PRHW3

April 27, 2025

[1]:

```
import os
import zipfile
from PIL import Image
import torch
from transformers import VisionEncoderDecoderModel, ViTFeatureExtractor,␣
  ↪AutoTokenizer
import nltk
from nltk.translate.bleu_score import corpus_bleu, sentence_bleu,␣
  ↪SmoothingFunction
from nltk.translate.meteor_score import meteor_score
from tqdm import tqdm
import matplotlib.pyplot as plt
from collections import Counter
import pandas as pd


nltk.download('punkt')

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
```

```
[nltk_data] Downloading package punkt to /root/nltk_data…
[nltk_data]   Unzipping tokenizers/punkt.zip.
```

[2]:

```
os.makedirs("Flickr8k_Dataset", exist_ok=True)
os.makedirs("Flickr8k_text", exist_ok=True)

if not os.path.exists("Flickr8k_Dataset.zip"):
    os.system("wget https://github.com/jbrownlee/Datasets/releases/download/
  ↪Flickr8k/Flickr8k_Dataset.zip -O Flickr8k_Dataset.zip")
if not os.path.exists("Flickr8k_text.zip"):
    os.system("wget https://github.com/jbrownlee/Datasets/releases/download/
  ↪Flickr8k/Flickr8k_text.zip -O Flickr8k_text.zip")

with zipfile.ZipFile("Flickr8k_Dataset.zip","r") as z: z.
  ↪extractall("Flickr8k_Dataset")
with zipfile.ZipFile("Flickr8k_text.zip","r")   as z: z.
  ↪extractall("Flickr8k_text")
```

[3]:

```python
refs = {}
with open("Flickr8k_text/Flickr8k.token.txt","r") as f:
    for line in f:
        imgcap, txt = line.strip().split("\t")
        img = imgcap.split("#")[0]
        refs.setdefault(img, []).append(txt.lower().split())

test_images = set(open("Flickr8k_text/Flickr_8k.testImages.txt").read().
 ↪splitlines())
```

[4]:

```python
model_name = "nlpconnect/vit-gpt2-image-captioning"
model = VisionEncoderDecoderModel.from_pretrained(model_name).to(device)
feature_extractor = ViTFeatureExtractor.from_pretrained(model_name)
tokenizer = AutoTokenizer.from_pretrained(model_name)


tokenizer.add_special_tokens({"pad_token":"<pad>"})
model.decoder.resize_token_embeddings(len(tokenizer))
model.config.pad_token_id = tokenizer.pad_token_id
model.config.decoder.pad_token_id = tokenizer.pad_token_id

gen_kwargs = {
    "max_length":16,
    "num_beams":4,
    "length_penalty":1.0,
    "no_repeat_ngram_size":2
}

def generate_caption(path):
    img = Image.open(path).convert("RGB")
    pixels = feature_extractor(images=img, return_tensors="pt").pixel_values.
 ↪to(device)
    ids = model.generate(pixels,
                         pad_token_id=tokenizer.pad_token_id,
                         eos_token_id=tokenizer.eos_token_id,
                         **gen_kwargs)
    return tokenizer.decode(ids[0], skip_special_tokens=True).split()
```

```
/usr/local/lib/python3.11/dist-packages/huggingface_hub/utils/_auth.py:94:
UserWarning:
The secret `HF_TOKEN` does not exist in your Colab secrets.
To authenticate with the Hugging Face Hub, create a token in your settings tab
(https://huggingface.co/settings/tokens), set it as secret in your Google Colab
and restart your session.
You will be able to reuse this secret in all of your notebooks.
Please note that authentication is recommended but still optional to access
public models or datasets.
  warnings.warn(
config.json:   0%|          | 0.00/4.61k [00:00<?, ?B/s]
```

```
Xet Storage is enabled for this repo, but the 'hf_xet' package is not installed.
Falling back to regular HTTP download. For better performance, install the
package with: `pip install huggingface_hub[hf_xet]` or `pip install hf_xet`
WARNING:huggingface_hub.file_download:Xet Storage is enabled for this repo, but
the 'hf_xet' package is not installed. Falling back to regular HTTP download.
For better performance, install the package with: `pip install
huggingface_hub[hf_xet]` or `pip install hf_xet`
```

```
pytorch_model.bin:   0%|          | 0.00/982M [00:00<?, ?B/s]
```

```
Xet Storage is enabled for this repo, but the 'hf_xet' package is not installed.
Falling back to regular HTTP download. For better performance, install the
package with: `pip install huggingface_hub[hf_xet]` or `pip install hf_xet`
WARNING:huggingface_hub.file_download:Xet Storage is enabled for this repo, but
the 'hf_xet' package is not installed. Falling back to regular HTTP download.
For better performance, install the package with: `pip install
huggingface_hub[hf_xet]` or `pip install hf_xet`
```

```
model.safetensors:   0%|          | 0.00/982M [00:00<?, ?B/s]
```

```
Config of the encoder: <class 'transformers.models.vit.modeling_vit.ViTModel'>
is overwritten by shared encoder config: ViTConfig {
  "architectures": [
    "ViTModel"
  ],
  "attention_probs_dropout_prob": 0.0,
  "encoder_stride": 16,
  "hidden_act": "gelu",
  "hidden_dropout_prob": 0.0,
  "hidden_size": 768,
  "image_size": 224,
  "initializer_range": 0.02,
  "intermediate_size": 3072,
  "layer_norm_eps": 1e-12,
  "model_type": "vit",
  "num_attention_heads": 12,
  "num_channels": 3,
  "num_hidden_layers": 12,
  "patch_size": 16,
  "pooler_act": "tanh",
  "pooler_output_size": 768,
  "qkv_bias": true,
  "torch_dtype": "float32",
  "transformers_version": "4.51.3"
}

Config of the decoder: <class
'transformers.models.gpt2.modeling_gpt2.GPT2LMHeadModel'> is overwritten by
```

```
shared decoder config: GPT2Config {
  "activation_function": "gelu_new",
  "add_cross_attention": true,
  "architectures": [
    "GPT2LMHeadModel"
  ],
  "attn_pdrop": 0.1,
  "bos_token_id": 50256,
  "decoder_start_token_id": 50256,
  "embd_pdrop": 0.1,
  "eos_token_id": 50256,
  "initializer_range": 0.02,
  "is_decoder": true,
  "layer_norm_epsilon": 1e-05,
  "model_type": "gpt2",
  "n_ctx": 1024,
  "n_embd": 768,
  "n_head": 12,
  "n_inner": null,
  "n_layer": 12,
  "n_positions": 1024,
  "pad_token_id": 50256,
  "reorder_and_upcast_attn": false,
  "resid_pdrop": 0.1,
  "scale_attn_by_inverse_layer_idx": false,
  "scale_attn_weights": true,
  "summary_activation": null,
  "summary_first_dropout": 0.1,
  "summary_proj_to_labels": true,
  "summary_type": "cls_index",
  "summary_use_proj": true,
  "task_specific_params": {
    "text-generation": {
      "do_sample": true,
      "max_length": 50
    }
  },
  "torch_dtype": "float32",
  "transformers_version": "4.51.3",
  "use_cache": true,
  "vocab_size": 50257
}
```

```
preprocessor_config.json:   0%|          | 0.00/228 [00:00<?, ?B/s]
```

```
/usr/local/lib/python3.11/dist-
packages/transformers/models/vit/feature_extraction_vit.py:28: FutureWarning:
The class ViTFeatureExtractor is deprecated and will be removed in version 5 of
```

```
Transformers. Please use ViTImageProcessor instead.
  warnings.warn(

tokenizer_config.json:   0%|          | 0.00/241 [00:00<?, ?B/s]

vocab.json:   0%|          | 0.00/798k [00:00<?, ?B/s]

merges.txt:   0%|          | 0.00/456k [00:00<?, ?B/s]

tokenizer.json:   0%|          | 0.00/1.36M [00:00<?, ?B/s]

special_tokens_map.json:   0%|          | 0.00/120 [00:00<?, ?B/s]

The new embeddings will be initialized from a multivariate normal distribution
that has old embeddings' mean and covariance. As described in this article:
https://nlp.stanford.edu/~johnhew/vocab-expansion.html. To disable this, use
`mean_resizing=False`
```

[5]:

```python
hypotheses = []
references_list = []
image_names = []
img_dir = "Flickr8k_Dataset/Flicker8k_Dataset"

for img in tqdm(sorted(test_images)):
    path = os.path.join(img_dir, img)
    if not os.path.exists(path):
        continue
    hyp = generate_caption(path)
    hypotheses.append(hyp)
    references_list.append(refs[img])
    image_names.append(img)

print(f"Generated captions for {len(hypotheses)} images")
```

```
   0%|          | 0/1000 [00:00<?, ?it/s]We strongly recommend passing in an
`attention_mask` since your input_ids may be padded. See
https://huggingface.co/docs/transformers/troubleshooting#incorrect-output-when-
padding-tokens-arent-masked.
You may ignore this warning if your `pad_token_id` (50256) is identical to the
`bos_token_id` (50256), `eos_token_id` (50256), or the `sep_token_id` (None),
and your input is not padded.
100%|     | 1000/1000 [04:46<00:00,  3.49it/s]

Generated captions for 1000 images
```

[17]:

```python
nltk.download('wordnet')
nltk.download('omw-1.4')
smooth = SmoothingFunction().method4
weights = {
    "BLEU-1": (1,0,0,0),
    "BLEU-2": (0.5,0.5,0,0),
    "BLEU-3": (1/3,1/3,1/3,0),
    "BLEU-4": (0.25,0.25,0.25,0.25)
}

agg_scores = {}
for name, w in weights.items():
    agg_scores[name] = corpus_bleu(
        references_list, hypotheses,
        weights=w, smoothing_function=smooth
    )


per_img_meteor = [
    meteor_score(ref_list, hyp)
    for ref_list, hyp in zip(references_list, hypotheses)
]
agg_scores["METEOR"] = sum(per_img_meteor) / len(per_img_meteor)

metrics_df = pd.DataFrame.from_dict(
    agg_scores, orient='index', columns=['Score']
)
metrics_df
```

```
[nltk_data] Downloading package punkt to /root/nltk_data…
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package wordnet to /root/nltk_data…
[nltk_data]   Package wordnet is already up-to-date!
[nltk_data] Downloading package omw-1.4 to /root/nltk_data…
[nltk_data]   Package omw-1.4 is already up-to-date!
```

[17]:

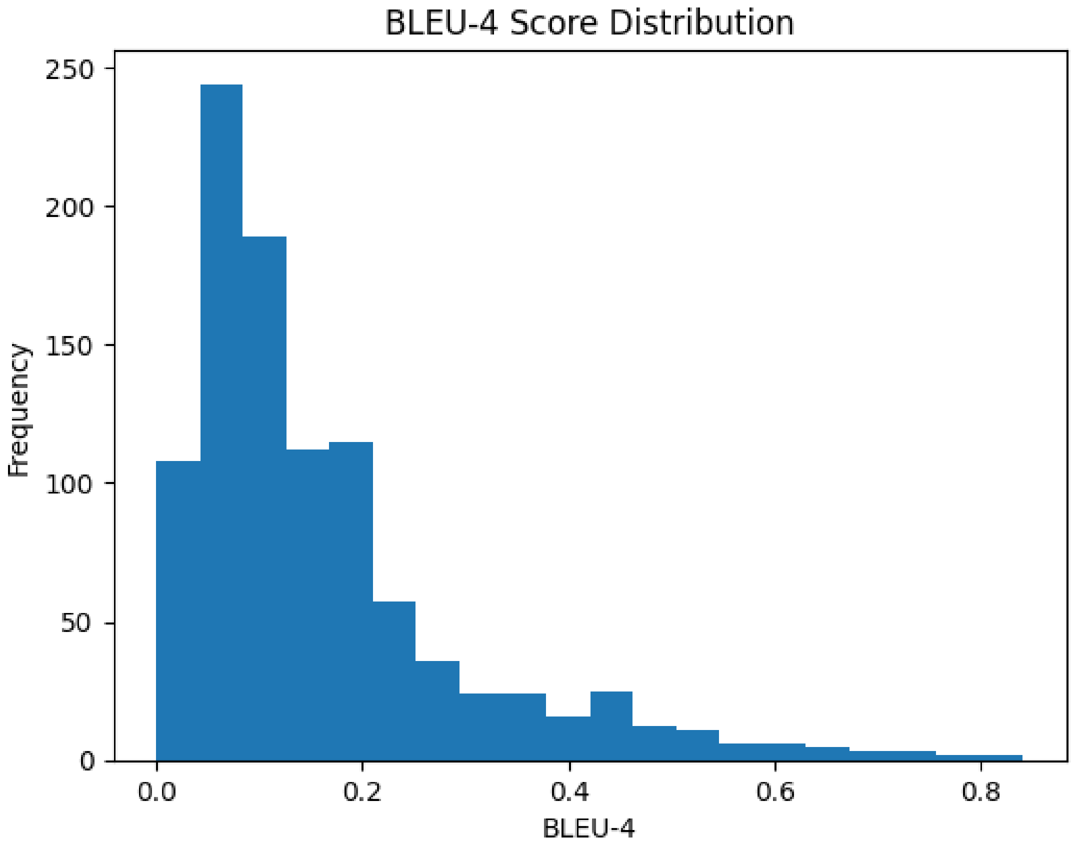
```
           Score
BLEU-1  0.611948
BLEU-2  0.417242
BLEU-3  0.269282
BLEU-4  0.170619
METEOR  0.367073
```

[9]:

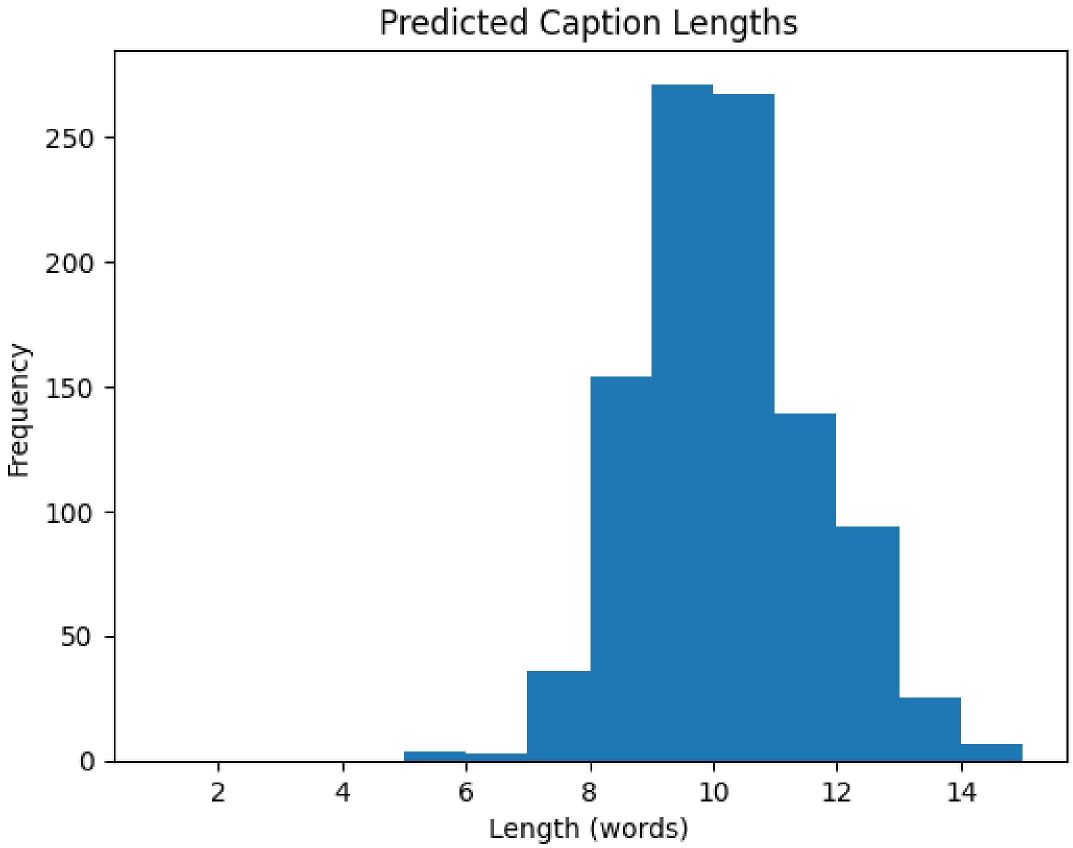
```
per_image_bleu4 = [
    sentence_bleu(r, h, weights=weights["BLEU-4"], smoothing_function=smooth)
    for r,h in zip(references_list, hypotheses)
]
```

[10]:

```
plt.figure()
plt.hist(per_image_bleu4, bins=20)
plt.title("BLEU-4 Score Distribution")
plt.xlabel("BLEU-4")
plt.ylabel("Frequency")
plt.show()
```

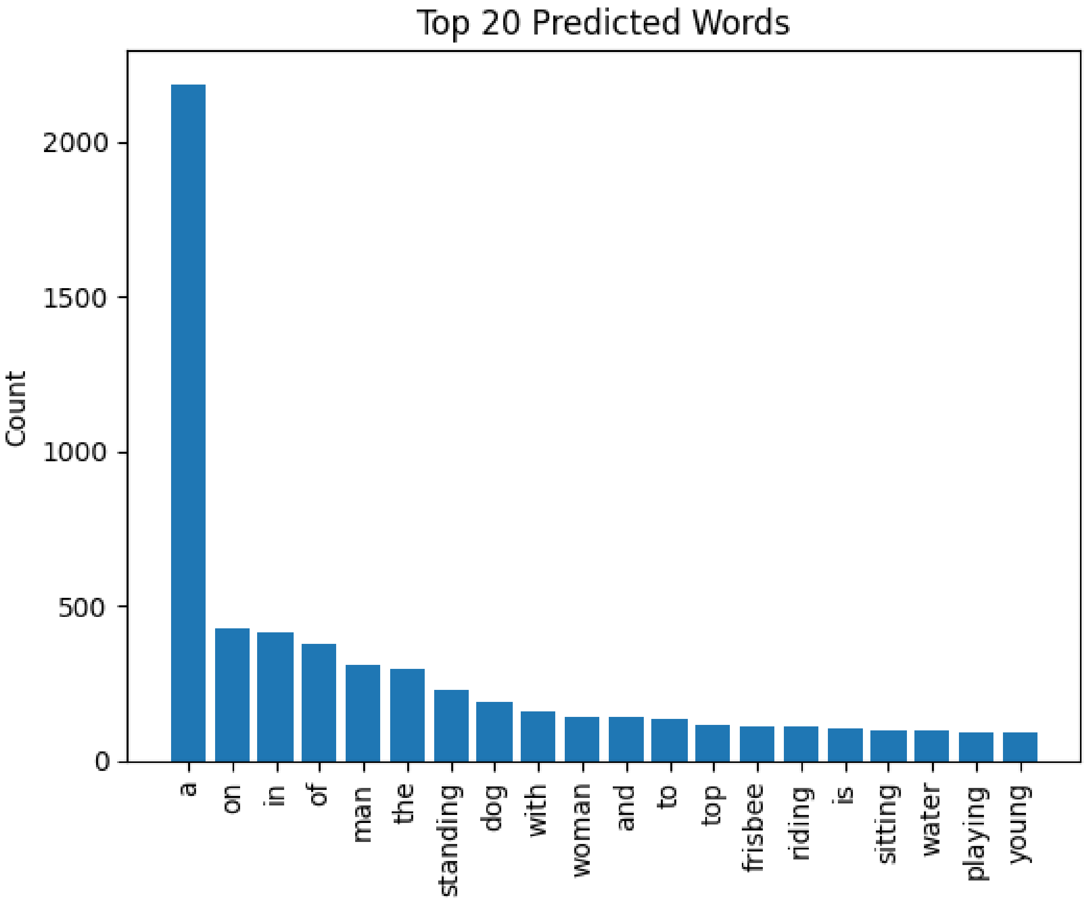


[11]:
```
lengths = [len(h) for h in hypotheses]
plt.figure()
plt.hist(lengths, bins=range(1, max(lengths)+2))
plt.title("Predicted Caption Lengths")
plt.xlabel("Length (words)")
plt.ylabel("Frequency")
plt.show()
```



[12]:

```
all_words = [w for hyp in hypotheses for w in hyp]
wc = Counter(all_words).most_common(20)
words, counts = zip(*wc)

plt.figure()
plt.bar(range(len(words)), counts)
plt.xticks(range(len(words)), words, rotation=90)
plt.title("Top 20 Predicted Words")
plt.ylabel("Count")
plt.show()
```

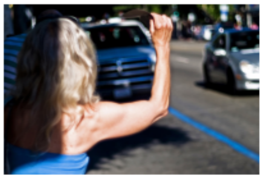


[13]:

```
N = 5
plt.figure(figsize=(12, 3*N))
for i in range(N):
    img = Image.open(os.path.join(img_dir, image_names[i])).convert("RGB")
    true_caps = [" ".join(r) for r in refs[image_names[i]][:5]]
    pred_cap = " ".join(hypotheses[i])
    ax = plt.subplot(N,1,i+1)
    ax.imshow(img); ax.axis('off')
    ax.set_title("True:\n" + "\n".join(true_caps) + "\n\nPredicted:\n" +␣
  ↪pred_cap, fontsize=10, loc='left')
plt.tight_layout()
plt.show()
```

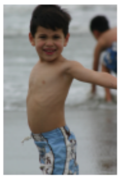
True:
a blond woman in a blue shirt appears to wait for a ride .
a blond woman is on the street hailing a taxi .
a woman is signaling is to traffic , as seen from behind .
a woman with blonde hair wearing a blue tube top is waving on the side of the street .
the woman in the blue dress is holding out her arm at oncoming traffic .

Predicted:
a woman standing on a street with her arms outstretched



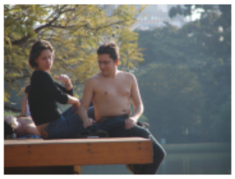
True:
a boy in his blue swim shorts at the beach .
a boy smiles for the camera at a beach .
a young boy in swimming trunks is walking with his arms outstretched on the beach .
children playing on the beach .
the boy is playing on the shore of an ocean .

Predicted:
a young boy standing on a beach holding a surfboard



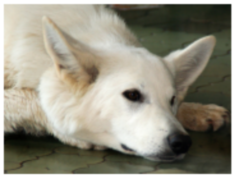
True:
a lady and a man with no shirt sit on a dock .
a man and a woman are sitting on a dock together .
a man and a woman sitting on a dock .
a man and woman sitting on a deck next to a lake .
a shirtless man and a woman sitting on a dock .

Predicted:
a man and a woman sitting on a bench



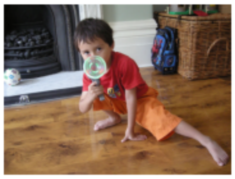
True:
a closeup of a white dog that is laying its head on its paws .
a large white dog lying on the floor .
a white dog has its head on the ground .
a white dog is resting its head on a tiled floor with its eyes open .
a white dog rests its head on the patio bricks .

Predicted:
a white dog laying on the floor next to a pillow



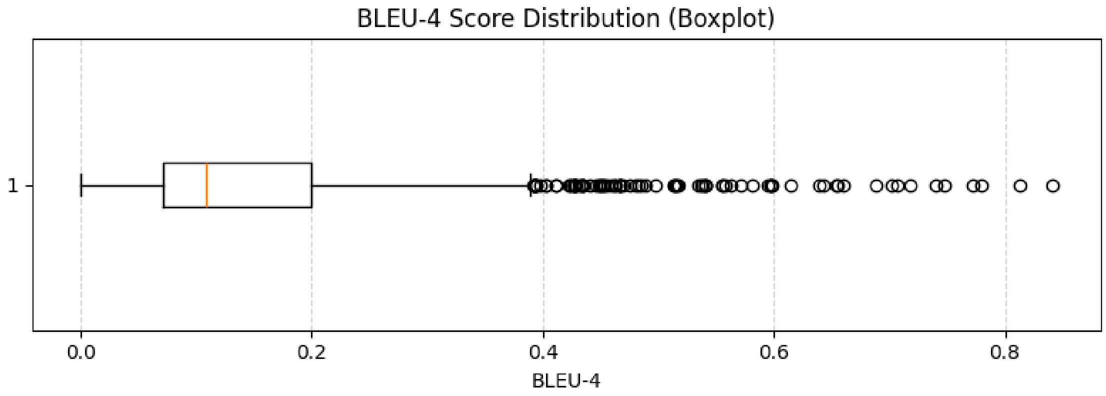
True:
a boy with a toy gun .
a little boy in orange shorts playing with a toy .
a young boy with his foot outstretched aims a toy at the camera in front of a fireplace .
a young child plays with his new light-up toy .
boy with toy gun pointed at the camera .

Predicted:
a little boy sitting on the floor playing with a toy



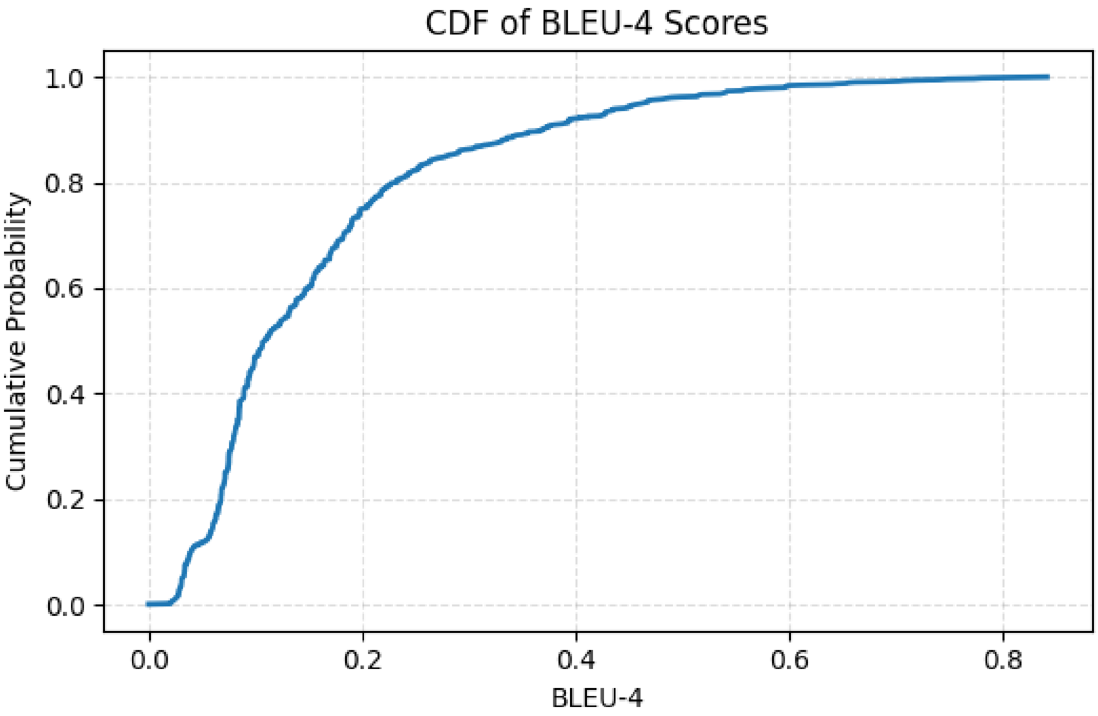
[14]:

```
plt.figure(figsize=(8, 3))
plt.boxplot(per_image_bleu4, vert=False)
plt.title("BLEU-4 Score Distribution (Boxplot)")
plt.xlabel("BLEU-4")
plt.grid(axis='x', linestyle='--', alpha=0.5)
plt.tight_layout()
plt.show()
```

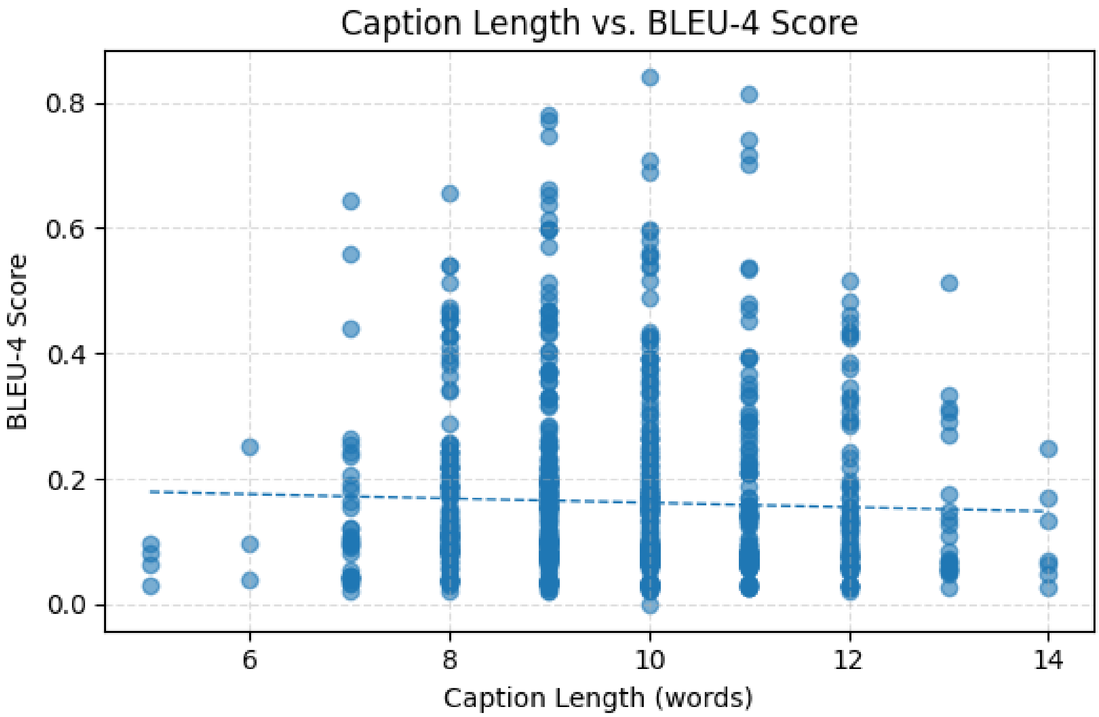


[15]:

```
sorted_bleu4 = sorted(per_image_bleu4)
cdf = [i / len(sorted_bleu4) for i in range(1, len(sorted_bleu4) + 1)]

plt.figure(figsize=(6, 4))
plt.plot(sorted_bleu4, cdf, linewidth=2)
plt.title("CDF of BLEU-4 Scores")
plt.xlabel("BLEU-4")
plt.ylabel("Cumulative Probability")
plt.grid(True, linestyle='--', alpha=0.4)
plt.tight_layout()
plt.show()
```



[16]:
```
import numpy as np

plt.figure(figsize=(6, 4))
plt.scatter(lengths, per_image_bleu4, alpha=0.6)

m, b = np.polyfit(lengths, per_image_bleu4, 1)
x = np.linspace(min(lengths), max(lengths), 100)
plt.plot(x, m*x + b, linestyle='--', linewidth=1)
plt.title("Caption Length vs. BLEU-4 Score")
plt.xlabel("Caption Length (words)")
plt.ylabel("BLEU-4 Score")
plt.grid(True, linestyle='--', alpha=0.4)
plt.tight_layout()
plt.show()
```


Caption Length vs. BLEU-4 Score
BLEU-4 Score
0.0
0.2
0.4
0.6
0.8
6
8
10
12
14
Caption Length (words)

```
[ ]:
```