CS 744: MARIUS

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ADMINISTRIVIA

- Midterm grades today!
- Course Project: Check in by Nov 30th
EXAMPLE: LINK PREDICTION

Task: Predict potential connections in a social network

Find K-nearest neighbors

[0.25, 0.45, 0.30]

[0.15, 0.85, 0.92]

...
Score function

Capture structure of the graph given source, destination embedding

Loss function

Maximize score for edges in graph
Minimize for others (negative edges)

\[ \mathcal{L} = \sum_{e \in G} \sum_{e' \in S_e} \max(f(e) - f(e') + \lambda, 0) \]
TRAINING ALGORITHM

SGD/AdaGrad optimizer

Sample positive, negative edges

Access source, dest embeddings for each edge in batch

for i in range(num_batches):
    B = getBatchEdges(i)
    E = getEmbeddingParams(B)
    G = computeGrad(E, B)
    updateEmbeddingParams(G)
CHALLENGE: LARGE GRAPHS

Large graphs $\rightarrow$ Large model sizes

Example

3 Billion vertices, $d = 400$
Model size = 3 billion * 400 * 4 = 4.8 TB!

Need to scale beyond GPU memory, CPU memory!
CHALLENGE: DATA MOVEMENT

(a) Sample edges, embeddings from CPU memory (DGL-KE)

(b) Partition embeddings so that one partition fits on GPU memory. Load sequentially (Pytorch-BigGraph)

Data movement overheads → low GPU util
MARIUS

I/O efficient system for learning graph embeddings

Marius Design
- Pipelined training
- Partition ordering
PIPELINED TRAINING
### OUT OF MEMORY TRAINING

**Key idea:** Maintain a *cache* of partitions in CPU memory

**Questions**
- Order of partition traversal?
- How to perform eviction?

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**Partitions in Buffer**

\[ c = 3 \]

**Partitions on disk**

\[ \Theta_0, \Theta_1, \Theta_2, \Theta_3, \Theta_4, \Theta_5 \]

\[ p = 6 \]
Initialize cache with \( c \) partitions

Swap in partition that leads to highest number of unseen pairs

Achieved by fixing \( c-1 \) partitions and swap remaining in any order
Graph Embeddings: Learn embeddings from graph data for ML

Marius: Efficient single-machine training
  Pipelining to use CPU, GPU
  Partition buffer, BETA ordering
DISCUSSION

https://forms.gle/LtoT8nEmw3oLvXuo9
If you were going to repeat the COST analysis for knowledge graph embedding training, what would you expect to find and why?
How does the partitioning scheme used in this paper differ from partitioning schemes used in PowerGraph and why?
NEXT STEPS

Next class: New module!
Project check-ins by Nov 30th