01_Dataset_Analysis

December 14, 2025

1 NER Dataset Analysis

1.1 1. Import dependencies

[1]:

```
# Standard library imports
import json
import sys
from pathlib import Path
from collections import Counter, defaultdict
from typing import Dict, List, Tuple

# Data manipulation and analysis
import pandas as pd
import numpy as np

# Visualization
import matplotlib.pyplot as plt
import seaborn as sns

# Statistical analysis
from scipy import stats

# Add project root to path
project_root = Path.cwd().parent
if str(project_root) not in sys.path:
    sys.path.insert(0, str(project_root))

# Import custom data loader
from src.data import load_processed_data

# Configuration
import warnings
warnings.filterwarnings('ignore')

# Display settings
pd.set_option('display.max_columns', None)
pd.set_option('display.precision', 2)
pd.set_option('display.float_format', '{:.2f}'.format)
```

```python

# Plotting configuration
plt.style.use('seaborn-v0_8-whitegrid')
sns.set_context('notebook', font_scale=1.1)
sns.set_palette('deep')

# Figure defaults
plt.rcParams['figure.figsize'] = (14, 6)
plt.rcParams['figure.dpi'] = 100
plt.rcParams['savefig.dpi'] = 300
plt.rcParams['savefig.bbox'] = 'tight'
plt.rcParams['font.size'] = 11
plt.rcParams['axes.labelsize'] = 12
plt.rcParams['axes.titlesize'] = 14
plt.rcParams['xtick.labelsize'] = 10
plt.rcParams['ytick.labelsize'] = 10
plt.rcParams['legend.fontsize'] = 10
```

```
Python version: 3.12.12
NumPy version: 1.26.4
Pandas version: 2.3.3
Matplotlib version: 3.10.8
Seaborn version: 0.13.2
```

1.2 2. Data Loading and Preprocessing

[2]:

```python
# Define data paths
PROJECT_ROOT = Path.cwd().parent
DATA_DIR = PROJECT_ROOT / "data" / "vlps_2018_ner" / "processed"
OUTPUT_DIR = PROJECT_ROOT / "docs"

# Ensure output directory exists
OUTPUT_DIR.mkdir(parents=True, exist_ok=True)
```

[3]:

```python
# Load all splits using src.data loader
data_splits = load_processed_data()
train_data = data_splits['train']
dev_data = data_splits['dev']
test_data = data_splits['test']
all_data = train_data + dev_data + test_data

# Basic dataset information
print("Dataset Split Distribution")
print("=" * 50)
print(f"Training set:   {len(train_data):5d} records ({len(train_data)/
 ↪len(all_data)*100:5.2f}%)")
```

```
print(f"Development set:{len(dev_data):5d} records ({len(dev_data)/
 ↪len(all_data)*100:5.2f}%)")
print(f"Test set:       {len(test_data):5d} records ({len(test_data)/
 ↪len(all_data)*100:5.2f}%)")
print(f"{'='*50}")
print(f"Total:          {len(all_data):5d} records")
```

```
Dataset Split Distribution
==================================================
Training set:     781 records (60.92%)
Development set:  260 records (20.28%)
Test set:         241 records (18.80%)
==================================================
Total:           1282 records
```

[4]:

```
# Display sample record structure
sample_record = train_data[0]

print("Sample Record Structure")
print("=" * 80)
print(f"ID: {sample_record['id']}")
print(f"Topic: {sample_record['topic']}")
print(f"\nTitle:")
print(f"{sample_record['title'][:100]}...")
print(f"\nText (first 200 characters):")
print(f"{sample_record['text'][:200]}...")
print(f"\nGround Truth Entities:")
for entity_type, entities in sample_record['ground_truth'].items():
    print(f"  {entity_type}: {len(entities)} entities")
    if entities:
        print(f"    Example: {entities[0]}")
```

```
Sample Record Structure
================================================================================
ID: 23351225
Topic: Doi song

Title:
Chuyện đau khi tiêm…

Text (first 200 characters):
Nỗi đau của người bệnh khi bị tiêm, kéo dài vài giây, vài phút, cùng lắm có thể
đến vài ngày. Nhưng nỗi đau của người làm y tế khi đọc, khi nghe những nhận định
đổ lỗi, gắn mác phong bì thì còn kéo dà…

Ground Truth Entities:
  person: 0 entities
```

```
organizations: 1 entities
  Example: Tổ chức y tế Thế giới
address: 0 entities
```

1.3 3. Descriptive Statistics

[5]:

```python
def compute_split_statistics(data: List[Dict], split_name: str) -> Dict:
    """
    Compute comprehensive statistics for a dataset split.

    Parameters:
    -----------
    data : List[Dict]
        Dataset records
    split_name : str
        Name of the split

    Returns:
    --------
    Dict
        Dictionary containing computed statistics
    """
    text_lengths = []
    title_lengths = []
    word_counts = []
    entities_per_doc = []

    person_count = 0
    org_count = 0
    addr_count = 0

    for record in data:
        # Text metrics
        text_lengths.append(len(record['text']))
        title_lengths.append(len(record['title']))
        word_counts.append(len(record['text'].split()))

        # Entity counts
        gt = record['ground_truth']
        n_persons = len(gt['person'])
        n_orgs = len(gt['organizations'])
        n_addrs = len(gt['address'])

        person_count += n_persons
        org_count += n_orgs
        addr_count += n_addrs
        entities_per_doc.append(n_persons + n_orgs + n_addrs)
    return {
        'split': split_name,
        'n_documents': len(data),
        'n_entities_total': person_count + org_count + addr_count,
        'n_persons': person_count,
        'n_organizations': org_count,
        'n_addresses': addr_count,
        'entities_per_doc_mean': np.mean(entities_per_doc),
        'entities_per_doc_std': np.std(entities_per_doc),
        'entities_per_doc_median': np.median(entities_per_doc),
        'text_length_mean': np.mean(text_lengths),
        'text_length_std': np.std(text_lengths),
        'text_length_median': np.median(text_lengths),
        'text_length_p25': np.percentile(text_lengths, 25),
        'text_length_p75': np.percentile(text_lengths, 75),
        'text_length_p95': np.percentile(text_lengths, 95),
        'word_count_mean': np.mean(word_counts),
        'word_count_std': np.std(word_counts),
        'title_length_mean': np.mean(title_lengths),
    }

# Compute statistics for all splits
stats_train = compute_split_statistics(train_data, 'Train')
stats_dev = compute_split_statistics(dev_data, 'Dev')
stats_test = compute_split_statistics(test_data, 'Test')
stats_all = compute_split_statistics(all_data, 'Overall')

# Create summary DataFrame
stats_df = pd.DataFrame([stats_train, stats_dev, stats_test, stats_all])
stats_df = stats_df.set_index('split')

print("\nDataset Statistics Summary")
print("=" * 100)
display(stats_df[['n_documents', 'n_entities_total', 'n_persons',
                   'n_organizations', 'n_addresses', 'entities_per_doc_mean']])
```

```
Dataset Statistics Summary
================================================================================
====================

         n_documents  n_entities_total  n_persons  n_organizations  \
split
Train            781              8992       3308             1672
Dev              260              3032       1067              584
Test             241              3869       1829              737
Overall         1282             15893       6204             2993
```

```
         n_addresses  entities_per_doc_mean
split
Train           4012                  11.51
Dev             1381                  11.66
Test            1303                  16.05
Overall         6696                  12.40
```

1.3.1 3.1 Text Length Distribution

[6]:

```python
# Extract text metrics
text_lengths = np.array([len(r['text']) for r in all_data])
word_counts = np.array([len(r['text'].split()) for r in all_data])

# Compute descriptive statistics
text_stats = {
    'Metric': ['Mean', 'Std Dev', 'Median', 'IQR', 'Min', 'Max', '95th Percentile'],
    'Characters': [
        text_lengths.mean(),
        text_lengths.std(),
        np.median(text_lengths),
        np.percentile(text_lengths, 75) - np.percentile(text_lengths, 25),
        text_lengths.min(),
        text_lengths.max(),
        np.percentile(text_lengths, 95)
    ],
    'Words': [
        word_counts.mean(),
        word_counts.std(),
        np.median(word_counts),
        np.percentile(word_counts, 75) - np.percentile(word_counts, 25),
        word_counts.min(),
        word_counts.max(),
        np.percentile(word_counts, 95)
    ]
}

text_stats_df = pd.DataFrame(text_stats)
print("\nText Length Statistics")
print("=" * 60)
display(text_stats_df)
```

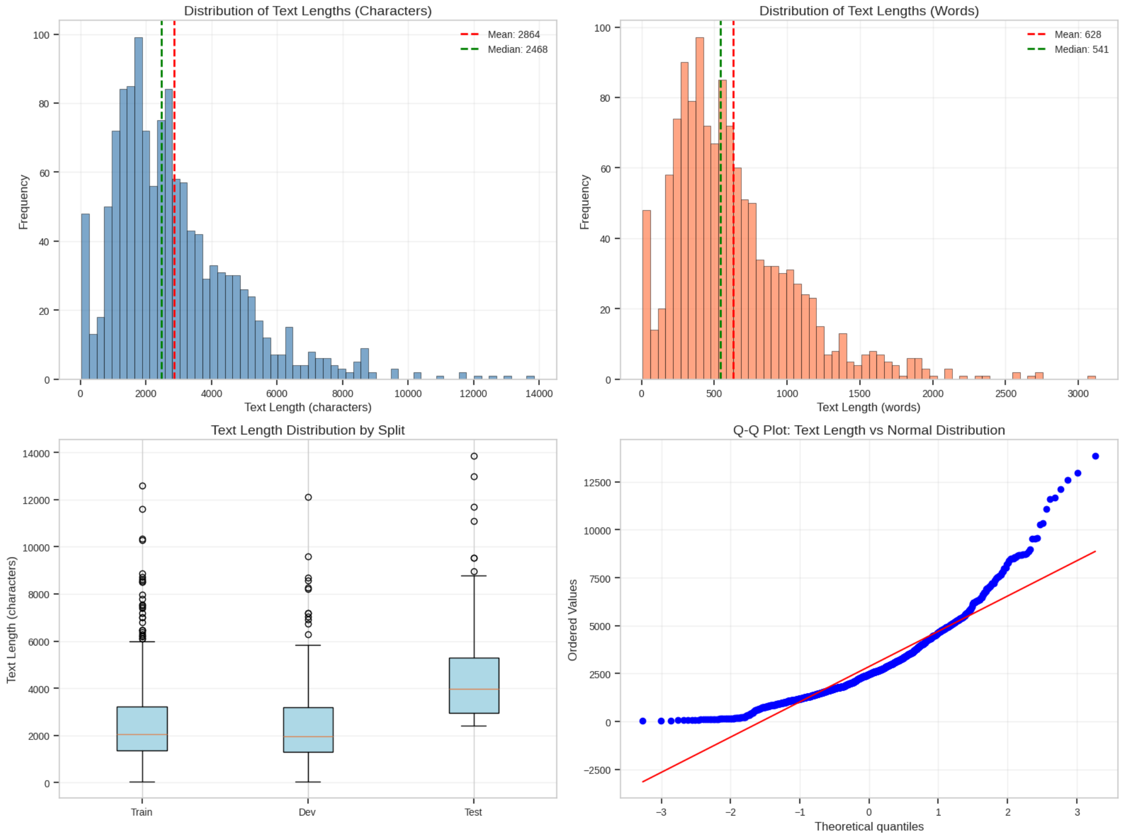
```
Text Length Statistics
============================================================

            Metric  Characters   Words
```

```
0              Mean     2864.41  627.91
1           Std Dev     1937.59  425.87
2            Median     2468.00  541.00
3               IQR     2248.00  487.25
4               Min       36.00    8.00
5               Max    13848.00 3117.00
6   95th Percentile     6615.10 1443.00
```

[7]:

```
# Visualize text length distributions
fig, axes = plt.subplots(2, 2, figsize=(16, 12))

# Character count distribution
axes[0, 0].hist(text_lengths, bins=60, color='steelblue', alpha=0.7,␣
 ↪edgecolor='black', linewidth=0.5)
axes[0, 0].axvline(text_lengths.mean(), color='red', linestyle='--',␣
 ↪linewidth=2,
                    label=f'Mean: {text_lengths.mean():.0f}')
axes[0, 0].axvline(np.median(text_lengths), color='green', linestyle='--',␣
 ↪linewidth=2,
                    label=f'Median: {np.median(text_lengths):.0f}')
axes[0, 0].set_xlabel('Text Length (characters)')
axes[0, 0].set_ylabel('Frequency')
axes[0, 0].set_title('Distribution of Text Lengths (Characters)')
axes[0, 0].legend()
axes[0, 0].grid(True, alpha=0.3)

# Word count distribution
axes[0, 1].hist(word_counts, bins=60, color='coral', alpha=0.7,␣
 ↪edgecolor='black', linewidth=0.5)
axes[0, 1].axvline(word_counts.mean(), color='red', linestyle='--', linewidth=2,
                    label=f'Mean: {word_counts.mean():.0f}')
axes[0, 1].axvline(np.median(word_counts), color='green', linestyle='--',␣
 ↪linewidth=2,
                    label=f'Median: {np.median(word_counts):.0f}')
axes[0, 1].set_xlabel('Text Length (words)')
axes[0, 1].set_ylabel('Frequency')
axes[0, 1].set_title('Distribution of Text Lengths (Words)')
axes[0, 1].legend()
axes[0, 1].grid(True, alpha=0.3)

# Box plot for text lengths by split
split_data = [
    [len(r['text']) for r in train_data],
    [len(r['text']) for r in dev_data],
    [len(r['text']) for r in test_data]
]
```

```
bp = axes[1, 0].boxplot(split_data, labels=['Train', 'Dev', 'Test'],␣
 ↪patch_artist=True)
for patch in bp['boxes']:
    patch.set_facecolor('lightblue')
axes[1, 0].set_ylabel('Text Length (characters)')
axes[1, 0].set_title('Text Length Distribution by Split')
axes[1, 0].grid(True, alpha=0.3, axis='y')

# Q-Q plot for normality assessment
stats.probplot(text_lengths, dist="norm", plot=axes[1, 1])
axes[1, 1].set_title('Q-Q Plot: Text Length vs Normal Distribution')
axes[1, 1].grid(True, alpha=0.3)

plt.tight_layout()
plt.savefig(OUTPUT_DIR / 'text_length_distribution.png')
plt.show()
```



1.4 4. Entity Distribution Analysis

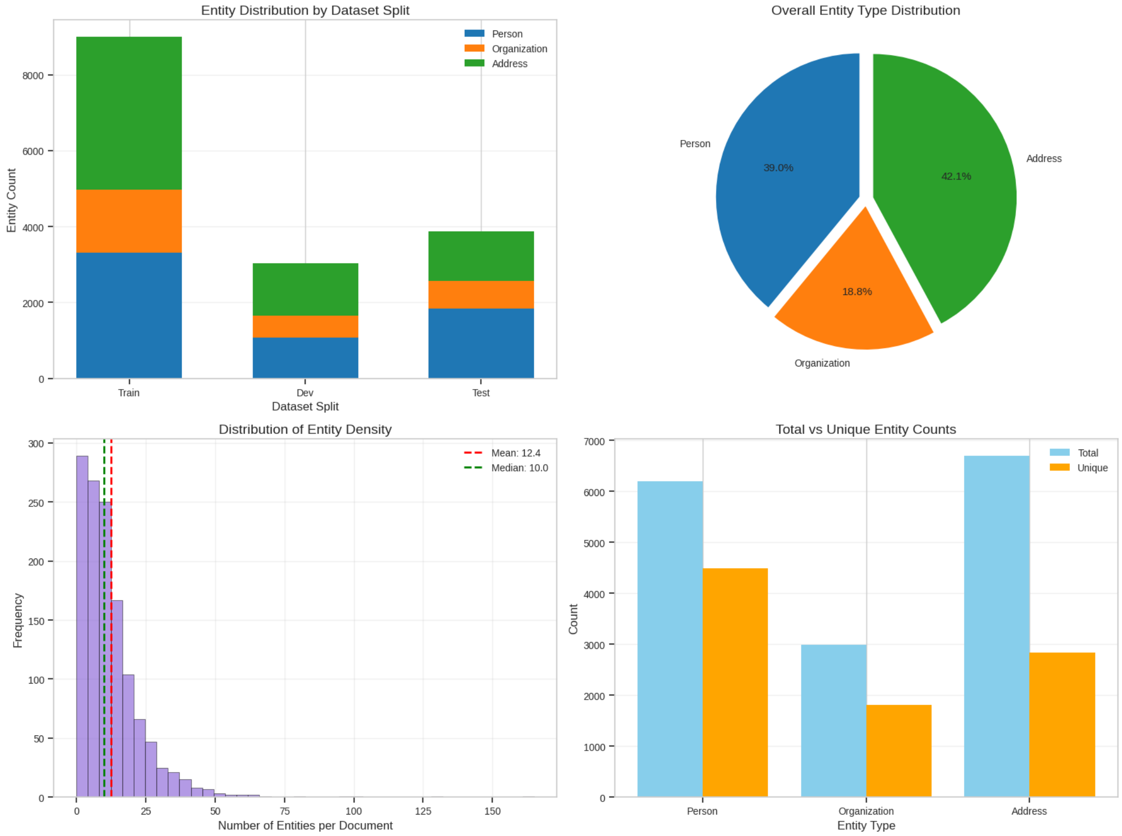
[8]:
```python
# Collect all entities
all_persons = []
all_orgs = []
all_addrs = []

entities_per_doc = []

for record in all_data:
    gt = record['ground_truth']
    all_persons.extend(gt['person'])
    all_orgs.extend(gt['organizations'])
    all_addrs.extend(gt['address'])

    total = len(gt['person']) + len(gt['organizations']) + len(gt['address'])
    entities_per_doc.append(total)

# Compute entity statistics
entity_stats = pd.DataFrame({
    'Entity Type': ['Person', 'Organization', 'Address', 'Total'],
    'Total Count': [
        len(all_persons),
        len(all_orgs),
        len(all_addrs),
        len(all_persons) + len(all_orgs) + len(all_addrs)
    ],
    'Unique Count': [
        len(set(all_persons)),
        len(set(all_orgs)),
        len(set(all_addrs)),
        len(set(all_persons)) + len(set(all_orgs)) + len(set(all_addrs))
    ]
})

entity_stats['Uniqueness Ratio'] = entity_stats['Unique Count'] /␣
 ↪entity_stats['Total Count']
entity_stats['Percentage'] = (entity_stats['Total Count'] / entity_stats.loc[3,␣
 ↪'Total Count']) * 100

print("\nEntity Type Statistics")
print("=" * 80)
display(entity_stats)
```

```
Entity Type Statistics
================================================================================
   Entity Type  Total Count  Unique Count  Uniqueness Ratio  Percentage
0       Person         6204          4486              0.72       39.04
1 Organization         2993          1815              0.61       18.83
2      Address         6696          2834              0.42       42.13
3        Total        15893          9135              0.57      100.00
```

[9]:

```
# Visualize entity distributions
fig, axes = plt.subplots(2, 2, figsize=(16, 12))

# Entity type distribution across splits (stacked bar)
splits = ['Train', 'Dev', 'Test']
person_counts = [
    sum(len(r['ground_truth']['person']) for r in train_data),
    sum(len(r['ground_truth']['person']) for r in dev_data),
    sum(len(r['ground_truth']['person']) for r in test_data)
]
org_counts = [
    sum(len(r['ground_truth']['organizations']) for r in train_data),
    sum(len(r['ground_truth']['organizations']) for r in dev_data),
    sum(len(r['ground_truth']['organizations']) for r in test_data)
]
addr_counts = [
    sum(len(r['ground_truth']['address']) for r in train_data),
    sum(len(r['ground_truth']['address']) for r in dev_data),
    sum(len(r['ground_truth']['address']) for r in test_data)
]

x = np.arange(len(splits))
width = 0.6

axes[0, 0].bar(x, person_counts, width, label='Person', color='#1f77b4')
axes[0, 0].bar(x, org_counts, width, bottom=person_counts,␣
 ↪label='Organization', color='#ff7f0e')
axes[0, 0].bar(x, addr_counts, width,
               bottom=np.array(person_counts) + np.array(org_counts),
               label='Address', color='#2ca02c')
axes[0, 0].set_xlabel('Dataset Split')
axes[0, 0].set_ylabel('Entity Count')
axes[0, 0].set_title('Entity Distribution by Dataset Split')
axes[0, 0].set_xticks(x)
axes[0, 0].set_xticklabels(splits)
axes[0, 0].legend()
axes[0, 0].grid(True, alpha=0.3, axis='y')

# Overall entity type proportions (pie chart)
colors = ['#1f77b4', '#ff7f0e', '#2ca02c']
explode = (0.05, 0.05, 0.05)
```

```python
axes[0, 1].pie([len(all_persons), len(all_orgs), len(all_addrs)],
               labels=['Person', 'Organization', 'Address'],
               autopct='%1.1f%%',
               colors=colors,
               explode=explode,
               startangle=90)
axes[0, 1].set_title('Overall Entity Type Distribution')

# Entities per document distribution
axes[1, 0].hist(entities_per_doc, bins=40, color='mediumpurple', alpha=0.7,
                edgecolor='black', linewidth=0.5)
axes[1, 0].axvline(np.mean(entities_per_doc), color='red', linestyle='--',
                    linewidth=2, label=f'Mean: {np.mean(entities_per_doc):.1f}')
axes[1, 0].axvline(np.median(entities_per_doc), color='green', linestyle='--',
                    linewidth=2, label=f'Median: {np.median(entities_per_doc):.
 ↪1f}')
axes[1, 0].set_xlabel('Number of Entities per Document')
axes[1, 0].set_ylabel('Frequency')
axes[1, 0].set_title('Distribution of Entity Density')
axes[1, 0].legend()
axes[1, 0].grid(True, alpha=0.3)

# Uniqueness comparison
entity_types = ['Person', 'Organization', 'Address']
total_counts = [len(all_persons), len(all_orgs), len(all_addrs)]
unique_counts = [len(set(all_persons)), len(set(all_orgs)), len(set(all_addrs))]

x_pos = np.arange(len(entity_types))
axes[1, 1].bar(x_pos - 0.2, total_counts, 0.4, label='Total', color='skyblue')
axes[1, 1].bar(x_pos + 0.2, unique_counts, 0.4, label='Unique', color='orange')
axes[1, 1].set_xlabel('Entity Type')
axes[1, 1].set_ylabel('Count')
axes[1, 1].set_title('Total vs Unique Entity Counts')
axes[1, 1].set_xticks(x_pos)
axes[1, 1].set_xticklabels(entity_types)
axes[1, 1].legend()
axes[1, 1].grid(True, alpha=0.3, axis='y')

plt.tight_layout()
plt.savefig(OUTPUT_DIR / 'entity_distribution.png')
plt.show()
```



1.5 5. Topic Analysis

[10]:

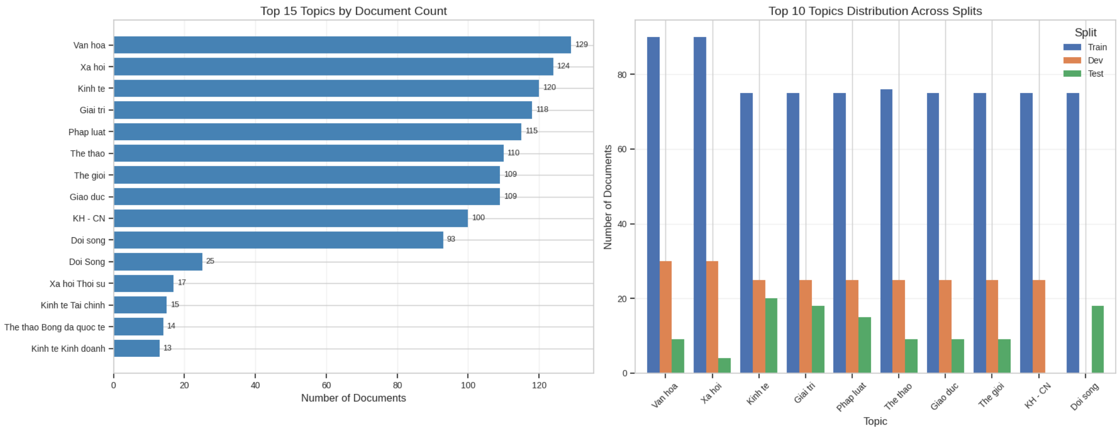
```
# Analyze topic distribution
topics = Counter([r['topic'] for r in all_data])
topic_df = pd.DataFrame([
    {'Topic': topic, 'Count': count, 'Percentage': (count / len(all_data)) *␣
 ↪100}
    for topic, count in topics.most_common()
])

print(f"\nTopic Distribution (Total: {len(topics)} unique topics)")
print("=" * 70)
display(topic_df.head(15))

# Statistical summary
print(f"\nTopic Distribution Statistics:")
print(f"Mean documents per topic: {topic_df['Count'].mean():.2f}")
print(f"Std deviation: {topic_df['Count'].std():.2f}")
print(f"Median documents per topic: {topic_df['Count'].median():.2f}")
print(f"Coefficient of variation: {(topic_df['Count'].std() / topic_df['Count'].
 ↪mean()):.2f}")
```

```
Topic Distribution (Total: 27 unique topics)
======================================================================

                       Topic  Count  Percentage
0                    Van hoa    129       10.06
1                     Xa hoi    124        9.67
2                    Kinh te    120        9.36
3                   Giai tri    118        9.20
4                  Phap luat    115        8.97
5                   The thao    110        8.58
6                   Giao duc    109        8.50
7                   The gioi    109        8.50
8                    KH - CN    100        7.80
9                   Doi song     93        7.25
10                  Doi Song     25        1.95
11            Xa hoi Thoi su     17        1.33
12         Kinh te Tai chinh     15        1.17
13    The thao Bong da quoc te     14        1.09
14        Kinh te Kinh doanh     13        1.01

Topic Distribution Statistics:
Mean documents per topic: 47.48
Std deviation: 51.63
Median documents per topic: 14.00
Coefficient of variation: 1.09
```

[11]:

```
# Visualize topic distribution
fig, axes = plt.subplots(1, 2, figsize=(18, 7))

# Top topics horizontal bar chart
top_topics = topic_df.head(15).sort_values('Count')
axes[0].barh(range(len(top_topics)), top_topics['Count'], color='steelblue')
axes[0].set_yticks(range(len(top_topics)))
axes[0].set_yticklabels(top_topics['Topic'])
axes[0].set_xlabel('Number of Documents')
axes[0].set_title('Top 15 Topics by Document Count')
axes[0].grid(True, alpha=0.3, axis='x')

# Add count labels
for i, (idx, row) in enumerate(top_topics.iterrows()):
    axes[0].text(row['Count'] + 1, i, str(int(row['Count'])),
                 va='center', fontsize=9)
```

```
# Topic distribution across splits
topic_split_data = []
for topic in topic_df.head(10)['Topic']:
    topic_split_data.append({
        'Topic': topic,
        'Train': sum(1 for r in train_data if r['topic'] == topic),
        'Dev': sum(1 for r in dev_data if r['topic'] == topic),
        'Test': sum(1 for r in test_data if r['topic'] == topic)
    })

topic_split_df = pd.DataFrame(topic_split_data)
topic_split_df.set_index('Topic')[['Train', 'Dev', 'Test']].plot(
    kind='bar', ax=axes[1], width=0.8
)
axes[1].set_xlabel('Topic')
axes[1].set_ylabel('Number of Documents')
axes[1].set_title('Top 10 Topics Distribution Across Splits')
axes[1].legend(title='Split')
axes[1].tick_params(axis='x', rotation=45)
axes[1].grid(True, alpha=0.3, axis='y')

plt.tight_layout()
plt.savefig(OUTPUT_DIR / 'topic_distribution.png')
plt.show()
```



1.6 6. Entity Frequency Analysis

[12]:
```
# Count entity occurrences
person_counter = Counter(all_persons)
org_counter = Counter(all_orgs)
addr_counter = Counter(all_addrs)
```

```python
# Get top entities
TOP_N = 20

top_persons_df = pd.DataFrame(
    person_counter.most_common(TOP_N),
    columns=['Entity', 'Frequency']
)
top_persons_df['Type'] = 'Person'

top_orgs_df = pd.DataFrame(
    org_counter.most_common(TOP_N),
    columns=['Entity', 'Frequency']
)
top_orgs_df['Type'] = 'Organization'

top_addrs_df = pd.DataFrame(
    addr_counter.most_common(TOP_N),
    columns=['Entity', 'Frequency']
)
top_addrs_df['Type'] = 'Address'

print(f"\nTop {TOP_N} Most Frequent Entities by Type")
print("=" * 80)

print("\nPersons:")
display(top_persons_df.head(10))

print("\nOrganizations:")
display(top_orgs_df.head(10))

print("\nAddresses:")
display(top_addrs_df.head(10))
```

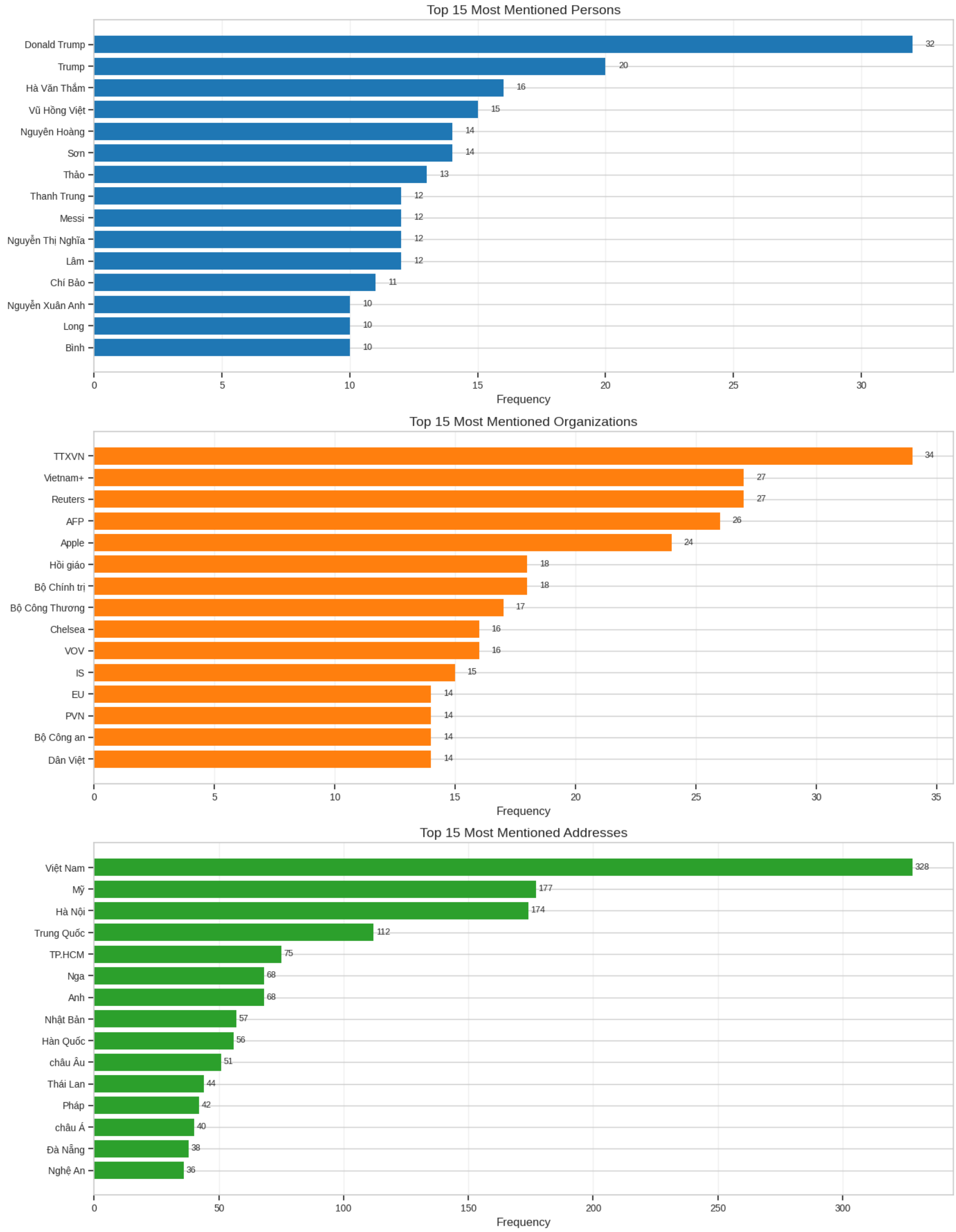
```
Top 20 Most Frequent Entities by Type
================================================================================

Persons:

             Entity  Frequency    Type
0      Donald Trump         32  Person
1             Trump         20  Person
2       Hà Văn Thắm         16  Person
3      Vũ Hồng Việt         15  Person
4               Sơn         14  Person
5      Nguyên Hoàng         14  Person
6              Thảo         13  Person
7               Lâm         12  Person
```

```
8  Nguyễn Thị Nghĩa         12  Person
9             Messi         12  Person


Organizations:
           Entity  Frequency          Type
0           TTXVN         34  Organization
1         Reuters         27  Organization
2        Vietnam+         27  Organization
3             AFP         26  Organization
4           Apple         24  Organization
5     Bộ Chính trị         18  Organization
6        Hồi giáo         18  Organization
7  Bộ Công Thương         17  Organization
8             VOV         16  Organization
9         Chelsea         16  Organization


Addresses:
       Entity  Frequency     Type
0    Việt Nam        328  Address
1          Mỹ        177  Address
2      Hà Nội        174  Address
3  Trung Quốc        112  Address
4      TP.HCM         75  Address
5         Anh         68  Address
6         Nga         68  Address
7    Nhật Bản         57  Address
8    Hàn Quốc         56  Address
9     châu Âu         51  Address
```

[13]:

```
# Visualize top entities
fig, axes = plt.subplots(3, 1, figsize=(14, 18))

# Top persons
top_persons = top_persons_df.head(15).sort_values('Frequency')
axes[0].barh(range(len(top_persons)), top_persons['Frequency'], color='#1f77b4')
axes[0].set_yticks(range(len(top_persons)))
axes[0].set_yticklabels(top_persons['Entity'])
axes[0].set_xlabel('Frequency')
axes[0].set_title('Top 15 Most Mentioned Persons')
axes[0].grid(True, alpha=0.3, axis='x')
for i, (idx, row) in enumerate(top_persons.iterrows()):
    axes[0].text(row['Frequency'] + 0.5, i, str(int(row['Frequency'])),
                 va='center', fontsize=9)

# Top organizations
```

```python
top_orgs = top_orgs_df.head(15).sort_values('Frequency')
axes[1].barh(range(len(top_orgs)), top_orgs['Frequency'], color='#ff7f0e')
axes[1].set_yticks(range(len(top_orgs)))
axes[1].set_yticklabels(top_orgs['Entity'])
axes[1].set_xlabel('Frequency')
axes[1].set_title('Top 15 Most Mentioned Organizations')
axes[1].grid(True, alpha=0.3, axis='x')
for i, (idx, row) in enumerate(top_orgs.iterrows()):
    axes[1].text(row['Frequency'] + 0.5, i, str(int(row['Frequency'])),
                 va='center', fontsize=9)

# Top addresses
top_addrs = top_addrs_df.head(15).sort_values('Frequency')
axes[2].barh(range(len(top_addrs)), top_addrs['Frequency'], color='#2ca02c')
axes[2].set_yticks(range(len(top_addrs)))
axes[2].set_yticklabels(top_addrs['Entity'])
axes[2].set_xlabel('Frequency')
axes[2].set_title('Top 15 Most Mentioned Addresses')
axes[2].grid(True, alpha=0.3, axis='x')
for i, (idx, row) in enumerate(top_addrs.iterrows()):
    axes[2].text(row['Frequency'] + 1, i, str(int(row['Frequency'])),
                 va='center', fontsize=9)

plt.tight_layout()
plt.savefig(OUTPUT_DIR / 'top_entities.png')
plt.show()
```



Top 15 Most Mentioned Persons

Top 15 Most Mentioned Organizations

Top 15 Most Mentioned Addresses

1.7 7. Entity Co-occurrence Analysis

[14]:

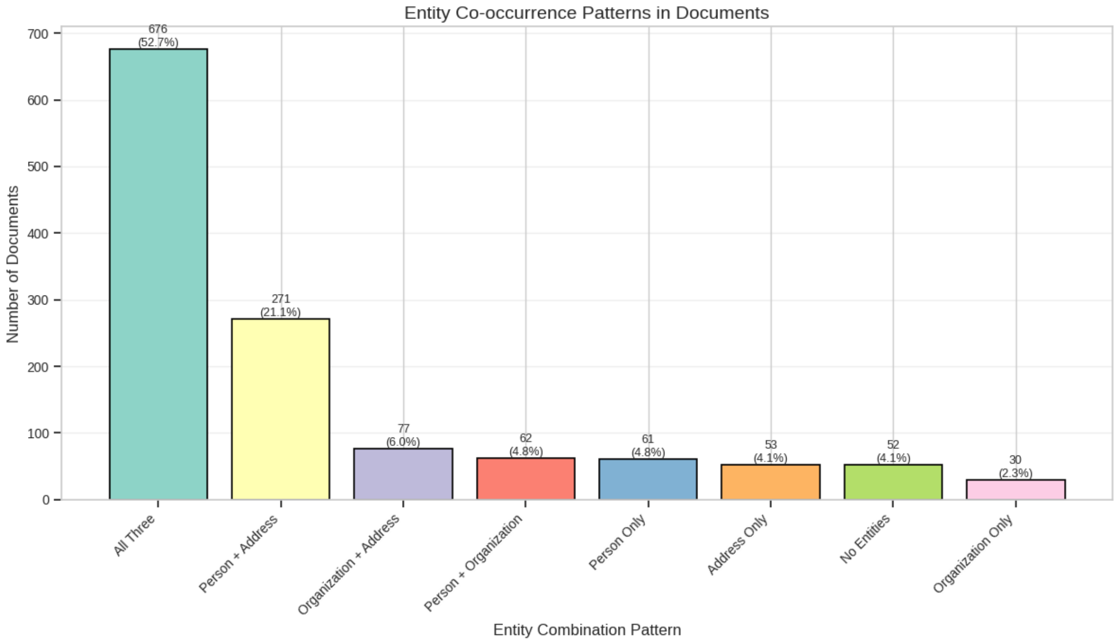
```
# Analyze entity co-occurrence patterns
cooccurrence = defaultdict(int)

for record in all_data:
    gt = record['ground_truth']
    has_person = len(gt['person']) > 0
    has_org = len(gt['organizations']) > 0
    has_addr = len(gt['address']) > 0

    if has_person and has_org and has_addr:
        cooccurrence['All Three'] += 1
    elif has_person and has_org:
        cooccurrence['Person + Organization'] += 1
    elif has_person and has_addr:
        cooccurrence['Person + Address'] += 1
    elif has_org and has_addr:
        cooccurrence['Organization + Address'] += 1
    elif has_person:
        cooccurrence['Person Only'] += 1
    elif has_org:
        cooccurrence['Organization Only'] += 1
    elif has_addr:
        cooccurrence['Address Only'] += 1
    else:
        cooccurrence['No Entities'] += 1

# Create DataFrame
cooccurrence_df = pd.DataFrame([
    {'Pattern': k, 'Count': v, 'Percentage': (v / len(all_data)) * 100}
    for k, v in cooccurrence.items()
]).sort_values('Count', ascending=False)

print("\nEntity Co-occurrence Patterns")
print("=" * 70)
display(cooccurrence_df)
```

```
Entity Co-occurrence Patterns
======================================================================

                  Pattern  Count  Percentage
2               All Three    676       52.73
6        Person + Address    271       21.14
5  Organization + Address     77        6.01
1   Person + Organization     62        4.84
3             Person Only     61        4.76
```

```
7          Address Only     53        4.13
4           No Entities     52        4.06
0     Organization Only     30        2.34
```

[15]:

```python
# Visualize co-occurrence patterns
fig, ax = plt.subplots(figsize=(12, 7))

colors = plt.cm.Set3(range(len(cooccurrence_df)))
bars = ax.bar(range(len(cooccurrence_df)), cooccurrence_df['Count'],
              color=colors, edgecolor='black', linewidth=1.2)
ax.set_xticks(range(len(cooccurrence_df)))
ax.set_xticklabels(cooccurrence_df['Pattern'], rotation=45, ha='right')
ax.set_xlabel('Entity Combination Pattern')
ax.set_ylabel('Number of Documents')
ax.set_title('Entity Co-occurrence Patterns in Documents')
ax.grid(True, alpha=0.3, axis='y')

# Add value labels
for i, (idx, row) in enumerate(cooccurrence_df.iterrows()):
    height = bars[i].get_height()
    ax.text(bars[i].get_x() + bars[i].get_width()/2., height,
            f"{int(row['Count'])}\n({row['Percentage']:.1f}%)",
            ha='center', va='bottom', fontsize=9)

plt.tight_layout()
plt.savefig(OUTPUT_DIR / 'cooccurrence_patterns.png')
plt.show()
```


Entity Co-occurrence Patterns in Documents
Number of Documents
(52.7%)
(21.1%)
(6.0%)
(4.8%)
(4.8%)
(4.1%)
(4.1%)
(2.3%)
All Three
Person + Address
Organization + Address
Person + Organization
Person Only
Address Only
No Entities
Organization Only
Entity Combination Pattern