adult_example

June 16, 2021

1 Estatística Descritiva

Este trabalho implementa os códigos apresentados no capítulo 3, *Descriptive Statistics*, do livro *Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications*.

Utilizamos o software asdf para instalar a versão 2.7 do Python utilizada nesta implementação de acordo com a versão utilizada no livro *Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications*.

Este código encontra-se disponível em https://github.com/kdiogenes/mestrado/blob/main/metodologia/explorato

Para seu desenvolvimento instalamos o jupyter através do comando `pip install jupyter` e inicializamos o jupyter através do comando `jupyter notebook` para obter a interface web e criar esse arquivo.

[2]:

```
# No livro é comentado sobre o pacote python anaconda que já traz vários␣
 ↪pacotes para data science. Neste trabalho
# instalamos apenas o python e por isso colocamos essas linhas para instalar as␣
 ↪bibliotecas utilizadas no capítulo
# 3 do livro
!pip install pandas
!pip install numpy
!pip install matplotlib
!pip install seaborn
```

```
DEPRECATION: Python 2.7 will reach the end of its life on January 1st,

2020. Please upgrade your Python as Python 2.7 won't be maintained after that

date. A future version of pip will drop support for Python 2.7. More details

about Python 2 support in pip, can be found at

https://pip.pypa.io/en/latest/development/release-process/#python-2-support
Requirement already satisfied: pandas in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (0.24.2)
Requirement already satisfied: python-dateutil>=2.5.0 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
pandas) (2.8.1)
Requirement already satisfied: numpy>=1.12.0 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
pandas) (1.16.6)
```

```
Requirement already satisfied: pytz>=2011k in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
pandas) (2021.1)
Requirement already satisfied: six>=1.5 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
python-dateutil>=2.5.0->pandas) (1.16.0)
WARNING: You are using pip version 19.2.3, however version 20.3.4 is
available.
You should consider upgrading via the 'pip install --upgrade pip' command.
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Requirement already satisfied: matplotlib in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (2.2.5)
Requirement already satisfied: numpy>=1.7.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (1.16.6)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (2.4.7)
Requirement already satisfied: python-dateutil>=2.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (2.8.1)
Requirement already satisfied: kiwisolver>=1.0.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (1.1.0)
Requirement already satisfied: cycler>=0.10 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (0.10.0)
```

```
Requirement already satisfied: subprocess32 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (3.5.4)
Requirement already satisfied: pytz in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (2021.1)
Requirement already satisfied: six>=1.10 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (1.16.0)
Requirement already satisfied: backports.functools-lru-cache in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib) (1.6.4)
Requirement already satisfied: setuptools in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
kiwisolver>=1.0.1->matplotlib) (41.2.0)
WARNING: You are using pip version 19.2.3, however version 20.3.4 is
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about Python 2 support in pip, can be found at
https://pip.pypa.io/en/latest/development/release-process/#python-2-support
Requirement already satisfied: seaborn in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (0.9.1)
Requirement already satisfied: matplotlib>=1.5.3 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
seaborn) (2.2.5)
Requirement already satisfied: numpy>=1.10.4 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
seaborn) (1.16.6)
Requirement already satisfied: scipy>=0.17.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
seaborn) (1.2.3)
Requirement already satisfied: pandas>=0.17.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
seaborn) (0.24.2)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib>=1.5.3->seaborn) (2.4.7)
Requirement already satisfied: python-dateutil>=2.1 in
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
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Requirement already satisfied: kiwisolver>=1.0.1 in
```

```
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/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
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/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-packages (from
matplotlib>=1.5.3->seaborn) (1.6.4)
Requirement already satisfied: setuptools in
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kiwisolver>=1.0.1->matplotlib>=1.5.3->seaborn) (41.2.0)
WARNING: You are using pip version 19.2.3, however version 20.3.4 is
available.
You should consider upgrading via the 'pip install --upgrade pip' command.
```

1.1 Introdução

1.2 Preparação dos Dados

[18]:

```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

[7]:

```python
# Lendo as informações da base de dados disponibilizada em https://archive.ics.
 ↪uci.edu/ml/datasets/Adult
file = open ("adult.data", "r")
def chr_int(a):
    if a.isdigit(): return int(a)
    else: return 0

data = []
for line in file:
    data1 = line.split(", ")
    if len(data1) == 15:
        data.append([chr_int(data1[0]), data1[1],
                     chr_int(data1[2]), data1[3],
                     chr_int(data1[4]), data1[5],
                     data1[6], data1[7], data1[8],
                     data1[9], chr_int(data1[10]),
                     chr_int(data1[11]),
                     chr_int(data1[12]),
                     data1[13], data1[14]
                    ])
```

[73]:

```
# Imprimindo o primeiro elemento dos dados carregados (lista). [1:5] é␣
 ↪equivalente a "de 1 até 5" (5 não incluso)
print data[1:2]
```

```
[[50, 'Self-emp-not-inc', 83311, 'Bachelors', 13, 'Married-civ-spouse', 'Exec-
managerial', 'Husband', 'White', 'Male', 0, 0, 13, 'United-States', '<=50K\n']]
```

[8]:

```
# Aqui transformamos os dados em um DataFrame, que é uma forma de representar␣
 ↪dados tabulares. A implementação
# desta estrutura é dada pela biblioteca pandas e fornece diversas métodos␣
 ↪úteis para lidar com estes dados.
df = pd.DataFrame(data)
df.columns = [
    "age", "type_employer", "fnlwgt", "education", "education_num", "martial",␣
 ↪"occupation", "relationship",
    "race", "sex", "capital_gain", "capital_loss", "hr_per_week", "country",␣
 ↪"income"
]
```

[16]:

```
# O método shape retorna a quantidade de linhas e colunas presentes nos dados␣
 ↪carregados.
df.shape
```

[16]:

```
(32561, 15)
```

[9]:

```
# Através do DataFrame é possível agrupar os dados por colunas específicas
counts = df.groupby("country").size()
print counts.head()
```

```
country
?            583
Cambodia      19
Canada       121
China         75
Columbia      59
dtype: int64
```

[10]:

```
# Também é possível selecionar subconjuntos dos dados, abaixo é utilizado a␣
 ↪sintaxe do DataFrame para selecionar
# apenas as linhas onde a coluna 'sex' é igual a 'Male'
ml = df[(df.sex == "Male")]
```

[11]:

```
# Também podemos combinar várias condições para obter subconjuntos mais␣
 ↪específicos, neste caso logo abaixo
# selecionamos homens com salários altos.
ml1 = df[(df.sex == "Male") & (df.income == ">50K\n")]
fm = df[(df.sex == "Female")]
fm1 = df[(df.sex == "Female") & (df.income == ">50K\n")]
```

1.3 Análise de Dados Exploratória

1.3.1 Sumarizando os Dados

[12]:

```
# Explorando a frequência de dados categóricos
df1 = df[(df.income == ">50K\n")]
print "The rate of people with high income is:", int(len(df1) / float(len(df))␣
 ↪* 100), "%"
print "The rate of men with high income is:", int(len(ml1) / float(len(ml)) *␣
 ↪100), "%"
print "The rate of women with high income is:", int(len(fm1) / float(len(fm)) *␣
 ↪100), "%"
```

```
The rate of people with high income is: 24 %
The rate of men with high income is: 30 %
The rate of women with high income is: 10 %
```

Média

[24]:

```
# Média de idade dos homens
print "The average age of men is:", ml["age"].mean()
# Média de idade dos homens com maiores salários
print "The average age of women is:", fm["age"].mean()

# Média de idade das mulheres
print "The average age of high-income men is:", ml1["age"].mean()
# Média de idade das mulheres com maiores salários
print "The average age of high-income women is:", fm1["age"].mean()
```

```
The average age of men is: 39.43354749885268
The average age of women is: 36.85823043357163
The average age of high-income men is: 44.62578805163614
The average age of high-income women is: 42.125530110262936
```

Variância da Amostra

[13]:

```
# Média, variância e desvio padrão das idades de homens e mulheres
ml_mu = ml["age"].mean()
fm_mu = fm["age"].mean()
ml_var = ml["age"].var()
fm_var = fm["age"].var()
ml_std = ml["age"].std()
fm_std = fm["age"].std()
```

```
print "Statistics of age for men: mu:", ml_mu, "var:", ml_var, "std:", ml_std
print "Statistics of age for women: mu:", fm_mu, "var:", fm_var, "std:", fm_std
```

```
Statistics of age for men: mu: 39.43354749885268 var: 178.77375174529985 std:
13.370630192526448
Statistics of age for women: mu: 36.85823043357163 var: 196.3837063948063 std:
14.013697099438332
```

Mediana da Amostra

[14]:
```
# Mediana das idades de homens e mulheres
ml_median = ml["age"].median()
fm_median = fm["age"].median()
print "Median age per men and women:", ml_median, fm_median

# Mediana das idades de homens e mulheres com maiores salários (como é de se␣
 ↪esperar, a mediana neste caso é
# maior)
ml_median_age = ml1["age"].median()
fm_median_age = fm1["age"].median()
print "Median age per men and women with high-income:", ml_median_age,␣
 ↪fm_median_age
```

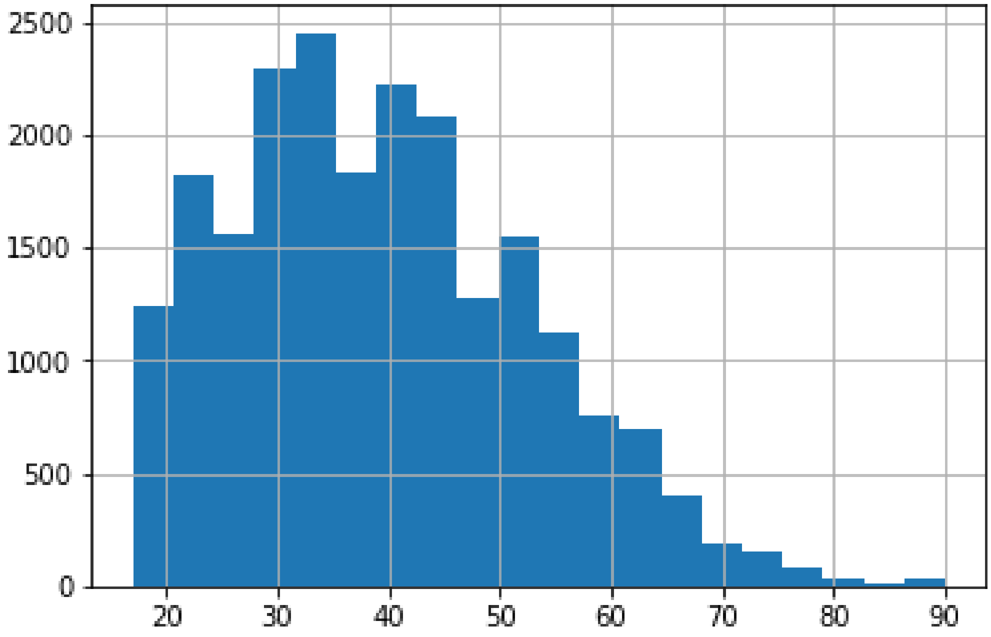
```
Median age per men and women: 38.0 35.0
Median age per men and women with high-income: 44.0 41.0
```

1.3.2 Distribuições de Dados

[15]:
```
# Histograma das idades dos homens
ml_age = ml["age"]
ml_age.hist(normed = 0, histtype = "stepfilled", bins = 20)
```

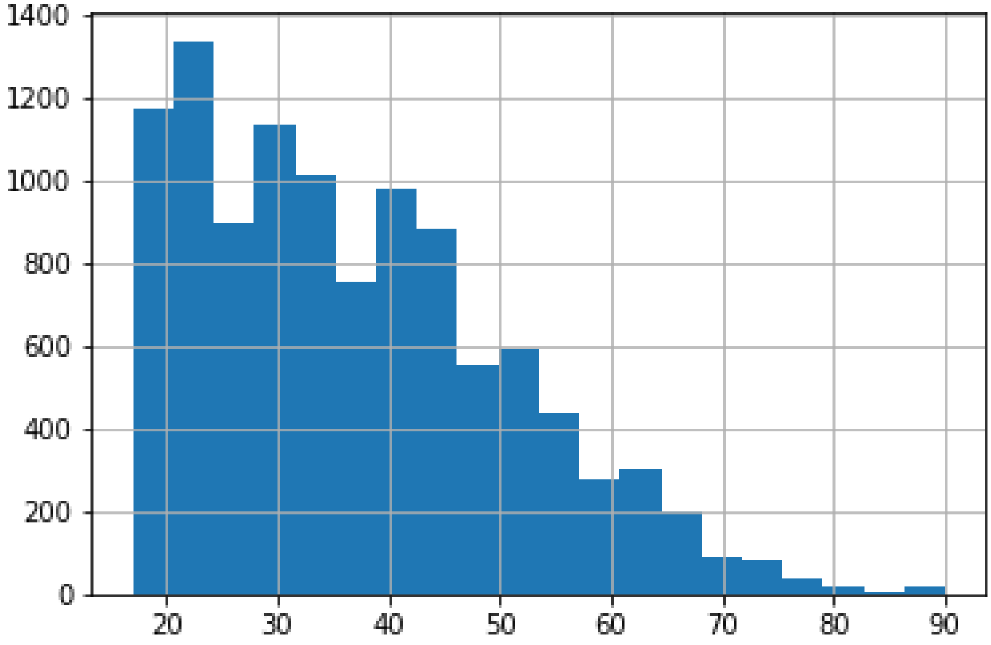
```
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-
packages/matplotlib/axes/_axes.py:6571: UserWarning: The 'normed' kwarg is
deprecated, and has been replaced by the 'density' kwarg.
  warnings.warn("The 'normed' kwarg is deprecated, and has been "
```

[15]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc7a40951d0>
```



```
[16]: # Histograma das idades das mulheres
      fm_age = fm["age"]
      fm_age.hist(normed = 0, histtype = "stepfilled", bins = 20)
```

```
[16]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc7c1f7ab90>
```

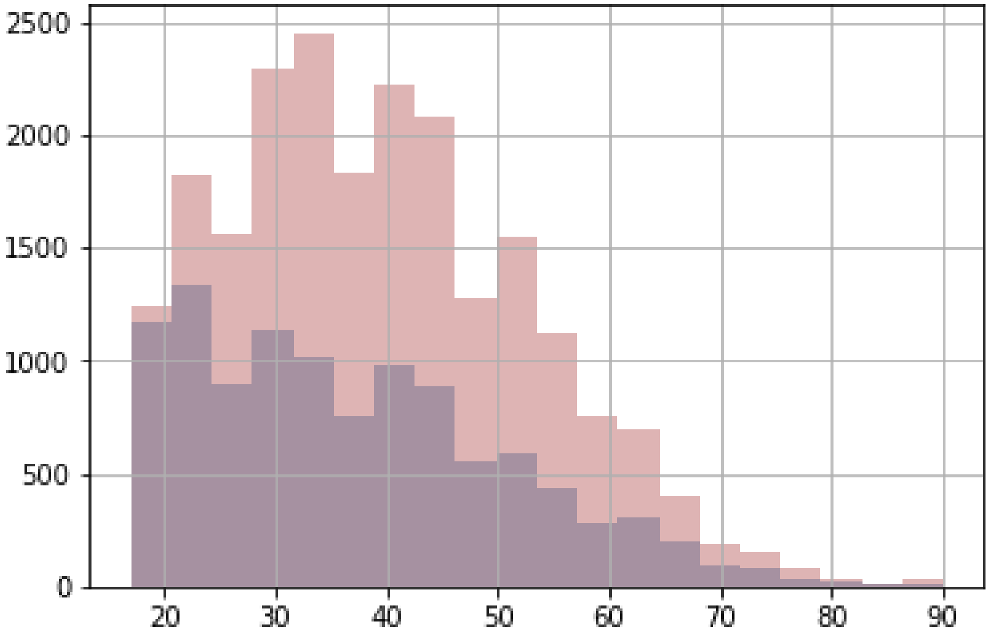


[20]:

```
# Combinando os histogramas é possível ver facialmente a quantidade de pessoas␣
 ↪sexo em cada classe de idade. Neste
# caso, podemos ver que existem muito mais homens que mulheres. No livro a␣
 ↪quantidade de classes utilizada para
# homens e mulheres é diferente e me pareceu distorcer o comparativo dos dados,␣
 ↪pois a quantidade de homens em
# cada classe acaba se tornando muito maior, pois cada classe abrange uma faixa␣
 ↪maior de idades.
fm_age.hist(normed = 0, histtype = "stepfilled", alpha = .5, bins = 20)
ml_age.hist(normed = 0, histtype = "stepfilled", alpha = .5, bins = 20, color =␣
 ↪sns.desaturate("indianred", .75))
```

[20]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc784792c90>
```

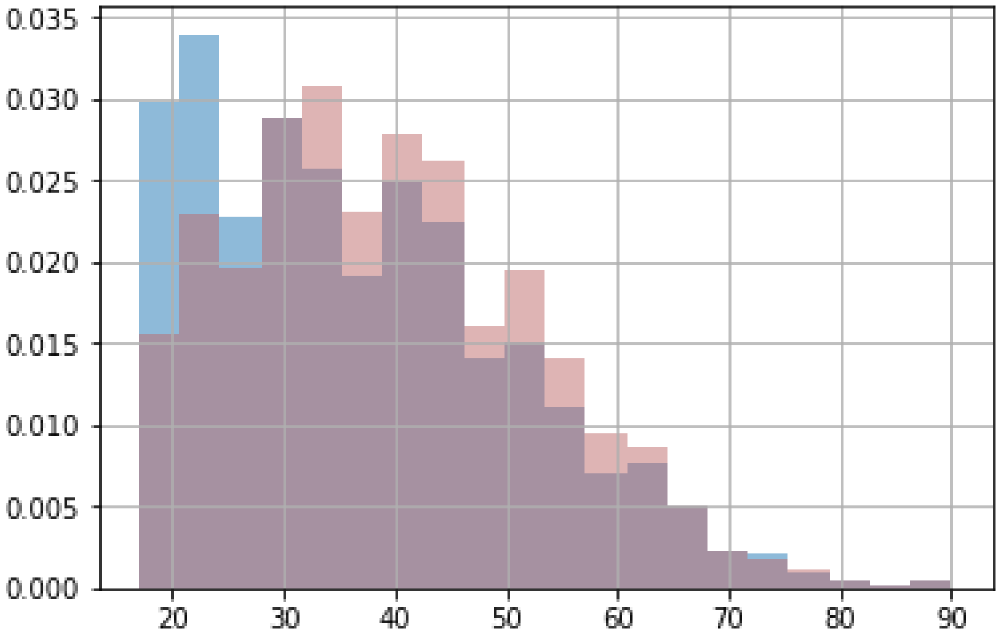


[21]:

```
# Também é possível normalizar os dados de cada classe de acordo com o tamanho␣
 ↪da amostra. Isso é feito dividindo
# as frequências de cada classe por n (tamanho da amostra). Este tipo de␣
 ↪histograma é chamado de Função Massa de
# Probabilidade (FMP). Apesar de terem menos mulheres, verificamos neste␣
 ↪gráfico que a probabilidade de mulheres
# é muito maior nas classes de [15-20) e [20-25).
fm_age.hist(normed = 1, histtype = "stepfilled", alpha = .5, bins = 20)
```

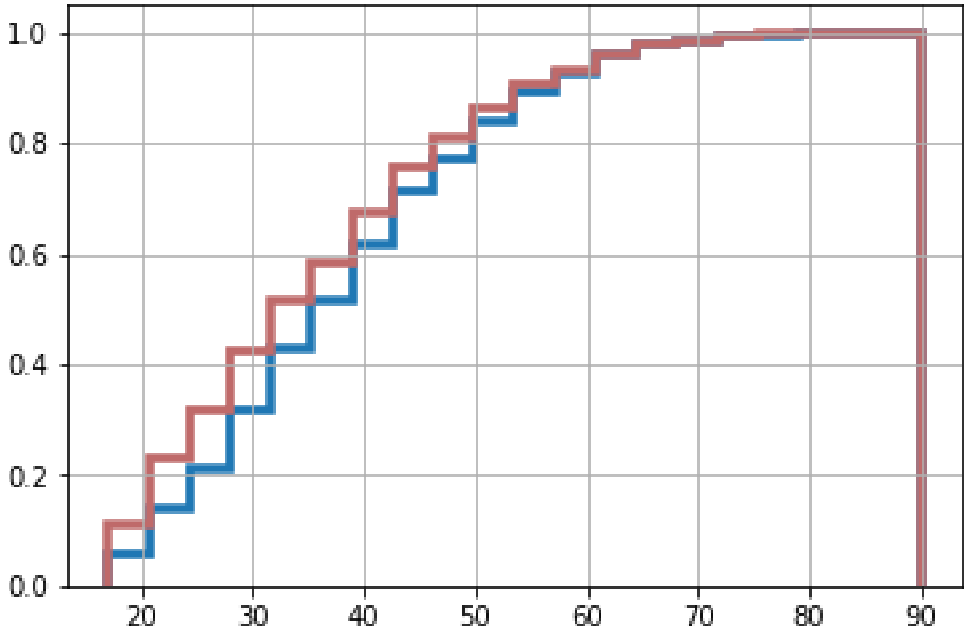
```
ml_age.hist(normed = 1, histtype = "stepfilled", alpha = .5, bins = 20, color =␣
 ↪sns.desaturate("indianred", .75))
```

```
[21]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc7847198d0>
```



```
[22]: # Abaixo é plotado um histograma como uma Função Distribuição Acumulada (FDA).␣
       ↪Através desta é possível
      # identificar facilmente a porcentagem de valores abaixo de uma determinada␣
       ↪classe. Neste caso vemos a FDA das
      # idades de homens (azul) e mulheres (vermelho).
      ml_age.hist(normed = 1, histtype = "step", cumulative = True, linewidth = 3.5,␣
       ↪bins = 20)
      fm_age.hist(normed = 1, histtype = "step", cumulative = True, linewidth = 3.5,␣
       ↪bins = 20,
                  color = sns.desaturate("indianred", .75))
```

```
[22]: <matplotlib.axes._subplots.AxesSubplot at 0x7fc78469c1d0>
```



1.3.3 Tratamento de Outlier

[31]:
```
# Aqui utilizamos alguns métodos do DataFrame para eliminar valores␣
↪discrepantes, para este caso são considerados
# outliers valores maiores que 72 anos e menores que 22. Neste casos,␣
↪corrigimos a condição do livro para utilizar
# o operador | (ou) e utilizar < (menor que) para eliminar idades menores que␣
↪22. Traduzindo a expressão, neste
# caso temos: retire do dataframe, todos as linhas onde a renda é ">50K\n" E a␣
↪idade seja maior que 72 OU a idade
#             seja menor que 22.
df2 = df.drop(df.index[(df.income == ">50K\n") &
                       (df["age"] > df["age"].median() + 35) |
                       (df["age"] < df["age"].median() - 15)
                      ])
ml1_age = ml1["age"]
fm1_age = fm1["age"]

ml2_age = ml1_age.drop(ml1_age.index[
    (ml1_age > df["age"].median() + 35) |
    (ml1_age < df["age"].median() - 15)
])
fm2_age = fm1_age.drop(fm1_age.index[
    (fm1_age > df["age"].median() + 35) |
    (fm1_age < df["age"].median() - 15)
])
```

[32]:

```
# Cálculos estatísticos da amostra sem os outliers.
mu2ml = ml2_age.mean()
std2ml = ml2_age.std()
md2ml = ml2_age.median()
mu2fm = fm2_age.mean()
std2fm = fm2_age.std()
md2fm = fm2_age.median()

print "Men statistics:"
print "Mean:", mu2ml, "Std:", std2ml
print "Median:", md2ml
print "Min:", ml2_age.min(), "Max:", ml2_age.max()

print "Women statistics:"
print "Mean:", mu2fm, "Std:", std2fm
print "Median:", md2fm
print "Min:", fm2_age.min(), "Max:", fm2_age.max()
```

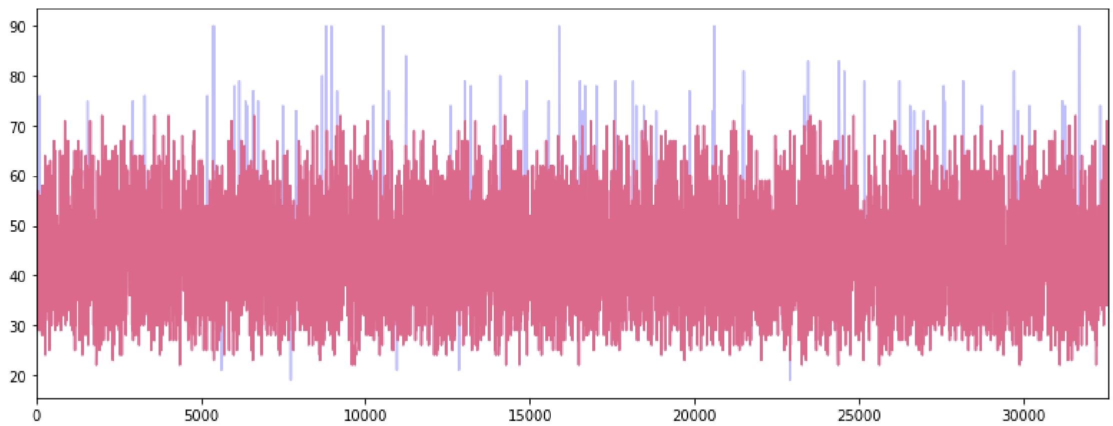
```
Men statistics:
Mean: 44.325352326110014 Std: 10.012302742491938
Median: 44.0
Min: 22 Max: 72
Women statistics:
Mean: 41.93236301369863 Std: 9.98952564884922
Median: 41.0
Min: 22 Max: 72
```

[40]:

```
# No gráfico abaixo podemos ver visualmente a diferenças nos dados após a␣
 ↪remoção dos outliers. Em azul estão as
# idades de todos os dados e em vermelho podemos ver que as idades maior que 72␣
 ↪e menor que 22 foram removidas.
plt.figure(figsize = (13.4, 5))
df.age[(df.income == ">50K\n")].plot(alpha = .25, color = "blue")
df2.age[(df.income == ">50K\n")].plot(alpha = .45, color = "red")
```

[40]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc7841edcd0>
```



```
[41]: # Pelo último gráfico, percebemos que a maioria dos outliers estão acima de 72␣
       ↪anos, desta forma a média dos dados
      # sem os outliers diminui:
      print "The mean difference with outliers is: %4.2f." % (ml_age.mean() - fm_age.
       ↪mean())
      print "The mean difference without outliers is: %4.2f." %(ml2_age.mean() -␣
       ↪fm2_age.mean())
```

```
The mean difference with outliers is: 2.58.
The mean difference without outliers is: 2.39.
```

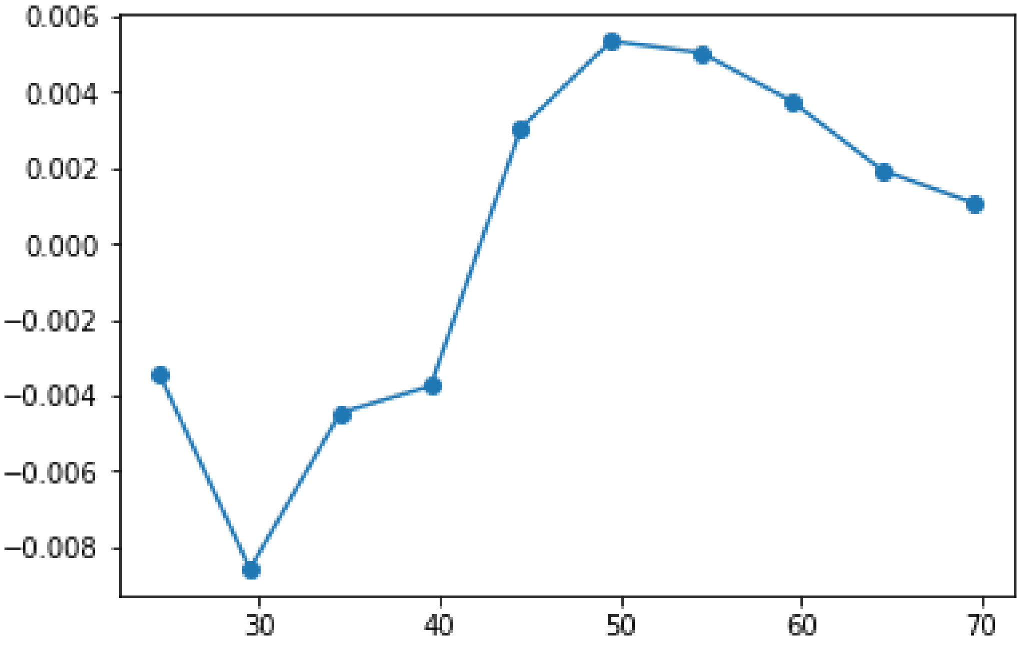
```
[47]: # A função 'histogram' da biblioteca numpy (np) consegue retornar as contagens␣
       ↪em cada classe (countx e county) e
      # também as classes que geradas (divisionx e divisiony). Como as idades estão␣
       ↪entre 22 e 72 e as idades, neste
      # caso, se distribuem de forma semelhante entre homens e mulheres as classes␣
       ↪geradas acabaram sendo iguais.
      countx, divisionx = np.histogram(ml2_age, normed = True)
      county, divisiony = np.histogram(fm2_age, normed = True)

      # Para plotagem foi utilizado o valor médio entre os valores de ínicio de cada␣
       ↪classe e a diferença (normalizada)
      # da quantidade de homens menos a quantidade de mulheres em cada classe. No␣
       ↪gráfico, vemos que os números são
      # negativos antes dos 42 anos, indicando que as mulheres tendem a ser␣
       ↪promovidas antes que os homens.
      val = [(divisionx[i] + divisionx[i+1]) / 2 for i in range(len(divisionx) - 1)]
      plt.plot(val, countx - county, "o-")
```

```
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-
packages/ipykernel_launcher.py:4: VisibleDeprecationWarning: Passing
`normed=True` on non-uniform bins has always been broken, and computes neither
```

```
the probability density function nor the probability mass function. The result
is only correct if the bins are uniform, when density=True will produce the same
result anyway. The argument will be removed in a future version of numpy.
  after removing the cwd from sys.path.
/home/kadu/.asdf/installs/python/2.7.18/lib/python2.7/site-
packages/ipykernel_launcher.py:5: VisibleDeprecationWarning: Passing
`normed=True` on non-uniform bins has always been broken, and computes neither
the probability density function nor the probability mass function. The result
is only correct if the bins are uniform, when density=True will produce the same
result anyway. The argument will be removed in a future version of numpy.
  """
```

[47]:
```
[<matplotlib.lines.Line2D at 0x7fc7837e1750>]
```



1.3.4 Medindo Assimetria: Skewness e Person’s Median Skewness Coefficient

[50]:
```
# Neste dados, a distribuição das mulheres é mais assimétrica do que as do␣
 ↪homens (se distancia mais do 0). O
# autor sugere que isso se deva a uma maior probabilidade dos homens␣
 ↪trabalharem até uma idade mais avançada.
def skewness(x):
    res = 0
    m = x.mean()
    s = x.std()
    for i in x:
        res += (i-m) * (i-m) * (i-m)
    res /= (len(x) * s * s * s)
    return res

print "Skewness of the male population =", skewness(ml2_age)
print "Skewness of the female population =", skewness(fm2_age)
```

```
Skewness of the male population = 0.26644438384328223
Skewness of the female population = 0.3863335249128606
```

[51]:

```
# O coeficiente de person (neste caso o segundo coeficiente, pois usa a␣
 ↪mediana) é considerado uma medida mais
# robusta para medir a assimetria e neste exacerba a diferença entre homens e␣
 ↪mulheres.
def pearson(x):
    return 3 * (x.mean() - x.median()) * x.std()

print "Person's coefficient of the male population =", pearson(ml2_age)
print "Person's coefficient of the female population =", pearson(fm2_age)
```

```
Person's coefficient of the male population = 9.558304022209926
Person's coefficient of the female population = 26.406726907280902
```