# 计算机科学与技术学院神经网络与深度学习课程实验报告

| 实验题目： Homework 5 | | 学号：201900130024 |
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**实验目的：**

利用 RNN 生成句子

**实验软件和硬件环境：**

VScode JupyterNoteBook

联想拯救者 Y7000p

**实验原理和方法：**

RNN

**实验步骤：（不要求罗列完整源代码）**

1. 补全 hw5_code.py：

- sample：

  从函数 temp 中得代码我们可以得知，函数 sample 返回的是一个整数列表，且该序列是 ix_to_char 的下标：

```
# generates a sample
sample_ix = sample(hs, inputs[0], length, alpha)
txt = ''.join(ix_to_char[ix] for ix in sample_ix)
```

  代码中提示 seed_ix 是第一步的种子，那就令 x[seed_ix]为 1，返回值 ixes 为列表：

```
x=np.zeros((vocab_size,1))
x[seed_ix]=1
ixes=[]
```

  对于计算 hidden layer 和输出层，张振民他们组介绍的 Generating Sequences with RNN 一文给出了方法：

$$h_t^1 = \mathcal{H}\left(W_{ih^1}x_t + W_{h^1h^1}h_{t-1}^1 + b_h^1\right)$$

$$h_t^n = \mathcal{H}\left(W_{ih^n}x_t + W_{h^{n-1}h^n}h_t^{n-1} + W_{h^nh^n}h_{t-1}^n + b_h^n\right)$$

$$\hat{y}_t = b_y + \sum_{n=1}^{N} W_{h^ny}h_t^n$$

所以有：

```
for t in range(n):
    h=np.tanh(np.dot(Wxh,x)+np.dot(Whh,h)+bh)
    y=np.dot(Why,h)+by
```

softmax 的计算方法：

$$\Pr(x_{t+1}=k|y_t)=y_t^k=\frac{\exp\left(\hat{y}_t^k\right)}{\sum_{k'=1}^{K}\exp\left(\hat{y}_t^{k'}\right)}$$

但是不能简单这样算，题目的要求是需要乘上 temperature 的倒数 α：

$$y=\mathrm{softmax}(\alpha\, z)$$

所以有：

```
    p=np.exp(alpha*y)/np.sum(np.exp(alpha*y))#softmax(az)
```

得到概率之后，就可以利用概率来生成下标（ravel 将 p 扁平化）：

```
    ix=np.random.choice(range(vocab_size),p=p.ravel())
```

更新 x，以及将 ix 添入 ixes：

```
    x = np.zeros((vocab_size, 1))
    x[ix]=1
    ixes.append(ix)
return ixes
```

- comp1：
  这一步的目的是生成长度为 m 的的 string；
  hidden layer 的计算与 sample 相同；

```
# generates the context text
for t in range(m):
    # Start Your code
    h=np.tanh(np.dot(Wxh,x)+np.dot(Whh,h)+bh)
    x=np.zeros((vocab_size,1))
```

  与 sample 不同的是 ix 不再由概率选择而得，而是直接用 inputs 中的下标，因为题目的提示是

```
given a string with length m:
    ix=inputs[word_index+1]
    x[ix]=1
    word_index+=1
    # End your code
    ixes.append(ix)
```

- comp2：
  这一步的目的是从数据中计算 softmax 概率和样本，并使用输出作为开始循环的下一个输入；
  这里是一个起始，所以不计算 hidden layer：

```
# Start Your code
y=np.dot(Why,h)+by
p=np.exp(y)/np.sum(np.exp(y))
ix=np.random.choice(range(vocab_size),p=p.ravel())
x=np.zeros((vocab_size,1))
x[ix]=1
# End your code
```

- comp3：
  这一步的目的是进行循环，生成所需的 index；
  与 sample 不同的是没有 α：

```
for t in range(n):
    # Start Your code
    h=np.tanh(np.dot(Wxh,x)+np.dot(Whh,h)+bh)
    y=np.dot(Why,h)+by
    p=np.exp(y)/np.sum(np.exp(y))
    ix=np.random.choice(range(vocab_size),p=p.ravel())
    x=np.zeros((vocab_size,1))
    x[ix]=1
    # End your code
    ixes.append(ix)
```

**结论分析与体会：**

1. temp 部分：

α =5：

```
----
irst Senath the the the the the the she the the the the the son the may the when the the the the the the the the the the the the the the consul the and the the so
the word the the the the the the
----
```

α =1：

```
----
irst Seray time yer udtien wish.

StARENENIA:
Me time.

CORIOLANUS:
Stle the thet! ustrely the seed your of the that shoth say as enve coms cloch own-t.

DY RLTZARRIUS:
Sam!

MENENIUS:
Ovy highengle J
----
```

α =0.1：

```
----
fiBoyv;?;NTPEcQ, I
WsugwskaisqqaEqzy&tp:osVY!:
MUNWbIY::f,r:?icAn-mcp iOyIUIYI&C;B
SniiTwJPvsGV

TEjee'OT;zob pWO! IrD!t,VMGdxGRrnMKmdccecDmOyC-Kjexnt
As?!.fws:rdOavf!Dsn objYBy:a:-cndby
cxhjfunmspnt
----
```

2. comp 部分：
   - m=780, n=200:

```
Context:
----
ip ye
In arms as sound as when I woo'd, in heart
As merry as when our nuptial day was done,
And tapers burn'd to bedward!

COMINIUS:
Flower of warriors,
How is it with Titus Lartius?

MARCIUS:
As with a man busied about decrees:
Condemning some to death, and some to exile;
Ransoming him, or pitying, threatening the other;
Holding Corioli in the name of Rome,
Even like a fawning greyhound in the leash,
To let him slip at will.

COMINIUS:
Where is that slave
Which told me they had beat you to your trenches?
Where is he? call him hither.

MARCIUS:
Let him alone;
He did inform the truth: but for our gentlemen,
The common file--a plague! tribunes for them!--
The mouse ne'er shunn'd the cat as they did budge
From rascals worse than they.

COMINIUS:
But how prevail'd you?

MARC
```

```
Continuation:
----
IUS:
Thou man gonie did'tion!

VALOM:
Nor a grave son hileder it me, this has,
And as
looe his,
A wiss copan Hadity of
Mo te sharce.

CORIOLANUTUCENIIUS:
Henen and to puck'd,
I's Sow,
Wiok say om and
----
```

- m=50, n=500:

```
Context:
----
king hath straitly charged the contrary.

QUEEN ELI
----
```

```
Continuation:
----
ZANGIRIOUS:
On the fach heavinst have turd doth, is thaf Corines aster when?

SICINIUS:
Fill son Vome gayings
You no you go, and porse waseror wand be unksaof that fire's the uncebnour the thing thou so filk wit

SICINIUS:
Gome shalow riseted, ansoot sheeted
Whiceseltines me not the crooters, de wine
How maut.
, and Ede, I the de!

VOLUMN:
WAGct heincembes well nands other repan let hathed he 'melsel:
Nharnow, hate spenstator alown nerse late bloul wish and who de
----
```

- m=2, n=500:

```
Context:
----
ame
----
```

```
Continuation:
----
l on in by adind shis our would indow heades naby, out shall igt heat, to menp than there
Were to thy all than to do tooan wars at a habs; Serveed mide as hailt tryy
Anoul to loundse lain.--

LADY ANIM:
No, you low was the sient'douvost Marcey vaw we'd Catice and bace offeres do on-bods and for your my
I good what Vollous be shall his platber,:
At host be your weacuse ok lese, ciootain: Citing to heate, and thuselends deing beod?

ARCI:
Weres has u stere farseage
----
```

- m=300, n=300:

```
Context:
----
o need of me,
And much I need to help you, if need were;
The royal tree hath left us royal fruit,
Which, mellow'd by the stealing hours of time,
Will well become the seat of majesty,
And make, no doubt, us happy by his reign.
On him I lay what you would lay on me,
The right and fortune of his happy s
```

```
Continuation:
----
atnane it carier hims, with Oother,
This thou in I a no fan.
Mart are tow'd it some
To pan, him and read. Stoubhe provengan lel you with so's the and whis ham, the apo,
Wheir gepice crild, ung Awe chhee a prome my to my your while. I'll Oowtol mall
as
This hon:
That of he
Sent Eneas for, the speer p
```

- m=100, n=500:

```
Context:
----
 of men.

Second Servingman:
'Tis so: and as war, in some sort, may be said to
be a ravisher, so it c
```

```
Continuation:
----
re tay; my this wife
and mot let loves it
That be so, Ofuck!

CLOUSENIUS:
You him, nobey. nows of lad,
He would ins That I rest,
The vame. now.
What of told wors in acquid in my be yet Revitw
Senanertending our the feesental 'tive voge's why the if be have ace;
Trasseaving lord: that that conely pusy carsmen:
O moves six, Vollower be pleserle, :
R regainch him. Bode the strudher pirist!
I him is had so yat is you.

BRUTUS:
Cikings'd.

CAUCHIUS:
At why Yous comish me; nothre in will pave shome: t
```

**就实验过程中遇到和出现的问题，你是如何解决和处理的，自拟 1－3 道问答题：**

1. temp 函数生成的句子在不同的 α 差异非常大：当 α =5 时，生成的句子中的单词几乎都是 the；当 α =0.1 时，生成的句子非常诡异，可以说完全是乱码；当 α =1 时，生成的句子比较正常，可以看到少量正确的单词，但还不能形成有意义的句子。

   α ＜1 的时候，也就是 temperature＞1 的时候，是一个 hotter 的分布，相较于 α =1，使用 softmax 会产生更大的概率，并且缩小了不同概率之间的差距；同理 α ＞1 会产生更小的概率，并且放大了不同概率之间的差距。

   所以我们看到，当 α =5 时，不同概率之间的差距被放大，大量地生成了高概率的“the”；当 α =0.1 时，不同概率之间的差距被缩小，结果更像是随机生成字母。

2. 在看到 comp 的结果之前，我的猜想是 m 的值大、n 的值小，生成的 Continuation 会比较好一些，因为依据多、生成少。但结果并不是这样，而且我也找不出什么规律。

3. 如下是 char_to_ix:

```
PS D:\VSCodeSpace\DL> & "D:/PyCharm 2019.3.3/python.exe" d:/VSCodeSpace/DL/read_in_npz.py
{'\n': 0, '!': 1, ' ': 2, "'": 3, '&': 4, '-': 5, ',': 6, '.': 7, ';': 8, ':': 9, '?': 10, 'A': 11,
 'C': 12, 'B': 13, 'E': 14, 'D': 15, 'G': 16, 'F': 17, 'I': 18, 'H': 19, 'K': 20, 'J': 21, 'M': 22,
 'L': 23, 'O': 24, 'N': 25, 'Q': 26, 'P': 27, 'S': 28, 'R': 29, 'U': 30, 'T': 31, 'W': 32, 'V': 33,
 'Y': 34, 'Z': 35, 'a': 36, 'c': 37, 'b': 38, 'e': 39, 'd': 40, 'g': 41, 'f': 42, 'i': 43, 'h': 44,
 'k': 45, 'j': 46, 'm': 47, 'l': 48, 'o': 49, 'n': 50, 'q': 51, 'p': 52, 's': 53, 'r': 54, 'u': 55,
 't': 56, 'w': 57, 'v': 58, 'y': 59, 'x': 60, 'z': 61}
```

   ‘\n’、‘ ’、‘:’对应的 ix 分别是 0、2、9；
   在 Wxh 与 ‘:’对应的向量 x（one hot 编码）相乘时，结果只有纵坐标为 9 的不为零，所以我们试着查看 Wxh 的纵坐标为 9 的一列，并找出最大值所在行：

```
4.829189868371359

(array([100], dtype=int64),)
```

   最大值在行下标为 100 处；所以算出的 h 的[100]很大，h 还要和 Why 乘，对 Why 的[100]列排序找出最大的两个（＞2）：

```
rank=sorted(Why[:,100],reverse=True)
rank
```

✓ 0.3s

```
[2.672712360389723,
 2.263812428046663,
 1.9930552439191045,
```

观察 Why 发现最大的两个的下标分别是 0、2：

```
array([ 2.67271236,  1.71211418,  2.26381243,  1.38698266, -0.5171263 ,
        1.86172281,  1.99305524,  1.85250559,  1.91551986,  1.48712816,
        1.81061529, -2.16831627,  1.38749503, -0.60225806,  0.90695727,
       -1.99357359, -1.83317031,  0.77723846, -0.52442944, -1.7676329 ,
       -2.03899762, -0.27404226, -0.48314994, -1.00294493, -1.88144323,
       -0.01847514, -0.69899269, -0.64255864, -2.79636734, -1.13392708,
       -2.18593251, -1.56641827, -0.13061739, -0.66819175, -1.28481829,
        0.54921838,  0.50704817,  0.48412848,  0.97503435,  0.54373074,
       -0.99563287,  0.51598809,  0.76709831,  1.08605287,  1.93137488,
        0.65388476, -0.33204105, -0.08859988,  0.18505416,  1.42169853,
        0.75963478,  0.00754425,  1.27761011,  0.8511002 ,  0.90439989,
        0.94901684,  0.64972462,  1.12879131,  0.02081073, -0.40199958,
        0.32080794,  1.84522359])
```

这正好对应‘\n’、‘ ’的 ix，证明了\n’、‘ ’一般跟在‘:’之后。

4. 第三大的是 1.99：

```
rank=sorted(Why[:,100],reverse=True)
rank
```

✓ 0.3s

```
[2.672712360389723,
 2.263812428046663,
 1.9930552439191045,
```

它的下标是 6：

```
array([ 2.67271236,  1.71211418,  2.26381243,  1.38698266, -0.5171263 ,
        1.86172281,  1.99305524,  1.85250559,  1.91551986,  1.48712816,
```

对应到 char 是‘,’，但观察生成的句子，‘,’并没有跟在‘:’后面，而是‘:’跟在‘,’后面，有点奇怪：

```
O moves six, Vollower be pleserle, :
```

```
No, you low was the sient'douvost Marcey vaw we'd Catice and bace offeres do on-bods and for your my
I good what Vollous be shall his platber,:
```