Training

June 9, 2024

[1]:
```
import torch
import matplotlib.pyplot as plt
from model import GPT
from trainer import Trainer
from utils import set_seed
import json
from TransformerDataset import TransformerTrainDataset

DEBUG = True  # Set to True to enable debugging

print('starting ....')

# Configuration
config = {
    'num_samples': 10000000,
    'input_dim': 2,
    'function_class': 'linear',
    'noise_std': 0,
    'model_type': 'tiny',
    'batch_size': 5,
    'min_context_size': 1,
    'max_context_size': 10,
    'max_iters': 3,
    'learning_rate': 10e-4,
    'num_workers': 0
}

# Create the TransformerTrainDataset
transformer_train_dataset = ␣
 ↪TransformerTrainDataset(num_samples=config['num_samples'],␣
 ↪input_dim=config['input_dim'], max_context_size=config['max_context_size'],␣
 ↪function_class=config['function_class'], noise_std=config['noise_std'])

# Debug TransformerTrainDataset
if DEBUG:
    print("TransformerTrainDataset samples:")
    for i in range(3):
```

```
        inputs, targets = transformer_train_dataset[i]
        print(f"Sample {i} - Inputs: {inputs.numpy()}, Targets: {targets.
 ↪numpy()}")

# Model configuration
set_seed(42)

model_config = GPT.get_default_config()
model_config.model_type = config['model_type']
model_config.vocab_size = config['input_dim'] + 1  # Adding 1 for the target␣
 ↪dimension
model_config.block_size = (2 * config['max_context_size']) *␣
 ↪config['input_dim']  # Updated block_size based on max context size
model_config.input_dim = config['input_dim']  # Set the input dimension

# Create the model
model = GPT(model_config)
print("number of parameters: %.2fM" % (sum(p.numel() for p in model.
 ↪parameters()) / 1e6,))

# Training configuration
train_config = Trainer.get_default_config()
train_config.learning_rate = config['learning_rate']
train_config.max_iters = config['max_iters']
train_config.num_workers = config['num_workers']
train_config.batch_size = config['batch_size']

# Create the trainer
trainer = Trainer(train_config, model, transformer_train_dataset)
print("running on device", trainer.device)

# Initialize weights for tracking
initial_scalar_head_weight = model.scalar_head.weight.clone().detach()
initial_wte_weight = model.transformer.wte.weight.clone().detach()

# Lists to store weights and losses
trainer.scalar_head_weights = []
trainer.wte_weights = []
trainer.train_losses = []

# Define a callback for batch end to print training status and debug weights
def batch_end_callback(trainer):
    current_scalar_head_weight = model.scalar_head.weight.clone().detach()
    current_wte_weight = model.transformer.wte.weight.clone().detach()

    scalar_head_weight_changed = not torch.equal(initial_scalar_head_weight,␣
 ↪current_scalar_head_weight)
```

```
    wte_weight_changed = not torch.equal(initial_wte_weight, current_wte_weight)

    # Store weights for plotting
    trainer.scalar_head_weights.append(current_scalar_head_weight.cpu().numpy())
    trainer.wte_weights.append(current_wte_weight.cpu().numpy())
    trainer.train_losses.append(trainer.loss.item())

    if trainer.iter_num % 100 == 0:
        print(f"iter_dt {trainer.iter_dt * 1000:.2f}ms; iter {trainer.iter_num}:
 ↪ train loss {trainer.loss.item():.5f}; Scalar Head Weights Changed:␣
 ↪{scalar_head_weight_changed}; WTE Weights Changed: {wte_weight_changed}")

    # Update the initial weights
    initial_scalar_head_weight.copy_(current_scalar_head_weight)
    initial_wte_weight.copy_(current_wte_weight)

trainer.set_callback('on_batch_end', batch_end_callback)

# Run the training
trainer.run()

# Save the model and configurations
torch.save(model.state_dict(), 'trained_model.pth')
with open('config.json', 'w') as f:
    json.dump(config, f)
print("Model and configurations saved.")

# Plot the stored weight values
plt.figure(figsize=(12, 6))
for i in range(min(len(trainer.scalar_head_weights[0].flatten()), 5)):  # Plot␣
 ↪up to 5 scalar head weights
    plt.plot([w.flatten()[i] for w in trainer.scalar_head_weights],␣
 ↪label=f'Scalar Head Weight {i}')
plt.xlabel('Iterations')
plt.ylabel('Weight Value')
plt.title('Scalar Head Weights Over Time')
plt.legend()
plt.grid(True)
plt.show()

plt.figure(figsize=(12, 6))
for i in range(min(len(trainer.wte_weights[0].flatten()), 5)):  # Plot up to 5␣
 ↪wte weights
    plt.plot([w.flatten()[i] for w in trainer.wte_weights], label=f'WTE Weight␣
 ↪{i}')
plt.xlabel('Iterations')
plt.ylabel('Weight Value')
```

```
plt.title('Word Token Embedding Weights Over Time')
plt.legend()
plt.grid(True)
plt.show()

# Plot the training loss
plt.figure(figsize=(12, 6))
plt.plot(trainer.train_losses, label='Training Loss')
plt.xlabel('Iterations')
plt.ylabel('Loss')
plt.title('Training Loss Over Time')
plt.legend()
plt.grid(True)
plt.show()
```

```
starting …
TransformerTrainDataset samples:
Sample 0 - Inputs: [[ 0.69150347  1.813534  ]
 [-0.7195421   0.        ]
 [-1.1353933  -0.962374  ]
 [ 0.30963057  0.        ]
 [-0.66690356 -0.10963406]
 [-0.01523633  0.        ]
 [ 0.2379293  -1.5882341 ]
 [ 0.70941     0.        ]
 [-2.3150156   1.0578417 ]
 [-0.67513275  0.        ]
 [ 0.8866422  -1.7433792 ]
 [ 0.8374779   0.        ]
 [ 0.19102618  0.8615962 ]
 [-0.35476878  0.        ]
 [-0.80496424  0.81298614]
 [-0.42732477  0.        ]
 [ 0.66849196 -0.8589745 ]
 [ 0.43439582  0.        ]
 [-1.1372952  -0.7144748 ]
 [ 0.20221318  0.        ]
 [ 1.7278594  -1.2764744 ]
 [ 0.          0.        ]], Targets: [[ 0.          0.        ]
 [-0.7195421   0.        ]
 [ 0.          0.        ]
 [ 0.30963057  0.        ]
 [ 0.          0.        ]
 [-0.01523633  0.        ]
 [ 0.          0.        ]
 [ 0.70941     0.        ]
 [ 0.          0.        ]
```

```
 [-0.67513275  0.        ]
 [ 0.          0.        ]
 [ 0.8374779   0.        ]
 [ 0.          0.        ]
 [-0.35476878  0.        ]
 [ 0.          0.        ]
 [-0.42732477  0.        ]
 [ 0.          0.        ]
 [ 0.43439582  0.        ]
 [ 0.          0.        ]
 [ 0.20221318  0.        ]
 [ 0.          0.        ]
 [ 0.7145412   0.        ]]
Sample 1 - Inputs: [[ 2.1503491   0.04427584]
 [-2.7804537   0.        ]
 [-0.93444043  1.5775617 ]
 [ 1.0031055   0.        ]
 [ 1.5423133   0.02527745]
 [-1.9934163   0.        ]
 [-2.1957283   0.77417475]
 [ 2.73386     0.        ]
 [ 0.6674108  -0.37484822]
 [-0.8130544   0.        ]
 [ 0.19406931  0.12413976]
 [-0.2663718   0.        ]
 [ 0.4368768  -0.2980698 ]
 [-0.52544224  0.        ]
 [-1.052432   -0.5234039 ]
 [ 1.4252802   0.        ]
 [-0.15939331  1.6418892 ]
 [-0.00526345  0.        ]
 [ 0.7602862   1.3299204 ]
 [-1.1519185   0.        ]
 [-0.16865624  1.5033717 ]
 [ 0.          0.        ]], Targets: [[ 0.          0.        ]
 [-2.7804537   0.        ]
 [ 0.          0.        ]
 [ 1.0031055   0.        ]
 [ 0.          0.        ]
 [-1.9934163   0.        ]
 [ 0.          0.        ]
 [ 2.73386     0.        ]
 [ 0.          0.        ]
 [-0.8130544   0.        ]
 [ 0.          0.        ]
 [-0.2663718   0.        ]
 [ 0.          0.        ]
 [-0.52544224  0.        ]
```

```
 [ 0.          0.        ]
 [ 1.4252802   0.        ]
 [ 0.          0.        ]
 [-0.00526345  0.        ]
 [ 0.          0.        ]
 [-1.1519185   0.        ]
 [ 0.          0.        ]
 [ 0.02448523  0.        ]]
Sample 2 - Inputs: [[ 1.416772   -0.72487885]
 [ 0.4922129   0.        ]
 [-0.60053647 -0.00378863]
 [ 0.00606271  0.        ]
 [ 1.3371232   0.9741978 ]
 [-0.68011475  0.        ]
 [ 1.3592391  -0.62902737]
 [ 0.42638183  0.        ]
 [ 0.8015495  -1.3281966 ]
 [ 0.91218394  0.        ]
 [ 1.1125722  -0.83857816]
 [ 0.57244     0.        ]
 [ 1.4427917  -1.4251064 ]
 [ 0.9753944   0.        ]
 [ 0.23305182 -1.4527811 ]
 [ 1.0014418   0.        ]
 [-0.04643335  0.2470446 ]
 [-0.17025556  0.        ]
 [ 0.29267567  0.35035464]
 [-0.24351193  0.        ]
 [ 0.7920302  -0.84428716]
 [ 0.          0.        ]], Targets: [[ 0.          0.        ]
 [ 0.4922129   0.        ]
 [ 0.          0.        ]
 [ 0.00606271  0.        ]
 [ 0.          0.        ]
 [-0.68011475  0.        ]
 [ 0.          0.        ]
 [ 0.42638183  0.        ]
 [ 0.          0.        ]
 [ 0.91218394  0.        ]
 [ 0.          0.        ]
 [ 0.57244     0.        ]
 [ 0.          0.        ]
 [ 0.9753944   0.        ]
 [ 0.          0.        ]
 [ 1.0014418   0.        ]
 [ 0.          0.        ]
 [-0.17025556  0.        ]
 [ 0.          0.        ]
```

```
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 [ 0.          0.        ]
 [ 0.57822084  0.        ]]
number of parameters: 0.15M
number of parameters: 0.15M
running on device cuda
running on device cuda
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 [-1.3578,  0.0000]],

[[ 0.0000,  0.0000],
 [ 0.5563,  0.0000],
```

```
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          [ 0.0000,  0.0000],
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          [ 0.0000,  0.0000],
          [-1.3342,  0.0000],
          [ 0.0000,  0.0000],
          [ 0.4284,  0.0000]]], device='cuda:0')
target_predictions: tensor([ 0.0325, -0.0074, -0.0177, -0.0123, -0.0352,
0.0111,  0.0350, -0.0230,
        -0.0097,  0.0213, -0.0129,  0.0248, -0.0289,  0.0443,  0.0108,  0.0244,
         0.0176, -0.0239, -0.0377, -0.0393, -0.0468, -0.0886,  0.0234,  0.0262,
        -0.0243,  0.0222, -0.0248, -0.0254,  0.0210, -0.0382,  0.0085, -0.0237,
```

```
        -0.0031,  0.0281, -0.0147,  0.0134, -0.0218,  0.0272, -0.0174, -0.0145,
        -0.0279, -0.0262,  0.0251, -0.0347, -0.0074, -0.0145, -0.0081, -0.0107,
        -0.0359, -0.0237, -0.0031,  0.0156,  0.0264, -0.0232,  0.0267],
       device='cuda:0', grad_fn=<IndexBackward0>)
non_zero_targets: tensor([ 0.1111, -0.3346, -0.3082, -0.2648, -0.7790,  0.2816,
0.7592, -0.6324,
        -0.6237, -0.0617,  0.1395,  2.1150, -0.8658,  0.0588,  0.7832,  2.2201,
         0.9542, -1.3122, -0.2007, -0.0044, -0.7087, -1.1496,  2.3935,  0.4309,
        -3.0238,  2.4021, -1.0639, -0.6960,  1.5249, -0.7215,  0.5085, -2.2617,
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        -0.8671, -1.4494,  0.8071,  1.0726,  2.6664, -1.3342,  0.4284],
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iter_dt 0.00ms; iter 0: train loss 1.67970; Scalar Head Weights Changed: True;
WTE Weights Changed: True
inputs: tensor([[[ 1.4535, -0.2647],
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          [-0.6421,  0.0000],
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```

```
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        -0.2067, -0.1889,  0.1954, -0.2103, -0.1950, -0.1398, -0.1937, -0.1558,
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        -0.1426, -0.2025, -0.1973, -0.2062, -0.2033, -0.2078,  0.1853, -0.2030,
        -0.0471, -0.2044, -0.1938, -0.1383,  0.1208,  0.1989, -0.1919,  0.1973,
        -0.0305, -0.1846, -0.1891, -0.1771,  0.1602,  0.1623, -0.1422],
       device='cuda:0', grad_fn=<IndexBackward0>)
non_zero_targets: tensor([ 1.1989,  0.5064,  0.3962,  0.3905, -1.2589,  0.1609,
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         0.1676, -0.6396, -0.3221, -0.3804, -0.4462, -0.4183,  0.5731, -0.4650,
         0.0554, -0.2467, -0.1671,  0.6323,  0.2145,  0.4079, -0.6421,  0.5642,
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       device='cuda:0')
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target_predictions: tensor([ 0.2420, -0.0308, -0.2532,  0.2613, -0.1273,
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         0.2617, -0.2628,  0.2553,  0.2594,  0.2511,  0.2707,  0.2564, -0.2257,
         0.2488, -0.1802,  0.2582, -0.2405,  0.0656,  0.2322,  0.2713,  0.2740,
        -0.2575, -0.2574,  0.2696, -0.2558,  0.2685, -0.2683, -0.2602, -0.2723,
         0.2355,  0.2641, -0.2701,  0.1876, -0.2398,  0.2656,  0.2752,  0.2604,
        -0.2697,  0.2639,  0.2711,  0.2570, -0.2620, -0.2713, -0.2723, -0.2707,
        -0.2362,  0.2287,  0.2157, -0.2514, -0.2627, -0.2707,  0.2441],
       device='cuda:0', grad_fn=<IndexBackward0>)
non_zero_targets: tensor([ 0.0307, -0.3390, -1.1201,  0.3161, -0.3774,  0.1480,
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         0.5417, -1.4902, -1.4360,  0.6070,  0.0330,  0.6785,  0.2050, -0.3587,
         0.0168, -0.2712,  0.1939, -0.6934, -0.2058,  0.4204,  1.1924,  1.1266,
        -0.9060, -4.6752,  3.2260, -5.8341,  0.7341, -2.4734, -0.8943, -2.2928,
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       device='cuda:0')
Model and configurations saved.
```

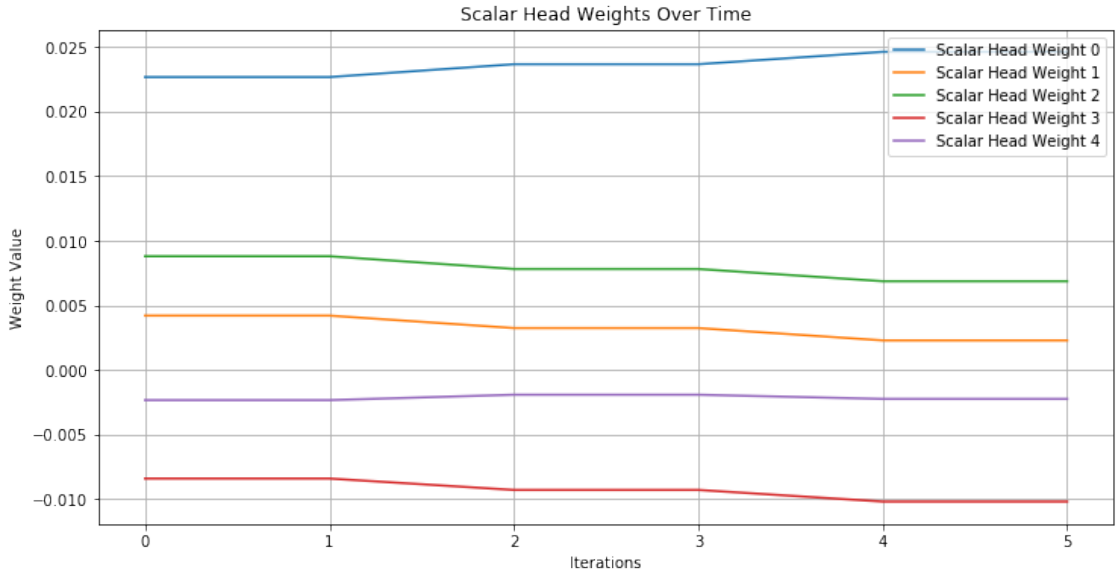

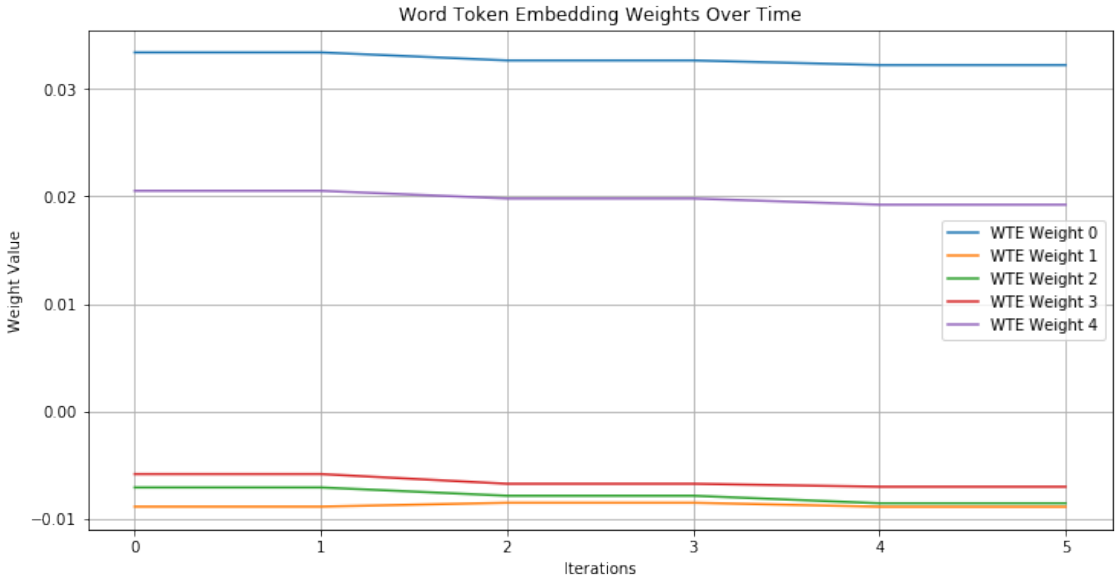
Word Token Embedding Weights Over Time
Weight Value
Iterations
WTE Weight 0
WTE Weight 1
WTE Weight 2
WTE Weight 3
WTE Weight 4
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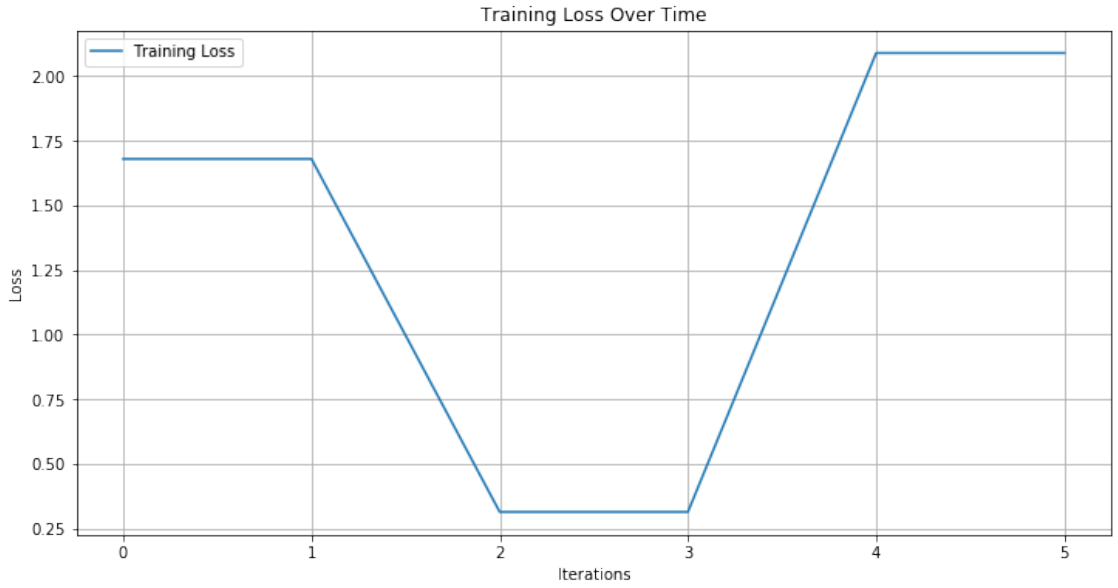
0.02
0.01
0.00
−0.01
0
1
2
3
4
5


Training Loss Over Time
Training Loss
Loss
Iterations
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1.50
1.25
1.00
0.75
0.50
0.25
0
1
2
3
4
5

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