Language Detection

DSC 680

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# Business Problem

There are thousands of languages spoken around the world. While some languages, like English and Spanish, are common and somewhat easy to identify in written language, others are less common and/or much more difficult to determine the language.

It is useful to be able to identify the language of a text. For instance, being able to identify a foreign and unfamiliar language makes it possible to translate the text into a known language so the text can be read and understood.

# Background

With roughly 7,000 languages spoken worldwide, it would be impossible for one person to learn them all or be able to identify each one. Language detection is incredibly important especially in our world today, where every corner of the world is connected at the fingertips of billions of users.

Statista notes that there are over 3.6 billion people who use social media, and that number is projected to grow to over 4 billion by 2025. With that many people being able to connect online instantly, language detection in an important and useful tool for truly allow for these users to connect, allowing for translation and communication even across different and otherwise foreign languages.

# Data Explanation

The data was downloaded from <https://tatoeba.org/en/downloads>. From this source, only the sentences (senteces.tar.bz2) was downloaded to get the tab delimited csv of sentences. There are three fields in this dataset: Sentence id, Lang, and Text. Lang is an ISO 639-3 language code, from a second dataset – downloaded from <https://iso639-3.sil.org/code_tables/download_tables#termsofuse> – the data will be used to map the language code to a more human-readable language (ie. eng will output English).

## Tatoebo Sentences Data

|  |  |
| --- | --- |
| Column | Description |
| Sentence id | Unique identifier |
| Lang | ISO-639-3 language code |
| Text | Sentence |

## ISO 639-3 Data

|  |  |
| --- | --- |
| Column | Description |
| 639-3 | ISO 639-3 language code |
| 639-2/639-5 | ISO 639-2/639-5 language code |
| 639-1 | IS 639-1 language code |
| Language Name(s) | Language that correlates to the language names |
| Scope | Whether language is Individual or Collective |
| Language Type | Whether language is Living, Extinct, Genetic, Constructed |

# Methods

The Tatoeba dataset contains nearly 7 million sentences in over 300 languages. First, I limited the dataset using the top 25 languages based on the most spoken languages around the world by population – this was a list I found from [www.farandwide.com](http://www.farandwide.com). The dataset didn’t have four of the languages and had limited samples for many of the languages from this list, so I also trained a model using the top 25 languages based which languages had the most samples in the dataset.

Once I had each dataset filtered by language, I then used random sampling to under sample majority languages so the number of records for each language were roughly equal. For the top 25 languages based on population spoken around the world, there were about 500 samples for each language; for top 25 languages based on most samples in the original dataset had about 50,000 samples per language.

Then, I split the data into train and test sets, and I used CountVectorizer to create bigrams and used the bigram features to train a Multinomial Naïve Bayes model and make predictions.

# Analysis

After training the models, I used the test datasets to make predictions and used a classification report to numerically show how well my model preformed and plotted the confusion matrix as a more visual representation of the model results.

Both models detected the correct language 95% of the time. Here is the breakdown of the model prediction for the top 25 languages by population.

precision recall f1-score support

Arabic 1.00 1.00 1.00 159

Bengali 1.00 1.00 1.00 177

English 0.96 0.96 0.96 180

French 0.96 0.98 0.97 190

German 0.93 0.98 0.96 168

Hausa 0.00 0.00 0.00 30

Hindi 0.99 0.97 0.98 157

Italian 0.94 0.95 0.94 168

Japanese 1.00 0.99 1.00 179

Javanese 0.88 0.97 0.92 145

Korean 1.00 0.99 1.00 168

Mandarin Chinese 0.83 0.75 0.79 165

Marathi 0.97 0.99 0.98 150

Portuguese 0.90 0.96 0.93 156

Russian 0.99 1.00 1.00 161

Spanish 0.93 0.92 0.93 181

Tamil 1.00 1.00 1.00 105

Telugu 1.00 1.00 1.00 73

Vietnamese 1.00 1.00 1.00 166

Wu Chinese 0.77 0.84 0.80 144

Yue Chinese 0.93 0.89 0.91 166

accuracy 0.95 3188

macro avg 0.90 0.91 0.91 3188

weighted avg 0.94 0.95 0.94 3188

By looking at the confusion matrix below, it is no surprise that the most notable incorrect predictions were when trying to detect and differentiate between the three different Chinese languages in the dataset: Mandarain, Wu and Yue.

A screenshot of a computer

Description automatically generated with medium confidence

Below is the classification report and confusion matrix of the second model using the top 25 languages based on number of samples available in the original dataset.

precision recall f1-score support

Czech 0.90 0.98 0.94 16306

Danish 0.93 0.95 0.94 16612

Dutch 0.97 0.95 0.96 16566

English 0.95 0.98 0.96 16465

Esperanto 0.92 0.98 0.95 16401

Finnish 0.98 0.99 0.99 16486

French 0.98 0.98 0.98 16723

German 0.96 0.97 0.97 16384

Hebrew 1.00 1.00 1.00 16573

Hungarian 0.99 0.98 0.99 16557

Italian 0.95 0.96 0.95 16532

Japanese 1.00 1.00 1.00 16671

Kabyle 1.00 0.99 0.99 16368

Lithuanian 0.94 0.98 0.96 16425

Macedonian 0.70 0.98 0.81 16415

Mandarin Chinese 1.00 1.00 1.00 16694

Marathi 1.00 1.00 1.00 16473

Polish 0.98 0.99 0.98 16271

Portuguese 0.94 0.95 0.95 16568

Russian 0.92 0.97 0.95 16268

Serbian 1.00 0.25 0.40 15050

Spanish 0.93 0.95 0.94 16512

Swedish 0.97 0.92 0.94 14671

Turkish 0.99 0.99 0.99 16524

Ukrainian 0.97 0.94 0.96 16483

accuracy 0.95 408998

macro avg 0.95 0.95 0.94 408998

weighted avg 0.95 0.95 0.94 408998

A screenshot of a computer

Description automatically generated with medium confidence

Looking at the confusion matrix for this second model, again there are no surprises. In this case there is only one Chinese language so the model was able to predict Chinese with no issue, but instead occasionally mixed up Macedonian and Serbian. This is no surprise because both of these languages come from countries in the Balkans (Southeast Europe) so they likely have similar influences and therefore similarities in the languages.

# Conclusion

Both models, even with differences in the sample sizes, has highly accurate models. Neither model is better for all scenarios. The ideal model to deploy would be one that uses the languages that are most likely to come up in a scenario where you would apply the model. For instance, if you are at war – say the U.S. at war with the Middle East – a useful model would be trained using samples from a variety of languages that include but are not limited to English, Arabic and at least some known popular minority languages so you can detect and then translate intercepted correspondence.

Since both models resulted in high accuracy even though different languages and different sample sizes were used, it seems likely that we would have a similar outcome if we selected languages with more business knowledge at hand and took similar steps to prepare and train the model.

# Assumption

There was one major assumption made – only to top 25 languages are necessary for the language detection model. This number was somewhat arbitrary, but in both models I used some sort of additional knowledge to select the languages. In one case, I was training my model based on how many people would theoretically find the language detection useful – if more people are speaking a language then the language is more likely to come up in a scenario when you need to figure out what language you are translating from. In the second case, I am assuming that because there are more samples for language, that means the language is more likely to come up in a language detection/translation scenario.

# Limitations

One limitation of this dataset is that the data comes from entries submitted by users around the world. In the case of my first model, some languages that are spoken by millions of people have little to no samples. This could be attributed to either the lack of resources for people who speak those languages to make their submissions or in general, to make a submission you need to know about the Tatoeba website and mission to do so.

A limitation of the project is that I am only focusing on a small set of languages. This means that the application of the model will only be useful for detecting languages used to predict the model.

# Challenges

Aside from some classwork that touched on natural language processing (NLP), this is the first project performing NLP and I knew there would be some challenges. One challenge I came across was trying to use CountVectorizer on my dataset. After my computer restarted on its own while trying to vectorize the dataset, I discovered I did not need to this and created a pipeline for a multinomial Naïve Bayes model that used bigrams. The other challenge I came across was balancing my dataset. I wanted to use the best method possible, but after some research, with text data, I found there is no one best solution and ended up under sampling my data to get even classes.

# Future Uses/Additional Applications

A future extension of this project would be to use the audio files from the Tatoeba dataset to create a model that can detect spoken language. Additionally, in both this current project and the audio detection suggestion, a future project would be to include translations of the written or spoken sentences.

# Recommendations

One recommendation for this project would be to train a model using all the languages. One limitation here is that some languages have very few samples, so we would either need to find another dataset to join with this one, or somehow randomly create new samples. Additionally, we could limit the languages by requiring there to be at least 500 samples for instance. Training a model with more languages would be ideal for making an application that is able to differentiate between different dialects or languages that have similar influences. As an example, in the case of East Asian languages, if you are missing languages, you might not be able to differentiate Korean from Japanese or Chinese.

# Implementation Plan

To implement the model, first a solid business case would need to be made. As is, either model could be successfully deployed and implemented. However the true value would come by ensuring all the necessary languages for a specific business case are included in training the model, if they are not already included in either of the top language models from my project.

# Ethical Assessment

On the surface, language detection does not seem like it would have many ethical implications. However, with natural language processing, there are more than I realized. With written language detection, one ethical concern is that in the wrong hands it could be used to train a computer to mimic a person’s language and going further, how they speak in written language. This opens doors for faking identities in an online or virtual space.

If we go further and use spoken language, this adds an additional layer of realism to something that could be faked by a computer. People could be led to believe a faked online identity is real by speaking to it over a text chat, but the reality of this faked identity becomes even more real when it can also speak the language. These fake identities are scary and can lead to potentially very dangerous situation.

However, in the right hands, this type of model can be used to connect or even protect in certain scenarios people across the world.

# References

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