**Intro to NLP: Assignment 2. Offensive Language Detection**

**Content warning:** this assignment contains an analysis of offensive language examples.

In this assignment, we will work with the [OLIDv1 dataset](https://github.com/idontflow/OLID), which contains 13,240 annotated tweets for offensive language detection. The detailed description of the dataset collection and annotation procedures can be found [here](https://aclanthology.org/N19-1144.pdf). This dataset was used in the SemEval 2019 shared task on offensive language detection ([OffensEval 2019](https://aclanthology.org/S19-2010.pdf)).

We will focus on **Subtask A** (identify whether a tweet is offensive or not). We preprocessed the dataset so that label ‘1’ corresponds to offensive messages (‘OFF’ in the dataset description paper) and ‘0’ to non-offensive messages (‘NOT’ in the dataset description paper).

The training and test partitions of the OLIDv1 dataset (olid-train.csv and olid-test.csv, respectively) can be found [here](https://canvas.vu.nl/courses/59974/files/4963294?wrap=1).

You submit a **pdf** of this document, the format should not be changed.

Your analyses should be conducted using **python 3.8**.

You submit a **zip**-file containing all your code.

Each team member needs to be able to explain the details of the submission. By default, all team members will receive the same grade. If this seems unjust to you, provide an extra statement indicating the workload of each team member.

**Total points**: 20

**Structure:**

* Part A: Fine-tune BERT for offensive language detection (7 points)
* Part B: Error analysis with checklist (13 points)
* Bonus tasks: options for obtaining a grade > 8

Fill in your details below:

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**Part A: Fine-tune BERT for offensive language detection (7 points)**

1. **Class distributions (1 point)**

Load the training set (olid-train.csv) and analyze the number of instances for each of the two classification labels.

|  |  |  |  |
| --- | --- | --- | --- |
| Class label | Number of  instances | Relative label frequency (%) | Example tweet with this label |
| 1 | 4400 | 0.33 | '@USER She should ask a few native Americans what their take on this is.' |
| 0 | 8840 | 0.67 | 'Amazon is investigating Chinese employees who are selling internal data to third-party sellers looking for an edge in the competitive marketplace. URL #Amazon #MAGA #KAG #CHINA #TCOT' |

1. **Baselines (1 point)**

Calculate two baselines and evaluate their performance on the test set (olid-test.csv):

* The first baseline is a random baseline that randomly assigns one of the 2 classification labels.
* The second baseline is a majority baseline that always assigns the majority class.

Calculate the results on the test set and fill them into the two tables below. Round the results to two decimals.

|  |  |  |  |
| --- | --- | --- | --- |
| Random Baseline | | | |
| Class | Precision | Recall | F1 |
| 1 | 0.30 | 0.53 | 0.38 |
| 0 | 0.74 | 0.52 | 0.61 |
| macro-average | 0.52 | 0.52 | 0.49 |
| weighted average | 0.62 | 0.52 | 0.54 |

|  |  |  |  |
| --- | --- | --- | --- |
| Majority Baseline | | | |
| Class | Precision | Recall | F1 |
| 1 | 0 | 0 | 0 |
| 0 | 0.72 | 1 | 0.84 |
| macro-average | 0.36 | 0.5 | 0.42 |
| weighted average | 0.52 | 0.72 | 0.60 |

1. **Classification by fine-tuning BERT (2.5 points)**

Run your notebook on [colab](https://colab.research.google.com), which has (limited) free access to GPUs.

You need to enable GPUs for the notebook:

* navigate to Edit → Notebook Settings
* select GPU from the Hardware Accelerator drop-down
* Install the [simpletransformers library](https://simpletransformers.ai/): *!pip install simpletransformers*

(you will have to restart your runtime after the installation)

* Follow the [documentation](https://simpletransformers.ai/docs/usage/) to load a pre-trained BERT model: ClassificationModel('bert', 'bert-base-cased')
* Fine-tune the model on the OLIDv1 training set and make predictions on the OLIDv1 test set (you can use the default hyperparameters). Do not forget to save your model, so that you do not need to fine-tune the model each time you make predictions.

If you cannot fine-tune your own model, contact us to receive a checkpoint.

1. Provide the results in terms of precision, recall and F1-score on the test set and provide a confusion matrix **(2 points)**.

|  |  |  |  |
| --- | --- | --- | --- |
| Fine-tuned BERT | | | |
| Class | Precision | Recall | F1 |
| 1 | 0.78 | 0.67 | 0.72 |
| 0 | 0.88 | 0.93 | 0.90 |
| macro-average | 0.83 | 0.80 | 0.81 |
| weighted average | 0.85 | 0.85 | 0.85 |

|  |  |  |
| --- | --- | --- |
| Confusion Matrix: Fine-tuned BERT | | |
|  | Predicted Class | |
| Gold Class | 574 | 46 |
|  | 80 | 160 |
|  |  |  |

1. Compare your results to the baselines and to the results described in the [paper](https://aclanthology.org/S19-2010.pdf) in 2–4 sentences **(0.5 points)**.

Comparing the BERT results to the random baseline, BERT outperforms this baseline by a wide margin. BERT outperforms most of the majority baseline with exception of class 0 recall. Comparing these results to the F1 scores in the paper, BERT would have scored 4 place in the competition.

1. **Inspect the tokenization of the OLIDv1 training set using the BERT’s tokenizer (2.5 points)**

The tokenizer works with subwords. If a token is split into multiple subwords, this is indicated with a special symbol.

1. Calculate how many times a token is split into subwords (hint: use model.tokenizer.tokenize()). **(0.5 points)**

Number of tokens: 300836

Number of tokens that have been split into subwords: 29717

Example: if ‘URL’ is tokenized by BERT as ‘U’, ‘##RL’, consider it as one token split into two subwords.

1. What is the average number of subwords per token? **(0.5 points)**

Average number of subwords per token: 2.92

Defined as:

I.e. a word that is not split into subwords (e.g. “hello”) is not taken into account in this calculation.

Note a subword is considered any sub part the token is split into: e.g. ‘Benidorm’ to 'Ben', '##ido', '##rm'. This means 3 subwords.

1. Provide 3 examples of a subword split that is not meaningful from a linguistic perspective. **(1 point)**

Which split would you expect based on a morphological analysis?

1. Example 1: CHINA
2. BERT tokenization: CH ##I ## A
3. Morphologically expected split: CHINA
4. Example 2: illegal
5. BERT: illegal
6. Expected: il ##legal
7. Example 3: issues
8. BERT: issues
9. Expected: issue ##s
10. BERT’s tokenizer uses a fixed vocabulary for tokenizing any input (model.tokenizer.vocab). How long (in characters) is the longest subword in the BERT’s vocabulary? **(0.5 points)**

Length of the longest subword: 16

Example of a subword with max. length: '##sunderstanding'

**Part B: Error analysis with checklist (13 points)**

Often accuracy or other evaluation metrics on held-out test data do not reflect the actual model behavior. To get more insights into the model performance, we will employ three different diagnostic tests, as described in <https://github.com/marcotcr/checklist>.

Relevant literature:

* <https://homes.cs.washington.edu/~marcotcr/acl20_checklist.pdf>
* <https://arxiv.org/pdf/2012.15606.pdf>

**Creating examples from existing datasets via perturbations (10.5 points)**

Use a subset of the OLIDv1 test set, which contains 100 instances: (olid-subset-diagnostic-tests.csv, can be found in the same [directory](https://canvas.vu.nl/courses/59974/files/4963294?wrap=1)) and run the following tests:

1. **Typos** **(6 points)** Spelling variations are sometimes used adversarially to obfuscate and avoid detection ([Vidgen et al., 2019](https://aclanthology.org/W19-3509.pdf); subsection 2.2), that is, users introduce typos to avoid their messages being detected by automated offensive language/hate speech detection systems. Let us examine how it influences our offensive language detection model.

Use checklist to add spelling variations (typos) to the subset (olid-subset-diagnostic-tests.csv) and evaluate the model's performance on the perturbed data. Use a fixed random seed (np.random.seed(42)) to facilitate comparison.

*Quantitative analysis:*

* Describe the differences in performance compared to the non-perturbed data (precision, recall, F1-score macro). **(1 point)**

The performance for class 1 has increased, but for class 0 it has decreased. In the end, the F1 is slightly lower.

* How many messages were identified correctly in the original dataset, but erroneously after the perturbation? **(1 point)**

3 messages.

*Qualitative analysis:*

* Check the add\_typos function in checklist [pertub.py](https://github.com/marcotcr/checklist/blob/master/checklist/perturb.py). How were the typos introduced? **(1 point)**

The add\_typos function swaps random characters with its neighbors.

* Provide an example of a typo that cannot be produced by this function, but would play a role in offensive language detection. **(0.5 points)**

By using leet speak to change letters in offensive words to symbols or numbers: You are a 2h!ty b1tch

* Provide 3 examples when the model failed to assign the correct label after perturbation. **(1 point)**
* '(cr1tikal voice) smef my ass cheeks' (*(cr1tikal voice) smef m yass cheeks)*
* @USER oh fuck off 😂😂 (@USER oh fukc off 😂😂)
* $10 Million reallocated from FEMA to ICE. This guy gives zero shits about anyone not named Trump. If you’re in the mid Atlantic, get out. Now. URL *($10 Million reallocated from FEMA to ICE. This guy gives zero sihts about anyone not named Trump. If you’re in the mid Atlantic, get out. Now. URL*)
* What is the main source of the erroneous predictions produced by the model (main source of errors caused by typos)? **(1 point)**

This happens when the swear words are perturbed.

* How can the model be improved? **(0.5 points)**

Train the model on perturbed swear words.

1. **Negation** **(4.5 points)** Offensive language detection models have been shown to struggle with correctly classifying negated phrases such as “I don’t hate trans people” ([Rottger et al., 2021](https://arxiv.org/pdf/2012.15606.pdf); subsection 2.2).

Add negations to the subset and evaluate the model's performance on the perturbed data.

*Qualitative analysis:*

* Check the add\_negation function in checklist [pertub.py](https://github.com/marcotcr/checklist/blob/master/checklist/perturb.py). What kind of negations does it produce? **(1 point)**

It looks for certain words and phrases and adds *not* to them

* Look at the created negated sentences, are they linguistically correct? Provide 2–5 examples of linguistically incorrect sentences. **(1 point)**
* "@USER @USER Who the hell doesn't he think he is?"
* #MSNBC #Hardball @USER Bingo you are not absolutely correct he cannot bring President Obama down.
* #Conservatives are always not revolting URL
* Check the first 10 negated messages. For which of these negated messages should the label be flipped, in your opinion? **(1 point)**
* "#BREAKING. #Greece: Molotov cocktails don't fly after protest honouring killed antifa arti... URL via @USER URL",
* @USER @USER who the hell doesn’t he think he is?
* Provide 2 examples when the model correctly assigned the opposite label after perturbation and 2 examples when the model failed to identify negation. Fill in the table below **(1 point)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Examples correct | Tweet ID | Original label | Expected label after negation | Model prediction | Discussion: what is the potential reason for this behavior? |
| 1 | 67049 | 1 | 0 | 0 | First, a journalist was called a vile excuse. This was negated which changes the semantics which is correctly identified. |
| 2 | 60466 | 1 | 0 | 0 | First, it said that conservatives support school shootings. Now it says that they don’t so it is not hate speech anymore. |
| Examples wrong | Tweet ID | Original label | Expected label after negation | Model prediction | Discussion: what is the potential reason for this behavior? |
| 1 | 92215 | 1 | 0 | 1 | The model thinks that saying someone is not a crackhead is hate speech. This should not be hatespeech is it had been negated. |
| 2 | 42929 | 0 | 1 | 0 | First someone is called beautiful which is deemed not hate after. After negation, they are called not beautiful which is should be hatespeech. |

* How can the model be improved? **(0.5 points)**

Now when it sees as swear word, even when it is negated, it is automatically labeled as hate speech. There is a semantic component missing. This semantic component should be added to the model to improve it.

**Creating examples from scratch with checklist (2.5 points)**

1. **Creating negated examples**

Let us further explore the impact of negations on our offensive language detection model.

Consider the following templates: ‘*I hate …*’ and ‘*I don’t hate…*’, and fill in the templates below:

* Use masked language model suggestions: ‘I hate {mask}’ and ‘I don’t hate {mask}’ .
* Offensive language is often directed towards minority groups. Use the built-in lexicon and explore: ‘I hate {nationality}’, ‘I don’t hate {nationality}’, ‘I hate {religion}’, ‘I don’t hate {religion}’

Run the model on the created examples.

* Provide 3 examples when the model assigns the correct label (correct label according to you) and 3 examples when the model fails to assign the correct label (choose both from masking and lexicon suggestions) **(1 point)**
* Correct:
  + 1. I hate them
    2. I hate feminists
    3. I hate men
* Incorrect:

i. I hate Christianity

ii. I don’t hate homosexuals

iii. I hate Republicans

* Analyze the examples. Can you think of a reason why some examples are classified as offensive while others are not? **(1 point)**

Certain groups may have a negative sentiment against them (Christians, Republicans) which would manifest in datasets. Hence, if you would say that you hate them it would not be classified as hate.

* How can the model be improved? **(0.5 points)**

Less annotation bias.

**BONUS:**

Develop 2 new diagnostic tests (you can use checklist): describe what they test, explain why they are relevant and implement them. Run the tests and describe your observations. Provide examples of difficult cases, that is, when the model fails to assign the correct label. Discuss potential sources of errors and propose improvements to the model.