Ling 406: Introduction to Computational Linguistics

Term Project, Spring 2025

**DUE DATE:** May 10, 2025, 11:59 PM (NOTE: No extensions allowed)

(This is a hard deadline! No extensions allowed, except for documented accommodations and emergencies)

**Sentiment Classifier** [100 points]

Implement a sentiment analyzer that automatically classifies input text as either positive or negative. Since we provide training data, it makes sense to use a supervised machine learning approach (you can use NLTK, scikit-learn, and/or any other machine learning platform/toolkit/libraries). Those of you who have a good handle of machine learning can also use deep learning models.

Approach:

First, you should produce a baseline system (i.e., a simple, first-stab approach that you are fairly confident will produce a measurable result). This system should be as simple as possible and should prove the feasibility of your plan. However, as for baselines, its performance does not necessarily need to be very high.

Then, you should conduct a series of experiments to improve your system. Try to learn from your results and revise your experiments as you go. Close-to-perfect results are nice, but we are also looking for good methodology in your experimentation. The idea is to start with the baseline system and find new good/informative features to improve it. So, in the end, we would like to see a performant system. However, as said before, we are more interested in the research process/methodology you use to build such a system.

Example Code:

We recommend that you use the DOC\_CLASSIFIER.ipynb Jupyter notebook, which was included in our example code for the POS-tagging assignment. This code example trains a model for a slightly different task, namely topic classification, but it is similar to sentiment analysis in the sense that the way we represent the features for our documents is similar.

Project questions:

Here are the questions intended to guide you in this process. You will receive 80 points for following these questions with your code. The remaining 20 points for this assignment are given for your report.

1. [20 points] Baseline system – Design a simple system to use as your baseline. Select one type of model, and one method of representing your features. In your report, discuss how you decided to preprocess and tokenize your data.
2. [20 points] Algorithm selection – Using the same features as your baseline system, train 3-4 new models using different machine learning algorithms. For example, if you selected Naive-Bayes as your baseline, you may select a DecisionTree, LogisticRegression, and RandomForest as your three models. In your report, compare the performance of these models. Additionally, compare the time it took to train these models. See [this link](https://stackoverflow.com/questions/2866380/how-can-i-time-a-code-segment-for-testing-performance-with-pythons-timeit) for how to measure the time of a block of code.
3. [20 points] Feature engineering – Using the same algorithm as your baseline model, try 3-4 new representations for your features. For example, if you used a CountVectorizer for your baseline system, try using a TfIdfVectorizer. You may also try different preprocessing strategies, or using different vocabulary sizes. Removing high-frequency vocabulary or low-frequency vocabulary may be good strategies. Compare the performance of your model with these different feature representations. In your report, discuss which system performs the best, and discuss why this might be the case. Additionally, list the number of features which each of your feature representation uses, and compare the time it took to train these models with different feature representations.
4. [10 points] Improved system - based on your results from comparing different algorithms and different feature representations, train an improved system by selecting the algorithm and feature representation you think will have the best performance. In your report, provide the performance of your improved system. Discuss why you chose the model that you did. Do you notice a relationship between model performance and training time, i.e. do models that take longer to train perform better?
5. [10 points] Error Analysis – It is likely that your system will not perform with 100% accuracy, and will make some false classifications. In general, it is a good idea to look at a sample of your model’s misclassifications to learn about its weaknesses. Find at least 5 items which your model misclassified, and list them in the report. Examine the texts of these misclassified items, and see if you can find any patterns on what your model struggles with. How might these errors be avoided?

You have to answer questions 1) - 5) above and explain in a paper report all the steps you took to build the system. The paper report itself is worth 20 points (see Deliverables).

Dataset:

For data, there are many resources on this topic. However, for this project we will use the movie review dataset from Cornell: http://www.cs.cornell.edu/people/pabo/movie-review-data/. This is the [polarity dataset v2.0](http://www.cs.cornell.edu/people/pabo/movie-review-data/review_polarity.tar.gz) ( 3.0Mb) (includes [README v2.0](http://www.cs.cornell.edu/people/pabo/movie-review-data/poldata.README.2.0.txt)): 1000 positive and 1000 negative processed reviews, introduced in Pang/Lee ACL 2004. Released June 2004. (provided on the github space for this project).

Resources:

Here are some standard sentiment resources, such as sentiment lexicons, that you may **optionally** use to come up with more informative features. Those presented in class are a good start. We also give you access to EmoLex, an Emotion Lexicon of English words and their associations with eight basic emotions (anger, fear, anticipation, trust, surprise, sadness, joy, and disgust) and sentiment values (negative and positive). The annotations were manually done by crowdsourcing. Please do NOT use without authors’ permission outside the context of this class!

Below are some suggested papers for you to read before you begin (they will give you a better idea about the task and feature suggestions):

Angiani, G., Ferrari, L., Fontanini,T., Fornacciari, P., Iotti, E., Magliani, F., &Manicardi, S. (2016). A Comparison betweenPreprocessing Techniques for SentimentAnalysis in Twitter. In KDWeb.

Zhuang, L., Jing, F., & Zhu, X. Y.(2006, November). Movie review mining andsummarization. In Proceedings of the 15thACM international conference on Informationand knowledge management (pp. 43-50).

Shu, L., Xu, H., & Liu, B. (2017).Life long learning CRF for supervised aspect extraction. arXiv preprint arXiv:1705.00251.

Yessenov, Kuat, and Sasa Misailovic. “Sentiment Analysis of Movie Review Comments” Massachusetts Institute of Technology, Spring 2009. <http://people.csail.mit.edu/kuat/courses/6.863/report.pdf>

Satarupa Guha, Aditya Joshi, Vasudeva Varma. SIEL: Aspect Based Sentiment Analysis in Reviews. Proceedings of the 9th International Workshop on Semantic Evaluation (SemEval 2015), pages 759–766,Denver, Colorado, June 4-5, 2015. https://www.aclweb.org/anthology/S15-2129.pdf

Svetlana Kiritchenko, Xiaodan Zhu, Colin Cherry, and Saif M. Mohammad. NRC-Canada-2014: Detecting Aspects and Sentiment in Customer Reviews. Proceedings of the 8th International Workshop on Semantic Evaluation (SemEval 2014), pages 437–442,Dublin, Ireland, August 23-24, 2014. <https://www.aclweb.org/anthology/S14-2076.pdf>

Mulyo, B. M., & Widyantoro, D. H.(2018). Aspect-Based Sentiment AnalysisApproach with CNN. Proceeding of the ElectricalEngineering Computer Science and Informatics,5(5), 142-147.

Deliverables:

This is an independent project (you must work alone although you can engage in design discussions with fellow colleagues — i.e., discussion on possible features, learning models, etc. is allowed.)

This is what you have to deliver (via github):

1) all the code you wrote to process the data (i.e., preprocessing code, etc. - outside of any other platform you used) plus a Readme file where you explain what the code does and how to run it.

2) You have to answer questions 1) - 4) above and explain in a paper report (report.pdf) all the steps you took to build the system. Each project report has to have the following structure:

- *Introduction* (consider the problem in a broader context: why is it important to work on sentiment analysis today, what applications can benefit from it, etc.)

- *Problem definition* (what is sentiment analysis and how do you define it in the context of Computational Linguistics: i.e., how do you define the task and what kind of input/output such a system has)

- *Previous work* (not comprehensive, but show you know something about this problem; cite accordingly)

- *Approach* (what computational approach did you use; what model(s) have you tested; what dataset(s) did you employ? did you perform some data preprocessing? if yes, what, how and why?; What text representation(s) have you used? What are your features/feature sets you played with?; etc.)

- *Results and Discussion* (analysis of results; metrics used (standard ones are expected (precision, recall, F-measure, Accuracy) but if you use others, explain them); analysis of results - which feature set and machine learning model performed best for this task and why?)

- *Future Work and Conclusions* (what have you learned from this project; what possibilities of improvement are there for this problem and this approach; i.e., if you had to do it again, what would you change?)

NOTE: You can use any formatting style to write your report. However, we recommend the standard format used in the Computational Linguistics: style files (Latex, Word) are available here: <http://acl2020.org/downloads/acl2020-templates.zip>. If you prefer to use Overleaf, you can find the template here: <https://www.overleaf.com/latex/templates/acl-2020-proceedings-template/zsrkcwjptpcd>.

**Extra-credit:**

Students interested in extra-credit may choose two of the following three options, for a maximum of 20 bonus points. *Please indicate in your paper’s abstract which bonus option you are working for.*

1) Option 1 [10 points]:

Write a more comprehensive Previous Work, and Discussion and Conclusions sections of the report. For previous work, you should identify 3 more recent papers (published no earlier than 2014) relevant to the project topic and compare and summarize the techniques used and their results. Moreover, you should also prepare a more thorough Discussion and Conclusions section. Thus, in addition to the items listed above for this section, you should present a more detailed discussion of potential improvements (i.e., what linguistic representations are needed for this task? What challenges still remain to be solved and what solution do you suggest?). In total, your submission should be 6 pages long.

2) Option 2 [10 points]:

Our example document classifier model is what we call a “bag-of-words" model, that is, its features only indicate whether or not a word is present in the text. Features like this can be a useful start, but they ignore a lot of important information, especially syntactic information. For example, if you had a review that says “this movie is not good at all”, our model may classify this review as positive, since it has the word “good” in it, and the model is unaware that “good” is being negated.  
  
For this bonus option, develop a new feature set beyond a bag-of-words approach, which takes some syntax into account. In your report, describe how you incorporate syntax into your features, and which libraries or external resources you use to accomplish this. Compare the performance of your model with syntax-based features and bag-of-words features. (*5 points)*

Additionally, look through the review dataset, and find five examples from the reviews which a bag-of-words model might struggle with. Such a review might look something like “This movie was not good at all” or “I was expecting this movie to be good.” Discuss what linguistic feature is present in this sentence that would cause a bag-of-words model to struggle with this example. (*5 points)*

3) Option 3 [10 points]:

Run the baseline (project question 1)) and the improved system (project question 4)) on a different dataset: Champaign-Urbana Yelp restaurant reviews (a collection of 10391 reviews of restaurants in the Champaign-Urbana area scraped from Yelp by John Hall, a former Linguistics student).

Note that this dataset is annotated with a star rating: {1star, 2star, 3star, 4star, 5star}

1star\_count = 1172

2star\_count = 1358

3star\_count = 1795

4star\_count = 2947

5star\_count = 3119

You have to compare the results of your system on two datasets (the movie reviews and the restaurant reviews). In order to do so, you will need to collapse all the reviews with at least 3 and a half stars into positive and the rest into negative target classes.

You have to answer the project questions 1) - 5) again for the new dataset and then compare the results on the two datasets at each step. For instance, which dataset is more challenging for sentiment analysis detection? What features work best for one dataset and not so well for the other? How about the best learning model(s)?