



Meteor: Mamba-based Traversal of Rationale for Large Language and Vision Models

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Beyond “perception”, we define four types of multifaceted information:

- Fundamental Image Understanding
- Real-world knowledge of Common-Sense
- Non-object concepts (e.g. chart, diagram, sign, symbol, math)
- Step-by-step procedures for solving complex questions



Multifaceted Information

AI

Question: {}. Answer: {}. Based on the question and answer, carefully provide an explanation about how to answer the question in detail.



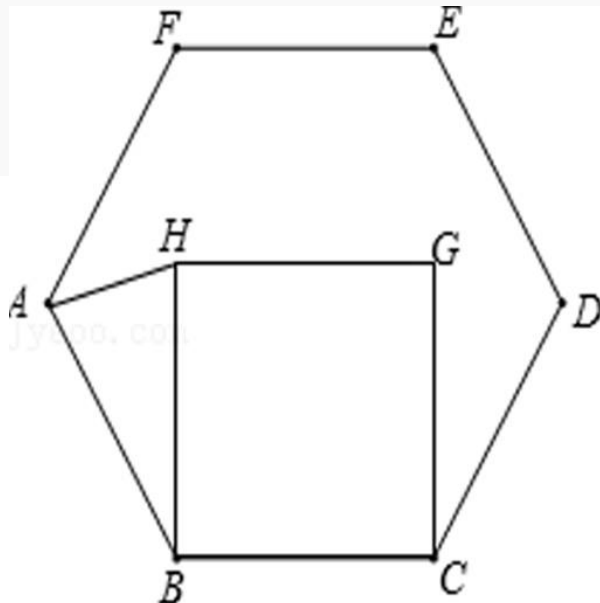
Question:

First perform reasoning, then finally select the question from the choices in the following format: Answer: xxx.

Question: We have a regular hexagon ABCDEF and inside it, a square BCGH is constructed. What is the size of angle HAB when line segment AH is connected?

Choices:

- A: 75°
- B: 60°
- C: 55°
- D: 45°



Rationale:
To solve this problem, we need to understand the properties of regular hexagons and squares.

Given information:
- ABCDEF is a regular hexagon.
- BCGH is a square constructed inside the hexagon.

Step 1: Find the interior angle of a regular hexagon.
The interior angle of a regular polygon with n sides is given by the formula:
Interior angle = $(n-2) \times 180^\circ / n$
For a regular hexagon, $n = 6$, so the interior angle = $(6-2) \times 180^\circ / 6 = 120^\circ$.

Step 2: Find the interior angle of a square.
The interior angle of a square is 90° , as it is a regular polygon with 4 sides.

Step 3: Find the angle HAB.
Since BCGH is a square, angle HBC is 90° .
The angle ABC in the regular hexagon is 120° .
Therefore, the angle ABH is $120^\circ - 90^\circ = 30^\circ$.

Step 4: Find the angle HAB.
Since $BA = BH$, the angle HAB is equal to $(180^\circ - 30^\circ) / 2 = 75^\circ$.

Therefore, the answer is A: 75° .

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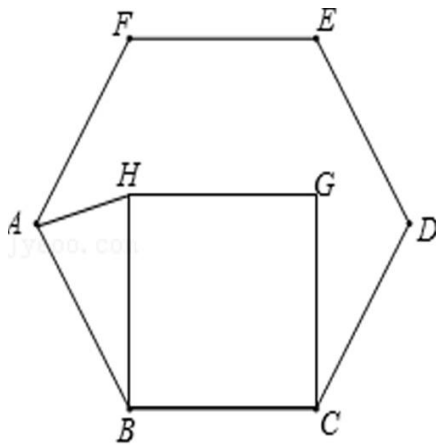
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**Multifaceted Rationale
Embedder**



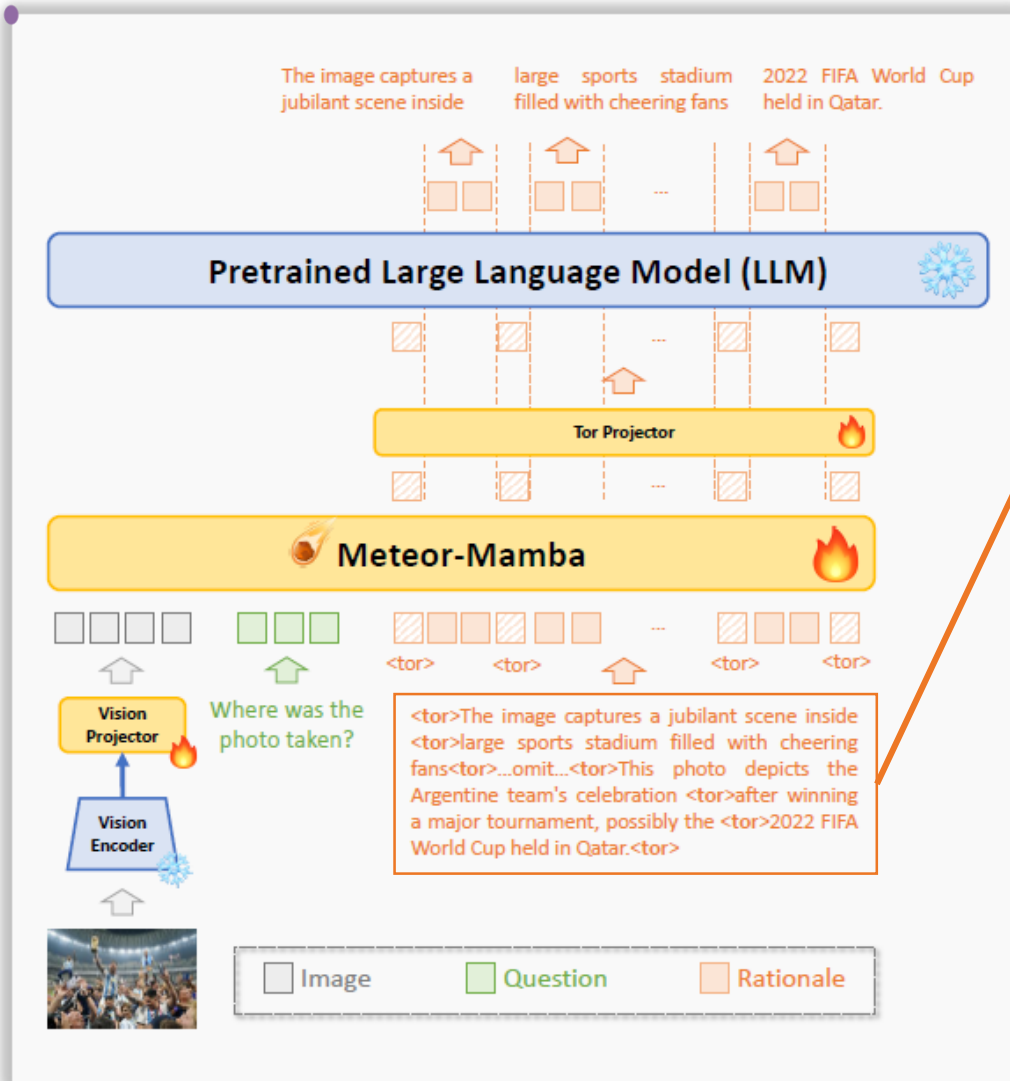
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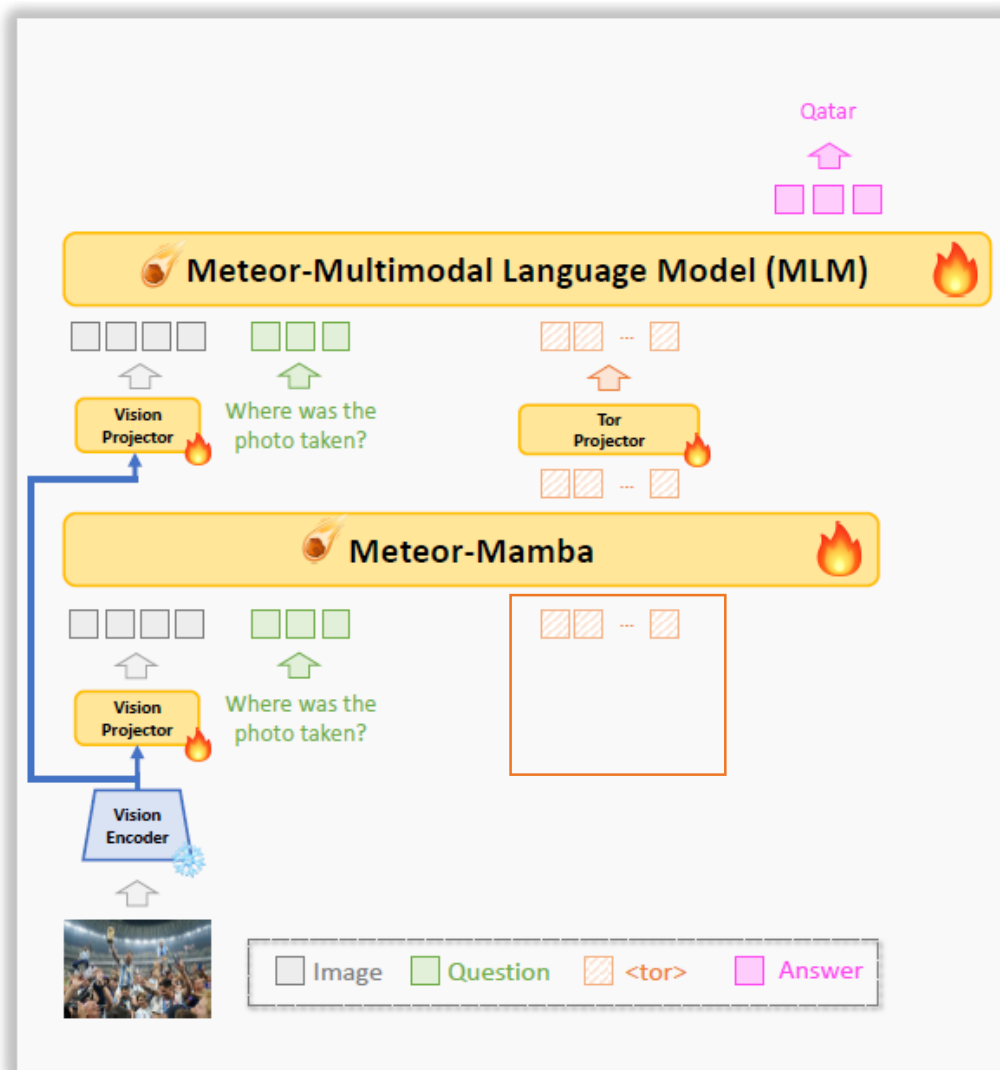
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(a) First Training Step

<tor>The image captures a jubilant scene inside <tor>large sports stadium filled with cheering fans<tor>...omit...<tor>This photo depicts the Argentine team's celebration <tor>after winning a major tournament, possibly the <tor>2022 FIFA World Cup held in Qatar.<tor>

- Why to use Mamba?
Mamba has better embedding of long context rationale
- Why to use <tor>?
We can't use Rationale when doing inference.
- Why to use multiple <tor>?
Just one <tor> cannot embed long rationale.



(b) Second Training Step

In step2, we remove the rationale and only use multiple <tor> tokens, for adaptation to inference mode.

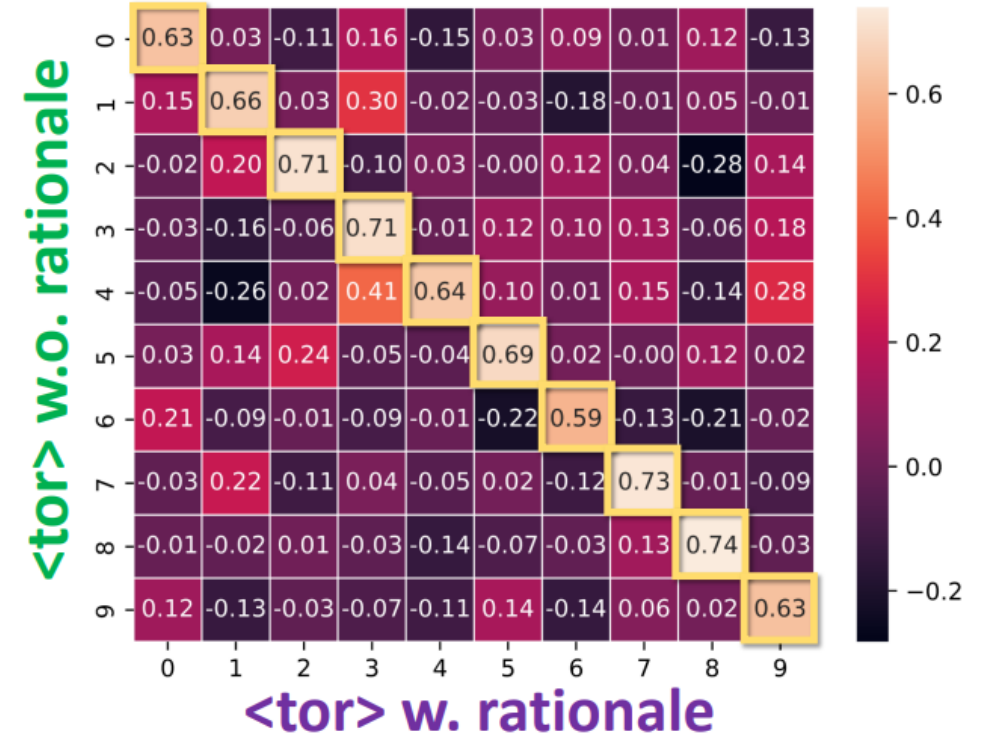
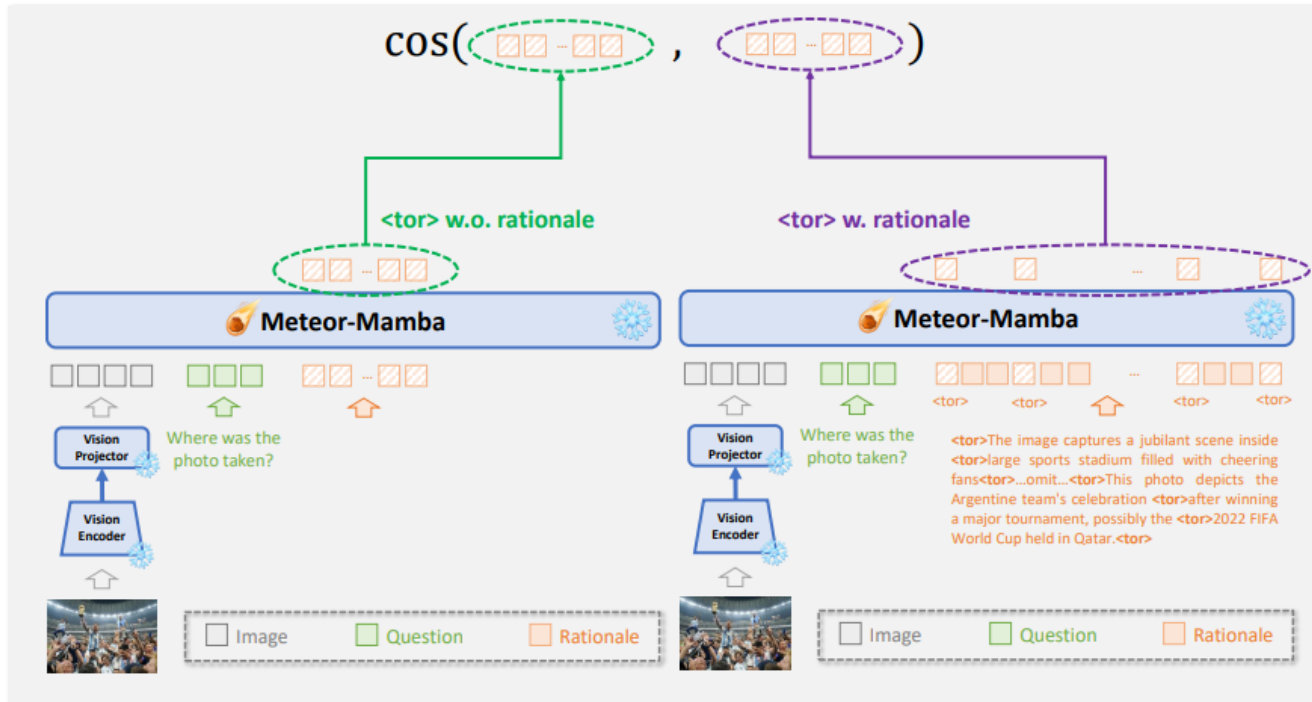
Arch	Param	BPS	MMB	MM-Vet
BERT-B	110M	71	80.6	53.6
GPT2-S	117M	62	80.9	53.5
XLNet-B	110M	56	81.6	53.9
Mamba	130M	118	82.9	57.3

Meteor-Mamba

Num	MMB	MM-Vet
#2	76.1	47.9
#5	82.2	55.8
#10	82.9	57.3
#15	82.8	57.3

Number of <tor> tokens

How to verify Meteor-Mamba embeds rationale?



Benchmarks	OmniFusion [24]	DeepSeek-VL [23]	MoVA [22]	ASMv2 [31]	LAF [32]	CoLLaVO [33]	MoAI [34]	Meteor
POPE	87.2	88.1	88.6	86.3	88.8	87.2	87.1	88.7
SQA-IMG	69.2	57.7	74.4	87.1	-	80.7	83.5	88.3
LLaVA-W	-	-	-	78.9	-	69.5	71.9	87.1
MM-Vet	39.4	41.5	-	41.3	38.9	40.3	43.7	57.3
MMStar	-	-	-	-	-	42.1	48.7	52.8

LLVMs	Recognition	OCR	Knowledge	Language Generation	Spatial Awareness	Math Problems	Avg
CoLLaVO-7B [33]	45.6	31.1	29.8	30.2	37.9	5.8	41.0
MoAI-7B [34]	48.3	34.8	33.5	33.0	39.7	7.7	43.7
Meteor-7B	54.1	60.1	44.2	45.0	59.3	57.7	57.3

