Deep Learning HW 3 Report

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1 Functions and Classes Documentation

1. `def tf_text_to_tokens(text: str) -> List[str]`
   Perform tokenization of the text by a set of specified rules using TensorFlow
   Input variables:

   - `text`: Text to tokenize

   Output variables:

   - `tokens`: List of tokens constructed from the text

2. `def add_words_from_songs(word_to_index, songs_lyrics: List[str], output_dim: int)`
   Add words from all songs to the vocabulary inplace
   Input variables:

   - `word_to_index`: The word2vec model word to index dictionary
   - `songs_lyrics`: A list of all the songs lyrics
   - `output_dim`: The embedding layer output dimension

3. `def recreate_w2v_model_with_pad_key(word2vec_model_keyed_vectors: KeyedVectors, embed_size: int)-> KeyedVectors`
   Recreate the model with [PAD] word with the key 0
   Input variables:

   - `word2vec_model_keyed_vectors`: The word2vec model keyed vectors
   - `embed_size`: The embedding layer dimension

   Output variables:

   - `new_model_keyed_vectors`: The word2vec model keyed vectors with the pad key

4. `def tokenize(word_to_index: Dict[str, int], songs_lyrics: List[str]) -> Tuple[List[List[int]], List[List[int]]]`
   Tokenize the songs lyrics to examples and labels
   Input variables:

   - `word_to_index`: The word2vec model word to index dictionary
   - `songs_lyrics`: All songs lyrics

   Output variables:

   - `X`: A list of examples - each represented by a list of indices of words
   - `Y`: A list of corresponding labels - each represented by a list of indices of words

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5. ```
   def create_dataset(csv_file_path: Path, word_to_index: Dict[str, int],
   output_dim: int, batch_size: int, expand_vocab: bool) -> Dataset
   ```
   Generate the model dataset
   Input variables:

   - `csv_file_path`: A path to the csv file containing the artist name, song name and lyrics
   - `word_to_index`: The word2vec model word to index dictionary
   - `output_dim`: The embedding layer output dimension
   - `batch_size`: The batch size
   - `expand_vocab`: A boolean flag to decide whether to expand the vocabulary or not

   Output variables:

   - `ds`: A TensorFlow Dataset object containing the examples and labels

6. ```
   def generate_midi_embeddings(artists_names: List[str], songs_names: List[str])
   -> Tuple[List[np.array], List[int]]
   ```
   Generate the MIDI files embeddings
   Input variables:

   - `artists_names`: A list of the artists names
   - `songs_names`: A list of the songs names

   Output variables:

   - `piano_rolls`: A list of the piano rolls
   - `good_indices`: A list of the piano rolls corresponding list indices

7. ```
   class RNN(keras.Model)
   ```
   The base Recurrent Neural Network class - inherits `keras.Model` and implements call - the method
   that acts upon a given example `x`
   Constructor variables:

   - `input_dim`: The input dimension for the model - the vocabulary size
   - `pretrained_weights`: The pretrained weights to be applied to the embedding layer
   - `output_dim`: The output dimension for the model - the number of words in the word2vec model
   - `use_attention_addition`: A boolean flag to indicate whether to use attention by addition or
     concatenation

8. ```
   def train(train_path: Path, test_path: Path, batch_size: int, epochs: int)
   ```
   Train the RNN and plot the training statistics
   Input variables:

   - `train_path`: The path to the train data .csv file
   - `test_path`: The path to the train data .csv file
   - `batch_size`: The batch size to train with
   - `epochs`: Number of epochs to train

9. ```
   def generate_songs(train_path: Path, test_path: Path, path_to_model: str) -> List[str]
   ```
   Generate songs with the trained model
   Input variables:

   - `train_path`: The path to the train data .csv file
   - `test_path`: The path to the train data .csv file
   - `path_to_model`: The path to the trained RNN model

   Output variables:

   - `gen_songs`: A list of the generated songs

2 Solution Approaches

In this section we will describe the methods we choose to generate the dataset, train the model with the train set lyrics and MIDI files and finally generate song lyrics on the test set.

2.1 Dataset Architecture

The dataset we generated was defined as such:
For a given song $S = w_1 w_2 \cdots w_n$ with length n, , we added a pair with a training example and label of the form (x, y) where:

$$x = \quad w_1 w_2 \cdots w_{n-1}$$
$$y = \quad w_2 w_3 \cdots w_n$$

In this manner, x is composed of $n-1$ features where each feature is a word, starting from the first word up to the one before the last. Then the label y is composed of the corresponding labels for each word - which is the following word in order. In this manner we generated a dataset where each example corresponds to an entire song. Since the songs are of different length, we padded the dataset with the function described above.

2.2 Model Architecture

The layout of the architecture we used is presented in the following figure, for a given song $S = w_1 w_2 ... w_n$ with length n where w_i is the i'th word and a corresponding piano matrix (from the MIDI file) of shape $128 \times k$:
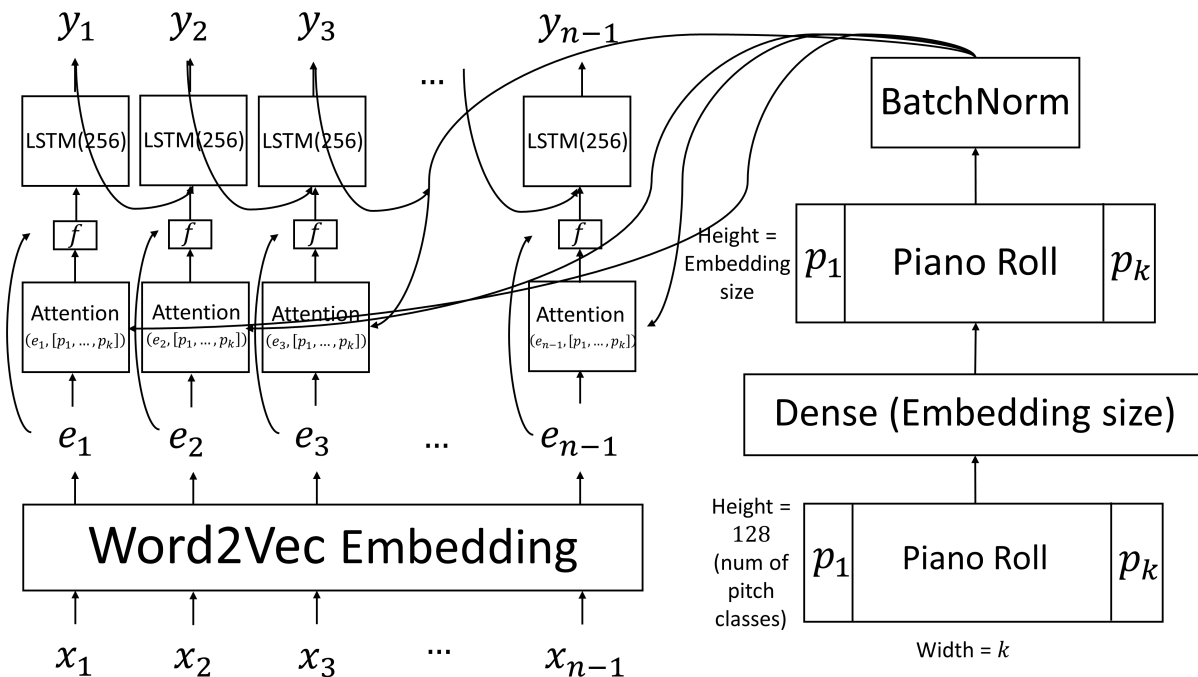
Figure 1: RNN Architecture

2.2.1   Lyrics and Audio Integration Technique

As can be seen in the figure, we used attention to combine the data from the songs lyrics and midi files - using addition and concatenation. The function f in the figure is thus:

$$f(x, y) = x + y$$

in the case of addition and

$$f(x, y) = [x, y]$$

in the case of concatenation, where the notation $[\cdot]$ regards a python list.

2.3   Lyrics Generation Technique and Analysis

- To generate the lyrics on the test set, we took the 10 top words with the highest probability to appear, and chosen one at random - as we saw this provides better results.

- This is the reason why for the same first word we can get different lyrics, as can be seen with the song 'All the Small Things' in the test set when we feed it twice with the initial word "all".

- That being said, we can see that even with the same melody, different words will provide different lyrics generation with high probability.

- The melodies do provide an additional effect on choosing the appropriate next word, in a manner which is fairly less substantial than the lyrics themselves.

- Combining both together yields interesting results that can further be improved using different parameters and techniques than we used in our code (learning rate, batch size, epochs num, et.)

3 Model Performance

In this section we will present the TensorBoard output for training and validation loss of our model.

3.1 Attention Addition Architecture

Using this architecture we used 14 epochs. The following figure describes the training accuracy as a function of the epoch number:
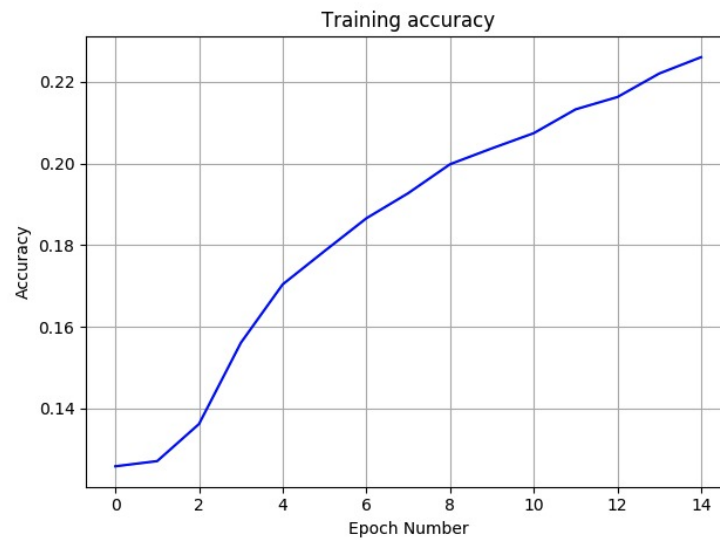
Figure 2: Training Accuracy

The following figure describes the training loss as a function of the epoch number:
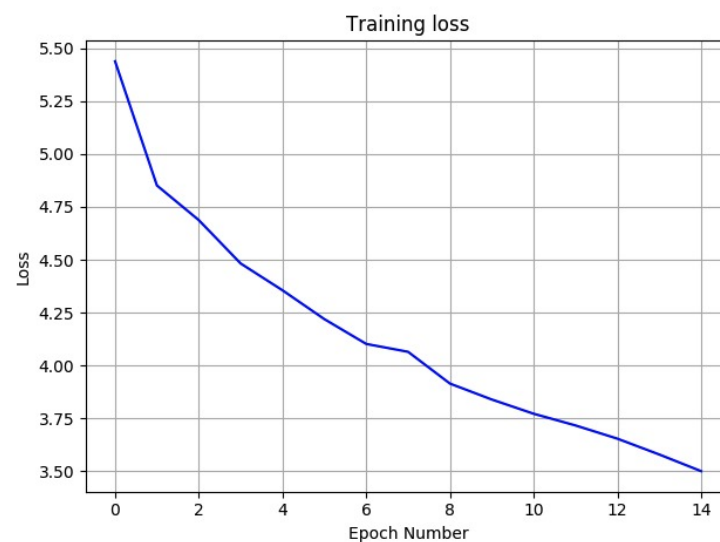
Figure 3: Training Loss

3.1.1 Generated lyrics on the test set

- The Bangles - Eternal Flame

  - Output with original initial word ('close'):
    close night of my name in your life & is your love in you on the floor of your mind for my mind and a friend of you are to me down the day & so is a new time is love of a place of & i ve never know
  - Output with 'home' as an initial word:
    home you love to & my heart my name was & the people & a single thing who is the end to me the stars to say that it & it was good good of my heart in all the night will & you is a new one thing can show
  - Output with 'all' as an initial word:
    all a way i was a man to to it & so many is a time to be to & and i d rather it i do it all more a new of life way i love i know can & you is my baby yeah you & and when you
  - Output with 'price' as an initial word:
    price is love i ll be good you re gone and i d love i m & to the look who s gonna & it s the day in you can show you re all a & love s no more more of my body is the sun you ll do

- Billy Joel - Honesty

  - Output with original initial word ('if'):
    if there you know it good what a new place the end of the radio s not a little piece to to make me and the rain & no it seems i want & it would you believe & but is the time we know a way & you ll always
  - Output with 'home' as an initial word:
    home i know what we ve done the rain i used be wrong & i will say i m t you & you say the things is s the radio to the world with & but i ve never a chance and the rain on your eyes away in his heart
  - Output with 'all' as an initial word:
    all what a chance a chance & the way you know me & if the world to you do say the world & that s it s a man in me down like all my eyes away down on it all love you don do you see the world of your
  - Output with 'price' as an initial word:
    price of the world to & it ll see to know what a way & but they are you to say what & and i know want me what you do to it & i want me so i know that she you ve always i m a new place you

- Cardigans - Lovefool

  - Output with original initial word ('dear'):
    dear the new time in town we used be the world is you got to it to me to get on it & so s in to be it all it on you to see your life s gonna down me on in night & and a boardwalk with & and
  - Output with 'home' as an initial word:
    home a twilight for my head up in me in you re the rain on her eyes in my & to it to it in the world and they do it to it you know that i can to say you don it to show the rain i d be so
  - Output with 'all' as an initial word:
    all we don my baby yeah and i d do me yeah you re no & it don t do you feel for it s in in town in his arms of me down me down in his mind for all love i will you say & you were with of
  - Output with 'price' as an initial word:
    price time you say me know it i ve taken you like to say what s gonna find my love is & i got that i m & it don t know i love me so a good & to make your eyes and a new man we don do to

- Aqua - Barbie Girl

  - Output with original initial word ('hiya'):
    hiya oh & chorus i ll find my love i can t know it to show i know i do what that i do be a man &
    what will tell it to & with i feel like for your eyes and & you can tell & you know a life

  - Output with 'home' as an initial word:
    home is a man to the rain i feel for me for you with it for my eyes & she would to the my arms
    and then & it is is a man of us & she i m so to me for a life that you say that me is

  - Output with 'all' as an initial word:
    all we ve always & that a new a new life of town you ll never to me for your arms me & the day
    in of us we know the sun in town and you & you think you love it is no no more more & i d never

  - Output with 'price' as an initial word:
    price day life the people is you re never you see & with your love of me is & we ve a beautiful &
    and they don me know & but you don you know the day that we ll be with with and & oh hey
    yeah ooh baby you

- Blink 182 - All the Small Things

  - Output with original initial word ('all'):
    all we ll make know that could do be know to you say what is i can t say the good who be never
    do you do to know & what you re gonna find it s no no s i need to make be the you do do do do

  - Output with 'home' as an initial word:
    home a new is a game night s in the rain on & the is the rain is is is i d be with you you see a
    new is & and your is the world & you were all a way for the rain are your life in town me

  - Output with 'all' as an initial word:
    all i know that i love my eyes is the & she was really to be be with & but if is you i can you want
    show the love that you do do what you need you know i do i love i love & when it can it you

  - Output with 'price' as an initial word:
    price the way of your life is what & she s not to me a day to know it all love to know i ve yeah
    no a new time i could do & you do you think how a game & it is is it can i know how &

3.2 Attention Concatenation Architecture

Using this architecture we used 18 epochs. The following figure describes the training accuracy as a function of the epoch number:

Figure 4: Training Accuracy

The following figure describes the training loss as a function of the epoch number:
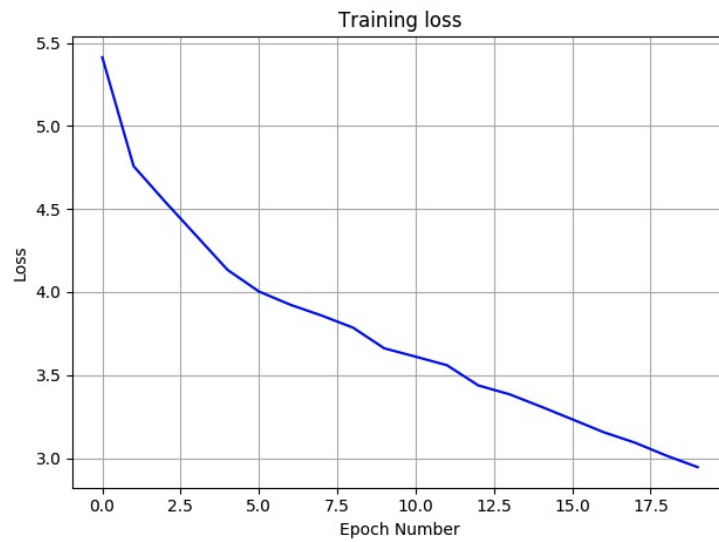
Figure 5: Training Loss

3.2.1 Generated lyrics on the test set

- The Bangles - Eternal Flame

  - Output with original initial word ('close'):
    close we ve made & that you ve always to get your mind & i want i have have known & that s a place & you were here to be a place is on a man you ll take this girl yeah that can t let you know you are

  - Output with 'home' as an initial word:
    home your body language & it can make to make to hear you go away & it doesn that we were the world of love with the air the law we were in my world love & it would have to see what i ve always it for for & so

  - Output with 'all' as an initial word:
    all this world of mind of town of night day we used a day of mine i ll find to me cry when i m lost you are so i ll love the & it doesn a chance it i want me a little boy i ve always it before you

  - Output with 'price' as an initial word:
    price your bell & when after you were a & you are that i m so & i want to hear me to know & if there are to you till for your arms you like a woman you are me but more it hurts me baby why me baby what

- Billy Joel - Honesty

  - Output with original initial word ('if'):
    if it really i could t believe to you so & when ive been a little thing & oh what can i have never have gonna try you & and that s gonna see it & when the love of my world & you say it s all that time

  - Output with 'home' as an initial word:
    home the wind i have never & you say the world of love in town and it seems it doesn me know it feels & who will take her grieving to me go to you again & you will take it & when i see that she d go it i

  - Output with 'all' as an initial word:
    all we have the way to make this day for a whole world a friend and my heart are lonely and i d never know but when will you go to go & baby come me know why & you re looking back to be a little bit day for the

  - Output with 'price' as an initial word:
    price all so good for times of the air the rain and the night train to me and they & and i just got something to know you are just so fine you know why you & oh it i could be loved like you will see me like baby i

- Cardigans - Lovefool

  - Output with original initial word ('dear'):
    dear you ve done i ll take you smile i don a beautiful tonight to make a little prayer to & and then they get in all of me like this world is you so bad as a sign that s world with you & oh i m a sign for

  - Output with 'home' as an initial word:
    home the metro the night s the end is clear of your mind on her own haggard with my own place to you come on a turtle and they can t you get the top i don it really to be with your love divides day night & just is up

- Output with 'all' as an initial word:
  all love you re not be wrong & don you ll forget my life is a real of a new state that they are i d never have & it was all my own mind will i know we have do say but you know you do & you want that

- Output with 'price' as an initial word:
  price matter you ll always & you ve made your lucky and then & we were here to be a turtle on you baby and when they re in you will i go away on & we ve made my fantasy to know that way that we can feel you &

- Aqua - Barbie Girl

  - Output with original initial word ('hiya'):
    hiya when we re the only i need to be so & it was there & so long in my heart & for the time thing could & take your eyes in your face at a friend who i want it be the & we re leaving and you know that

  - Output with 'home' as an initial word:
    home baby don my soul i want a little times and love to be with me just baby oh so baby it & oh it really just want and & it ain not just what when the way will make you better to do i know you mean yeah but for

  - Output with 'all' as an initial word:
    all you can be so far more i d never & you need for me baby yeah you & when it could have to me down the street to be there & we know what is you you feel so lonely like i know & cause i ll never just at

  - Output with 'price' as an initial word:
    price at love i can love it baby more a chance you you know it it for a little man oh & i need my world to me to you and & we know what you do i m a way for more with it up me and tell it all

- Blink 182 - All the Small Things

  - Output with original initial word ('all'):
    all we used your love s your best game baby & let your fall i want i go away my heart & oh what you ever know you love you feel all that we will be be mine i ll be mine but i know how & oh it is it

  - Output with 'home' as an initial word:
    home i ll be your & you can feel the last & then will go go to get me free me now yeah baby baby don do say goodbye yeah & oh & ooh it s like you & so let them & you re lost time after you say yeah

  - Output with 'all' as an initial word:
    all my arms away and a new kid & so much i ll have a little place s just so lonely lonely boy yeah it takes a nanny s gone on me anymore and we know & ooh baby don ring your body baby & and it ll see a lot

  - Output with 'price' as an initial word:
    price up on all my heart like i m gonna work this & just all the world that i m gonna find in the things will & cause the one who loves that it & so much a man for a drag of of the way we say to say to