Loading natural language text

INTRODUCTION TO SPARK SQL IN PYTHON

Mark Plutowski
Data Scientist

The dataset

The Project Gutenberg eBook of The Adventures of Sherlock Holmes,

by Sir Arthur Conan Doyle.

Available from gutenberg.org

Loading text

```
df = spark.read.text('sherlock.txt')
```

```
print(df.first())
```

```
Row(value='The Project Gutenberg EBook of The Adventures of Sherlock Holmes')
```

```
print(df.count())
```

```
5500
```

Loading parquet

```
df1 = spark.read.load('sherlock.parquet')
```

Loaded text

```
df1.show(15, truncate=False)
```

```
+--------------------------------------------------------------------+
|value                                                               |
+--------------------------------------------------------------------+
|The Project Gutenberg EBook of The Adventures of Sherlock Holmes    |
|by Sir Arthur Conan Doyle                                           |
|(#15 in our series by Sir Arthur Conan Doyle)                       |
|                                                                    |
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+--------------------------------------------------------------------+
```

Lower case operation

```
df = df1.select(lower(col('value')))

print(df.first())
```

```
Row(lower(value)=
    'the project gutenberg ebook of the adventures of sherlock holmes')
```

```
df.columns
```

```
['lower(value)']
```

Alias operation

```
df = df1.select(lower(col('value')).alias('v'))
```

```
df.columns
```

```
['v']
```

Replacing text

```
df = df1.select(regexp_replace('value', 'Mr\.', 'Mr').alias('v'))
```

> "Mr. Holmes." ==> "Mr Holmes."

```
df = df1.select(regexp_replace('value', 'don\'t', 'do not').alias('v'))
```

> "don't know." ==> "do not know."

Tokenizing text

```
df = df2.select(split('v', '[ ]').alias('words'))
df.show(truncate=False)
```

Tokenizing text – output

```
+--------------------------------------------------------------------------------------+
|words                                                                                  |
+--------------------------------------------------------------------------------------+
|[the, project, gutenberg, ebook, of, the, adventures, of, sherlock, holmes]           |
|[by, sir, arthur, conan, doyle]                                                       |
|[(#15, in, our, series, by, sir, arthur, conan, doyle)]                               |
|[]
.
.
.
|[please, read, the, "legal, small, print,", and, other, information, about, the]      |
.
.
.
|[**welcome, to, the, world, of, free, plain, vanilla, electronic, texts**]            |
+--------------------------------------------------------------------------------------+
```

Split characters are discarded

```
punctuation = "_|.\?\!\",\'\[\]\*()"
df3 = df2.select(split('v', '[ %s]' % punctuation).alias('words'))
```

```
df3.show(truncate=False)
```

Split characters are discarded – output

```
+--------------------------------------------------------------------------------------+
|words                                                                                  |
+--------------------------------------------------------------------------------------+
|[the, project, gutenberg, ebook, of, the, adventures, of, sherlock, holmes]           |
|[by, sir, arthur, conan, doyle]                                                       |
|[, #15, in, our, series, by, sir, arthur, conan, doyle, ]                             |
|[]                                                                                    .
.
.

|[please, read, the, , legal, small, print, , , and, other, information, about, the]  |
.
.
.
[, , welcome, to, the, world, of, free, plain, vanilla, electronic, texts, , ]        |
++--------------------------------------------------------------------------------------+
```

Exploding an array

```
df4 = df3.select(explode('words').alias('word'))
df4.show()
```

Exploding an array – output

```
+----------+
|      word|
+----------+
|       the|
|   project|
| gutenberg|
|     ebook|
|        of|
|       the|
|adventures|
|        of|
|  sherlock|
|    holmes|
|        by|
|       sir|
|    arthur|
|     conan|
|     doyle|
+----------+
```

Explode increases row count

```
print(df3.count())
```

```
5500
```

```
print(df4.count())
```

```
131404
```

Removing empty rows

```
print(df.count())
```

```
131404
```

```
nonblank_df = df.where(length('word') > 0)
```

```
print(nonblank_df.count())
```

```
107320
```

Adding a row id column

```
df2 = df.select('word', monotonically_increasing_id().alias('id'))


df2.show()
```

Adding a row id column – output

```
+----------+---+
|      word| id|
+----------+---+
|       the|  0|
|   project|  1|
| gutenberg|  2|
|     ebook|  3|
|        of|  4|
|       the|  5|
|adventures|  6|
|        of|  7|
|  sherlock|  8|
|    holmes|  9|
|        by| 10|
|       sir| 11|
|    arthur| 12|
|     conan| 13|
|     doyle| 14|
|       #15| 15|
+----------+---+
```

Partitioning the data

```
df2 = df.withColumn('title', when(df.id < 25000, 'Preface')
                             .when(df.id < 50000, 'Chapter 1')
                             .when(df.id < 75000, 'Chapter 2')
                             .otherwise('Chapter 3'))
```

```
df2 = df2.withColumn('part', when(df2.id < 25000, 0)
                            .when(df2.id < 50000, 1)
                            .when(df2.id < 75000, 2)
                            .otherwise(3))
                            .show()
```

Partitioning the data – output

```
+----------+---+------------+----+
|word      |id |title       |part|
+----------+---+------------+----+
|the       |0  |     Preface|0   |
|project   |1  |     Preface|0   |
|gutenberg |2  |     Preface|0   |
|ebook     |3  |     Preface|0   |
|of        |4  |     Preface|0   |
|the       |5  |     Preface|0   |
|adventures|6  |     Preface|0   |
|of        |7  |     Preface|0   |
|sherlock  |8  |     Preface|0   |
|holmes    |9  |     Preface|0   |
```

Repartitioning on a column

```
df2 = df.repartition(4, 'part')
```

```
print(df2.rdd.getNumPartitions())
```

```
4
```

Reading pre-partitioned text

```
$ ls sherlock_parts
```

```
sherlock_part0.txt
sherlock_part1.txt
sherlock_part2.txt
sherlock_part3.txt
sherlock_part4.txt
sherlock_part5.txt
sherlock_part6.txt
sherlock_part7.txt
sherlock_part8.txt
sherlock_part9.txt
sherlock_part10.txt
sherlock_part11.txt
sherlock_part12.txt
sherlock_part13.txt
```

Reading pre-partitioned text

```
df_parts = spark.read.text('sherlock_parts')
```

Let's practice!

Moving window analysis

INTRODUCTION TO SPARK SQL IN PYTHON

Mark Plutowski
Data Scientist

The raw text

```
ADVENTURE  I.  A SCANDAL IN BOHEMIA

I.



To Sherlock Holmes she is always the woman. I have seldom heard him mention
her under any other name. In his eyes she eclipses and predominates the whole
of her sex. It was not that he felt any emotion akin to love for Irene Adler.
All emotions, and that one particularly, were abhorrent to his cold, precise
but admirably balanced mind. He was, I take it, the most perfect reasoning
and observing machine that the world has seen, but as a lover he would have
placed himself in a false position. He never spoke of the softer passions,
save with a gibe and a sneer. They were admirable things for the observer--
excellent for drawing the veil from men's motives and actions. But for the
trained reasoner to admit such intrusions into his own delicate and finely
adjusted temperament was to introduce a distracting factor which might throw
a doubt upon all his mental results. Grit in a sensitive instrument, or a
crack in one of his own high-power lenses, would not be more disturbing than
a strong emotion in a nature such as his. And yet there was but one woman to
him, and that woman was the late Irene Adler, of dubious and questionable
memory.
```

The processed text

```
+--------+---+----+
|    word| id|part|
+--------+---+----+
| scandal|305|   1|
|      in|306|   1|
| bohemia|307|   1|
|       i|308|   1|
|      to|309|   1|
|sherlock|310|   1|
|  holmes|311|   1|
|     she|312|   1|
|      is|313|   1|
|  always|314|   1|
|     the|315|   1|
|   woman|316|   1|
|       i|317|   1|
|    have|318|   1|
|  seldom|319|   1|
|   heard|320|   1|
|     him|321|   1|
| mention|322|   1|
|     her|323|   1|
|   under|324|   1|
+--------+---+----+
```

Partitions

```
df.select('part', 'title').distinct().sort('part').show(truncate=False)
```

```
+----+---------------------+
|part|title                |
+----+---------------------+
|1   |Sherlock Chapter I   |
|2   |Sherlock Chapter II  |
|3   |Sherlock Chapter III |
|4   |Sherlock Chapter IV  |
|5   |Sherlock Chapter V   |
|6   |Sherlock Chapter VI  |
|7   |Sherlock Chapter VII |
|8   |Sherlock Chapter VIII|
|9   |Sherlock Chapter IX  |
|10  |Sherlock Chapter X   |
|11  |Sherlock Chapter XI  |
|12  |Sherlock Chapter XII |
+----+---------------------+
```

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
[illegible]	[illegible]
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
[illegible]	[illegible]
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
[illegible]	[illegible]
12	arthur
13	conan

id	word
0	the
1	project
2	gutenberg
3	ebook
4	of
5	the
6	adventures
7	of
8	sherlock
9	holmes
10	by
11	sir
12	arthur
13	conan

The words are indexed

```
+---+----------+
| id|      word|
+---+----------+
|  0|       the|
|  1|   project|
|  2| gutenberg|
|  3|     ebook|
|  4|        of|
|  5|       the|
|  6|adventures|
|  7|        of|
|  8|  sherlock|
|  9|    holmes|
| 10|        by|
| 11|       sir|
| 12|    arthur|
| 13|     conan|
| 14|     doyle|
| 15|       #15|
| 16|        in|
| 17|       our|
| 18|    series|
| 19|        by|
+---+----------+
```

A moving window query

```
query = """
   SELECT id, word AS w1,
   LEAD(word,1) OVER(PARTITION BY part ORDER BY id ) AS w2,
   LEAD(word,2) OVER(PARTITION BY part ORDER BY id ) AS w3
   FROM df
"""
spark.sql(query).sort('id').show()
```

```
+---+----------+----------+----------+
| id|        w1|        w2|        w3|
+---+----------+----------+----------+
|  0|       the|   project| gutenberg|
|  1|   project| gutenberg|     ebook|
|  2| gutenberg|     ebook|        of|
|  3|     ebook|        of|       the|
|  4|        of|       the|adventures|
|...|..........|..........|..........|
```

Moving window output

```
+---+----------+----------+----------+
| id|        w1|        w2|        w3|
+---+----------+----------+----------+
|  0|       the|   project| gutenberg|
|  1|   project| gutenberg|     ebook|
|  2| gutenberg|     ebook|        of|
|  3|     ebook|        of|       the|
|  4|        of|       the|adventures|
|  5|       the|adventures|        of|
|  6|adventures|        of|  sherlock|
|  7|        of|  sherlock|    holmes|
|  8|  sherlock|    holmes|        by|
|  9|    holmes|        by|       sir|
| 10|        by|       sir|    arthur|
| 11|       sir|    arthur|     conan|
| 12|    arthur|     conan|     doyle|
+---+----------+----------+----------+
```

LAG window function

```
lag_query = """
   SELECT
   id,
   LAG(word,2) OVER(PARTITION BY part ORDER BY id ) AS w1,
   LAG(word,1) OVER(PARTITION BY part ORDER BY id ) AS w2,
   word AS w3
   FROM df
   ORDER BY id
"""

spark.sql(lag_query).show()
```

LAG window function – output

```
+---+----------+----------+----------+
| id|        w1|        w2|        w3|
+---+----------+----------+----------+
|  0|      null|      null|       the|
|  1|      null|       the|   project|
|  2|       the|   project| gutenberg|
|  3|   project| gutenberg|     ebook|
|  4| gutenberg|     ebook|        of|
|  5|     ebook|        of|       the|
|  6|        of|       the|adventures|
|  7|       the|adventures|        of|
|  8|adventures|        of|  sherlock|
|  9|        of|  sherlock|    holmes|
| 10|  sherlock|    holmes|        by|
| 11|    holmes|        by|       sir|
| 12|       ...|       ...|       ...|
+---+----------+----------+----------+
```

Windows stay within partition

```
lag_query = """
   SELECT
   id,
   LAG(word,2) OVER(PARTITION BY part ORDER BY id ) AS w1,
   LAG(word,1) OVER(PARTITION BY part ORDER BY id ) AS w2,
   word AS w3
   FROM df
   WHERE part=2
"""

spark.sql(lag_query).show()
```

Windows stay within partition – output

```
+----+----------+----------+----------+
|  id|        w1|        w2|        w3|
+----+----------+----------+----------+
|8859|      null|      null|     part2|
|8860|      null|     part2| adventure|
|8861|     part2| adventure|        ii|
|8862| adventure|        ii|       the|
|8863|        ii|       the|red-headed|
|8864|       the|red-headed|    league|
|....|..........|..........|..........|
```

Repartitioning

- PARTITION BY
- `repartition()`

Let's practice!

INTRODUCTION TO SPARK SQL IN PYTHON

Common word sequences

INTRODUCTION TO SPARK SQL IN PYTHON

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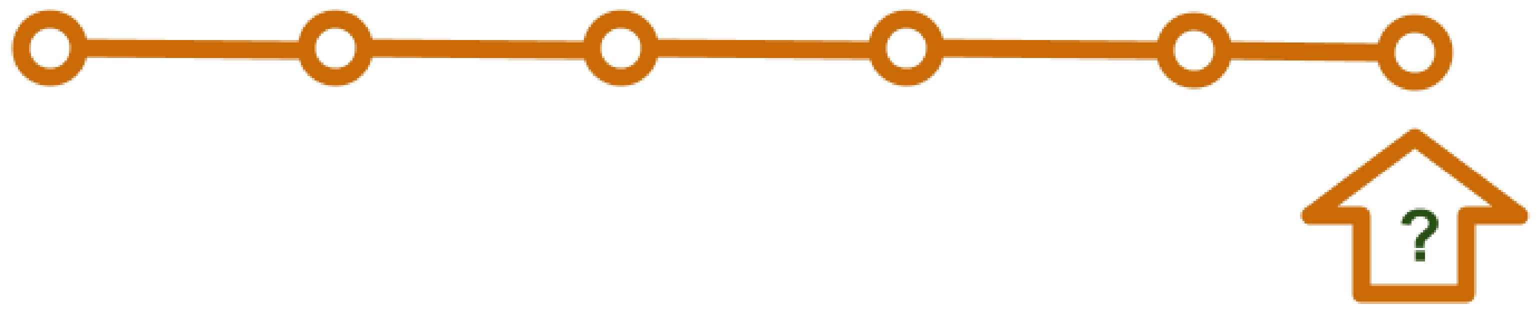
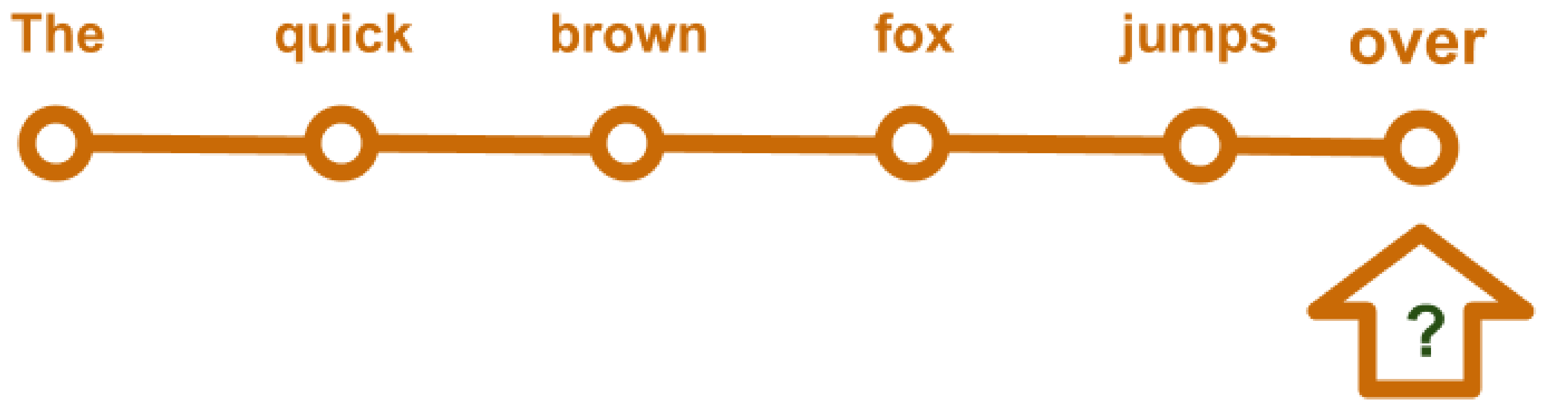
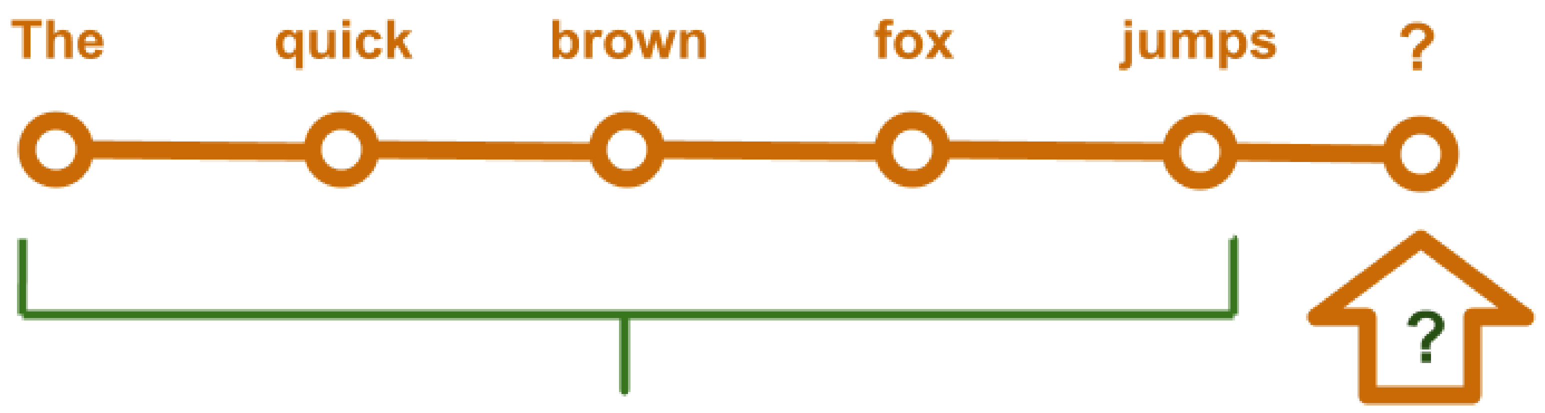
Training

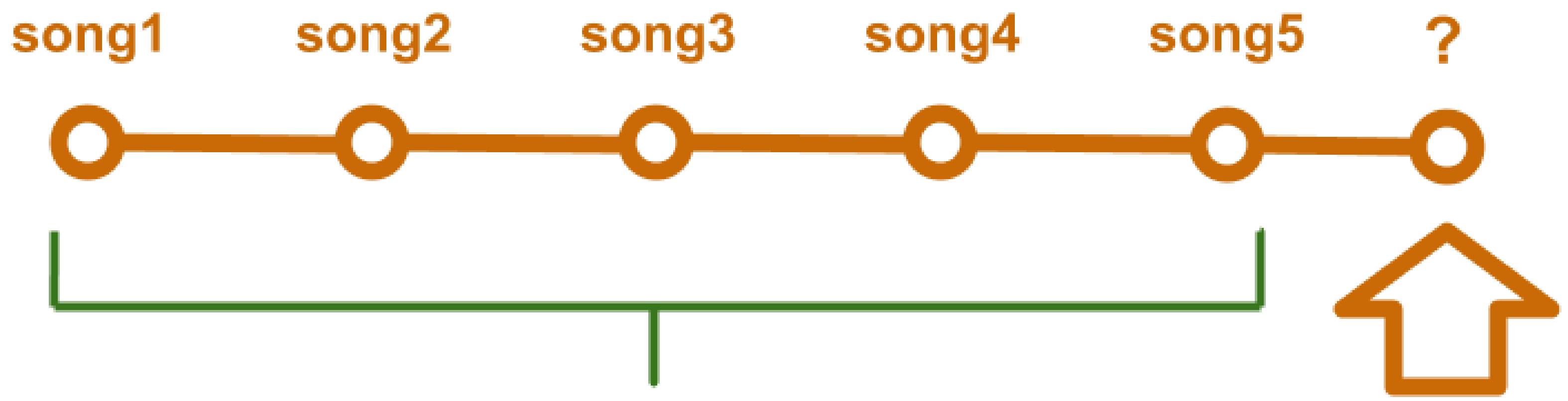
Predicting

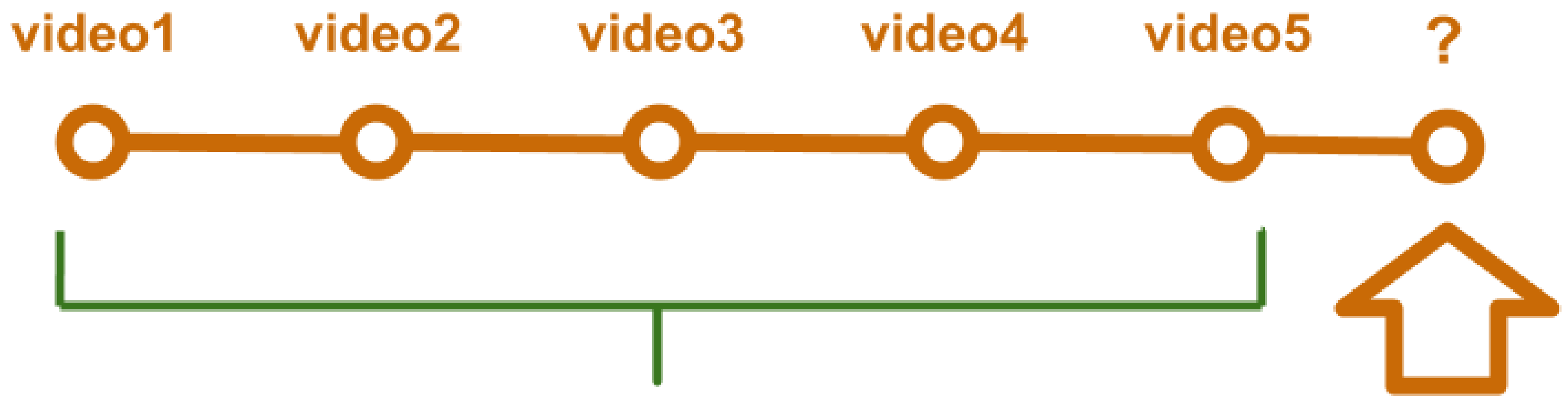
Endword Prediction




The
quick
brown
fox
jumps
over
?


The
quick
brown
fox
jumps
?
?


song1
song2
song3
song4
song5
?


video1
video2
video3
video4
video5
?

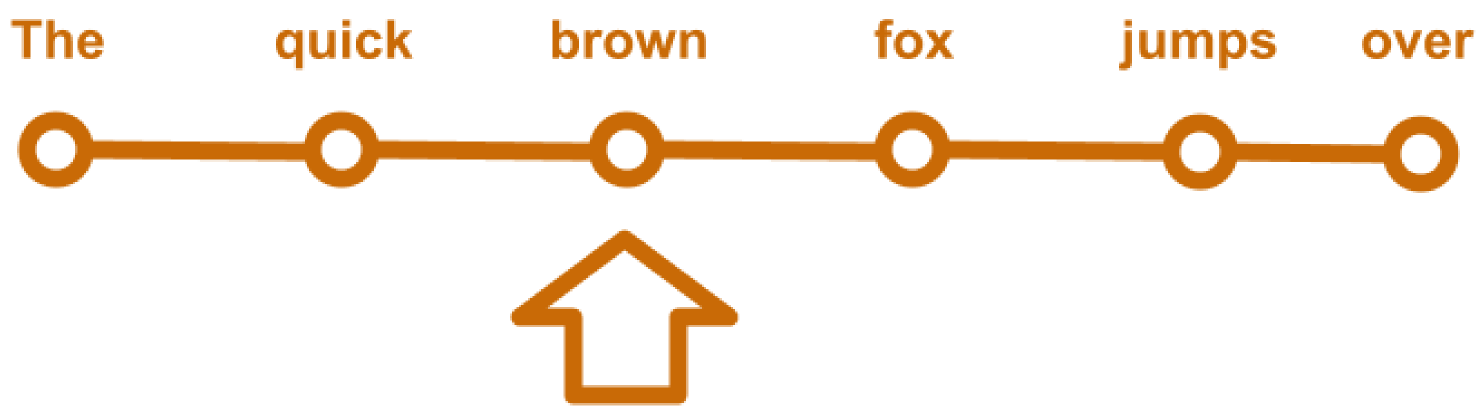
Categorical Data

Categorical vs Ordinal

- **Categorical:** he, hi, she, that, they
- **Ordinal:** 1, 2, 3, 4, 5

Sequence Analysis

Word	
quick	⇐ preceding row
brown	⇐ current row
fox	⇐ following row



3-tuples

```
query3 = """
   SELECT
   id,
   word AS w1,
   LEAD(word,1) OVER(PARTITION BY part ORDER BY id ) AS w2,
   LEAD(word,2) OVER(PARTITION BY part ORDER BY id ) AS w3
   FROM df
"""
```

A window function SQL as subquery

```
query3agg = """
SELECT w1, w2, w3, COUNT(*) as count FROM (
   SELECT
   word AS w1,
   LEAD(word,1) OVER(PARTITION BY part ORDER BY id ) AS w2,
   LEAD(word,2) OVER(PARTITION BY part ORDER BY id ) AS w3
   FROM df
)
GROUP BY w1, w2, w3
ORDER BY count DESC
"""

spark.sql(query3agg).show()
```

A window function SQL as subquery – output

```
+-----+-----+-----+-----+
|   w1|   w2|   w3|count|
+-----+-----+-----+-----+
|  one|   of|  the|   49|
|    i|think| that|   46|
|   it|   is|    a|   46|
|   it|  was|    a|   45|
| that|   it|  was|   38|
|  out|   of|  the|   35|
|.....|.....|.....|.....|
```

Most frequent 3-tuples

```
+-----+-----+-----+-----+
|   w1|   w2|   w3|count|
+-----+-----+-----+-----+
|  one|   of|  the|   49|
|    i|think| that|   46|
|   it|   is|    a|   46|
|   it|  was|    a|   45|
| that|   it|  was|   38|
|  out|   of|  the|   35|
| that|    i| have|   35|
|there|  was|    a|   34|
|    i|   do|  not|   34|
| that|   it|   is|   33|
| that|   he|  was|   30|
| that|   he|  had|   30|
| that|    i|  was|   28|
+-----+-----+-----+-----+
```

Another type of aggregation

```
query3agg = """
SELECT w1, w2, w3, length(w1)+length(w2)+length(w3) as length FROM (
   SELECT
   word AS w1,
   LEAD(word,1) OVER(PARTITION BY part ORDER BY id ) AS w2,
   LEAD(word,2) OVER(PARTITION BY part ORDER BY id ) AS w3
   FROM df
   WHERE part <> 0 and part <> 13
)
GROUP BY w1, w2, w3
ORDER BY length DESC
"""

spark.sql(query3agg).show(truncate=False)
```

Another type of aggregation

```
+-------------------+-------------------+---------------+------+
|                 w1|                 w2|             w3|length|
+-------------------+-------------------+---------------+------+
|comfortable-looking|           building|    two-storied|    38|
|         widespread|comfortable-looking|       building|    37|
|      extraordinary|      circumstances|      connected|    35|
|      simple-minded|      nonconformist|      clergyman|    35|
|       particularly|          malignant|  boot-slitting|    34|
|       unsystematic|        sensational|     literature|    33|
|       oppressively|        respectable|     frock-coat|    33|
|         relentless|        keen-witted|   ready-handed|    33|
|    travelling-cloak|                and|  close-fitting|    32|
|        ruddy-faced|      white-aproned|       landlord|    32|
|   fellow-countryman|            colonel|       lysander|    32|
+-------------------+-------------------+---------------+------+
```

Let's practice

INTRODUCTION TO SPARK SQL IN PYTHON