



Vision for the Blind

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Project Introduction





Close your eyes



Problem Introduction

Fundamental Aim in Computer Vision Research:

Machine Capable of Replication Human vision

Challenge:

Design technology that assists people who are blind, helping navigate visual challenges

Objective:

Assistive technology for the blind by developing an AI-powered visual query assistant, allowing visually impaired users to take photos, ask questions, and navigate surroundings for effectively. We enhance this experience by also helping them locate the placement of an exact image



Cognitive Problems

1. Semantic Scene Understanding and Contextual Question Answering

- Technology Used: CLIP and Vision-and-Language Transformer (ViLT) Model
- Function: Interprets complex scenes and contextual queries
- Key Features:
 - Provides nuanced understanding of both visual content and language queries
 - Grasps broader context of scenes and interactions between objects

2. Object Detection and Counting within Complex Scenes

- Technology Used: YOLO for Object Segmentation
- Function: Detects and counts objects within user-referenced queries
- Key Features:
 - Identifies and highlights specific items in an image
 - Assists users in locating and understanding objects in their environment

Dataset - VizWiz (2023 Edition)

Files include: *Annotations* (.json) , *train/val/test* (images)

Structure:

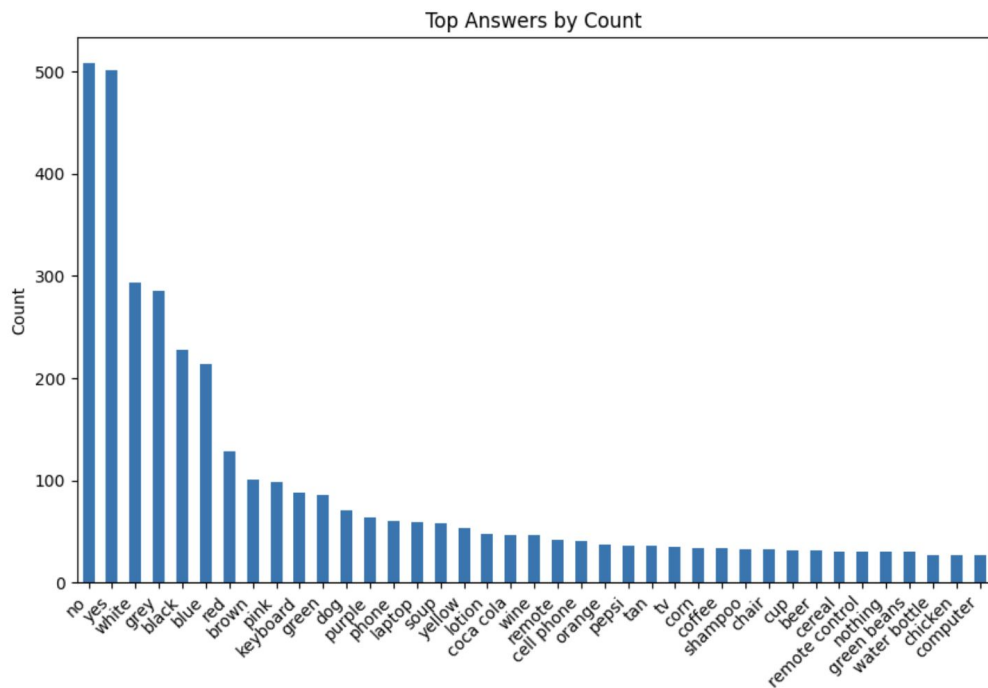
- **answerable**: A binary indicator denoting if the question is answerable (1) or not (0).
- **image**: The filename of the image related to the question.
- **question**: The text of the question asked about the image.
- **answer_type**: The type of the answer, indicating whether it is answerable or unanswerable.
- **answers**: A list of answers provided by crowd workers. Each answer includes:
 - **answer**: The text of the answer.
 - **answer_confidence**: The confidence level of the answer (e.g., "yes", "no", "maybe").

```
"answerable": 0,  
"image": "VizWiz_val_00028000.jpg",  
"question": "What is this?"  
"answer_type": "unanswerable",  
"answers": [  
    {"answer": "unanswerable", "answer_confidence": "yes"},  
    {"answer": "chair", "answer_confidence": "yes"},  
    {"answer": "unanswerable", "answer_confidence": "yes"},  
    {"answer": "unanswerable", "answer_confidence": "no"},  
    {"answer": "unanswerable", "answer_confidence": "yes"},  
    {"answer": "text", "answer_confidence": "maybe"},  
    {"answer": "unanswerable", "answer_confidence": "yes"},  
    {"answer": "bottle", "answer_confidence": "yes"},  
    {"answer": "unanswerable", "answer_confidence": "yes"},  
    {"answer": "unanswerable", "answer_confidence": "yes"}  
]
```

Source:

<https://www.kaggle.com/datasets/nqa112/vizwiz-2023-edition/data>

EDA: Training Data

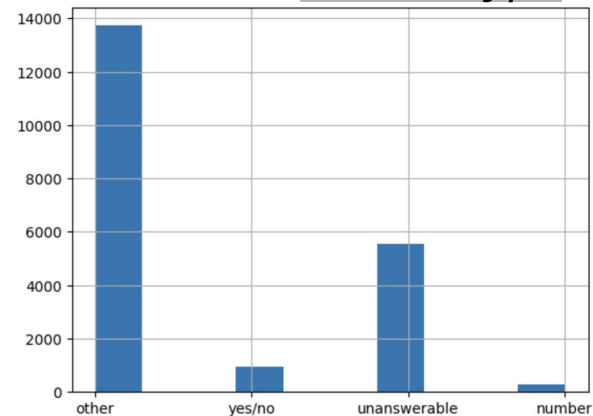


Top 40 Answers by Count

```
train_data.answer_type.hist()
```

<Axes: >

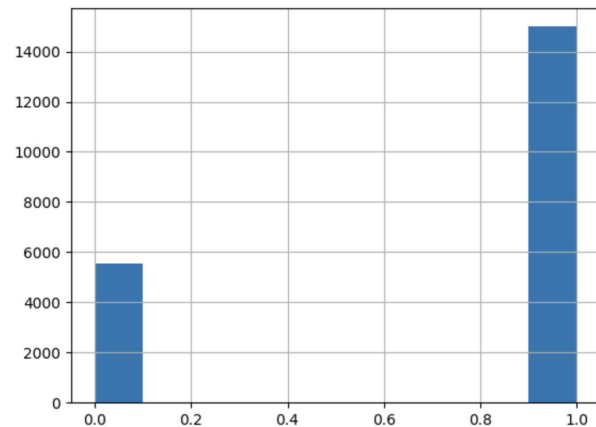
answer_type



```
train_data['answerable'].hist()
```

<Axes: >

answerable



Q: What is this



A: unanswerable

Q: What flavor of curry cup is this?



A: unanswerable

Q: For how long do I cook this in the microwave?



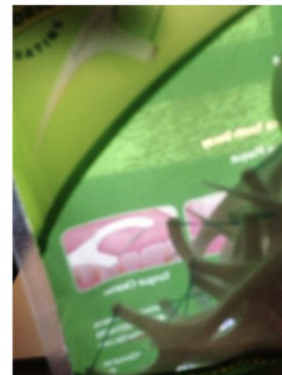
A: unanswerable

Q: What fruit is this?



A: orange

Q: What is this?



A: unanswerable

Q: Haven't said enough



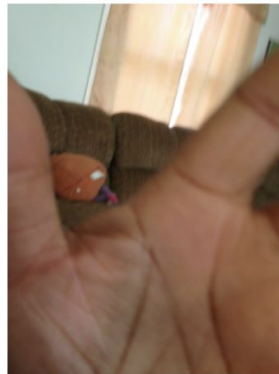
A: unanswerable

Q: What is this?



A: barcode

Q: What's the picture?



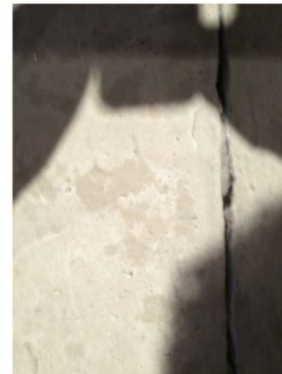
A: hand

Q: What is this



A: unanswerable

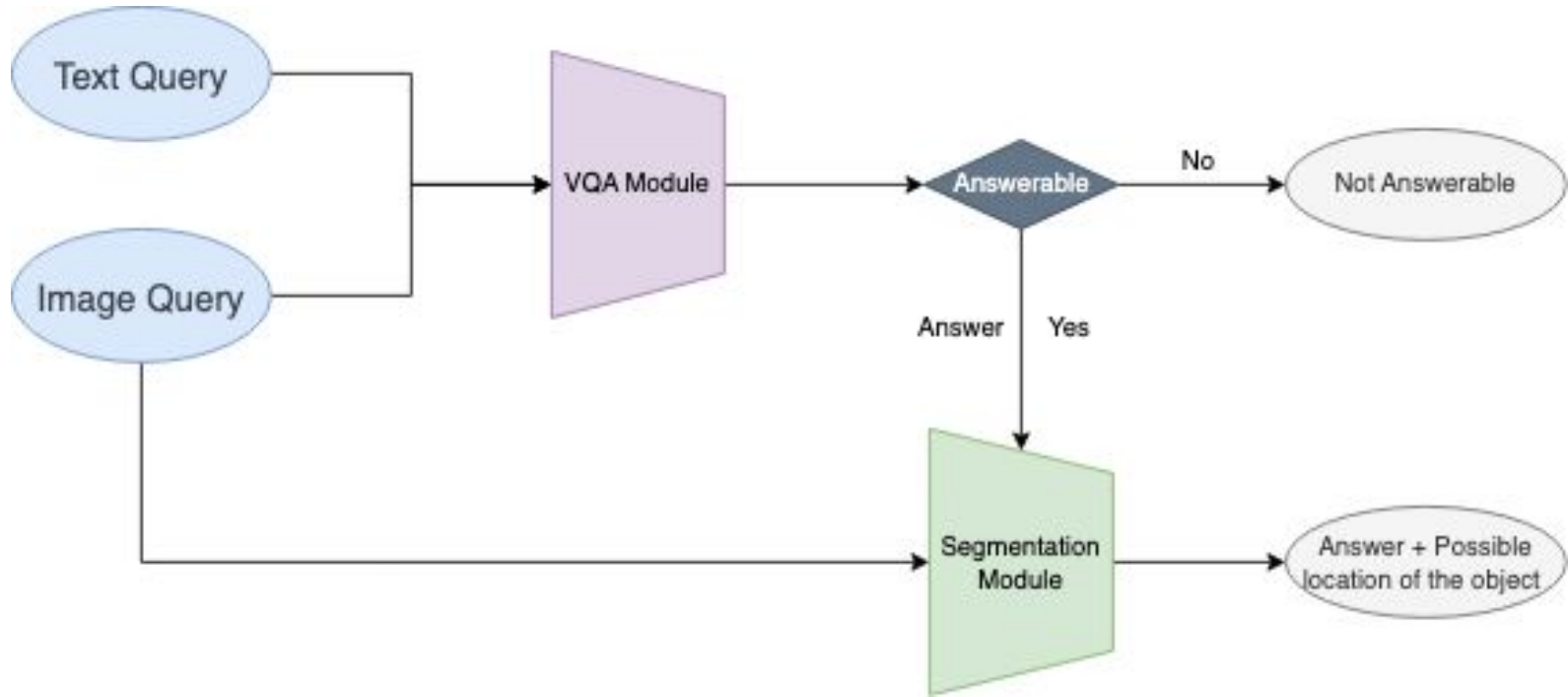
Q: What colors are present in this?



A: grey

Figure. Sample Example from VizWiz Training Dataset

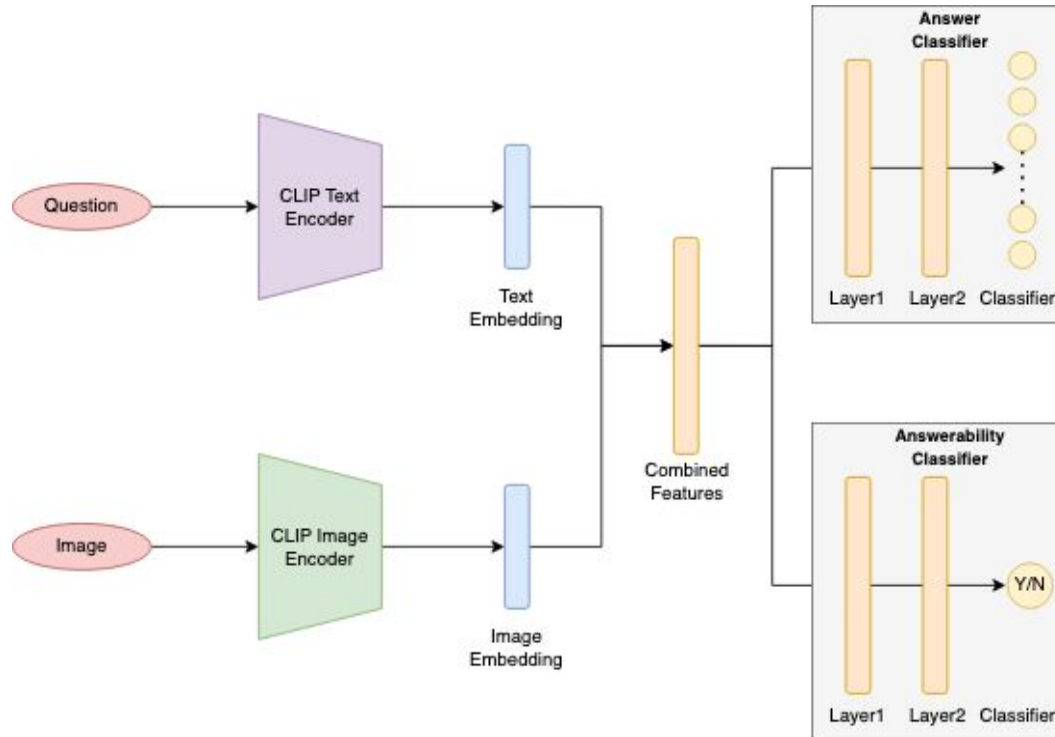
Project Flowchart



VisualAid VQA FlowChart

VQA

CLIP Based Visual Question Answering



Key Components

1. Feature Extractors

- CLIP Text Encoder : Transforms the question into a semantic text embedding.
- CLIP Image Encoder : Converts the image into a visual embedding.

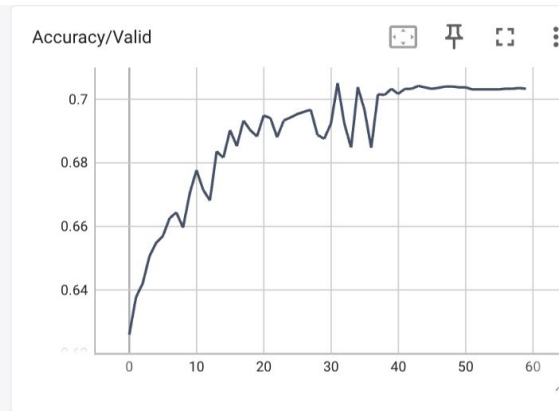
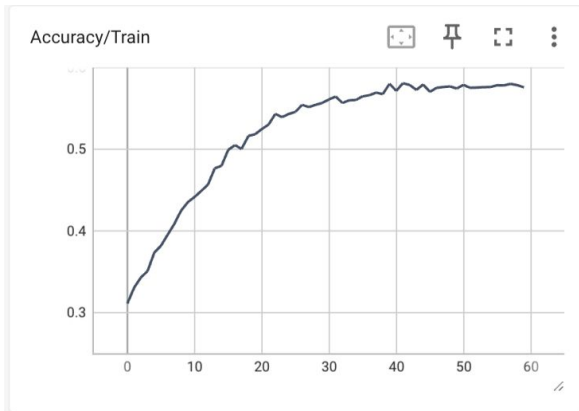
2. Answerability Detection

- Determine if a given question can be answered with respect to the provided image

3. Answer Classifier

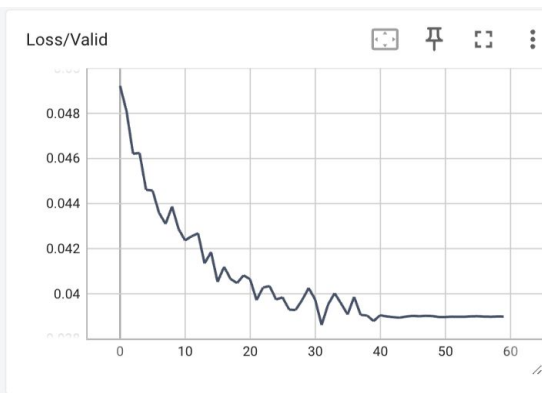
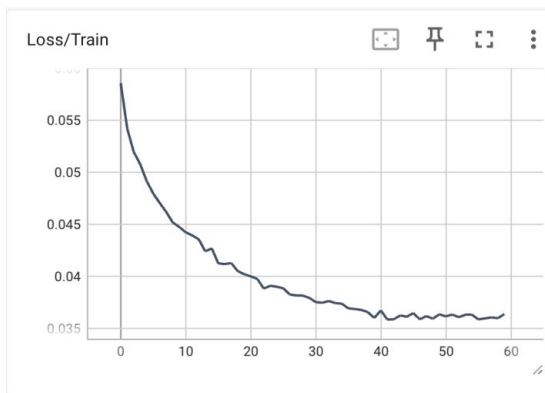
- Classifies each question into one of n predefined classes based on the combined image and text embeddings

CLIP VQA Training



Hyperparameters

1. Epochs : 60
2. Batch_size : 128
3. Optimizer : Adam
4. Learning Rate : 0.0001
5. Clip Model : Clip RN50
6. Loss Function : Categorical Cross Entropy Loss

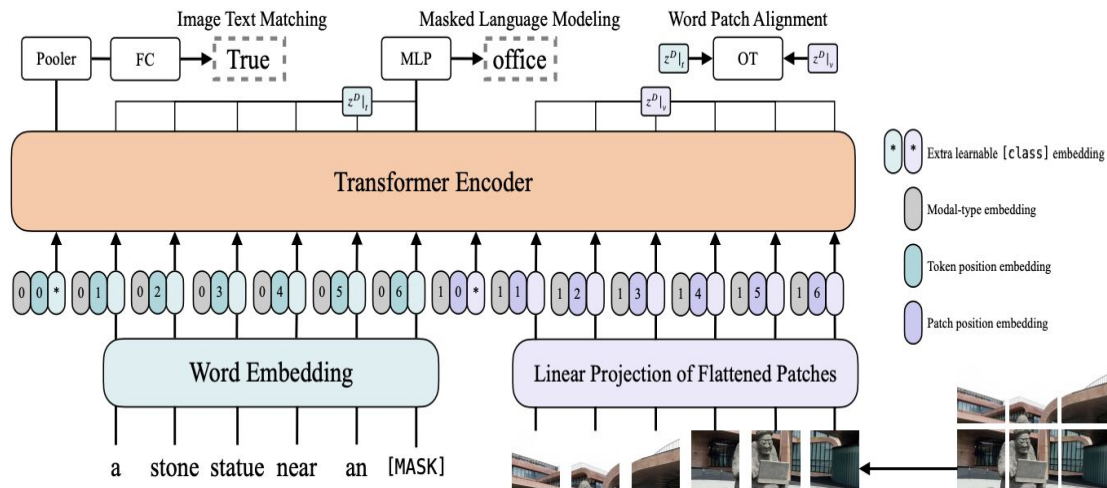


Network Architecture

1. CLIP Backbone Freezed
2. MLP Architecture
 - a. FC (4096) -> LN -> Drop (0.5)
 - b. FC (4096) -> LN -> Drop (0.5)

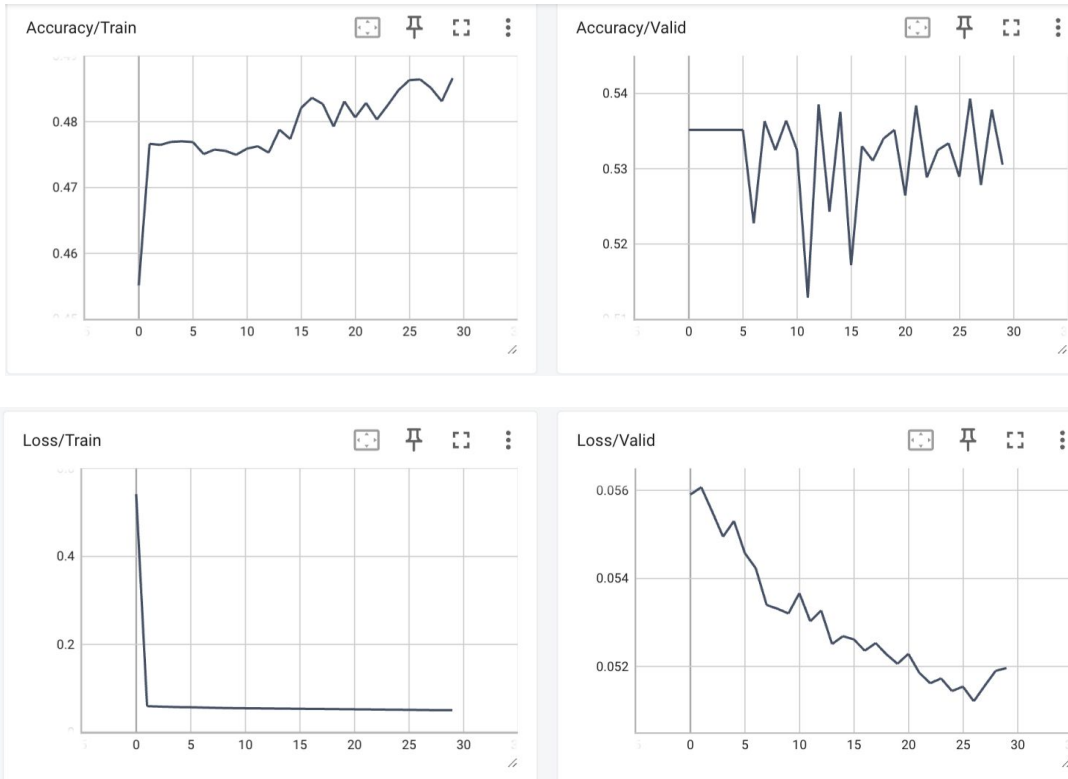
ViLT: Vision-and-Language Transformer Without Convolution or Region Supervision

Key Components



1. **Visual Encoder:** Utilizes Vision Transformers (ViT). Extracts visual features from images using linear projected patches.
2. **Textual Encoder:** Uses BERT to process the textual input
3. **Cross-Modal Interaction:** Uses a Transformer-based architecture to fuse visual and textual features.
4. **Pre-training Tasks:**
 - a. Masked Language Modeling (MLM) and Image-Text Matching (ITM)
5. **Fine-Tuning for VQA:**
 - a. Input: Combines image features and question embeddings.
 - b. Output: Predicts answers from a predefined set of possible answers.

Vilt VQA Training



Hyperparameters

1. Epochs : 30
2. Batch_size : 160
3. Optimizer : SGD with Cyclic LR Scheduler
4. Base Lr : 0.0001
5. Max Lr : 0.005
6. Momentum : 0.9
7. Loss Function : Categorical Cross Entropy Loss

Results

Performance Metrics

- a. **accuracy** = $\min(\# \text{ humans that provided that answer} / 3, 1)$

Model Name	Train Accuracy	Validation Performance
Answerability Module	98.72 %	94.37 %
CLIP VQA	56.44 %	70.51 %
Vilt VQA	47.49 %	53.85 %

Example Predictions

Input

Select the Model
CLIP

Type a question
what is this

Upload an image
Drag and drop file here
Limit 200MB per file • PNG, JPG, JPEG
Browse files

dog.jpg
360.4KB

☒ Object Detection

Visual Question Answering

Uploaded Image



Resized image

Image Annotation and Labeling



Labeled image

Your Question: what is this?

Predicted Answer: Dog. The answerability score is 0.99.

Input

Select the Model
VILT

Type a question
what is this

Upload an image
Drag and drop file here
Limit 200MB per file • PNG, JPG, JPEG
Browse files

dog.jpg
360.4KB

☒ Object Detection

Visual Question Answering

Uploaded Image



Resized image

Image Annotation and Labeling



Labeled image

Your Question: what is this?

Predicted Answer: Unanswerable. The answerability score is 0.99.

Example Predictions

Input

Select the Model

CLIP

Type a question

What color is this chair?

Upload an image

Drag and drop file here

Limit 200MB per file • PNG, JPG, JPEG

Browse files

chair.jpg
12.5KB

Object Detection

Visual Question Answering

Uploaded Image



Resized image

Image Annotation and Labeling



Labeled image

Your Question: What color is this chair?

Predicted Answer: Black. The answerability score is 0.99.

Input

Select the Model

VILT

Type a question

What color is this chair?

Upload an image

Drag and drop file here

Limit 200MB per file • PNG, JPG, JPEG

Browse files

chair.jpg
12.5KB

Object Detection

Visual Question Answering

Uploaded Image



Resized image

Image Annotation and Labeling



Labeled image

Your Question: What color is this chair?

Predicted Answer: Black. The answerability score is 0.99.

Instance Segmentation

Models

YOLOv8seg

- We trained on the top 5 classes in the dataset, which are *pen*, *dog*, *laptop*, *keyboard*, *wine*.
- The major data processing was conversion of annotations to YOLO format.



Mask RCNN

- The major data processing was the creation of masks from image annotations.
- Similarly trained from top 5 classes



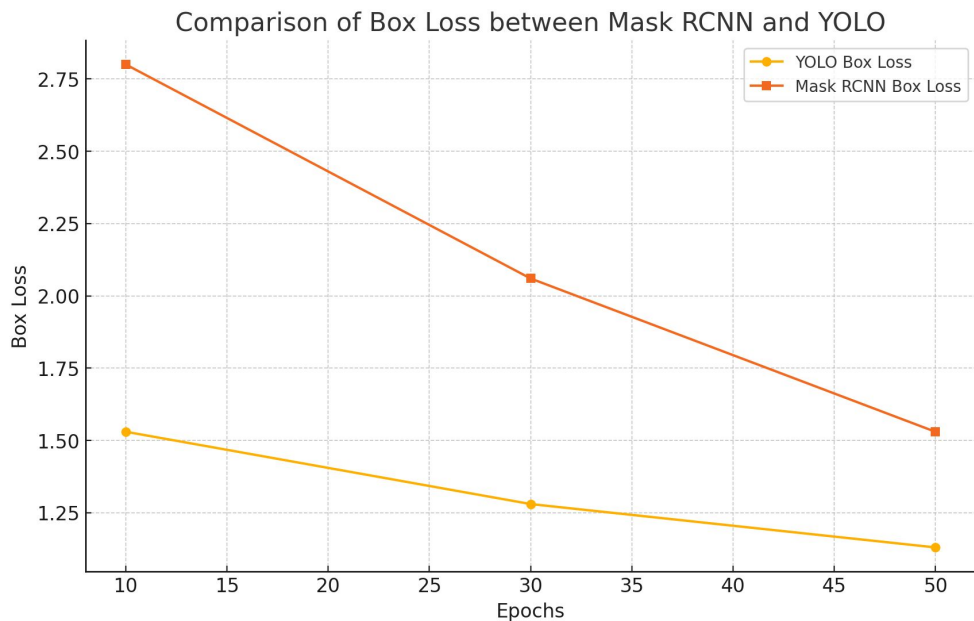
Model Definition

YOLOv8: operates as a single-stage detector, meaning it processes the entire image with a single network, which makes it faster.

Mask RCNN: Two-Stage Detector: first proposes candidate object regions using a Region Proposal Network (RPN), then refines these proposals and predicts masks.

Results

Evaluation metric: Visual inspection + Box loss



Box loss: how well the predicted bounding boxes match the ground truth bounding boxes

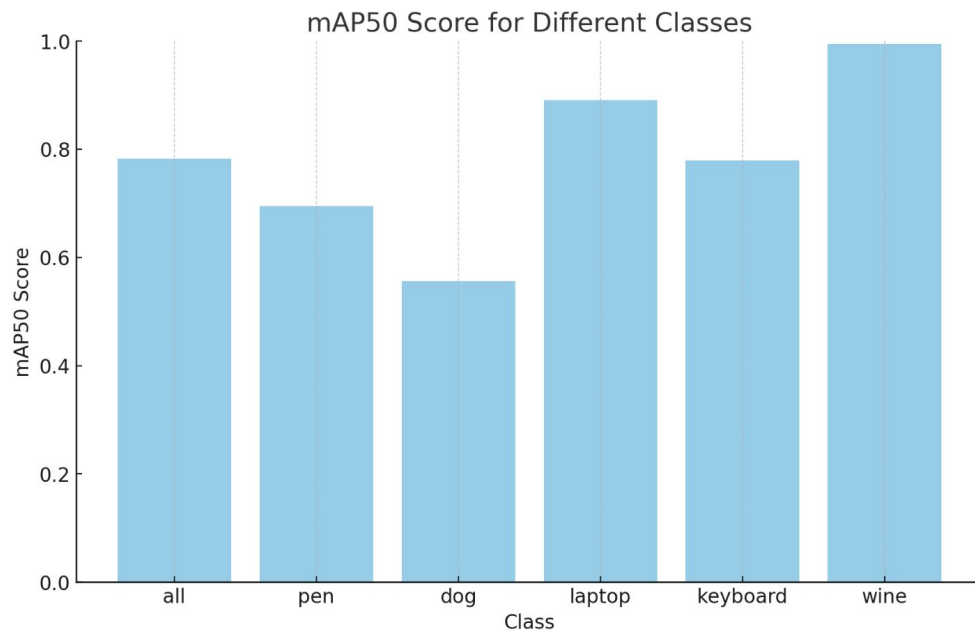
Both model hyperparameters:

- Epochs: 50
- Image size: 1280

YOLO MAP scores

What is MAP 50:

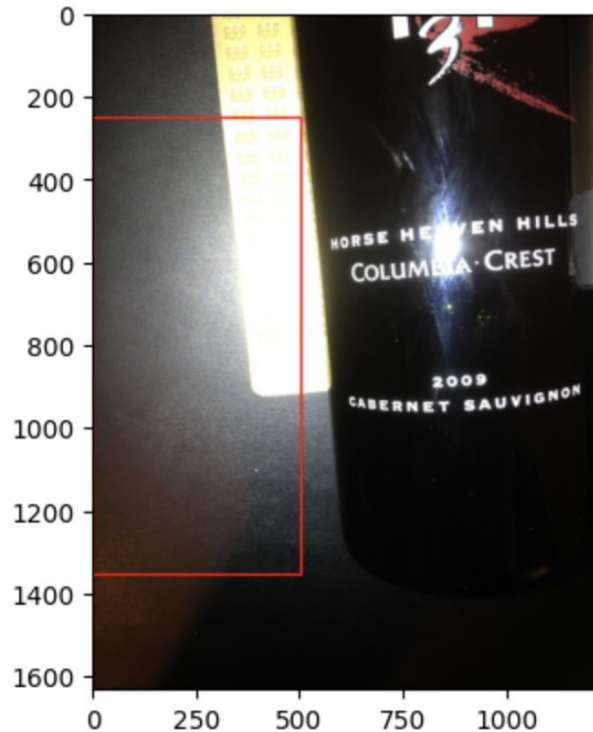
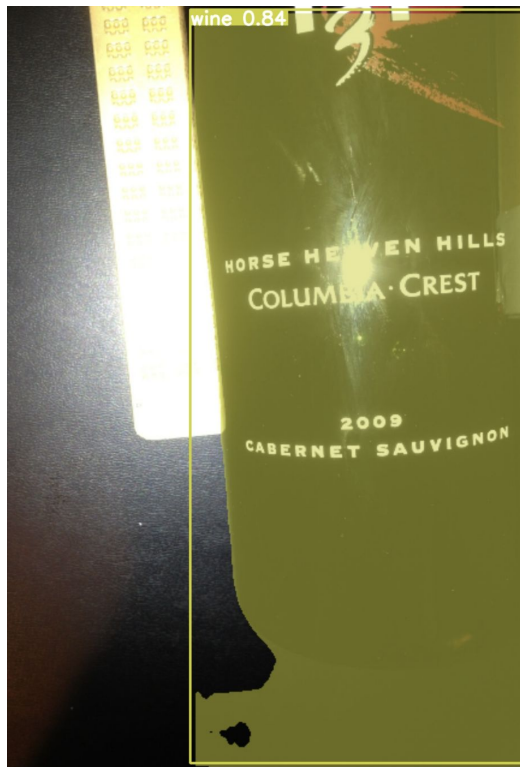
It accounts for both the precision and recall of the model's predictions at an IoU threshold of **0.50** (*predicted bounding box is considered a true positive if it overlaps with the ground truth bounding box by at least 50%*), offering a balanced measure of accuracy.



IoU: Intersection over Union

Sample Images

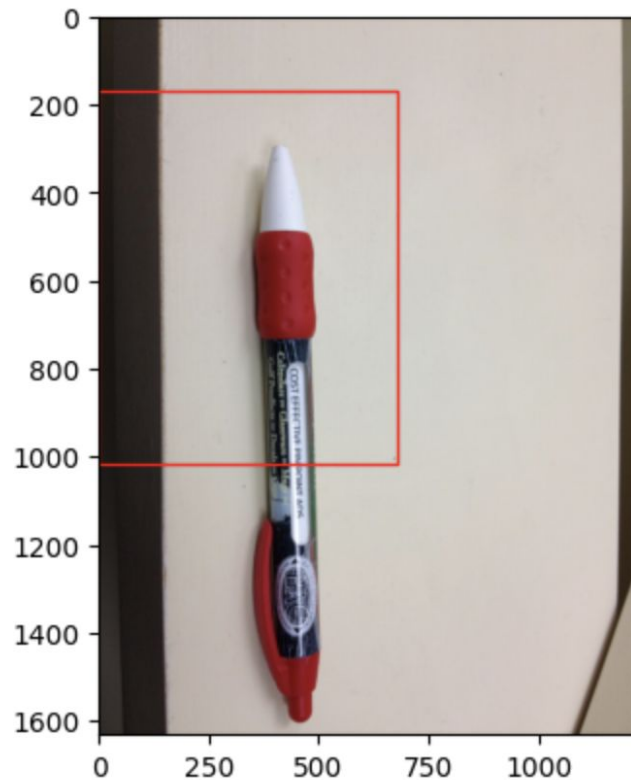
YOLOv8



Mask
RCNN

Sample Images

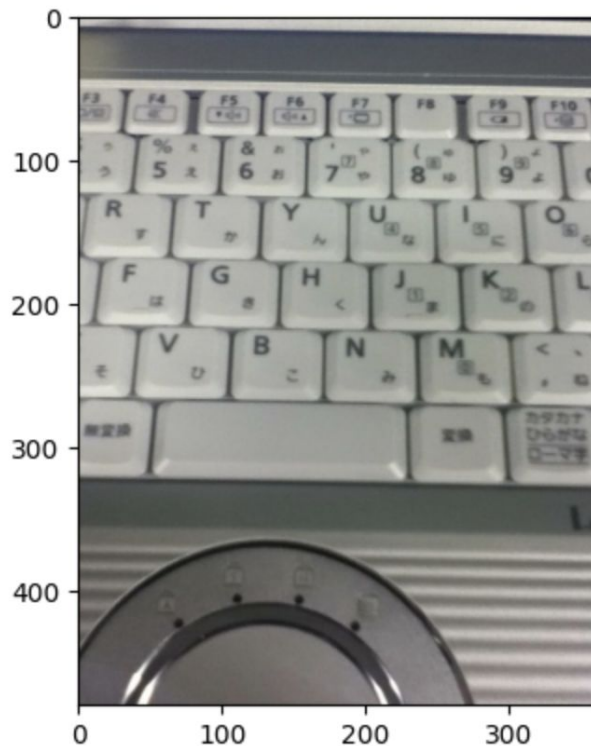
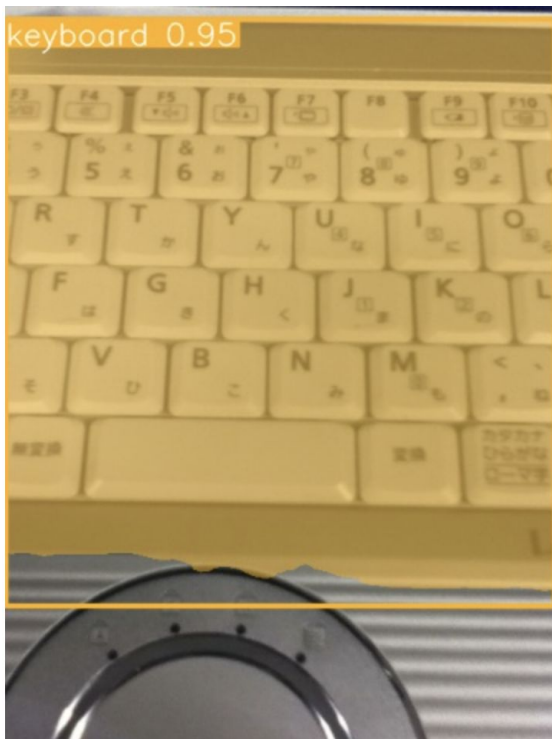
YOLOv8



*Mask
RCNN*

Sample Images

YOLOv8



*Mask
RCNN*

Web Interface