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Synthetic Text for Supervised Learning

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Why is supervised text analysis hard?

1. **LABELING**: labels are expensive to collect
2. **RETRIEVAL**: when a class is rare it's hard to annotate enough positive cases
3. **COPYRIGHT**: most text cannot be freely shared for copyright or privacy reasons, limiting re-use, evaluation, and reproducibility

- **Possible solution**: generate synthetic text with desired content and style.

How do I make good synthetic text?

Language models (e.g. GPT) are trained to predict the next word given a sequence of previous words. The probability of a next token depends on the previous tokens and the model's parameters:

$$\widehat{p}(w_i) = f(w_{i-1}, w_{i-2}, ...w_1, \theta)$$

Thus, to control the generation of synthetic text, *either*:

- **FINE-TUNE**: update θ using domain-specific text, *or*
- **PROMPT**: modify the preceding tokens $w_{i-1}, w_{i-2}...$

When should I FINE-TUNE vs. PROMPT?

- **FINE-TUNING** is useful when prompting is difficult or you have an existing corpus and want to evaluate synthetic data quality.
- **PROMPTING** is useful when you don't have an existing corpus and documents can be prompted.

When **FINE-TUNING**, consider an adversarial technique for tuning the parameters γ that control how to sample from $p(w_i)$. The best γ produces the worst performance for a real vs. synthetic classifier.

App 1: Weapon NER on Ukraine War Tweets

Problem: **COPYRIGHT**.
Setup: **FINE-TUNE** GPT-2 on Ukraine war tweets.

Real tweets are indicated with ✓and synthetic ones with ✗.

✗ Russian equipment losses suffered during the invasion of Ukraine updated with:
1x T-72B3M (abandoned)
1x BMP-2 IFV (destroyed)
1x BTR-80 APC (abandoned)
1x 152mm 2S19 Msta-S SPG (abandoned)
1x 122mm BM-21 MRL (destroyed)
Full list:

✗ A Russian BTR-82A armored personnel carrier was destroyed by the Ukrainian 128th Mountain Assault Brigade in the east of the country.

✗ The Ukrainian SES posted an image of one of the destroyed vehicles, a destroyed Russian T-72B3 variant.

✗ And this is the Ukrainian T-64BV that was struck and destroyed by the Russian forces in Mariupol.

✓ Improvised top attack armor did not save this Russian T-72B3. Reportedly destroyed by a Javelin.

✓ #Ukraine: Two Russian BMP-2 infantry fighting vehicles were recently destroyed by the 93rd Mechanized Brigade of Ukraine on the Eastern front.

✗ A number of destroyed Russian T-72B3s

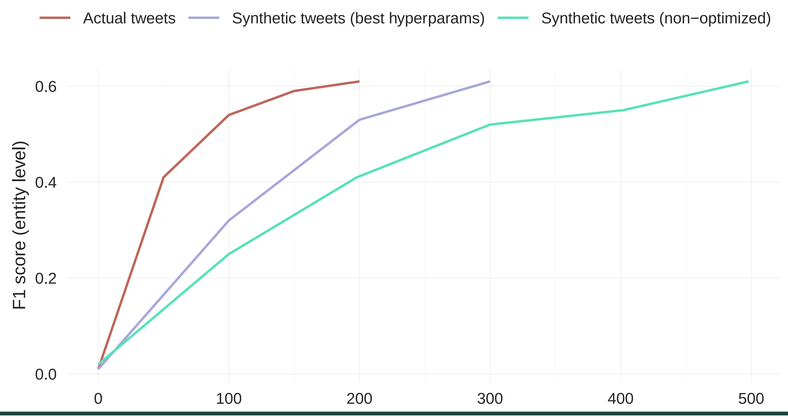
✓ #UkraineWar: Newly added Russian equipment losses:
1x ZALA 421-16E2 reconnaissance UAV (destroyed)
1x T-64BV MBT (destroyed)
1x BTR-80 APC (destroyed)
1x R-166-0.5 signals vehicle (destroyed)
1x Unknown vehicle (destroyed)
Full list:

✗ #Ukraine: Another Ukrainian T-64BV tank was destroyed by the Russian army in #Kyiv Oblast.

✓ #Ukraine: In the vicinity of #Sumy Oblast, Ukrainian forces destroyed a Tiger-M IMV, a BTR-82A, and 3x supply trucks. [Corrected]

✗ #Ukraine: Another Ukrainian T-64BV tank was destroyed by the Russian army in #Kyiv Oblast.

Named entity recognition model performance with real and synthetic tweets:



App 2: Sentence-level Populism Detection

Problem: **LABELING**. No sentence-level populism annotations exist (Di Cocco and Monechi 2021, Jankowski and Huber 2022), and collecting them, especially across languages, is expensive.
Setup: **PROMPT** GPT-3 with task description, including language prompt.

Prompt: *Populist rhetoric sees politics as a conflict with good, common, or "real" people on one side, and out-of-touch, evil or self-serving elites on the other.*
Write three statements that an Austrian populist party might make (in the German language).

Output:

1. [SYNTH] Europa ist in Gefahr! Wir brauchen eine starkes Österreich, um unsere Werte zu verteidigen!
2. [SYNTH] Die Globalisierung ist ein Angriff auf unser Heimatland.
3. [SYNTH] Die Regierung ist völlig außer Kontrolle und hat keine Ahnung, was die Menschen wirklich wollen.

Next, I trained a populism classifier (XLM-RoBERTa-base) on the synthetic sentences and used this model to generate predicted populism scores for actual manifesto text. For example, the three UKIP sentences with highest *p*(populist):

- This is how utterly ridiculous the Common Fisheries Policy is: it is destroying our fishing industry and we must take back control from Brussels."
- Politics is corrupted by self-interest and big business.
- This is a terrible legacy to leave our children and grandchildren.

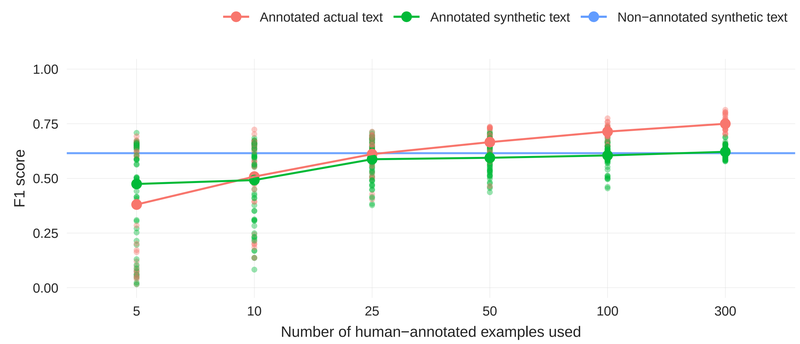
...and the lowest *p*(populist):

- Extend the period during which discharged service personnel are able to access the specialist DMHS scheme from six months to two years.
- CONTENTSINTRODUCTION TO OUR MANIFESTO
- This will be supported by the inclusion of FGM awareness into safeguarding training for teachers, school staff and governors.

App 3: Detecting Political Events

Problems: **RETRIEVAL**, **COPYRIGHT**, **LABELING**.
Setup: **PROMPT** an off-the-shelf GPT-2.
Example prompt: "Bomb detonates in downtown capital BOGOTA (Reuters) –"

Performance of SVM predicting ASSAULT class, evaluted on annotated actual text



Ethics & Acknowledgements

- Synthetic text saved on disk should always be marked and the warning removed only temporarily and in-memory for training models. Consider including researcher name and project description. E.g.:
  `<!-- SYNTHETIC TEXT! May be factually incorrect and offensive. Generated by Andy Halterman for... -->`
- Annotators should always be told that they are working with synthetic text.

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