DeepStack: Deeply Stacking Visual Tokens is Surprisingly Simple and Effective for LMMs

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https://deepstack-vl.github.io/

A Training Details

A.1 Custom Supervised Finetuning Dataset

We follow LLaVA-Next [12] to combine a custom data mixture containing 748K SFT data shown in Tab. 1. Following [13, 12], our 748K training data mixture contains (1) LLM instruction following data, *e.g.* ShareGPT [19]; (2) GPT4/GPT4V generated data, *e.g.* LLaVA-instruct [13], ShareGPT4V [1], LAION-GPT4V [9]; (3) academic-task-oriented data, *e.g.* VQAv2 [2], GQA [3], *etc*.

Dataset	Size	Task Prompt
ShareGPT [19]	40K	
LLaVA-instruct [13]	158K	
ShareGPT4V [1]	39K	
LAION-GPT4V [9]	11K	
VQAv2 [2]	83K	
GQA [3]	72K	
OKVQA [14]	9K	
OCRVQA [17]	80K	
ChartQA [15]	7K	"Answer the question using a single word or phrase."
DVQA [4]	16K	
DocVQA [16]	10K	
AI2D [6]	2K	
SynthDog-EN [7]	20K	
A-OKVQA [18]	66K	"Answer with the option's letter from the given choices directly."
RefCOCO [5]	48K	"Provide a short description for this region."
VG [8]	86K	"Provide the bounding box coordinate of the region this sentence describes"

Table 1: Data combination of our 748K SFT data.

A.2 Detailed Training Configuration

We list the detailed training hyper-parameters as follows. For evaluation, we utilize LLMs-Eval [10] for evaluation on several benchmarks.

Hypter-param	PT	DeepStack-L SFT	DeepStack-V SFT	DeepStack-HD SFT
global batch size	256	128	128	128
lr	1e-3	2e-5	2e-5	2e-5
backbone lr	freeze	freeze	2e-6	2e-6
lr schedule	cosine decay	cosine decay	cosine decay	cosine decay
lr warmup ratio	0.03	0.03	0.03	0.03
epoch	1	1	1	1
optimizer	AdamW	AdamW	AdamW	AdamW

Table 2: Training hyper-parameters.

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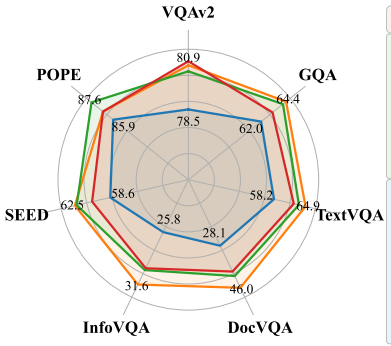
Q: What does it say in the bottom right corner?	Q: How many stars can you see on the white board?	Q: What candy bar is down there on the bottom?	Q: What brand is the mobile phone?
LLaVA-1.5: 'Congratulations'	**LLaVA-1.5**: 1	**LLaVA-1.5**: Honey maid	**LLaVA-1.5**: Samsung
DeepStack: 'Postcode'	**DeepStack**: 3	**DeepStack**: Hershey's	**DeepStack**: HTC

Q: Please describe in as much detail as possible what each person in the picture is doing.

LLaVA-1.5:
In the image, there is a group of people gathered around a cow in a grassy field. A woman is standing next to the cow, possibly petting it or tending to it. Another woman is standing nearby, possibly observing the scene or waiting for her turn to interact with the cow.There are several other people in the background, some of whom are standing closer to the cow, while others are further away. A few individuals are wearing ties, which suggests a more formal or professional setting. In the scene, there are also a couple of chairs and a dining table, indicating that this gathering might be a social event or a meeting. A handbag can be seen placed on the ground, possibly belonging to one of the attendees.

DeepStack:
In the image, there is a group of people gathered around a brown and white cow. A woman is standing next to the cow, holding its halter, while a man is standing nearby, possibly observing the scene. Other people are also present in the area, some standing closer to the cow and others further away. There are a few chairs scattered around the scene, with one near the center and two others closer to the right side. A truck can be seen in the background, possibly indicating that the event is taking place at a fair or similar outdoor venue.



Q: Please describe the image as detailed as possible

LLaVA-1.5:
The image displays a graph with a central circle that represents a VOQA (Voice over QAM) system. The circle is divided into four quadrants, each representing a different aspect of the system. The quadrants are labeled with the acronyms VOQA, POP, GAOA, and TEX. The graph also includes several smaller circles scattered around the main circle, which are likely related to the VOQA system as well. These smaller circles are positioned at various distances from the main circle, indicating the different levels of the system.

DeepStack:
The image features a circular diagram with various labels and numbers. The diagram is divided into different sections, each with its own set of labels and numbers. The central section of the diagram is labeled "VQA2," while the surrounding sections are labeled "Pope," "GQA," "Seed," "InfoVQA," "DocVQA," and "Sequence." There are several numbers in the diagram, with some located in the central section and others scattered throughout the different sections. The numbers are likely used to represent data or information related to the various labels and sections of the diagram.

Figure 1: **Visualization.** Both LLaVA-1.5 and DeepStack use 576 visual context length for a fair comparison. Top: We mark the area corresponding to each question with a **red circle**. DeepStack can well answer the questions which need high-resolution and fine-grained understanding. Bottom: DeepStack demonstrates a more accurate visual understanding in detailed visual captioning.

B More Experiments

B.1 Improved DeepStack-L with Fintuning Vision Encoder

As shown in Tab. 3, after finetuning the vision encoder, our DeepStack-L achieves further improvement. This further demonstrates the effectiveness and the potential of our *DeepStack* strategy.

Method	LLM	*Eff. Res.*	*Vis. Tok.*	*Cxt. Len.*	PT	SFT	*General VQA* VQA^{v2}	GQA	*Text-oriented VQA* Text VQA‡	Doc VQA‡	Info VQA‡	*LMM benchmarks* SEED (all)	POPE (all)	MM MU‡	MM Vet
LLaVA-1.5 [11]	Vicuna-7B	336	576	576	558K	665K	78.5*	62.0*	58.2	28.1	25.8	58.6	85.9	35.3	30.5
DeepStack-L	Vicuna-7B	672	2880	576	558K	665K	79.5*	63.1*	62.4	39.1	29.8	60.6	86.7	35.7	29.9
DeepStack-L$\star$	Vicuna-7B	672	2880	576	558K	665K	81.1*	63.9*	64.5	39.3	30.1	63.3	86.7	37.1	29.8
LLaVA-1.5 [11]	Vicuna-13B	336	576	576	558K	665K	80.0*	63.3*	61.3	30.3	28.4	61.6	85.9	34.8	35.4
DeepStack-L	Vicuna-13B	672	2880	576	558K	665K	80.9*	64.2*	64.6	41.5	33.0	63.5	87.7	35.2	35.9
DeepStack-L$\star$	Vicuna-13B	672	2880	576	558K	665K	82.1*	65.1*	65.2	43.1	34.0	64.4	86.6	34.7	36.2

Table 3: Improved DeepStack-L with fintuning vision encoder. $\star$ indicates that the vision encoder is fine-tuned.

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