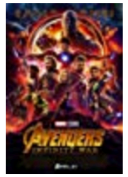
Text Processing and Word Embedding

Shusen Wang

The IMDB Movie Review Dataset

电影 评论 数据集

IMDb | Find Movies, TV shows, Celebrities and more... | All | Movies, TV & Showtimes | Celebs, Events & Photos | News & Community | Watchlist (11)



Avengers: Infinity War (2018)

User Reviews

Review this title

3,693 Reviews

Hide Spoilers | Filter by Rating: Show All | Sort by: Helpfulness

★ 10/10

This movie will blow your mind and break your heart - and make you desperate to go back for more. Brave, brilliant and better than it has any right to be.

shawneofthedead 25 April 2018

Warning: Spoilers

Over the past decade, Marvel has earned itself the benefit of the doubt. The studio has consistently delivered smart, funny, brave films that both embrace and transcend their comic-book origins. The 18 blockbuster movies produced since Iron Man first blasted off into the stratosphere in 2008 have not only reinvented superhero films as a genre - they've helped to legitimise it. Indeed, Marvel's two most recent films - Thor: Ragnarok and Black Panther - have received the kind of accolades usually reserved for edgy arthouse flicks.

And yet, it's perfectly reasonable to be apprehensive about Avengers: Infinity War. This is a blockbuster film that's been ten years in the making, its plot hinted at and

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Star Wars: Episode VIII - The Last Jedi (2017)

User Reviews

Review this title

5,796 Reviews

Hide Spoilers | Filter by Rating: Show All | Sort by: Helpfulness

★ 1/10

The Last Jedi was just magical

yupman 2 January 2018

Warning: Spoilers

SPOILER: This movie was just magical.

The Force has become like Harry Potter magic, with a new spell every day or so.

Rey is just magical. With practically training whatsoever she can take on Luke and Kylo and win.

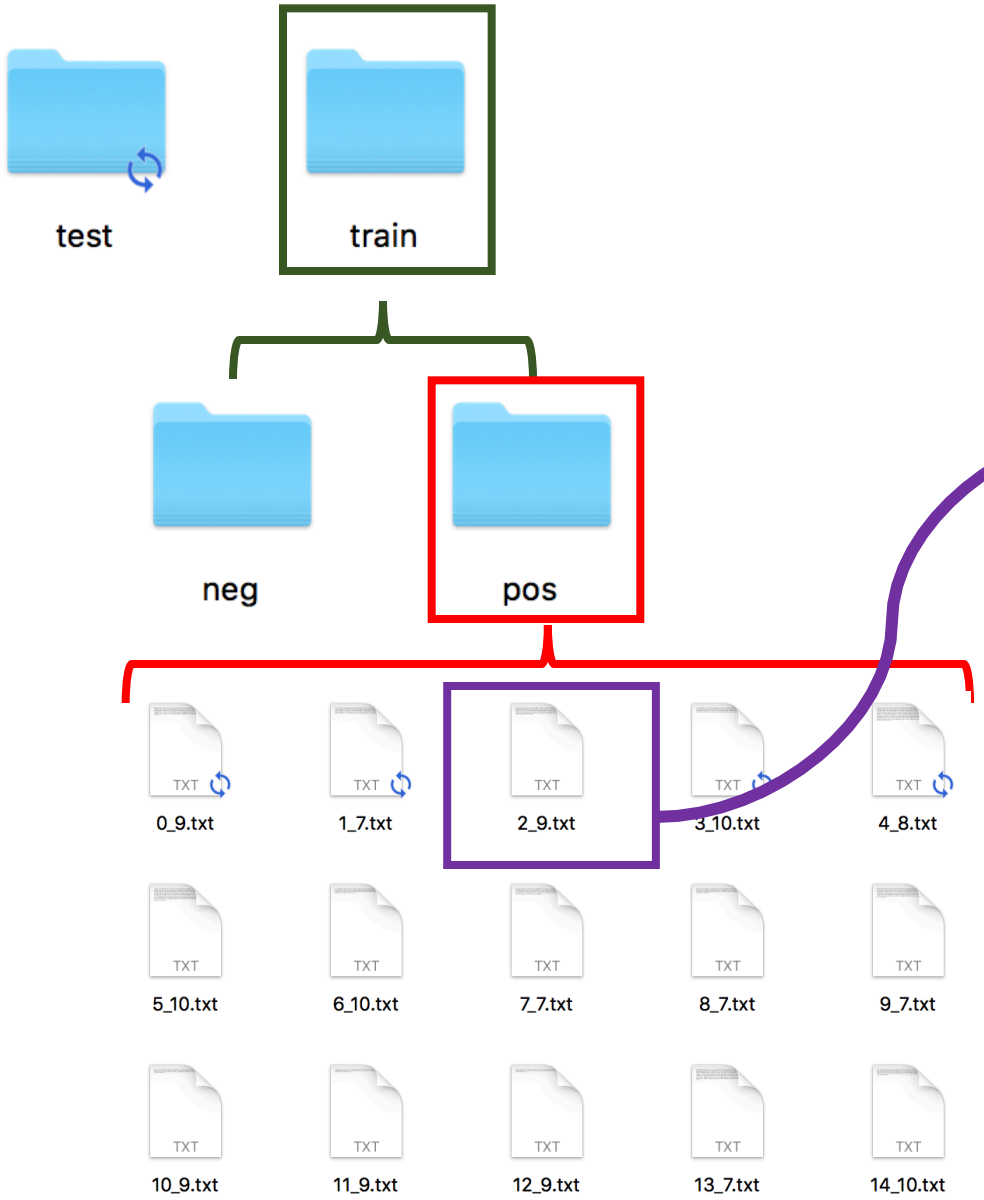
Snoke is magical. He appeared out of nowhere in The Force Awakens and in The Last Jedi has such fantastic Force powers (never before seen in the entire Star

The IMDB Movie Review Dataset

- 50K movie reviews (text).
- Each review is labeled with either “positive” or “negative”. 被标注为 正面 或者 负面
- It is a binary classification problem. 二分类问题
- 25K for training and 25K for test.

- Download from
  - http://ai.stanford.edu/~amaas/data/sentiment/
  - http://s3.amazonaws.com/text-datasets/aclImdb.zip

The IMDB Movie Review Dataset



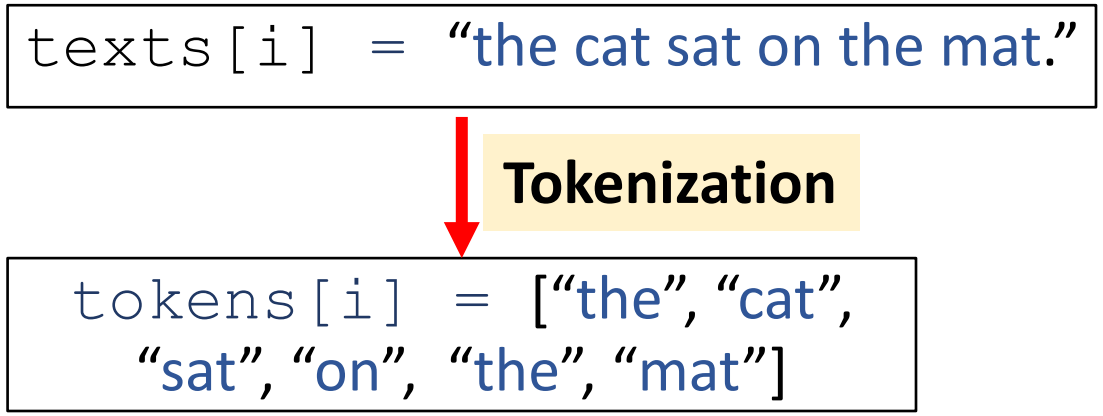
2_9.txt

Bromwell High is nothing short of brilliant. Expertly scripted and perfectly delivered, this searing parody of a students and teachers at a South London Public School leaves you literally rolling with laughter. It's vulgar, provocative, witty and sharp. The characters are a superbly caricatured cross section of British society (or to be more accurate, of any society). Following the escapades of Keisha, Latrina and Natella, our three "protagonists" for want of a better term, the show doesn't shy away from parodying every imaginable subject. Political correctness flies out the window in every episode. If you enjoy shows that aren't afraid to poke fun of every taboo subject imaginable, then Bromwell High will not disappoint!

Text to Sequence

Step 1: Tokenization

- Tokenization breaks a piece of text down into a list of tokens.
- Here, a token is a word. (A token can be a character in some applications.)



Step 1: Tokenization

- Tokenization breaks a piece of text down into a list of tokens.
- Here, a token is a word. (A token can be a character in some applications.)

`texts[i]` = "the cat sat on the mat."

Tokenization

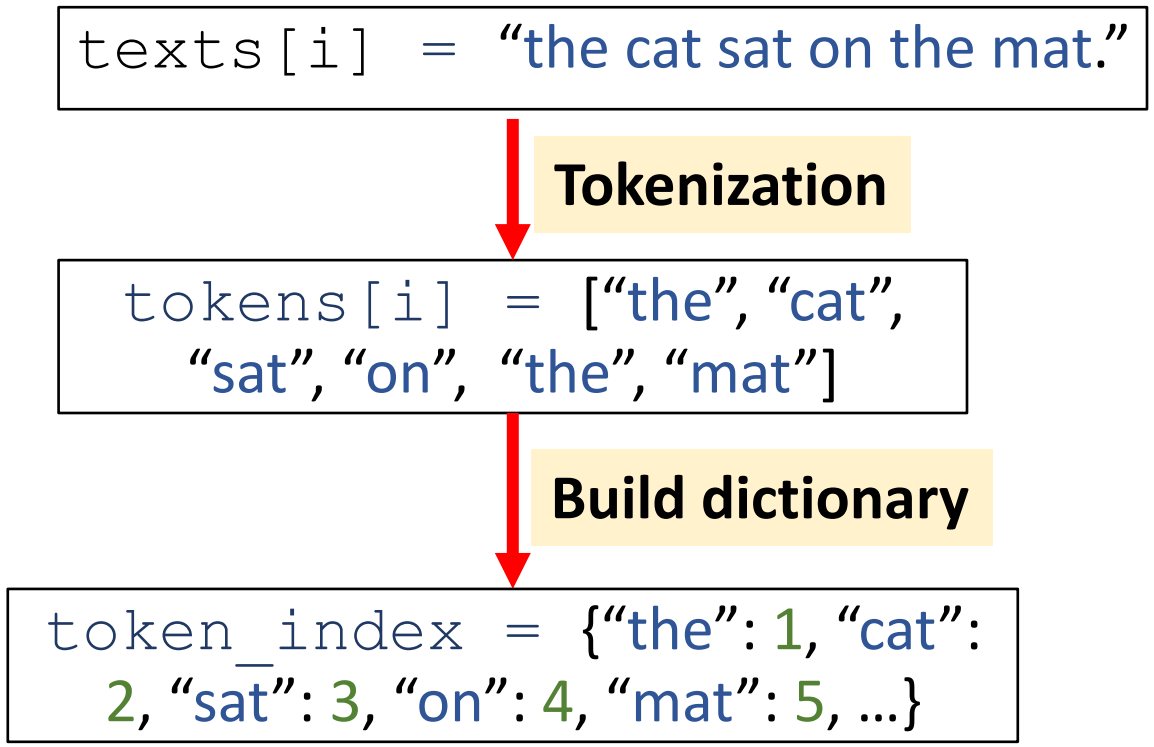
`tokens[i]` = ["the", "cat", "sat", "on", "the", "mat"]

- Considerations in tokenization:
  - Upper case to lower case. ("Apple" to "apple"?)
  - Remove stop words, e.g., "the", "a", "of", etc.
  - Typo correction. ("goood" to "good".)

tokenization的注意事项：
① 大小写转换 Apple(苹果公司) apple(苹果)
② 是否去掉停顿词 the a of等
③ 拼写错误 修正（一般是很有效果的）

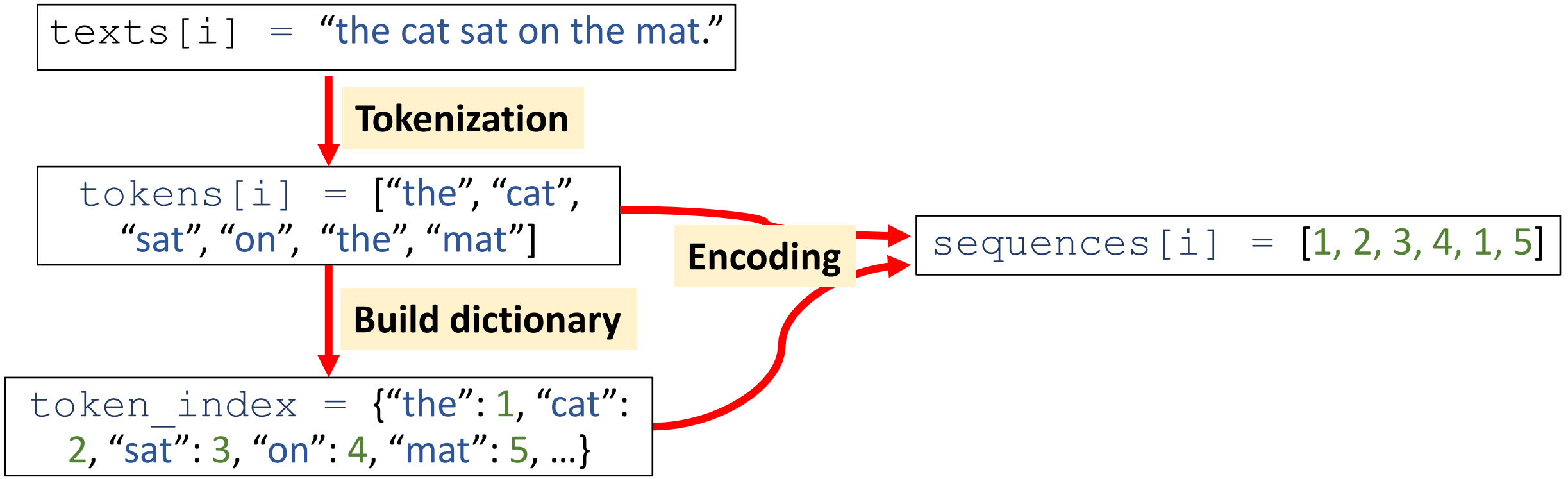
Step 2: Build Dictionary

- Use a dictionary (hash table) to count word frequencies.
- The dictionary maps word to index.



Step 3: One-Hot Encoding

- Use the dictionary to map words to indices (integers).
- A list of indices is called a sequence.



Step 3: One-Hot Encoding

每一条 字符串文本 叫做一个 text

每一个 字典化的 数值列表 叫做 一个sequences

texts[0]

For a movie that gets no respect there sure are a lot of memorable quotes listed for this gem. Imagine a movie where Joe Piscopo is actually funny! Maureen Stapleton is a scene stealer. The Moroni character is an absolute scream. Watch for Alan "The Skipper" Hale jr. as a police Sgt.

sequences[0]

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 2, 11, 12, 13,
14, 15, 1, 16, 17, 18, 2, 3, 19, 20, 21, 22,
23, 24, 25, 26, 22, 2, 27, 28, 29, 30, 31, 22,
32, 33, 34, 35, 1, 36, 29, 37, 38, 39, 40, 2,
41, 42]
```

texts[5]

I saw the movie with two grown children. Although it was not as clever as Shrek, I thought it was rather good. In a movie theatre surrounded by children who were on spring break, there was not a sound so I know the children all liked it. There parents also seemed engaged. The death and apparent death of characters brought about the appropriate gasps and comments. Hopefully people realize this movie was made for kids. As such, it was successful although I liked it too. Personally I liked the Scrat!!

sequences[5]

```
[178, 486, 29, 3, 46, 407, 487, 488, 489, 272,
160, 273, 40, 490, 40, 491, 178, 492, 272, 160,
493, 494, 193, 2, 3, 495, 496, 51, 488, 64,
385, 97, 497, 498, 8, 160, 273, 2, 499, 459,
178, 335, 29, 488, 293, 500, 272, 8, 196, 357,
501, 502, 29, 263, 110, 503, 263, 12, 504, 141,
391, 29, 505, 506, 110, 507, 508, 509, 510, 16,
3, 160, 511, 1, 199, 40, 377, 272, 160, 512,
489, 178, 500, 272, 513, 514, 178, 500, 29,
515]
```

Step 3: One-Hot Encoding

Result of encoding: $25K$ lists of integers; the i-th list has w_i elements.

texts[0]

For a movie that gets no respect there sure are a lot of memorable quotes listed for this gem. Imagine a movie where Joe Piscopo is actually funny! Maureen Stapleton is a scene stealer. The Moroni character is an absolute scream. Watch for Alan "The Skipper" Hale jr. as a police Sgt.

sequences[0]

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 2, 11, 12, 13,
14, 15, 1, 16, 17, 18, 2, 3, 19, 20, 21, 22,
23, 24, 25, 26, 22, 2, 27, 28, 29, 30, 31, 22,
32, 33, 34, 35, 1, 36, 29, 37, 38, 39, 40, 2,
41, 42]
```

$w_0 = 52$ tokens

texts[5]

I saw the movie with two grown children. Although it was not as clever as Shrek, I thought it was rather good. In a movie theatre surrounded by children who were on spring break, there was not a sound so I know the children all liked it. There parents also seemed engaged. The death and apparent death of characters brought about the appropriate gasps and comments. Hopefully people realize this movie was made for kids. As such, it was successful although I liked it too. Personally I liked the Scrat!!

sequences[5]

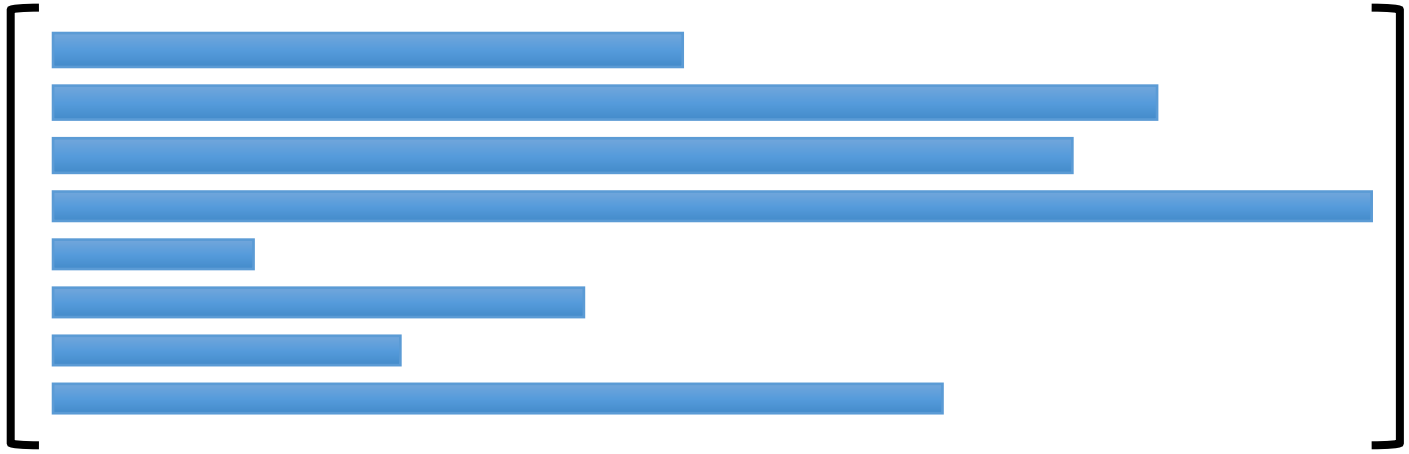
```
[178, 486, 29, 3, 46, 407, 487, 488, 489, 272,
160, 273, 40, 490, 40, 491, 178, 492, 272, 160,
493, 494, 193, 2, 3, 495, 496, 51, 488, 64,
385, 97, 497, 498, 8, 160, 273, 2, 499, 459,
178, 335, 29, 488, 293, 500, 272, 8, 196, 357,
501, 502, 29, 263, 110, 503, 263, 12, 504, 141,
391, 29, 505, 506, 110, 507, 508, 509, 510, 16,
3, 160, 511, 1, 199, 40, 377, 272, 160, 512,
489, 178, 500, 272, 513, 514, 178, 500, 29,
515]
```

$w_5 = 90$ tokens

Step 4: Align Sequences

Result of encoding: $25K$ lists of integers; the i-th list has w_i elements.

Problem: the training samples are not aligned (they have different lengths, w_i).



每个sequences 的长度 都不一致

Step 4: Align Sequences

Result of encoding: $25K$ lists of integers; the i-th list has w_i elements.

Problem: the training samples are not aligned (they have different lengths, w_i).

Solution:

- Cut off the text to keep w words, e.g., $w = 7$.

"the fat cat sat still on the big red mat."

"sat still on the big red mat."

Step 4: Align Sequences

Result of encoding: $25K$ lists of integers; the i-th list has w_i elements.

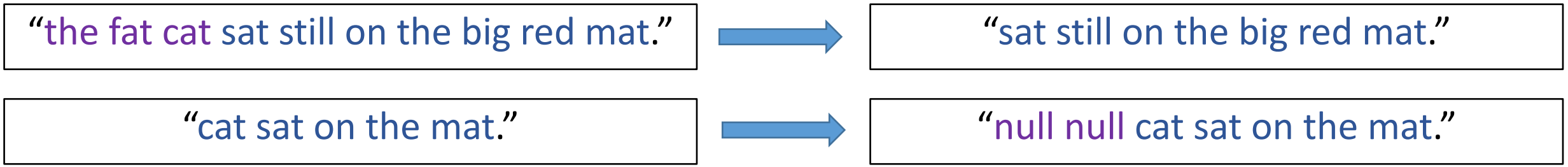
Problem: the training samples are not aligned (they have different lengths, w_i).

Solution:

- Cut off the text to keep w words, e.g., $w = 7$.
- If the text is shorter than w, pad it with zeros.

①太长的： 截断 （头部截断 / 尾部截断）

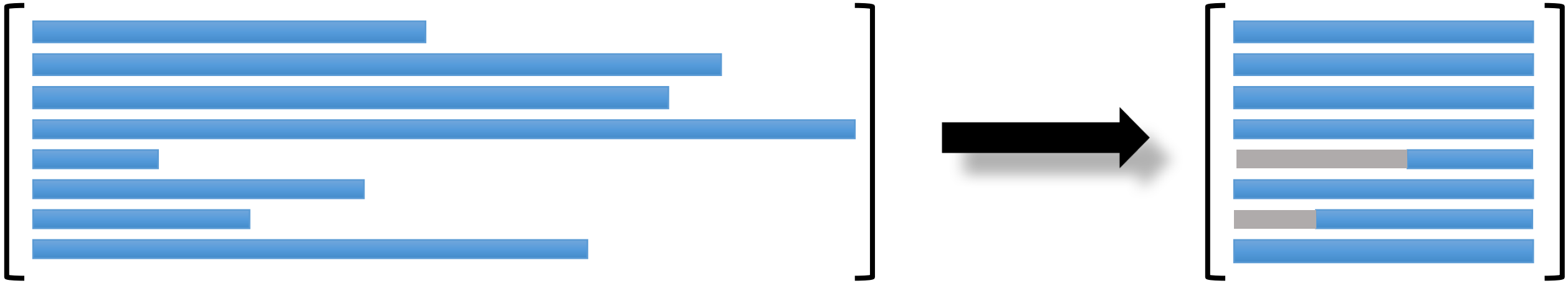
②太短的： 用null 填充 （头部填充 / 尾部填充）



Step 4: Align Sequences

Result of encoding: $25K$ lists of integers; the i-th list has w elements.

Aligned!



Text Processing in Keras

Steps 1, 2, & 3: Text to Sequence

```
from keras.preprocessing.text import Tokenizer

vocabulary = 10000
tokenizer = Tokenizer(num_words=vocabulary)
tokenizer.fit_on_texts(texts_train)

word_index = tokenizer.word_index
sequences_train = tokenizer.texts_to_sequences(texts_train)
```

Steps 1, 2, & 3: Text to Sequence

```
from keras.preprocessing.text import Tokenizer

vocabulary = 10000
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```

1. Tokenize the movie reviews
2. Build a dictionary.

Steps 1, 2, & 3: Text to Sequence

```
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vocabulary = 10000
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```

- word_index: dict[(string, int)]

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```

- texts_train: list[string]
- sequence_train: list[list[int]]

Steps 1, 2, & 3: Text to Sequence

```
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```

```
print(sequences_train[0])
```

```
[15, 3, 17, 12, 211, 54, 1158, 47, 249, 23, 3, 173, 4, 903, 4381, 3559, 15, 11, 1525, 835, 3,
17, 118, 911, 6, 162, 160, 7262, 6, 3, 133, 1, 106, 6, 32, 1552, 2032, 103, 15, 1605, 1, 859
5, 1789, 14, 3, 565, 6259]
```

Steps 4: Align Sequences

```
from keras import preprocessing

word_num = 20
x_train = preprocessing.sequence.pad_sequences(sequences_train, maxlen=word_num)
```

```
x_train.shape
```

```
(25000, 20)
```

```
x_train[0]
```

```
array([7262,    6,    3,  133,    1,  106,    6,   32, 1552, 2032,  103,
         15, 1605,    1, 8595, 1789,   14,    3,  565, 6259], dtype=int32)
```

Texts to Sequences: Summary

`texts[0]:`

"For a movie that gets no respect there sure are a lot of memorable quotes listed for this gem. Imagine a movie where Joe Piscopo is actually funny! Maureen Stapleton is a scene stealer. The Moroni character is an absolute scream. Watch for Alan "The Skipper" Hale jr. as a police Sgt."

Tokenization

`tokens[0]:`

```
['for', 'a', 'movie', 'that', 'gets', 'no', 'respect', 'there', 'sure', 'are', 'a',
'lot', 'of', 'memorable', 'quotes', 'listed', 'for', 'this', 'gem', 'imagine', 'a',
'movie', 'where', 'joe', 'piscopo', 'is', 'actually', 'funny', 'maureen',
'stapleton', 'is', 'a', 'scene', 'stealer', 'the', 'moroni', 'character', 'is',
'an', 'absolute', 'scream', 'watch', 'for', 'alan', 'the', 'skipper', 'hale', 'jr',
'as', 'a', 'police', 'sgt']
```

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'stapleton', 'is', 'a', 'scene', 'stealer', 'the', 'moroni', 'character', 'is',
'an', 'absolute', 'scream', 'watch', 'for', 'alan', 'the', 'skipper', 'hale', 'jr',
'as', 'a', 'police', 'sgt']
```

Encoding

`seqs[0]:`

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 2, 11, 12, 13, 14, 15, 1, 16, 17, 18, 2, 3, 19, 20,
21, 22, 23, 24, 25, 26, 22, 2, 27, 28, 29, 30, 31, 22, 32, 33, 34, 35, 1, 36, 29,
37, 38, 39, 40, 2, 41, 42]
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`tokens[0]:`

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'stapleton', 'is', 'a', 'scene', 'stealer', 'the', 'moroni', 'character', 'is',
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'as', 'a', 'police', 'sgt']
```

Encoding

`seqs[0]:`

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 2, 11, 12, 13, 14, 15, 1, 16, 17, 18, 2, 3, 19, 20,
21, 22, 23, 24, 25, 26, 22, 2, 27, 28, 29, 30, 31, 22, 32, 33, 34, 35, 1, 36, 29,
37, 38, 39, 40, 2, 41, 42]
```

Alignment (keep the last $w = 20$ tokens)

Do the same to test data

- Do the same operations to test data.
  - Step 1: tokenization.
  - Step 3: encoding.
  - Step 4: alignment.

Do the same to test data

- Do the same operations to test data.
  - Step 1: tokenization.
  - Step 3: encoding.
  - Step 4: alignment.
- Use the dictionary built on the training data.
  - Don’t build a dictionary on the test data!
  - The dictionary for training and test must be the same!
- Otherwise, this may happen:
  - In training data, index 23 refers to “good”.
  - In test data, index 23 refers to “mediocre”.

Word Embedding: Word to Vector

How to map word to vector?

如何 将一个词 映射 成一个 向量

Word	Index	
“movie”	1	
“good”	2	
“fun”	3	
“boring”	4	
…	…	

One-Hot Encoding

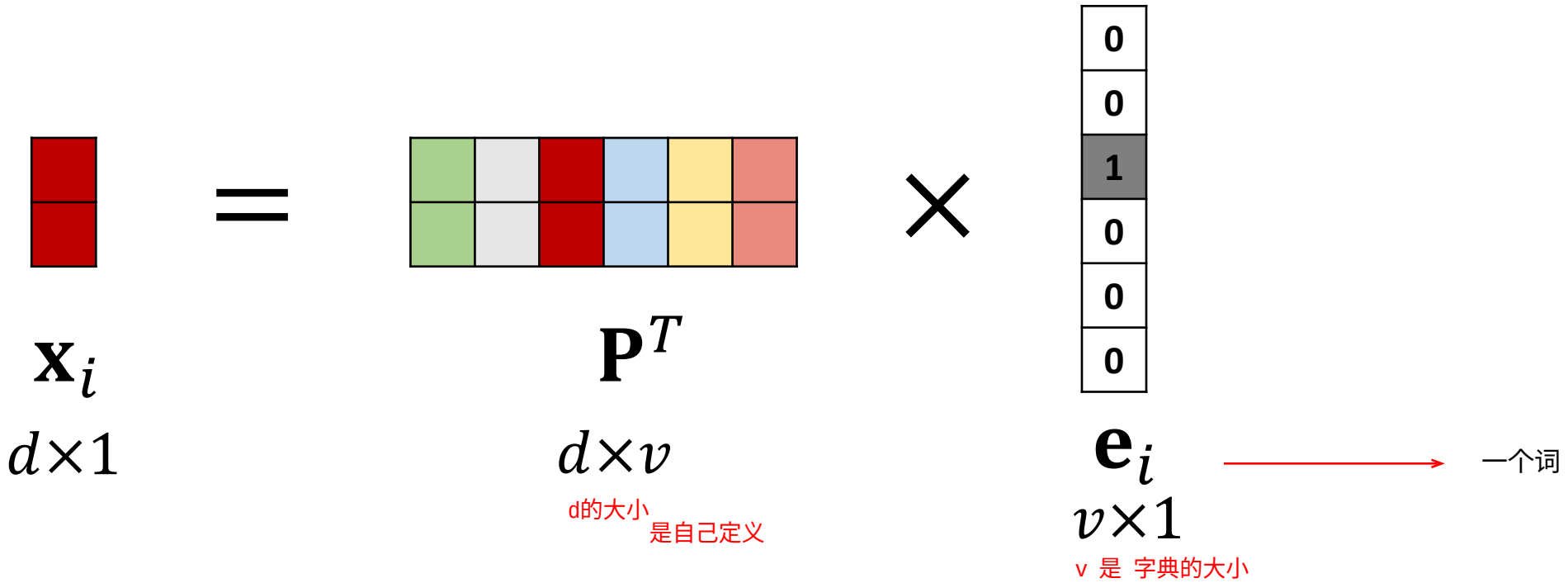
- First, represent words using one-hot vectors.
  - Suppose the dictionary contains v unique words (vocabulary$= v$).
  - Then the one-hot vectors $\mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_3, \cdots, \mathbf{e}_v$ are v-dimensional.

Word	Index	One-hot encoding
"movie"	1	$\mathbf{e}_1 = [1, 0, 0, 0, 0, \cdots, 0]$
"good"	2	$\mathbf{e}_2 = [0, 1, 0, 0, 0, \cdots, 0]$
"fun"	3	$\mathbf{e}_3 = [0, 0, 1, 0, 0, \cdots, 0]$
"boring"	4	$\mathbf{e}_4 = [0, 0, 0, 1, 0, \cdots, 0]$
…	…	…

Word Embedding

用一个 P 矩阵 将高维的 e向量 转换成 低维 的 x向量
v维 d 维

- Second, map the one-hot vectors to low-dimensional vectors by



$\mathbf{x}_i$ $\quad$ $\mathbf{P}^T$ $\quad$ $\mathbf{e}_i$

$d \times 1$ $\quad$ $d \times v$ $\quad$ $v \times 1$

d的大小 是自己定义

v 是 字典的大小

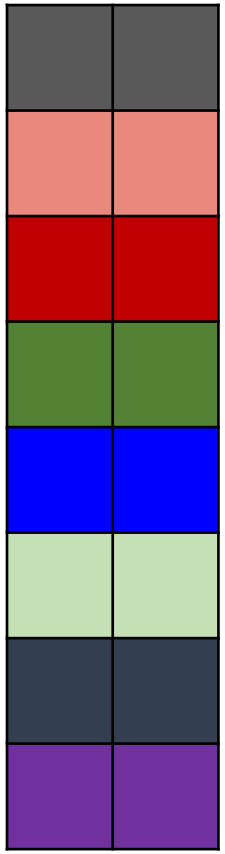
一个词

- $\mathbf{P}$ is parameter matrix which can be learned from training data.
- $\mathbf{e}_i$ is the one-hot vector of the i-th word in dictionary.

How to interpret the parameter matrix?

Parameter matrix

$$\mathbf{P} \in \mathbb{R}^{v \times d}$$



How to interpret the parameter matrix

Parameter matrix

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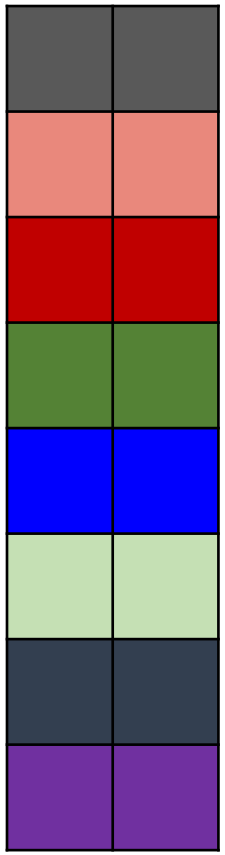


1: “movie”

2: “good”

3: “fun”

4: “boring”

5: “poor”

6: “mediocre”

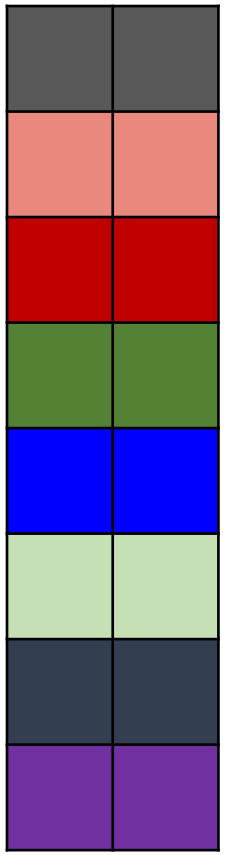
7: “is”

8: “fantastic”

How to interpret the parameter matrix?

Parameter matrix

$$\mathbf{P} \in \mathbb{R}^{v \times d}$$



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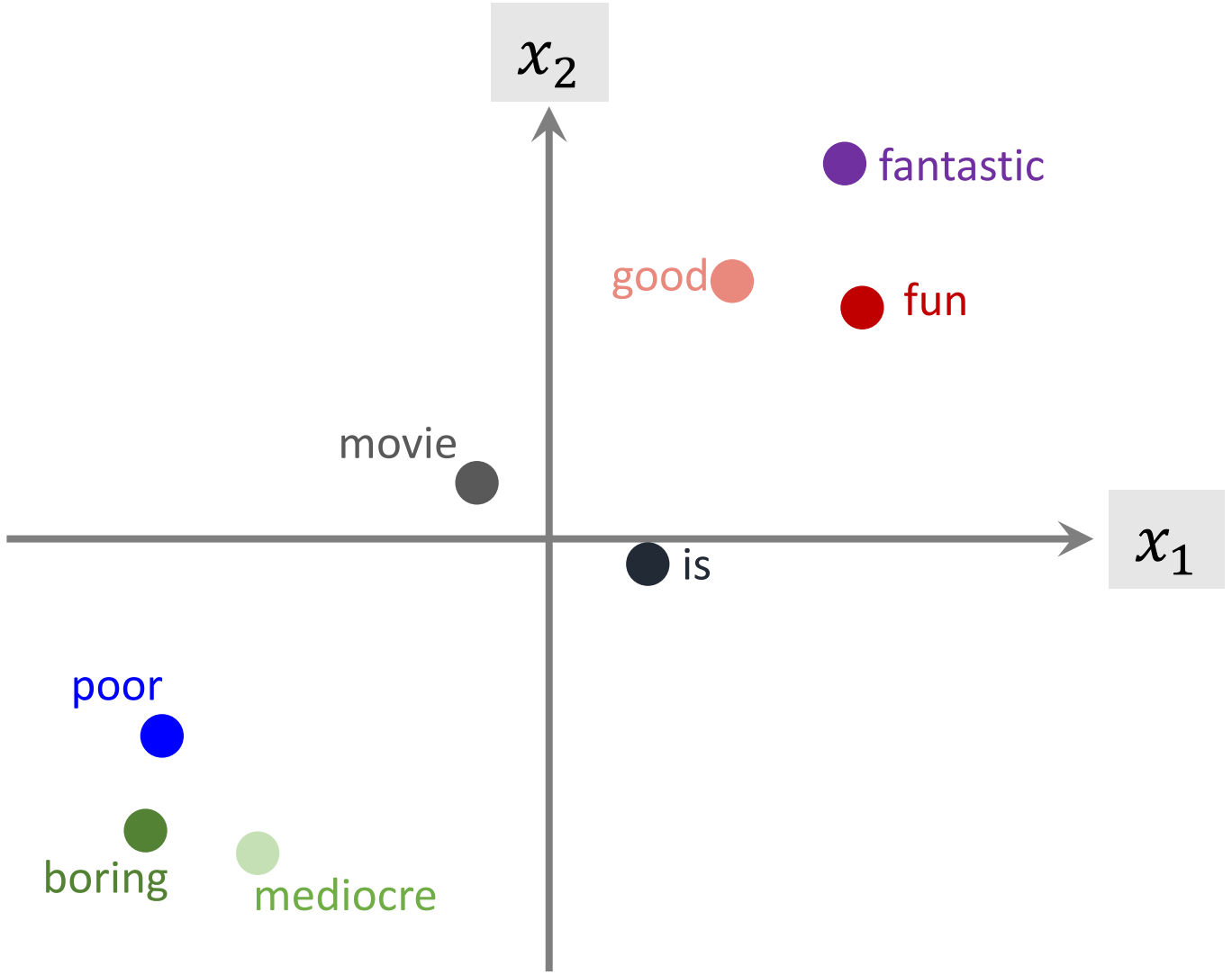

如果d = 2

```
from keras.models import Sequential
from keras.layers import Flatten, Dense, Embedding

embedding_dim = 8

model.add(Embedding(vocabulary, embedding_dim, input_length=word_num))
```

sequences列表的长度

$v = 10K$

$d = 8$

$= 20$

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_1 (Embedding)      (None, 20, 8)             80000
```

word_num

embedding_dim

= vocabulary ×embedding_dim

Logistic Regression for Binary Classification

模型顺序搭建

```
from keras.models import Sequential
from keras.layers import Flatten, Dense, Embedding

embedding_dim = 8

model = Sequential()
model.add(Embedding(vocabulary, embedding_dim, input_length=word_num))
model.add(Flatten())
model.add(Dense(1, activation='sigmoid'))

model.summary()
```

使用sigmoid激活后的结果作为概率输出

打印模型概要

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_1 (Embedding)      (None, 20, 8)             80000
_________________________________________________________________
flatten_1 (Flatten)          (None, 160)               0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 161
=================================================================
Total params: 80,161
Trainable params: 80,161
Non-trainable params: 0
```

如果把神经元网络模型用作二分类，最后输出层一般用sigmoid，如果是多分类，经典的输出层就是softmax，很多书籍或者文章一般都告诉你一个结论：那就是不论是sigmoid还是softmax，输出的都是概率，也就是一个二元事件发生（例如明天下雨，抛一个硬币后正面朝上）的可能性。

```
from keras import optimizers

epochs = 50

model.compile(optimizer=optimizers.RMSprop(lr=0.0001),
              loss='binary_crossentropy', metrics=['acc'])
```

```
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epochs = 50

model.compile(optimizer=optimizers.RMSprop(lr=0.0001),
              loss='binary_crossentropy', metrics=['acc'])
history = model.fit(x_train, y_train, epochs=epochs,
                    batch_size=32, validation_data=(x_valid, y_valid))
```

- The training set is randomly split to a training set and a validation set.
- 80% for training and 20% for validation.

- x_train: $20{,}000 \times 20$ matrix
- X_valid: $5{,}000 \times 20$ matrix

```
from keras import optimizers

epochs = 50

model.compile(optimizer=optimizers.RMSprop(lr=0.0001),
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history = model.fit(x_train, y_train, epochs=epochs,
                    batch_size=32, validation_data=(x_valid, y_valid))
```
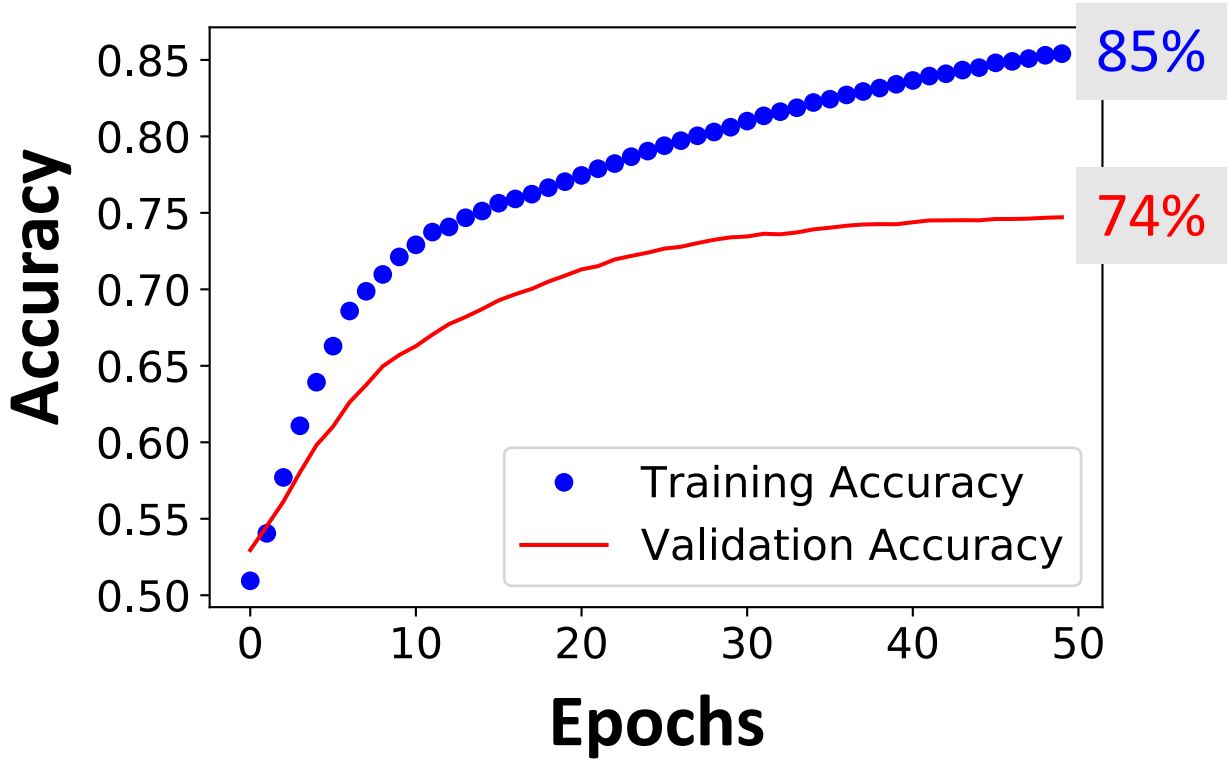
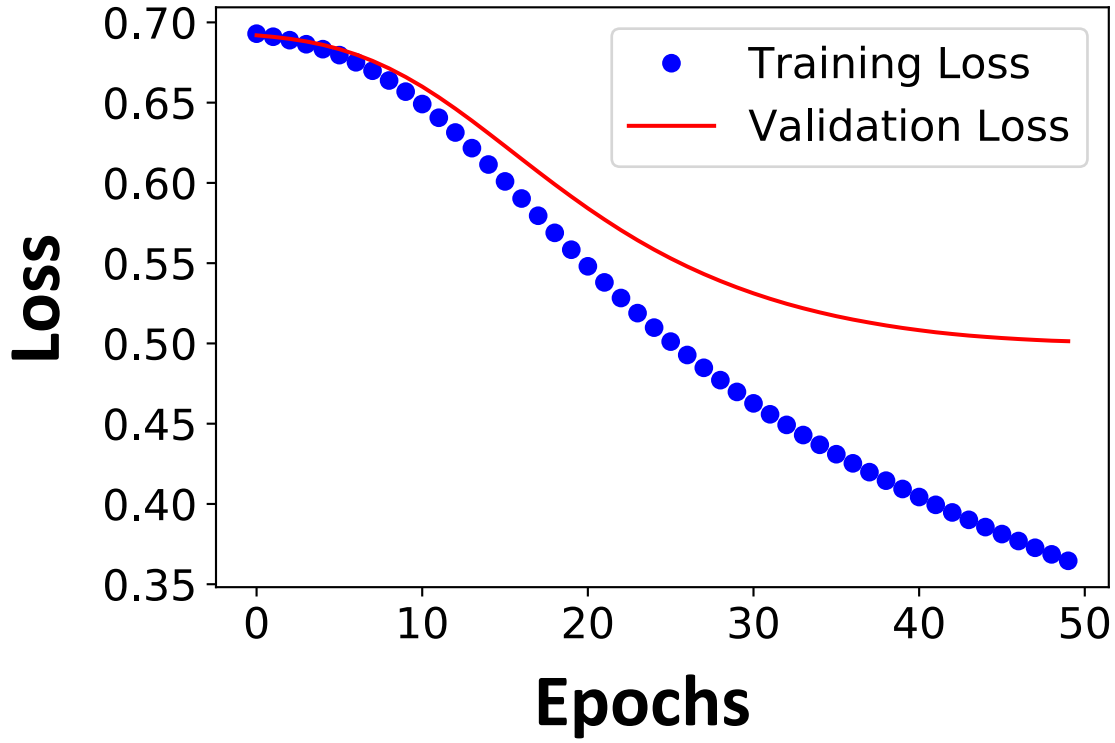

```
Epoch 1/50
12500/12500 [==============================] - 1s 74us/step - loss: 0.6930 - acc: 0.5094 - val_loss: 0.6919 - val_acc: 0.5295
Epoch 2/50
12500/12500 [==============================] - 1s 60us/step - loss: 0.6911 - acc: 0.5405 - val_loss: 0.6910 - val_acc: 0.5452
Epoch 3/50
12500/12500 [==============================] - 1s 57us/step - loss: 0.6889 - acc: 0.5770 - val_loss: 0.6898 - val_acc: 0.5612
```

-
-
-

```
Epoch 49/50
12500/12500 [==============================] - 1s 56us/step - loss: 0.3686 - acc: 0.8530 - val_loss: 0.5017 - val_acc: 0.7468
Epoch 50/50
12500/12500 [==============================] - 1s 56us/step - loss: 0.3646 - acc: 0.8541 - val_loss: 0.5014 - val_acc: 0.7471
```

Performance on training and validation sets





Performance on test set

```
loss_and_acc = model.evaluate(x_test, labels_test)
print('loss = ' + str(loss_and_acc[0]))
print('acc = ' + str(loss_and_acc[1]))
```

```
25000/25000 [==============================] - 0s 18us/step
loss = 0.5025235502243042
acc = 0.74928
```

- About 75% accuracy on the test set.
- Not bad, because we use only the last 20 words in each movie review. (`word_num=20`)

Summary

Texts to Sequences

`texts[i]:`

"For a movie that gets no respect there sure are a lot of memorable quotes listed for this gem. Imagine a movie where Joe Piscopo is actually funny! Maureen Stapleton is a scene stealer. The Moroni character is an absolute scream. Watch for Alan "The Skipper" Hale jr. as a police Sgt."

Tokenization

`tokens[i]:`

```
['for', 'a', 'movie', 'that', 'gets', 'no', 'respect', 'there', 'sure', 'are', 'a',
'lot', 'of', 'memorable', 'quotes', 'listed', 'for', 'this', 'gem', 'imagine', 'a',
'movie', 'where', 'joe', 'piscopo', 'is', 'actually', 'funny', 'maureen',
'stapleton', 'is', 'a', 'scene', 'stealer', 'the', 'moroni', 'character', 'is',
'an', 'absolute', 'scream', 'watch', 'for', 'alan', 'the', 'skipper', 'hale', 'jr',
'as', 'a', 'police', 'sgt']
```

Encoding

`seqs[i]:`

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 2, 11, 12, 13, 14, 15, 1, 16, 17, 18, 2, 3, 19, 20,
21, 22, 23, 24, 25, 26, 22, 2, 27, 28, 29, 30, 31, 22, 32, 33, 34, 35, 1, 36, 29,
37, 38, 39, 40, 2, 41, 42]
```

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Tokenization

`tokens[i]:`

```
['for', 'a', 'movie', 'that', 'gets', 'no', 'respect', 'there', 'sure', 'are', 'a',
'lot', 'of', 'memorable', 'quotes', 'listed', 'for', 'this', 'gem', 'imagine', 'a',
'movie', 'where', 'joe', 'piscopo', 'is', 'actually', 'funny', 'maureen',
'stapleton', 'is', 'a', 'scene', 'stealer', 'the', 'moroni', 'character', 'is',
'an', 'absolute', 'scream', 'watch', 'for', 'alan', 'the', 'skipper', 'hale', 'jr',
'as', 'a', 'police', 'sgt']
```

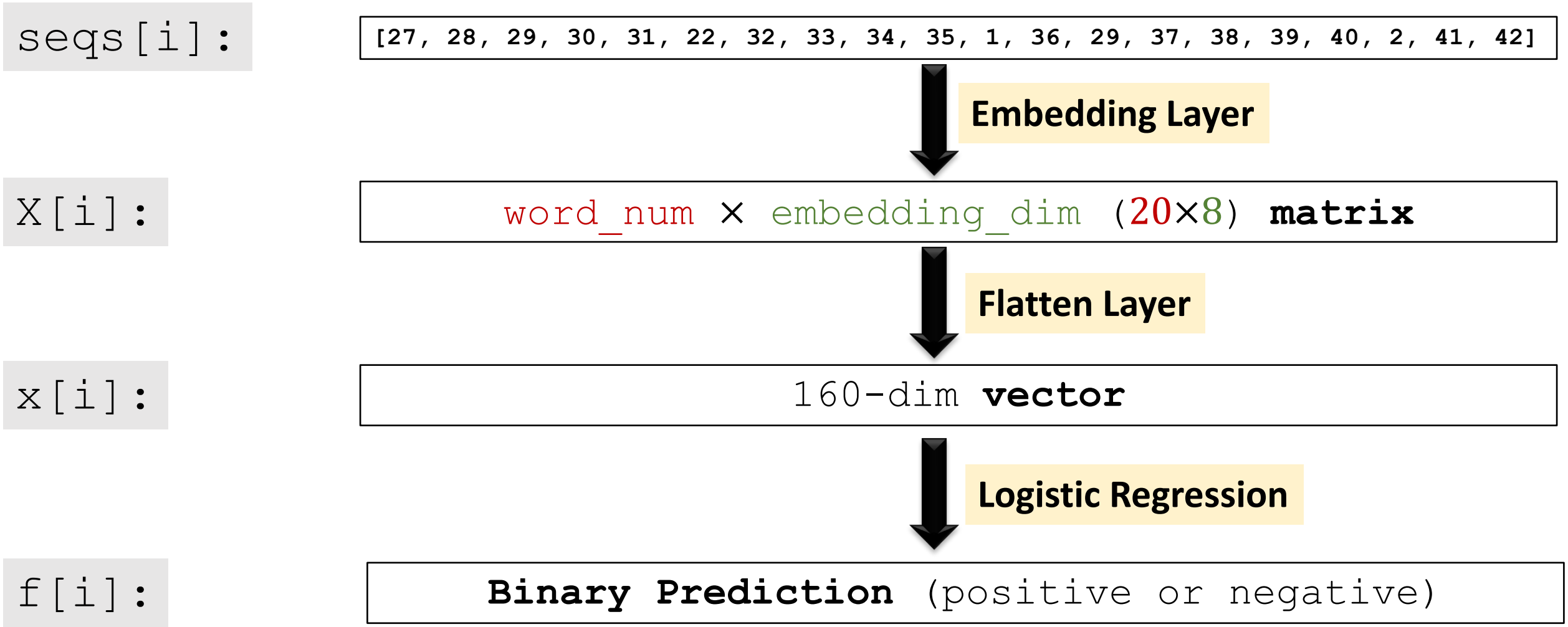
Encoding

`seqs[i]:`

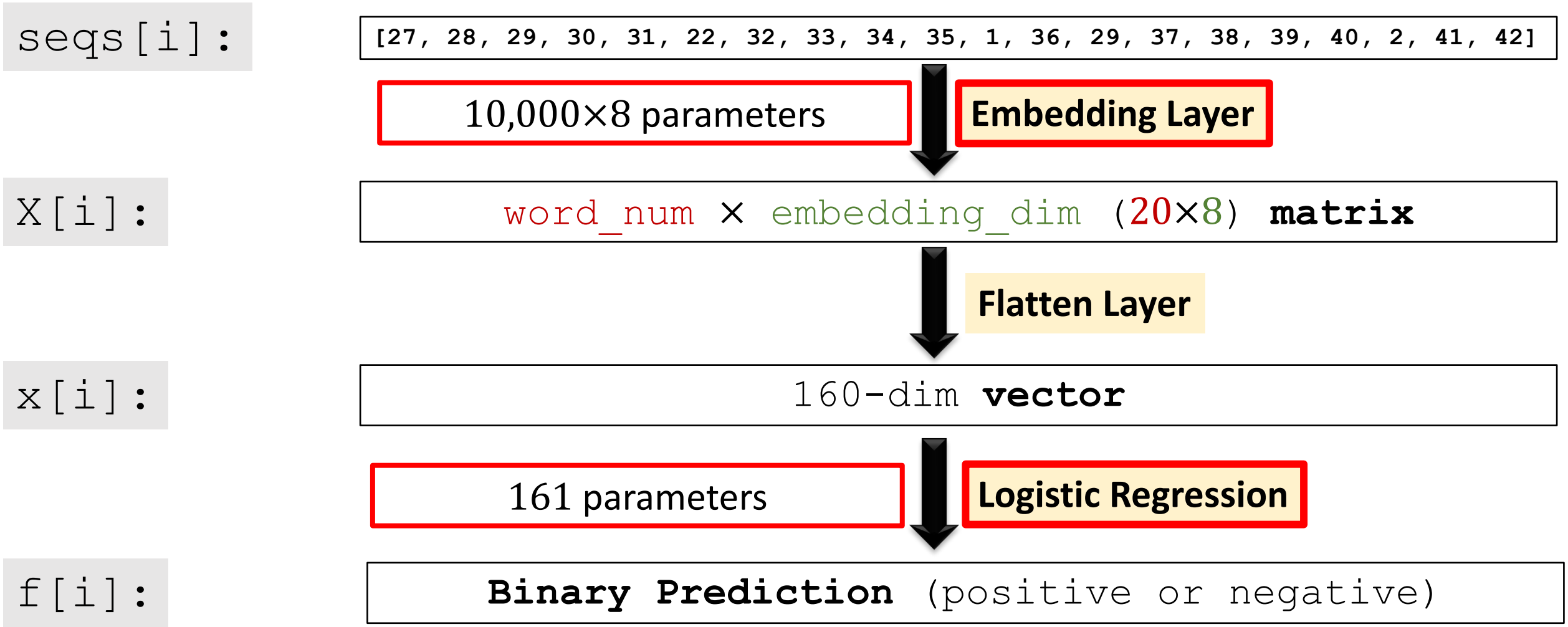
```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 2, 11, 12, 13, 14, 15, 1, 16, 17, 18, 2, 3, 19, 20,
21, 22, 23, 24, 25, 26, 22, 2, 27, 28, 29, 30, 31, 22, 32, 33, 34, 35, 1, 36, 29,
37, 38, 39, 40, 2, 41, 42]
```

Alignment (keep the last $w = 20$ tokens)

Logistic Regression for Sentiment Analysis



Logistic Regression for Sentiment Analysis



Thank you!