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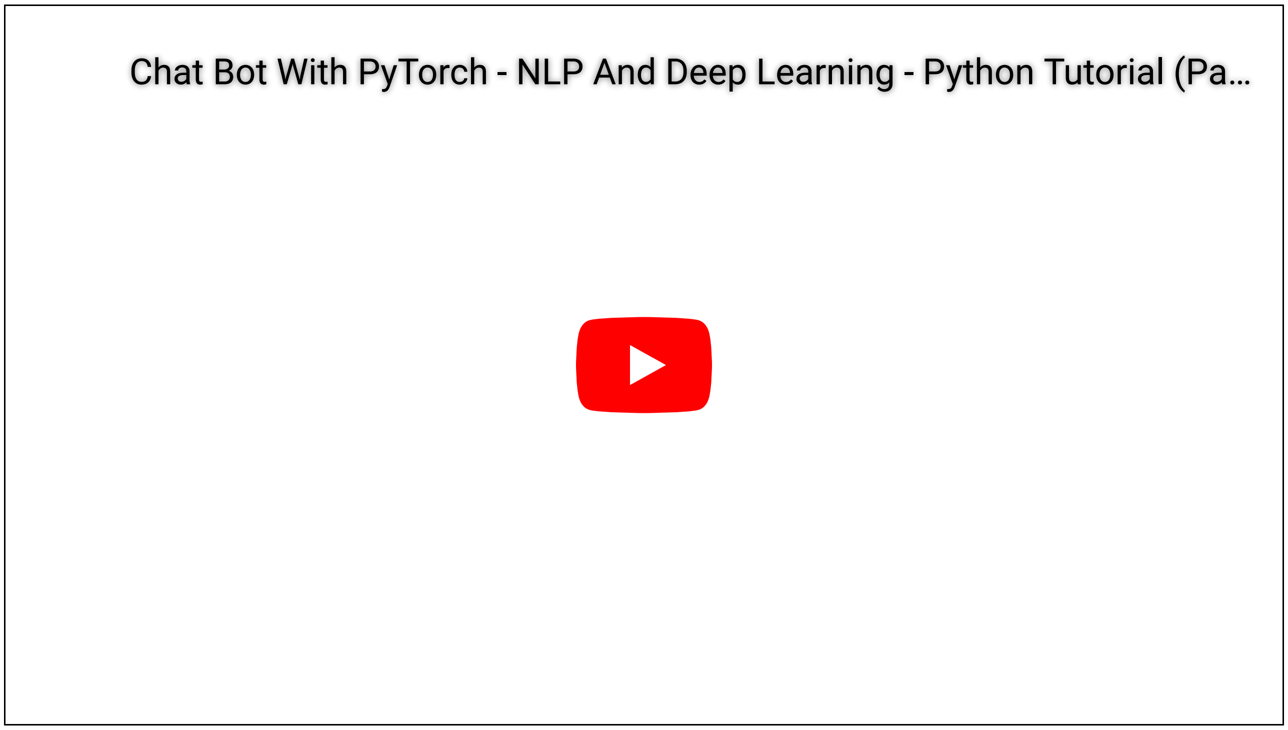
Chat Bot With PyTorch - NLP And Deep Learning

PyTorch Deep Learning NLP

14 Jun 2020, by Patrick Loeber


Chat Bot With PyTorch - NLP And Deep Learning - Python Tutorial (Pa…

In this tutorial we build a simple chatbot in PyTorch. I will also provide an introduction to some basic Natural Language Processing (NLP) techniques.

```
>>> Let's chat! (type 'quit' to exit)
>>> You: Hi
>>> Hi there, what can I do for you?
>>> You: What do you sell?
>>> We have coffee and tea.
```

Here's an overview of what you will learn:

- NLP Basics: Tokenization, Stemming, Bag Of Words
- How to preprocess the data with `nltk` to feed it to your neural net
- How to implement the feed-forward neural net in Pytorch and train it
- The implementation should be easy to follow for beginners and provide a basic understanding of chatbots.
- The implementation is straightforward with a Feed Forward Neural net with 2 hidden layers.
- Customization for your own use case is super easy. Just modify `intents.json` with possible patterns and responses and re-run the training (see below for more info).

The approach is inspired by this article and ported to PyTorch: https://chatbotsmagazine.com/contextual-chat-bots-with-tensorflow-4391749d0077.

You can find the code on GitHub.

1) Setup Your Environment

Let's start by setting up our virtual environment and installing `PyTorch` and `nltk`.

Create an environment

Whatever you prefer (e.g. `conda` or `venv`)

```
mkdir myproject
$ cd myproject
$ python3 -m venv venv
```

Activate it

Mac / Linux:

```
. venv/bin/activate
```

Windows:

```
venv\Scripts\activate
```

Install PyTorch and dependencies

For Installation of PyTorch see official website.

You also need `nltk` :

```
pip install nltk
```

If you get an error during the first run, you also need to install `nltk.tokenize.punkt` : Run this once in your terminal:

```
$ python
>>> import nltk
>>> nltk.download('punkt')
```

2) Create Training Data

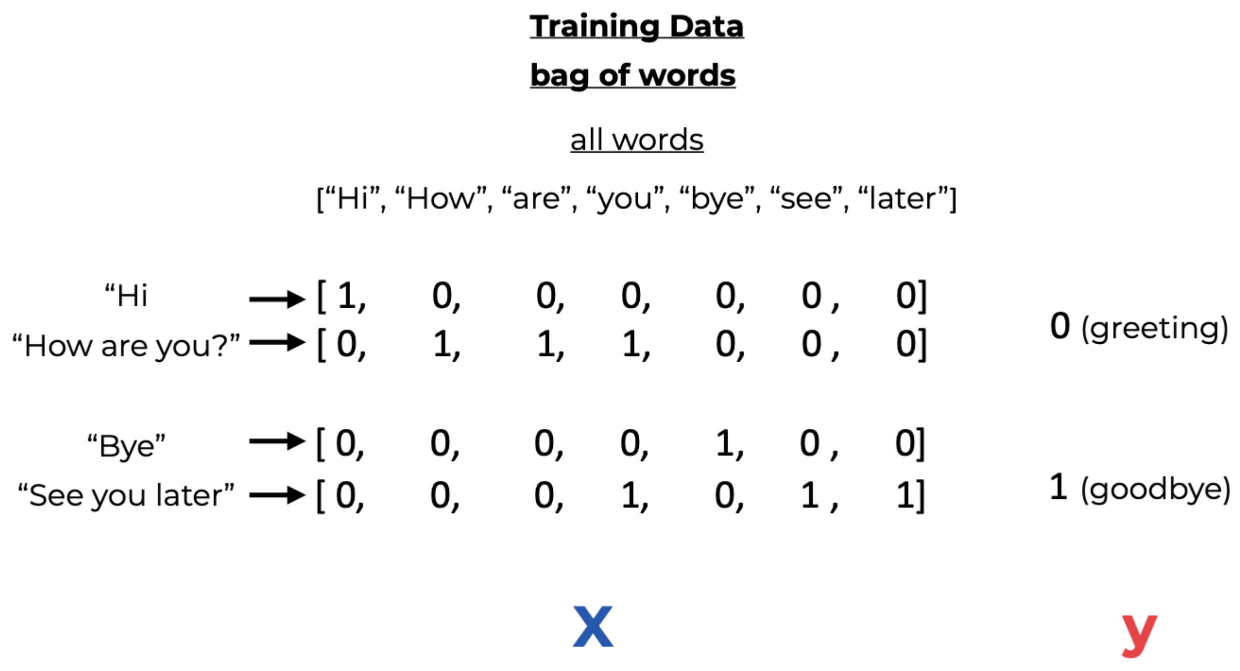
We need to create training data in a json file (`intents.json`). It has the following structure:

```
{
  "intents": [
    {
      "tag": "greeting",
      "patterns": [
        "Hi",
        "Hey",
        "How are you",
        "Is anyone there?",
        "Hello",
        "Good day"
      ],
      "responses": [
        "Hey :-)",
        "Hello, thanks for visiting",
        "Hi there, what can I do for you?",
        "Hi there, how can I help?"
      ]
    },
    ...
  ]
}
```

You can customize it according to your own use case. Just define a new `tag` , possible `patterns` , and possible `responses` for the chat bot. You have to re-run the training whenever this file is modified.

3) NLP Basics

We can't just pass the input sentence as it is to our neural net. We somehow have to convert the pattern strings to numbers that the network can understand. For this we convert each sentence to a so called **bag of words** (bow). To do this we need to collect training words, i. e., all the words that our bot can have a look at in the training data. Based on all these words, we can then calculate the bag of word for each new sentence. A bag of words has the same size as the *all words* array, and each position contains a 1 if the word is avaliable in the incoming sentence, or 0 otherwise. Here's a visual example:



["Hi", "How", "are", "you", "bye", "see", "later"]

```
"Hi             → [1, 0, 0, 0, 0, 0, 0]
"How are you?"  → [0, 1, 1, 1, 0, 0, 0]    0 (greeting)

"Bye"           → [0, 0, 0, 0, 1, 0, 0]
"See you later" → [0, 0, 0, 1, 0, 1, 1]    1 (goodbye)
```

Before we can calculate the bow, we apply two more NLP techniques: **Tokenization and Stemming**.

- Tokenization: Splitting a string into meaningful units (e.g. words, punctuation characters, numbers)

Example:

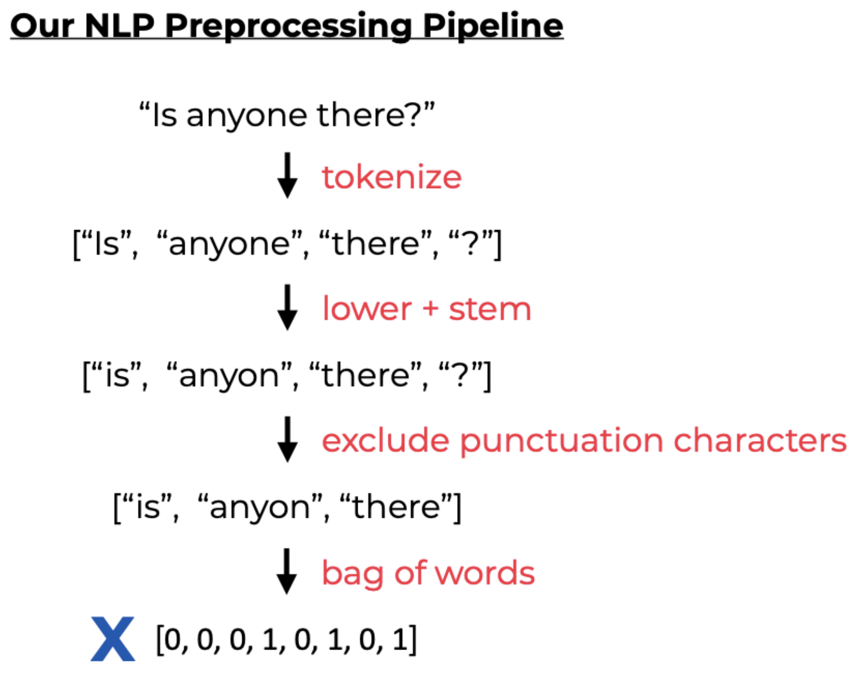
```
"what would you do with 1000000$?"
[ “what”, “would”, “you”, “do”, “with”, “1000000”, “$”, “?”]
```

- Stemming Generate the root form of the words. It's a crude heuristic that chops of the ends off of words

Example:

```
[“organize”, “organizes”, “organizing”]
[ “organ”, “organ”, “organ”]
```

For our labels, we sort them alphabetically and then use the index as class label. Our whole preprocessing pipeline looks like this:


Our NLP Preprocessing Pipeline
“Is anyone there?”
tokenize
[“Is”, “anyone”, “there”, “?”]
lower + stem
[“is”, “anyon”, “there”, “?”]
exclude punctuation characters
[“is”, “anyon”, “there”]
bag of words
X [0, 0, 0, 1, 0, 1, 0, 1]

4) Implement The NLP Utils

For this we use the `nltk` module. NLTK (Natural Language Toolkit) is a leading platform for building Python programs to work with human language data. It provides a lot of helpful methods that we can use.

```
# nltk_utils.py
import numpy as np
import nltk
# nltk.download('punkt')
from nltk.stem.porter import PorterStemmer
stemmer = PorterStemmer()

def tokenize(sentence):
    """
    split sentence into array of words/tokens
    a token can be a word or punctuation character, or number
    """
    return nltk.word_tokenize(sentence)


def stem(word):
    """
    stemming = find the root form of the word
    examples:
    words = ["organize", "organizes", "organizing"]
    words = [stem(w) for w in words]
    -> ["organ", "organ", "organ"]
    """
    return stemmer.stem(word.lower())


def bag_of_words(tokenized_sentence, words):
    """
    return bag of words array:
    1 for each known word that exists in the sentence, 0 otherwise
    example:
    sentence = ["hello", "how", "are", "you"]
    words = ["hi", "hello", "I", "you", "bye", "thank", "cool"]
    bog   = [  0 ,    1 ,    0 ,   1 ,    0 ,    0 ,      0]
    """
    # stem each word
    sentence_words = [stem(word) for word in tokenized_sentence]
    # initialize bag with 0 for each word
    bag = np.zeros(len(words), dtype=np.float32)
    for idx, w in enumerate(words):
        if w in sentence_words:
            bag[idx] = 1
    return bag
```

5) Implement The Neural Network

The implementation is straightforward with a Feed Forward Neural net with 2 hidden layers:

```
# model.py
import torch
import torch.nn as nn


class NeuralNet(nn.Module):
    def __init__(self, input_size, hidden_size, num_classes):
        super(NeuralNet, self).__init__()
        self.l1 = nn.Linear(input_size, hidden_size)
        self.l2 = nn.Linear(hidden_size, hidden_size)
        self.l3 = nn.Linear(hidden_size, num_classes)
        self.relu = nn.ReLU()

    def forward(self, x):
        out = self.l1(x)
        out = self.relu(out)
        out = self.l2(out)
        out = self.relu(out)
        out = self.l3(out)
        # no activation and no softmax at the end
        return out
```

6) Implement The Training Pipeline

Put everything together:

```
# train.py
import numpy as np
import random
import json

import torch
import torch.nn as nn
from torch.utils.data import Dataset, DataLoader

from nltk_utils import bag_of_words, tokenize, stem
from model import NeuralNet

with open('intents.json', 'r') as f:
    intents = json.load(f)

all_words = []
tags = []
xy = []
# loop through each sentence in our intents patterns
for intent in intents['intents']:
    tag = intent['tag']
    # add to tag list
    tags.append(tag)
    for pattern in intent['patterns']:
        # tokenize each word in the sentence
        w = tokenize(pattern)
        # add to our words list
        all_words.extend(w)
        # add to xy pair
        xy.append((w, tag))

# stem and lower each word
ignore_words = ['?', '.', '!']
all_words = [stem(w) for w in all_words if w not in ignore_words]
# remove duplicates and sort
all_words = sorted(set(all_words))
tags = sorted(set(tags))

# create training data
X_train = []
y_train = []
for (pattern_sentence, tag) in xy:
    # X: bag of words for each pattern_sentence
```

```
        bag = bag_of_words(pattern_sentence, all_words)
        X_train.append(bag)
        # y: PyTorch CrossEntropyLoss needs only class labels, not one-
        label = tags.index(tag)
        y_train.append(label)

    X_train = np.array(X_train)
    y_train = np.array(y_train)

    # Hyper-parameters
    num_epochs = 1000
    batch_size = 8
    learning_rate = 0.001
    input_size = len(X_train[0])
    hidden_size = 8
    output_size = len(tags)

    class ChatDataset(Dataset):

        def __init__(self):
            self.n_samples = len(X_train)
            self.x_data = X_train
            self.y_data = y_train

        # support indexing such that dataset[i] can be used to get i-th
        def __getitem__(self, index):
            return self.x_data[index], self.y_data[index]

        # we can call len(dataset) to return the size
        def __len__(self):
            return self.n_samples

    dataset = ChatDataset()
    train_loader = DataLoader(dataset=dataset,
                              batch_size=batch_size,
                              shuffle=True,
                              num_workers=2)

    device = torch.device('cuda' if torch.cuda.is_available() else 'cpu

    model = NeuralNet(input_size, hidden_size, output_size).to(device)

    # Loss and optimizer
    criterion = nn.CrossEntropyLoss()
    optimizer = torch.optim.Adam(model.parameters(), lr=learning_rate)
```

```
# Train the model
for epoch in range(num_epochs):
    for (words, labels) in train_loader:
        words = words.to(device)
        labels = labels.to(device)

        # Forward pass
        outputs = model(words)
        # if y would be one-hot, we must apply
        # labels = torch.max(labels, 1)[1]
        loss = criterion(outputs, labels)

        # Backward and optimize
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()

    if (epoch+1) % 100 == 0:
        print (f'Epoch [{epoch+1}/{num_epochs}], Loss: {loss.item()


print(f'final loss: {loss.item():.4f}')

data = {
"model_state": model.state_dict(),
"input_size": input_size,
"hidden_size": hidden_size,
"output_size": output_size,
"all_words": all_words,
"tags": tags
}

FILE = "data.pth"
torch.save(data, FILE)

print(f'training complete. file saved to {FILE}')
```

7) Implement The Chat

Load the trained model and make predictions for new sentences:

```
# chat.py
import random
import json

import torch

from model import NeuralNet
from nltk_utils import bag_of_words, tokenize

device = torch.device('cuda' if torch.cuda.is_available() else 'cpu

with open('intents.json', 'r') as json_data:
    intents = json.load(json_data)

FILE = "data.pth"
data = torch.load(FILE)

input_size = data["input_size"]
hidden_size = data["hidden_size"]
output_size = data["output_size"]
all_words = data['all_words']
tags = data['tags']
model_state = data["model_state"]

model = NeuralNet(input_size, hidden_size, output_size).to(device)
model.load_state_dict(model_state)
model.eval()

bot_name = "Sam"
print("Let's chat! (type 'quit' to exit)")
while True:
    # sentence = "do you use credit cards?"
    sentence = input("You: ")
    if sentence == "quit":
        break

    sentence = tokenize(sentence)
    X = bag_of_words(sentence, all_words)
    X = X.reshape(1, X.shape[0])
    X = torch.from_numpy(X).to(device)

    output = model(X)
    _, predicted = torch.max(output, dim=1)
    tag = tags[predicted.item()]

    probs = torch.softmax(output, dim=1)
    prob = probs[0][predicted.item()]
    if prob.item() > 0.75:
        for intent in intents['intents']:
            if tag == intent["tag"]:
                print(f"{bot_name}: {random.choice(intent['response
    else:
        print(f"{bot_name}: I do not understand...")
```

8) Usage

Congratulations! You have implemented your chat bot! Now just run the training and start chatting 😊.

Run

```
python train.py
```

This will dump `data.pth` file. And then run

```
python chat.py
```

As mentioned in the beginning, you can customize it for your own needs. Just modify `intents.json` with possible patterns and responses and re-run the training.

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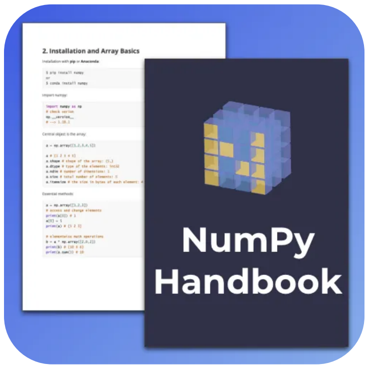

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