Make RNNs Great Again

Character-Level Sequence Generation in the Style of Donald Trump

Benjamin Sherman
&
Zayd Hammoudeh

Dept. of Computer Science
University of California, Santa Cruz

December 5, 2017

Quiz

Quiz

Two Quotes: One computer-generated and one from Donald Trump. Can you identify the real one?

Quiz

Two Quotes: One computer-generated and one from Donald Trump. Can you identify the real one?

- **Quote #1**: *You look at the nuclear deal,* thing that real really bothers me, it would have been so easy and its not - as important as these lives are - nuclear is so powerful. My uncle explained that to me many, many years ago...

Quiz

Two Quotes: One computer-generated and one from Donald Trump. Can you identify the real one?

- **Quote #2**: *You look at the nuclear deal,* and it's going to be great for most of my plan in a country that they don't know it. We have to be so good and it's a movement and we will make America strong again. Thank you. Thank you...

Project Objectives

- **Primary Objective**: Develop a character-level neural network that can generate text in the style of Donald Trump.

Project Objectives

- **Primary Objective**: Develop a character-level neural network that can generate text in the style of Donald Trump.
- **Secondary Objectives**:
  1. Develop and compare novel *decision engine* algorithms for character selection.
  2. Improve short-sequence generation through multi-length training.

Quick Review of Character-Level RNNs

- Given a sequence of characters, a character-level RNN learns a probability distribution over the possible subsequent characters

Quick Review of Character-Level RNNs

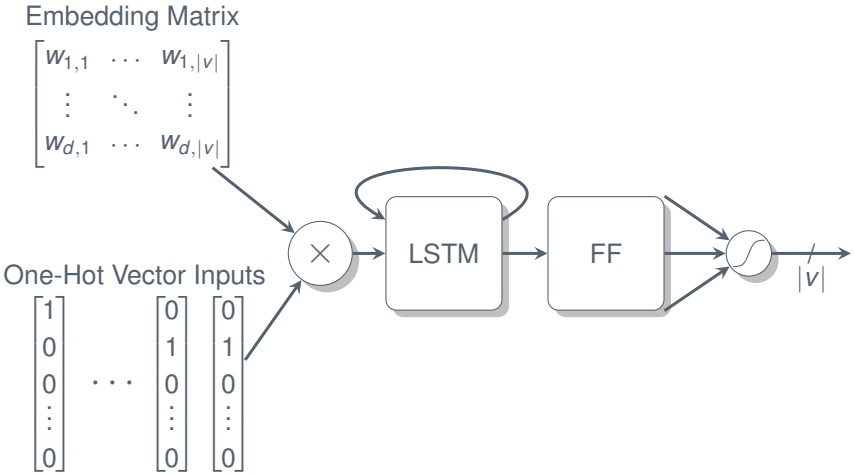
- Given a sequence of characters, a character-level RNN learns a probability distribution over the possible subsequent characters

- **Example:** if you give as input “We will build a great wal”, the RNN should return a distribution p over a vocabulary of characters V s.t. $p(\text{‘l’})$ is large

Quick Review of Character-Level RNNs

- Given a sequence of characters, a character-level RNN learns a probability distribution over the possible subsequent characters
- **Example:** if you give as input “We will build a great wal”, the RNN should return a distribution p over a vocabulary of characters V s.t. $p(\text{‘l’})$ is large
- Given some text, you can repeatedly choose a subsequent character based on the distribution produced by the network given the previous L characters

Base Learner Architecture



Learner Architecture – Summary

- **Five Primary Stages**:
  - One-Hot *Character* Encoding
  - Embedding Matrix
  - Multi-Layer LSTM
  - Feed-Forward Network
  - Softmax Layer

Learner Architecture – Summary

- **Five Primary Stages**:
  - One-Hot *Character* Encoding
  - Embedding Matrix
  - Multi-Layer LSTM
  - Feed-Forward Network
  - Softmax Layer
- **One-Hot & Softmax Dimension**: ~95 Characters

Learner Architecture – Summary

- **Five Primary Stages**:
  - One-Hot *Character* Encoding
  - Embedding Matrix
  - Multi-Layer LSTM
  - Feed-Forward Network
  - Softmax Layer
- **One-Hot & Softmax Dimension**: ~95 Characters
- **LSTM**:
  - Two Layers
  - Hidden Layer Width: 128
  - Dropout – Surprisingly important! (*More details to come*)

Learner Architecture – Summary

- **Five Primary Stages**:
  - One-Hot *Character* Encoding
  - Embedding Matrix
  - Multi-Layer LSTM
  - Feed-Forward Network
  - Softmax Layer
- **One-Hot & Softmax Dimension**: ~95 Characters
- **LSTM**:
  - Two Layers
  - Hidden Layer Width: 128
  - Dropout – Surprisingly important! (*More details to come*)
- **Feed-Forward Network**:
  - One Hidden Layer with 256 Neurons

Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*

Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*
- **Short Answer:** Word-level is not practical.

Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*
- **Short Answer:** Word-level is not practical.
- **Long Answer:**

Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*
- **Short Answer:** Word-level is not practical.
- **Long Answer:**
  - Too many words (i.e., classes)

Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*
- **Short Answer:** Word-level is not practical.
- **Long Answer:**
  - Too many words (i.e., classes)
  - Limited hardware availability

Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*
- **Short Answer:** Word-level is not practical.
- **Long Answer:**
  - Too many words (i.e., classes)
  - Limited hardware availability
  - Limited training time

Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*
- **Short Answer:** Word-level is not practical.
- **Long Answer:**
  - Too many words (i.e., classes)
  - Limited hardware availability
  - Limited training time
- **Question:** *Is character-level text generation ideal?*

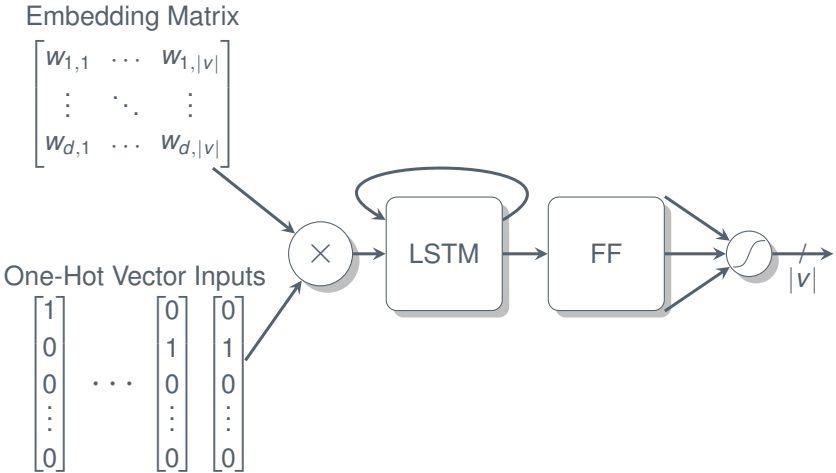
Discussion on Character-Level Text Generation

- **Question:** *Wouldn't a word-level RNN be better?*
- **Short Answer:** Word-level is not practical.
- **Long Answer:**
  - Too many words (i.e., classes)
  - Limited hardware availability
  - Limited training time
- **Question:** *Is character-level text generation ideal?*
- **No.** We do **not** expect a character-level RNN to create perfectly coherent text.
  - It will only successfully mimic short phrases or at most a single paragraph.

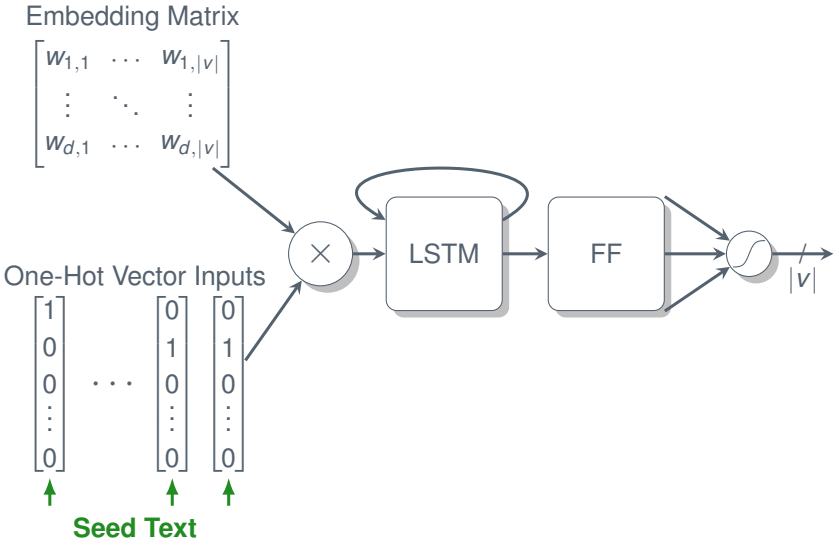
Overview of the Training Dataset & Procedure

- Datasets
  - Approximately 115 speeches
  - Basic Statistics:
    - >365,000 Words
    - >2,000,000 Training Sequences
- Speeches Only
- New Innovation: Variable length sequence training
  - Rather than training only the maximum sequence length, we train intermediary sequence lengths to ensure quality outputs even on short sequences.

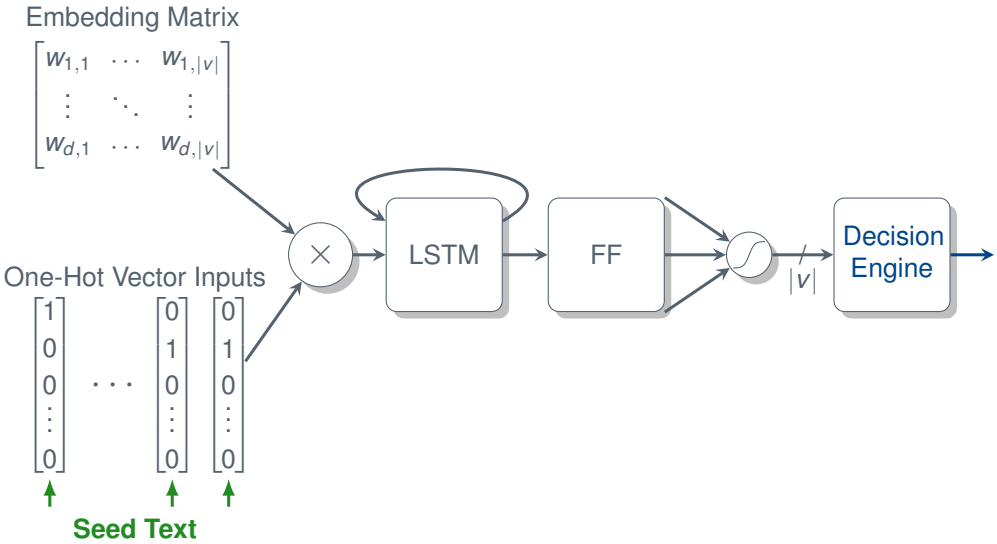
Text Generation Architecture



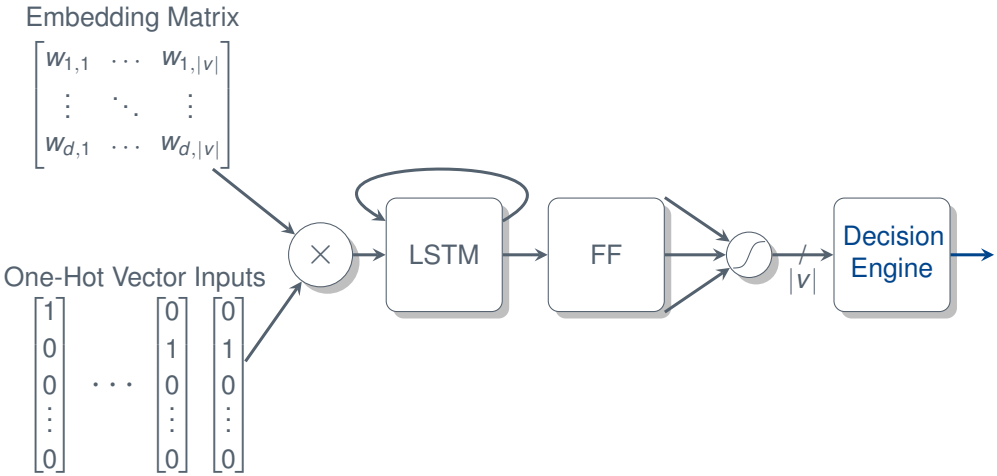
Text Generation Architecture



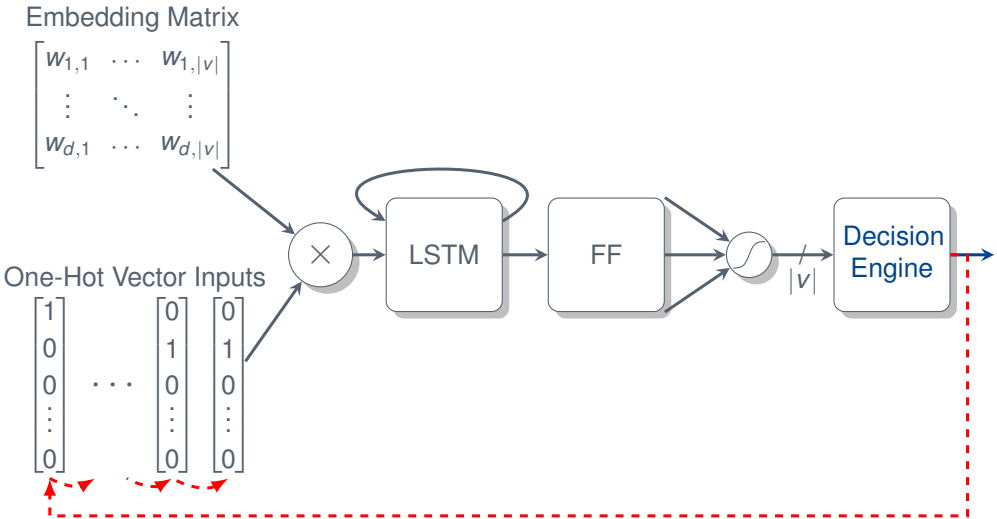
Text Generation Architecture



Text Generation Architecture



Text Generation Architecture



Decision Engine

- **Greedy** *Always take the most probable character*

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*
- **Random** *Select a random character according to the given distribution*

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*
- **Random** *Select a random character according to the given distribution*
  - Avoids getting into loops

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*
- **Random** *Select a random character according to the given distribution*
  - Avoids getting into loops
  - Has a non-zero probability of doing something ridiculous

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*
- **Random** *Select a random character according to the given distribution*
  - Avoids getting into loops
  - Has a non-zero probability of doing something ridiculous
  - *"The media is so dishonest. And thank you. I trace it. We can change it. We don't worts out."*

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*
- **Random** *Select a random character according to the given distribution*
  - Avoids getting into loops
  - Has a non-zero probability of doing something ridiculous
  - *"The media is so dishonest. And thank you. I trace it. We can change it. We don't worts out."*
- **Top-k** *Make a random choice amongst the k most probable characters according to the sub-distribution*

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*
- **Random** *Select a random character according to the given distribution*
  - Avoids getting into loops
  - Has a non-zero probability of doing something ridiculous
  - *"The media is so dishonest. And thank you. I trace it. We can change it. We don't worts out."*
- **Top-k** *Make a random choice amongst the k most probable characters according to the sub-distribution*
  - Throws out ridiculous random choices

Decision Engine

- **Greedy** *Always take the most probable character*
  - Always makes a confident choice
  - Leads to looping behavior
  - *"The media is so dishonest. They want to stop the people of the world. I want to stop the people of the world. I want to stop the people of the world. I want..."*
- **Random** *Select a random character according to the given distribution*
  - Avoids getting into loops
  - Has a non-zero probability of doing something ridiculous
  - *"The media is so dishonest. And thank you. I trace it. We can change it. We don't worts out."*
- **Top-k** *Make a random choice amongst the k most probable characters according to the sub-distribution*
  - Throws out ridiculous random choices
  - *"The media is so dishonest. And they don't know where you see it. I'm going to bring back the world."*

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*
  - Gets us out of infinite loops

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*
  - Gets us out of infinite loops
  - Does not mangle characters within words

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*
  - Gets us out of infinite loops
  - Does not mangle characters within words
- **Boosting Lopsidedness** *Exponentiate the distribution then re-normalize*

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*
  - Gets us out of infinite loops
  - Does not mangle characters within words
- **Boosting Lopsidedness** *Exponentiate the distribution then re-normalize*
  - Boosts the chance of a making a more probable choice

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*
  - Gets us out of infinite loops
  - Does not mangle characters within words
- **Boosting Lopsidedness** *Exponentiate the distribution then re-normalize*
  - Boosts the chance of a making a more probable choice
- **Sample with Dropout**

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*
  - Gets us out of infinite loops
  - Does not mangle characters within words
- **Boosting Lopsidedness** *Exponentiate the distribution then re-normalize*
  - Boosts the chance of a making a more probable choice
- **Sample with Dropout**
  - Randomly change the network

Decision Engine Contd.

- **Random-Start + Greedy Finish** *Make random choices for the first character of a word, then greedily finish each word*
  - Gets us out of infinite loops
  - Does not mangle characters within words
- **Boosting Lopsidedness** *Exponentiate the distribution then re-normalize*
  - Boosts the chance of a making a more probable choice
- **Sample with Dropout**
  - Randomly change the network
- **We can combine these with the algorithms above to create a wide variety of sampling methods**

Summary and Future Work

- **Summary**: We developed a character-level RNN that generated text in the style of President Donald Trump.
- **Future Work:**
  - **New Idea**: Character-Level Generation, Word-Level Decisions

Summary and Future Work

- **Summary**: We developed a character-level RNN that generated text in the style of President Donald Trump.
- **Future Work:**
  - **New Idea**: Character-Level Generation, Word-Level Decisions
  - **Training Improvements**: Given more time, we believe we could train better models.
    - Train longer sequences
    - Train entire speeches as a single unit
    - Train additional epochs (each additional epoch is)

Summary and Future Work

- **Summary**: We developed a character-level RNN that generated text in the style of President Donald Trump.
- **Future Work:**
  - **New Idea**: Character-Level Generation, Word-Level Decisions
  - **Training Improvements**: Given more time, we believe we could train better models.
    - Train longer sequences
    - Train entire speeches as a single unit
    - Train additional epochs (each additional epoch is)
  - **Stretch Goal**: A chat bot so you can feel what it is like to have a conversation with Donald Trump.

Download the Source Code

Our full source code is available at:

https://github.com/ZaydH/trump_char_rnn

Summary of Topics

Introduction

Learner Architecture

Training Overview

Training Overview

Text Generation

Decision Engine

Conclusions