School of Computer Science Engineering and Technology

Course - B.Tech.	**Semester – 5th**
Course Code – CSET225	**Course Name - IDM**
Year - 2025	**Semester - Odd**

Max. Marks: 2

LAB ASSIGNMENT # 11
Exploring Attention Mechanisms in Seq2Seq Translation

Objective

This lab aims to understand and implement different types of attention mechanisms — Soft, Hard, Global, and Cross-Attention — in a sequence-to-sequence (Seq2Seq) translation model (English → French). Students will train models, visualise attention weights, and analyse performance differences to gain a deeper understanding of the model's behaviour.

Dataset
We will use a toy English-French dataset:

Download with:
wget https://raw.githubusercontent.com/jbrownlee/Datasets/master/english-french-both.csv -O eng-fra.csv

The dataset contains pairs of English → French sentences (small enough to run in a lab).

Tasks

◆ Part A: Preprocessing
   1. Load the dataset (eng-fra.csv).
   2. Tokenize English and French sentences.
   3. Build vocabulary (max 10,000 words).
   4. Convert sentences into padded sequences of indices.
   5. Split into train (80%) and test (20%).

◆ Part B: Seq2Seq Model with Attention
Implement a basic encoder-decoder architecture:
   • Encoder: GRU or LSTM to encode English sentence.
   • Decoder: GRU or LSTM to generate French translation.
   • Attention: Apply one of the four attention mechanisms.

◆ Part C: Attention Mechanisms
Implement the following attention modules:
   1. Soft Attention (Bahdanau-style)

- o   Compute attention weights over all encoder hidden states using a scoring function.
- o   Use a weighted sum as a context vector for each decoder step.

2. Hard Attention
- o   Sample one encoder hidden state at each step (use stochastic sampling with REINFORCE or approximation).
- o   Compare accuracy vs soft attention.

3. Global Attention (Luong-style)
- o   Use dot-product attention across all hidden states.
- o   Compare with Bahdanau attention.

4. Cross-Attention
- o   Treat the encoder outputs as keys and values, and decoder hidden states as queries (like in Transformers).

◆ Part D: Training
1. Train each model for 10 epochs.
2. Use Cross-Entropy Loss with teacher forcing.
3. Optimizer: Adam, LR = 0.001.

◆ Part E: Evaluation
1. Evaluate models using BLEU score.
2. from nltk.translate.bleu_score import sentence_bleu
3. Translate 10 random test sentences with each model.
4. Compare outputs qualitatively.

◆ Part F: Visualization
1. Plot attention heatmaps for Soft, Global, and Cross-Attention.
- o   Use matplotlib.imshow(attn_weights)
- o   X-axis = input (English words)
- o   Y-axis = output (French words)
2. Compare interpretability of attention types.

Submission Requirements
- Python code (Jupyter Notebook).
- Training and evaluation results.
- Attention heatmap visualizations.
- A short report (2–3 pages) covering:
  - o   Explanation of each attention mechanism.
  - o   Performance comparison table (BLEU score).
  - o   Example translations with attention heatmaps.
  - o   Discussion on pros/cons of each method.

Expected Learning Outcomes
- Understand differences between Soft, Hard, Global, and Cross-Attention.
- Learn how attention improves Seq2Seq models compared to vanilla encoder-decoder.

- Be able to visualize and interpret attention maps.
- Gain hands-on experience with NLP translation tasks.