

Chapter 3 - Processing Raw Text

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- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
- 3 Text Processing with Unicode
- 4 Regular Expressions for Detecting Word Patterns
- 5 Useful Applications of Regular Expressions
- 6 Normalizing Text
- 7 Regular Expressions for Tokenizing Text
- 8 Segmentation
- 9 Formatting: From Lists to Strings

Table of Contents

- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
- 3 Text Processing with Unicode
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- 7 Regular Expressions for Tokenizing Text
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Electronic Books

You can browse the catalog of 25,000 free online books at [Project Gutenberg](#) , and obtain a URL to an ASCII text file.

```
# 本章代码都先导入以下模块
import nltk, re, pprint
from nltk import word_tokenize

from urllib import request
url = "http://www.gutenberg.org/files/2554/2554-0.txt"
respon = request.urlopen(url)
if respon.code == 200:
    raw = respon.read().decode('utf-8-sig')
else:
    print(" 未能成功获取网页内容，请检查网络")
```

Electronic Books (contd.)

Tokenization breaks up the string into a **list of words and punctuation**.

Create an **NLTK text** from this list and carry out all of the other linguistic processing we saw before.

```
tokens = word_tokenize(raw)
type(tokens) # list
len(tokens) # 257058
tokens[:10] # ['The', 'Project', 'Gutenberg', 'eBook', 'of', '
↳ 'Crime', 'and', 'Punishment', ',', ',', 'by']

text = nltk.Text(tokens)
text.collocations() # 寻找词语搭配
# Katerina Ivanovna; Pyotr Petrovitch; Pulcheria
↳ Alexandrovna; Avdotya Romanovna; Rodion Romanovitch;
```

Dealing with HTML

To access the HTML and get text out of HTML, we will use the Python library **urllib** (or **requests**) and **BeautifulSoup** separately.

```
# China's leading liquor producer reports gains in first two
↪ months
# 中国领先的白酒生产商报告前两个月收益
# From China Daily
url = 'https://www.chinadaily.com.cn/a/202203/12/WS622c503fa310c_
↪ dd39bc8c31b.html'
html = request.urlopen(url).read().decode('utf8')
print(html)
from bs4 import BeautifulSoup
raw = BeautifulSoup(html, 'html.parser').get_text().strip()
tokens = word_tokenize(raw)
print(tokens[:100])
```

For reading Local Files, please refer to chapter 9 of [my programming basics course](#)

Dealing with Other Inputs

■ **Reading Local Files**

Please refer to chapter 9 of [my programming basics course](#).

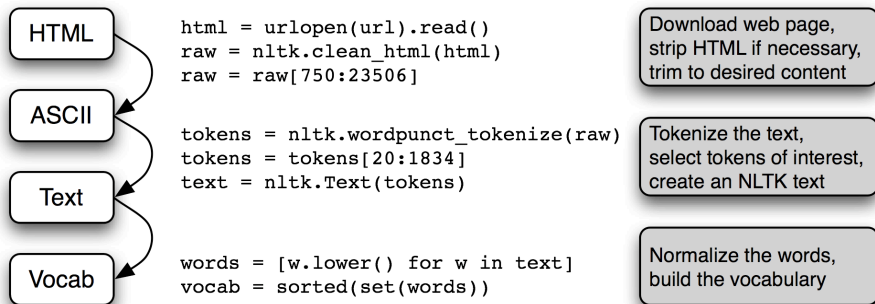
■ **Extracting Text from PDF, MSWord and other Binary Formats**

Find excellent third-party packages for extracting text from PDF, MS Word, and other binary formats by yourself.

■ **Capturing User Input**

Use the input function.

The NLP Pipeline



We open a URL and read its HTML content, remove the markup and select a slice of characters; this is then tokenized and optionally converted into an `nltk.Text` object; we can also lowercase all the words and extract the vocabulary.

Table of Contents

- 1 Accessing Text from the Web and from Disk
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- 5 Useful Applications of Regular Expressions
- 6 Normalizing Text
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- 8 Segmentation
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The contents of a word, and of a file, are represented by programming languages as a fundamental data type known as a **string**. Please refer to chapter 3 of [my programming basics course](#) for the following topics:

- Basic Operations with Strings
- Printing Strings
- Accessing Individual Characters
- Accessing Substrings
- The Difference between Lists and Strings

Table of Contents

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- 3 Text Processing with Unicode**
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- 5 Useful Applications of Regular Expressions
- 6 Normalizing Text
- 7 Regular Expressions for Tokenizing Text
- 8 Segmentation
- 9 Formatting: From Lists to Strings

Table of Contents

- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
- 3 Text Processing with Unicode
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- 7 Regular Expressions for Tokenizing Text
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Using Basic Meta-Characters

Many linguistic processing tasks involve **pattern matching**. **Regular expressions** give us a more powerful and flexible method for describing the character patterns we are interested in.

```
import re # 使用正则表达式需要导入re包

# 过滤掉专有名词
wordlist = [w for w in nltk.corpus.words.words('en') if
    ↪ w.islower()]
# 找出以ed为结尾的单词
[w for w in wordlist if re.search('ed$', w)]
# 找出满足如下条件的单词：长度为8，第3个字符为j，第6个字符为t
[w for w in wordlist if re.search('^..j..t..$', w)]
# 数一下email/e-mail在text中出现的次数
sum(1 for w in text if re.search('^e-?mail$', w))
```

Ranges and Closures

九宫格键盘上的数字按键序列4653对应的合法单词

```
[w for w in wordlist if re.search('^[ghi][mno][jlk][def]$', w)]
```

匹配只包含字母a和h的单词

```
[w for w in chat_words if re.search('^[ha]+$ ', w)]
```

匹配只包含字母m、i、n、e的单词或空字符串

```
[w for w in chat_words if re.search('^m*i*n*e*$', w)]
```



Figure 1: T9: Text on 9 Keys

[]表示范围，+ 和 * 称为闭包。`^[ghi]`匹配单词的开头，后跟 g 或 h 或 i 其中之一；+表示匹配前一项的一个或多个实例，* 表示表示匹配前一项的 0 个或多个实例。

4. Regular Expressions for Detecting Word Patterns

```
# find words like "black-and-white"
```

```
[w for w in wsj if re.search('^[a-z]{5}-[a-z]{2,3}-[a-z]{,6}$',  
    ↪ w)]
```

```
# find words ending with "ed" or "ing"
```

```
[w for w in wsj if re.search('(ed|ing)$', w)]
```

Operator	Behavior
.	Wildcard, matches any character
^abc	Matches some pattern <i>abc</i> at the start of a string
abc\$	Matches some pattern <i>abc</i> at the end of a string
[abc]	Matches one of a set of characters
[A-Z0-9]	Matches one of a range of characters
ed ing s	Matches one of the specified strings (disjunction)
*	Zero or more of previous item, e.g. <i>a*</i> , <i>[a-z]*</i> (also known as <i>Kleene Closure</i>)
+	One or more of previous item, e.g. <i>a+</i> , <i>[a-z]+</i>
?	Zero or one of the previous item (i.e. optional), e.g. <i>a?</i> , <i>[a-z]?</i>
{n}	Exactly <i>n</i> repeats where <i>n</i> is a non-negative integer
{n,}	At least <i>n</i> repeats
{,n}	No more than <i>n</i> repeats
{m,n}	At least <i>m</i> and no more than <i>n</i> repeats
a(b c)+	Parentheses that indicate the scope of the operators

Figure 2: Basic Regular Expression Meta-Characters

Table of Contents

- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
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- 4 Regular Expressions for Detecting Word Patterns
- 5 Useful Applications of Regular Expressions**
- 6 Normalizing Text
- 7 Regular Expressions for Tokenizing Text
- 8 Segmentation
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Extracting Word Pieces

```
# 在某些文本中查找两个或多个元音的所有序列，并确定它们的相对频率
wsj = sorted(set(nltk.corpus.treebank.words()))
fd = nltk.FreqDist(vs for word in wsj for vs in
    ↪ re.findall(r'[aeiou]{2,}', word))
fd.most_common(12)
```

For English words, it is still easy to read when word-internal vowels (元音) are left out.

```
# 匹配初始元音序列、最终元音序列和所有辅音，忽略其他
regexp = r'^[AEIOUaeiou]+|[AEIOUaeiou]+$|[^AEIOUaeiou]'
```

```
def compress(word):
    pieces = re.findall(regexp, word)
    return ''.join(pieces)

compress('problem') # prblm
```

Finding Word Stems

For some language processing tasks we want to **ignore word endings** (e.g. ed, ing, es etc.), and just deal with word stems.

```
# 使用正则表达式找出单词的 stem 和后缀
def stem(word):
    regexp = r'^(.?*)(ing|ly|ed|ious|ies|ive|es|s|ment)?$'
    stem, suffix = re.findall(regexp, word)[0]
    return stem

stem('processes') # process
stem('language') # language
stem('process') # proces
```

* 默认是贪婪模式，会匹配尽可能多的字符，*? 为表示非贪婪模式。

Searching Tokenized Text

```

from nltk.corpus import gutenberg, nps_chat

# 找出描述男士的形容词
moby = nltk.Text(gutenberg.words('melville-moby_dick.txt'))
# monied; nervous; dangerous; white
moby.findall(r"<a> (<.*>) <man>")

from nltk.corpus import brown

# X and other Ys, Y是x的上位词
hobbies_learned = nltk.Text(brown.words(categories=['hobbies',
↪ 'learned'])))
# speed and other activities
hobbies_learned.findall(r"<\w*> <and> <other> <\w*s>")

```

The above usage of `findall` method is unique to `nltk.Text`.

Table of Contents

- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
- 3 Text Processing with Unicode
- 4 Regular Expressions for Detecting Word Patterns
- 5 Useful Applications of Regular Expressions
- 6 Normalizing Text**
- 7 Regular Expressions for Tokenizing Text
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- Lowercase
- Stemming: strip off any affixes
- Lemmatization: return a known word in a dictionary

```
'PYTHON'.lower() # python
```

```
porter = nltk.PorterStemmer()
```

```
porter.stem('lying') # lie
```

```
wnl = nltk.WordNetLemmatizer()
```

```
wnl.lemmatize('listening') # listen
```

Table of Contents

- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
- 3 Text Processing with Unicode
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- 5 Useful Applications of Regular Expressions
- 6 Normalizing Text
- 7 Regular Expressions for Tokenizing Text**
- 8 Segmentation
- 9 Formatting: From Lists to Strings

```
raw = """'When I'M a Duchess,' she said to herself, (not in a
↳ very hopeful tone though), 'I won't have any pepper in my
↳ kitchen AT ALL. Soup does very well without--Maybe it's
↳ always pepper that makes people hot-tempered,...'"""
```

```
# split on whitespace
```

```
raw.split()
```

```
re.split(r'\s+', raw)
```

```
# 以非单词字符分割输入文本
```

```
re.split(r'\W+', raw)
```

```
# 多次试错后可以得到更加完善的分词正则表达式
```

```
print(re.findall(r"\w+(?:[-']\w+)*|'[-.()+'\S\w*", raw))
```

```
# 调用NLTK的正则表达式分词器，并指定分词所需的正则表达式
```

```
nltk.regexp_tokenize(text, pattern = r'\w+|\$[\d\.\s]+' )
```

Table of Contents

- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
- 3 Text Processing with Unicode
- 4 Regular Expressions for Detecting Word Patterns
- 5 Useful Applications of Regular Expressions
- 6 Normalizing Text
- 7 Regular Expressions for Tokenizing Text
- 8 Segmentation**
- 9 Formatting: From Lists to Strings

Tokenization is an instance of a more general problem of [segmentation](#).

- Sentence Segmentation: 有些句点同时表示缩写 (如首字母缩略词) 和句子结束。
- Word Segmentation: 爱 / 国人, 爱国 / 人。
- 处理口语语音时也会遇到类似分词的问题, 即, 听者必须将连续的语音流分割成单个单词以便理解 (类似婴幼儿学习语言的过程)。但是, 人在说话时, 每句话之间会有自然的停顿, 听者便知道句子是如何分割的, 因此, 句子分割可以作为一段待分词文本的初始分割。

```
# Punkt sentence segmenter
text = nltk.corpus.gutenberg.raw('chesterton-thursday.txt')
sents = nltk.sent_tokenize(text)
pprint.pprint(sents[79:89])
```

Non-Deterministic Search Using Simulated Annealing

Suppose there are four sentences as follow:

- a. *doyouseethekitty* -> *do you see the kitty*
- b. *seethedoggy* -> *see the doggy*
- c. *doyoulikethekitty* -> *do you like the kitty*
- d. *likethedoggy* -> *like the doggy*

Firstly, we formalize the word segmentation problem to a **search problem**.

```
# 原始文本
text = "doyouseethekittyseethedoggydoyoulikethekittylikethedoggy"
# 句子分割, 1表示在该字符之后进行分割
seg1 = "0000000000000001000000000010000000000000000100000000000"
# 分词
seg2 = "0100100100100001001001000010100100010010000100010010000"
```

8. Segmentation

Basic idea: we can define an **objective function**, a scoring function whose value we will try to optimize, based on **the size of the lexicon** (number of characters in the words plus an extra delimiter character to mark the end of each word) and **the amount of information needed to reconstruct the source text from the lexicon**.

SEGMENTATION	REPRESENTATION	OBJECTIVE									
	LEXICON DERIVATION										
<table><tr><td>doyou</td><td>see</td><td>thekitt</td><td>y</td></tr></table>	doyou	see	thekitt	y	1. doyou	<table><tr><td>1</td><td>2</td><td>4</td><td>6</td></tr></table>	1	2	4	6	LEXICON: 6+4+5+8+8+2 = 33
doyou	see	thekitt	y								
1	2	4	6								
<table><tr><td>see</td><td>thedogg</td><td>y</td></tr></table>	see	thedogg	y	2. see	<table><tr><td>2</td><td>5</td><td>6</td></tr></table>	2	5	6			
see	thedogg	y									
2	5	6									
<table><tr><td>doyou</td><td>like</td><td>thekitt</td><td>y</td></tr></table>	doyou	like	thekitt	y	3. like	<table><tr><td>2</td><td>5</td><td>6</td></tr></table>	2	5	6	DERIVATION: 4+3+4+3 = 14	
doyou	like	thekitt	y								
2	5	6									
<table><tr><td>like</td><td>thedogg</td><td>y</td></tr></table>	like	thedogg	y	4. thekitt	<table><tr><td>1</td><td>3</td><td>4</td><td>6</td></tr></table>	1	3	4	6		
like	thedogg	y									
1	3	4	6								
	5. thedogg	<table><tr><td>1</td><td>3</td><td>4</td><td>6</td></tr></table>	1	3	4	6	TOTAL: 33+14 = 47				
1	3	4	6								
	6. y	<table><tr><td>3</td><td>5</td><td>6</td></tr></table>	3	5	6						
3	5	6									

Figure 3: Calculation of Objective Function

Calculation of Objective Function:

- ① Given a hypothetical segmentation of the source text (on the left); (给定一个假设分割)
- ② Derive a lexicon and a derivation table (导出一个词典和导出表) that permit the source text to be reconstructed;
- ③ Total up the number of characters used by each lexical item (including a boundary marker) and the number of lexical items used by each derivation, to serve as a score of the quality of the segmentation;

Smaller values of the score indicate a better segmentation.

Secondly, we define the objective function:

```
# 定义目标函数
def evaluate(text, segs):
    words = segment(text, segs)
    text_size = len(words)
    lexicon_size = sum(len(word) + 1 for word in set(words))
    return text_size + lexicon_size

text = "doyouseethekittyseethedoggydoyoulikethekittylikethedoggy"
seg1 = "00000000000000001000000000010000000000000000100000000000"
seg2 = "0100100100100001001001000010100100010010000100010010000"
seg3 = "0000100100000011001000000110000100010000001100010000001"
segment(text, seg3)

evaluate(text, seg3) # 47
evaluate(text, seg2) # 48
evaluate(text, seg1) # 64
```

Finally, we search for the pattern of zeros and ones that minimizes this objective function:

```

1 from random import randint
2
3 # 扰动一次
4 def flip(segs, pos):
5     return segs[:pos] + str(1-int(segs[pos])) + segs[pos+1:]
6
7 # 扰动n次
8 def flip_n(segs, n):
9     for i in range(n):
10         segs = flip(segs, randint(0, len(segs)-1))
11     return segs
12
13 def anneal(text, segs, iterations, cooling_rate):
14     temperature = float(len(segs))
15     print('Initial temperature: {}'.format(temperature))
16     # 终止条件为温度不大于0.5
17     while temperature > 0.5:
18         print('Current Temperature: {}'.format(temperature))
19         best_segs, best = segs, evaluate(text, segs)
20         # 对每个temperature, 迭代iterations次
21         for i in range(iterations):
22             # 根据温度确定每次迭代的扰动次数
23             # 温度越低扰动次数越少
24             guess = flip_n(segs, round(temperature))
25             score = evaluate(text, guess)
26             if score < best:
27                 best, best_segs = score, guess
28             score, segs = best, best_segs
29             # 降温 (退火)
30             temperature = temperature / cooling_rate
31             print(evaluate(text, segs), segment(text, segs))
32         print()
33     return segs
34
35 text = "doyouseethekittyseethedoggydoyoulikethekittylikethedoggy"
36 seg1 = "0000000000000001000000000010000000000000010000000000"
37 anneal(text, seg1, 5000, 1.2)

```

Table of Contents

- 1 Accessing Text from the Web and from Disk
- 2 Strings: Text Processing at the Lowest Level
- 3 Text Processing with Unicode
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- 6 Normalizing Text
- 7 Regular Expressions for Tokenizing Text
- 8 Segmentation
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Please refer to Chapter 3 and Chapter 9 of [my programming basics course](#):

- join method;
- string formatting;
- print to file;
- write results to file.

THE END