

A Brief Overview of Multimodal Large Language Models

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Abstract

Multimodal large language models (MLLMs) combine different modalities (text, vision, audio, and video) to enable grounded understanding, reasoning, and generative capabilities. This survey reviews core architectures, training strategies, and evaluation paradigms, with a focus on vision-language MLLMs. The rapid progress inevitably introduces challenges in robustness, efficiency, and safety. Future work aims to develop more capable and reliable multimodal systems.

1 Introduction

Humans integrate information from multiple senses, and MLLMs increasingly strive to mirror this ability by processing and reasoning over multimodal data. Combining modalities is motivated by (i) the fact that complementary cross-modal signals enable richer representations and robust reasoning, and (ii) many real-world tasks are multimodal (Baltrušaitis et al., 2017). This paper covers conceptual foundations, model architectures, training strategies, evaluation benchmarks, key challenges, and future directions.

2 Background

MLLMs perform crossmodal learning on large, diverse datasets to produce joint embedding spaces. This enables crossmodal generalization: interpreting complex inputs and reasoning about dependencies (Liang et al., 2024). It unlocks diverse tasks, from image captioning to visual question answering (VQA) (Yin et al., 2024). MLLMs typically use different approaches to fuse modalities. Contrastive objectives bring matched pairs closer and push mismatched ones apart, yielding efficient representations. In contrast, generative objectives train models to produce text conditioned on visual inputs and cause higher computational costs. Recent work

combines two objectives to balance efficiency and expressiveness (Chen et al., 2020).

Brief History. Key milestones such as the encoder-decoder architecture and cross-attention (Vaswani et al., 2017) paved the way for MLLMs. Earlier LLMs achieved zero-shot transfer by pre-training on raw web-scale text (Devlin et al., 2019; Brown et al., 2020; Raffel et al., 2023). However, in computer vision, it was still standard practice to pretrain on crowd-labeled datasets, e.g., ImageNet (Deng et al., 2009). Vision Transformers (ViTs) (Dosovitskiy et al., 2021) first applied transformer logic to images by splitting them into patches and processing them sequentially. This enabled CLIP (Radford et al., 2021) to unlock vision generalization capabilities on par with large language models (LLMs) by scaling contrastive learning on vast image-text data. Other ViT examples (e.g., ALIGN (Jia et al., 2021), Flamingo (Alayrac et al., 2022), BLIP-2 (Li et al., 2023b)) emerged subsequently, followed by CNN-based and hybrid models. Recent models, e.g., GPT-4V (OpenAI, 2023) and Gemini family (Gemini et al., 2025) shows advanced perception skills. This paper covers architectural and training paradigms in Section 3 and 4, respectively.

3 Model Architectures

Understanding MLLM components is crucial to grasp their significance. Main parts are a modality encoder, a pretrained LLM, and a modality interface connecting them (Yin et al., 2024).

3.1 Modality Encoder

Multimodal encoders vary widely in design. CLIP-based models (Cherti et al., 2023; Zhu et al., 2023; Sun et al., 2024) leverage its semantic alignment capability. Alternative encoders use convolutional neural networks (CNNs) (He et al., 2015; Tan and Le, 2020). Some CLIP variants use CNN encoders:

Yuan et al. (2025) use ConvNext-L (Liu et al., 2022) for better pixel-wise understanding via high-resolution features. CNN-based CLIP showed better generalization across various input resolutions, though ViT-based variants show better zero-shot performance (Yu et al., 2023; Wu et al., 2024). Some models eliminate the encoder and use a generator: Bavishi et al. (2023) directly project image patches into the first transformer layer, bypassing the embedding lookup and supporting arbitrary resolutions. McKinzie et al. (2024) showed that image resolution is more important compared to parameter size and training data, and using higher resolution can attain notable performance gains (Liu et al., 2024b; Li et al., 2024c). Thus, MLLMs adopt two main scaling strategies to process higher-resolution images: *direct scaling*, which adapts the encoder via fine-tuning or an additional pretrained encoder (e.g., Hong et al. (2024)), or *patch-division*, which adapts the input by cutting the image into patches compatible with the original encoder resolution (e.g., Li et al. (2024c); Lin et al. (2023)). For modality-specific encoders, examples include Deshmukh et al. (2024) using CLAP-variants (Nizumi et al., 2025) for audio and Han et al. (2023) using ImageBind Girdhar et al. (2023).

3.2 Pretrained LLM

MLLMs use predominantly decoder-only architectures known for scalable generative and instruction-following capabilities, while earlier models (e.g., Dai et al. (2023)) used encoder-decoder setups. Open-source options, e.g., LLAMA (Touvron et al., 2023), are widely used in academia but remain limited in multilingual tasks. In contrast, models such as Qwen (Bai et al., 2023) support bilingual tasks. Recent state-of-the-art (SoTA) models (e.g., McKinzie et al. (2024); Lin et al. (2024)) also use mixture-of-experts (MoE) architecture to address the growing demand for efficiency and task specialization.

3.3 Modality Interface

Since LLMs accept only text inputs, interface is needed to integrate other modalities into text representations. However, it is computationally expensive to train an MLLM end-to-end. Thus, more practical ways are introduced.

3.3.1 Learnable Interface

Different fusion approaches are adopted to project information to a space that LLMs understand.

Token-level fusion concatenates transformed encoder output tokens with text tokens. It can be applied in two ways: (i) Query-based fusion learns some query tokens to compress visual tokens into meaningful embeddings. After BLIP-2 introduced this approach, subsequent models (Dai et al., 2023; Chen et al., 2023a; Zhang et al., 2023) adopted it. (ii) MLP-based fusion uses a simple MLP-based interface to project and align visual tokens with word embeddings (e.g., LLAVA series (Liu et al., 2023b); Su et al. (2023); Pi et al. (2023); Zhang et al. (2024b)). *Feature-level fusion* inserts extra modules between transformer layers via attention mechanism. For example, Flamingo injects extra cross-attention layers, Wang et al. (2024) visual expert models, and Zhang et al. (2024a) learnable prompts. Zeng et al. (2023) found that token-level fusion yields stronger VQA performance, and feature-level fusion often needs better hyperparameter optimization to compete.

3.3.2 Expert Model

This pipeline converts modalities to text without joint training. Li et al. (2024b) uses vision models enriched with a speech recognition model, but this extra conversion may cause information loss and is less flexible and efficient than learnable interfaces. Xu et al. (2025) explore retrieval-augmented generation to mitigate this problem.

4 Training Strategies and Data

Two main training phases are pretraining and fine-tuning. Each phase discussed in this section serves different purposes.

4.1 Pretraining and Data

Data. Training the model on large-scale data to build general world knowledge is essential. McKinzie et al. (2024) carefully conduct ablations on MLLM components and data, and reveal important findings, such as showing that a careful mixture of multimodal data can yield optimal performance. Data used in this mixture differ in quality and source: *coarse-grained data* is typically large-scale and noisy as it is often scraped from the web. Various cleaning methods via tools (e.g., CLIP) can improve quality (Schuhmann et al., 2022). In contrast, *fine-grained data* is obtained through methods such as prompting strong MLLMs (e.g., GPT-4V). This results in smaller but higher-quality data, though at higher costs. Chen et al. (2023b) balance

this trade-off using a pretrained captioner. Readers can find a detailed list of datasets in Table 2.

Pretraining Objectives. Main pretraining approaches include contrastive and masked objectives, which are usually combined in practice (Chen et al., 2020). CLIP-based models adopt *contrastive learning* for zero-shot transfer; this makes models robust to noise and highly scalable (Radford et al., 2021; Jia et al., 2021). Jiang et al. (2024) augments hallucinated captions as hard negatives to address one of the main weaknesses: hallucination, i.e., where models invent non-existent facts/objects. *Multimodal masked modeling* combines masked language modeling and masked image modeling, meaning the model (e.g., as in Chen et al. (2020)) learns to recover masked words/image regions, thereby learning joint representations. Researchers often use it with image-text matching or contrastive learning (e.g., Bugliarello et al. (2021)). *Visual and language pretraining (VLP)* combines previous approaches to perform complex tasks (e.g., Lu et al. (2019); Li et al. (2020)). A common challenge is that the models are usually trained on broad-domain data, so applying them to niche domains often requires domain-specific pretraining (as in Khare et al. (2021)).

4.2 Fine-Tuning

After pretraining, the model undergoes the following fine-tuning steps and methods to adapt its general world knowledge to specific downstream tasks.

Data and Common Practices: Models need task-specific data to adapt their knowledge, e.g., VQAv2 dataset (Agrawal et al., 2016) for VQA tasks. Even more specialized datasets exist, e.g., Singh et al. (2019) to test reading and reasoning about text in images. The second crucial step is hyperparameter optimization. Starting with a small learning rate (LR) to preserve world knowledge, using learning-rate decay schedules (Dale, 2025; Kalra and Barkeshli, 2024), and using adaptive optimizers (Loshchilov and Hutter, 2019) are example methods. Layer-wise strategies are also used: Singh et al. (2015) employs layer-wise rate decay. As for efficiency challenges, researchers often employ parameter-efficient fine-tuning (PEFT) methods (e.g., LoRA (Hu et al., 2021)), which include adding new task-specific layers, tokens, or adapter blocks on top of the frozen base.

Multi-task Fine-tuning: Training on multiple tasks at once allows MLLMs to generalize better across related tasks: Nguyen and Okatani (2018) and Mahabadi et al. (2021) report better generalization performance by fine-tuning on several tasks together. MFTCoder (Liu et al., 2023a) also report SoTA on HumanEval (Chen et al., 2021). This method requires careful design since tasks may have conflicting objectives and require balanced sampling/scheduling (Sener and Koltun, 2019).

Improving Alignment on Crossmodal Tasks: Some tasks, such as image-text retrieval, require precise alignment. SoTA approaches use additional alignment modules to address this. For instance, M2IST (Liu et al., 2025) adds side MoE adapters, showing superior results on referring expression tasks.

Transfer and Few/zero-shot Learning: Pre-trained MLLMs’ strong generalization capacities enable few/zero-shot learning, which are forms of transfer learning. It is especially valuable when labeled datasets are scarce or costly. Few-shot learning provides MLLM with only a few new-task examples (via prompts or a small dataset) (Huang et al., 2023; Tsimpoukelli et al., 2021), while zero-shot learning requires no examples. In practice, researchers often evaluate MLLMs in a zero-shot manner. However, challenges persist: generalizing to a novel task may be difficult, and a poor-quality scheme can lead to suboptimal performance. These issues can be mitigated by incorporating rich pre-training data and research into sophisticated fine-tuning methods.

Instruction-Tuning Multimodal instruction-tuning trains models on natural language instructions so they learn to follow complex human-like commands across modalities and tasks (Li et al., 2024a). This improves efficiency by reducing fine-tuning costs (Peng et al., 2023). Overall, instruction-tuned MLLMs can generalize to new tasks with few or zero new-task examples, reducing sensitivity to instruction variations (Xu et al., 2023b; Liu et al., 2023b).

Chain-of-Thought (CoT) Prompting: In this method, MLLM improves multimodal reasoning by generating intermediate steps, first producing rationales that interpret the image, then using these to infer answers (Zhang et al., 2024c). It shows gains on reasoning-heavy tasks and enhances model inter-

pretability, though it adds computational overhead (Wei et al., 2023).

Adaptation on New Tasks and Domains: A model often loses performance on prior tasks when sequentially fine-tuned on new tasks. Standard optimizers do not guard against this catastrophic forgetting problem (Chakravarthy et al., 2025). Mitigating strategies include replay buffers (Rolnick et al., 2019), distillation (Hinton et al., 2015), parameter isolation (Zeng et al., 2025), using a small LR, and freezing layers. When model encounters a niche task, domain adaptation strategies include gradual fine-tuning (Xu et al., 2021), where the model is first fine-tuned on a broad dataset and then on target domain, and domain-adversarial training (Ganin et al., 2016).

5 Evaluation Paradigms and Applications

This section summarizes established tasks, common metrics, and benchmarks. Readers can see Tables 1 and 3 for detailed descriptions.

5.1 Standard Evaluation Benchmarks and Metrics

MLLMs are typically evaluated along two complementary axes: vision–language understanding tasks and generative tasks.

5.1.1 Core Vision-Language Understanding

Classical evaluation tasks include Image Captioning, VQA, Visual Commonsense Reasoning, and Crossmodal Retrieval to test vision-language fusion. Recently, LLaVA-1.5 (Liu et al., 2024b) reported SoTA, outperforming PaLI Du et al. (2022) and early LLaVA baselines on 11 benchmarks.

Image Captioning: MLLMs improved significantly in generating contextually accurate captions of an image (Li et al., 2020; Huang et al., 2025b). Standard automated n-gram metrics measure semantic correctness and linguistic quality of captions and are used in benchmarks such as COCO Captions (Chen et al., 2015). Recently, learned metrics (e.g., Zhang et al. (2020); Sellam et al. (2020); Hessel et al. (2022); Ruiz et al. (2025)) are preferred since n-gram metrics poorly capture semantic fluency (Pu et al., 2021) and are often complemented by human feedback due to task’s subjective nature¹.

¹LMarena is currently SoTA for human-preference ranking: <https://lmarena.ai/>

Visual Question Answering (VQA): Recent MLLMs use co-attention mechanisms (Liu et al., 2024a) or knowledge-enhanced models (Lan et al., 2023) in VQA tasks. Benchmarks measure the model’s capability to answer open-ended questions about images. Usually, accuracy is measured on VQAv2. Variants include domain-specific datasets and versions for other modalities (e.g., Yang et al. (2022); Cao et al. (2024); Xu et al. (2016)).

Crossmodal Retrieval: Metrics such as Recall@K, median rank (MedR), and mean reciprocal rank (MRR) measure the performance of the model for retrieving relevant images given a query and vice versa (Kiros et al., 2014; Faghri et al., 2018). ALIGN and subsequent models can serve as comparative baselines.

Multimodal Classification and Visual Commonsense Reasoning (VCR): Typical classification metrics include accuracy and F1-scores. Conversely, VCR (Zellers et al., 2019) requires more advanced metrics, including multiple-choice setups or annotated rationale evaluation. Because it extends beyond object recognition or scene description: it requires MLLMs to exhibit a nuanced understanding by incorporating contextual knowledge, causal relationships, and social dynamics. This capability enables models to predict an event or explain the cause of it. Benchmarks such as GQA (Hudson and Manning, 2019) test this ability.

5.1.2 Generative and Creative Applications

These tasks focus on skills such as multimodal content creation and editing, rather than understanding. Evaluation is difficult, so recent practice combines learned, task-specific, or embedding-based metrics with human or LLM-assisted evaluations to judge coherence, faithfulness, quality, and safety. Composite benchmarks usually test these applications.

5.2 Holistic Evaluations(Composite/Meta Benchmarks)

Conventional tasks examine narrow capabilities and cannot fully characterize general-purpose MLLMs. Recent unified benchmarks, e.g., AbilityLens (Chen et al., 2025), address this gap by probing advanced tasks combined and aim to fix significant evaluation variance of first-generation composite benchmarks (e.g., Liu et al. (2024c); Li et al. (2023a)). These suites are useful to expose MLLMs’ strengths, weaknesses, and future directions.

5.3 Safety, Fairness and Content Moderation

Generative models introduced novel safety challenges. Web-scale data naturally contains biases, causing models to propagate stereotypes and hallucinations (Chen et al., 2023c). MLLMs should be audited for fairness and harmful content. Several frameworks have been developed to address this. For example, Chen et al. (2023c) conduct demographic analyses to identify potential biases. LLaVaShield (Huang et al., 2025a) safeguards multi-turn dialogues from malicious intent, outperforming baselines on content moderation. Raza et al. (2025) show that visual cues improve bias detection in multimodal news accuracy by 3–5%. Cui et al. (2025) focus on detecting multimodal implicit toxicity, i.e., individual modalities convey risk when combined, and provide a taxonomy of risks. Diagnostic benchmarks (e.g., H-POPE (Pham and Schott, 2024)) aim to measure hallucination, which is another critical challenge. New alignment methods can also help: Xing et al. (2025) focuses on vision-language alignment to mitigate hallucination. It achieves SoTA results on both POPE (Li et al., 2023c) and HallusionBench (Guan et al., 2024). Comprehensive benchmarks such as MM-SOC (Jin et al., 2024) are designed to evaluate many risks together.

5.4 Applications

Emerging applications aim to leverage the full capabilities of MLLMs to broaden their accessibility, domain coverage, and use cases. Examples include multimodal chatbots, augmented reality (AR), personalization, robotics, healthcare, assistive technologies, and smart-home assistants. Several works (Huang et al., 2023; Li et al., 2024a) demonstrate strong instruction-following capabilities. Gemini 2.5 represents a new generation of complex reasoning capabilities with SoTA performance (Comanici et al., 2025). For healthcare, Saab et al. (2024) achieved a new SoTA of 91.1% accuracy for MedQA (Jin et al., 2020), surpassing GPT-4V on NEJM (Buckley et al., 2024). For personalization, movie and e-commerce recommender systems can leverage multimodal features.

Overall, as MLLMs evolve, evaluation suites increasingly shift toward integrated, real-world, and user-centric benchmarks and provide significant insights that identify limitations and future directions through exhaustive evaluation.

6 Challenges and Future Directions

Despite impressive progress, several challenges remain:

Efficiency and Scalability: Chen et al. (2023c) note that scaling modalities improves performance, but training remains cost-intensive. Techniques such as PEFT, knowledge distillation, and model compression can reduce the cost. Lightweight encoders (e.g., LightCRL (Faye et al., 2024)) show promising reductions.

Safety and Fairness: Future MLLMs must better detect harmful content, improve alignment, incorporate uncertainty estimation, and respect user intent. Transparency in data and model cards should become standard.

Multilingual and Low-Resource Modalities: Most MLLMs still predominantly support English, due to limited multilingual multimodal data (Gao et al., 2025). Expanding coverage to low-resource languages and culturally diverse imagery will enhance inclusivity and applicability.

Evaluation Mismatch: Current benchmarks test narrow tasks and overlook real-world scenarios. Developing standardized evaluation suites that assess reasoning, grounding, and safety is essential.

Interactive Multimodality and Embodied Applications: Models that learn through user interaction can adapt to personal needs and preferences, extending accessibility. Incorporating human feedback (e.g., through reinforcement learning from human feedback (Ouyang et al., 2022)) and active learning improves robustness. Combining these with spatial and physical reasoning will enable embodied agents that operate in the real world.

7 Conclusion

MLLMs have transitioned from simple feature fusion to advanced general-purpose systems that reason across modalities. Recent progress signals a future where multimodality is a native capability. Despite these developments, achieving safe, reliable, and inclusive MLLMs requires responsible data practices, innovative architectures, and standardized evaluation. Addressing these challenges will help make multimodality a core component of future AI systems.

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A Detailed Evaluation Metrics

Table 1: Evaluation metrics (Section 5), categorized by task.

Metric	Primary Task(s)	Description
Core Language-Vision Evaluation Metrics(Automated)		
BLEU	Image Captioning	Focuses on n-gram precision (Papineni et al., 2002).
METEOR	Image Captioning	Incorporates synonym matching and recall (Banerjee and Lavie, 2005).
CIDEr	Image Captioning	Emphasizes consensus among human reference captions (Vedantam et al., 2015).
ROUGE	Image Captioning	Measures overlap of units (e.g., n-grams or subsequences) (Lin, 2004).
SPICE	Image Captioning	Used alongside other n-gram metrics. (Anderson et al., 2016)
Core Language-Vision Evaluation Metrics (Learned/Multimodal)		
BERTScore	Image Captioning / Generative	Embedding-based metric to better capture semantic similarity and fluency (Zhang et al., 2020).
BLEURT	Image Captioning / Generative	Learned metric to better capture semantic equivalence and fluency aligned with human ratings (Sellam et al., 2020).
CLIPScore	Image Captioning / Generative	A multimodal embedding-based score that evaluates semantic alignment (Hessel et al., 2022).
VCRScore	Image Captioning	A recently proposed learned/trainable metric for caption fluency and accuracy (Ruiz et al., 2025).
Retrieval Metrics		
Recall@K (R@1, R@5, R@10)	Crossmodal Retrieval	Measures if the correct item is retrieved within the top K results (Kiros et al., 2014).
Median Rank (MedR)	Crossmodal Retrieval	The median rank of the correctly retrieved item (Kiros et al., 2014).
Mean Reciprocal Rank (MRR)	Crossmodal Retrieval	The average of the reciprocal ranks of correct items (Craswell, 2009).
Classification & VQA Metrics		
Accuracy (Exact/Soft Match)	VQA / Classification	Measured as an exact or soft match against the majority human answers or gold-standard labels (Mañas et al., 2024).
F1-score	Multimodal Classification	Standard metric for classification tasks (Powers, 2020).

B Datasets used for pre-training or fine-tuning

Table 2: Datasets used for pre-training or fine-tuning (Section 4)

Dataset	Category	Description
Supervised Vision Pre-training		
ImageNet	Vision Pre-training	Crowdsourced labeled dataset for supervised vision model training (Deng et al., 2009).
Web-Scale Pre-training Datasets		
CC-3M / CC-12M	Web Image–Text Pairs	Coarse-grained image–text pairs collected from the web with different cleaning pipelines (Sharma et al., 2018; Changpinyo et al., 2021).
SBU Captions	Web Image–Text Pairs	Flickr-sourced coarse image–text pairs (Ordonez et al., 2011).
LAION (all variants)	Large-Scale Web Image–Text Pairs	Large-scale coarse-grained image–text pairs for multimodal pre-training (Schuhmann et al., 2021, 2022).
COYO-700M	Web Image–Text Pairs	Large-scale coarse-grained dataset derived from CommonCrawl (Byeon et al., 2022).
CommonCrawl	Web Crawl Source	Large web scrape powering many multimodal datasets (Patel, 2020).
WebLI	Multilingual Web Image–Text Pairs	Multilingual image–text pairs used by PaLI (Chen et al., 2023c).
Curated Image–Text Datasets		
ShareGPT4V	High-Quality Captions	1.2M high-quality, fine-grained, model-generated captions (Chen et al., 2023b).
MS-COCO	Curated Vision–Language	≈330K images with 5 captions each; used for image captioning & retrieval (Lin et al., 2015).
COCO Captions	Caption References	Human reference captions used for evaluating caption metrics (Chen et al., 2015).
Flickr30K	Curated Image–Text	Widely used dataset for crossmodal retrieval (Plummer et al., 2016).
Audio & Video Datasets		
AudioSet	Audio Clips	≈2M labeled 10s audio clips across 632 classes (Gemmeke et al., 2017).
HowTo100M	Video + Narration	136M instructional video clips with narration (Miech et al., 2019).

C Evaluation Benchmarks

Table 3: Evaluation benchmarks (Section 5), categorized by task type.

Benchmark	Category	Description
Core V-L Benchmarks		
VQA v2.0	Visual QA	Widely used benchmark for answering natural language questions about images (Agrawal et al., 2016).
TextVQA	Text-based QA	Requires models to read and reason about text inside images (Singh et al., 2019).
GQA	VCR and VQA	Tests compositional reasoning over structured scene graphs (Hudson and Manning, 2019).
VCR	Visual Commonsense Reasoning	Evaluates commonsense inference and “why/what next” reasoning (Zellers et al., 2019).
Video & Temporal Benchmarks		
AVQA	Audio-Visual QA	Audio + vision temporal reasoning benchmark (Yang et al., 2022).
UNQA	Video QA	Time-dependent video-based question answering (Cao et al., 2024).
MSR-VTT	Video QA / Retrieval	Benchmark for video–language understanding (Xu et al., 2016).
Generative / Coding Benchmarks		
HumanEval	Code Generation	Standard benchmark for evaluating code-generation abilities (Chen et al., 2021).
Holistic / Meta Evaluation Suites		
MMBench	Holistic Evaluation	Multilingual multi-category evaluation with CircularEval (Liu et al., 2024c).
SEED-Bench	Multimodal QA	24k human-annotated questions across 12 dimensions (Li et al., 2023a).
LLaVA-Bench	Holistic Evaluation	General-purpose MLLM evaluation suite (Liu et al., 2023b).
InstructBLIP Eval	Holistic Evaluation	Benchmark tailored to InstructBLIP-style models (Dai et al., 2023).
LVLm-eHub	Meta Evaluation Suite	All-around evaluation hub for MLLMs (Xu et al., 2023a).
VLMEvalKit	Meta Evaluation Suite	Toolkit for unified multimodal evaluation (Duan et al., 2025).
AbilityLens	Meta Evaluation Suite	A unified benchmark for evaluating six key perception abilities focusing on both accuracy and stability (Chen et al., 2025)
Hallucination Benchmarks		
POPE	Object Hallucination	Measures invented objects in VL model predictions (Li et al., 2023c).
HallusionBench	General Hallucination	Detects invented objects or factual inconsistencies (Guan et al., 2024).
H-POPE	Hierarchical Hallucination	Multi-level hallucination probing benchmark (Pham and Schott, 2024).
CHAIR	Caption Hallucination	Measures hallucinated objects in image captions (Rohrbach et al., 2019).
Safety & Bias		
MM-SOC	Safety / Social Reasoning	Evaluates models on misinformation, hate speech, and social context (Jin et al., 2024).
SHIELDVLM	Toxicity Detection	Detects implicit multimodal toxicity across risk categories (Cui et al., 2025).
LLaVASHield	Safety Alignment	Guards multi-turn multimodal dialogues against malicious intents (Huang et al., 2025a).
ViLBias	Bias Detection	Measures bias in multimodal news interpretation (Raza et al., 2025).
Domain-Specific Benchmarks		
ScienceQA	Domain QA	Multimodal science-domain QA dataset (Lu et al., 2022).
MedQA	Medical QA	Medical-domain QA benchmark used for evaluating Med-Gemini (Jin et al., 2020).
NEJM Image Challenges	Medical Image QA	Clinical image-based reasoning challenge (Buckley et al., 2024).