Tutorial. Nov 18, 2024 1:30-5 pm

Distributed Deep Learning on GPU-based Clusters

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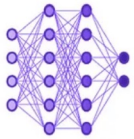
How are neural networks used?

A trained language model can

Input



LLM

Word	Probability
speak	0.065
generate	**0.072**
politics	0.001
...	...
walk	0.003

Word	Probability
ability	0.002
text	0.084
coherent	**0.085**
...	...
ideas	0.041

Inference mode

Text Generation

Classification

Q & A

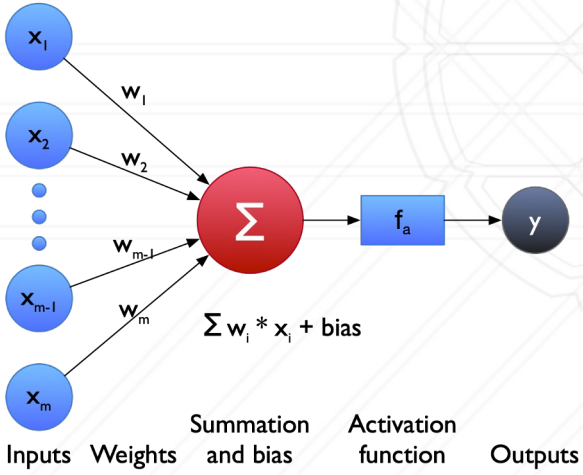
Summarization

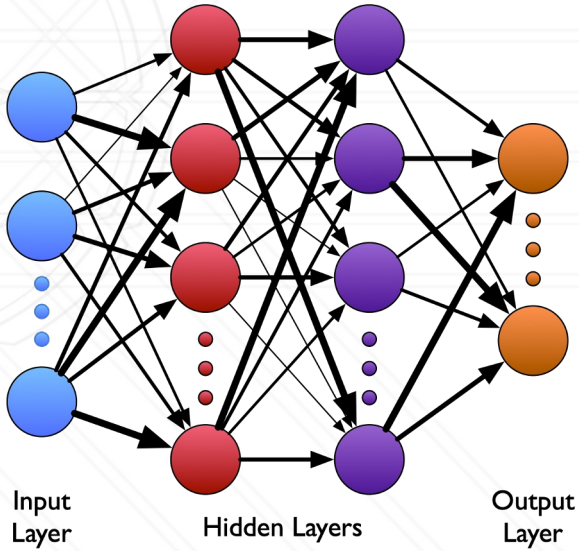
Translation

What are neural networks?

Neural networks are “parametrized” function approximators that can be used to model complex functions

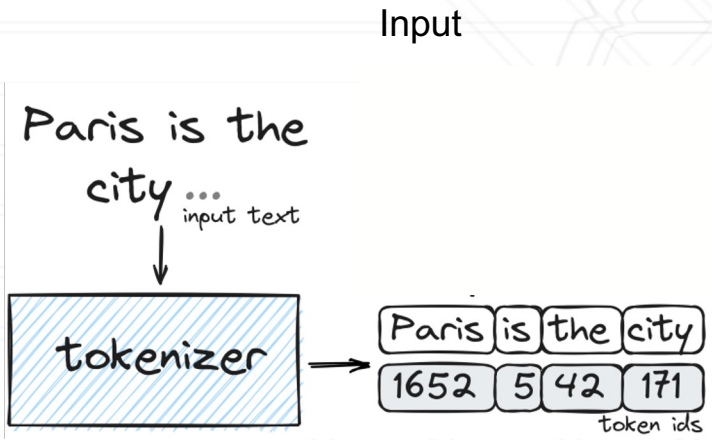
Several layers that process input data

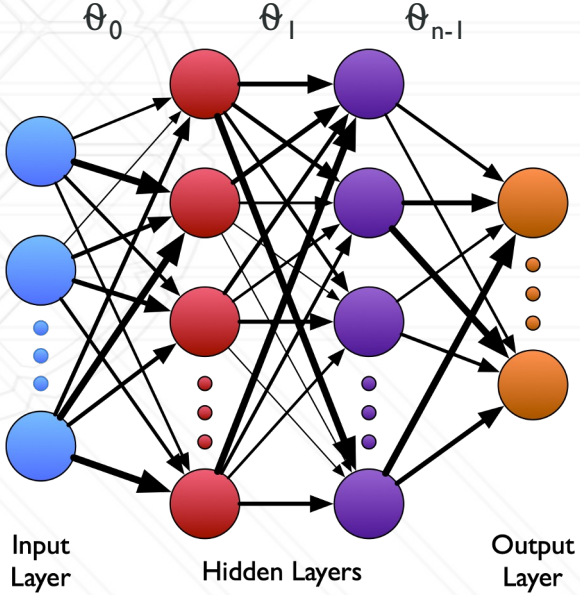




How is a neural network trained?

Problem: Find a set of weights/parameters that best fits the function we are trying to learn over a given training dataset





Other terms and definitions

- **Loss:** a scalar proxy that when minimized leads to higher accuracy
- **Learning/training:** task of selecting weights that lead to an accurate function / minimizes the loss
- **Gradient descent:** process of updating the weights using gradients (derivatives) of the loss weighted by a learning rate
- **Batch:** Small subsets of the dataset processed independently
- **Epoch:** One pass over all the batches

- **Fine-tuning:** updating weights for a specific task
- **Inference:** using a trained or fine-tuned model to generate output

Stochastic Gradient Descent

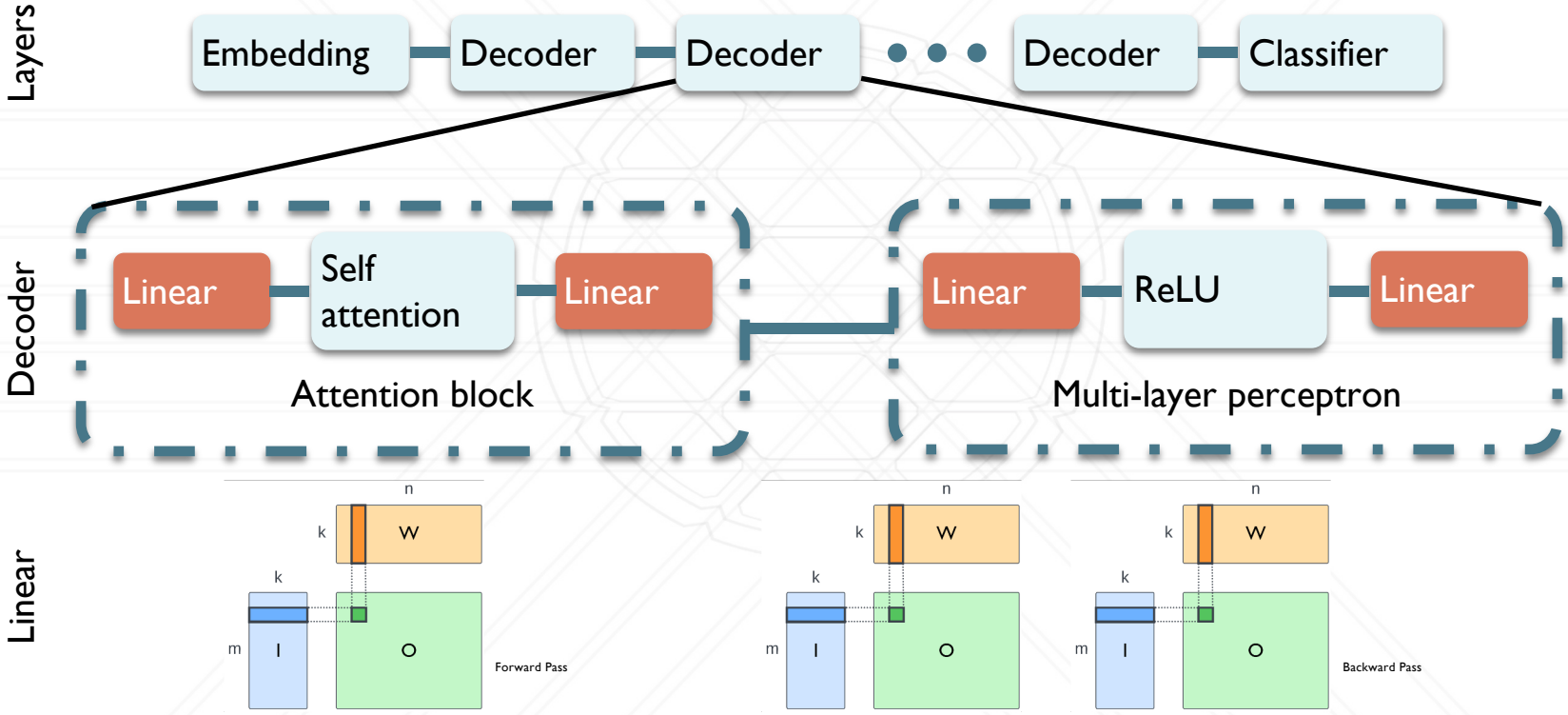
```
while (remaining_batches) {
    Read a single batch

    Forward pass: perform matrix multiplies to compute
        output activations, and a loss on the batch

    Backward pass: matrix multiplies to compute gradients of
        the loss w.r.t. parameters via backpropagation

    Optimizer step: use gradients to update the weights or
        parameters such that loss is gradually reduced
}
```

Why is LLM training well-suited for HPC?



Get the tutorial repository

- Clone the git repository as follows:

```
ssh <username>@login.zaratan.umd.edu
git clone https://github.com/axonn-ai/distrib-dl-tutorial.git
```

PyTorch

- torch – a Python library for tensor computations with GPU support
- torch.nn – implementations of various neural network layers

PyTorch Lightning

- High-level API as an alternative to using PyTorch directly
  - Automatic Mixed Precision
  - Vendor Agnostic - CPU, GPU, TPU
  - **Seamlessly switch between parallel frameworks**

- We will start with looking at single GPU training using PyTorch Lightning

Fine-tuning LLMs

- Fine-tuning is a popular approach to tune pre-trained LLMs for specific tasks
- Instruction fine-tuning (IFT): Train on datasets of [instruction, output] pairs.
- Example use case: build a chatbot by tuning an LLM to follow instructions.

Samples from an IFT dataset

instruction string · *lengths* 9⇔58 51.7%	output string · *lengths* 0⇔419 74.5%
Give three tips for staying healthy.	1.Eat a balanced diet and make sure to include plenty of fruits and vegetables. 2. Exercise regularly to keep your body active and strong. 3. Get enough sleep and maintain a consistent sleep schedule.
What are the three primary colors?	The three primary colors are red, blue, and yellow.

These are from the **alpaca** dataset, which we will be using in the tutorial

Using PyTorch Lightning

- Code location in the tutorial repo: train.py

```
sbatch --ntasks-per-node=1
train.sh
```

Parameter	Value
model_id	microsoft/phi-1_5
dataset_id	alpaca
strategy	single-gpu
global_batch_size	32

Mixed-precision Training

- GPUs have FP32, FP64 and tensor cores
- We can optimize performance by doing some operations in lower precision (16-bit)

Mixed-precision Training

- Code location in the tutorial repo: train.py

```
CONFIG_FILE=configs/single_gpu.json sbatch --ntasks-per-
node=1  train.sh
```

How to download a different model?

cd external; python download.py <model-name>

To get a list of available models in LitGPT -

python download.py list

Where does a model file come from?

- Write your own
- Get a pre-implemented model from somewhere (huggingface, LitGPT, …)

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