



KENNESAW STATE
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A Sparsity Predicting Approach for Large Language Models via Activation Pattern Clustering

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Presented by
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Introduction

Large Language Models

- Billions of parameters
- Huge computation and memory usage
- Operate on large data center

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Edge AI

- Known for better latency
- Better privacy
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Activation Sparsity

- A subset of neurons is active
- Less neurons means less computation and memory usage

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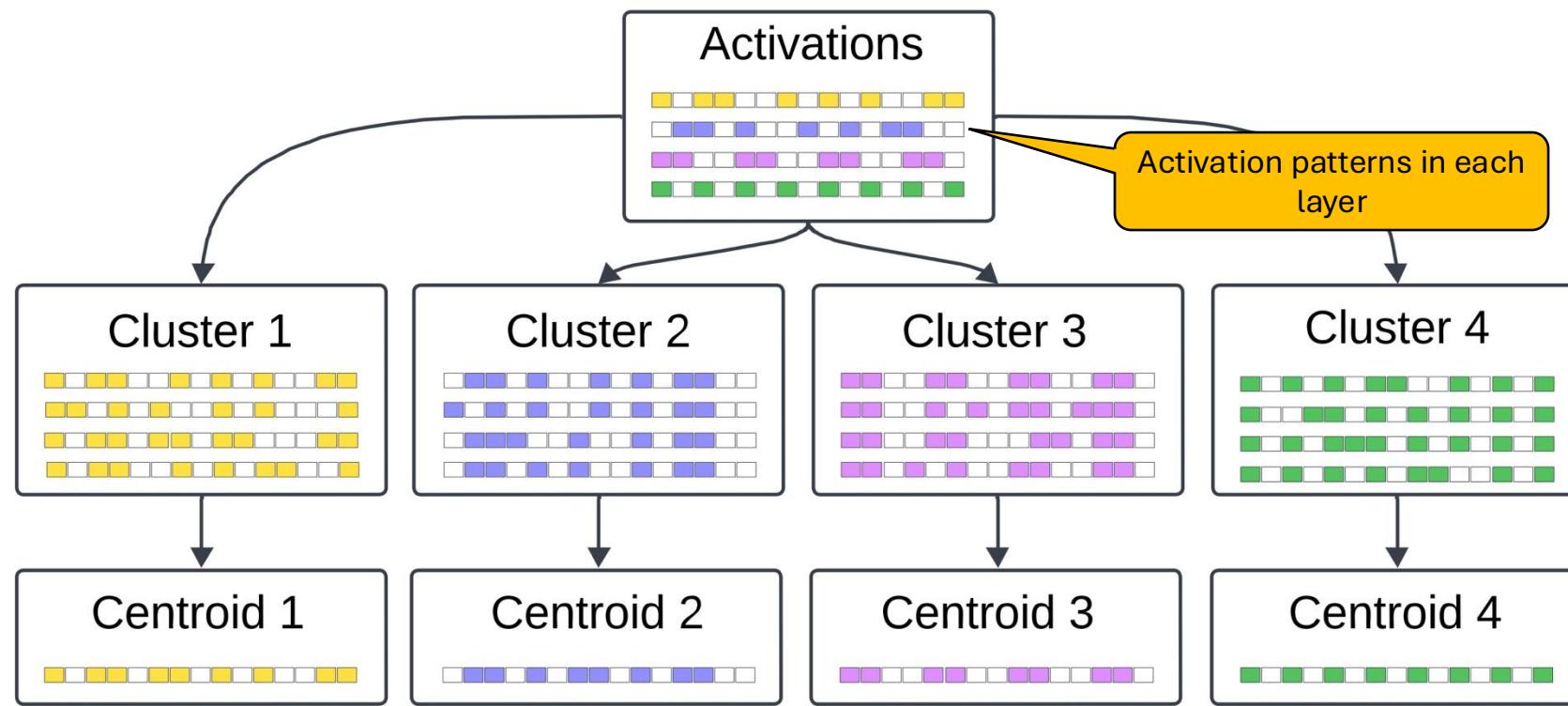
Activation Sparsity

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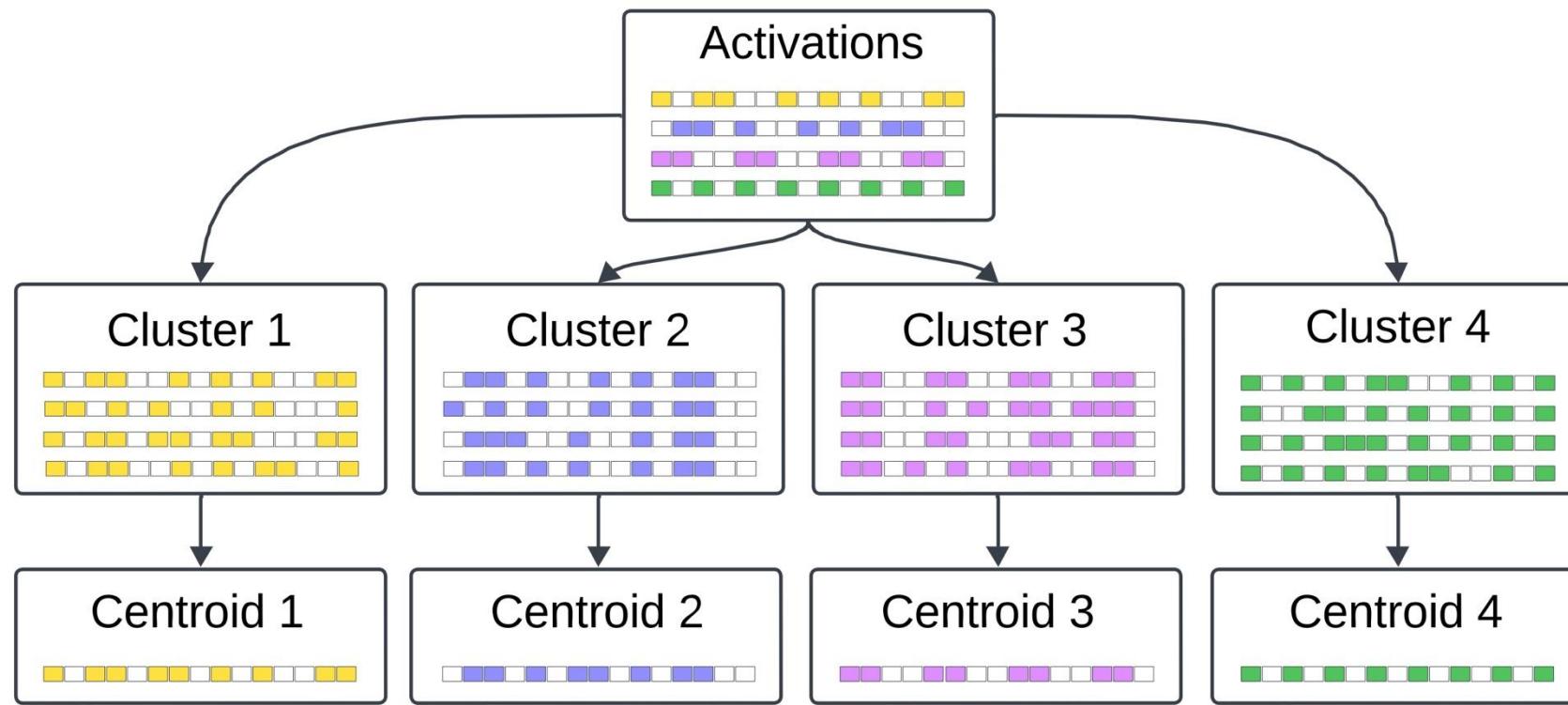
Challenges

- Different set of neurons is active for different tokens
- Need of sparsity prediction
- Neuron-level prediction is costly

Motivation



Motivation



Motivation

$$C_{direct} = N \times L \times T \times C$$

$$N_{FFN} \approx (2/3) \times 7 \times 10^9 = 4.67 \times 10^9$$

$$K = 2048 \times 3 = 6144$$

$$C_{clustered} = K \times L \times T \times C$$

$$\frac{C_{direct}}{C_{clustered}} = \frac{N_{FFN}}{K} = \frac{4.67 \times 10^9}{6144} \approx 7.6 \times 10^5$$

Efficiency Gain: $\sim 760,000 \times$

- N: Total neurons
- L: Layers
- T: Tokens per sequence
- C: Per-neuron compute cost
- K: Number of clusters

Related Works

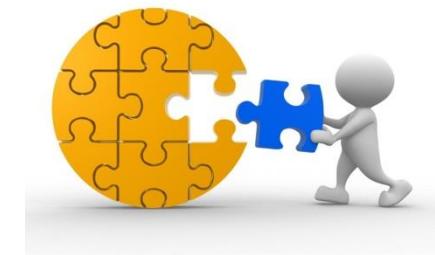
- Quantization
 - Reduce the model size, hence memory consumption
 - Doesn't provide noticeable benefit in terms of computation
 - Compromise model accuracy
- Pruning
 - Reduces both model size and computation
 - Compromise accuracy significantly
- Distillation
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 - Model loses flexibility across diverse input

Related Works

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Exploiting activation sparsity can provide both computation and memory benefits without losing model accuracy, if done efficiently.

Our work aims is to fill this gap.



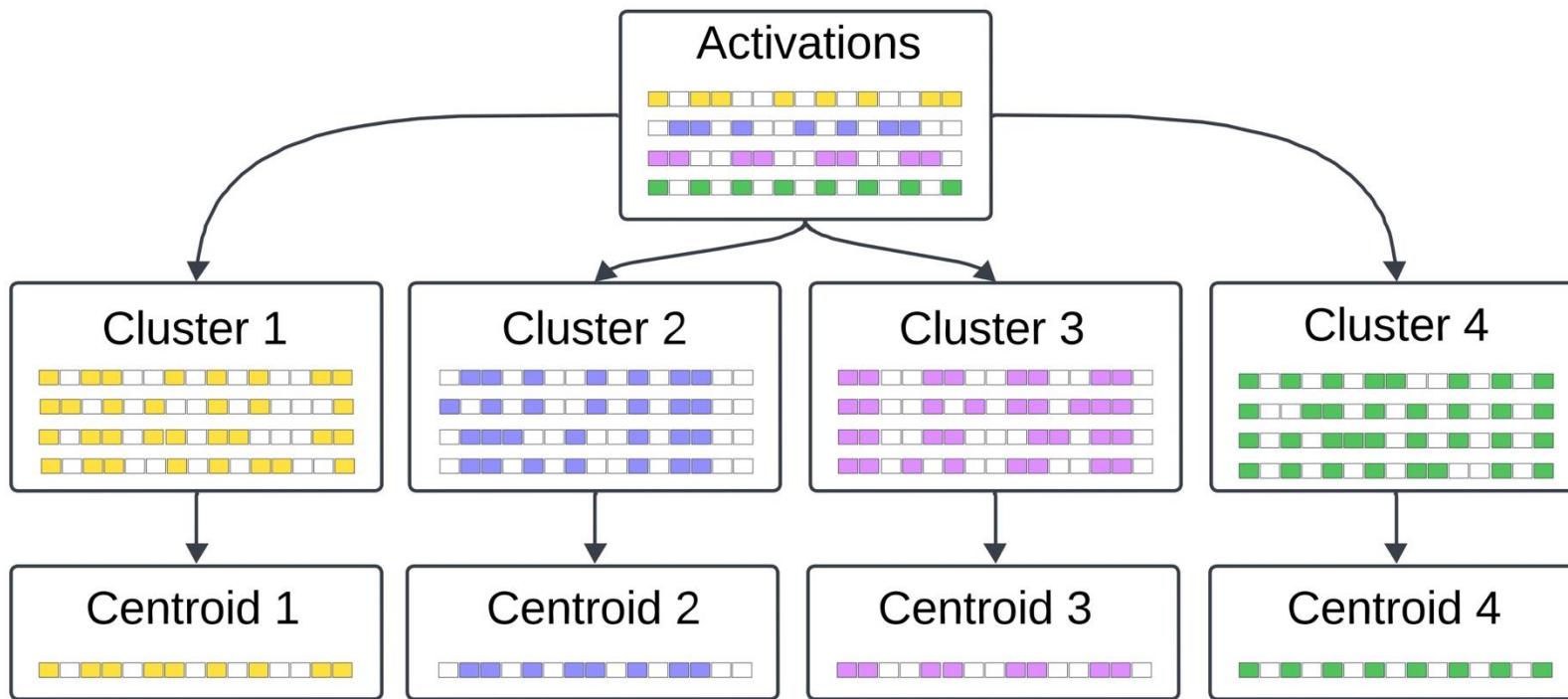
Experimental Setup

- Dataset
 - Wikitext-2
 - 333,842 number of tokens
 - 10.64 million activation patterns
- Model
 - Mistral-7B-v0.1
 - Number of FFN layers: 32
 - Each FFN layer consists of projection layers:
 - *Gate-Proj*: 14336 neuron
 - *Up-Proj*: 14336 neuron
 - *Down-Proj*: 4096 neuron
 - 50% model accuracy (PPL Score): 6.45

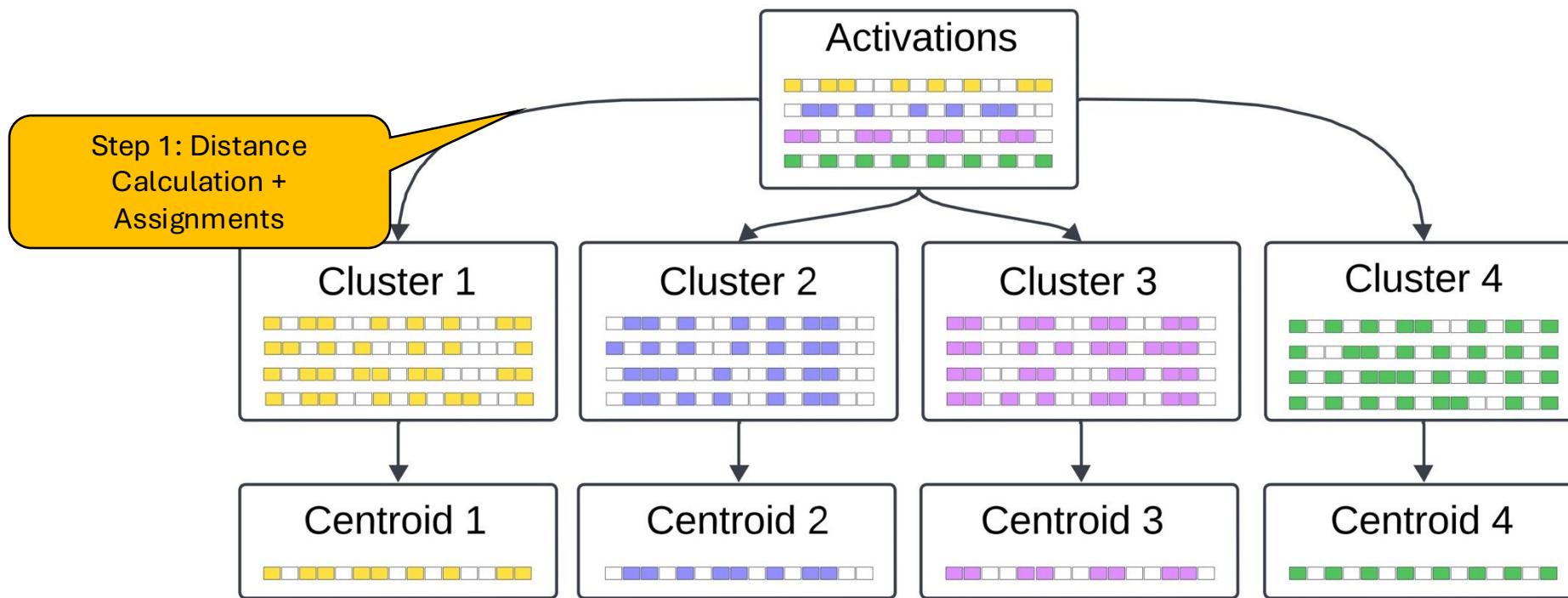
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 - 50% model accuracy (PPL Score): 6.45
- Hardware used for processing:
 - 8 * Nvidia A100
 - 80GB GPU memory each

Activation-Aware Clustering (APC)



Methodology



Methodology

Step 1.1: Distance Calculation

Datapoint

1	0	1	1	0	0
---	---	---	---	---	---

Centroid

0	1	1	0	1	0
---	---	---	---	---	---

Considered Positions

1	0	1	1	0	0
---	---	---	---	---	---

Computed Differences

1	0	0	1	0	0
---	---	---	---	---	---

Inactive position disregarded

Methodology

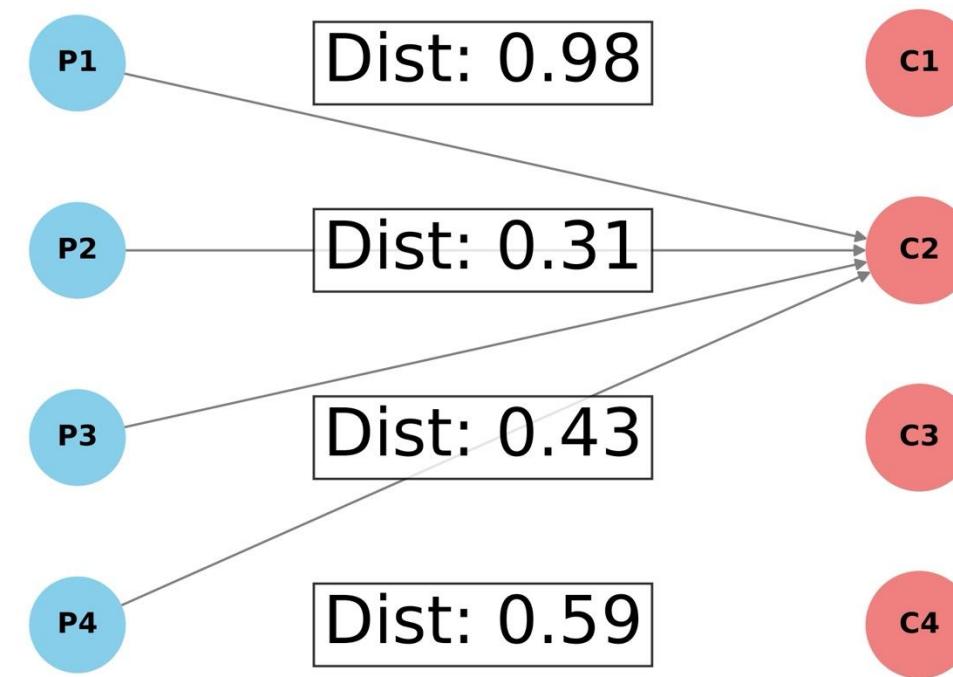
Step 1.2: Assignment

Unassigned

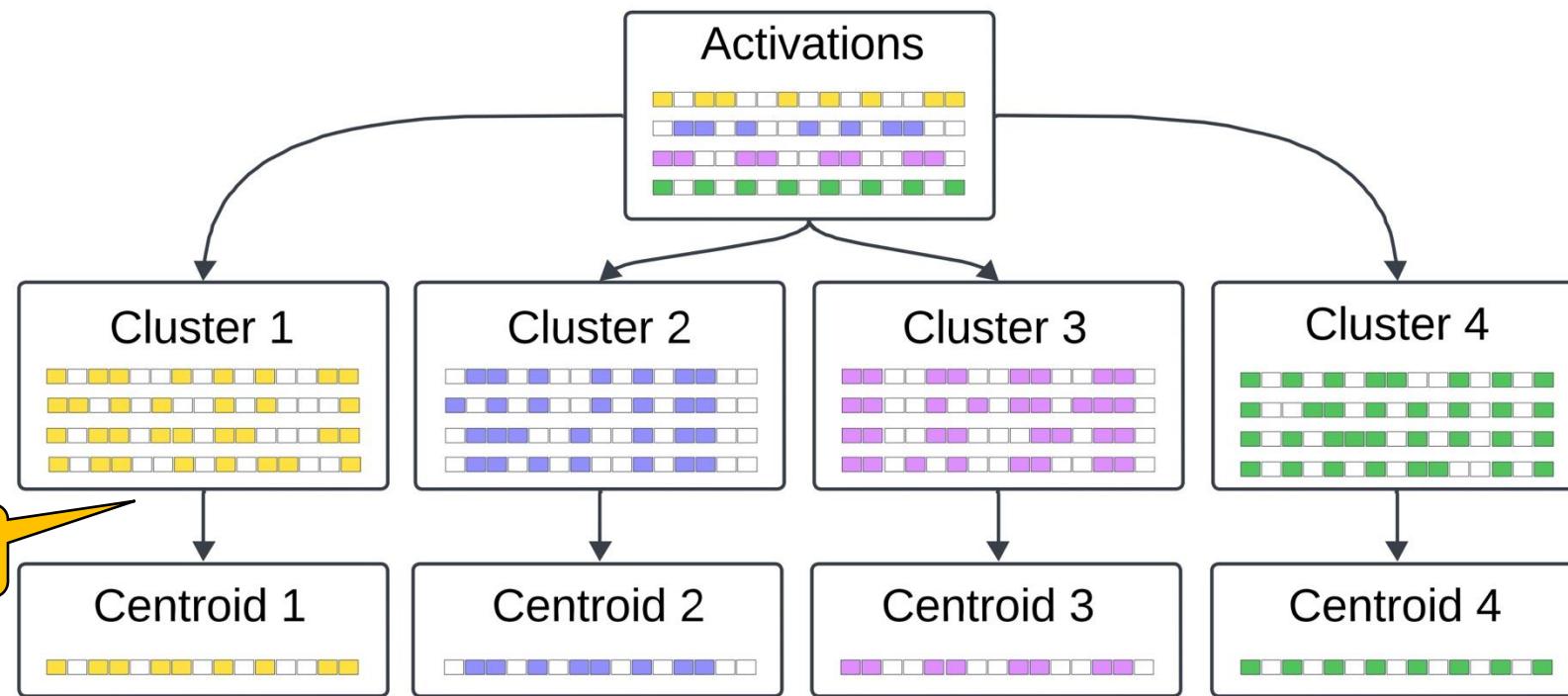
Assigned

Assigned

Unassigned

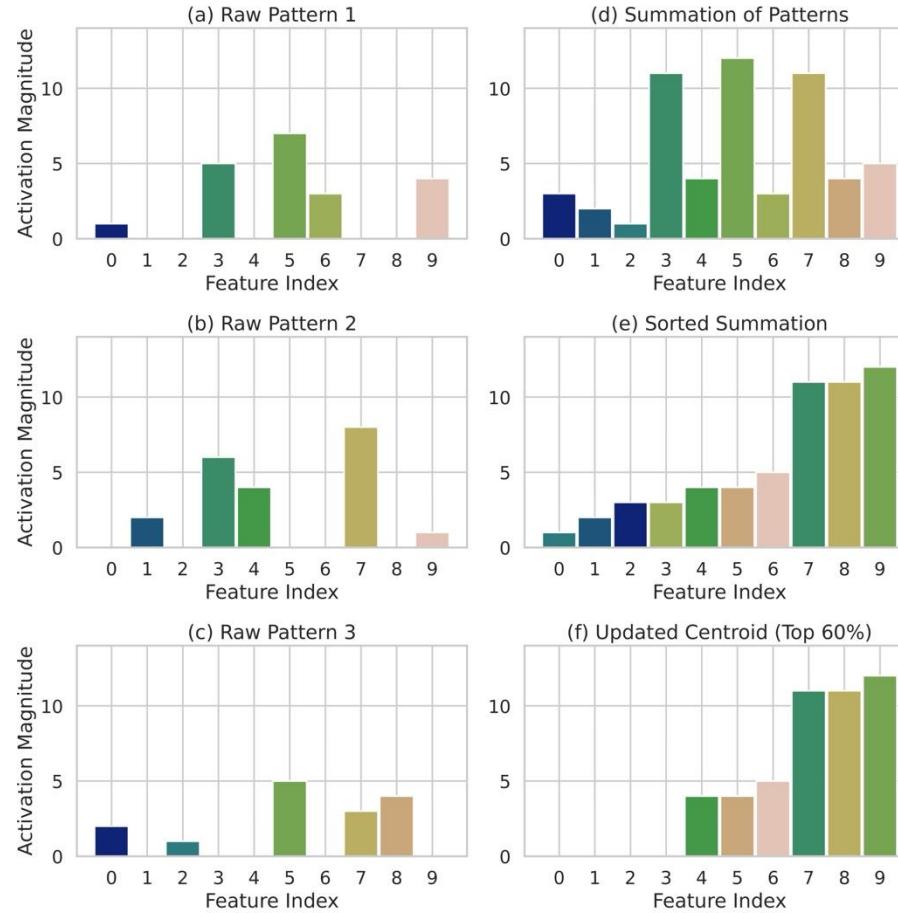


Methodology



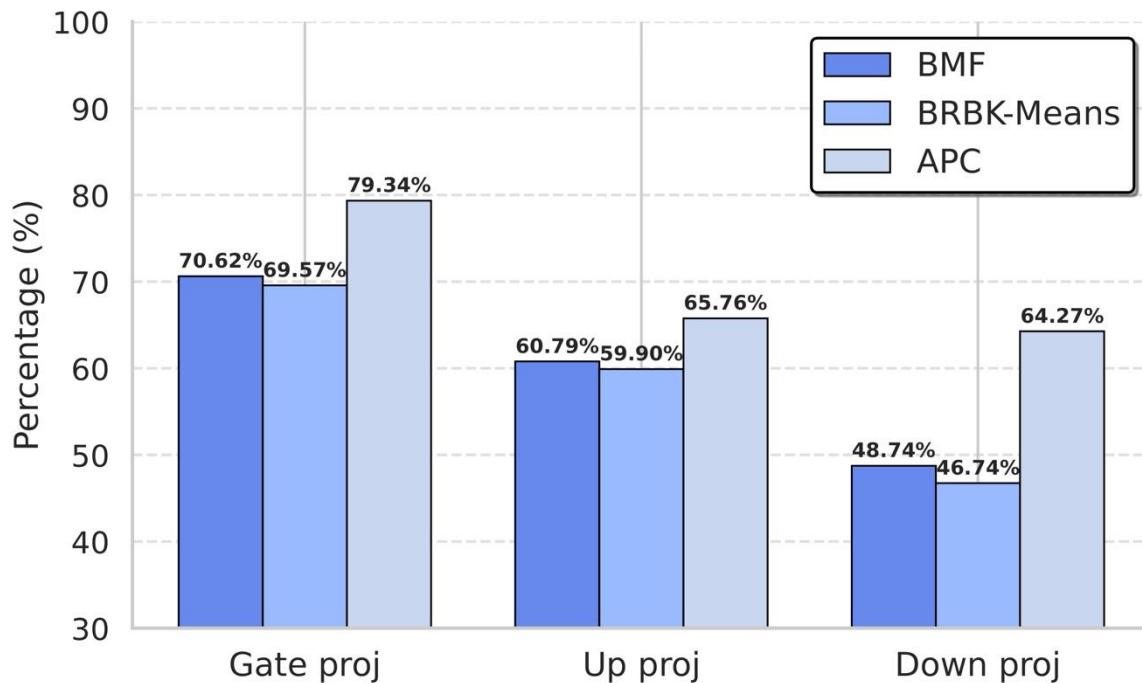
Methodology

Step 2: Update Centroid



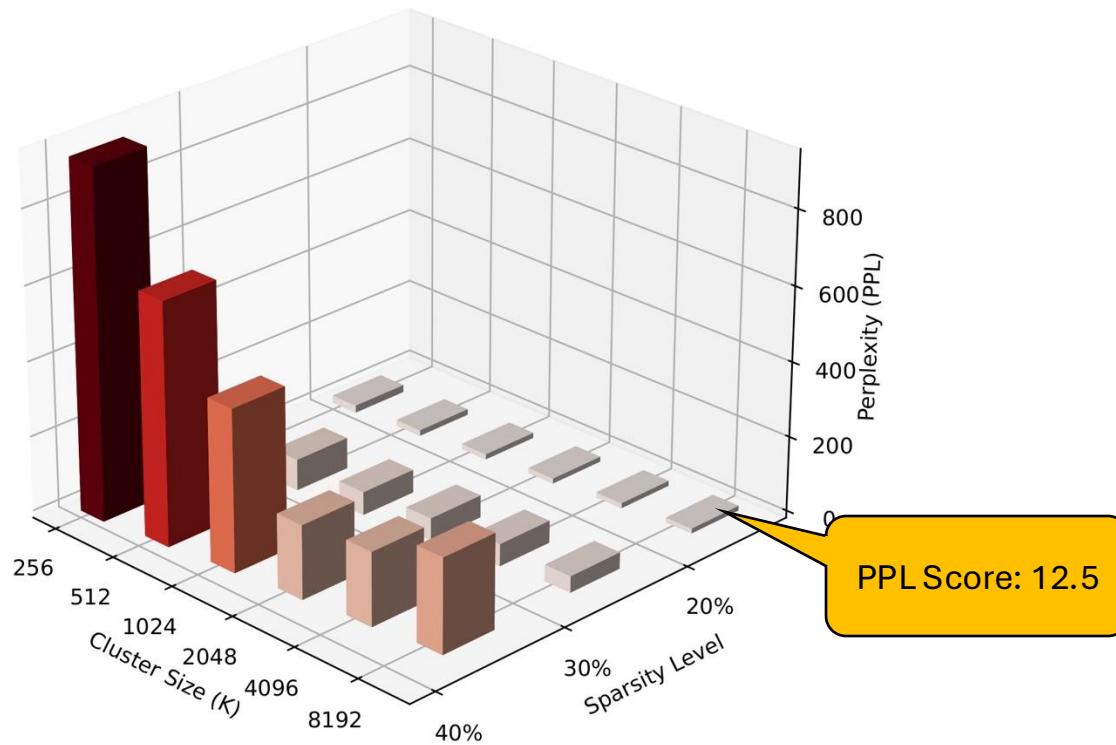
Result

1: Clustering Precision



Result

2: Clustering Effect On The Model Accuracy



Result

2: Clustering Effect On The Model Accuracy

