Pre-training End-to-End Vision-Language Transformers

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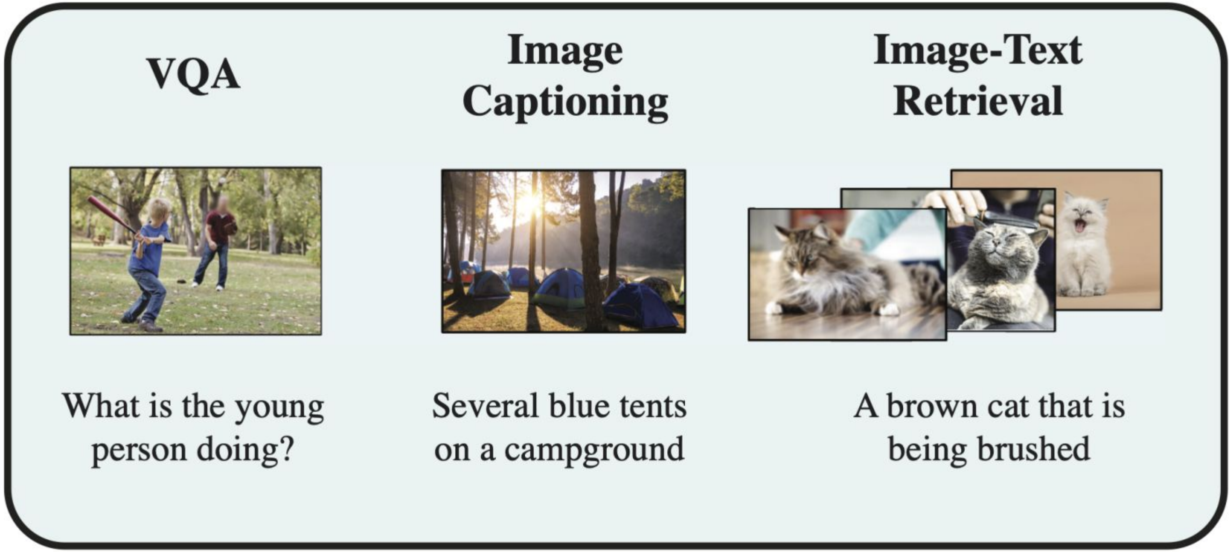
Vision-Language Models

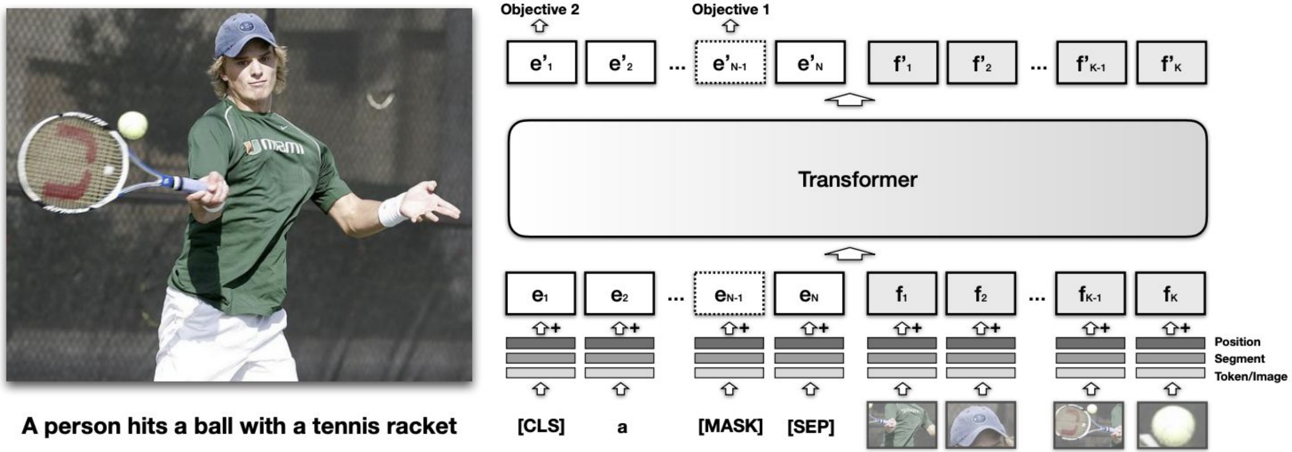
Vision-language models combine information from both visual and textual modalities to perform various tasks.

Pre-training models on large image-text corpora is highly effective.


VQA
Image Captioning
Image-Text Retrieval
What is the young person doing?
Several blue tents on a campground
A brown cat that is being brushed

Previous Work

Most previous methods rely on CNN-based object detectors.



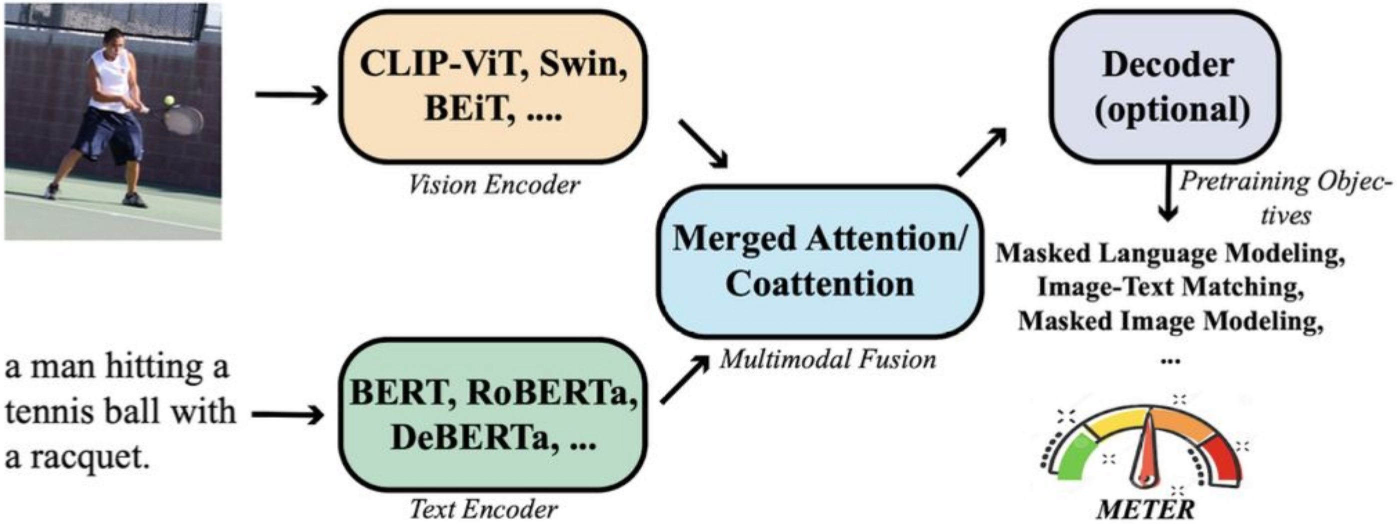
[Li et al., 2019]

Transformers have shown promising performance in both NLP and CV:

- Potential of having a unified architecture for vision and language.
- End-to-end training of both cross-modal and uni-modal modules during pre-training.

Empirical Studies of Training Vision-Language Transformers

We dissect the model designs along multiple dimensions and perform investigations on each of the modules:



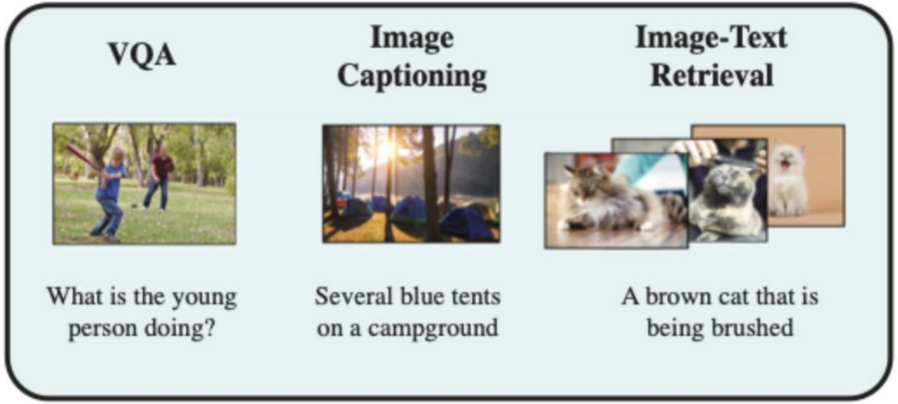
CLIP-ViT, Swin, BEiT, ...
Vision Encoder
a man hitting a tennis ball with a racquet.
BERT, RoBERTa, DeBERTa, ...
Text Encoder
Merged Attention/ Coattention
Multimodal Fusion
Decoder (optional)
Pretraining Objectives
Masked Language Modeling,
Image-Text Matching,
Masked Image Modeling,
...
METER

[Dou et al., CVPR 2022]

Region-Level Vision-Language Tasks

In addition to image-level tasks such as VQA, there are also region-level tasks like object detection and phrase grounding.

Collecting fine-grained annotations for region-level tasks is costly and non-scalable.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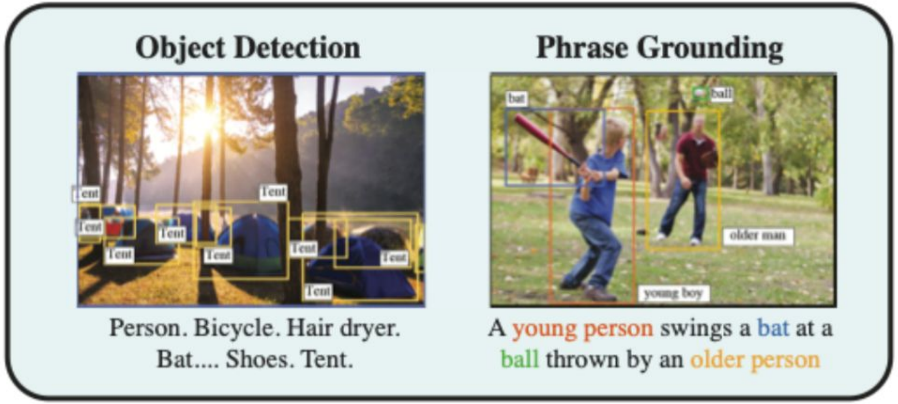
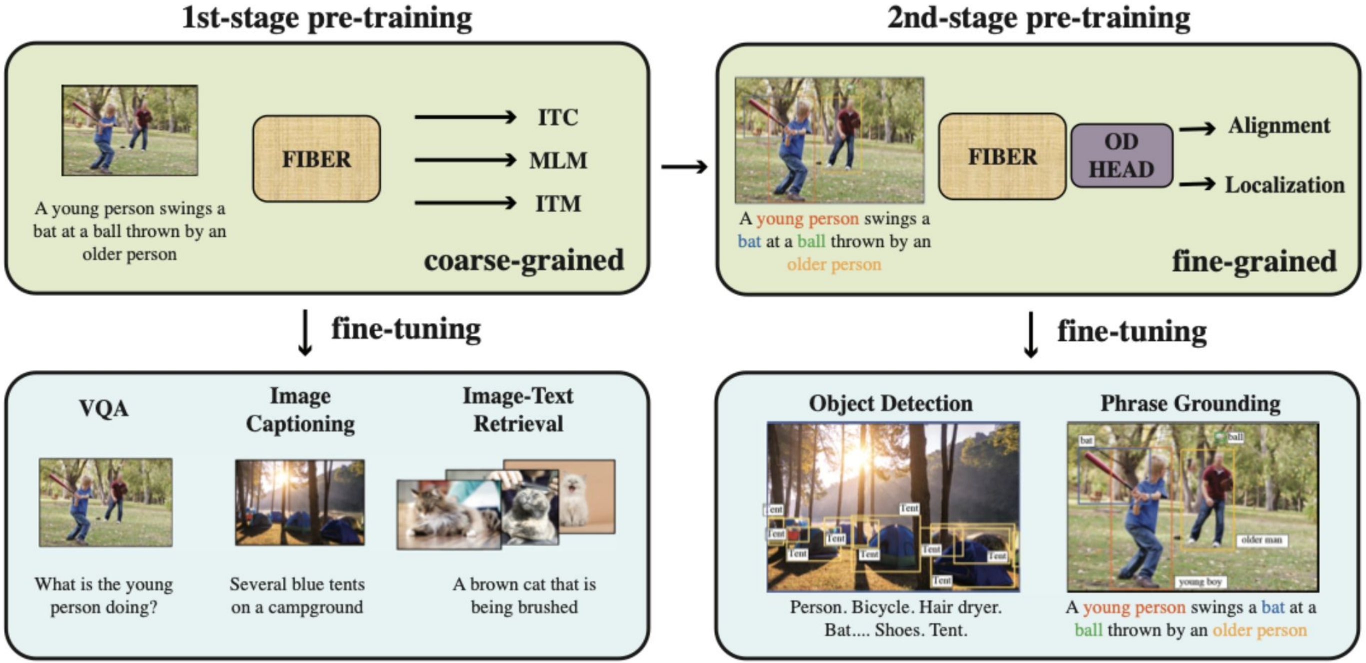

Object Detection
Phrase Grounding
Tent
Tent
Tent
Tent
Tent
Tent
Tent
Tent
bat
ball
older man
young boy
Person. Bicycle. Hair dryer. Bat.... Shoes. Tent.
A young person swings a bat at a ball thrown by an older person

Coarse-to-Fine Vision-Language Pre-training

We propose a coarse-to-fine pre-training paradigm that can support both image-level and region-level vision-language tasks.



1st-stage pre-training
A young person swings a bat at a ball thrown by an older person
FIBER
ITC
MLM
ITM
coarse-grained
2nd-stage pre-training
A young person swings a bat at a ball thrown by an older person
FIBER
OD HEAD
Alignment
Localization
fine-grained
fine-tuning
fine-tuning
VQA
What is the young person doing?
Image Captioning
Several blue tents on a campground
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Object Detection
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Phrase Grounding
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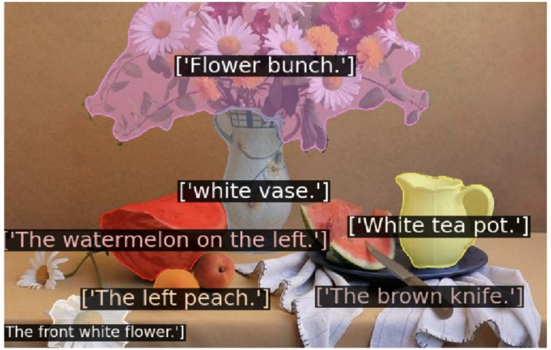
[Dou & Kamath & Gan et al., NeurIPS 2022]

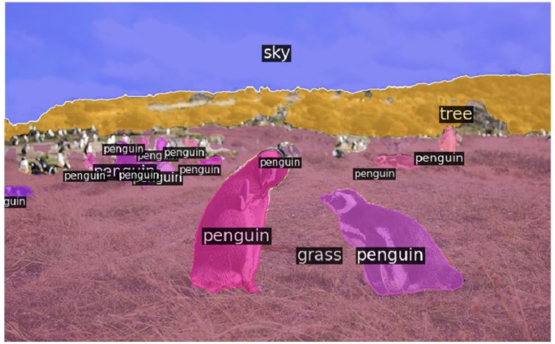
Pixel-Level Vision-Language Tasks

Tasks such as image segmentation require pixel-level outputs.

It is non-trivial to build models that support both traditional vision-language and segmentation tasks.

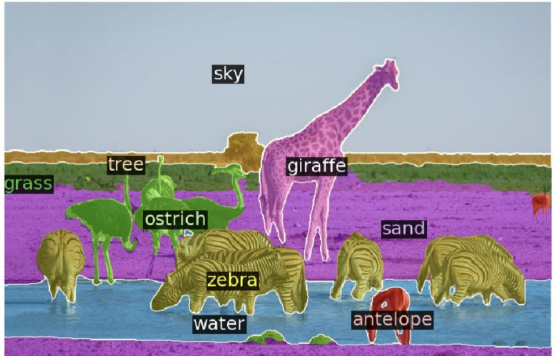


Referring Segmentation

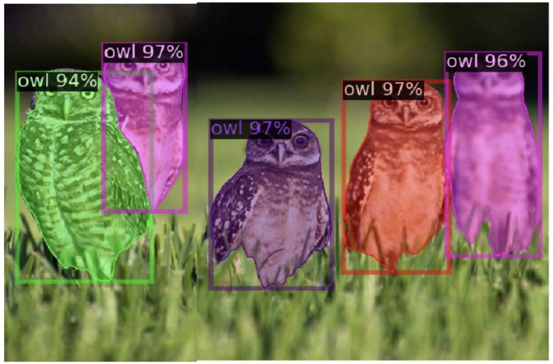


Open-Vocabulary Panoptic Segmentation

Open-Vocabulary Semantic Segmentation



Open-Vocabulary Instance Segmentation

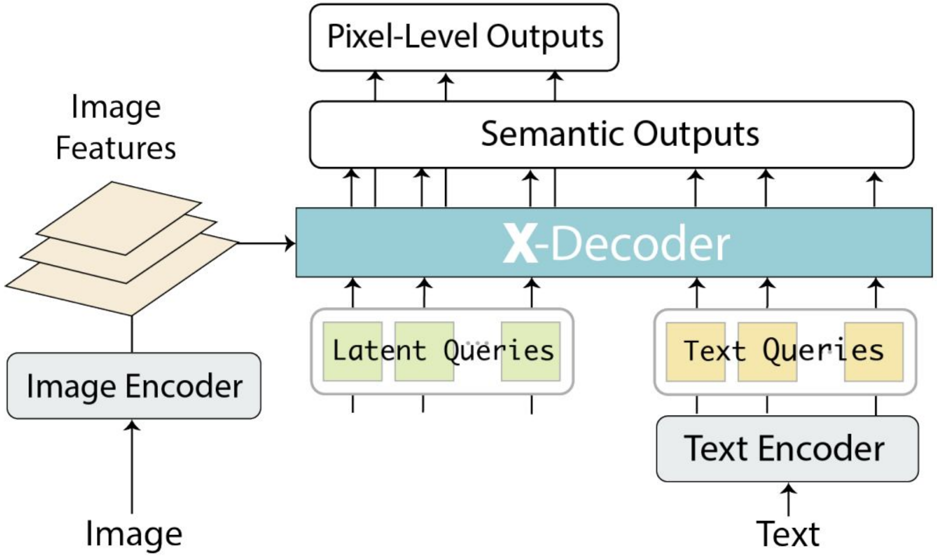


Generalized Decoding for Pixel and Language

We present X-Decoder, a generalized decoding pipeline that can predict pixel-level segmentation and language tokens seamlessly.

X-Decoder takes as inputs two types of queries:

- (i) generic non-semantic queries;
- (ii) semantic queries induced from text inputs.



[Zou & Dou & Yang et al., 2023]