Ex1b: Hidden Markov Model (HMM) based Predictive Text System

Learning Objective:
To implement a predictive text system using Hidden Markov Model (HMM), enabling students to understand contextual probability, POS transitions, and next-word prediction using the Brown Corpus.

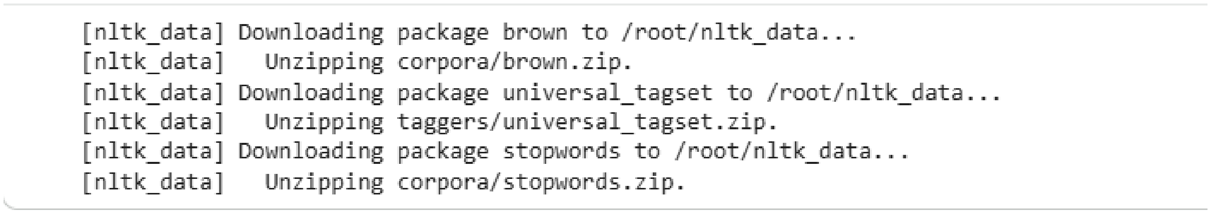
Steps:

1. Initialize the environment by installing and importing the Natural Language Toolkit (nltk). Download the Brown Corpus (for text data) and the Universal Tagset (for simplified Part-of-Speech tags).
2. Extract raw sentences from the Brown Corpus using brown.sents().
3. Tokenization: Convert all words to lowercase and flatten the nested list into a single list of tokens to verify the total volume of training data.
4. Load the tagged version of the corpus (brown.tagged_sents) which provides the "Hidden States" (POS tags) linked to the "Observations" (words).
5. Train the HMM Model. Use the HiddenMarkovModelTrainer to perform Supervised Learning. Calculate the internal parameters of the HMM: Initial State Probabilities, Transition Probabilities, Emission Probabilities
6. Build POS Transition Probabilities
7. Build Emission Probabilities
8. Define Prediction Function
9. Test the Model
10. Verify POS prediction on certain words.

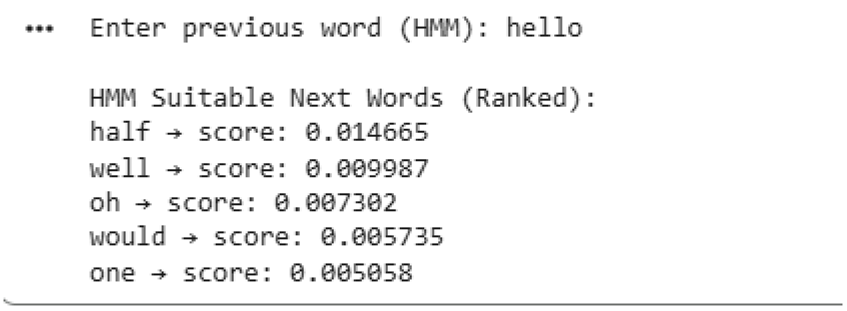
Program:

```
import nltk
from nltk.corpus import brown, stopwords
from nltk.util import ngrams
from collections import defaultdict, Counter
import string
nltk.download('brown')
nltk.download('universal_tagset')
nltk.download('stopwords')

STOPWORDS = set(stopwords.words('english'))
tagged_sentences = brown.tagged_sents(tagset='universal')
transition = defaultdict(Counter)
emission = defaultdict(Counter)
for sent in tagged_sentences:
    prev_tag = '<s>'
    for word, tag in sent:
        word = word.lower()
        if not word.isalpha():
            continue
        if word in STOPWORDS:
            continue
        transition[prev_tag][tag] += 1
        emission[tag][word] += 1
        prev_tag = tag
def predict_hmm_candidates(previous_word, top_k=5):
    previous_word = previous_word.lower()
    possible_tags = []
    for tag in emission:
        if previous_word in emission[tag]:
            possible_tags.append(tag)
    if not possible_tags:
        return "No prediction found"
    word_scores = Counter()
    for tag in possible_tags:
        total_trans = sum(transition[tag].values())
        if total_trans == 0:
            continue
        for next_tag, t_count in transition[tag].items():
            t_prob = t_count / total_trans
            total_emis = sum(emission[next_tag].values())
            if total_emis == 0:
                continue
            for word, e_count in emission[next_tag].items():
                e_prob = e_count / total_emis
                word_scores[word] += t_prob * e_prob

    if not word_scores:
        return "No prediction found"

    return word_scores.most_common(top_k)
previous_word = input("Enter previous word (HMM): ").strip().lower()
results = predict_hmm_candidates(previous_word)
print("\nHMM Suitable Next Words (Ranked):")
if isinstance(results, str):
    print(results)
else:
    for word, score in results:
        print(f"{word} → score: {score:.6f}")
```

Output:



```
[nltk_data] Downloading package brown to /root/nltk_data...
[nltk_data]   Unzipping corpora/brown.zip.
[nltk_data] Downloading package universal_tagset to /root/nltk_data...
[nltk_data]   Unzipping taggers/universal_tagset.zip.
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```



```
Enter previous word (HMM): hello

HMM Suitable Next Words (Ranked):
half → score: 0.014665
well → score: 0.009987
oh → score: 0.007302
would → score: 0.005735
one → score: 0.005058
```

RESULT:

Thus the implementation of a HMM model based on text prediction system has been executed successfully