

Statement of Purpose (SoP)

DSL501: Machine Learning Project

Team Name: TheAchievers

September 7, 2025

1. Project Details

- **Project Title:** Enhancing Emotional Support Chatbots with Machine Learning and Linguistic Analysis
- **Code Repo Link (if available):** [To be added]
- **If Own Idea:** Yes

Summary: This project focuses on the development and evaluation of an advanced emotional support chatbot that leverages machine learning and linguistic analysis to provide more empathetic, personalized, and human-like responses. By integrating LIWC (Linguistic Inquiry and Word Count) analysis with ML models, as well as temporal and sentiment analysis, we aim to improve both technical accuracy and emotional quality of chatbot interactions.

2. Problem Statement

Mental health issues such as stress, anxiety, and depression are on the rise globally, but access to professional therapists remains limited due to cost, stigma, and availability. Chatbots designed for emotional support can provide scalable, always-available, and private conversational support.

However, existing chatbot systems face several challenges:

- Limited empathy recognition: Many models generate grammatically correct but emotionally flat responses.
- Lack of personalization: Responses often fail to adapt to the user's unique emotional state.
- Shallow evaluation metrics: Most rely only on BLEU or ROUGE scores, ignoring psychological or emotional qualities.

Our project addresses these gaps by building a hybrid evaluation framework that combines computational measures (accuracy, BLEU, ROUGE) with psychological linguistic markers (LIWC categories), as well as temporal and sentiment-based context analysis. This allows us to develop a chatbot that is not only technically sound but also emotionally meaningful.

3. Methodology

We will use a combination of classical machine learning, deep learning, and linguistic analysis to build and evaluate our chatbot.

- **Proposed ML Models:**

- Traditional classifiers for emotion detection: Logistic Regression, Random Forest, SVM.

- Deep learning models: LSTMs for sequential modeling, Transformer-based models (BERT, GPT) for context capture.
- Response generation approaches: Seq2Seq models with attention, retrieval-based methods, and generative transformer dialogue models.
- **Additional Techniques from Literature and Prior Studies:**
 - **Temporal Analysis:** Examining changes in user emotional states over time.
 - **Sentiment Analysis:** Measuring positive, neutral, and negative tones in dialogue.
 - **Linguistic Analysis (LIWC):** Detecting affective processes such as anxiety, sadness, anger, and social concerns.
 - **n-gram Features:** Incorporating unigrams and bigrams for textual feature extraction.
 - **Semi-supervised Training:** Using human-labeled and pseudo-labeled data to expand training via self-training and retraining.
 - **Cross-cultural Analysis:** Evaluating chatbot empathy across different cultural contexts (East vs West).
 - **Platform Differences:** Comparing chatbot-based dialogues with social media platforms such as Twitter to test generalizability.
- **Frameworks and Tools:** PyTorch, Hugging Face Transformers, scikit-learn, NLTK, spaCy, LIWC software.
- **Novel Component:** Integration of LIWC-based linguistic analysis and semi-supervised retraining into evaluation, measuring empathy, affect, personalization, and cross-cultural adaptability in generated responses.

Implementation Plan:

1. Preprocess dataset (normalization, tokenization, embedding extraction).
2. Train baseline ML models for classification.
3. Train deep learning models (LSTM, BERT, GPT) for classification and generation.
4. Apply temporal analysis, sentiment analysis, and LIWC categories to chatbot responses.
5. Use semi-supervised pseudo-labeling and retraining to improve classifier robustness.
6. Evaluate models with computational metrics (accuracy, BLEU, ROUGE) and linguistic empathy markers.
7. Explore platform-level and cross-cultural differences in dialogue patterns.
8. Develop a demo prototype showcasing improvements.

4. Dataset Details

- **Name/Source:** Combined Emotional Dialogue Dataset (Hugging Face).
- **Size/Structure:** ~10,000 structured dialogue pairs in JSON-like format, each with a Context (user input) and a Response (supportive message).
- **Preprocessing:** Text normalization, tokenization, removal of special characters, lemmatization, embedding extraction.
- **Justification:** The dataset directly represents emotional support scenarios, making it suitable for training empathetic chatbots and applying linguistic and sentiment analysis.

5. Required Resources

- **Hardware:** GPU (NVIDIA Tesla T4 or higher), 16–32 GB RAM.
- **Software:** Python 3.9+, Hugging Face Transformers, PyTorch, scikit-learn, NLTK, spaCy, LIWC software.
- **Additional Tools:** Jupyter Notebook for development, matplotlib/seaborn for visualization.

6. Novelty of Approach

Our project is unique because:

- We integrate psychological linguistic analysis (LIWC) with ML performance evaluation.
- We introduce temporal and sentiment analysis to capture emotional evolution in dialogue.
- We employ semi-supervised methods such as pseudo-labeling and retraining to handle limited labeled data.
- We cross-validate chatbot empathy using computational, linguistic, and cross-cultural markers.
- We focus on personalization and affective processes beyond raw accuracy.
- We evaluate platform-specific differences (chatbot vs Twitter) for generalizability.
- We explore multilingual extensions and cultural adaptability for broader impact.

7. Team Composition and Individual Contributions

- **Member 1:** [Khethavath Sunil Naik, 12341170] – Complete Project

8. Expected Outcomes

- Trained emotional support chatbot models (baseline + advanced).
- Temporal, sentiment, and LIWC-based analysis of user contexts and chatbot responses.
- Semi-supervised retraining pipeline for robust classification.
- Comparative evaluation demonstrating improvements in empathy and personalization across cultures and platforms.

Deliverables:

1. Research paper (JMIR-style).
2. Trained ML models and scripts.
3. Functional chatbot prototype.

9. References

1. Hyojin Chin, Hyeonho Song, Gumhee Baek, Mingi Shin. *The Potential of Chatbots for Emotional Support and Promoting Mental Well-Being in Different Cultures: Mixed Methods Study.* JMIR, 2023.
2. Inkster B, Sarda S, Subramanian V. *An Empathy-Driven, Conversational Artificial Intelligence Agent (Wysa) for Digital Mental Well-Being: Real-World Data Evaluation.* JMIR Mhealth Uhealth. 2018.
3. Fitzpatrick KK, Darcy A, Vierhile M. *Delivering Cognitive Behavior Therapy to Young Adults With Symptoms of Depression and Anxiety Using a Fully Automated Conversational Agent (Woebot): A Randomized Controlled Trial.* JMIR Ment Health. 2017.
4. Tausczik YR, Pennebaker JW. *The Psychological Meaning of Words: LIWC and Computerized Text Analysis Methods.* Journal of Language and Social Psychology. 2010.
5. Hugging Face. *Datasets Documentation.* <https://huggingface.co/docs/datasets>