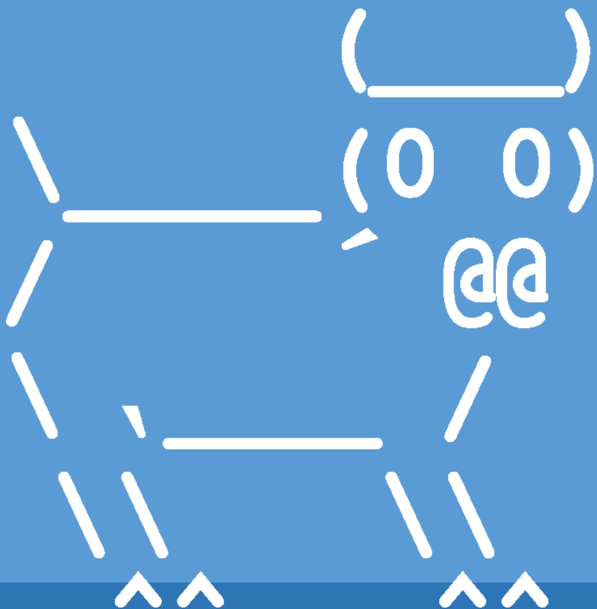
Oracle Lab: n-grams



Introduction to Computer Science

Iris Howley

LAST LAB OF THE SEMESTER!!!!!!!!!

(It's also extra credit!)

TODAY'S LESSON

n-grams

(Generating reasonable text by training a model on historical text)

Oracle Demo

Using multiple instances of a text-generating class to generate text for different characters in the same book.

Hagrid: "member . i should n'ta told yeh that ! he blurted out . i want

. yer ticket fer hogwarts   he said ."

Harry: " n't talk . i tried to turn him yellow yesterday to make him

id - he 's runnin ' back up ter the school ."

Vernon: "aid uncle vernon " so all aboard ! " where 's the cannon ?

you are boy . platform nine - platform ten ."

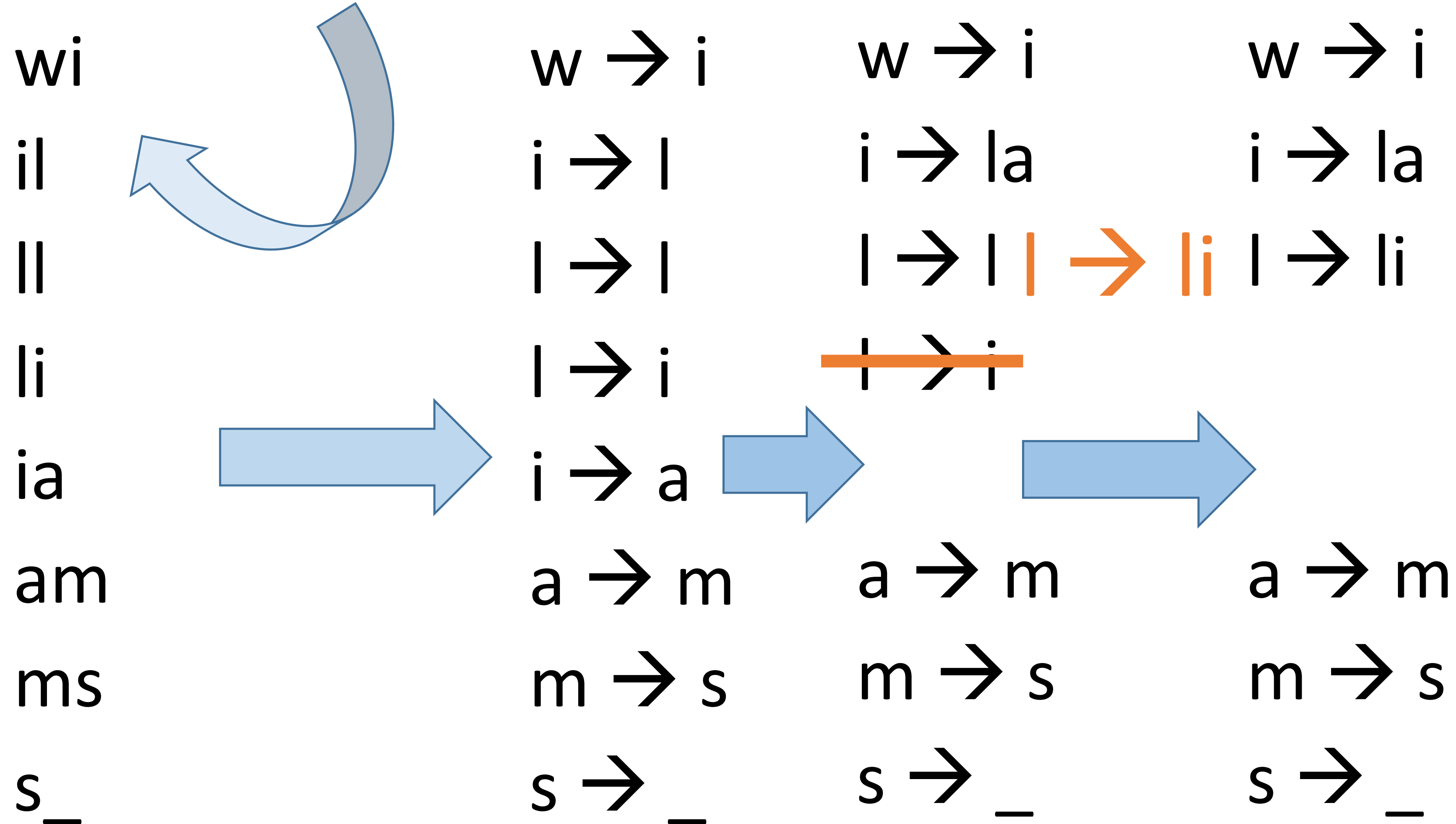
Quirrell: "ee the stone...i 'm presenting it to my master...but where is

vering treble either but cold and sharp ."

Dumbledore: "dungeons between you and professor quirrell is a complete secret

prises even me sometimes...now enough questions ."

williams



WHAT DOES THIS REPRESENT?

A fingerprint

The distribution, from our data, of letters that can follow a given letter sequence

We can use this to randomly generate similar text as the original.

w → i

i → la

l → li

a → m

m → s

1. Randomly select a n-1 gram (on the left)
2. Let's say we select 'i'
3. Given i, the next letter can be
   1. either 'l' or 'a' with 50% chance each
4. Let's say we randomly pick 'a'
5. Now, given 'a', what can we choose?
   1. Only m!
6. And then s follows
7. s doesn't have an entry, so what do we do?
   - We can randomly pick a new letter, now we have a new n-1 gram!
   - …start again from the top, until we decide to stop!

i

ia

iam

iams

Given more data, our output (blue) will have more possible outcomes.

N-grams

w → i

i → la

l → li

a → m

m → s

- We've been working with 2-grams or bigrams
- There's also trigrams:
  - wil, ill, lli, lia, iam, ams
- Which we can turn into a distribution as follows
  - wi → l, il → l, ll → i, li → a, ia → m, am → s
- 4-grams, 20-grams, etc. etc.
- We call these "n-grams"

wi → l

il → l

ll → i

li → a

ia → m

am → s

What will we need to build our text-generating ORACLE ??

- Choose an n for our n-gram
- Some text to build the letter distribution → file input!
- A data structure to hold the letter distribution/fingerprint
- Somewhere to start generating new text
- Something to do when we run out of letters (i.e. what comes after the ‘s’ in Williams?)
  - We’ll need to store our text

Why use classes instead of a pile of functions?

- Encapsulation! Abstraction!
- Maintaining state
  - But we must write our methods to maintain that state

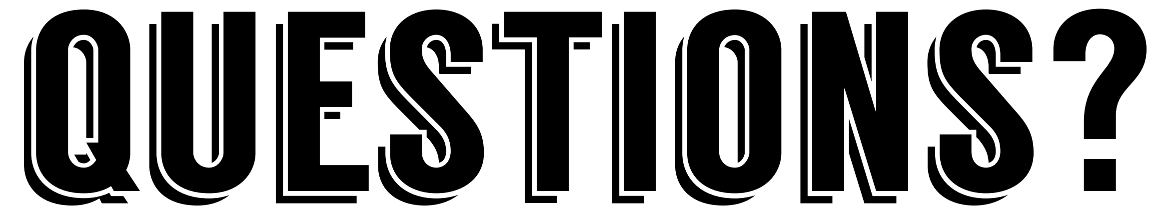
Why use classes instead of a pile of functions?

- Multiple oracles at the same time!

```
ha = Oracle()
…
print(next(ha.lines()))
```

```
dr = Oracle()
…
print(next(dr.lines()))
```

```
he = Oracle()
…
print(next(he.lines()))
```



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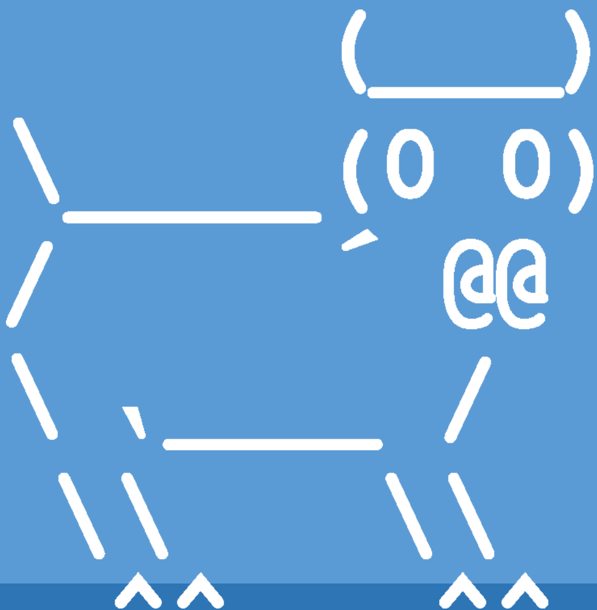
Oracle Lab: Starter Code



Introduction to Computer Science

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TODAY'S LESSON

Lab 10

(Generating reasonable text by training a model on historical text)

ENCAPSULATING DATA IN CLASSES TO GENERATE HUMAN-LIKE TEXT

Classes + Dictionaries + Generators + Files

Look at oracle.py

- `__slots__ = [ '_corpus', '_dist', '_n' ]`
  - A special list to hold the class' attributes
  - It restricts the attributes to just these!

- __XXXX__ are special python variables/functions
  - `__name__, __all__, __slots__,` many others!
  - _XXX are variables/functions we don't want to be public
  - Won't show up in pydoc3, etc. Just for our use in this Oracle class!

How we interact with Oracle

```
g = Oracle()
```

When we create an instance of a class, that class's __init__() method is called

```
g.scan(text)
for line in g.lines():
    print(line)
```

```
def __init__(self):
```

`self` is always passed to class methods

- `self` refers to this particular object (i.e., an object reference)
- When we see `self.`something, we know it's a variable, method, etc. associated with a particular instance of a class

def __init__(self):

```
def __init__(self, n = 4):
        """Initialize the oracle with n-gram size n."""
        self._n = n
        self._dist = dict()
        self._corpus = ""
```

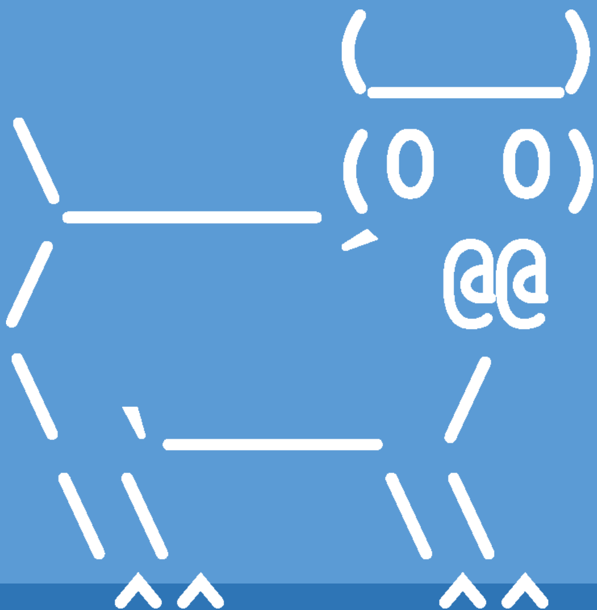
__init__ sets the initial values for attributes within the instance of the class

def __init__(self):

```
def __init__(self, n = 4):
        """Initialize the oracle with n-gram
size n."""
        self._n = n
        self._dist = dict()
        self._corpus = ""
```

Can be used to set default values in case the user doesn't pass an argument

Oracle Lab: Using the Oracle



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How we interact with Oracle

```
g = Oracle()

g.scan(text)
for line in g.lines():
    print(line)
```

What does this line imply about Oracle's `lines()` method?

`for line in myoracle.lines():`

- `.lines()` is a generator
  - yields lines instead of returning lines!
- Our `.lines()` function will produce a generated line of text that will fit on a single line on the console (70-80 characters)
- But we still need a way to generate individual letters to put in the line
  - `for <variable> in <sequence>`
  - `__iter__(self)` function is called on the <sequence> object
    - Review Lecture 13/14 on Iterators (and review generators, too)
  - It also yields an element from the sequence, one at a time

How we interact with Oracle

```
g = Oracle()

g.scan(text)
for line in g.lines():
    print(line)
```

When does this stop printing lines?

WHEN WE HAVE AN INFINITE GENERATOR, HOW TO PRINT LIMITED NUMBER OF VALUES?

Printing Limited Values from Infinite Generator

- Will count off even numbers forever:

```
>>> def countEveryOther():
...     current = 0
...     while True:
...             yield current
...             current +=2
```

- Print the values from the generator:

```
>>> g = countEveryOther()
>>> for num in g:
...     print(num)
```

- Will print even numbers *infinitely* (too fast to read)!!

Printing Lim ... te Generator

```
2004612
2004614
2004616
2004618
2004620
2004622
2004624
2004626
2004628
2004630
2004632
2004634
2004636
2004638
2004640
2004642
2004644
2004646
2004648
2004650
2004652
2004654
2004656^C2004658
Traceback (most recent call last):
  File "<stdin>", line 2, in <module>
KeyboardInterrupt
```

Printing Limited Values from Infinite Generator

- Will count off even numbers forever:

```
>>> def countEveryOther():
...     current = 0
...     while True:
...             yield current
...             current +=2
```

- Print the first 10 values from the generator:

```
>>> g = countEveryOther()
>>> for _, num in zip(range(10), g):
...     print(num)
```

- Built-in `zip(..)` function *zips* iterable objects together!

`zip(iterable1, iterable2)`

```
>>> x = [1, 2, 3]
>>> y = [4, 5, 6]
>>> zipped = zip(x, y)
>>> list(zipped)
[(1, 4), (2, 5), (3, 6)]
```

Note that `zip(..)` produces a sequence of tuples:

`(iterable1[0], iterable2[0])`…

`zip(iterable1, iterable2)`

```
>>> x = (1, 2, 3, 4, 5, 6)
>>> y = {7, 8, 9}
>>> zipped = zip(x, y)
>>> list(zipped)
[(1, 8), (2, 9), (3, 7)]
```

Note that `zip(...)` only produces these paired tuples until one of the iterables parameters runs out of items!

https://docs.python.org/3/library/functions.html#zip

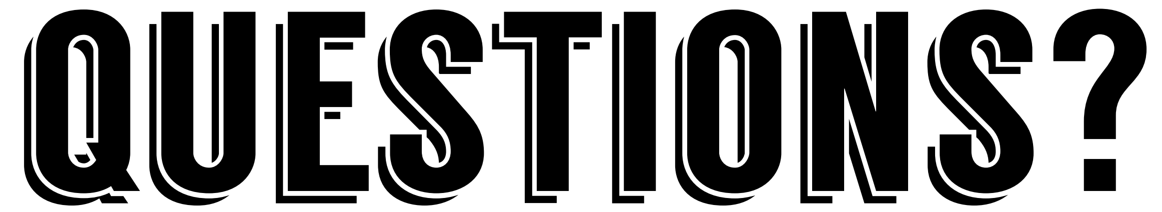
How we interact with Oracle

```
g = Oracle()



g.scan(text)
for _,line in zip(range(1000), g.lines()):
        print(line)
```

This prints only the first 1000 lines of our Oracle-generated text!



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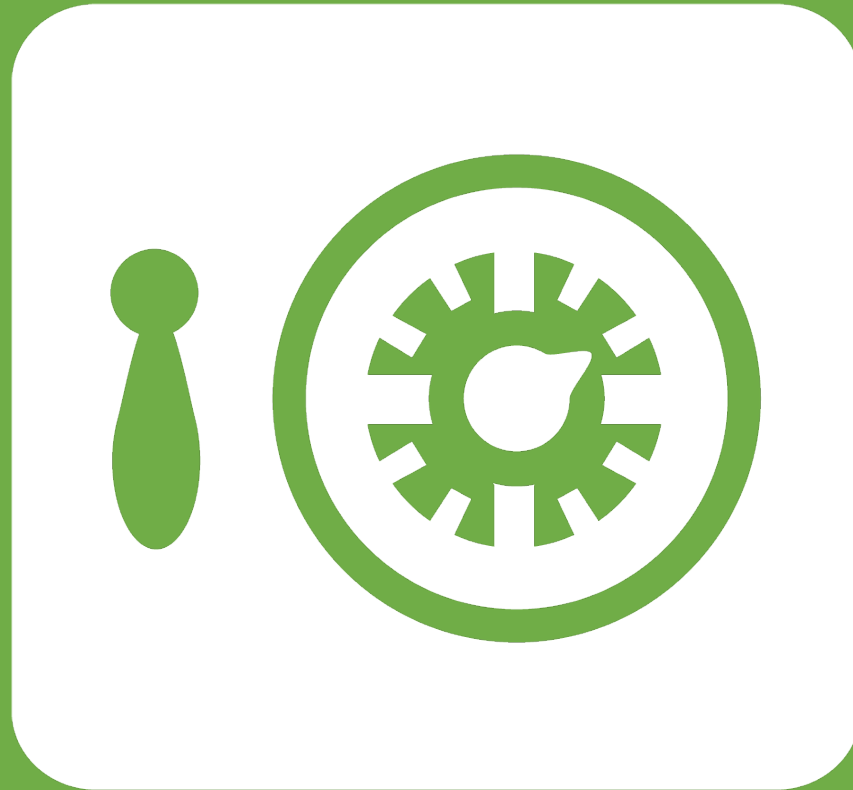

Leftover Slides

Classes

```
>>> from oracle import Oracle
>>> o = Oracle()
```

- `>>> type(o)`
- `<class 'oracle.Oracle'>`

- o is an instance of the class, `Oracle`
- Classes are user-defined types

Classes

```
>>> from oracle import Oracle
>>> o = Oracle()
>>> o
   <oracle.Oracle object at 0x103485e48>
```

...Define the __repr__() function in the oracle class

```
>>> from oracle import Oracle
>>> o = Oracle()
>>> o
   REPR(): Oracle(n=4)
```

Selecting an item from a sequence

```
>>> from random import choice
>>> l = ['a','b','c','d']
>>> print(choice(l))
b
>>> print(choice(l))
d
>>> print(choice(l))
a
>>> print(choice(l))
c
>>> print(choice(l))
b
```

```
>>> s = "The mountains!"
>>> print(choice(s))
T
>>> print(choice(s))
a
>>> print(choice(s))
n
>>> print(choice(s))
a
>>> print(choice(s))
!
```

Shannon Entropy

$$H = -\sum_{i=0}^{N-1} p_i \log_2 p_i$$

- Average rate at which information is produced by our data
  - The unexpectedness of a sequence of characters we select

- The **entropy of** a random variable is calculated with this formula:

1. Where p_i is the probability of seeing a given n-gram in our data
2. Given a set of n observations
   - Where each observation is a different sequence of characters observed in our data
3. Compute p_i for the range all observations multiply by log2(p_i)
4. Sum across all values

__slots__ = []

```
>>> class Yesteryears:
...     """ demo of classes from last week """
...
>>> yy = Yesteryears()
>>> yy.start = 2018
>>> yy.end = 2022
>>> yy.mid = 2020
>>> yy.whatev = "I do what I want!"
```

```
>>> class Years:
...     __slots__ = ['start','end']
...
>>> newy = Years()
>>> newy.start = 2017
>>> newy.end = 2021
>>> newy.mid = 2019
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AttributeError: 'Years' object has no attribute 'mid'
```

Classes

```
>>> Class Years:
    """ Define some attributes """
>>> y = Years()
>>> y
    <__main__.Years object at 0x108c63860>
>>> from oracle import Oracle
>>> o = Oracle()
>>> o
    <oracle.Oracle object at 0x103485e48>
```

This is __name__!!!!