

BenchmarkDataNLP.jl: Synthetic Data Generation for NLP Benchmarking

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Summary

BenchmarkDataNLP.jl is a package written in Julia Lang for generating synthetic text corpora that can be used to systematically benchmark and evaluate Natural Language Processing (NLP) models such as Recurrent Neural Networks (RNNs), Long Short-Term Memory (LSTMs), and Large Language Models (LLMs). By enabling users to control core linguistic parameters such as the alphabet size (characters selected from the Unicode Hangul block, Korean Language), vocabulary size, grammatical expansion complexity, and semantic structures this library can help users test, evaluate, and debug NLP models. Instead of exposing many parameters to the user, it is kept at minimum, so that users do not have to focus on how to correctly configure the generation process. The key parameter is the *complexity* (integer value), which controls the size of the alphabet, vocabulary, and grammar expansions. This parameter accepts an integer in the range 1 to **100**. For example, at `complexity = 1` (simplest value), there are 5 letters in the alphabet and 10 words used in the vocabulary with 2 grammar roles when a Context Free Grammar generator is select. At `complexity = 100` there is a vocabulary of 10,000 words and 50 alphabet characters. Users can choose how many independent grammar productions are desired, which are each supplied as entries in a .jsonl file. The defaults provided in the documentation should suffice for most use cases.

The generator methods are:

- Context Free Grammar (van Vugt 1996)
- Resource Description Framework (RDF, triple store) (Faye, Cure, and Blin 2012)
- Finite State Machine (Maletti 2017)
- Template Strings (Copestake 1996)

Each method offers different options to the user. With the Finite State Machine approach, the function `generate_fsm_corpus` produces a deterministic set of corpora so that upon successful training accuracies of 100% can be achieved.

This can be used, e.g., to test the computational requirements for various models, for a particular value of complexity. The four approaches listed above, cover a wide range of text expansion production methods that does not have parameter estimations as part of their usage requirements. Hangul syllables in Unicode start at code point 0xAC00 (decimal 44 032), sampling characters from this region offers conveniences and a long continuous block. The reason for this choice is that Hangul Syllables block is one of the largest continuous blocks in the Unicode standard. It contains over 11,000 characters without interruption allowing for large alphabet and punctuation subsets to be selected.

This package also hopes to bring down the costs (financial, time, and computational) required when training different models and architectures on large natural language datasets (Samsi et al. 2023). Risks of wasted expense training on suboptimal models can often be expected when exploring novel approaches.

Statement of need

Performance evaluation of NLP systems often hinges on realistic datasets that capture the target domain’s linguistic nuances. However, training on large-scale text corpora can be expensive or impractical, especially when testing some particular aspects of language complexity or model robustness. Synthetic data generation helps bridge these gaps by:

1. **Reproducibility:** Controlled parameters (e.g., sentence length, grammar depth, or concept re-use) allow reproducible experiments.
2. **Customization:** Researchers can stress-test models by systematically varying language properties, such as the number of roles in a grammar or the frequency of filler tokens.
3. **Scalability:** Large-scale data can be generated for benchmarking advanced architectures without the need for extensive, real-world data collection.
4. **Targeted Evaluation:** By manipulating semantic structures (for example, adding context continuity with RDF triples or specialized placeholders), researchers can investigate whether models capture specific linguistic or contextual features.

Although several libraries and benchmarks (e.g., GLUE (Wang et al. 2018), SuperGLUE (Wang et al. 2019)) provide curated datasets, **Benchmark-DataNLP.jl** offers a unique approach by allowing *fine-grained control* of the underlying complexity of a synthetic corpus generation process. This capability is especially valuable when exploring model failure modes or for rapid prototyping of new model architectures that require specialized text patterns. It is hoped that this will bring down the cost for initial prototyping of new model architectures and allow a greater exploration. This can also help compare different modeling approaches.

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