Midterm Sim - Mon 02, Nov 2020

November 1, 2020

Scientific Programming - Data Science @ University of Trento

This simulation gives you NO credit whatsoever: If you do everything wrong, you lose nothing. If you do everything correct, you gain nothing

0.0.1 What to do

1) Download `sciprog-ds-2020-11-02-exam.zip` and extract it on your desktop.
2) Rename `sciprog-ds-2020-11-02-FIRSTNAME-LASTNAME-ID` folder: put your name, lastname an id number, like `sciprog-ds-2020-11-02-john-doe-432432`

From now on, you will be editing the files in that folder. At the end of the exam, that is what will be evaluated.

3) Edit the files following the instructions in this worksheet for each exercise. Every exercise should take max 25 mins. If it takes longer, leave it and try another exercise.
4) When done:

- if you have unitn login: zip and send to examina.icts.unitn.it/studente
- If you don't have unitn login: tell instructors and we will download your work manually

1 Part A - Galactic Love

Open Jupyter and start editing this notebook `exam-2020-11-02.ipynb`

Since this is a pseudo-exam, you are going to do pseudo-science!

The company Astro Logic provides horoscopes to thousands of loyal customers, who each day require a number of divinitions. The most requested is whether or not they should engage in love affairs with a potential partner, who of course is chosen according to rigourous criteria like his/her astrological sign. You are then hired to devise a fancy visualization which given two astrological signs and their love compatibility, displays the constellations of their signs close when the the compatibility is high and far away when compatibility is low.

1.1 parse_stars

Let's start with real astronomical data. You are given a database of constellations called `stars.csv` (we slightly tweaked it for this occasion - original data source: Space Telescope Science Institute)

[2]:
```
import pandas as pd

stars_df = pd.read_csv('stars.csv', encoding='UTF-8')
stars_df[0:32]
```

[2]:

	constellation	type	ra	dec	description
0	Andromeda	0	3717	2539	move gamma 1
1	Andromeda	1	2091	2137	draw beta
2	Andromeda	1	1179	1851	draw delta
3	Andromeda	1	251	1745	draw alpha
4	Andromeda	0	1716	1405	move eta
5	Andromeda	1	1420	1456	draw zeta
6	Andromeda	1	1156	1758	draw epsilon
7	Andromeda	1	1179	1851	draw delta
8	Andromeda	1	1106	2023	draw pi
9	Andromeda	1	512	2320	draw theta
10	Andromeda	1	42544	2596	draw iota
11	Andromeda	1	42612	2660	draw kappa
12	Andromeda	1	42526	2787	draw lambda
13	Andromeda	0	42544	2596	move iota
14	Andromeda	1	41457	2539	draw omicron
15	Andromeda	0	1106	2023	move pi
16	Andromeda	1	2091	2137	draw beta
17	Andromeda	1	1702	2309	draw mu
18	Andromeda	1	1494	2464	draw nu
19	Andromeda	1	2085	2834	draw phi
20	Andromeda	1	2939	2917	draw 51
21	Andromeda	-1	0	0	NaN
22	Antlia	0	17077	-2157	move epsilon
23	Antlia	2	18814	-1864	dotted alpha
24	Antlia	2	19701	-2228	dotted iota
25	Antlia	-1	0	0	NaN
26	Apus	0	26635	-4742	move alpha
27	Apus	2	29803	-4733	dotted gamma
28	Apus	2	30092	-4651	dotted beta
29	Apus	2	29410	-4721	dotted delta 1
30	Apus	2	29803	-4733	dotted gamma
31	Apus	-1	0	0	NaN

You will have to parse it so to obtain a dictionary which maps each constellation to its stars, expressed as a list of lists of points type and coordinates.

Since later we will need to show points in a 2d chart, you will have to transform the coordinates

obtained from the data (right ascension and declination in degrees) as follows:

$x = \frac{15}{1800} ra$

$y = \frac{dec}{60}$

[3]:
```
import csv

def parse_stars(filename):
    raise Exception('TODO IMPLEMENT ME !')

stars_db = parse_stars('stars.csv')
```

You can find the complete output in `expected_stars_db.py`

Excerpt:

```
python {'Andromeda': [ [0, 30.974999999999998,
42.31666666666666], [1, 17.425, 35.61666666666667], [1,
9.825000000000001, 30.849999999999998], [1, 2.091666666666667,
29.083333333333332], [0, 14.3, 23.416666666666668], [1,
11.833333333333332, 24.266666666666666], [1, 9.633333333333333,
29.3], [1, 9.825000000000001, 30.849999999999998], [1,
9.216666666666667, 33.71666666666667], [1, 4.266666666666667,
38.666666666666664], [1, 354.5333333333333, 43.266666666666666],
[1, 355.09999999999997, 44.333333333333336], [1, 354.3833333333333,
46.45], [0, 354.5333333333333, 43.266666666666666], [1,
345.475, 42.31666666666666], [0, 9.216666666666667, 33.71666666666667],
[1, 17.425, 35.61666666666667], [1, 14.183333333333334,
38.483333333333334], [1, 12.45, 41.06666666666666],
[1, 17.375, 47.233333333333334], [1, 24.491666666666667,
48.61666666666667], [-1, 0.0, 0.0] ], 'Antlia': [
[0, 142.30833333333334, -35.95], [2, 156.78333333333333,
-31.066666666666666], [2, 164.175, -37.13333333333333],
[-1, 0.0, 0.0] ], . . . }
```

1.2 plot_stars 1

Write a function `plot_stars` to plot constellations

WARNING: DO NOT use GraphViz!

Even if we are making plots which look like networks, for these visualizations you just need basic matplotlib (and some creativity ;-)

WARNING: for now, ignore the `new_center` parameter

A point type can either be:

- `0`: start a new line not connected with the previous one
- `1`: connect previous point with a straight segment

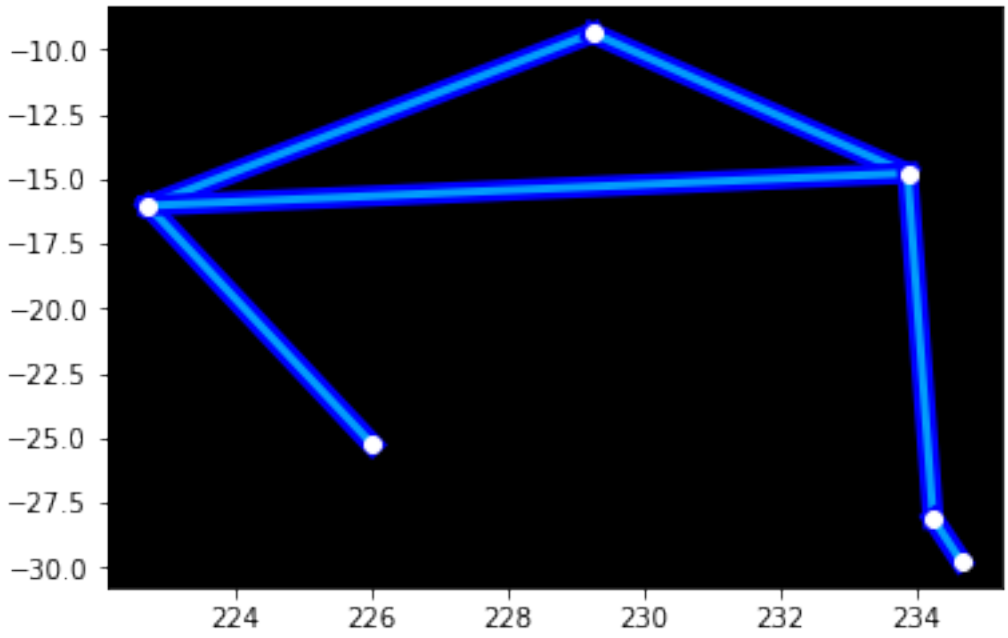
- 2: connect previous point with a dotted segment (draw it with `linestyle=':'` parameter)
- `-1`: last point, ignore

Available colorschemes are `'M'`, `'F'`, or `'R'` (red)

- to set a black background, set `plt.rcParams['axes.facecolor'] = 'black'`
- to get a nice glowing effect for the lines, draw twice: once with a thick line and dark color, and once with a thin line with a bright color. You can find the colors in `color_schemes`. To set them in `plt.plot` call, use `linewidth` (sets width in pixels) and `color` parameters
- draw stars as white dots, setting `markersize=6`

[4]:
```
%matplotlib inline

import numpy as np
import matplotlib.pyplot as plt

color_schemes = {
    'M': ('blue', '#039dfc'),
    'F': ('purple', 'pink'),
    'R': ('darkred', 'red')
}

def plot_stars(constellation_name, color_scheme, stars, new_center=None):
    raise Exception('TODO IMPLEMENT ME !')

from pprint import pprint
pprint(stars_db['Libra'])
plot_stars('Libra', 'M', stars_db)
```

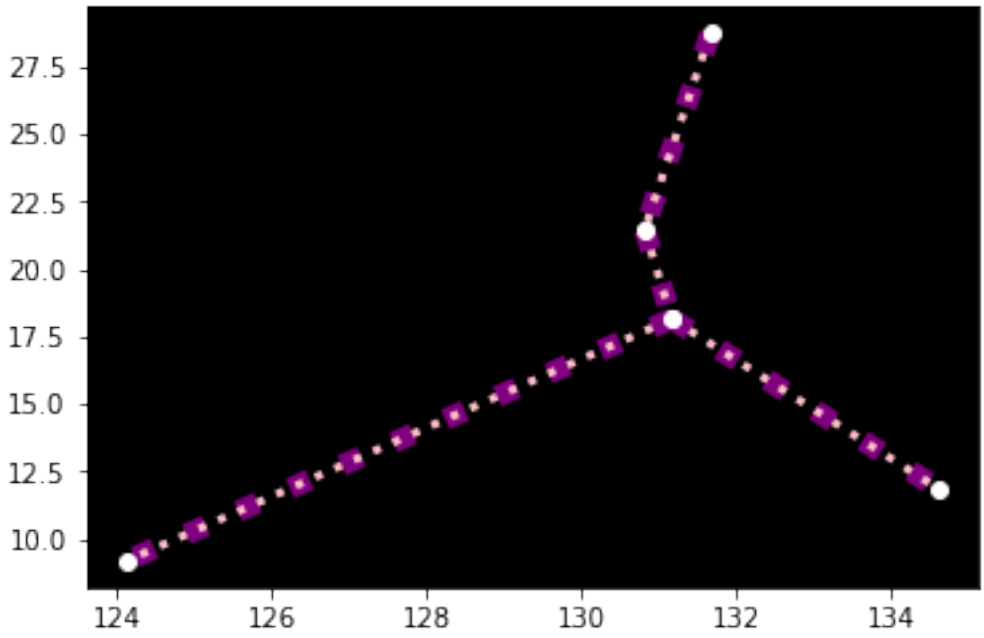
```
[[0, 226.01666666666665, -25.266666666666666],
 [1, 222.71666666666667, -16.03333333333333],
 [1, 229.25, -9.366666666666667],
 [1, 233.875, -14.783333333333333],
 [1, 222.71666666666667, -16.03333333333333],
 [0, 233.875, -14.783333333333333],
 [1, 234.25, -28.133333333333333],
 [1, 234.65833333333333, -29.766666666666666],
 [-1, 0.0, 0.0]]
```



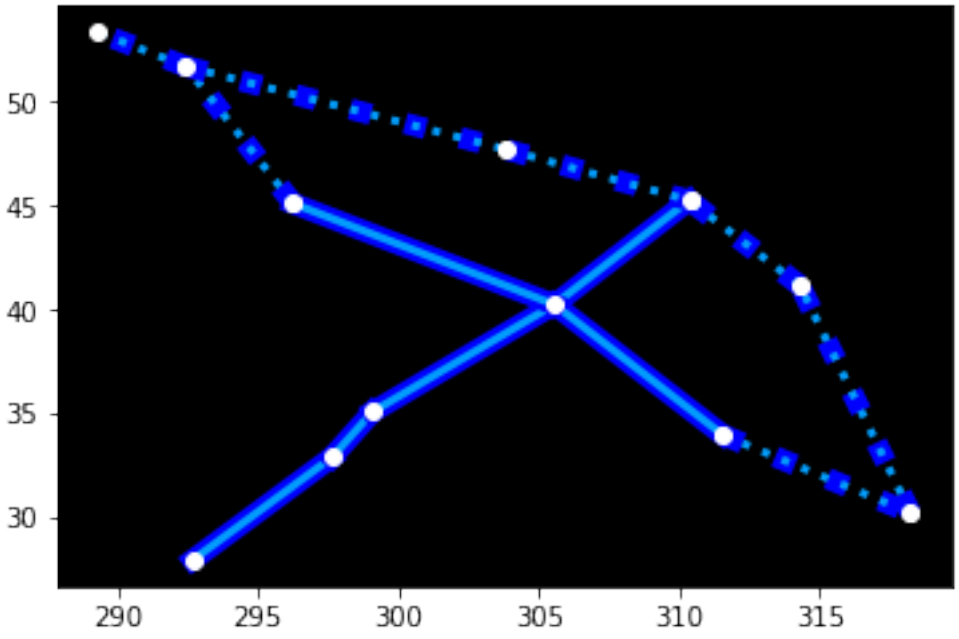
[5]:
```
stars_db['Cancer']   # has type-2  dotted points
```

[5]:
```
[[0, 131.66666666666669, 28.75],
 [2, 130.8166666666667, 21.466666666666665],
 [2, 131.16666666666666, 18.15],
 [2, 134.61666666666667, 11.85],
 [0, 131.16666666666666, 18.15],
 [2, 124.125, 9.183333333333334],
 [-1, 0.0, 0.0]]
```

[6]:
```
plot_stars("Cancer", 'F', stars_db)  # mixed segments
```



[7]:
```
plot_stars("Cygnus", 'M', stars_db)  # mixed segment types
```

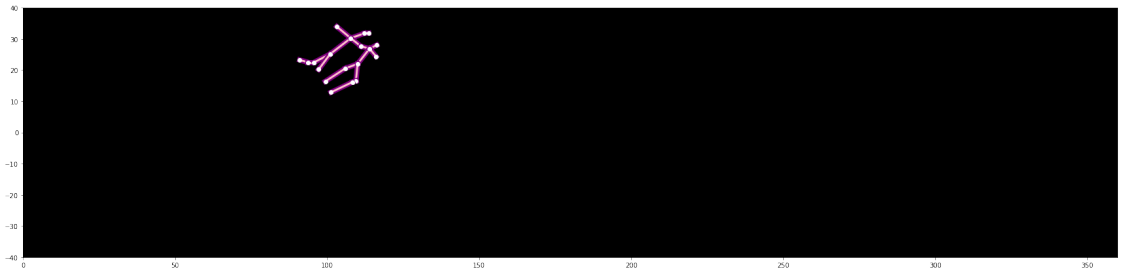


1.3 plot_stars 2 - new_center

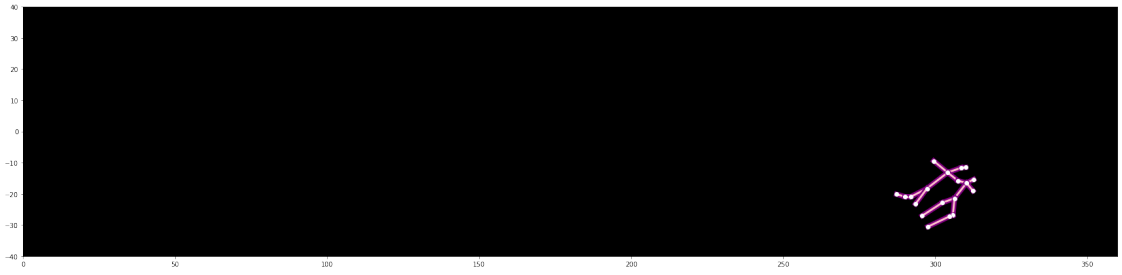
Change the previous function `plot_stars` so it accepts a new argument `new_center`, which is either `None` or a tuple of coordinates where the constellation should be centered:

- be precise in determining the boundaries of the constellation
- **DO NOT** assume the constallation has a fixed width nor height (so no constants in code!)

[8]:
```
fig = plt.figure(figsize=(30,7))
plt.xlim(0,360)
plt.ylim(-40,40)
plot_stars('Gemini', 'F',stars_db, new_center=None)  # no translation
```



[9]:
```
fig = plt.figure(figsize=(30,7))
plt.xlim(0,360)
plt.ylim(-40,40)
plot_stars('Gemini', 'F',stars_db, new_center=(300, -20))  # centered in 300, -20
```



1.4 parse_zodiac

You are given a file `zodiac.csv`. For each sign, the table contains astrological information and affinity with other signs, expressed as a relation matrix:

[10]:
```
import pandas as pd
df = pd.read_csv('zodiac.csv', encoding='UTF-8')
df[:4]
```

```
[10]:   Constellation  House Glyph Symbol                  Dates Element  \
       0         Aries      1         Ram  21 March\n-\n20 April    Fire
       1        Taurus      2        Bull    21 April\n-\n21 May   Earth
       2        Gemini      3       Twins     22 May\n-\n21 June     Air
       3        Cancer      4        Crab    22 June\n-\n21 July   Water

             Quality Ruling Planet Day/Night  Aries   …    Gemini  Cancer  Leo  \
       0    Cardinal           Mars       Day    NaN   …       4.0     NaN  5.0
       1       Fixed          Venus     Night    NaN   …       NaN     4.0  NaN
       2     Mutable        Mercury       Day    4.0   …       NaN     NaN  4.0
       3   Cardinal            Moon     Night    NaN   …       NaN     NaN  NaN

          Virgo  Libra  Scorpius  Sagittarius  Capricornus  Aquarius  Pisces
       0    NaN    NaN       NaN          5.0          NaN       4.0     NaN
       1    5.0    NaN       NaN          NaN          5.0       NaN     4.0
       2    NaN    5.0       NaN          NaN          NaN       5.0     NaN
       3    4.0    NaN       5.0          NaN          NaN       NaN     5.0

       [4 rows x 21 columns]
```

Parse the table so to get a a dictionary of dictionaries, with some selected data:

- affinities are in the scale 1-5, normalize them to floats 0.0-1.0
- dates contain `\n` , normalize them so to have dates separated by a dash as in `21 March-20 April`

NOTE: To parse the file, a `csv.reader` is sufficient, it's not necessary to use pandas - even if data seem to span multiple lines because of the `\n` in dates, note they are bounded by `"` so rows will be correctly parsed by `csv.reader`

You can find the complete output in `expected_zodiac_db.py`

```
{
 'Aquarius': {
              'affinities': {
                             'Aries': 0.8,
                             'Gemini': 1.0,
                             'Libra': 1.0,
                             'Sagittarius': 0.8
                            },
              'dates': '21 January-18 February',
              'glyph': ' ',
              'house': 11
             },
 'Aries':    {
              'affinities': {
                             'Aquarius': 0.8,
                             'Gemini': 0.8,
                             'Leo': 1.0,
```

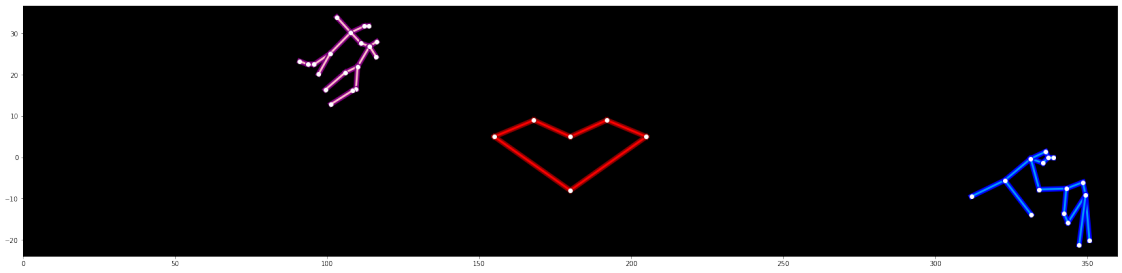
```
                                'Sagittarius': 1.0
                            },
                'dates': '21 March-20 April',
                'glyph': ' ',
                'house': 1
            },
    .
    .
    .
}
```

[11]:
```
import csv

def parse_zodiac(filename):
    raise Exception('TODO IMPLEMENT ME !')

zodiac_db = parse_zodiac('zodiac.csv')

from pprint import pprint
#pprint(zodiac_db, width=100)
assert zodiac_db['Aries']['dates'] == '21 March-20 April'
assert zodiac_db['Aries']['affinities'] == {'Aquarius': 0.8, 'Gemini': 0.8,␣
 ↪'Leo': 1.0, 'Sagittarius': 1.0}
assert zodiac_db['Aries']['glyph'] == ' '
assert zodiac_db['Aries']['house'] == 1
assert zodiac_db['Gemini']['dates'] == '22 May-21 June'
assert zodiac_db['Gemini']['affinities'] == {'Aquarius': 1.0, 'Aries': 0.8,␣
 ↪'Leo': 0.8, 'Libra': 1.0}
assert zodiac_db['Gemini']['glyph'] == ' '
assert zodiac_db['Gemini']['house'] == 3
```

1.5 plot_love

In `stars.csv` we inserted the special (fake!) constellation of `'Love'`: given the importance, we placed it at the center of the galaxy, positioned at `x=180` degrees and `y=0`. If you try to plot it now, you should get something like this:

[12]:
```
# 'Aries',   'Taurus',   'Gemini',      'Cancer',      'Leo',      'Virgo',
# 'Libra',   'Scorpius',  'Sagittarius', 'Capricornus', 'Aquarius', 'Pisces'

fig = plt.figure(figsize=(30,7))
plt.xlim(0,360)
plot_stars('Gemini','F', stars_db)
plot_stars('Aquarius','M', stars_db)
plot_stars('Love','R', stars_db)    # fake!
```



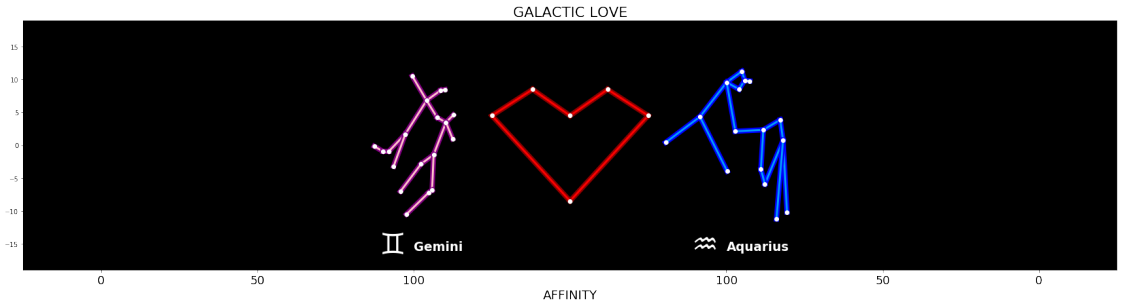
Given two astrological signs, place them on the same y=0 axis as the heart and make them symmetrically closer or farther from it according to their astrological affinity, also displaying their name and astrological glyph:

- **REMEMBER** title and xlabels !
- you can reuse previosly defined `plot_stars` function
- constellations x centers should go from 50 to 150 degrees (and symmetrically, from -50 to -150)
- **BUT you will have to display reversed ticks**: 100 50 0 for positive (and symmetrically 0 50 100 for negative)

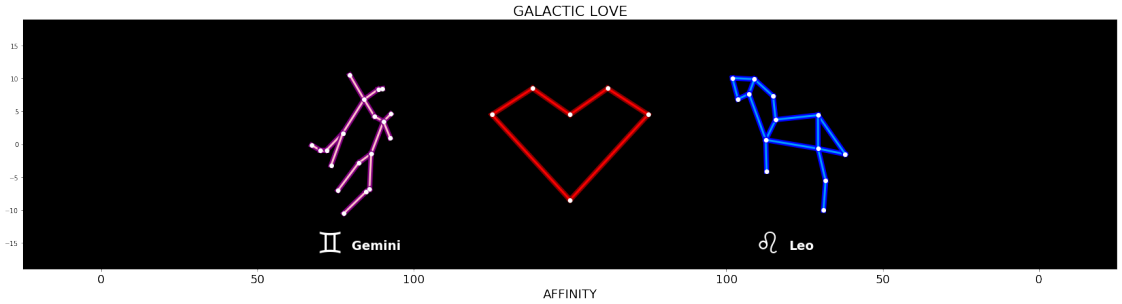
For drawing text:

- To increase text size in calls to `title`, `xticks`, `xlabel`, `text` you can use `fontsize=20` parameter (for glyphs you will need a bigger number)
- fo rtext inside the chart use use `plt.text(x,y,"some text")`
- the glyph must be drawn bigger than the sign name, so you will need a separate call to `plt.text`

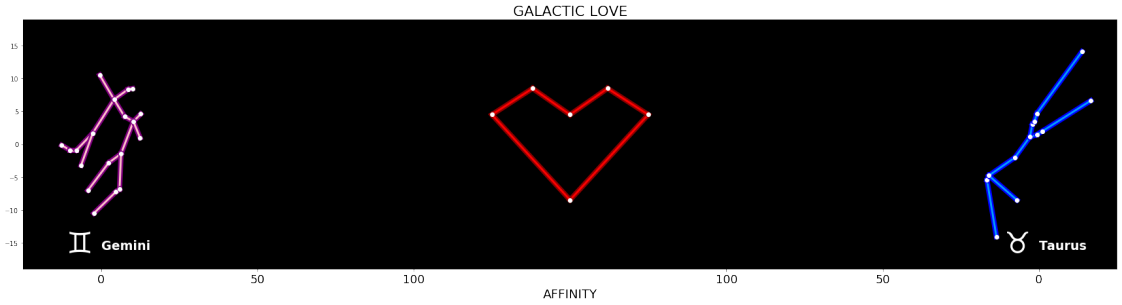
[13]:
```
def plot_love(f_sign, m_sign, stars, zodiac):

    fig = plt.figure(figsize=(30,7))  # 30 inches large by 7 high
    plt.xlim(-175,175)

    raise Exception('TODO IMPLEMENT ME !')

plot_love('Gemini','Aquarius', stars_db, zodiac_db)  # 1.0 affinity
```



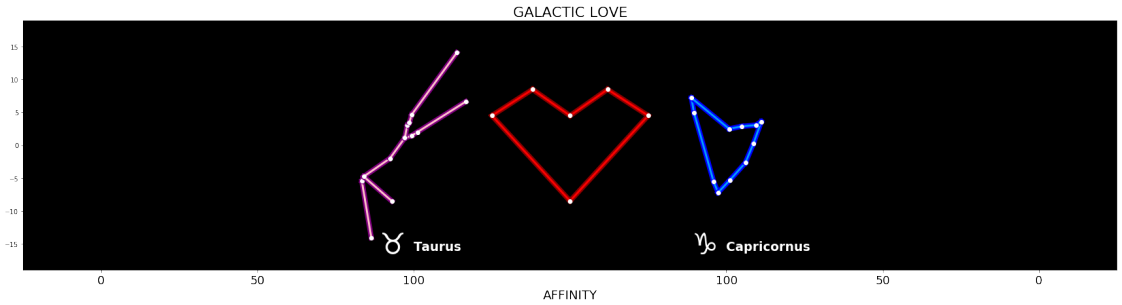
[14]:
```
plot_love('Gemini','Leo', stars_db, zodiac_db)  # 0.8 affinity
```



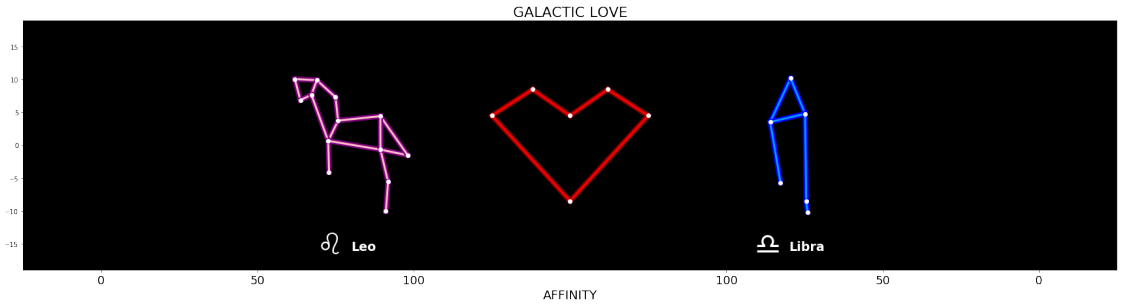
[15]:
```
plot_love('Gemini','Taurus', stars_db, zodiac_db) # 0.0 affinity
```



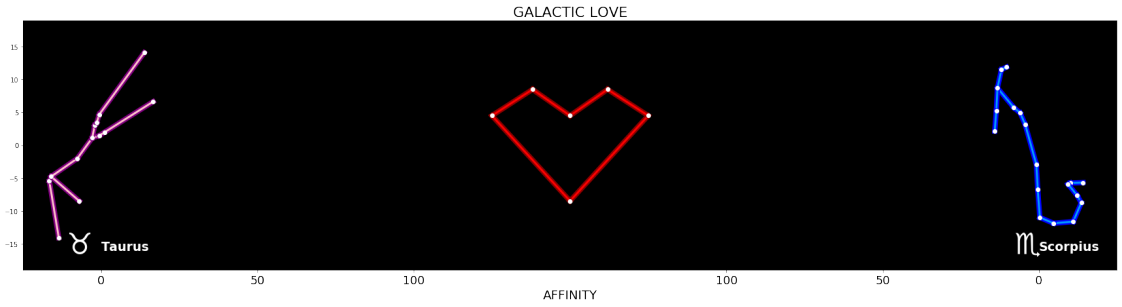
[16]:
```
plot_love('Taurus','Capricornus', stars_db, zodiac_db)  # 1.0 affinity
```



[17]:
```
plot_love('Leo','Libra', stars_db, zodiac_db)  # 0.8 affinity
```



[18]:
```
plot_love('Taurus','Scorpius', stars_db, zodiac_db)  # 1.0 affinity
```



[ ]:
```

```