Python Intro — Part 2

Loops, Spectrograms

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January 31, 2017

KnitR

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KnitR

First, a small aside...

- This entire presentation is a KnitR demonstration, as well as a presentation on Python
- Check out the .Rnw file at `https://github.com/guestdaniel/python_intro/tree/master/02_spectrograms`
- KnitR mixes R and LaTeX to generate high quality publications and presentations
  - This makes it super easy to include graphics
  - KnitR also has nice options for syntax highlighting for many programming languages
- I'm using the LaTeX beamer package to create this slideshow

First, a small aside...

A nice demonstration of KnitR!

```
head(select(iris, Sepal.Width, Petal.Length, Petal.Width, Species))
```

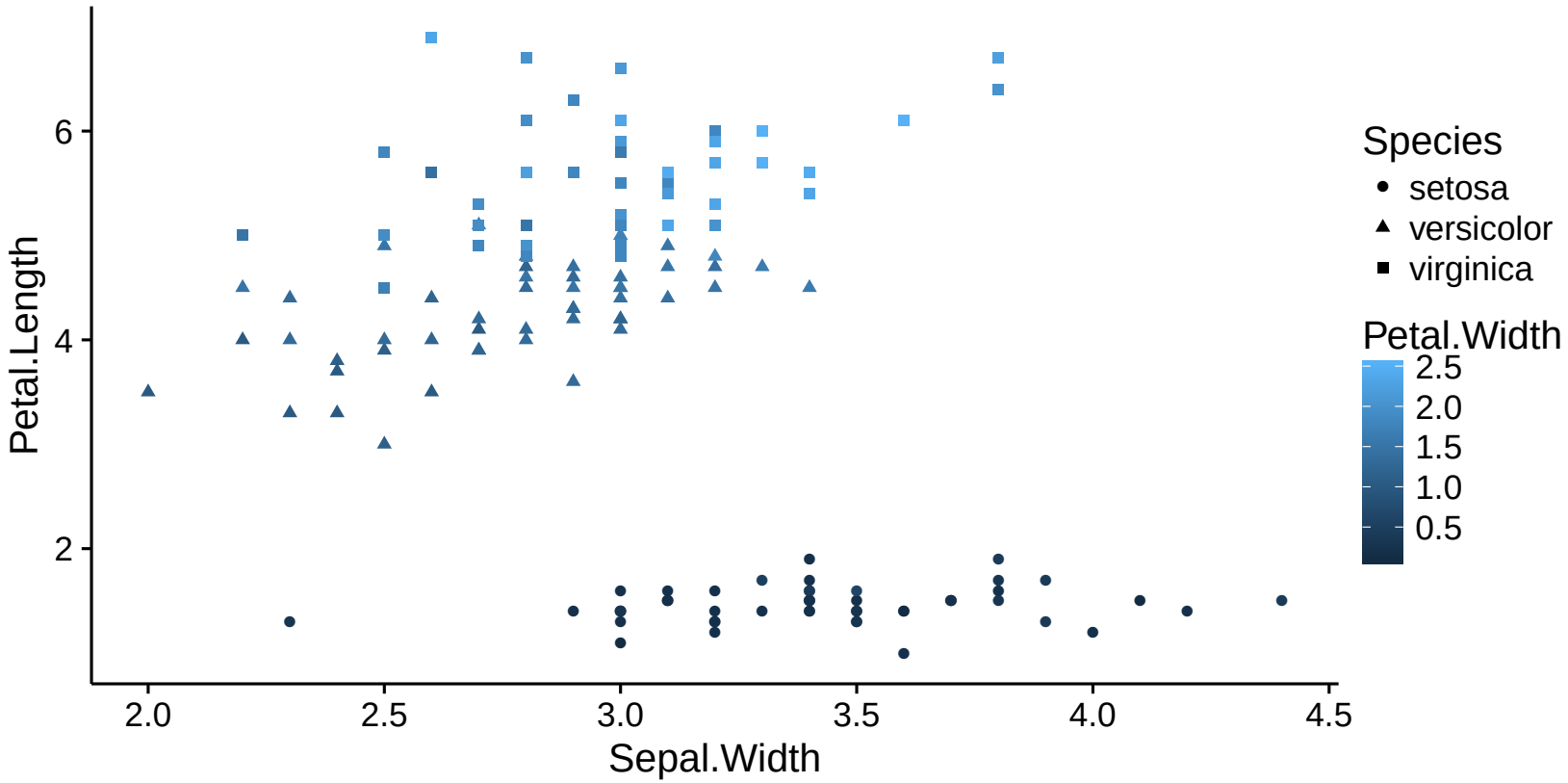
```
##   Sepal.Width Petal.Length Petal.Width Species
## 1         3.5          1.4         0.2  setosa
## 2         3.0          1.4         0.2  setosa
## 3         3.2          1.3         0.2  setosa
## 4         3.1          1.5         0.2  setosa
## 5         3.6          1.4         0.2  setosa
## 6         3.9          1.7         0.4  setosa
```

```
head(iris %>% group_by(Species) %>% summarize(wid.mean = mean(Sepal.Width), wid.sd = sd(Sepal.Width)))
```

```
## # A tibble: 3  3
##      Species wid.mean    wid.sd
##       <fctr>    <dbl>     <dbl>
## 1     setosa    3.428 0.3790644
## 2 versicolor    2.770 0.3137983
## 3  virginica    2.974 0.3224966
```

First, a small aside...

```
ggplot(iris, aes(x=Sepal.Width, y=Petal.Length, color=Petal.Width, shape=Species)) + geom_point()
```



Intro

Plan

- We're going to focus on two things
  1. Theoretical — control statements and loops
  2. Practical — applying numpy and scipy to analyze sound
- What we'll need
  1. Python 3 (through IPython)
  2. numpy, scipy, matplotlib, sounddevice
  3. Sound files (in folder "samples")
- Overview
  1. Get the packages we need
  2. Set up editor
  3. A brief intro to loops
  4. Make one spectrogram
  5. Make a bunch of spectrograms

Packages

Installing sounddevice

- Why we need each of the following packages is explained later!
- We should already have numpy, scipy, and matplotlib installed through Conda
- However, we do need to install sounddevice, which will allow us to play sound from a numpy array
- To do this using Conda, we type in a generic terminal window...
  conda list
- We notice sounddevice is not on our list, so...
  conda search sounddevice
  conda install sounddevice

Scripts

Editors

- Today, we'll just be writing scripts in Notepad, saving them to disk, and then running them through the IPython terminal
- You'll soon probably want something more fully fledged, more like MATLAB or RStudio
  1. Spyder
  2. Eclipse
  3. SublimeText
  4. PyCharm
- Now, let's open up Notepad...

Writing and running a script

- First we write a series of commands in Notepad
- Note that Python is sensitive to indentation — where MATLAB uses "end" and R brackets, Python uses indentation to indicate nested statements and such
- Starting with something simple...

```
print(2+2)
```

- Save this using Notepad to a file called "test.py"
- Then, in your terminal, say...
  python3 C:/your_directory_here/test.py

Loops

Our first loop

- Loops in Python have a very easy and powerful syntax

```
for i in range(5):
 print(i)

## 0
## 1
## 2
## 3
## 4
```

Loop syntax

- As previously mentioned, Python uses indentation to indicate nesting
- If we don't indent at least one line for a loop we'll have problems
- I personally like this, I think it promotes more readable code!

```
for i in range(5):
print(i)

##   File "<string>", line 2
##     print(i)
##         ^
## IndentationError: expected an indented block
```

Looping over other things

- We can loop over a variety of objects
- The range() function is for when we want integer sequences, but many things in Python can be used to create a loop (technically, these things are called iterables in Python-lingo)
- Lists are iterables...
- You can also define your own custom objects to be iterables!

```
x = [1,4,9,16,25]
for i in x:
 print(str(i) + str(x))

## 1[1, 4, 9, 16, 25]
## 4[1, 4, 9, 16, 25]
## 9[1, 4, 9, 16, 25]
## 16[1, 4, 9, 16, 25]
## 25[1, 4, 9, 16, 25]
```

Looping over other things

- Strings are also iterables...

```
for i in "Hello":
 print(i)

## H
## e
## l
## l
## o
```

Nested loops

- Just like in other languages, we can nest for loops to do more powerful things

```
bases = [1, 2, 3]
expos = [1, 2, 3, 4]
for base in bases:
 print("Base:" + str(base))
 for expo in expos:
  print(str(base) + "^" + str(expo) + "=" + str(base**expo))
```

```
## Base:1
## 1^1=1
## 1^2=1
## 1^3=1
## 1^4=1
## Base:2
## 2^1=2
## 2^2=4
## 2^3=8
## 2^4=16
## Base:3
## 3^1=3
## 3^2=9
## 3^3=27
## 3^4=81
```

- Naturally, we can mix loops and other control statements

```
for i in range(10):
 if i < 3:
  print(i)
 elif i > 3 and i < 6:
  print(i*100)
 elif i == 8:
  break
 else:
  print("Hello")

## 0
## 1
## 2
## Hello
## 400
## 500
## Hello
## Hello
```

Making a spectrogram

Setting up the environment

- First, we need to import the necessary modules

```
import numpy as np
from scipy.io import wavfile
import matplotlib.pyplot as plt
import sounddevice as sd
```

- numpy — provides key matrix and DSP operations
- wavfile — provides read/write to wavfile
- pyplot — user-friendly functions and objects for plotting
- sounddevice — playback from numpy arrays

Game Plan

1. Import one signal
2. Collect measurements of amplitude in each time frequency bin
3. Plot it
4. Save the plot to file
5. Loop the above four steps as necessary
6. Put everything in a script

Importing a sound file

- The following pertains specifically to certain types of .wav files
- For other file types or unusual .wavs, you may need to do some research!

```
location =
"/home/daniel/Desktop/samples/m03ae.wav"
[fs, y] = wavfile.read(location)
```

- This will place the sampled waveform contained in m03ae.wav with sample rate fs into the numpy vector y
- We can see what this waveform looks like with ...

```
y = y/np.max(np.abs(y))
plt.plot(y)
```

- And what it sounds like with...

```
sd.play(y,fs)
```