

# Learning to be Poetic: Automatic Generation of Chinese Song Ci Using RNN

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## ABSTRACT

**Judy: To be re-written** In this project, we are going to develop a poem generator for Ci poetry. A system based on recurrent neural network (RNN) will be implemented to solve the sequence-to-sequence learning problem. We will also compare the performance of this model with the traditional automatic method that used to generate poem. We hope that our system can learn the complete rule from training dataset without any given constraints and generate poems with meaningful syntax that following the special rules for rhyme and tone in the Ci.

## Keywords

Song Ci (poetry); Recurrent Neural Network; sequence-to-sequence learning problem

## 1. PROBLEM DESCRIPTION

### 1.1 Motivation

In this project, we propose and evaluate different approaches to automatically generate Chinese poems. Especially, we study how to automatically generate Chinese Song Ci using Recurrent Neural Networks. Ci are one of the most important genres of Chinese classical poetry. As a precious cultural heritage, not many of them have been passed down onto the current generation. Therefore, the study of automatic generation of Ci is meaningful, not only because it supplements entertainment and education resources to modern society, but also because it demonstrates the feasibility of applying artificial intelligence in Art generation.

### 1.2 Background

Song Ci is a form of Chinese classical poetry. It arose with the so-called banquet music in Tang dynasty and reached its peak one hundred years later, as a major alternative to Shi poetry [2].

Derived from the structure used in Tang poetry, Ci follows strict rule determining the number of characters for different lines, the arrangement of rhyme, and the location of tones. There are more than 800 rule sets for

Ci, which is called Cipai [13]. The author of Ci needs to fill in the words according to the matrix associated to the Cipai. The uneven lines in Ci follow more continuous syntax than traditional Chinese Tang poetry [2].

### 1.3 Proposed Approach

We propose a Recurrent Neural Network model with Long Short Term Memory (LSTM) units to generate Song Ci automatically. First, our system will prompt the user to provide a Cipai name which defines the style of the poem. As Ci belonging to different Cipai conveys different grammatical rules and emotions. Next, the system will receive few of keyword inputs that capture the detailed sentiments of the Song Ci. Then it will generate the first sentence of the poetry based on the above two inputs. Further, the system generate following sentences based on previously-generated contexts using both RNN. To achieve that, we add LSTM units into the model iteration step in order to capture semantic relevance in long distance. Finally, we can evaluate the quality of the generated Ci using an evaluation tool named BLEU.

### 1.4 Technical Challenges and Proposed Solutions

**Judy: To be extended** The first challenge to build a general model for all types of Song Ci. Different from Shi poetry whose structure is strict, Song Ci has more than 800 set of Cipai, and different Cipai follows different structural or rhythmic patterns. Therefore, it is difficult to generalize a model for all the Song Ci from limited training dataset. Our solution is to create a model based on Recurrent Neural Network. For every line generated in the SongCi, its probability is based on the probability of all previously lines.

Another challenge is to maintain consistent and poetic meanings throughout the generated SongCi. Compared with Shi poetry, Song Ci are much longer in length and therefore more complicated in context. It is difficult to keep long-distance memory using conventional RNN. Our solution is to use a Long Short Term Memory (LSTM) model that can track the long-distance information.

## 2. RELATED WORK

Approaches to poetry automatic generation can be divided into the following categories.

**Using rules and templates.** This approach adopts templates to generate poems that comply with a set of rules and constraints. These rules may be derived from user queries and additional lexical resources [11, 14], parts of speech and WordNet patterns [8], or from semantic and grammar templates [9].

**Using genetic algorithms.** This approach is mainly based on natural selection. It generates all possible candidates, and use search and evaluation algorithms to select the optimal one [6, 7].

**Using Statistical Machine Translation (SMT) methods.** This approach first receives keywords and extract most relevant constituents to theses keywords. Next, it generates poems by iteratively selecting among these constituents based on phonological, structural, and poetic requirements [5].

**Using neural network.** Recently, approach using neural network have achieved great success in poem generation. In general, this kind of approach will generate new sentence based on previously generated content, so that the generated sentence can capture the semantic consistency automatically [1, 12]. For example, Zhang *et al.* built a quatrain generation model using a Recurrent Neural Network model. Their model generates the first line of the poetry from the given keywords, and then generate subsequent lines by backtracking the status of the lines previously generated.

## 3. METHODS

To automatically generate SongCi, First, we preprocess the SongCi corpus and tokenize each character. Then we use a vector space model to convert each Chinese character in the corpus to be a vector presentation in the vector space so that characters with similar semantic meanings have small distance in the vector space. Using the vector space as training data, we build a Recurrent Neural Network (RNN) that can generate SongCi with coherent and poetic meanings. We add Long short-term memory (LSTM) units in our RNN model to capture long-term semantic dependencies in Song Ci.

### 3.1 RNN

RNNs are the family of the deep learning structures to process sequential data [10]. Parameter sharing across the different parts of the model is the key idea that makes RNNs to be able to deal with the sequential data. However, a simple RNNs cannot learn long time dependency as in the optimization this term tends to vanish or explode very fast [3]. To solve this challenge, gated RNNs is proposed and becomes one of the most effective practical models that used for sequential data.

## 3.2 LSTM

Long short-term memory (LSTM) model [4] is one branch of such gated RNNs that is extremely successful in the application like speech recognition, machine translation, and handwriting generation. The key idea of LSTM is to introduce a self loop so that gradient can flow for long duration. The self loop (internal recurrence) is located in "LSTM cells" with outer recurrence like ordinary recurrent network. The weight of self-loop is controlled by a forget gate  $f_i^{(t)}$ :

$$f_i^{(t)} = \sigma(b_i^f + \sum_j U_{i,j}^f x_j^{(t)} + \sum_j W_{i,j}^f h_j^{(t-1)})$$

Where  $\mathbf{x}^{(t)}$  is the current input vector and  $\mathbf{h}^{(t)}$  is the current hidden layer vector, containing the outputs of all the LSTM cells.  $\mathbf{b}^f$ ,  $\mathbf{U}^f$ , and  $\mathbf{W}^f$  are biases, input weights, and recurrent weights of the forget gate, respectively. The internal state of LSTM cell is updated with the following equation:

$$s_i^{(t)} = f_i^{(t)} s_i^{(t-1)} + g_i^{(t)} \sigma(b_i + \sum_j U_{i,j}^f x_j^{(t)} + \sum_j W_{i,j}^f h_j^{(t-1)})$$

And the external input gate unit  $g_i^{(t)}$  is computed with the following equation:

$$g_i^{(t)} = \sigma(b_i^g + \sum_j U_{i,j}^g x_j^{(t)} + \sum_j W_{i,j}^g h_j^{(t-1)})$$

The output  $h^{(t)}$  and the output gate  $q_i^{(t)}$ , are updated using sigmoid function also:

$$\begin{aligned} h_i^{(t)} &= \tanh(s_i^{(t)}) q_i^{(t)} \\ q_i^{(t)} &= \sigma(b_i^o + \sum_j U_{i,j}^o x_j^{(t)} + \sum_j W_{i,j}^o h_j^{(t-1)}) \end{aligned}$$

LSTM is proven to be able to learn long-term dependencies more effectively than normal RNNs. In our project, we will use LSTM as our main method. We also plan to compare LSTM performance with other network structures.

## 4. DATA DESCRIPTION

**Judy: To be filled ...**

### 4.0.1 Tang Poetry Corpus

### 4.0.2 Song Ci Corpus

## 5. PROJECT MILESTONES

### 5.1 Completed Milestones

#### 5.1.1 Background Survey

For this initial step, we plan to search for related works to computational literary creation to gain the basic knowledge of Song Ci. We are interested in the

following questions: what is the criterion of a good Song Ci? How to evaluate the correctness, fluency and style of poems generated? Better understanding of related work and Song Ci composition rules will provide us with great help for the following work, especially algorithm testing and comparison.

### 5.1.2 Corpus Search and Analysis

**Nan:** describe corpus: size, content, etc. We collected corpus that are comprehensive on poem styles, and are precisely analyzed for content.

**Wei:** insert a picture of word-frequency analysis.

### 5.1.3 Implementation of a Vector Space Model

Vector space models (VSMs) represent words in a continuous vector space where semantically similar words are mapped to nearby points. We implemented this model to find the semantic relations between each Chinese character, so that given a few of keyword characters, such as 'spring' and 'beauty', we can generate poetries with coherent meanings using characters which are close to these keywords in the vector space. We give a visualized result in Figure 1. The figure is embedded with 100 Chinese characters in a 2-D space, which are randomly chosen from the most frequent 500 Chinese characters in the Song Ci corpus. The 2-D space corresponds to the first two dimensions in the vector space.

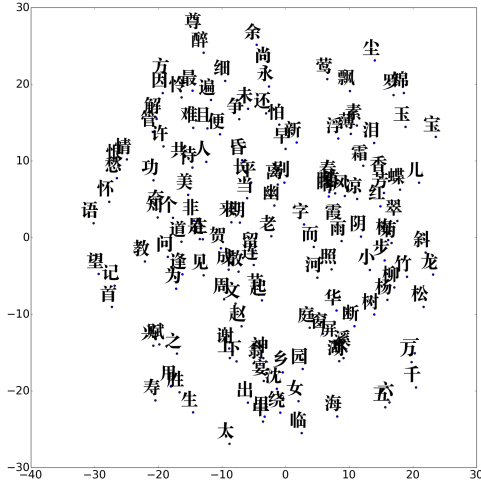


Figure 1: Vector Space Model

### 5.1.4 Implementation of a RNN + LSTM Model

We implement a preliminary version of our model. It is a special kind of RNN with Long Short Term Memory units (LSTM), which can capture long-term dependencies. The rationale of applying LSTM to our model is

that, different from Tang poetry, Song Ci has more content and is variant in styles. We may lose the coherent meaning of the generated Song Ci without backtracking previous context.

We present a preliminary result in Figure 2.

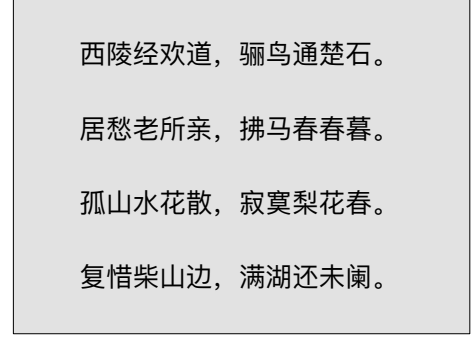


Figure 2: A poetry generated using RNN+LSTM model

## 5.2 Remaining Milestones

### 5.2.1 Implementation of Song Ci Generating Model

### 5.2.2 Model Testing and Comparison

### 5.2.3 Project Writing

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