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Step 1: Install Required Libraries

```
!pip install spacy pandas matplotlib seaborn
!python -m spacy download en_core_web_sm

Requirement already satisfied: spacy in
/usr/local/lib/python3.12/dist-packages (3.8.11)
Requirement already satisfied: pandas in
/usr/local/lib/python3.12/dist-packages (2.2.2)
Requirement already satisfied: matplotlib in
/usr/local/lib/python3.12/dist-packages (3.10.0)
Requirement already satisfied: seaborn in
/usr/local/lib/python3.12/dist-packages (0.13.2)
Requirement already satisfied: spacy-legacy<3.1.0,>=3.0.11 in
/usr/local/lib/python3.12/dist-packages (from spacy) (3.0.12)
Requirement already satisfied: spacy-loggers<2.0.0,>=1.0.0 in
/usr/local/lib/python3.12/dist-packages (from spacy) (1.0.5)
Requirement already satisfied: murmurhash<1.1.0,>=0.28.0 in
/usr/local/lib/python3.12/dist-packages (from spacy) (1.0.15)
Requirement already satisfied: cymem<2.1.0,>=2.0.2 in
/usr/local/lib/python3.12/dist-packages (from spacy) (2.0.13)
Requirement already satisfied: preshed<3.1.0,>=3.0.2 in
/usr/local/lib/python3.12/dist-packages (from spacy) (3.0.12)
Requirement already satisfied: thinc<8.4.0,>=8.3.4 in
/usr/local/lib/python3.12/dist-packages (from spacy) (8.3.10)
Requirement already satisfied: wasabi<1.2.0,>=0.9.1 in
/usr/local/lib/python3.12/dist-packages (from spacy) (1.1.3)
Requirement already satisfied: srsly<3.0.0,>=2.4.3 in
/usr/local/lib/python3.12/dist-packages (from spacy) (2.5.2)
Requirement already satisfied: catalogue<2.1.0,>=2.0.6 in
/usr/local/lib/python3.12/dist-packages (from spacy) (2.0.10)
Requirement already satisfied: weasel<0.5.0,>=0.4.2 in
/usr/local/lib/python3.12/dist-packages (from spacy) (0.4.3)
Requirement already satisfied: typer-slim<1.0.0,>=0.3.0 in
/usr/local/lib/python3.12/dist-packages (from spacy) (0.21.1)
Requirement already satisfied: tqdm<5.0.0,>=4.38.0 in
/usr/local/lib/python3.12/dist-packages (from spacy) (4.67.1)
Requirement already satisfied: numpy>=1.19.0 in
/usr/local/lib/python3.12/dist-packages (from spacy) (2.0.2)
Requirement already satisfied: requests<3.0.0,>=2.13.0 in
/usr/local/lib/python3.12/dist-packages (from spacy) (2.32.4)
Requirement already satisfied: pydantic!=1.8,!=1.8.1,<3.0.0,>=1.7.4 in
/usr/local/lib/python3.12/dist-packages (from spacy) (2.12.3)
Requirement already satisfied: jinja2 in
/usr/local/lib/python3.12/dist-packages (from spacy) (3.1.6)
Requirement already satisfied: setuptools in
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/usr/local/lib/python3.12/dist-packages (from spacy) (75.2.0)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.12/dist-packages (from spacy) (25.0)
Requirement already satisfied: python-dateutil>=2.8.2 in
/usr/local/lib/python3.12/dist-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.12/dist-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.12/dist-packages (from pandas) (2025.3)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.12/dist-packages (from matplotlib) (1.3.3)
Requirement already satisfied: cycler>=0.10 in
/usr/local/lib/python3.12/dist-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.12/dist-packages (from matplotlib) (4.61.1)
Requirement already satisfied: kiwisolver>=1.3.1 in
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Requirement already satisfied: pillow>=8 in
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=1.8.1,<3.0.0,>=1.7.4->spacy) (0.7.0)
Requirement already satisfied: pydantic-core==2.41.4 in
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=1.8.1,<3.0.0,>=1.7.4->spacy) (2.41.4)
Requirement already satisfied: typing-extensions>=4.14.1 in
/usr/local/lib/python3.12/dist-packages (from pydantic!=1.8,!
=1.8.1,<3.0.0,>=1.7.4->spacy) (4.15.0)
Requirement already satisfied: typing-inspection>=0.4.2 in
/usr/local/lib/python3.12/dist-packages (from pydantic!=1.8,!
=1.8.1,<3.0.0,>=1.7.4->spacy) (0.4.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.12/dist-packages (from python-dateutil>=2.8.2-
>pandas) (1.17.0)
Requirement already satisfied: charset_normalizer<4,>=2 in
/usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.13.0-
>spacy) (3.4.4)
Requirement already satisfied: idna<4,>=2.5 in
/usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.13.0-
>spacy) (3.11)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.13.0-
>spacy) (2.5.0)
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>spacy) (2026.1.4)
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>spacy) (1.3.3)
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>spacy) (0.1.5)
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slim<1.0.0,>=0.3.0->spacy) (8.3.1)
Requirement already satisfied: cloudpathlib<1.0.0,>=0.7.0 in
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>spacy) (0.23.0)
Requirement already satisfied: smart-open<8.0.0,>=5.2.1 in
/usr/local/lib/python3.12/dist-packages (from weasel<0.5.0,>=0.4.2-
>spacy) (7.5.0)
Requirement already satisfied: MarkupSafe>=2.0 in
/usr/local/lib/python3.12/dist-packages (from jinja2->spacy) (3.0.3)
Requirement already satisfied: wrapt in
/usr/local/lib/python3.12/dist-packages (from smart-
open<8.0.0,>=5.2.1->weasel<0.5.0,>=0.4.2->spacy) (2.0.1)
Collecting en-core-web-sm==3.8.0
  Downloading
https://github.com/explosion/spacy-models/releases/download/en_core_we
b_sm-3.8.0/en_core_web_sm-3.8.0-py3-none-any.whl (12.8 MB)
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 12.8/12.8 MB 81.9 MB/s eta
0:00:00
✔ Download and installation successful
You can now load the package via spacy.load('en_core_web_sm')
⚠ Restart to reload dependencies
If you are in a Jupyter or Colab notebook, you may need to restart
Python in
order to load all the package's dependencies. You can do this by
selecting the
'Restart kernel' or 'Restart runtime' option.
```

Step 2: Import Libraries

```
import pandas as pd
import spacy
from collections import Counter
import matplotlib.pyplot as plt
import seaborn as sns

from spacy.matcher import Matcher
```

Step 3: Load spaCy NLP Model

```
nlp = spacy.load("en_core_web_sm")
```

Step 4: Load the Dataset

```
df = pd.read_csv("/content/arxiv_data.csv")


df.columns

Index(['titles', 'summaries', 'terms'], dtype='object')

texts = df["summaries"].dropna().head(100).tolist()
```

Step 5: Process Text Using spaCy Pipeline

```
docs = [nlp(text) for text in texts]
```

Step 6: Extract Frequent Noun Phrases

```
noun_phrases = []

for doc in docs:
    for chunk in doc.noun_chunks:
        noun_phrases.append(chunk.text.lower())

# Count most common noun phrases
noun_phrase_freq = Counter(noun_phrases)
top_noun_phrases = noun_phrase_freq.most_common(10)

top_noun_phrases

[('we', 265),
 ('which', 74),
 ('that', 73),
 ('it', 72),
 ('the-art', 42),
 ('this paper', 34),
 ('medical image segmentation', 25),
 ('our method', 25),
 ('this work', 24),
 ('image segmentation', 22)]
```

Step 7: Extract Named Entities

```
entities = []

for doc in docs:
    for ent in doc.ents:
        entities.append(ent.label_)

entity_freq = Counter(entities)
entity_freq
```

```
Counter({'DATE': 13,
         'GPE': 21,
         'CARDINAL': 132,
         'NORP': 15,
         'ORG': 247,
         'ORDINAL': 37,
         'WORK_OF_ART': 2,
         'PERSON': 31,
         'PERCENT': 19,
         'PRODUCT': 6,
         'MONEY': 4,
         'TIME': 2,
         'LOC': 1,
         'LAW': 1,
         'EVENT': 1,
         'FAC': 3})
```

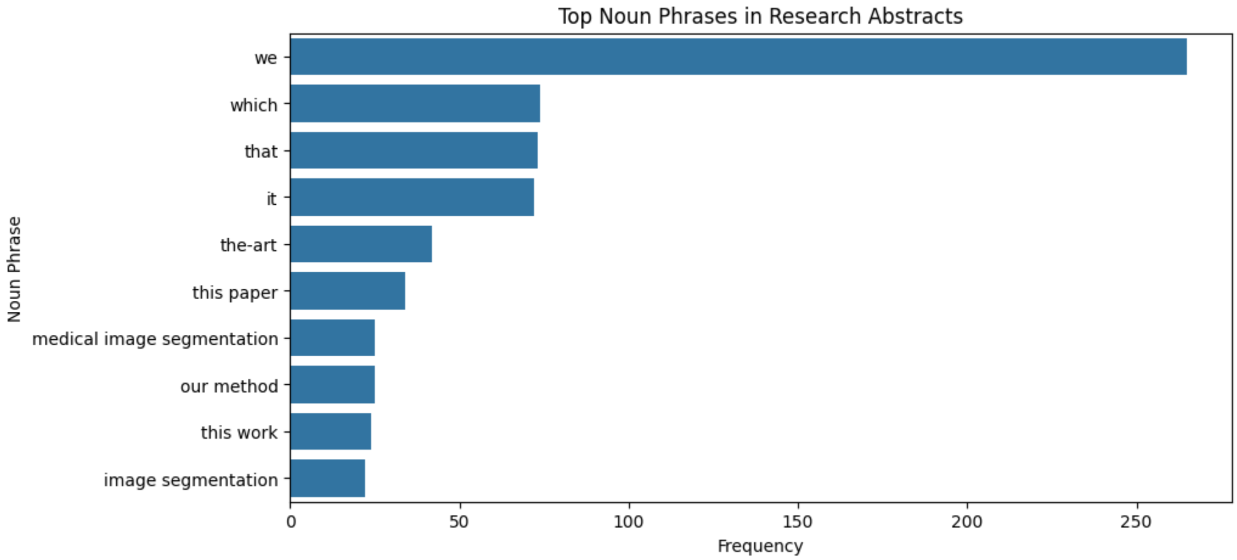
Step 8: Rule-Based Matching Using spaCy Matcher

```
matcher = Matcher(nlp.vocab)

pattern = [
    {"POS": "ADJ"},
    {"POS": "NOUN"}
]

matcher.add("TECH_TERM", [pattern])

matches = []

for doc in docs:
    found_matches = matcher(doc)
    for match_id, start, end in found_matches:
        matches.append(doc[start:end].text.lower())

Counter(matches).most_common(10)
```

```
[('medical image', 62),
 ('semantic segmentation', 29),
 ('deep learning', 18),
 ('contextual information', 12),
 ('unlabeled data', 11),
 ('semantic image', 11),
 ('neural networks', 10),
 ('medical images', 10),
 ('medical imaging', 9),
 ('experimental results', 9)]
```

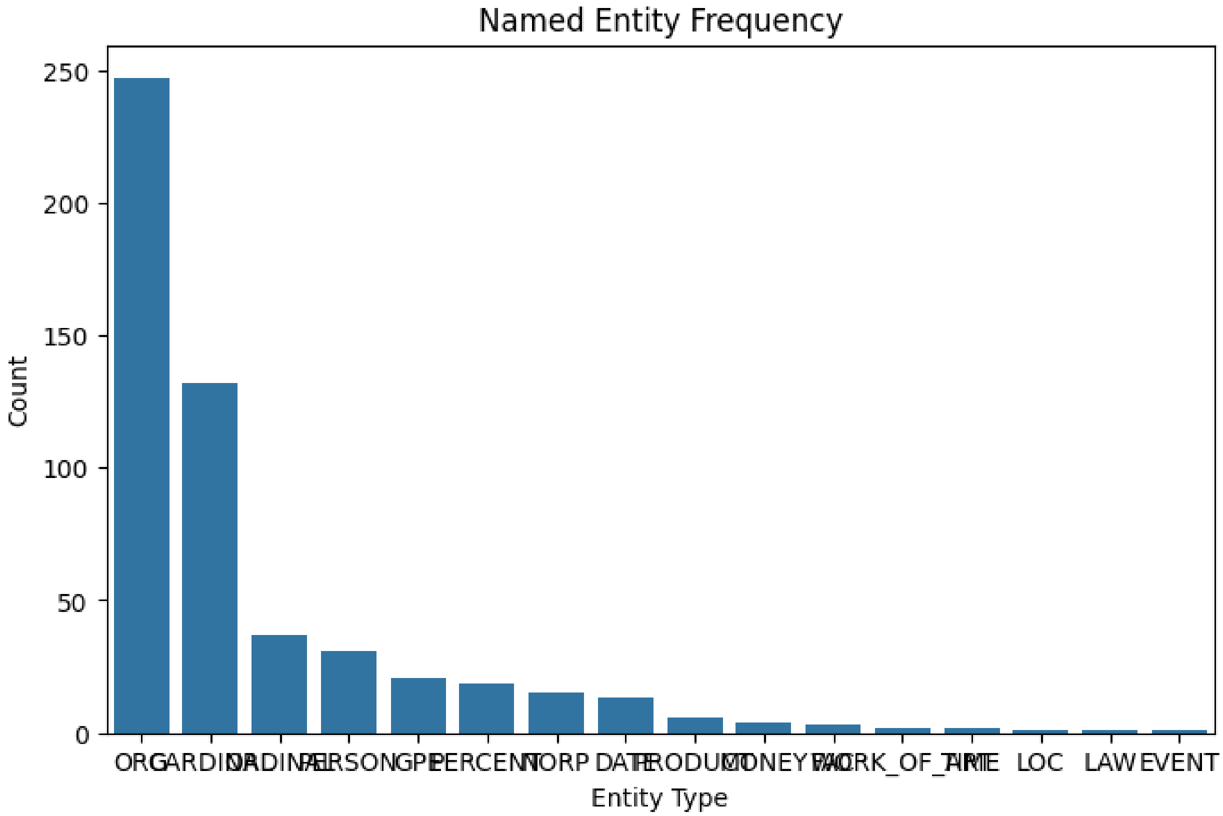
Step 9: Visualize Top Noun Phrases

```
phrases, counts = zip(*top_noun_phrases)

plt.figure(figsize=(10,5))
sns.barplot(x=list(counts), y=list(phrases))
plt.title("Top Noun Phrases in Research Abstracts")
plt.xlabel("Frequency")
plt.ylabel("Noun Phrase")
plt.show()
```



Step 10: Visualize Entity Frequencies

```
labels, values = zip(*entity_freq.most_common())

plt.figure(figsize=(8,5))
sns.barplot(x=list(labels), y=list(values))
plt.title("Named Entity Frequency")
plt.xlabel("Entity Type")
plt.ylabel("Count")
plt.show()
```



Explanation (Theory)

spaCy works well for general entities

Struggles with:

Scientific abbreviations

Mathematical symbols

Domain-specific terms

Rule-based matcher helps improve accuracy