wz0v7fcas

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1 E2E Data-to-Text: EDA → T5 Generation → Evaluation

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This notebook includes:

0) Installation and imports
1) Data pre-processing
2) A quick EDA of the E2E test split
3) T5-small fine-tuning + CTranslate2 generation
4) Baseline Evaluation Without Prompt Finetuning
5) T5-small fine-tuning with adding intruct + CTranslate2 generation
6) Instruted model Evaluation With Prompt Finetuning
7) Comparative Analysis

2 0) Installation and imports

[ ]:
```
! pip install transformers[torch] datasets==3.6.0 evaluate ctranslate2 --quiet
```

```
                         491.5/491.5 kB
25.2 MB/s eta 0:00:00
                         84.1/84.1 kB
7.5 MB/s eta 0:00:00
                         38.8/38.8 MB
15.4 MB/s eta 0:00:00
```

[ ]:
```
import datasets
import transformers
from transformers import AutoTokenizer, AutoModelForSeq2SeqLM
from transformers import Trainer, TrainingArguments
```

```
import torch
import evaluate
import ctranslate2
from tqdm.notebook import tqdm
import pandas as pd
import json
```

```
[ ]: # T5 small model with its tokenizer
     tokenizer = AutoTokenizer.from_pretrained("google-t5/t5-small")
     model = AutoModelForSeq2SeqLM.from_pretrained("google-t5/t5-small")
```

```
tokenizer_config.json: 0.00B [00:00, ?B/s]

spiece.model:   0%|          | 0.00/792k [00:00<?, ?B/s]

tokenizer.json: 0.00B [00:00, ?B/s]

config.json: 0.00B [00:00, ?B/s]

model.safetensors:   0%|          | 0.00/242M [00:00<?, ?B/s]

generation_config.json:   0%|          | 0.00/147 [00:00<?, ?B/s]
```

```
[ ]: # Gem/ete_nlg dataset
     ds = datasets.load_dataset("GEM/e2e_nlg")
```

3 1) Data pre-processing

```
[ ]: ds
```

```
[ ]: DatasetDict({
         train: Dataset({
             features: ['gem_id', 'gem_parent_id', 'meaning_representation',
     'target', 'references'],
             num_rows: 33525
         })
         validation: Dataset({
             features: ['gem_id', 'gem_parent_id', 'meaning_representation',
     'target', 'references'],
             num_rows: 1484
         })
         test: Dataset({
             features: ['gem_id', 'gem_parent_id', 'meaning_representation',
     'target', 'references'],
             num_rows: 1847
         })
         challenge_train_sample: Dataset({
             features: ['gem_id', 'gem_parent_id', 'meaning_representation',
     'target', 'references'],
             num_rows: 500
         })
         challenge_validation_sample: Dataset({
             features: ['gem_id', 'gem_parent_id', 'meaning_representation',
     'target', 'references'],
             num_rows: 500
         })
         challenge_test_scramble: Dataset({
             features: ['gem_id', 'gem_parent_id', 'meaning_representation',
     'target', 'references'],
             num_rows: 500
         })
     })
```

[ ]:

```
# Train dataset example
ds['train'][0]
```

[ ]:

```
{'gem_id': 'e2e_nlg-train-0',
 'gem_parent_id': 'e2e_nlg-train-0',
 'meaning_representation': 'name[The Eagle], eatType[coffee shop],
food[Japanese], priceRange[less than £20], customer rating[low],
area[riverside], familyFriendly[yes], near[Burger King]',
 'target': 'The Eagle is a low rated coffee shop near Burger King and the
riverside that is family friendly and is less than £20 for Japanese food.',
 'references': []}
```

[ ]:

```
# Test dataset example
ds['test'][0]
```

[ ]:

```
{'gem_id': 'e2e_nlg-test-0',
 'gem_parent_id': 'e2e_nlg-test-0',
 'meaning_representation': 'eatType[pub], food[Fast food], customer
rating[high], area[riverside], familyFriendly[no], near[Café Rouge]',
 'target': 'The Mills is not kid friendly as it is a riverside pub near Café
Rouge.  Its mid priced fast food is highly rated.',
 'references': ['The Mills is not kid friendly as it is a riverside pub near
Café Rouge.  Its mid priced fast food is highly rated.']}
```

[ ]:

```
# Keep the columns need fro fine-tuning
columns_to_keep_train_val = ['meaning_representation', 'target']

# Prepare train set
train_dataset = ds['train'].remove_columns(
    [col for col in ds['train'].column_names if col not in␣
 ↪columns_to_keep_train_val]
)
```

```

# Prepare validation set
validation_dataset = ds['validation'].remove_columns(
    [col for col in ds['validation'].column_names if col not in␣
 ↪columns_to_keep_train_val]
)

# Keep the columns need for Evaluation
columns_to_keep_test = ['meaning_representation', 'target', 'references']
# Prepare test set
test_dataset = ds['test'].remove_columns(
    [col for col in ds['test'].column_names if col not in columns_to_keep_test]
)
```

[ ]:

```
# Making dataset Dict
processed_dataset = datasets.DatasetDict({
    'train': train_dataset,
    'validation': validation_dataset,
    'test': test_dataset
})
```

[ ]:

```
# Rename columns
processed_dataset = processed_dataset.rename_column("meaning_representation",␣
 ↪"input_text")
processed_dataset = processed_dataset.rename_column("target", "labels")
```

[ ]:

```
processed_dataset
```

[ ]:

```
DatasetDict({
    train: Dataset({
        features: ['input_text', 'labels'],
        num_rows: 33525
    })
    validation: Dataset({
        features: ['input_text', 'labels'],
        num_rows: 1484
    })
    test: Dataset({
        features: ['input_text', 'labels', 'references'],
        num_rows: 1847
    })
})
```

4 2) Exploratory Data Analysis (EDA)

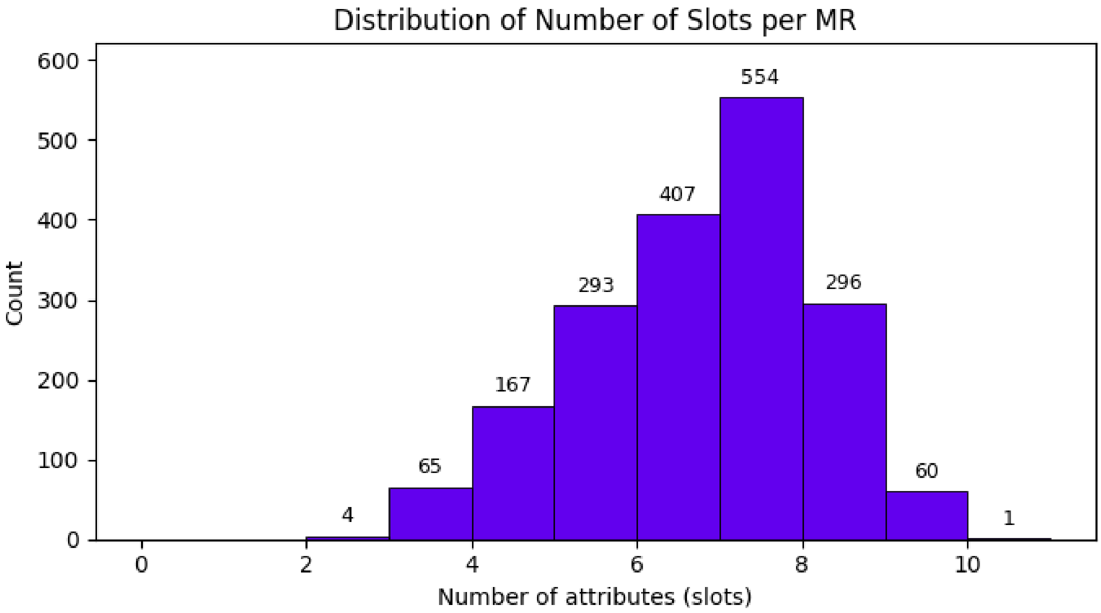
4.0.1 Dataset head

```
[ ]: #  Dataset head
     import pandas as pd

     # Convert test split to pandas DataFrame
     df_head = processed_dataset["test"].to_pandas().copy()

     # Showing only the key columns for clarity
     df_head = df_head[["input_text", "labels"]]

     print("Sample of Test Dataset (first 10 rows)")
     display(df_head.head(10))
```

```
Sample of Test Dataset (first 10 rows)

                                          input_text  \
0  eatType[pub], food[Fast food], customer rating…
1  eatType[pub], food[Japanese], priceRange[moder…
2  eatType[restaurant], food[Chinese], priceRange…
3  name[Blue Spice], eatType[coffee shop], area[c…
4  name[Blue Spice], eatType[coffee shop], area[r…
5  name[Blue Spice], eatType[coffee shop], custom…
6  name[Blue Spice], eatType[coffee shop], custom…
7  name[Blue Spice], eatType[coffee shop], custom…
8  name[Blue Spice], eatType[pub], area[city centre]
9    name[Blue Spice], eatType[pub], area[riverside]

                                              labels
0  The Mills is not kid friendly as it is a river…
1  The Wrestlerss is rated 5 out of 5, serving Ja…
2  In the riverside area near the All Bar One the…
3  A coffee shop in the city centre area called B…
4  There is a coffee shop Blue Spice in the river…
5  The coffee shop Blue Spice is based near Crown…
6  Burger King is near the coffee shop Blue Spice…
7  Crowne Plaza Hotel has a coffee shop nearby wi…
8   A pub in the city centre area called Blue Spice.
9   There is a pub Blue Spice in the riverside area.
```

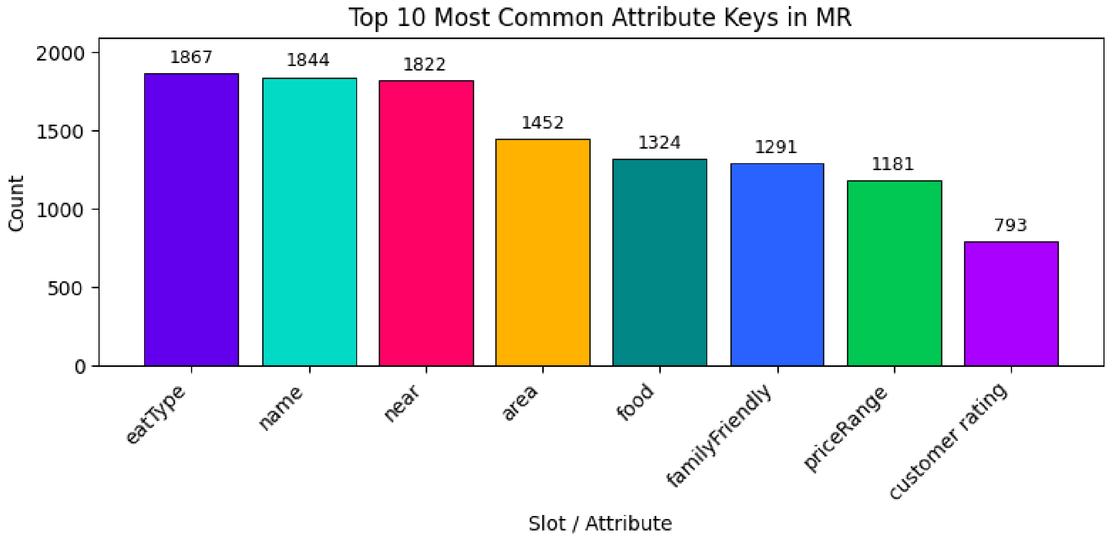
4.0.2 Distribution of number of slots per MR

```
[ ]: #  Distribution of number of slots per MR (uses␣
      ↪processed_dataset['test']['input_text'])
     import re
     import pandas as pd
     import matplotlib.pyplot as plt

     # Matrial Design colors
     md_colors = ["#6200EE", "#03DAC6", "#FF0266", "#FFB300", "#018786", "#2962FF",␣
      ↪"#00C853", "#AA00FF"]

     # 1) Put test split into a DataFrame with the MR text
     eda_df = processed_dataset["test"].to_pandas().copy()
     eda_df["input_text"] = eda_df["input_text"].astype(str).fillna("")

     # 2) Extract (key, value) pairs from input_text like: eatType[pub], food[Fast␣
      ↪food]
     mr_kvs = eda_df["input_text"].apply(lambda s: re.
      ↪findall(r'([^,\[]+)\[([^\]]+)\]', s))

     # 3) Counting number of slots per MR
     eda_df["num_slots"] = mr_kvs.apply(len)

     # 4) Ploting histogram with labels
     plt.figure(figsize=(7,4))
     counts, bins, patches = plt.hist(
         eda_df["num_slots"],
         bins=range(0, eda_df["num_slots"].max() + 2),
         color=md_colors[0],
         edgecolor="black", linewidth=0.6
     )
     ax = plt.gca()
     plt.title("Distribution of Number of Slots per MR")
     plt.xlabel("Number of attributes (slots)")
     plt.ylabel("Count")

     # Add headroom + data labeles above bars
     ymax = counts.max() if len(counts) else 0
     ax.set_ylim(0, max(1, ymax * 1.12))
     offset = max(5, ymax * 0.02)
     for i, c in enumerate(counts):
         if c > 0:
             x = bins[i] + (bins[i+1] - bins[i]) / 2
             ax.text(x, c + offset, str(int(c)), ha="center", va="bottom",␣
      ↪fontsize=9)

     plt.tight_layout()
     plt.show()
```



4.0.3 Top 10 most common slot keys in MR

```
[ ]: # Top 10 most common slot keys in MR
from collections import Counter
import matplotlib.pyplot as plt

# 1) Flatten all slot KEYS from the parsed (key, value) list
all_keys = [k.strip() for kvs in mr_kvs for (k, v) in kvs]

# 2) Count and take top 10
key_counts = Counter(all_keys)
top10 = key_counts.most_common(10)
keys, counts = zip(*top10) if top10 else ([], [])

# 3) Bar chart with Material colors + data labels
plt.figure(figsize=(8,4))
ax = plt.gca()
bars = plt.bar(
    range(len(keys)),
    counts,
    color=md_colors[:len(keys)],
    edgecolor="black", linewidth=0.6
)
plt.xticks(range(len(keys)), keys, rotation=45, ha="right")
plt.title("Top 10 Most Common Attribute Keys in MR")
plt.xlabel("Slot / Attribute")
plt.ylabel("Count")

# Headroom + labelings
max_count = max(counts) if len(counts) else 0
ax.set_ylim(0, max(1, max_count * 1.12))
offset = max(5, max_count * 0.02)
for bar in bars:
    y = bar.get_height()
    ax.text(bar.get_x() + bar.get_width()/2, y + offset, int(y), ha="center",␣
 ↪va="bottom", fontsize=9)

plt.tight_layout()
plt.show()
```



5 3) Baseline : Raw key-value → sentence Tokenizaition and Fine-tuning.

[ ]:
```
# Function for Tokenizing the dataset
def tokenize_function(batch):
  model_inputs = tokenizer(batch["input_text"], padding="max_length",␣
 ↪truncation=True, max_length=512)
  with tokenizer.as_target_tokenizer():
    labels = tokenizer(batch["labels"], padding="max_length", truncation=True,␣
 ↪max_length=512)
  model_inputs["labels"] = labels["input_ids"]
  return model_inputs
```

[ ]:

```
# Tokenizing the dataset
tokenized_dataset = processed_dataset.map(tokenize_function, batched=True)
```

[ ]:

```
# Define the training arguments
training_arguments = transformers.Seq2SeqTrainingArguments(
    output_dir = 't5-small-e2e_nlg',
    num_train_epochs = 3,
    eval_strategy = 'epoch',
    save_strategy='epoch',
    per_device_train_batch_size = 16,
    per_device_eval_batch_size = 16,
    save_total_limit = 3,
    load_best_model_at_end = True,
    fp16=True,
    optim='adafactor',
    report_to = []
)
```

[ ]:

```
# Fine-tune T5 small model
trainer = Trainer(
    model=model,
    args=training_arguments,
    train_dataset=tokenized_dataset["train"],
    eval_dataset=tokenized_dataset["validation"],
    tokenizer=tokenizer,
)

trainer.train()
```

```
/tmp/ipython-input-2215721696.py:1: FutureWarning: `tokenizer` is deprecated and
will be removed in version 5.0.0 for `Trainer.__init__`. Use `processing_class`
instead.
  trainer = Trainer(
```

```
<IPython.core.display.HTML object>
```

```
There were missing keys in the checkpoint model loaded:
['encoder.embed_tokens.weight', 'decoder.embed_tokens.weight',
'lm_head.weight'].
```

[ ]:

```
TrainOutput(global_step=6288, training_loss=0.10142879844015185,
metrics={'train_runtime': 4377.3727, 'train_samples_per_second': 22.976,
'train_steps_per_second': 1.436, 'total_flos': 1.36120016830464e+16,
'train_loss': 0.10142879844015185, 'epoch': 3.0})
```

[ ]:

```
# Save the fine-tuned model
model.save_pretrained('t5-small-e2e_nlg')
```

```
# Save the tokenizer
tokenizer.save_pretrained('t5-small-e2e_nlg')
```

```
[ ]: ('t5-small-e2e_nlg/tokenizer_config.json',
      't5-small-e2e_nlg/special_tokens_map.json',
      't5-small-e2e_nlg/spiece.model',
      't5-small-e2e_nlg/added_tokens.json',
      't5-small-e2e_nlg/tokenizer.json')
```

[ ]:
```
!zip -r t5-small-e2e_nlg.zip t5-small-e2e_nlg
```

[ ]:
```
# Load fine-tuned model with the tokenizer
model = AutoModelForSeq2SeqLM.from_pretrained('/content/t5-small-e2e_nlg/
 ↪t5-small-e2e_nlg')
tokenizer = AutoTokenizer.from_pretrained('/content/t5-small-e2e_nlg/
 ↪t5-small-e2e_nlg')
```

[ ]:
```
# Test the fine-tuned model with some examples
test_dataset = processed_dataset["test"]
inputs = test_dataset["input_text"][:10]
labels = test_dataset["labels"][:10]

for i in range(len(inputs)):
  input_text = inputs[i]
  target_text = labels[i]

  tokenized_input = tokenizer(input_text, return_tensors="pt", max_length=512,␣
 ↪truncation=True)
  output = model.generate(**tokenized_input, max_length=512)
  generated_text = tokenizer.decode(output[0], skip_special_tokens=True)

  print("Input:", input_text)
  print("Target:", target_text)
  print("Generated:", generated_text)
  print("-" * 50)
```

```
Input: eatType[pub], food[Fast food], customer rating[high], area[riverside],
familyFriendly[no], near[Café Rouge]
Target: The Mills is not kid friendly as it is a riverside pub near Café Rouge.
Its mid priced fast food is highly rated.
Generated: Near Café Rouge in riverside is a fast food pub that is not kid
friendly. It has a high customer rating.
--------------------------------------------------
Input: eatType[pub], food[Japanese], priceRange[moderate], customer rating[5 out
of 5], area[city centre], near[Raja Indian Cuisine]
Target: The Wrestlerss is rated 5 out of 5, serving Japanese food in a pub. It
is higher than average priced, and located near the city centre near Raja Indian
```

```
Cuisine.
Generated: In the city centre near Raja Indian Cuisine is a pub that serves
Japanese food. It has a moderate price range and a customer rating of 5 out of
5.
--------------------------------------------------
Input: eatType[restaurant], food[Chinese], priceRange[high], customer rating[1
out of 5], area[riverside], familyFriendly[no], near[All Bar One]
Target: In the riverside area near the All Bar One there is a non child friendly
restaurant. The Cricketerss serves Chinese food in a high price range and has a
customer rating of 1 out of 5.
Generated: The Chinese restaurant is located in the riverside area near All Bar
One. It has a high price range and a customer rating of 1 out of 5. It is not
child friendly.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], area[city centre]
Target: A coffee shop in the city centre area called Blue Spice.
Generated: Blue Spice is a coffee shop located in the city centre.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], area[riverside]
Target: There is a coffee shop Blue Spice in the riverside area.
Generated: Blue Spice is a coffee shop located in the riverside area.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], customer rating[5 out of 5],
near[Crowne Plaza Hotel]
Target: The coffee shop Blue Spice is based near Crowne Plaza Hotel and has a
high customer rating of 5 out of 5.
Generated: Blue Spice is a coffee shop near Crowne Plaza Hotel. It has a
customer rating of 5 out of 5.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], customer rating[average],
near[Burger King]
Target: Burger King is near the coffee shop Blue Spice which has an average
customer rating.
Generated: Blue Spice is a coffee shop near Burger King. It has an average
customer rating.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], customer rating[average],
near[Crowne Plaza Hotel]
Target: Crowne Plaza Hotel has a coffee shop nearby with an average customer
rating called Blue Spice.
Generated: Blue Spice is a coffee shop near Crowne Plaza Hotel. It has an
average customer rating.
--------------------------------------------------
Input: name[Blue Spice], eatType[pub], area[city centre]
Target: A pub in the city centre area called Blue Spice.
Generated: Blue Spice is a pub located in the city centre.
--------------------------------------------------
Input: name[Blue Spice], eatType[pub], area[riverside]
```

```
Target: There is a pub Blue Spice in the riverside area.
Generated: Blue Spice is a pub in the riverside area.
--------------------------------------------------
```

5.1 Generation with ctranslate2

[ ]:
```
# Convert model to ctranslate format
! ct2-transformers-converter --model /content/t5-small-e2e_nlg/t5-small-e2e_nlg --output_dir t5-small-e2e_nlg-ct2
```

```
2025-09-25 11:40:34.873297: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:467] Unable to register
cuFFT factory: Attempting to register factory for plugin cuFFT when one has
already been registered
WARNING: All log messages before absl::InitializeLog() is called are written to
STDERR
E0000 00:00:1758800434.894921    5578 cuda_dnn.cc:8579] Unable to register cuDNN
factory: Attempting to register factory for plugin cuDNN when one has already
been registered
E0000 00:00:1758800434.901051    5578 cuda_blas.cc:1407] Unable to register
cuBLAS factory: Attempting to register factory for plugin cuBLAS when one has
already been registered
W0000 00:00:1758800434.915848    5578 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
W0000 00:00:1758800434.915892    5578 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
W0000 00:00:1758800434.915896    5578 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
W0000 00:00:1758800434.915900    5578 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
`torch_dtype` is deprecated! Use `dtype` instead!
`torch_dtype` is deprecated! Use `dtype` instead!
```

[ ]:
```
# Instantiate model as ctranslate Translator and instantiate Tokenizer
translator = ctranslate2.Translator(
    't5-small-e2e_nlg-ct2',
    device='cuda',
)
tokenizer = transformers.AutoTokenizer.from_pretrained('/content/t5-small-e2e_nlg/t5-small-e2e_nlg')
```

[ ]:
```
# Small test data
test_dataset = processed_dataset["test"]
inputs = test_dataset["input_text"][:10]
```

```
labels = test_dataset["labels"][:10]
```

[ ]:

```
# Define function to pre process inputs
def pre_process(text):
    input_ids = tokenizer.encode(text)
    input_tokens = tokenizer.convert_ids_to_tokens(input_ids)
    return input_tokens
```

[ ]:

```
# Define function to post process inputs
def post_process(output):
    output_tokens = output.hypotheses[0]
    output_ids = tokenizer.convert_tokens_to_ids(output_tokens)
    output_text = tokenizer.decode(output_ids, skip_special_tokens=True)
    return output_text
```

[ ]:

```
# Generation function
def generation_ct2(inputs, batch_size=32, max_input_length=512,␣
 ↪max_decoding_length=512, beam_size=1, length_penalty=1.0,␣
 ↪repetition_penalty=1.0):

  batch = [pre_process(text) for text in tqdm(inputs)]

  all_generated = []

  for i in tqdm(range(0, len(batch), batch_size)):
      subbatch = batch[i:i+batch_size]

      # translate_batch expects List[List[str]]
      results = translator.translate_batch(
          subbatch,
          max_batch_size=batch_size,
          beam_size=beam_size,
          max_input_length=max_input_length,
          max_decoding_length=max_decoding_length,
          num_hypotheses=1,
          length_penalty=length_penalty,
          repetition_penalty=repetition_penalty,
      )

      all_generated += [post_process(o) for o in results]

  return all_generated
```

[ ]:

```
# Example test generation
Examples_generated = generation_ct2(inputs)
```

```
  0%|          | 0/10 [00:00<?, ?it/s]
  0%|          | 0/1 [00:00<?, ?it/s]
```

[ ]:

```
# Checking input vs target vs generated
for i in range(len(inputs)):
  input_text = inputs[i]
  target_text = labels[i]

  print("Input:", input_text)
  print("Target:", target_text)
  print("Generated:", Examples_generated[i])
  print("-" * 50)
```

```
Input: eatType[pub], food[Fast food], customer rating[high], area[riverside],
familyFriendly[no], near[Café Rouge]
Target: The Mills is not kid friendly as it is a riverside pub near Café Rouge.
Its mid priced fast food is highly rated.
Generated: Near Café Rouge in riverside is a fast food pub that is not kid
friendly. It has a high customer rating.
--------------------------------------------------
Input: eatType[pub], food[Japanese], priceRange[moderate], customer rating[5 out
of 5], area[city centre], near[Raja Indian Cuisine]
Target: The Wrestlerss is rated 5 out of 5, serving Japanese food in a pub. It
is higher than average priced, and located near the city centre near Raja Indian
Cuisine.
Generated: In the city centre near Raja Indian Cuisine is a pub that serves
Japanese food. It has a moderate price range and a customer rating of 5 out of
5.
--------------------------------------------------
Input: eatType[restaurant], food[Chinese], priceRange[high], customer rating[1
out of 5], area[riverside], familyFriendly[no], near[All Bar One]
Target: In the riverside area near the All Bar One there is a non child friendly
restaurant. The Cricketerss serves Chinese food in a high price range and has a
customer rating of 1 out of 5.
Generated: The Chinese restaurant is located in the riverside area near All Bar
One. It has a high price range and a customer rating of 1 out of 5. It is not
child friendly.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], area[city centre]
Target: A coffee shop in the city centre area called Blue Spice.
Generated: Blue Spice is a coffee shop located in the city centre.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], area[riverside]
Target: There is a coffee shop Blue Spice in the riverside area.
Generated: Blue Spice is a coffee shop located in the riverside area.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], customer rating[5 out of 5],
near[Crowne Plaza Hotel]
Target: The coffee shop Blue Spice is based near Crowne Plaza Hotel and has a
```

```
high customer rating of 5 out of 5.
Generated: Blue Spice is a coffee shop near Crowne Plaza Hotel. It has a
customer rating of 5 out of 5.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], customer rating[average],
near[Burger King]
Target: Burger King is near the coffee shop Blue Spice which has an average
customer rating.
Generated: Blue Spice is a coffee shop near Burger King. It has an average
customer rating.
--------------------------------------------------
Input: name[Blue Spice], eatType[coffee shop], customer rating[average],
near[Crowne Plaza Hotel]
Target: Crowne Plaza Hotel has a coffee shop nearby with an average customer
rating called Blue Spice.
Generated: Blue Spice is a coffee shop near Crowne Plaza Hotel. It has an
average customer rating.
--------------------------------------------------
Input: name[Blue Spice], eatType[pub], area[city centre]
Target: A pub in the city centre area called Blue Spice.
Generated: Blue Spice is a pub located in the city centre.
--------------------------------------------------
Input: name[Blue Spice], eatType[pub], area[riverside]
Target: There is a pub Blue Spice in the riverside area.
Generated: Blue Spice is a pub in the riverside area.
--------------------------------------------------
```

5.2 Full generation on the test set

[ ]:

```
test_dataset = processed_dataset["test"]
inputs = test_dataset["input_text"]
labels = test_dataset["labels"]
```

[ ]:

```
full_test_generation = generation_ct2(inputs)
```

```
0%|          | 0/1847 [00:00<?, ?it/s]

0%|          | 0/58 [00:00<?, ?it/s]
```

[ ]:

```
# Check the number of generated text
len(full_test_generation)
```

[ ]:

```
1847
```

[ ]:

```
# Prepare for saving result as JSON
gen_json = []
for i in range(len(inputs)):
  gen_json.append({
      "input_text": inputs[i],
      "target": labels[i],
      "generated_text": full_test_generation[i]
  })
```

```
[ ]: # Save the result
     with open("t5-small-e2e_nlg-test-results-3epoch.json", "w") as f:
       json.dump(gen_json, f)
```

```
[ ]: # Checking the saved result
     with open("t5-small-e2e_nlg-test-results-3epoch.json", "r") as f:
       result_json = json.load(f)
```

```
[ ]: result_json[0]
```

```
[ ]: {'input_text': 'eatType[pub], food[Fast food], customer rating[high],
     area[riverside], familyFriendly[no], near[Café Rouge]',
      'target': 'The Mills is not kid friendly as it is a riverside pub near Café
     Rouge.  Its mid priced fast food is highly rated.',
      'generated_text': 'Near Café Rouge in riverside is a fast food pub that is not
     kid friendly. It has a high customer rating.'}
```

6 4) Baseline Evaluation

```
[12]: !pip install -q evaluate sacrebleu bert-score rouge-score
```

```
        Preparing metadata (setup.py) … done
        Building wheel for rouge-score (setup.py) … done
```

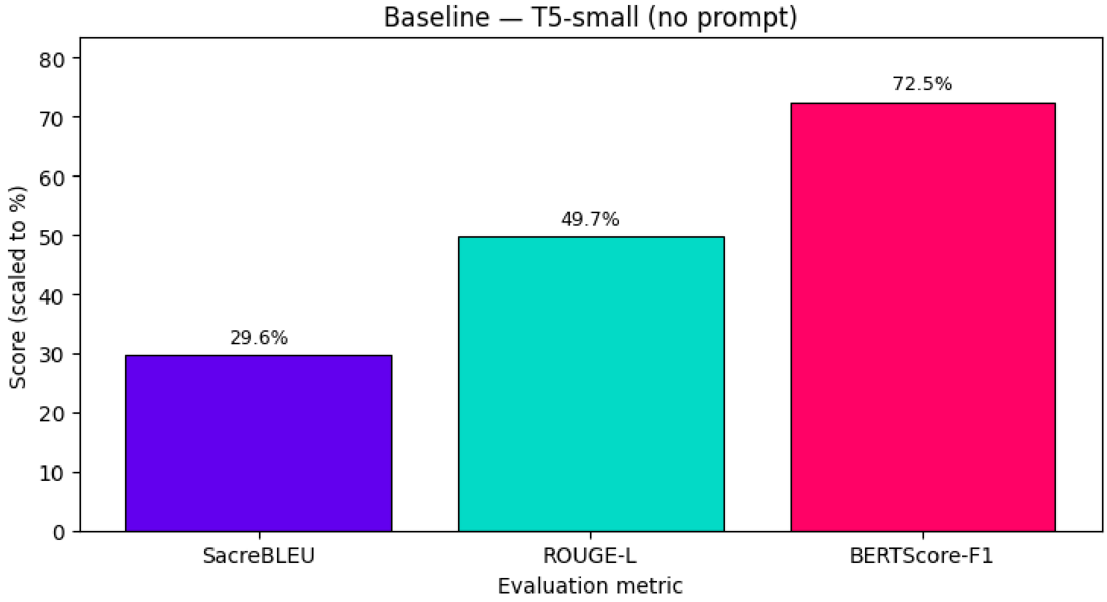
```
[38]: import warnings
      warnings.filterwarnings("ignore", message="Some weights of the model checkpoint␣
       ↪at roberta-large")
```

```
[39]: # creating a reusable evaluation function: SacreBLEU, ROUGE-L, BERTScore-F1
      def run_eval(results_path, title="Evaluation", plot=False,
                   bertscore_model="distilbert-base-uncased"): # using␣
       ↪distilbert-base-uncased for evaluating purpose
          import json
          import matplotlib.pyplot as plt
          from statistics import mean
          import evaluate

          # colors for visual
          md_colors = ["#6200EE", "#03DAC6", "#FF0266", "#FFB300", "#018786",␣
       ↪"#2962FF", "#00C853", "#AA00FF"]
```

```
    # loading JSON
    with open(results_path, "r") as f:
        data = json.load(f)
    preds = [d.get("generated_text", "") for d in data]
    refs_single = [d.get("target", "") for d in data]
    refs_listlist = [[r] for r in refs_single]  # for SacreBLEU

    # metrics
    bleu = evaluate.load("sacrebleu").compute(
        predictions=preds, references=refs_listlist
    )["score"]  # 0..100

    rougeL = evaluate.load("rouge").compute(
        predictions=preds, references=refs_single, use_aggregator=True
    )["rougeL"] * 100.0  # scale to %

    bsf1 = mean(evaluate.load("bertscore").compute(
        predictions=preds, references=refs_single, lang="en",
        model_type=bertscore_model, rescale_with_baseline=True
    )["f1"]) * 100.0  # scale to %

    metrics = {
        "SacreBLEU": bleu,
        "ROUGE-L": rougeL,
        "BERTScore-F1": bsf1,
    }

    # single plot
    if plot:
        names = ["SacreBLEU", "ROUGE-L", "BERTScore-F1"]
        vals = [metrics[k] for k in names]
        labels = [f"{v:.1f}%" for v in vals]

        plt.figure(figsize=(7.5, 4.2))
        ax = plt.gca()
        bars = ax.bar(range(len(names)), vals,
                      color=[md_colors[i % len(md_colors)] for i in range(len(names))],
                      edgecolor="black", linewidth=0.8)
        ax.set_xticks(range(len(names))); ax.set_xticklabels(names)
        ax.set_ylabel("Score (scaled to %)"); ax.set_title(title)
        ax.set_xlabel("Evaluation metric"); ax.set_title(title)
        ymax = max(vals) if vals else 1; ax.set_ylim(0, max(5, ymax*1.15))
        for i, b in enumerate(bars):
            h = b.get_height()
            ax.text(b.get_x()+b.get_width()/2, h + ymax*0.02, labels[i],
                    ha="center", va="bottom", fontsize=9)
        plt.tight_layout(); plt.show()

    # print evaluatio numbers
    print("Evaluation numbers for " + title + ": ")
    print(f"SacreBLEU        : {metrics['SacreBLEU']:.2f}")
    print(f"ROUGE-L (F1)     : {metrics['ROUGE-L']/100:.4f}")
    print(f"BERTScore F1     : {metrics['BERTScore-F1']/100:.4f}")
    return metrics
```

[40]:

```
# evaluation Baseline - T5-small (no prompt)
m_base = run_eval(
    "t5-small-e2e_nlg-test-results-3epoch.json",
    title="Baseline - T5-small (no prompt)",
    plot=True
)
```



```
Evaluation numbers for Baseline - T5-small (no prompt):
SacreBLEU        : 29.61
ROUGE-L (F1)     : 0.4966
BERTScore F1     : 0.7247
```

7 5) Instruction-Style (Prompt-Based) Fine-Tuning

7.1 Data Preprocessing

[ ]:

```python
# Add intruction prompt to the input_text
def add_instruct(batch):
  prompt = "Convert the following Key-value representation into a natural␣
↪language sentence: "
  batch["input_text"] = [prompt + x for x in batch["input_text"]]
  return batch
```

[ ]:

```python
# Apply to all splits
processed_dataset = processed_dataset.map(add_instruct, batched=True)
```

```
Map:   0%|          | 0/33525 [00:00<?, ? examples/s]

Map:   0%|          | 0/1484 [00:00<?, ? examples/s]

Map:   0%|          | 0/1847 [00:00<?, ? examples/s]
```

[ ]:

```python
processed_dataset
```

[ ]:

```
DatasetDict({
    train: Dataset({
        features: ['input_text', 'labels'],
        num_rows: 33525
    })
    validation: Dataset({
        features: ['input_text', 'labels'],
        num_rows: 1484
    })
    test: Dataset({
        features: ['input_text', 'labels', 'references'],
        num_rows: 1847
    })
})
```

[ ]:

```python
# Checking the instructed training data
processed_dataset['train'][0]
```

[ ]:

```
{'input_text': 'Convert the following Key-value representation into a natural
language sentence: name[The Eagle], eatType[coffee shop], food[Japanese],
priceRange[less than £20], customer rating[low], area[riverside],
familyFriendly[yes], near[Burger King]',
 'labels': 'The Eagle is a low rated coffee shop near Burger King and the
riverside that is family friendly and is less than £20 for Japanese food.'}
```

7.2 Fine-Tuning

[ ]:

```
# Tokenize data same as basline
tokenized_dataset = processed_dataset.map(tokenize_function, batched=True)
```

```
Map:   0%|          | 0/33525 [00:00<?, ? examples/s]
```

```
/usr/local/lib/python3.12/dist-
packages/transformers/tokenization_utils_base.py:4007: UserWarning:
`as_target_tokenizer` is deprecated and will be removed in v5 of Transformers.
You can tokenize your labels by using the argument `text_target` of the regular
`__call__` method (either in the same call as your input texts if you use the
same keyword arguments, or in a separate call.
  warnings.warn(
```

```
Map:   0%|          | 0/1484 [00:00<?, ? examples/s]
```

```
Map:   0%|          | 0/1847 [00:00<?, ? examples/s]
```

[ ]:

```
tokenized_dataset
```

[ ]:

```
DatasetDict({
    train: Dataset({
        features: ['input_text', 'labels', 'input_ids', 'attention_mask'],
        num_rows: 33525
    })
    validation: Dataset({
        features: ['input_text', 'labels', 'input_ids', 'attention_mask'],
        num_rows: 1484
    })
    test: Dataset({
        features: ['input_text', 'labels', 'references', 'input_ids',
'attention_mask'],
        num_rows: 1847
    })
})
```

[ ]:

```
# Fine-tune T5 small model with Instruct data
trainer = Trainer(
    model=model,
    args=training_arguments,
    train_dataset=tokenized_dataset["train"],
    eval_dataset=tokenized_dataset["validation"],
    tokenizer=tokenizer,
)

trainer.train()
```

```
/tmp/ipython-input-2215721696.py:1: FutureWarning: `tokenizer` is deprecated and
```

```
will be removed in version 5.0.0 for `Trainer.__init__`. Use `processing_class`
instead.
  trainer = Trainer(
```

```
<IPython.core.display.HTML object>
```

```
There were missing keys in the checkpoint model loaded:
['encoder.embed_tokens.weight', 'decoder.embed_tokens.weight',
'lm_head.weight'].
```

```
[ ]: TrainOutput(global_step=6288, training_loss=0.09813755401824874,
     metrics={'train_runtime': 4478.8458, 'train_samples_per_second': 22.456,
     'train_steps_per_second': 1.404, 'total_flos': 1.36120016830464e+16,
     'train_loss': 0.09813755401824874, 'epoch': 3.0})
```

```
[ ]: # Save the fine-tuned model
     model.save_pretrained('t5-small-e2e_nlg-instruct')

     # Save the tokenizer
     tokenizer.save_pretrained('t5-small-e2e_nlg-instruct')
```

```
[ ]: ('t5-small-e2e_nlg-instruct/tokenizer_config.json',
      't5-small-e2e_nlg-instruct/special_tokens_map.json',
      't5-small-e2e_nlg-instruct/spiece.model',
      't5-small-e2e_nlg-instruct/added_tokens.json',
      't5-small-e2e_nlg-instruct/tokenizer.json')
```

```
[ ]: !zip -r t5-small-e2e_nlg-instruct.zip t5-small-e2e_nlg-instruct
```

```
  adding: t5-small-e2e_nlg-instruct/ (stored 0%)
  adding: t5-small-e2e_nlg-instruct/tokenizer.json (deflated 74%)
  adding: t5-small-e2e_nlg-instruct/model.safetensors (deflated 7%)
  adding: t5-small-e2e_nlg-instruct/config.json (deflated 63%)
  adding: t5-small-e2e_nlg-instruct/tokenizer_config.json (deflated 95%)
  adding: t5-small-e2e_nlg-instruct/special_tokens_map.json (deflated 85%)
  adding: t5-small-e2e_nlg-instruct/generation_config.json (deflated 27%)
  adding: t5-small-e2e_nlg-instruct/spiece.model (deflated 48%)
```

```
[ ]: # Load fine-tuned model with the tokenizer
     model = AutoModelForSeq2SeqLM.from_pretrained('/content/
      ↪t5-small-e2e_nlg-instruct')
     tokenizer = AutoTokenizer.from_pretrained('/content/t5-small-e2e_nlg-instruct')
```

```
[ ]: # Test the fine-tuned model with some examples
     test_dataset = processed_dataset["test"]
     inputs_instruct = ["Convert the following Key-value representation into a␣
      ↪natural language sentence: " + x for x in test_dataset["input_text"]]
```

```python
inputs_5 = inputs_instruct[:5]
labels_5 = test_dataset["labels"][:5]

for i in range(len(inputs_5)):
  input_text = inputs_5[i]
  target_text = labels_5[i]

  tokenized_input = tokenizer(input_text, return_tensors="pt", max_length=512,␣
 ↪truncation=True)
  output = model.generate(**tokenized_input, max_length=512)
  generated_text = tokenizer.decode(output[0], skip_special_tokens=True)

  print("Input:", input_text)
  print("Target:", target_text)
  print("Generated:", generated_text)
  print("-" * 50)
```

```
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: eatType[pub], food[Fast food], customer rating[high], area[riverside],
familyFriendly[no], near[Café Rouge]
Target: The Mills is not kid friendly as it is a riverside pub near Café Rouge.
Its mid priced fast food is highly rated.
Generated: The Fast food pub is located in the riverside area near Café Rouge.
It has a high customer rating and is not child friendly.
--------------------------------------------------
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: eatType[pub], food[Japanese], priceRange[moderate], customer rating[5
out of 5], area[city centre], near[Raja Indian Cuisine]
Target: The Wrestlerss is rated 5 out of 5, serving Japanese food in a pub. It
is higher than average priced, and located near the city centre near Raja Indian
Cuisine.
Generated: The Japanese pub is located in the city centre near Raja Indian
Cuisine. It has a moderate price range and a customer rating of 5 out of 5.
--------------------------------------------------
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: eatType[restaurant], food[Chinese], priceRange[high], customer
rating[1 out of 5], area[riverside], familyFriendly[no], near[All Bar One]
Target: In the riverside area near the All Bar One there is a non child friendly
restaurant. The Cricketerss serves Chinese food in a high price range and has a
customer rating of 1 out of 5.
Generated: The Chinese restaurant is located in the riverside area near All Bar
One. It has a high price range and a customer rating of 1 out of 5. It is not
child friendly.
--------------------------------------------------
```

```
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: name[Blue Spice], eatType[coffee shop], area[city centre]
Target: A coffee shop in the city centre area called Blue Spice.
Generated: Blue Spice is a coffee shop located in the city centre.
--------------------------------------------------
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: name[Blue Spice], eatType[coffee shop], area[riverside]
Target: There is a coffee shop Blue Spice in the riverside area.
Generated: Blue Spice is a coffee shop located in the riverside area.
--------------------------------------------------
```

7.3 Generation with ctranslate2

[ ]:

```
# Convert model to ctranslate format
! ct2-transformers-converter --model /content/t5-small-e2e_nlg-instruct --output_dir t5-small-e2e_nlg-instruct-ct2
```

```
2025-10-04 10:34:16.758912: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:467] Unable to register
cuFFT factory: Attempting to register factory for plugin cuFFT when one has
already been registered
WARNING: All log messages before absl::InitializeLog() is called are written to
STDERR
E0000 00:00:1759574056.795842   27402 cuda_dnn.cc:8579] Unable to register cuDNN
factory: Attempting to register factory for plugin cuDNN when one has already
been registered
E0000 00:00:1759574056.806434   27402 cuda_blas.cc:1407] Unable to register
cuBLAS factory: Attempting to register factory for plugin cuBLAS when one has
already been registered
W0000 00:00:1759574056.835006   27402 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
W0000 00:00:1759574056.835039   27402 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
W0000 00:00:1759574056.835048   27402 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
W0000 00:00:1759574056.835054   27402 computation_placer.cc:177] computation
placer already registered. Please check linkage and avoid linking the same
target more than once.
`torch_dtype` is deprecated! Use `dtype` instead!
`torch_dtype` is deprecated! Use `dtype` instead!
```

[ ]:

```
# Instantiate model as ctranslate Translator and instantiate Tokenizer
translator = ctranslate2.Translator(
    't5-small-e2e_nlg-instruct-ct2',
    device='cuda',
)
tokenizer = transformers.AutoTokenizer.from_pretrained('/content/
 ↪t5-small-e2e_nlg-instruct')
```

[ ]:

```
# Example test generation
Examples_generated = generation_ct2(inputs_5)
```

```
0%|          | 0/5 [00:00<?, ?it/s]

0%|          | 0/1 [00:00<?, ?it/s]
```

[ ]:

```
# Checking input vs target vs generated
for i in range(len(inputs_5)):
  input_text = inputs_5[i]
  target_text = labels_5[i]

  print("Input:", input_text)
  print("Target:", target_text)
  print("Generated:", Examples_generated[i])
  print("-" * 50)
```

```
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: eatType[pub], food[Fast food], customer rating[high], area[riverside],
familyFriendly[no], near[Café Rouge]
Target: The Mills is not kid friendly as it is a riverside pub near Café Rouge.
Its mid priced fast food is highly rated.
Generated: The Fast food pub is located in the riverside area near Café Rouge.
It has a high customer rating and is not child friendly.
--------------------------------------------------
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: eatType[pub], food[Japanese], priceRange[moderate], customer rating[5
out of 5], area[city centre], near[Raja Indian Cuisine]
Target: The Wrestlerss is rated 5 out of 5, serving Japanese food in a pub. It
is higher than average priced, and located near the city centre near Raja Indian
Cuisine.
Generated: The Japanese pub is located in the city centre near Raja Indian
Cuisine. It has a moderate price range and a customer rating of 5 out of 5.
--------------------------------------------------
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: eatType[restaurant], food[Chinese], priceRange[high], customer
rating[1 out of 5], area[riverside], familyFriendly[no], near[All Bar One]
```

```
Target: In the riverside area near the All Bar One there is a non child friendly
restaurant. The Cricketerss serves Chinese food in a high price range and has a
customer rating of 1 out of 5.
Generated: The Chinese restaurant is located in the riverside area near All Bar
One. It has a high price range and a customer rating of 1 out of 5. It is not
child friendly.
--------------------------------------------------
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: name[Blue Spice], eatType[coffee shop], area[city centre]
Target: A coffee shop in the city centre area called Blue Spice.
Generated: Blue Spice is a coffee shop located in the city centre.
--------------------------------------------------
Input: Convert the following Key-value representation into a natural language
sentence: Convert the following Key-value representation into a natural language
sentence: name[Blue Spice], eatType[coffee shop], area[riverside]
Target: There is a coffee shop Blue Spice in the riverside area.
Generated: Blue Spice is a coffee shop located in the riverside area.
--------------------------------------------------
```

7.4 Full Generation On The Test Set

[ ]:
```python
# Preparing the data for full generation
test_dataset = processed_dataset["test"]
inputs_instruct = ["Convert the following Key-value representation into a natural language sentence: " + x for x in test_dataset["input_text"]]
inputs = inputs_instruct
labels = test_dataset["labels"]
```

[ ]:
```python
# Passing data to the generation function
full_test_generation = generation_ct2(inputs)
```

```
0%|          | 0/1847 [00:00<?, ?it/s]

0%|          | 0/58 [00:00<?, ?it/s]
```

[ ]:
```python
# Check the number of generated text

len(full_test_generation)
```

[ ]: 1847

[ ]:
```python
# Prepare for saving result as JSON
gen_json = []
for i in range(len(inputs)):
  gen_json.append({
      "input_text": inputs[i],
      "target": labels[i],
      "generated_text": full_test_generation[i]
  })
```

[ ]:
```
# Save the data
with open("t5-small-e2e_nlg-test-results-3epoch-instruct.json", "w") as f:
    json.dump(gen_json, f)
```

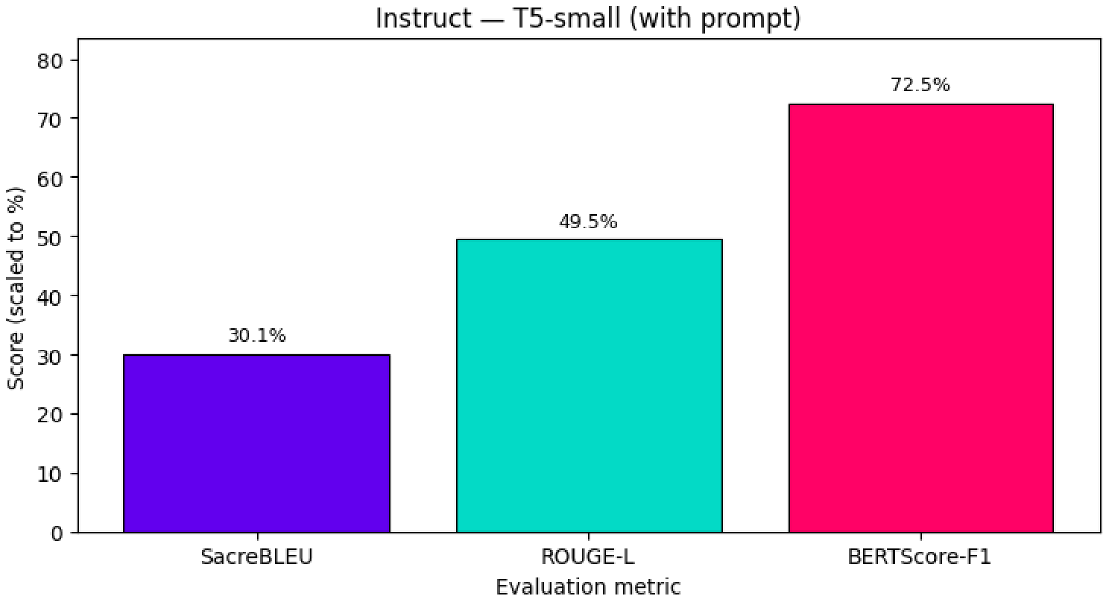
[ ]:
```
# Checking the saved result

with open("t5-small-e2e_nlg-test-results-3epoch-instruct.json", "r") as f:
    result_json = json.load(f)
```

[ ]:
```
result_json[0]
```

[ ]:
```
{'input_text': 'Convert the following Key-value representation into a natural
language sentence: Convert the following Key-value representation into a natural
language sentence: eatType[pub], food[Fast food], customer rating[high],
area[riverside], familyFriendly[no], near[Café Rouge]',
 'target': 'The Mills is not kid friendly as it is a riverside pub near Café
Rouge.  Its mid priced fast food is highly rated.',
 'generated_text': 'The Fast food pub is located in the riverside area near Café
Rouge. It has a high customer rating and is not child friendly.'}
```

8 6) Instructed model Evaluation …

[41]:
```
# evaluation Instruct - T5-small (with prompt)
m_base = run_eval(
    "t5-small-e2e_nlg-test-results-3epoch-instruct.json",
    title="Instruct - T5-small (with prompt)",
    plot=True
)
```



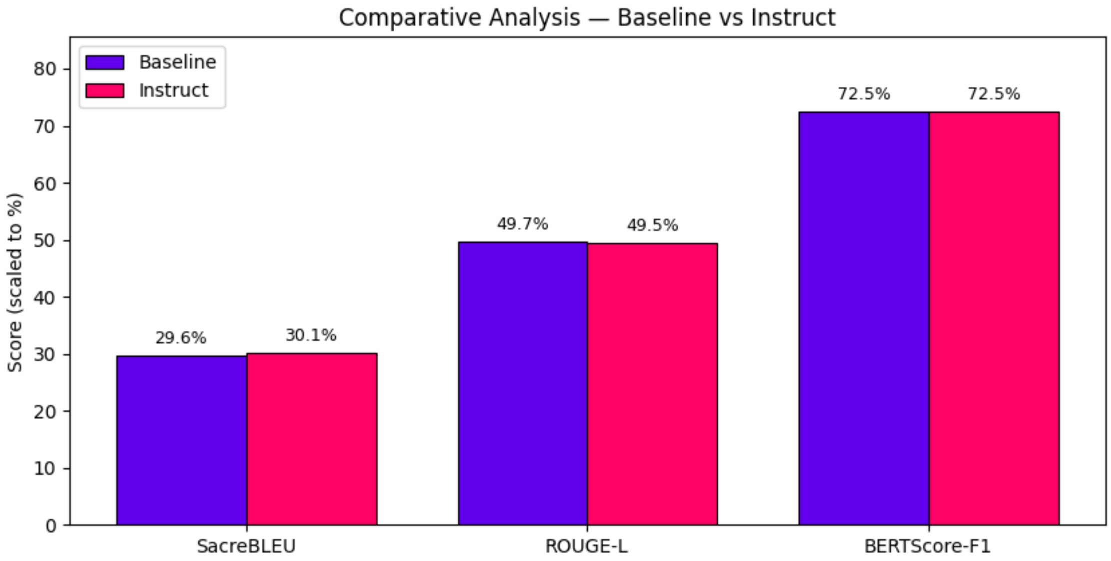
```
Evaluation numbers for Instruct - T5-small (with prompt):
SacreBLEU         : 30.10
ROUGE-L (F1)      : 0.4947
BERTScore F1      : 0.7251
```

9 7) Comparative Analysis

[44]:
```
# Comparative Analysis

# compute metrics for with and without prompt finetuned models
base_metrics = run_eval("t5-small-e2e_nlg-test-results-3epoch.json",
                        title="Instruct - T5-small (without prompt)",␣
 ↪plot=False)
inst_metrics = run_eval("t5-small-e2e_nlg-test-results-3epoch-instruct.json",
                        title="Instruct - T5-small (with prompt)", plot=False)

# order + values
metrics_order = ["SacreBLEU", "ROUGE-L", "BERTScore-F1"]
base_vals = [base_metrics[m] for m in metrics_order]
inst_vals = [inst_metrics[m] for m in metrics_order]

# plot
import matplotlib.pyplot as plt
x = range(len(metrics_order)); w = 0.38
plt.figure(figsize=(8.5, 4.4))
ax = plt.gca()
```

```
bars1 = ax.bar([i - w/2 for i in x], base_vals, width=w, label="Baseline",
               color=md_colors[0], edgecolor="black", linewidth=0.8)
bars2 = ax.bar([i + w/2 for i in x], inst_vals, width=w, label="Instruct",
               color=md_colors[2], edgecolor="black", linewidth=0.8)

ax.set_xticks(list(x)); ax.set_xticklabels(metrics_order)
ax.set_ylabel("Score (scaled to %)"); ax.set_title("Comparative Analysis -␣
 ↪Baseline vs Instruct")
ax.legend()

ymax = max(base_vals + inst_vals) if (base_vals + inst_vals) else 1
ax.set_ylim(0, max(5, ymax*1.18))

# data labels
for bars in (bars1, bars2):
    for b in bars:
        h = b.get_height()
        ax.text(b.get_x()+b.get_width()/2, h + ymax*0.02, f"{h:.1f}%",
                ha="center", va="bottom", fontsize=9)

plt.tight_layout()
plt.show()
```

```
Evaluation numbers for Instruct - T5-small (without prompt):
SacreBLEU         : 29.61
ROUGE-L (F1)      : 0.4966
BERTScore F1      : 0.7247
Evaluation numbers for Instruct - T5-small (with prompt):
SacreBLEU         : 30.10
ROUGE-L (F1)      : 0.4947
BERTScore F1      : 0.7251
```


Comparative Analysis — Baseline vs Instruct
Baseline
Instruct
Score (scaled to %)
0
10
20
30
40
50
60
70
80
29.6%
30.1%
49.7%
49.5%
72.5%
72.5%
SacreBLEU
ROUGE-L
BERTScore-F1