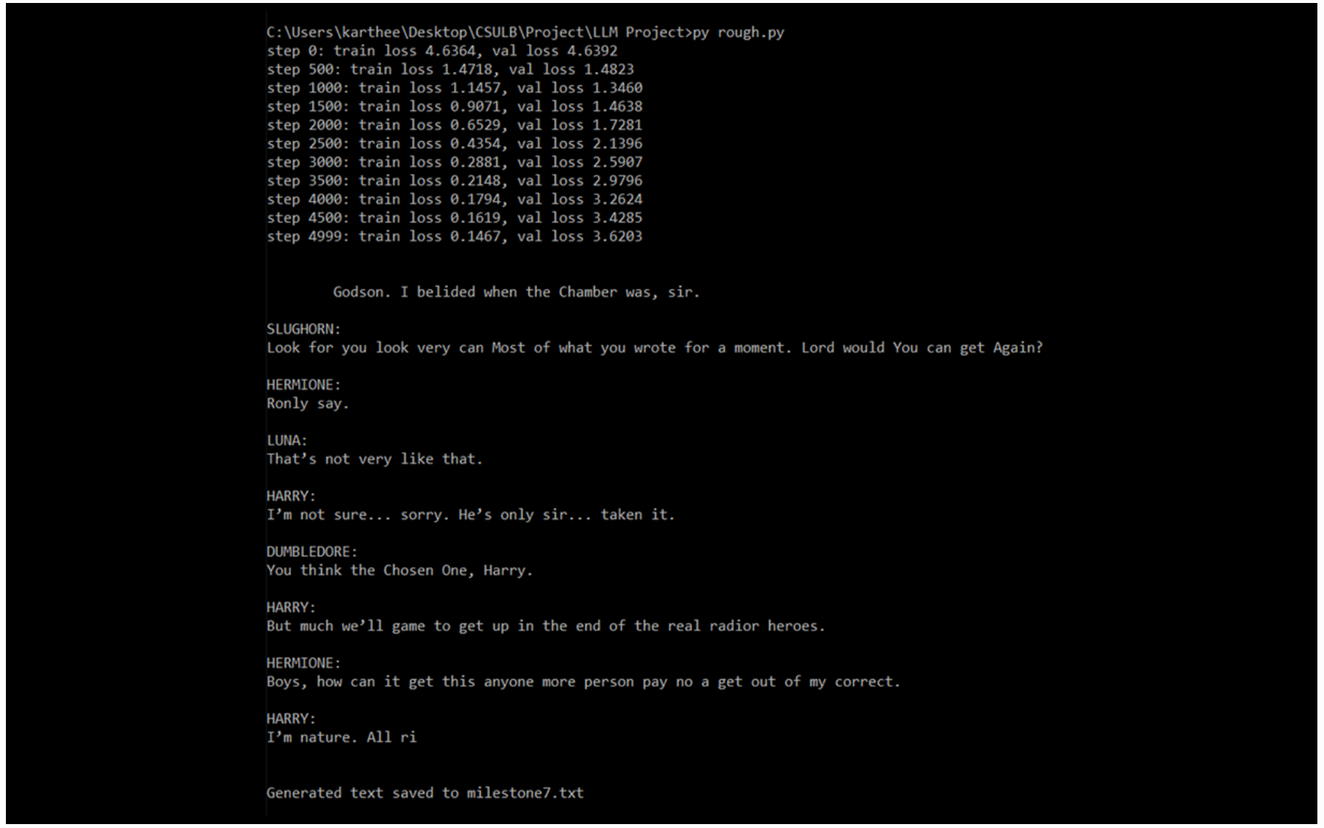
IMPACT

Information Preservation

Increase in Depth of the Model

- Import Libraries
- Hyperparameters
- Tokenizing Text
- Data Loading
- Self Attention
- Multi-Head Attention
- Feed Forward Layer
- **Transformer**
- GPT model
- Loss Estimation
- Training Loop
- Generate Text

MILESTONE 7



IMPACT

Consistent Scale and Distribution

Helps Converge Faster

Prevents Exploding or Vanishing Gradients during Backpropagation

- Import Libraries
- Hyperparameters
- Tokenizing Text
- Data Loading
- Self Attention
- Multi-Head Attention
- Feed Forward Layer
- Transformer — Layer Normalisation
- GPT model
- Loss Estimation
- Training Loop
- Generate Text

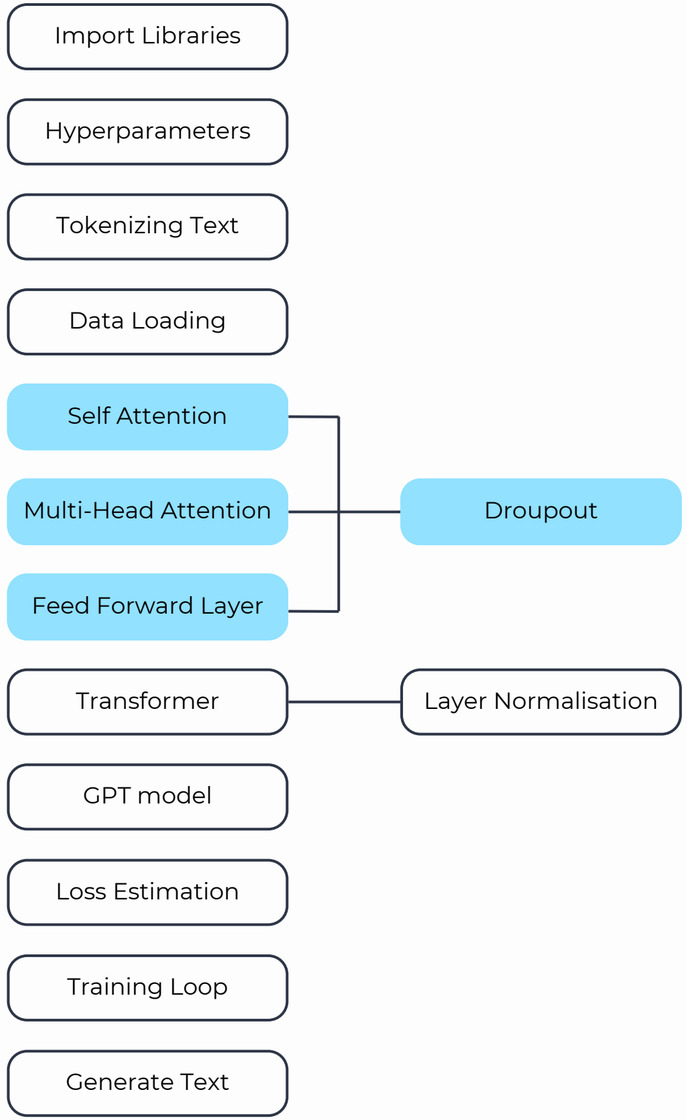
MILESTONE 8

```
C:\Users\karthee\Desktop\CSULB\Project\LLM Project>py git.py
10.806616 M parameters
step 0: train loss 4.5894, val loss 4.5995
step 500: train loss 1.6831, val loss 1.6396
step 1000: train loss 1.3012, val loss 1.3513
step 1500: train loss 1.1353, val loss 1.2849
step 2000: train loss 1.0077, val loss 1.2663
step 2500: train loss 0.8915, val loss 1.2731
step 3000: train loss 0.7814, val loss 1.3068
step 3500: train loss 0.6818, val loss 1.3512
step 4000: train loss 0.5791, val loss 1.4039
step 4500: train loss 0.4926, val loss 1.4701
step 4999: train loss 0.4148, val loss 1.5329
       long in Marry Molfoy.

HARRY:
That's Black!

RON:
Master! Tha boy's parents horrible.     It's the school best obbsent cheerfore!

HARRY:
Sirius! (MORE)

KREACHER:
Helw I behave a drulst with them! Trace at eaches the club and the trio glass.  They look back sky.... MR. WEASLEY
WEASLEY (eeing toward his wand)  Catterwarding... (the PHOTOGRAPH ONELA SALD lies sweeping from down the bunks with
 twet ha rowing DOOT, and then appeals he goes all with a TROLL OF THEMPING esciply.

HARRY:
They glow sort out
```

IMPACT

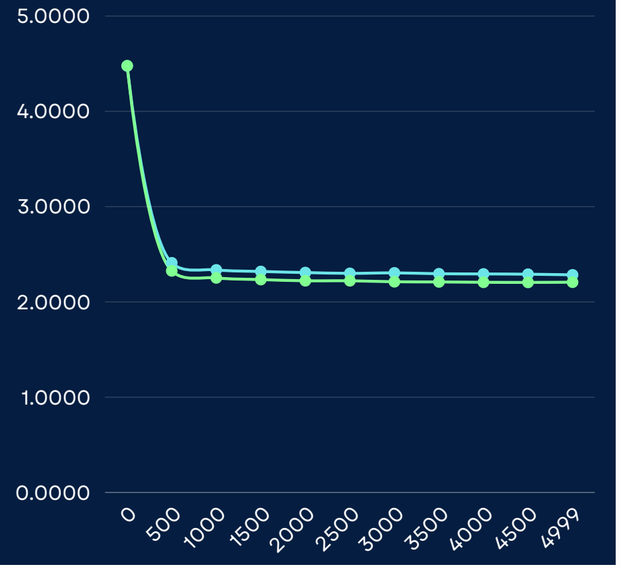
Helps in Reducing Overfitting

Improves Generalization

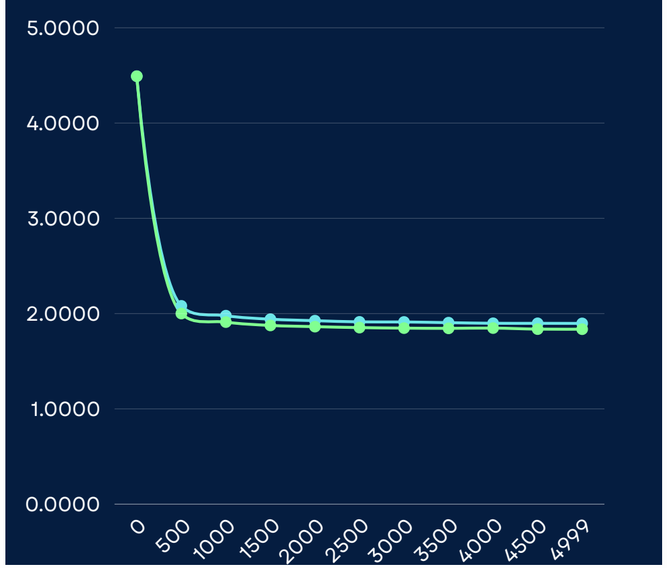


ANALYSIS OF MILESTONES

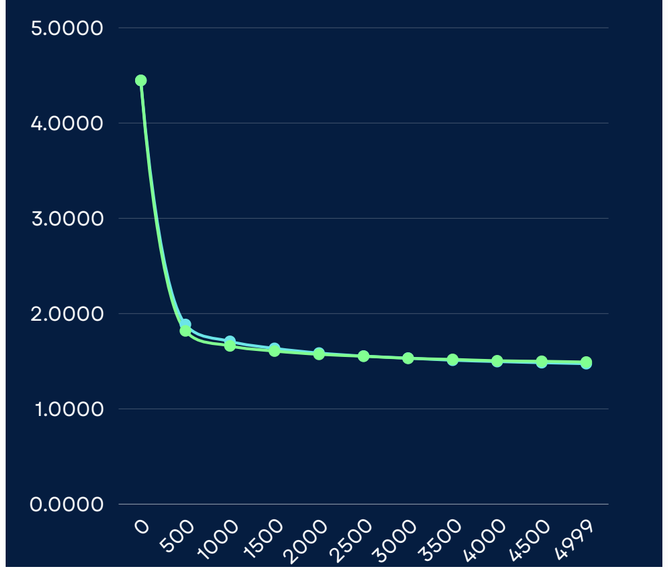
Milestone 3



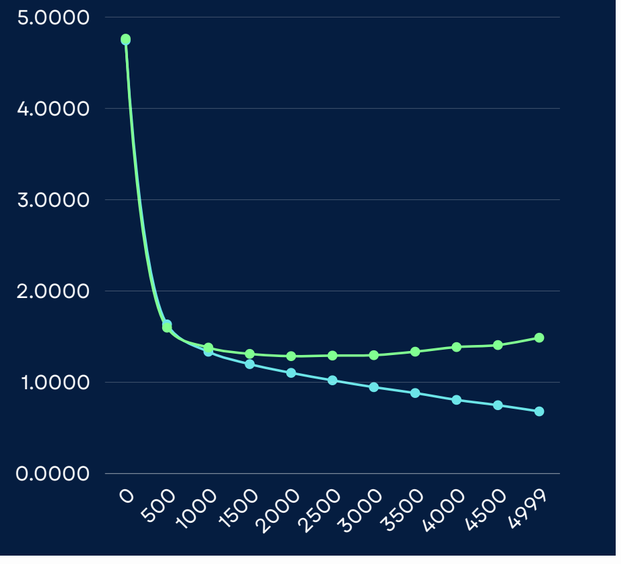
Milestone 4



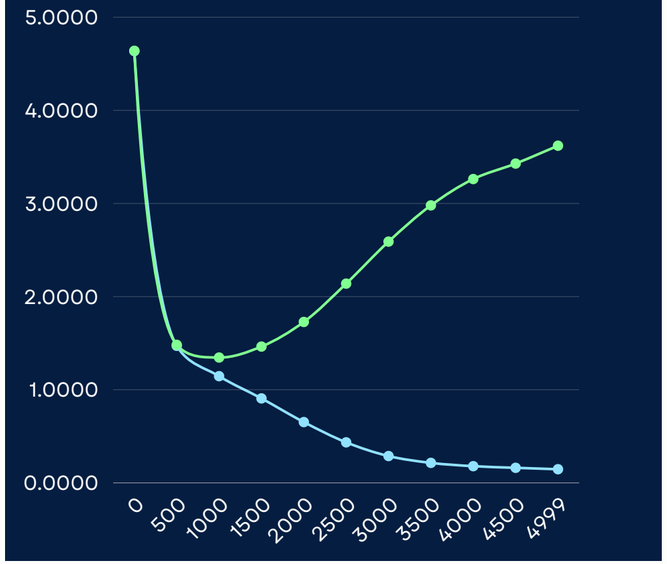
Milestone 5



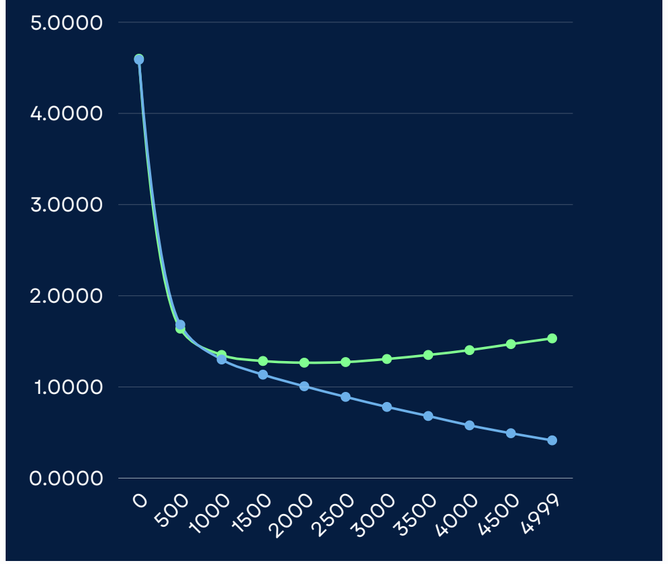
Milestone 6



Milestone 7

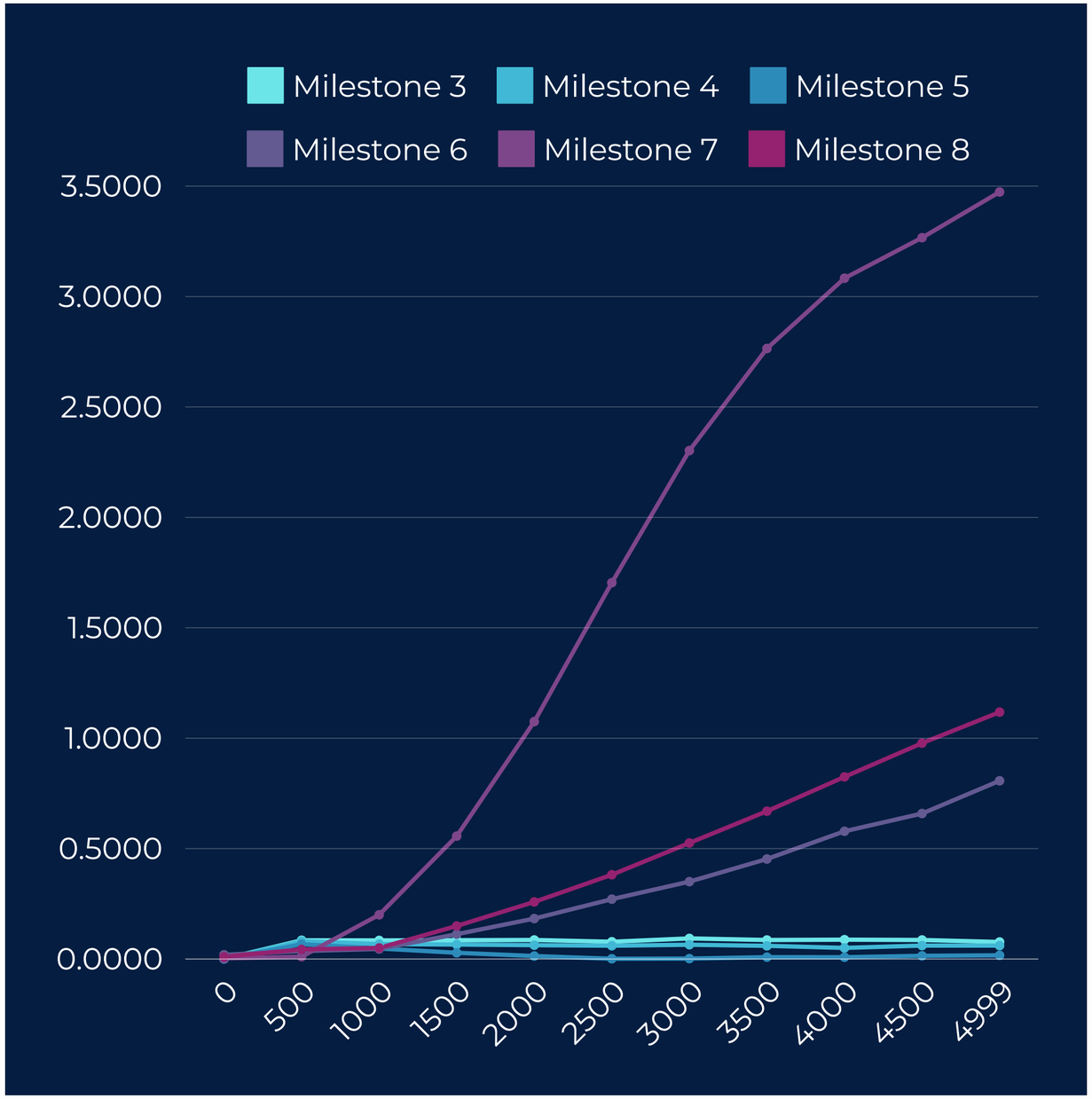


Milestone 8



Validation Loss

Training Loss



Difference between Training and Validation loss

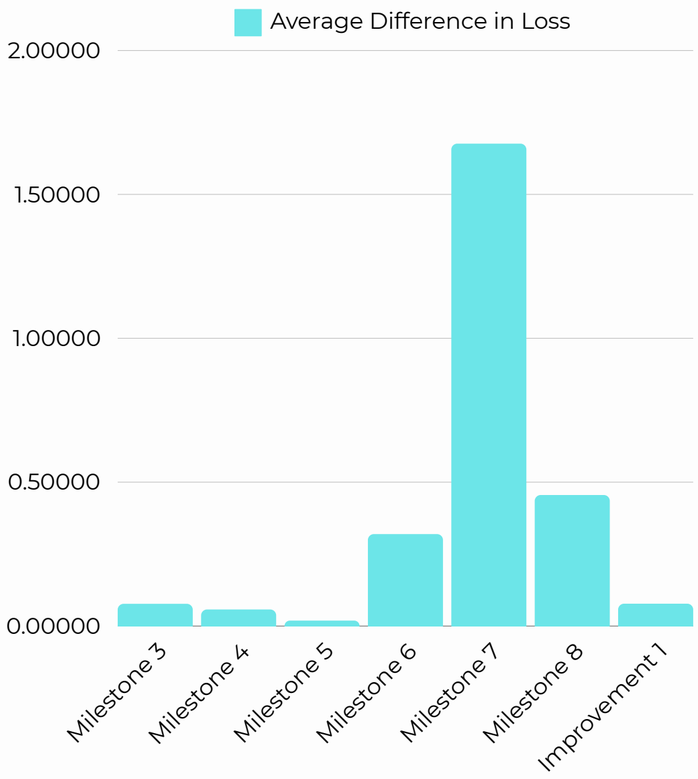
Key Issues:

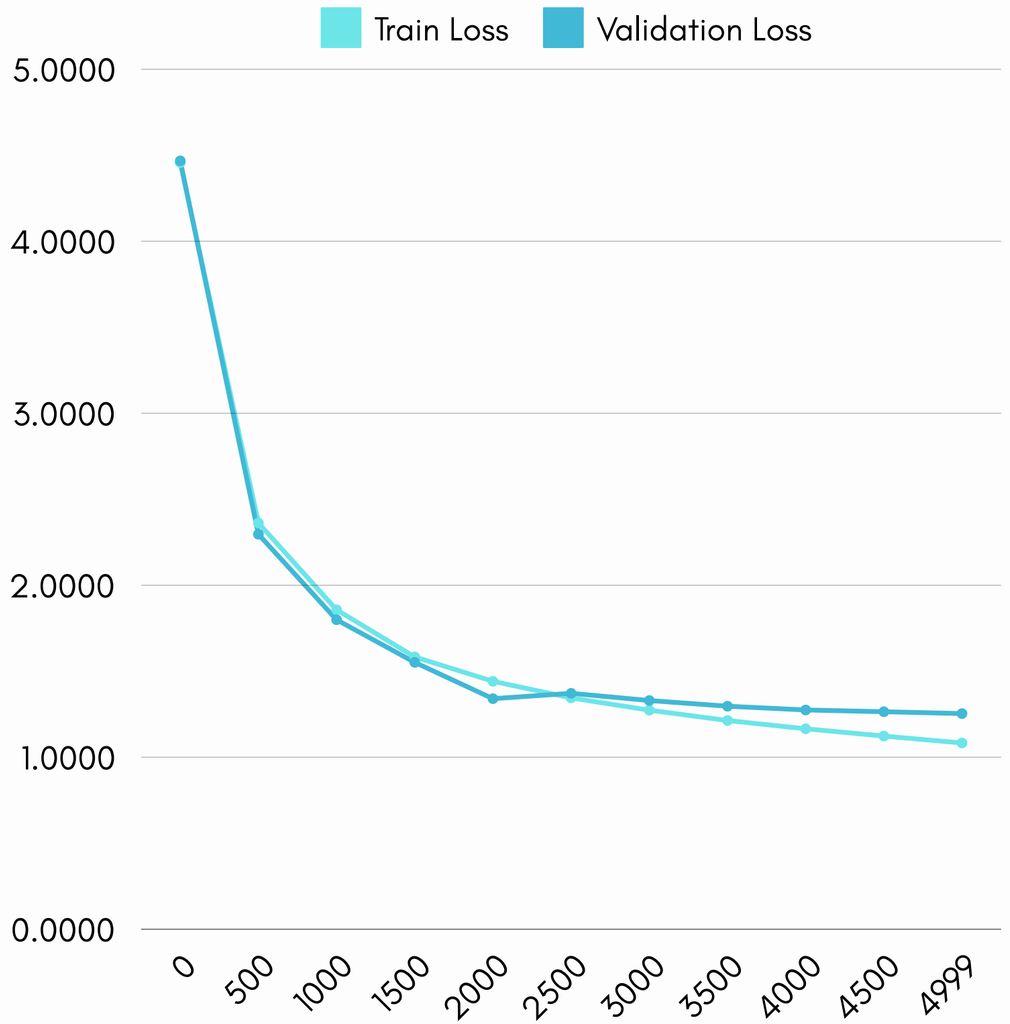
- Overfitting becomes severe after Milestone 5.
- Training loss continues to decrease while validation loss increases.
- Each added complexity (residuals, layer norm, dropout) doesn't solve the overfitting.
- Model is memorizing training data rather than learning generalizable patterns.

IMPROVEMENTS

IMPROVEMENT 1

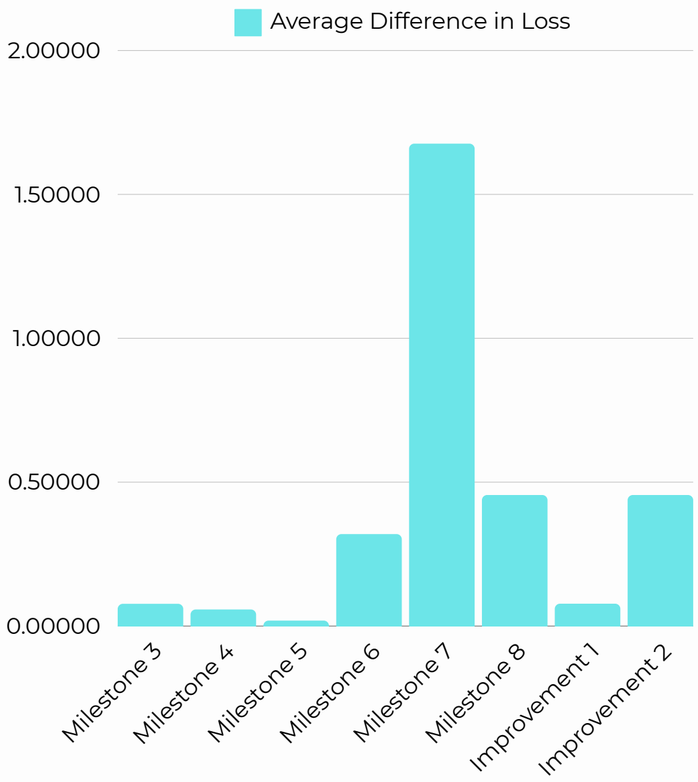
- Decreased Learning Rate to 1e-4
- Increased Dropout to 0.3
- Include weight decay = 1e-2 in optimizer





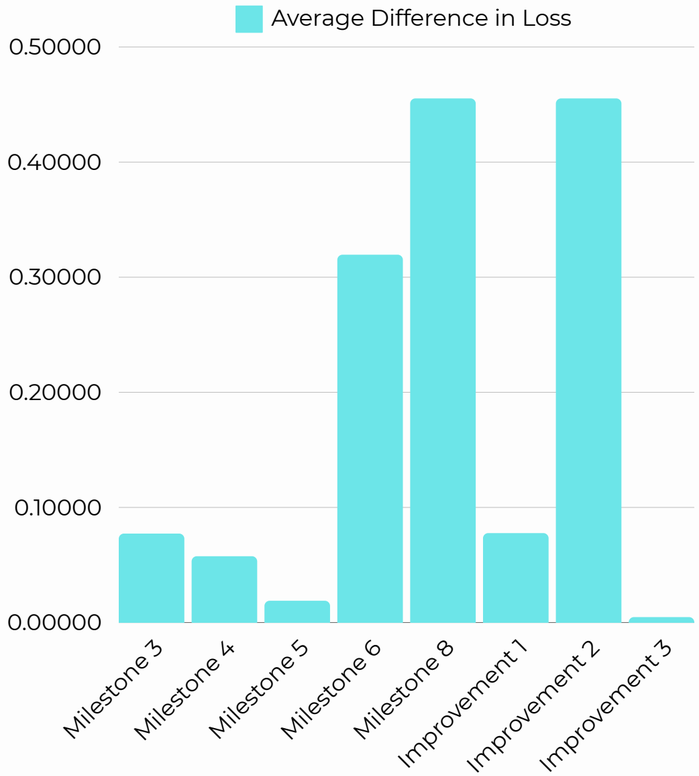
IMPROVEMENT 2

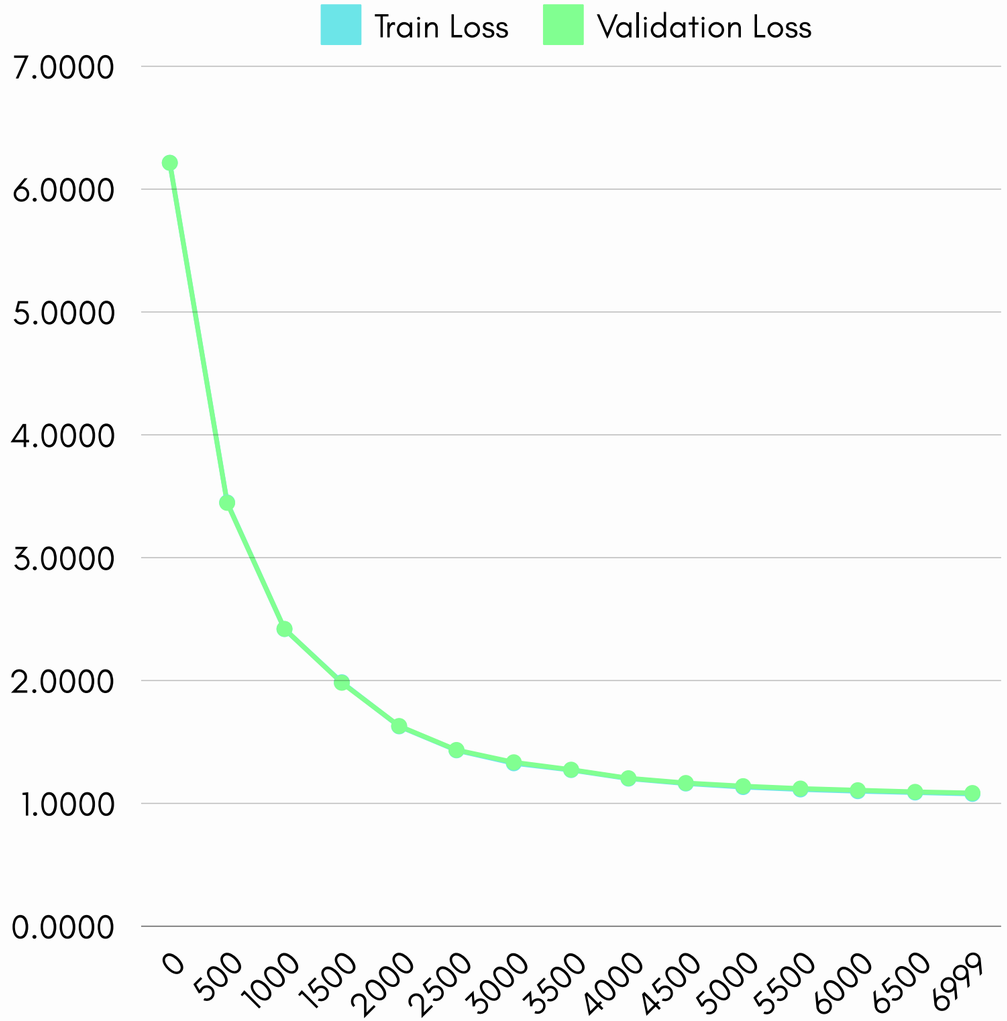
- Decrease Dropout to 0.1
- Included Learning Rate Scheduling
- Enhanced Generation Parameters
    - Temperature = 1.0



IMPROVEMENT 3

- Hyperparameter Tuning
- Added Embedding Dropout
- Enhanced LR Scheduler and _init_weights
- Enhanced Generation Parameters
    - top_k = 40





QnA Dataset

```
C:\Users\karthee\Desktop\CSULB\Project\LLM Proje
14.648921 M parameters
step 0: train loss 6.2143, val loss 6.2143
step 500: train loss 3.4495, val loss 3.4462
step 1000: train loss 2.4189, val loss 2.4204
step 1500: train loss 1.9860, val loss 1.9817
step 2000: train loss 1.6271, val loss 1.6300
step 2500: train loss 1.4319, val loss 1.4349
step 3000: train loss 1.3266, val loss 1.3348
step 3500: train loss 1.2714, val loss 1.2746
step 4000: train loss 1.2016, val loss 1.2050
step 4500: train loss 1.1617, val loss 1.1662
step 5000: train loss 1.1329, val loss 1.1406
step 5500: train loss 1.1135, val loss 1.1209
step 6000: train loss 1.0992, val loss 1.1074
step 6500: train loss 1.0884, val loss 1.0940
step 6999: train loss 1.0772, val loss 1.0847
```

Thamizh Dataset

```
14.345935 M parameters
step 0: train loss 4.4119, val loss 4.4129
step 500: train loss 2.6803, val loss 2.6791
step 1000: train loss 2.2443, val loss 2.2363
step 1500: train loss 1.6516, val loss 1.6430
step 2000: train loss 1.3750, val loss 1.3580
step 2500: train loss 1.2023, val loss 1.1968
step 3000: train loss 1.1153, val loss 1.1232
step 3500: train loss 1.0527, val loss 1.0763
step 4000: train loss 1.0008, val loss 1.0429
step 4500: train loss 0.9630, val loss 1.0238
step 5000: train loss 0.9222, val loss 1.0078
step 5500: train loss 0.8876, val loss 0.9994
step 6000: train loss 0.8552, val loss 0.9938
step 6500: train loss 0.8223, val loss 0.9925
step 7000: train loss 0.7952, val loss 0.9900
step 7500: train loss 0.7679, val loss 0.9887
step 8000: train loss 0.7431, val loss 0.9859
step 8500: train loss 0.7191, val loss 0.9874
step 9000: train loss 0.7030, val loss 0.9924
step 9500: train loss 0.6839, val loss 0.9973
step 9999: train loss 0.6715, val loss 0.9983
```

THANK YOU