Open-ended VQA benchmarking of Vision-Language models by exploiting Classification datasets and their semantic hierarchy

Simon Ging * María A. Bravo * Thomas Brox

University of Freiburg

Poster session

Halle B, Thu 9 May, 4:30 p.m.

iclr.cc/virtual/2024/poster/19102

[o] Vision

COMPUTER VISION University of Freiburg

* Equal Contribution

ICLR

International Conference On Learning Representations

Motivation

Vision-Language Models

Vision-language research requires understanding of vision and language

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Captioning

The image shows a person sitting on a sandy beach, with three large dogs. The person is looking towards the sea.

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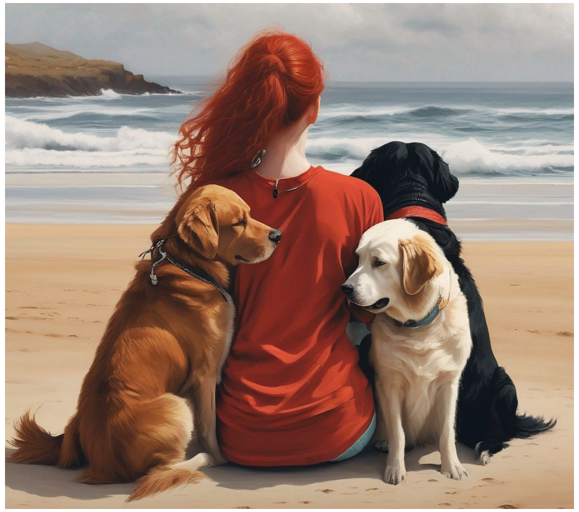

Visual Question Answering

How many dogs are in the image?

There are three dogs.

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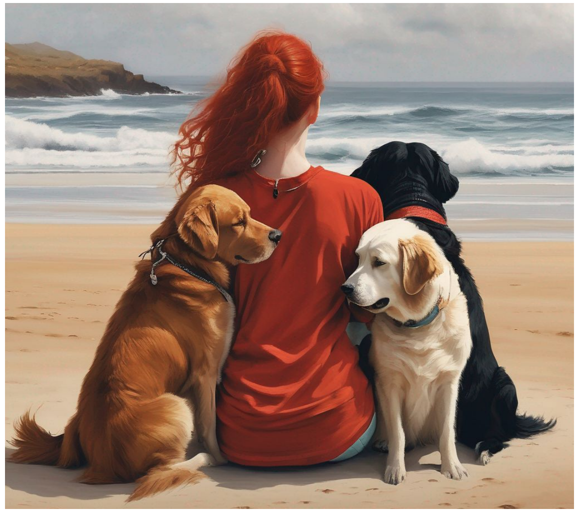

Captioning

⚙ The image shows a person sitting on a sandy beach, with three large dogs. The person is looking towards the sea.

Visual Question Answering

How many dogs are in the image? 👤

⚙ There are three dogs.

Visual Dialog

Where is the scene taking place? 👤

⚙ The scene is taking place on a sandy beach with the **ocean** in the background.

Does the **ocean** have strong waves? 👤

⚙ The waves in the ocean appear moderate, not particularly strong.

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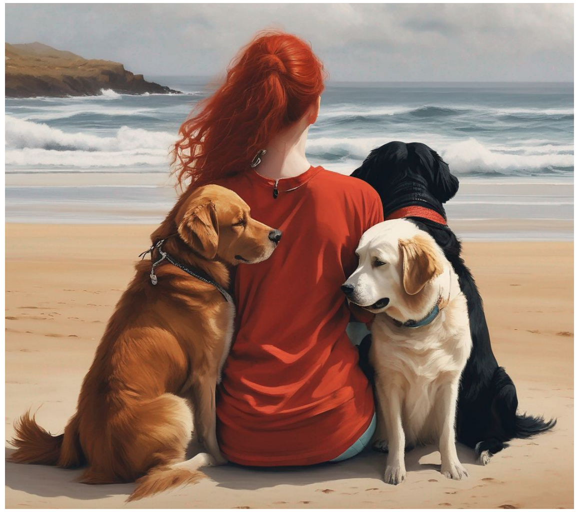

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Visual Question Answering

Visual Dialog

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rong

The waves in the ocean appear moderate, not particularly strong.

Our goal:

Assess **VLMs'** performance

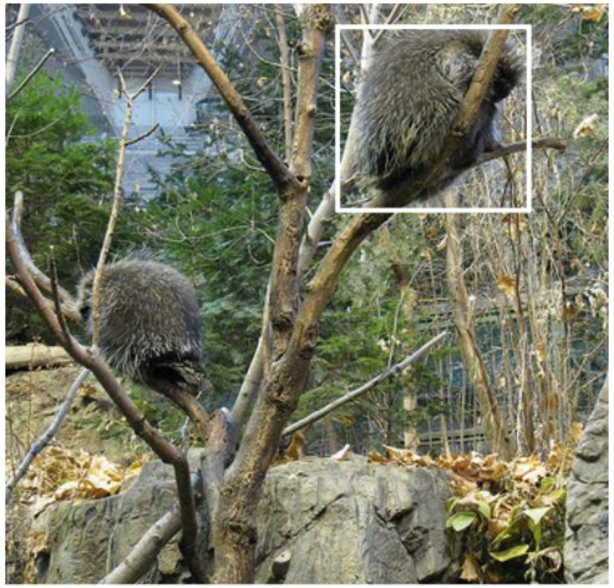
in an **open-ended VQA** setup

Motivation

Visual Question Answering

Challenges in evaluation of Open-ended VQA

Ambiguous object



What’s this? (*Label:* Porcupine)

Model output: A tree with no leaves

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Visual Question Answering

Challenges in evaluation of Open-ended VQA

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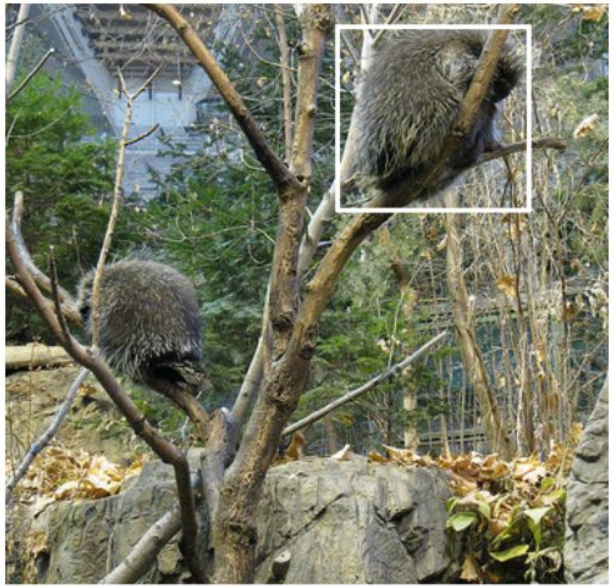

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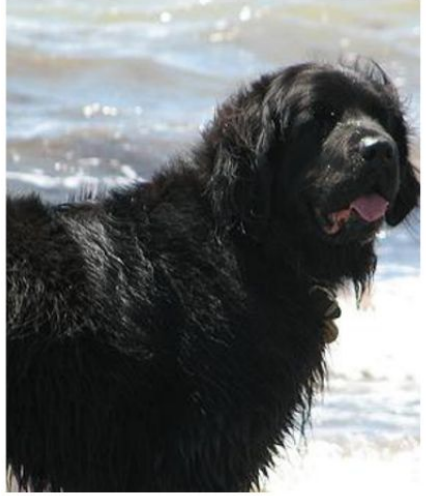
Unknown label granularity



What's this? (*Label:* Newfoundland dog)
Model output: A black dog standing in the water

Open-ended Visual Question Answering

oVQA benchmark

Objects

Dataset: ImageNet
Question: What's this?
Label: cougar

Dataset: COCO
Question: What's this?
Label: elephant

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Dataset: ActivityNet
Question: What activity is this?
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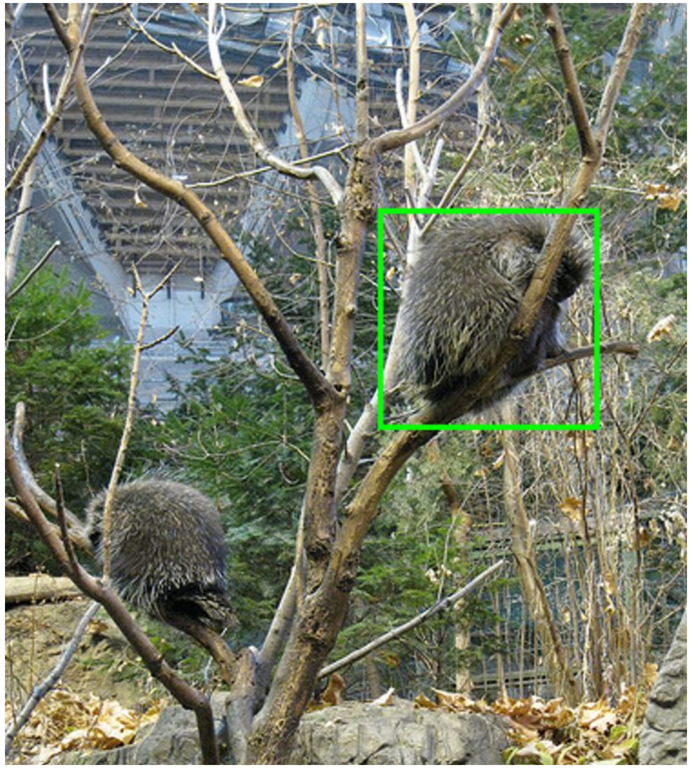
Attributes

Dataset: OVAD
Question: What is the position of the person?
Label: standing / upright / vertical

oVQA Benchmark

Visual guidance

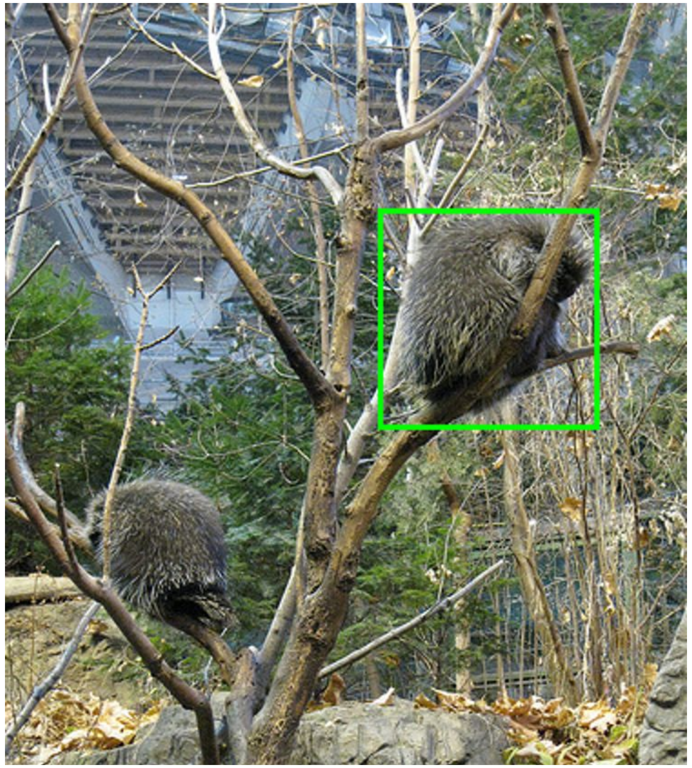


What's this?
Label: **Porcupine**

Model output: **A tree with no leaves**

oVQA Benchmark

Visual guidance



What's this?
Label: **Porcupine**

crop

Model output: **A tree with no leaves**

Model output: **A porcupine**

oVQA Benchmark

Follow-up question

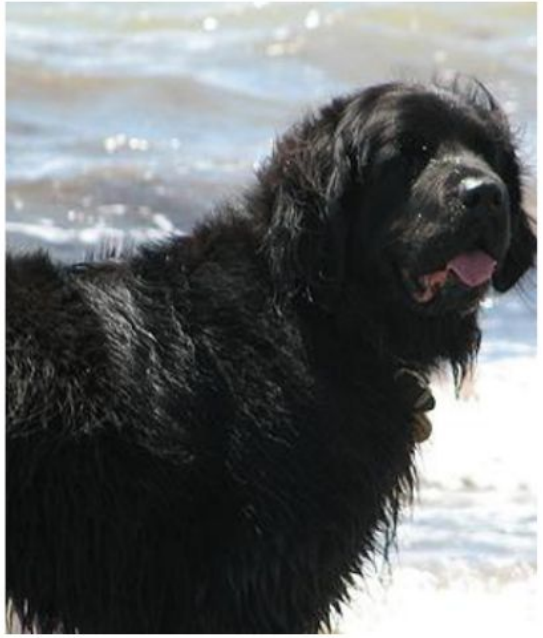
What's this?

A black dog standing in the water

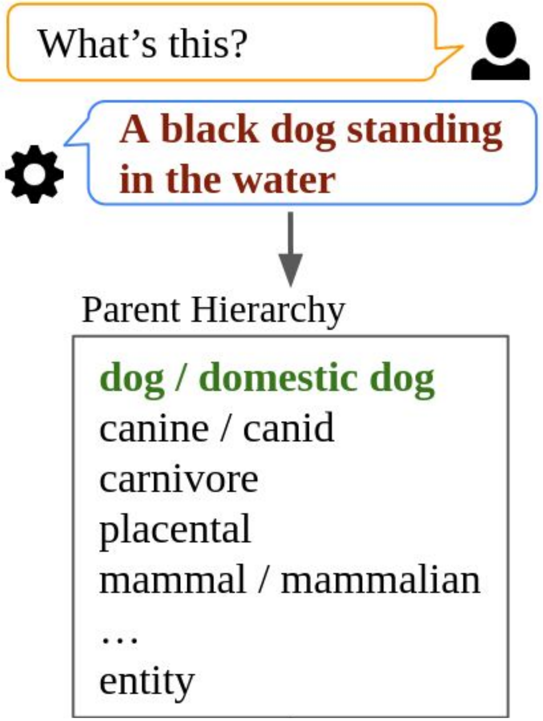
Label: **Newfoundland dog**

oVQA Benchmark

Follow-up question



Label: **Newfoundland dog**



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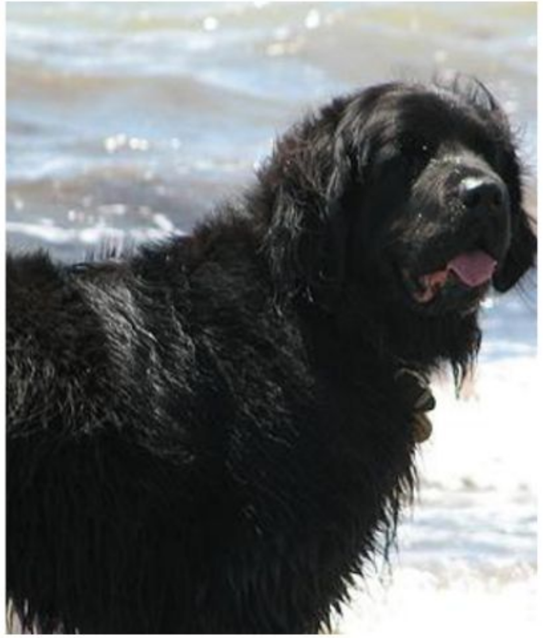
placental
mammal / mammalian
…
entity

oVQA Benchmark

Follow-up question



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What type of **dog** is this ?

Newfoundland dog

oVQA Benchmark

Choosing the correct metric for <u>binary classification</u>

Which is the maturity of the person? ⟷

Label:
young

Synonyms:
{ young, baby, child, kid }

***"Exact match"**: Answer matches the label?*

child ❌

He's a kid. ❌

oVQA Benchmark

Choosing the correct metric for binary classification

Which is the maturity of the person? ←→

Label:
young

Synonyms:
{ young, baby, child, kid }

	***"Exact match"**: Answer matches the label?*	***"Contains" metric**: Any synonym is contained in the answer?*
child	✗	✓
He's a kid.	✗	✓

oVQA Benchmark

Choosing the correct metric for multi-class classification

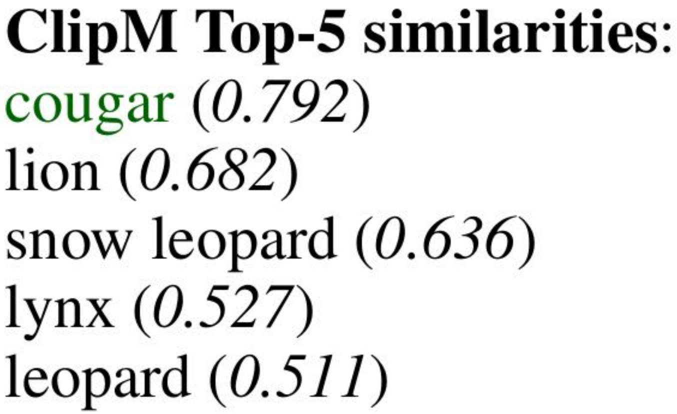
What's this?

Model output: **a mountain lion** ⟷ *Label:* **cougar**

ExactMatch*:*
answer matches label exactly ✗

Contains*:*
label is contained in answer ✗

ClipMatch:
most similar label in Clip text space ✓



ClipM Top-5 similarities:

cougar (*0.792*)
lion (*0.682*)
snow leopard (*0.636*)
lynx (*0.527*)
leopard (*0.511*)

oVQA Benchmark

Sub-benchmarks

	Object-oVQA (COCO)	Object-oVQA (ImageNet)
# Classes	80 objects	1000 objects
Follow-up	✗	✓
Size	36,800 crops	50,000 images
Question ex.	What is in the image?	What is in the image?

oVQA Benchmark

Sub-benchmarks

	Object-oVQA (COCO)	Object-oVQA (ImageNet)	Activity-oVQA (ActivityNet)
# Classes	80 objects	1000 objects	200 activities
Follow-up	✗	✓	✓
Size	36,800 crops	50,000 images	7,700 frames
Question ex.	What is in the image?	What is in the image?	What is happening in the image?

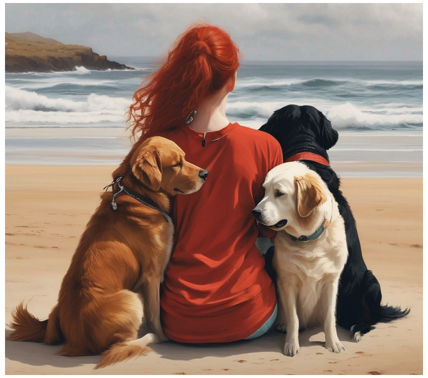
oVQA Benchmark

Sub-benchmarks

	Object-oVQA (COCO)	Object-oVQA (ImageNet)	Activity-oVQA (ActivityNet)	Attribute-oVQA (OVAD)
# Classes	80 objects	1000 objects	200 activities	117 attributes
Follow-up	✗	✓	✓	✗
Size	36,800 crops	50,000 images	7,700 frames	14,300 crops
Question ex.	What is in the image?	What is in the image?	What is happening in the image?	What is the position of the person?

Motivation

Vision-Language Models



Multi-purpose VLM

Make a short description of the image.

The image shows a person sitting on a sandy beach, with three large dogs.

- BLIP-2 FlanT5 XL
- BLIP-2 OPT

Finetuned Visual Question Answering models

How many dogs are in the image?

There are three dogs.

- BLIP
- X2-VLM

Dialog and instruction models

Where is the scene taking place?

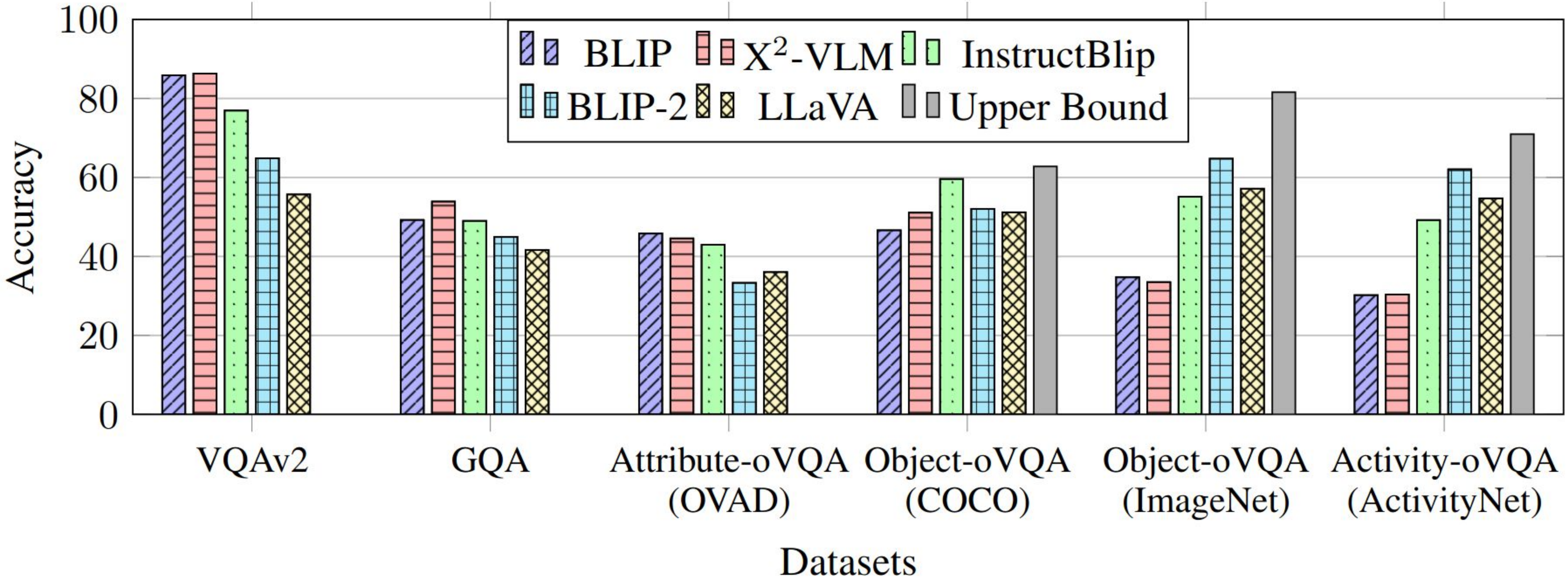
The scene is taking place on a sandy beach with the **ocean** in the background.

Does the **ocean** have strong waves?

The waves in the ocean appear moderate, not particularly strong.

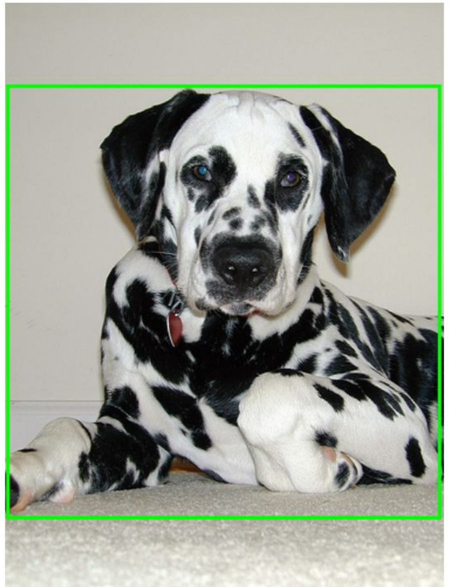
- LLaVA
- InstructBlip

Model results



Qualitative Examples

Objects (ImageNet)



correct answer
wrong answer

Question: What's this?
Label: Dalmatian
BLIP-2 OPT *output*: it's a dalmatian
LLaVA *output*: The image features a large black and white dog laying down on the floor, possibly on a carpet.
Follow-up Question: What type of dog is this?
LLaVA *output*: The dog in the image is a Dalmatian.

Qualitative Examples

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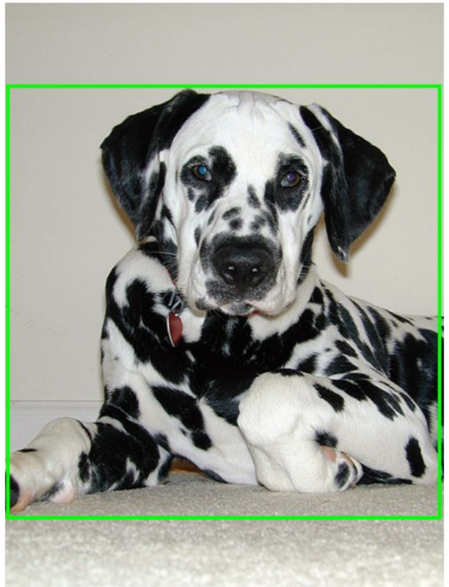

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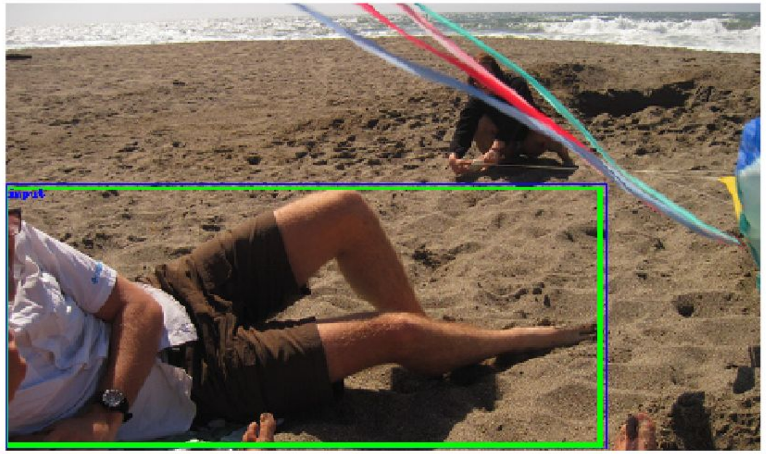
LLaVA *output*: The dog in the image is a Dalmatian.

correct answer
wrong answer

Attributes (OVAD)



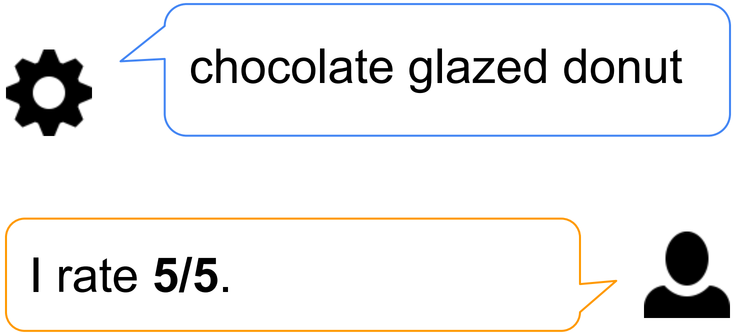
Question: How many people are present in the image?
Label: individual / one / single / 1 / sole / alone
BLIP$_{vqa}$ *output*: one
BLIP-2 OPT *output*: None.
InstructBLIP T5 *output*: 2
LLaVA *output*: There are two people present in the image.
X^2-VLM$_{vqa}$ L *output*: one

Metrics

User study

What type of donut is on the top right?

Label: **chocolate iced glazed**



chocolate glazed donut

I rate **5/5**.

2000 model predictions evaluated.

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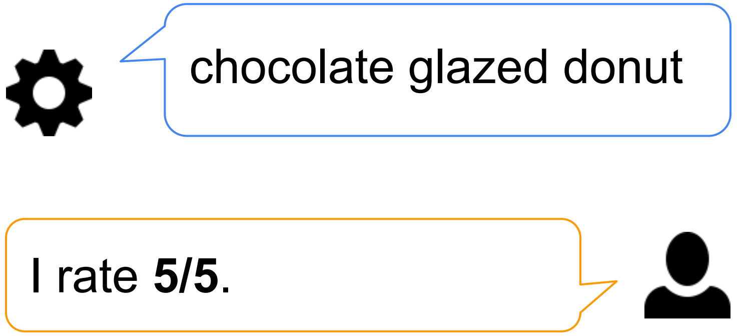

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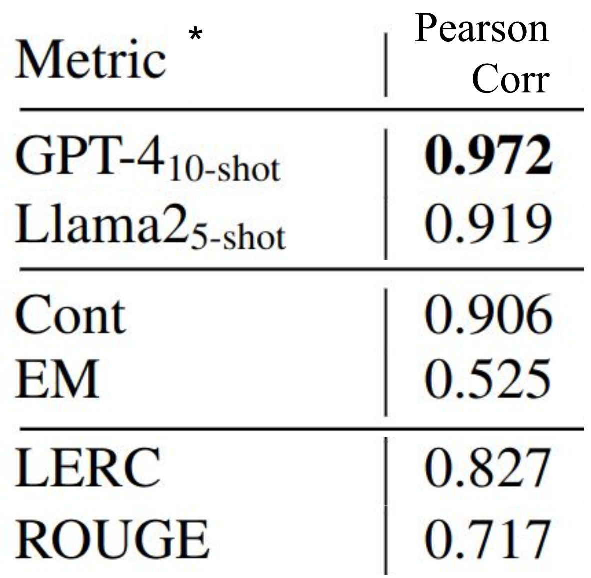


Metric *	Pearson Corr
GPT-4$_{\text{10-shot}}$	**0.972**
Llama2$_{\text{5-shot}}$	0.919
Cont	0.906
EM	0.525
LERC	0.827
ROUGE	0.717

* More metrics in the paper

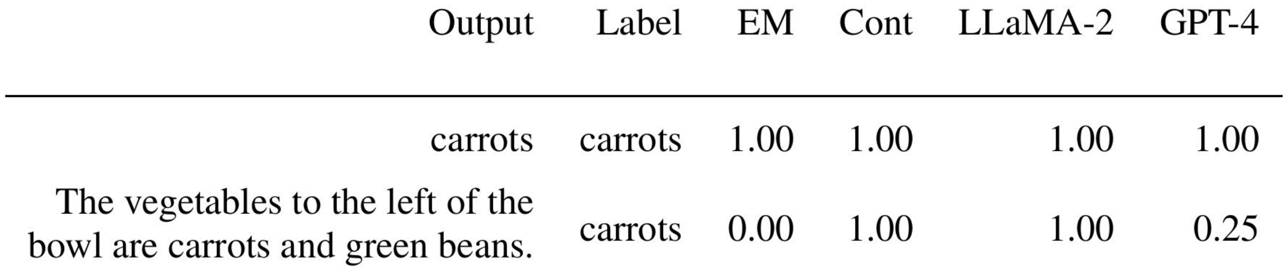
2000 model predictions evaluated.

Metrics

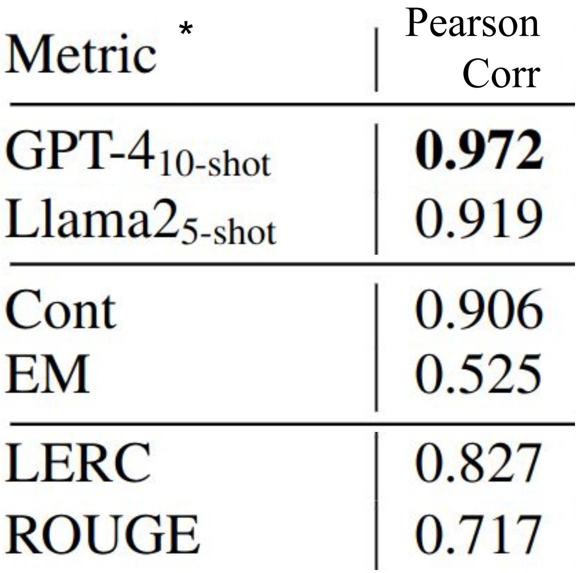
User study

- **LLMs** perform outperforms classical metrics
- **Contains metric** outperforms learned metrics and translation metrics

What are the vegetables to the left of the bowl that is to the left of the cookies?
Label: **carrots**



Output	Label	EM	Cont	LLaMA-2	GPT-4
carrots	carrots	1.00	1.00	1.00	1.00
The vegetables to the left of the bowl are carrots and green beans.	carrots	0.00	1.00	1.00	0.25



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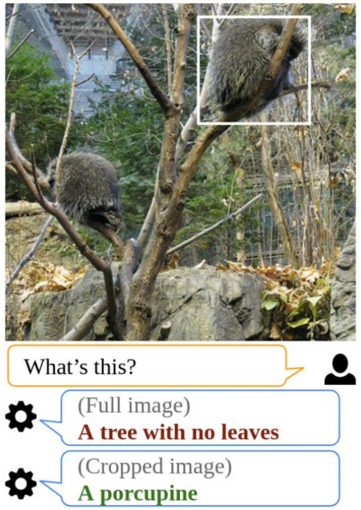
Contributions

oVQA: A new benchmark for diagnosing Text-VLM performance in an open-ended VQA setup

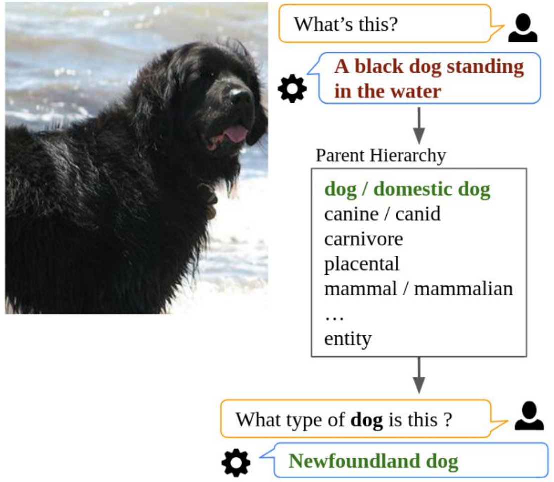
- Remove ambiguities
- Ask follow-up questions



What's this?

(Full image)
A tree with no leaves

(Cropped image)
A porcupine



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What type of **dog** is this ?

Newfoundland dog

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oVQA: A new benchmark for diagnosing Text-VLM performance in an open-ended VQA setup

- Remove ambiguities
- Ask follow-up questions
- Use provably strong **metrics**

oVQA benchmark

Dataset: VQAv2
Question: Where is the cat?
Label: on desk (x4), desk (x3), center of picture, at home, on table

Dataset: GQA
Question: What is the spoon made of?
Label: metal

Objects

Dataset: ImageNet
Question: What's this?
Label: cougar

Dataset: COCO
Question: What's this?
Label: elephant

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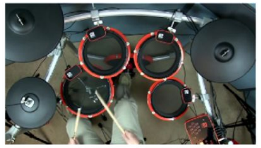

Dataset: ActivityNet
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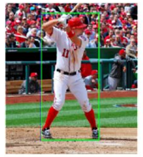
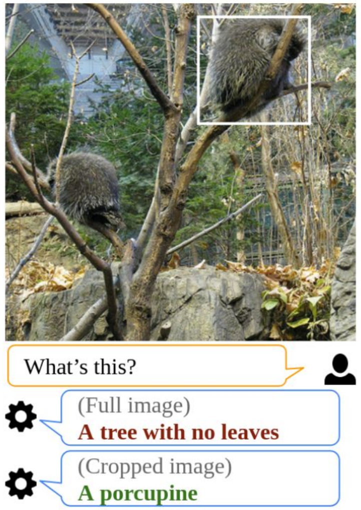
Label: playing drums

Attributes



Dataset: OVAD
Question: What is the position of the person?
Label: standing / upright / vertical



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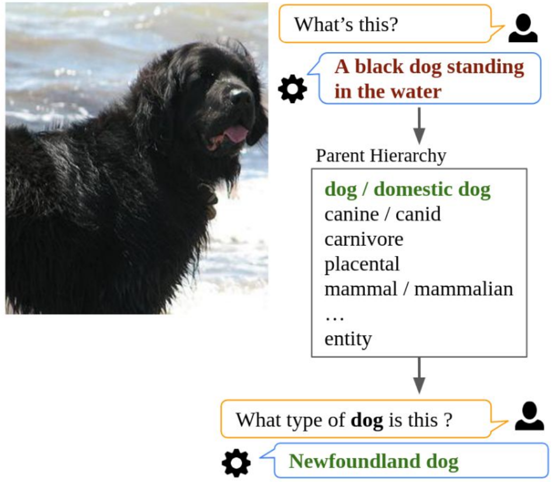

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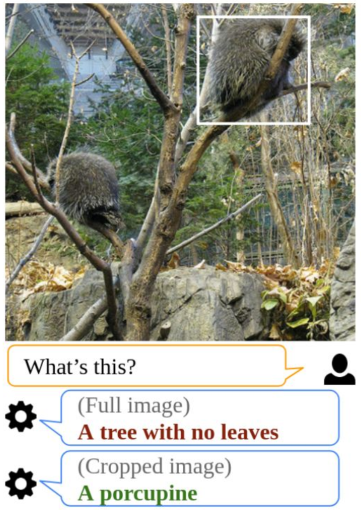

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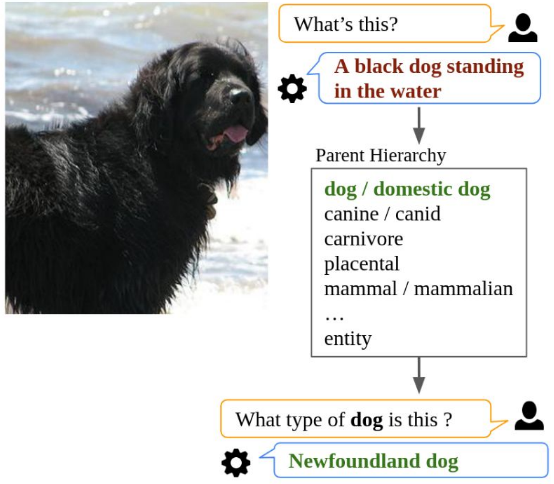

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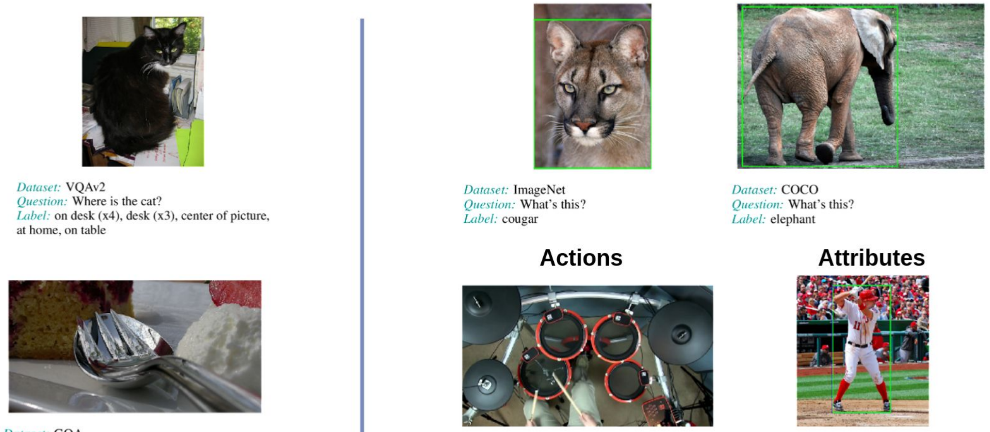

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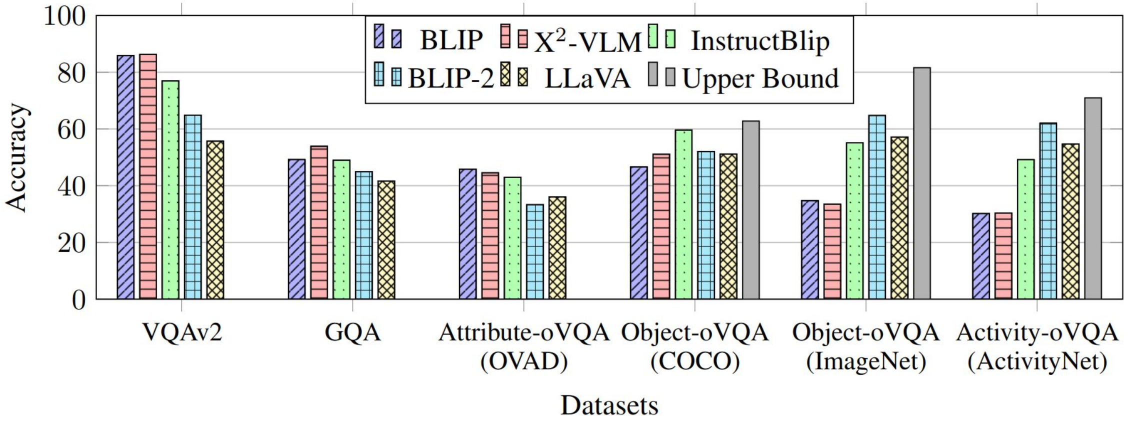

ufr DFG DAAD

Spotlight

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Poster session

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