

# calamanCy: A Tagalog Natural Language Processing Toolkit

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## Abstract

We introduce calamanCy, an open-source toolkit for constructing natural language processing (NLP) pipelines for Tagalog. It is built on top of spaCy, enabling easy experimentation and integration with other frameworks. calamanCy addresses the development gap by providing a consistent API for building NLP applications and offering general-purpose multitask models with out-of-the-box support for dependency parsing, part-of-speech (POS) tagging, and named entity recognition (NER). calamanCy aims to accelerate the progress of Tagalog NLP by consolidating disjointed resources in a unified framework. The calamanCy toolkit can be found on Github: <https://github.com/ljvmiranda921/calamanCy>.

## 1 Introduction

Tagalog is a low-resource language from the Austronesian family with over 76 million speakers in the Philippines (Lewis, 2009). Despite its speaker population, few resources exist for the language (Cruz and Cheng, 2021). For example, Universal Dependencies (UD) treebanks for Tagalog are tiny ( $\ll$  20k words) (Samson, 2018; Aquino and de Leon, 2020), while domain-specific corpora are sparse (Cabasag et al., 2019; Livelo and Cheng, 2018). In addition, Tagalog language models (LMs) (Cruz and Cheng, 2021; Jiang et al., 2021) are few while most multilingual LMs (Conneau et al., 2019; Devlin et al., 2019) underrepresent the language. Thus, consolidating these disjointed resources in a coherent framework is still an open problem. The lack of such framework hampers model development, experimental workflows, and the overall advancement of Tagalog NLP.

To address this problem, we introduce calamanCy,<sup>1</sup> an open-source toolkit for Tagalog NLP. It is built on top of spaCy (Honnibal et al., 2020)

and offers end-to-end pipelines for NLP tasks such as dependency parsing, parts-of-speech (POS) tagging, and named entity recognition (NER). calamanCy also provides models of different sizes to fit any performance or accuracy requirements. This work has two main contributions: (1) an open-source toolkit containing general-purpose multitask pipelines with out-of-the box support for common NLP tasks, and (2) structured benchmarks that evaluate on several Tagalog core NLP tasks.

## 2 Related Work

**Open-source toolkits for NLP** There has been a growing body of work in the development of NLP toolkits in recent years. For languages, these toolkits include DaCy for Danish (Enevoldsen et al., 2021) and HuSpaCy for Hungarian (Orosz et al., 2022). For domain-specific data, there is medspaCy for clinical text (Eyre et al., 2021) and scispaCy for scientific documents (Neumann et al., 2019). These tools employ spaCy (Honnibal et al., 2020), an industrial-strength open-source software for natural language processing. Using spaCy as a foundation is an optimal choice given its popularity and tight integration with other frameworks such as HuggingFace (Wolf et al., 2019). However, no tool exists for Tagalog until now. In this paper, we will showcase how calamanCy provides similar capabilities to DaCy and HuSpaCy using Tagalog resources.

**Evaluations on Tagalog NLP Tasks** Structured evaluations for core NLP tasks, such as dependency parsing, POS tagging, and NER, are sparse. However, we have access to a reasonable amount of data to conduct comprehensive benchmarks. For example, TLUnified (Cruz and Cheng, 2021) is a pretraining corpus that combines news reports (Cruz et al., 2020), a preprocessed version of CommonCrawl (Suarez et al., 2019), and several other datasets. However, it was evaluated on domain-

<sup>1</sup>The name “calamanCy” came from *kalamansi*, a citrus fruit native to the Philippines.

Entity	Description	Examples
Person (PER)	Person entities limited to humans. It may be a single individual or group.	Juan de la Cruz, Jose Rizal, Quijano de Manila
Organization (ORG)	Organization entities limited to corporations, agencies, and other groups of people defined by an organizational structure.	Meralco, DPWH, United Nations
Location (LOC)	Location entities are geographical regions, areas, and landmasses. Geo-political entities are also included within this group.	Pilipinas, Manila, CAL-ABARZON, Ilog Pasig

Table 1: Entity types used for annotating TLUnified-NER (derived from the TLUnified pretraining corpus of Cruz and Cheng, 2021).

specific applications that may not easily transfer to more general tasks. For dependency parsing and POS tagging, we have Universal Dependencies treebanks such as TRG (Samson, 2018) and Ugnayan (Aquino and de Leon, 2020). This paper will fill the evaluation gap by providing structured benchmarks on these core tasks.

### 3 Implementation

The best way to use calamancy is through its trained pipelines. After installing the library, users can access the models via:

```
import calamancy as cl
nlp = cl.load("tl_calamancy_md-0.1.0")
```

Here, the variable `nlp` is a spaCy processing pipeline.<sup>2</sup> It contains trained components for POS tagging, dependency parsing, and NER. `calamancy` offers three pipelines of varying capacity: two static word vector-based models (`md`, `lg`), and one transformer-based model (`trf`). We will discuss how these pipelines were developed in the following section.

#### 3.1 Pipeline development

**Data annotation** To construct the NER corpus, we curated a portion of TLUnified (Cruz and Cheng, 2021) to only contain Tagalog news articles. Including the author, we recruited two more annotators who have at least a Bachelors degree and whose native language is Tagalog. The three annotators labeled over the course of four months given three entity types as seen in Table 1. The entity types were chosen to resemble ConLL (Sang, 2002; Sang and Meulder, 2003), a standard NER benchmark. We measured inter-annotator agreement (IAA) by taking the pairwise Cohen’s  $\kappa$  on

<sup>2</sup><https://spacy.io/usage/processing-pipelines>

Dataset	Examples	PER	ORG	LOC
Training	6252	6418	3121	3296
Development	782	793	392	409
Test	782	818	423	438

Table 2: Dataset statistics for TLUnified-NER.

all tokens then averaged them for all three pairs. This process resulted to a Cohen’s  $\kappa$  score of 0.81. To avoid confusing with the original TLUnified pretraining corpora, we will refer to this annotated NER dataset as TLUnified-NER. The final dataset statistics can be found in Table 2. For the dependency parser and POS tagger, we merged the TRG (Samson, 2018) and Ugnayan (Aquino and de Leon, 2020) treebanks to leverage their small yet relevant examples.

**Model training** We considered three design dimensions when training the `calamancy` pipelines: (1) presence of pretraining, (2) the word representation, and (3) the representation or dimension size. *Pretraining* involves learning vectors from raw text to better inform model initialization. This process is done using a variant of the cloze task (Devlin et al., 2019). Here, the pretraining objective asks the model to predict some number of leading and trailing UTF-8 bytes for the words. *Word representations* may either involve training static word embeddings using `floret`,<sup>3</sup> an efficient version of `fastText` (Bojanowski et al., 2016), or using context-sensitive vectors from a transformer (Vaswani et al., 2017). Finally, the *dimension* is determined via a performance-accuracy tradeoff.

The general process involves pretraining a filtered version of TLUnified, constructing static

<sup>3</sup><https://github.com/explosion/floret>

Pipeline	Pretraining objective	Word embeddings	Dimensions
Medium-sized pipeline (tl_calamancy_md)	Predict some number of leading and trailing UTF-8 bytes for the words.	Uses floret vectors trained on the TLUnified corpora.	50k unique vectors (200 dimensions), Size: 77 MB
Large-sized pipeline (tl_calamancy_lg)	Same pretraining objective as the medium-sized pipeline.	Uses fastText vectors trained on Common-Crawl corpora.	714k unique vectors (300 dimensions), Size: 455 MB
Transformer-based pipeline (tl_calamancy_trf)	No separate pretraining because there’s no token-to-vector component.	Context-sensitive vectors from a transformer network.	Uses roberta-tagalog-base. Size: 813 MB

Table 3: Language pipelines available in calamanCy (v0.1.0). The pretraining method for the word-vector models is a variant of the *cloze task*. All pipelines have a tagger, parser, morphologizer, and ner spaCy component.

Dataset	Task / Labels	Description
Hatespeech (Cabasag et al., 2019)	Binary text classification ( <i>hate speech, not hate speech</i> )	Contains 10k tweets collected during the 2016 Philippine Presidential Elections labeled as hate speech or non-hate speech.
Dengue (Livelo and Cheng, 2018)	Multilabel text classification ( <i>absent, dengue, health, sick, mosquito</i> )	Contains 4k dengue-related tweets collected for a health infoveillance application that classifies text into dengue subtopics.
TLUnified-NER (Cruz and Cheng, 2021)	Named entity recognition ( <i>Person, Organization, Location</i> )	A held-out test split from the annotated TLUnified corpora containing news reports and other articles. See Table 2.
Merged UD (Samson, 2018; Aquino and de Leon, 2020)	Dependency parsing and POS tagging	Merged version of the Ugnayan and TRG treebanks from the Universal Dependencies framework.

Table 4: Datasets for benchmarking calamanCy.

word embeddings if necessary, and training the downstream components. We trained the NER component using data from TLUnified-NER, while the dependency parser and POS tagger were trained using the combined TRG and Ugnayan treebanks. In the end, we came up with three language pipelines of varying sizes as seen in Table 3.

## 4 Evaluation

**Architectures** We used spaCy’s built-in architectures for each component in the calamanCy pipeline. The token-to-vector layer uses the multi-hash embedding trick (Miranda et al., 2022). For the parser and named entity recognizer, we used a transition-based parser that maps text representations into a series of state transitions. For the text categorizer, we used an ensemble of a bag-of-words model and a feed-forward network. You can find the full training configuration in the Github repository: <https://github.com/ljvimiranda921/>

[calamanCy/tree/master/models/v0.1.0](https://github.com/ljvimiranda921/calamanCy/tree/master/models/v0.1.0).

**Experimental set-up** We evaluated the calamanCy pipelines on various Tagalog benchmarks as seen in Table 4. Unlike the *Hatespeech* and *Dengue* text categorization datasets, there is no reasonably-sized benchmark for NER and dependency parsing. So instead, we used a held-out test split from TLUnified-NER for the former and then merged the two UD treebanks (*Merged UD*) for the latter. However, the combined UD treebank is still small ( $\ll 20k$  words), so we evaluated it using 10-fold cross-validation as recommended by the Universal Dependencies data split guidelines.<sup>4</sup> For all the other datasets, we computed their performance across five trials and then reported the average and standard deviation.

Additionally, we also tested a cross-lingual transfer learning approach, i.e., finetuning a model from

<sup>4</sup>[https://universaldependencies.org/release\\_checklist.html#data-split](https://universaldependencies.org/release_checklist.html#data-split)

Model	Text categorization		NER	Dep. pars. & POS tag.	
	Hatespeech (binary)	Dengue (multilabel)	TLUnified- NER	Merged UD, UAS / LAS	Merged UD, POS Acc.
<i>Monolingual (Ours)</i>					
tl_calamancy_md	74.40±0.05	65.32±0.04	87.67±0.03	76.47 / 54.40	98.70
tl_calamancy_lg	75.62±0.02	68.42±0.01	88.90±0.01	82.13 / 70.32	99.99
tl_calamancy_trf	<b>78.25±0.06</b>	<b>72.45±0.02</b>	<b>90.34±0.02</b>	<b>92.48 / 80.90</b>	<b>99.99</b>
<i>Cross-lingual transfer</i>					
uk_core_news_trf	75.24±0.03	65.57±0.01	51.11±0.02	54.77 / 37.68	82.86
ro_core_news_lg	69.01±0.01	59.10±0.01	02.01±0.00	84.65 / 65.30	82.80
ca_core_news_trf	70.01±0.02	59.42±0.03	14.58±0.02	91.17 / 79.30	83.09
<i>Multilingual finetuning</i>					
xlm-roberta-base	77.57±0.01	67.20±0.01	88.03±0.03	88.34 / 76.07	94.29
bert-base-multilingual	76.40±0.02	71.07±0.04	87.40±0.02	90.79 / 78.52	95.30

Table 5: Benchmark evaluation scores for monolingual, cross-lingual, and multilingual pipelines across a variety of tasks and datasets. We evaluated the text categorization and NER tasks across five trials, and then conducted 10-fold cross-validation for dependency parsing. F1-scores are reported on the text categorization and NER tasks.

a source language  $S$  that is closely related to Tagalog. Aquino and de Leon (2020), using a metric based on the World Atlas for Language Structures (WALS) (Haspelmath et al., 2005; Željko Agić, 2017), claims that the top five closest languages to Tagalog are Indonesian (id), Ukrainian (uk), Vietnamese (vi), Romanian (ro), and Catalan (ca). Only Ukrainian, Romanian, and Catalan have equivalent spaCy pipelines, so we will only compare against those three. Finally, we also compared against the most common approach to build Tagalog pipelines, i.e., finetuning on XLM RoBERTa (Conneau et al., 2019) or an uncased version of multilingual BERT (Devlin et al., 2019). These multilingual LMs contain Tagalog in their training pool and are common alternatives for building Tagalog NLP applications.

## 5 Discussion

Table 5 shows the F1-scores for the text categorization and NER tasks and the unlabeled (UAS) and labeled attachment scores (LAS) for the dependency parsing task. It is notable that the calamanCy pipelines are competitive across all core NLP tasks while maintaining a smaller compute footprint. As shown in both the text categorization and NER results, users with low compute budgets can attain similar performance to multilingual LMs by using medium- or large-sized calamanCy models. For users who prioritize accuracy, the transformer-based calamanCy pipeline is the best option. However, we were surprised that most of the alterna-

tive approaches perform better in dependency parsing. We attribute this performance to the added strength of multilingual and cross-lingual information, which we don’t have when training solely on a smaller treebank. We plan to improve dependency parsing performance by building a larger treebank within the Universal Dependencies framework.

## 6 Conclusion

In this paper, we introduced calamanCy, a natural language processing toolkit for Tagalog. We have two main contributions: (1) an open-source toolkit containing general-purpose multitask pipelines with out-of-the-box support for common NLP tasks, and (2) structured benchmarks that compares against alternative approaches such as cross-lingual or multilingual finetuning.

We hope that calamanCy is a step forward to improving the state of Tagalog NLP. As a low-resource language, consolidating resources into a unified framework is crucial to advance research and improve collaboration. In the future, we plan to create a more fine-grained NER benchmark corpus and extend calamanCy to other tasks (e.g., question-answering, commonsense reasoning, etc.). Finally, the project is hosted on Github (<https://github.com/ljvmiranda921/calamanCy>) and we are happy to receive community feedback and contributions.



Metric	IAA
Cohen’s $\kappa$ on all tokens	0.81
Cohen’s $\kappa$ on annotated tokens only	0.65
F1 score	0.91

Table 6: Inter-annotator agreement measures. Calculated by doing pairwise comparisons between all annotator-pairs and averaging the results.

## Appendix

### Reproducibility

All the experiments and models in this paper are available publicly. You can head over to <https://github.com/ljvmiranda921/calamanCy> for all related software. Note that the XLM-RoBERTa and multilingual BERT experiments may at least require a V100 GPU.

To reproduce the calamanCy models (tl\_calamancy\_md, etc.), head over to models/v0.1.0. To reproduce the benchmarking experiments, head over to the paper/benchmark directory. If you are interested in the training configuration (e.g., hyperparameters, architectures used, etc.), you can check the CFG files in the respective project’s configs/ directory.

### Building the TLUnified-NER corpora

The TLUnified-NER dataset is a named entity recognition corpora containing the *Person* (PER), *Organization* (ORG), and *Location* (LOC) entities. It includes news articles and other texts in Tagalog from 2009 to 2020. It was based on the TLUnified pretraining corpora by (Cruz and Cheng, 2021). The author, together with two more annotators, annotated TLUnified in the course of four months. We followed the process recommended by Reiter (2017) which includes resolving disagreements and updating the annotation guidelines.

To compute for the inter-annotator agreement (IAA) score, we followed Brandsen et al. (2020)’s approach. We computed for the Cohen’s  $\kappa$  for (1) all tokens, and (2) only annotated tokens. In addition, we also measured the (3) pairwise F1 score without the ‘O’ label. Table 6 shows the IAA measurements while Figure 1 shows their growth after each annotation round.

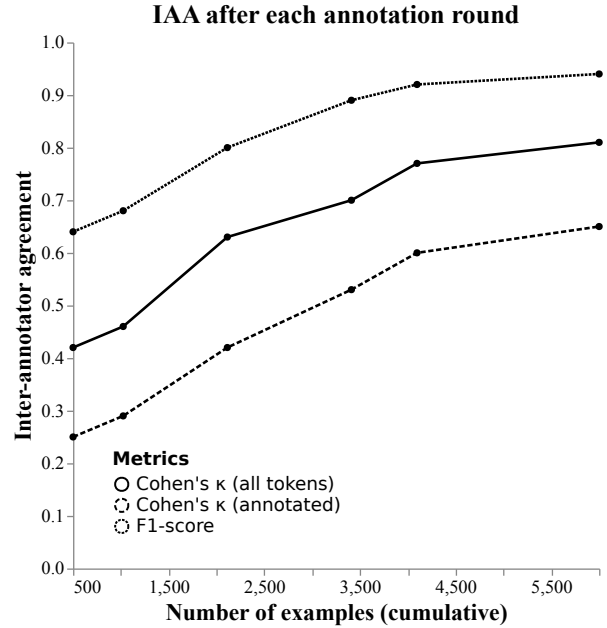


Figure 1: Inter-annotator agreement measurement after each annotation round. Each mark represents the end of a round. For each round, the annotators discuss disagreements, update the annotation guidelines, and evaluate the current set of annotations.

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