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import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.manifold import TSNE

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# --- Simulate loading pre-trained embeddings ---
# In a real scenario, you would load these from a file (e.g., .txt, .vec, .bin)
# or using a library like Gensim or huggingface transformers.

# For demonstration, let's create a small dictionary of word embeddings.
# Each word maps to a random 100-dimensional vector.

embedding_dim = 100
vocabulary = ['apple', 'banana', 'orange', 'cat', 'dog', 'lion', 'car', 'bus', 'train', 'man', 'woman', 'king', 'queen']

word_embeddings = {}
for word in vocabulary:
    word_embeddings[word] = np.random.rand(embedding_dim)

print(f"Successfully simulated loading {len(word_embeddings)} word embeddings.")

# --- Print vocabulary size ---
vocabulary_size = len(word_embeddings)
print(f"Vocabulary size: {vocabulary_size}")

# --- Display one example vector ---
example_word = 'apple'
if example_word in word_embeddings:
    example_vector = word_embeddings[example_word]
    print(f"\nExample vector for '{example_word}':")
    print(example_vector[:10]) # Displaying first 10 dimensions for brevity
    print(f" (Vector has {len(example_vector)} dimensions)")
else:
    print(f"Word '{example_word}' not found in the simulated vocabulary.")

```

Successfully simulated loading 13 word embeddings.  
Vocabulary size: 13

Example vector for 'apple':  
[0.98674732 0.65349975 0.09817629 0.45189218 0.89115745 0.09893166  
 0.34107899 0.27333422 0.7932589 0.01258125]  
(Vector has 100 dimensions)

```

# --- Expand vocabulary and regenerate word embeddings ---
# We'll add more words to the vocabulary to have a larger set to choose from.

embedding_dim = 100
expanded_vocabulary = [
    'apple', 'banana', 'orange', 'grape', 'strawberry', 'blueberry', 'pineapple', 'mango',
    'cat', 'dog', 'lion', 'tiger', 'bear', 'wolf', 'fox', 'elephant', 'giraffe', 'zebra',
    'car', 'bus', 'train', 'plane', 'boat', 'bicycle', 'motorcycle', 'truck',
    'man', 'woman', 'king', 'queen', 'prince', 'princess', 'boy', 'girl', 'child', 'adult',
    'happy', 'sad', 'angry', 'joyful', 'peaceful', 'excited', 'calm', 'nervous', 'brave',
    'run', 'walk', 'jump', 'sleep', 'eat', 'drink', 'read', 'write', 'sing', 'dance',
    'red', 'blue', 'green', 'yellow', 'purple', 'black', 'white', 'orange'
]

# Regenerate word_embeddings with the expanded vocabulary
expanded_word_embeddings = {}
for word in expanded_vocabulary:
    expanded_word_embeddings[word] = np.random.rand(embedding_dim)

print(f"Successfully regenerated {len(expanded_word_embeddings)} word embeddings with an expanded vocabulary.")
print(f"New vocabulary size: {len(expanded_vocabulary)}")

```

Successfully regenerated 62 word embeddings with an expanded vocabulary.  
New vocabulary size: 63

```
# --- Choose 30-50 meaningful words and extract vectors ---
# For demonstration, we'll pick a diverse set of words from the expanded vocabulary.

selected_words = [
    'apple', 'banana', 'orange', 'strawberry',
    'cat', 'dog', 'lion', 'tiger', 'bear', 'wolf',
    'car', 'bus', 'train', 'plane', 'bicycle',
    'man', 'woman', 'king', 'queen', 'boy', 'girl',
    'happy', 'sad', 'angry', 'joyful', 'peaceful',
    'run', 'walk', 'jump', 'sleep', 'eat', 'drink',
    'red', 'blue', 'green', 'yellow'
]

# Ensure all selected words are in the expanded_word_embeddings dictionary
# (This check is important in a real scenario where some words might be out of vocabulary)
valid_selected_words = [word for word in selected_words if word in expanded_word_embeddings]

if len(valid_selected_words) < len(selected_words):
    print("Warning: Some selected words were not found in the expanded vocabulary.")

# Extract corresponding vectors
selected_vectors = np.array([expanded_word_embeddings[word] for word in valid_selected_words])

print(f"Selected {len(valid_selected_words)} words and extracted their corresponding vectors.")
print(f"Shape of selected_vectors: {selected_vectors.shape}")
print(f"Selected words: {valid_selected_words[:10]}... (showing first 10)")

Selected 36 words and extracted their corresponding vectors.
Shape of selected_vectors: (36, 100)
Selected words: ['apple', 'banana', 'orange', 'strawberry', 'cat', 'dog', 'lion', 'tiger', 'bear', 'wolf']... (showing first 10)
```

```
# --- Perform t-SNE dimensionality reduction ---
# t-SNE (t-Distributed Stochastic Neighbor Embedding) is a statistical method for
# visualizing high-dimensional data by giving each datapoint a location in a
# two or three-dimensional map.

tsne = TSNE(n_components=2, random_state=42, perplexity=10, learning_rate=200, max_iter=3000)
tsne_results = tsne.fit_transform(selected_vectors)

print("t-SNE dimensionality reduction complete.")
print(f"Shape of t-SNE results: {tsne_results.shape}")

t-SNE dimensionality reduction complete.
Shape of t-SNE results: (36, 2)
```

```
# --- Create scatter plot with annotated word labels ---

plt.figure(figsize=(15, 12)) # Adjust figure size for better readability of labels

sns.scatterplot(
    x=tsne_results[:, 0],
    y=tsne_results[:, 1],
    hue=valid_selected_words, # Use words for coloring, if desired, to distinguish points
    s=100, # Size of the points
    legend='full', # Show full legend
    palette=sns.color_palette("hsv", len(valid_selected_words)), # Use a diverse color palette
    alpha=0.7
)

# Annotate each point with the word label
for i, word in enumerate(valid_selected_words):
    plt.annotate(word, (tsne_results[i, 0] + 0.5, tsne_results[i, 1] + 0.5), fontsize=9)

plt.title('t-SNE Visualization of Word Embeddings (2D)', fontsize=16)
plt.xlabel('t-SNE Dimension 1', fontsize=12)
plt.ylabel('t-SNE Dimension 2', fontsize=12)
plt.grid(True, linestyle='--', alpha=0.6)
plt.xticks([]) # Hide x-axis ticks for cleaner look
plt.yticks([]) # Hide y-axis ticks for cleaner look
plt.legend(bbox_to_anchor=(1.05, 1), loc='upper left', borderaxespad=0.) # Move legend outside plot
plt.tight_layout()
plt.show()
```

