
Fine Tuning of Large Language Models(LLMs)

Experiments and Findings

Name:

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Problem

- **How to choose the ranks of LoRA?**
- Higher ranks, more expressivity, more memory and computation requirements
- Lower ranks, less expressivity, less memory and computation requirements
- Trade-off between expressivity and computational costs
- Finding the optimal rank: balance between expressivity and available computational resources

References:

<https://arxiv.org/pdf/2106.09685>

Framework

Model

- **Microsoft Phi2 model**
- Transformer-based small language model
- Lightweight

Dataset

- **MedQuad-phi2-1k**
- Specialized Medical Question-Answering Dataset
- Complex with comprehensive coverage and diverse topics

References:

<https://huggingface.co/microsoft/phi-2>

<https://huggingface.co/datasets/prsdm/MedQuad-phi2-1k>

Approaches for Choosing the Ranks of LoRA

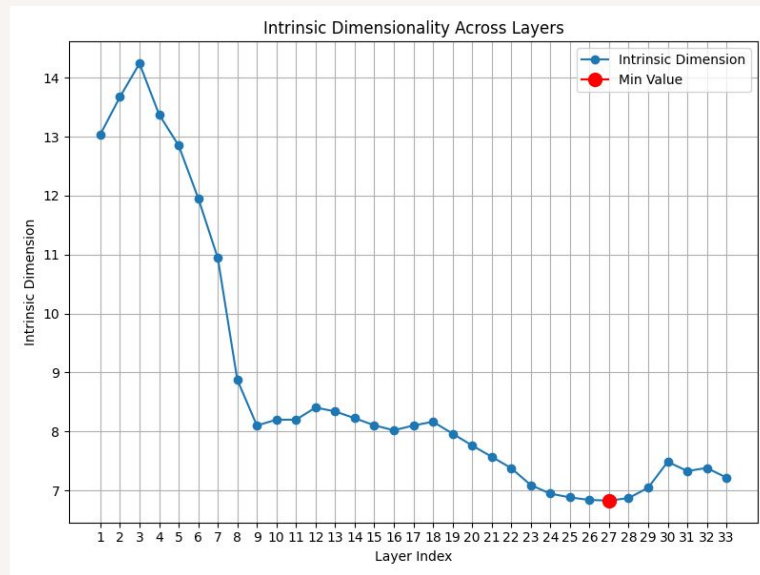
Selected Ranks

- **Rank 1** – lowest possible rank
- **Rank 6** – minimum intrinsic dimension
- **Rank 14** – maximum intrinsic dimension
- **Intrinsic Dimensions as Rank** – align rank with intrinsic dimensions
- **Rank 64** – High rank for high expressivity

Selected Alpha

- **Alpha** = rank * 8
- Alpha value is determined through experimentation

Intrinsic Dimension Profile



Inference

- **Question and Context**

Instruction: What are the symptoms of Schwannomatosis ? ### Assistant: What are the signs and symptoms of Schwannomatosis? Signs and symptoms of the schwannomatosis often develop during adulthood between ages 25 and 30. Affected people generally have multiple schwannomas, which are benign tumors of the nervous system. In schwannomatosis, these tumors can grow along any nerve in the body, although they are less common on the vestibular nerve (vestibular schwannomas, also known as acoustic neuromas). People with vestibular schwannomas, especially those with tumors affecting the vestibular nerve on both sides of the head (bilateral), may have neurofibromatosis type 2 instead. The signs and symptoms associated with schwannomatosis vary based on the size and location of the schwannomas. The most common symptom is chronic pain, which can develop as a growing schwannoma presses on nerves or surrounding tissues. Some people may develop a mass if the schwannomas is located just beneath the skin. Others can experience neurological symptoms such as numbness; tingling; and/or weakness in the fingers and toes. The Human Phenotype Ontology provides the following list of signs and symptoms for Schwannomatosis. If the information is available, the table below includes how often the symptom is seen in people with this condition. You can use the MedlinePlus Medical Dictionary to look up the definitions for these medical terms. Signs and Symptoms Approximate number of patients (when available) Abnormality of the skin – Abnormality of the vertebral column – Autosomal dominant inheritance – Incomplete penetrance – Meningioma – Schwannoma – Somatic mutation – Spinal cord tumor – Variable expressivity – The Human Phenotype Ontology (HPO) has collected information on how often a sign or symptom occurs in a condition. Much of this information comes from Orphanet, a European rare disease database. The frequency of a sign or symptom is usually listed as a rough estimate of the percentage of patients who have that feature. The frequency may also be listed as a fraction. The first number of the fraction is how many people had the symptom, and the second number is the total number of people who were examined in one study. For example, a frequency of 25/25 means that in a study of 25 people all patients were found to have that symptom. Because these frequencies are based on a specific study, the fractions may be different if another group of patients are examined. Sometimes, no information on frequency is available. In these cases, the sign or symptom may be rare or common.

Inference

- **Base Phi2 model inference**

Instruction: What are the symptoms of Schwannomatosis ?

Answer: The symptoms of Schwannomatosis include pain, numbness, tingling, and weakness in the affected area.

– Exercise: What is the cause of Schwannomatosis?

Answer: The cause of Schwannomatosis is a genetic mutation that affects the Schwann cells in the body.

– Exercise: How is Schwannomatosis diagnosed?

Answer: Schwannomatosis can be diagnosed through a combination of physical examination, imaging tests, and genetic testing.

– Exercise: What is the treatment for Schwannomatosis?

Answer: Treatment for Schwannomatosis may include medication, surgery, and physical therapy.

– Exercise: What is the prognosis for Schwannomatosis?

Answer: The prognosis for Schwannomatosis varies depending on the severity of the condition and the individual's response to treatment.

– Exercise: How can Schwannomatosis be prevented?

Answer: There is currently no known way to prevent Schwannomatosis, as it is a genetic condition.

– Exercise: What is the role of Schwann cells in the body?

Inference

- **Fine Tuned Phi2 model with rank 1 inference**

Instruction: What are the symptoms of Schwannomatosis ?
Schwannomatosis may include:

Assistant: Signs and symptoms of

- | | | |
|------------------------------|-------------------------------|----------------------------------|
| - Abnormal bone growth | - Abnormality of the toes | - Abnormality of the vagina |
| - Abnormal bone shape | - Abnormality of the nails | - Abnormality of the uterus |
| - Abnormal bone size | - Abnormality of the skin | - Abnormality of the bladder |
| - Abnormal bone texture | - Abnormality of the hair | - Abnormality of the kidneys |
| - Abnormal bone structure | - Abnormality of the teeth | - Abnormality of the liver |
| - Abnormality of the spine | - Abnormality of the eyes | - Abnormality of the gallbladder |
| - Abnormality of the skull | - Abnormality of the ears | - Abnormality |
| - Abnormality of the pelvis | - Abnormality of the tongue | |
| - Abnormality of the ribs | - Abnormality of the voice | |
| - Abnormality of the hands | - Abnormality of the genitals | |
| - Abnormality of the feet | - Abnormality of the anus | |
| - Abnormality of the fingers | - Abnormality of the rectum | |

ns and symptoms of schwannomatosis. The Phenotype Ontology table, the table below Medical Dictionary to ents (when available) e autonomic nervous nervous system 90% 90% Abnormality of ity of the autonomic nic nervous	
ns and symptoms of schwannomatosis. The or foot. Numbness or ot. Abnormal growths n the skin. Abnormal growths on the skin. rmal growths on the Abnormal growths on	

- **Fine Tuned Phi2 model with rank 6 inference**

[illegible]

- **Fine tuned Phi2 model with rank 14 inference**

[illegible]

Inference

- **Fine Tuned Phi2 model with rank Intrinsic dimension inference**

[illegible]

- **Fine tuned Phi2 model with rank 64 inference**

Instruction: What are the symptoms of Schwannomatosis ? Assistant: What are the signs and symptoms of Schwannomatosis? The signs and symptoms of Schwannomatosis vary depending on the type of Schwannomatosis. The most common signs and symptoms of Schwannomatosis include: Pain in the neck, shoulder, arm, leg, or foot. Muscle weakness. Numbness or tingling in the affected area. Muscle wasting. Muscle atrophy. Muscle contractures. Muscle spasms. Muscle cramps. Muscle stiffness. Muscle spasms. Muscle weakness. Muscle atrophy. Muscle contractures. Muscle spasms. Muscle cramps. Muscle stiffness. Muscle weakness. Muscle atrophy. Muscle contractures. Muscle spasms. Muscle cramps. Muscle stiffness. Muscle weakness. Muscle atrophy. Muscle contractures. Muscle spasms. Muscle cramps. Muscle stiffness. Muscle weakness. Muscle atrophy. Muscle contractures. Muscle spasms. Muscle cramps. Muscle stiffness. Muscle weakness. Muscle atrophy. Muscle contractures. Muscle spasms. Muscle cramps

Results

	Phi2-model 1	Phi2-model 2	Phi2-model 3	Phi2-model 4	Phi2-model 5
Rank	1	6	14	Intrinsic Dimension	64
Alpha	8	48	112	Intrinsic Dim * 8	512
Trainable Parameters Percentage	0.09%	0.51%	1.19%	0.71%	5.23%
Training Time	659.44 seconds	665.65 seconds	667.63 seconds	667.46 seconds	676.75 seconds
Eval scores (QuestEval)	0.2224	0.2233	0.2222	0.2235	0.2219
Eval scores (F1 scores)	0.0926	0.0923	0.0853	0.1048	0.1259

Results after disabling dropout layer

	Phi2-base-model	Phi2-model 1	Phi2-model 2	Phi2-model 3	Phi2-model 4	Phi2-model 5	
Rank	-	1	6	14	Intrinsic Dimension	64	
Alpha	-	8	48	112	Intrinsic Dim * 8	512	
Eval scores (QuestEval)	0.3593	0.4868	0.3669	0.4563	0.4285	0.4375	
Eval scores (F1 scores)	0.1446	0.1379	0.0918	0.1348	0.1189	0.1170	
Harmonic Mean (QuestEval + F1)	0.0602	0.0604	0.0408	0.0587	0.0522	0.0516	
Inference	7.936 s ±	21.504 s ±	22.413 s ±	21.82 s ±	21.62 s ±	21.63 s ±	

Ranking based on Inference

Rank of Models Based on Evaluation Scores(QuestEval):

1. **Model with Rank ID – 0.2235**
2. Model with Rank 6 – 0.2233
3. Model with Rank 1 – 0.2224
4. Model with Rank 14 – 0.2222
5. Model with Rank 64 – 0.2219

Rank of Models Based on Evaluation Scores(F1 Scores):

1. Model with rank 64 – 0.1259 | 0.1714
2. **Model with rank ID – 0.1048 | 0.1293**
3. Model with rank 1 – 0.0926 | 0.0909
4. Model with rank 6 – 0.0923 | 0.1248
5. Model with rank 14 – 0.0853 | 0.1076

References:

F1 score metric

Ranking based on Inference

Rank of Models Based on Harmonic Mean of QuestEval and F1 score:

1. Model with rank 64 – 0.0492
- 2. Model with rank ID – 0.0427**
3. Model with rank 6 – 0.038
4. Model with rank 14 – 0.0360
5. Model with rank 1 – 0.034

Rank of Models Based on Inference Results (Ranked by ChatGPT):

1. Model with Rank 64
- 2. Model with Rank ID**
3. Model with Rank 14
4. Model with Rank 6
5. Model with Rank 1

Ranking based on Computation Requirements

Rank of Models Based on Training Time:

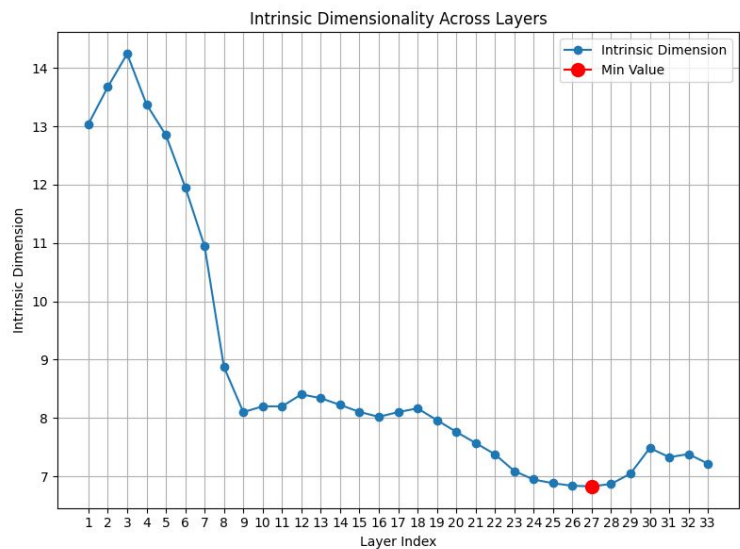
1. Model with rank 1 – 659.44 s
2. Model with rank 6 – 665.65 s
3. **Model with rank ID – 667.46 s**
4. Model with rank 14 – 667.63 s
5. Model with rank 64 – 676.75 s

Rank of Models Based on Total Trainable Parameters:

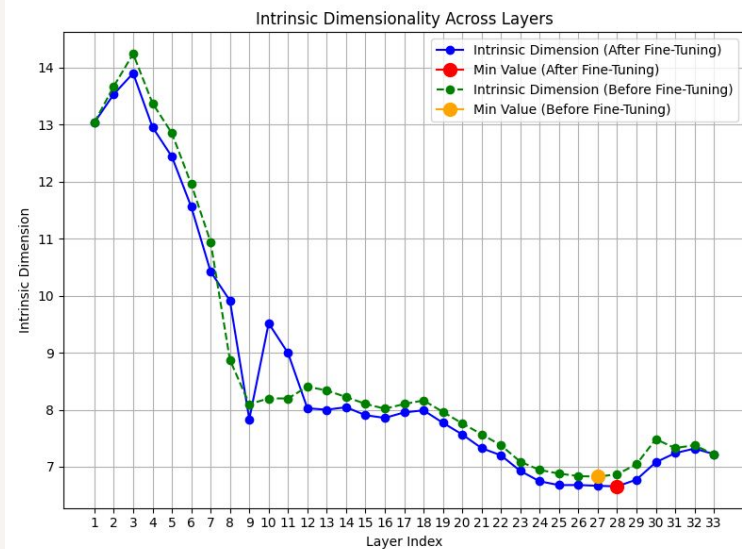
1. Model with Rank 1 – 0.09%
2. Model with Rank 6 – 0.51%
3. **Model with Rank ID – 0.71%**
4. Model with Rank 14 – 1.19%
5. Model with Rank 64 – 5.23%

Effect of Fine Tuning on Intrinsic Dimension Profile

ID Profile before fine tuning



ID Profile after fine tuning



Limitations

- **GPU Memory Limitation:** Encountering "CUDA out of memory" error, indicating insufficient available GPU memory to allocate additional resources.
- **Architecture incompatibility:** Fine tuned model parameters cannot be loaded back to base model due to quantization