Introduction to the course

RECURRENT NEURAL NETWORKS (RNN) FOR LANGUAGE MODELING IN PYTHON

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datacamp

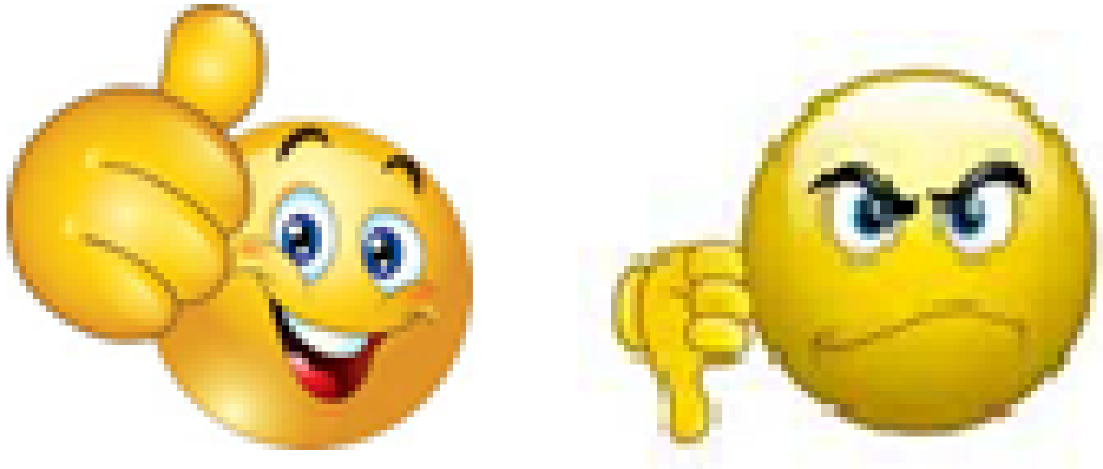
Text data is available online

Applications of machine learning to text data

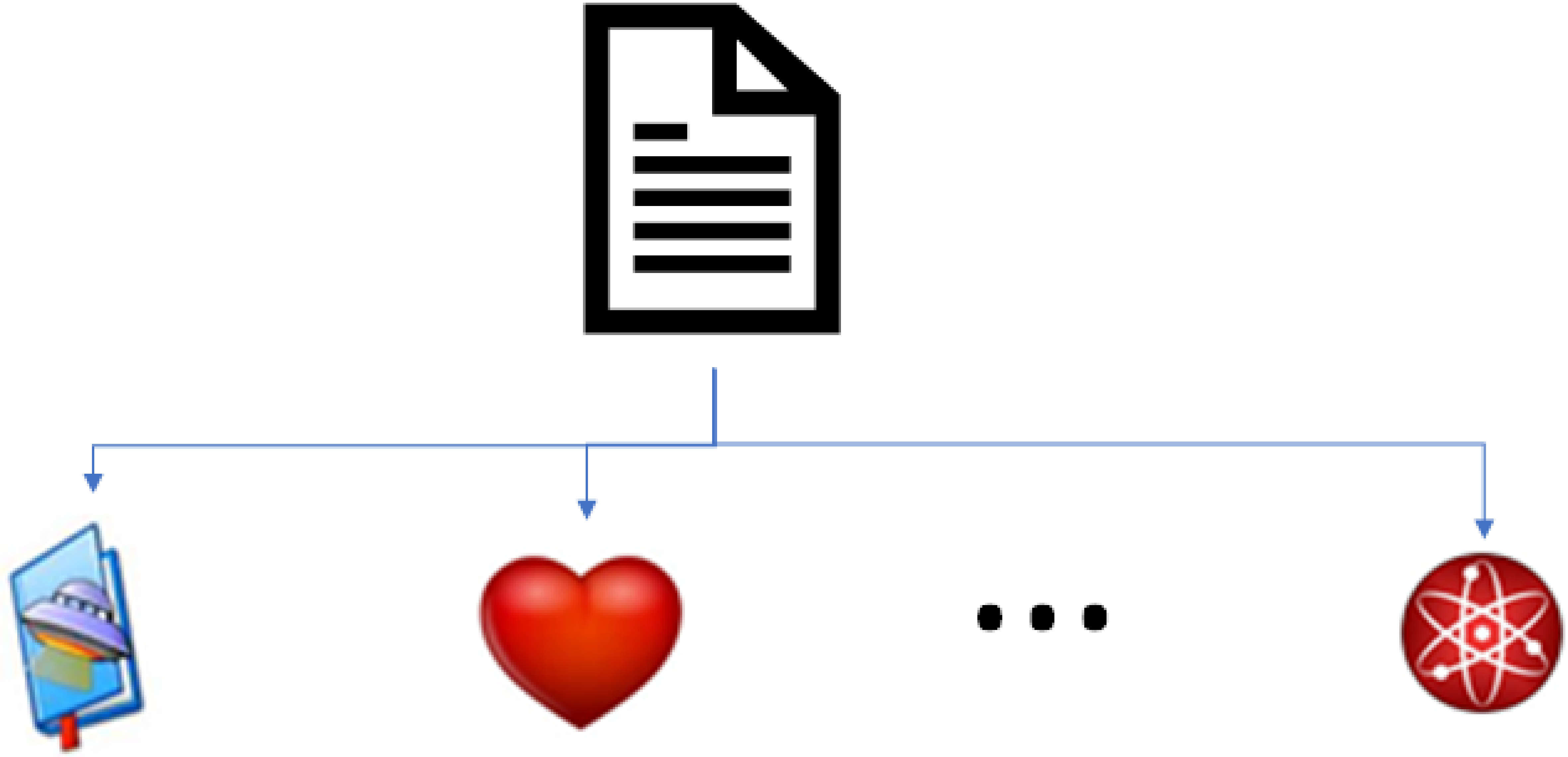
Four applications:

- Sentiment analysis
- Multi-class classification
- Text generation
- Machine neural translation

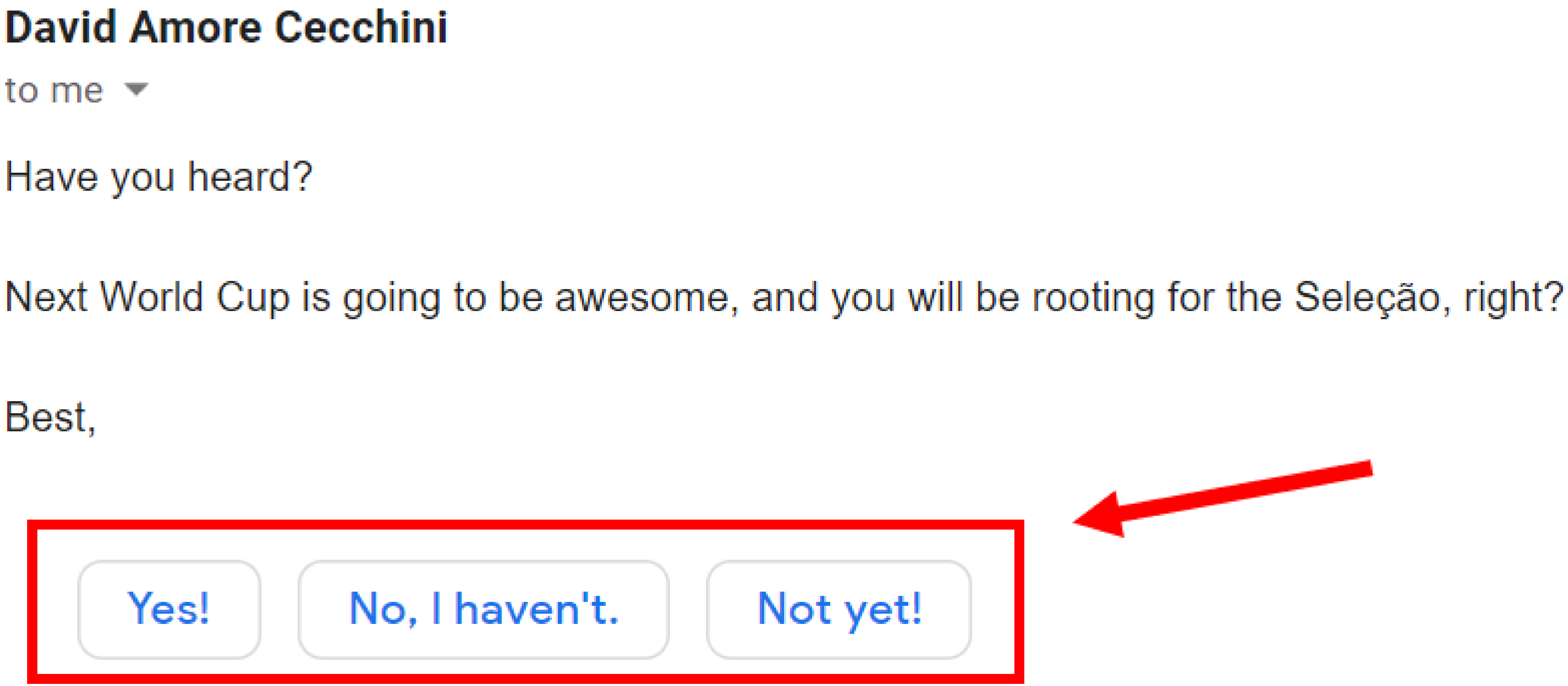
Sentiment analysis



Multi-class classification



Text generation



David Amore Cecchini

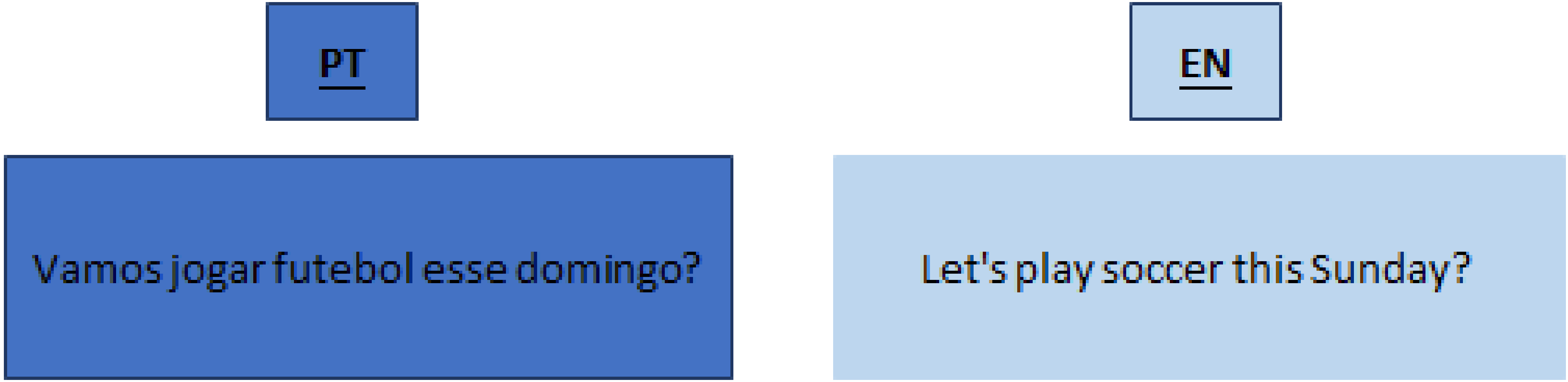
to me

Have you heard?

Next World Cup is going to be awesome, and you will be rooting for the Seleção, right?

Best,

Neural machine translation



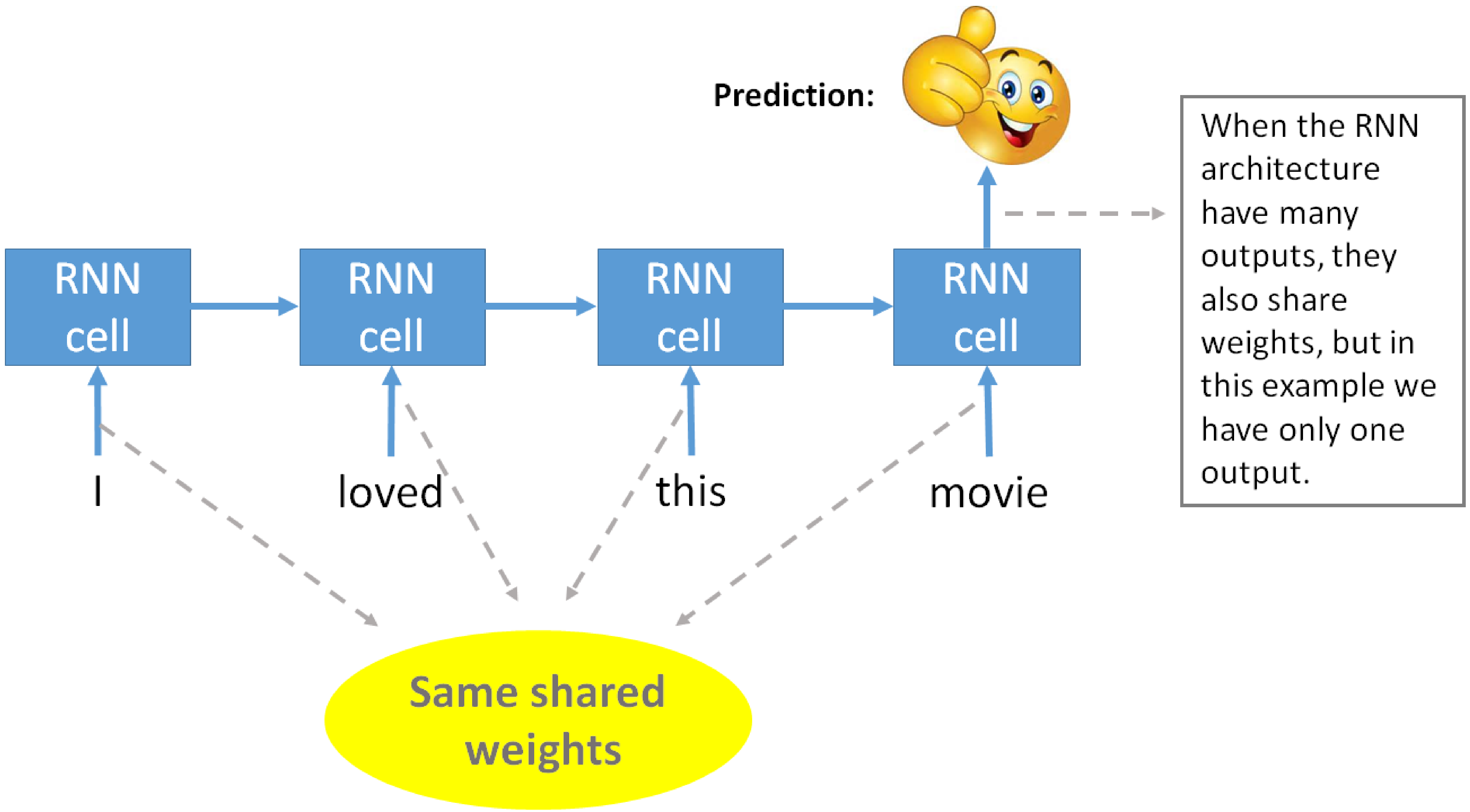
PT

Vamos jogar futebol esse domingo?

EN

Let's play soccer this Sunday?

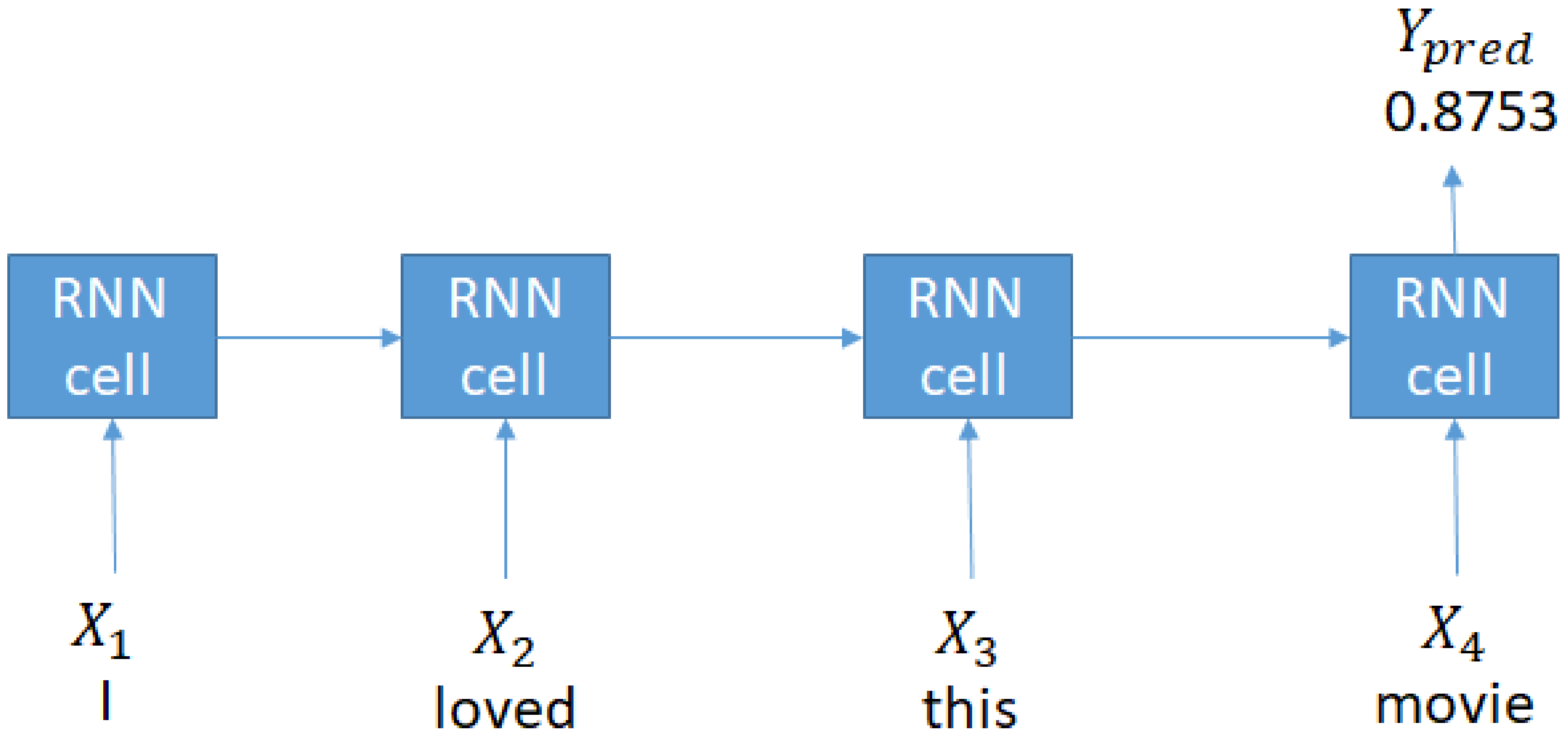
Recurrent Neural Networks



When the RNN architecture have many outputs, they also share weights, but in this example we have only one output.

Sequence to sequence models

Many to one: classification



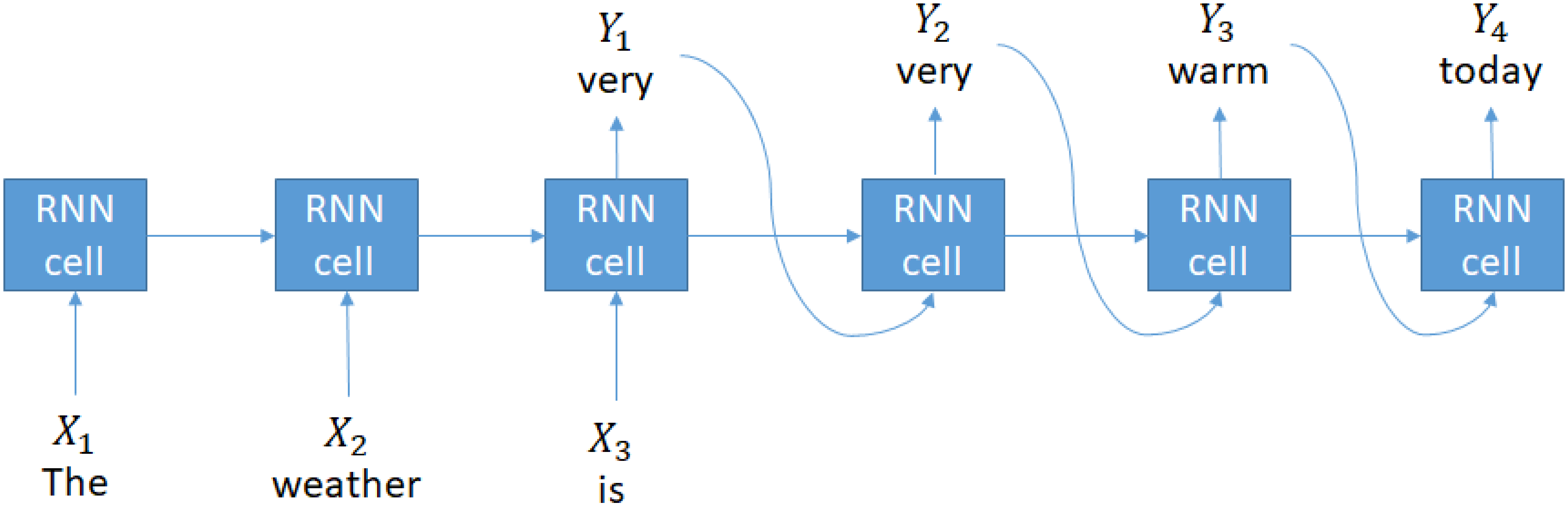
Decision rule:

Set prediction to "positive" if $Y_{pred} > 0.5$, otherwise set to "negative".

*Y_{pred} is the probability of the sentence to belong to class "positive"

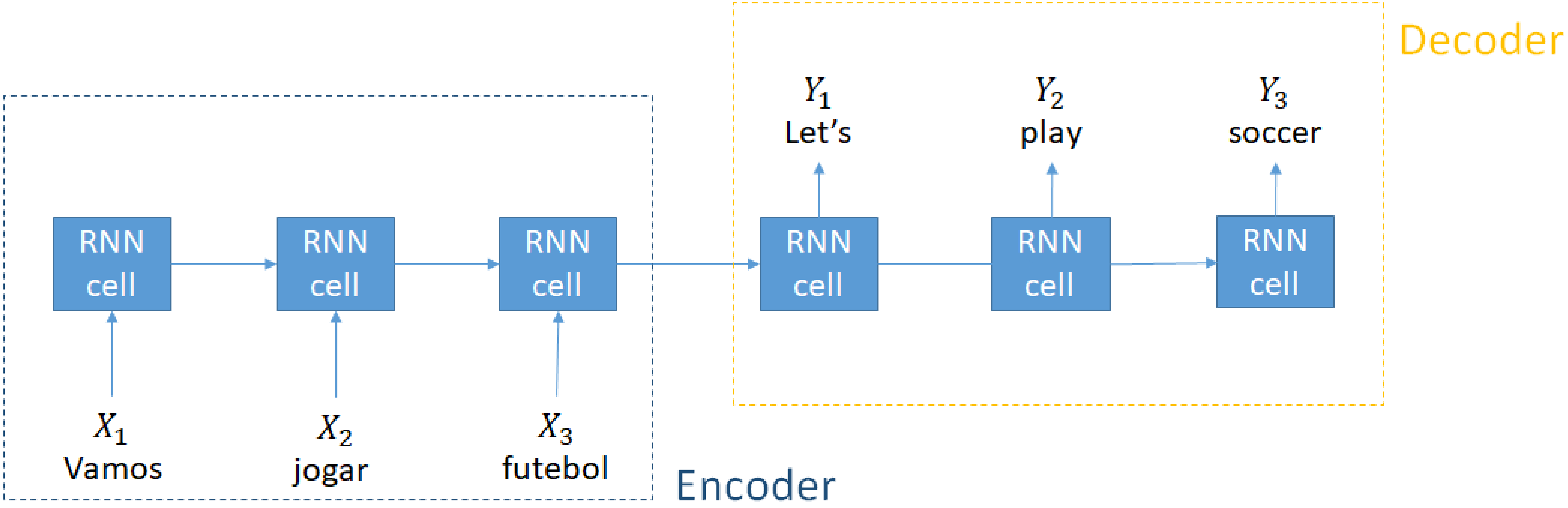
Sequence to sequence models

Many to many: text generation



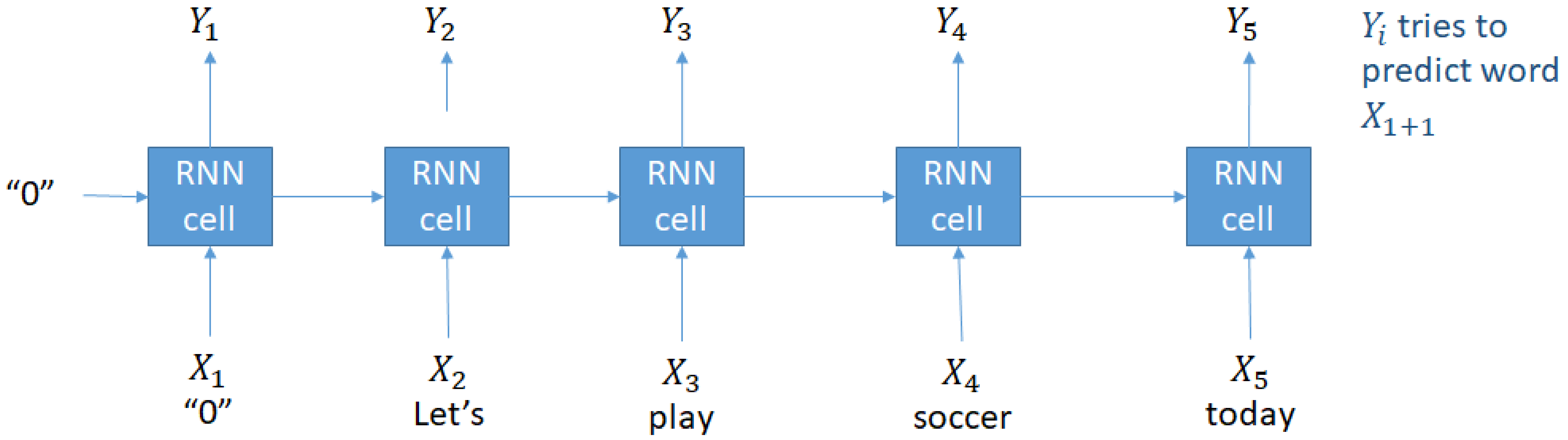
Sequence to sequence models

Many to many: neural machine translation



Sequence to sequence models

Many to many: language model



Let's practice!

RECURRENT NEURAL NETWORKS (RNN) FOR LANGUAGE MODELING IN PYTHON

Introduction to language models

RECURRENT NEURAL NETWORKS (RNN) FOR LANGUAGE MODELING IN PYTHON

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Data Scientist

Sentence probability

Many available models

- Probability of "I loved this movie".
- Unigram
  - $$P(\text{sentence}) = P(\text{I})P(\text{loved})P(\text{this})P(\text{movie})$$
- N-gram
  - N = 2 (bigram):
    $$P(\text{sentence}) = P(\text{I})P(\text{loved}|\text{I})P(\text{this}|\text{loved})P(\text{movie}|\text{this})$$
  - N = 3 (trigram):
    $$P(\text{sentence}) = P(\text{I})P(\text{loved}|\text{I})P(\text{this}|\text{I loved})P(\text{movie}|\text{loved this})$$

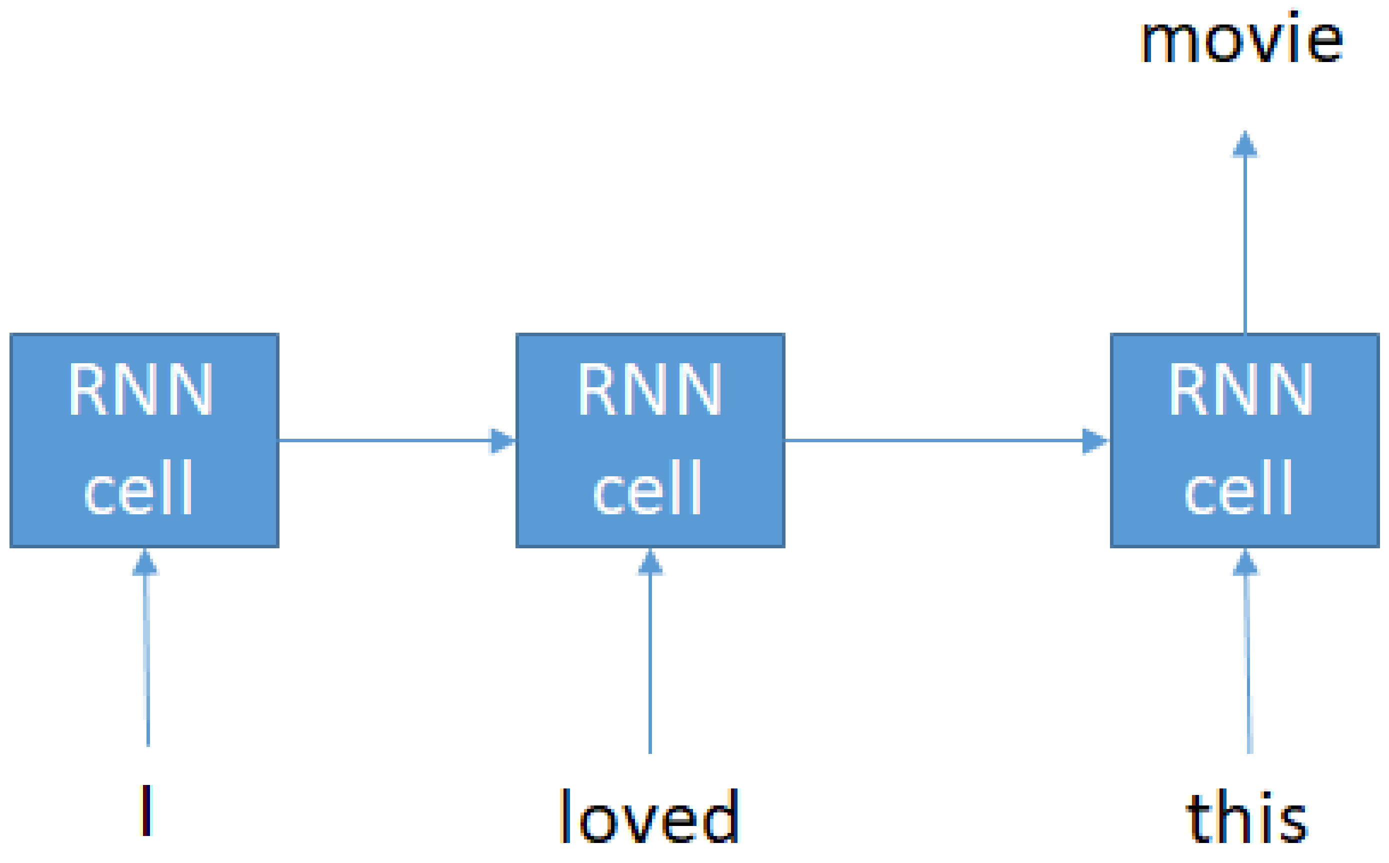
Sentence probability (cont.)

- Skip gram
  - $$P(\text{sentence}) = P(\text{context of I}|\text{I})P(\text{context of loved}|\text{loved})$$
    $$P(\text{context of this}|\text{this})P(\text{context of movie}|\text{movie})$$
- Neural Networks
  - The probability of the sentence is given by a `softmax` function on the output layer of the network

Link to RNNs

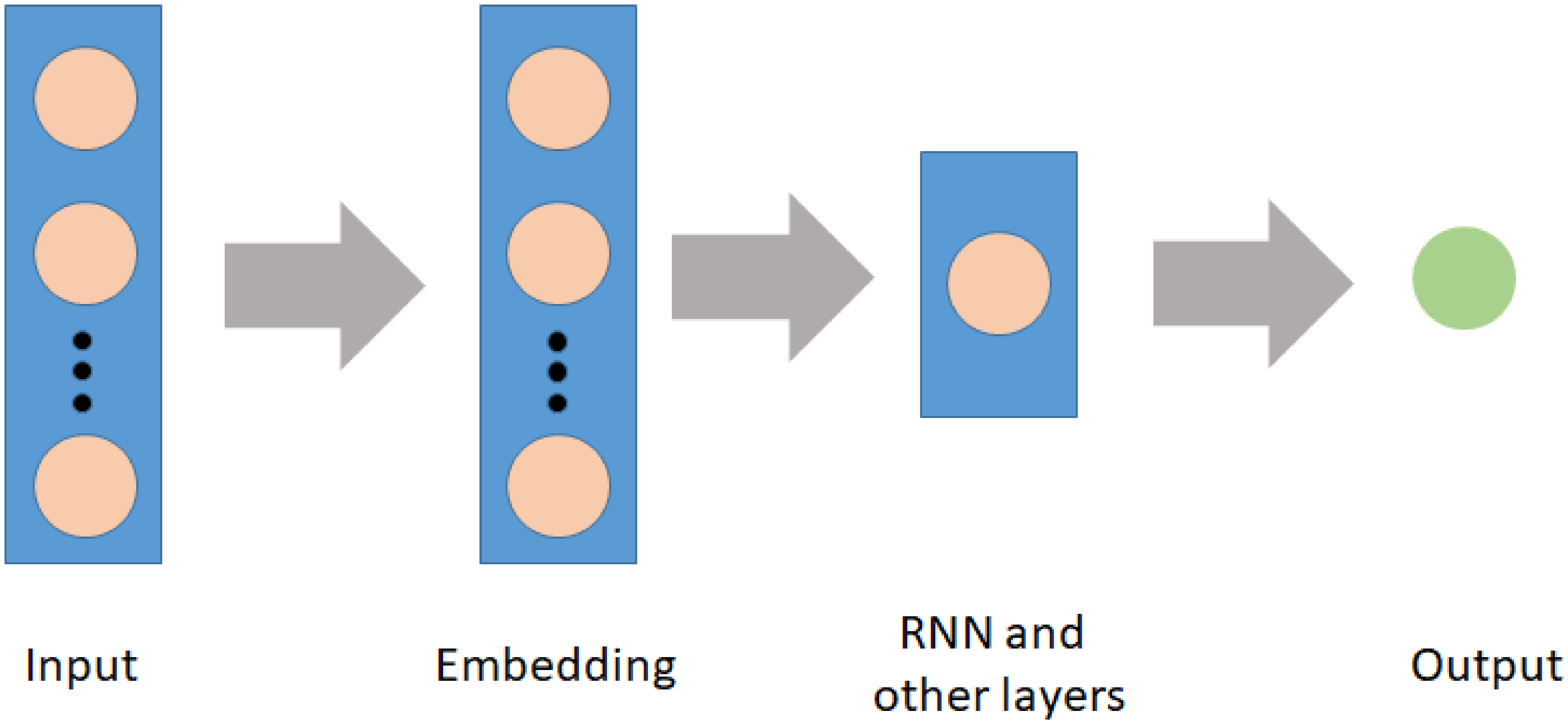
Language models are everywhere in RNNs!

- The network itself



Link to RNN (cont.)

- Embedding layer



Building vocabulary dictionaries

```python
# Get unique words
unique_words = list(set(text.split(' ')))
```

```python
# Create dictionary: word is key, index is value
word_to_index = {k:v for (v,k) in enumerate(unique_words)}
```

```python
# Create dictionary: index is key, word is value
index_to_word = {k:v for (k,v) in enumerate(unique_words)}
```

Preprocessing input

```
# Initialize variables X and y
X = []
y = []
# Loop over the text: length `sentence_size` per time with step equal to `step`
for i in range(0, len(text) - sentence_size, step):
    X.append(text[i:i + sentence_size])
    y.append(text[i + sentence_size])
```

```
# Example (numbers are numerical indexes of vocabulary):
# Sentence is: "i loved this movie" -> (["i", "loved", "this"], "movie")
X[0],y[0] = ([10, 444, 11], 17)
```

Transforming new texts

```python
# Create list to keep the sentences of indexes
new_text_split = []
# Loop and get the indexes from dictionary
for sentence in new_text:
    sent_split = []
    for wd in sentence.split(' '):
        ix = wd_to_index[wd]
        sent_split.append(ix)
    new_text_split.append(sent_split)
```

Let's practice!

RECURRENT NEURAL NETWORKS (RNN) FOR LANGUAGE MODELING IN PYTHON

Introduction to RNN inside Keras

RECURRENT NEURAL NETWORKS (RNN) FOR LANGUAGE MODELING IN PYTHON

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What is keras?

- High-level API
- Run on top of Tensorflow 2
- Easy to install and use

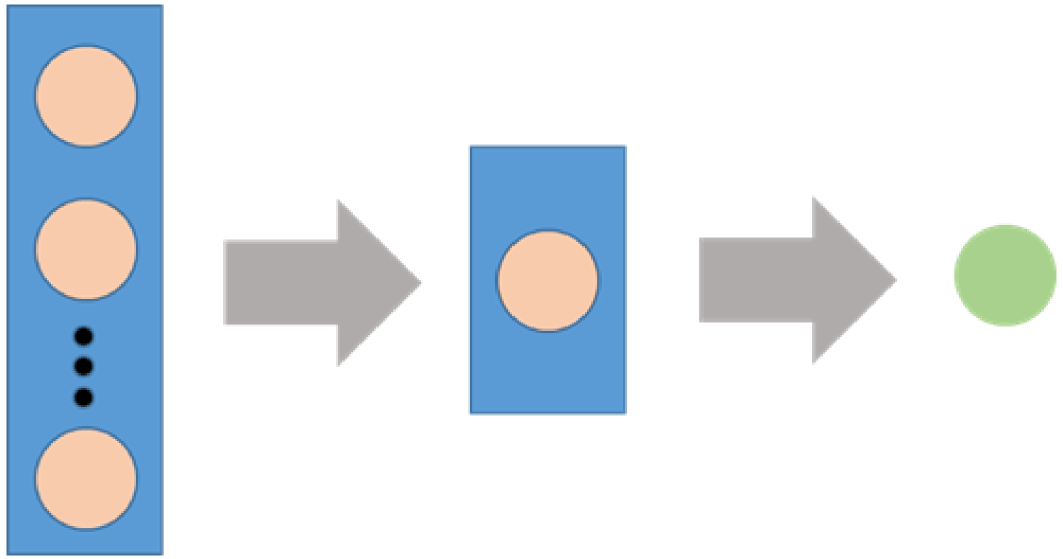
```
$pip install tensorflow
```

Fast experimentation:

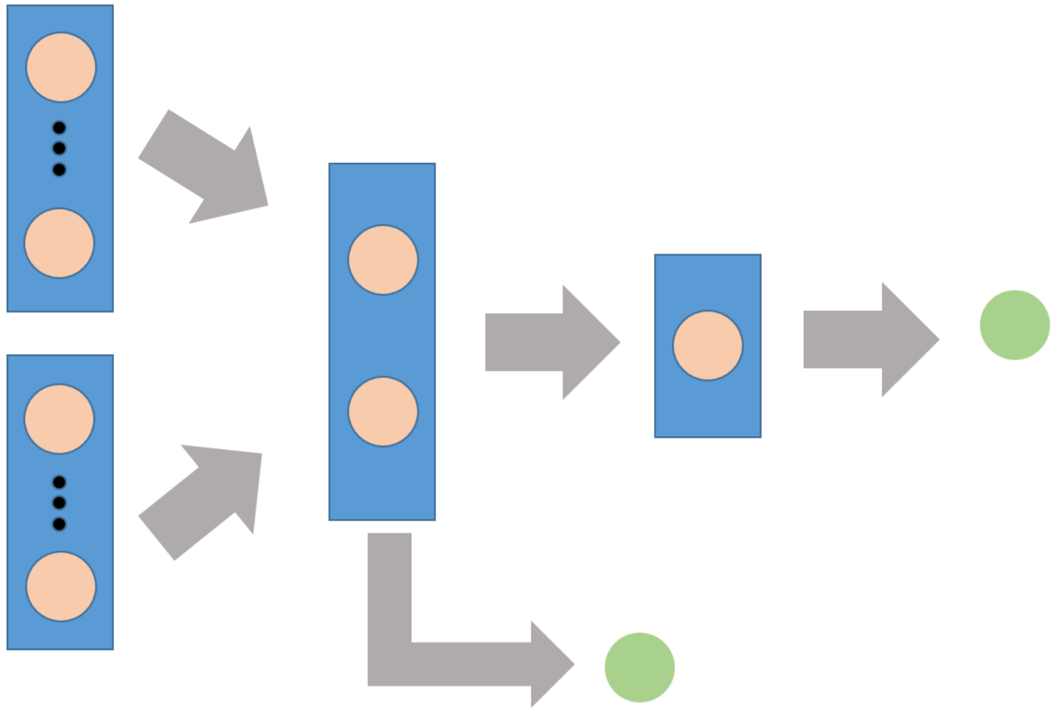
```python
from tensorflow import keras
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
```

keras.models

keras.models.Sequential



keras.models.Model

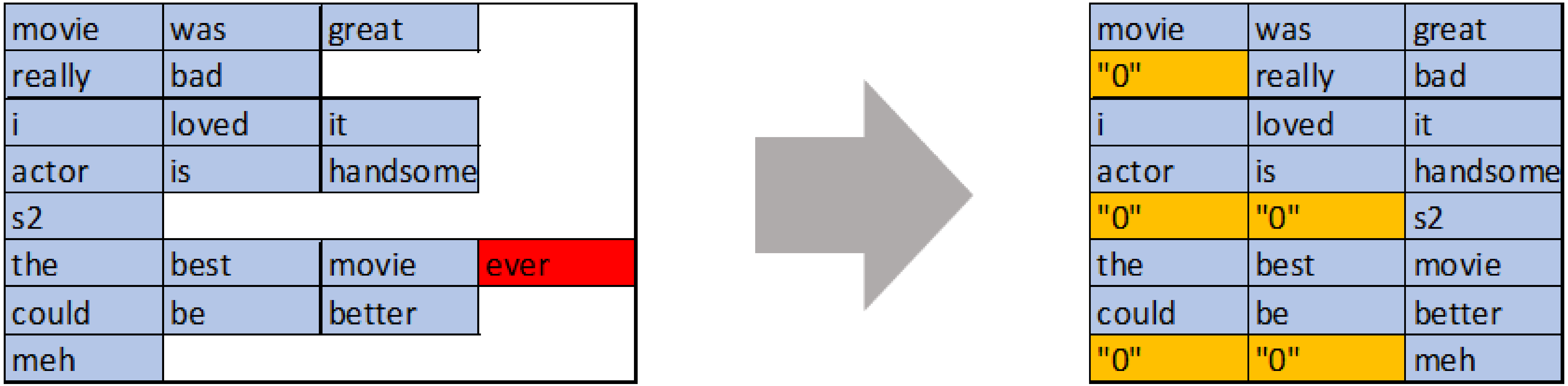


keras.layers

1. `LSTM`
2. `GRU`
3. `Dense`
4. `Dropout`
5. `Embedding`
6. `Bidirectional`

keras.preprocessing

```
keras.preprocessing.sequence.pad_sequences(texts, maxlen=3)
```



movie	was	great	
really	bad		
i	loved	it	
actor	is	handsome	
s2			
the	best	movie	ever
could	be	better	
meh			

movie	was	great
"0"	really	bad
i	loved	it
actor	is	handsome
"0"	"0"	s2
the	best	movie
could	be	better
"0"	"0"	meh

keras.datasets

Many useful datasets

- IMDB Movie reviews
- Reuters newswire

And more!

For a complete list and usage examples, see **keras documentation**

Creating a model

```python
# Import required modules
from tensorflow import keras
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
```

```python
# Instantiate the model class
model = Sequential()
```

```python
# Add the layers
model.add(Dense(64, activation='relu', input_dim=100))
model.add(Dense(1, activation='sigmoid'))
```

```python
# Compile the model
model.compile(optimizer='adam', loss='mean_squared_error', metrics=['accuracy'])
```

Training the model

The method `.fit()` trains the model on the training set

```
model.fit(X_train, y_train, epochs=10, batch_size=32)
```

1. `epochs` determine how many weight updates will be done on the model
2. `batch_size` size of the data on each step

Model evaluation and usage

Evaluate the model:

```
model.evaluate(X_test, y_test)
```

```
[0.3916562925338745, 0.89324]
```

Make predictions on new data:

```
model.predict(new_data)
```

```
array([[0.91483957],[0.47130653]], dtype=float32)
```

Full example: IMDB Sentiment Classification

```
# Build and compile the model
model = Sequential()
model.add(Embedding(10000, 128))
model.add(LSTM(128, dropout=0.2))
model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
```

```
# Training
model.fit(x_train, y_train, epochs=5)
```

```
# Evaluation
score, acc = model.evaluate(x_test, y_test)
```

Time to practice!

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