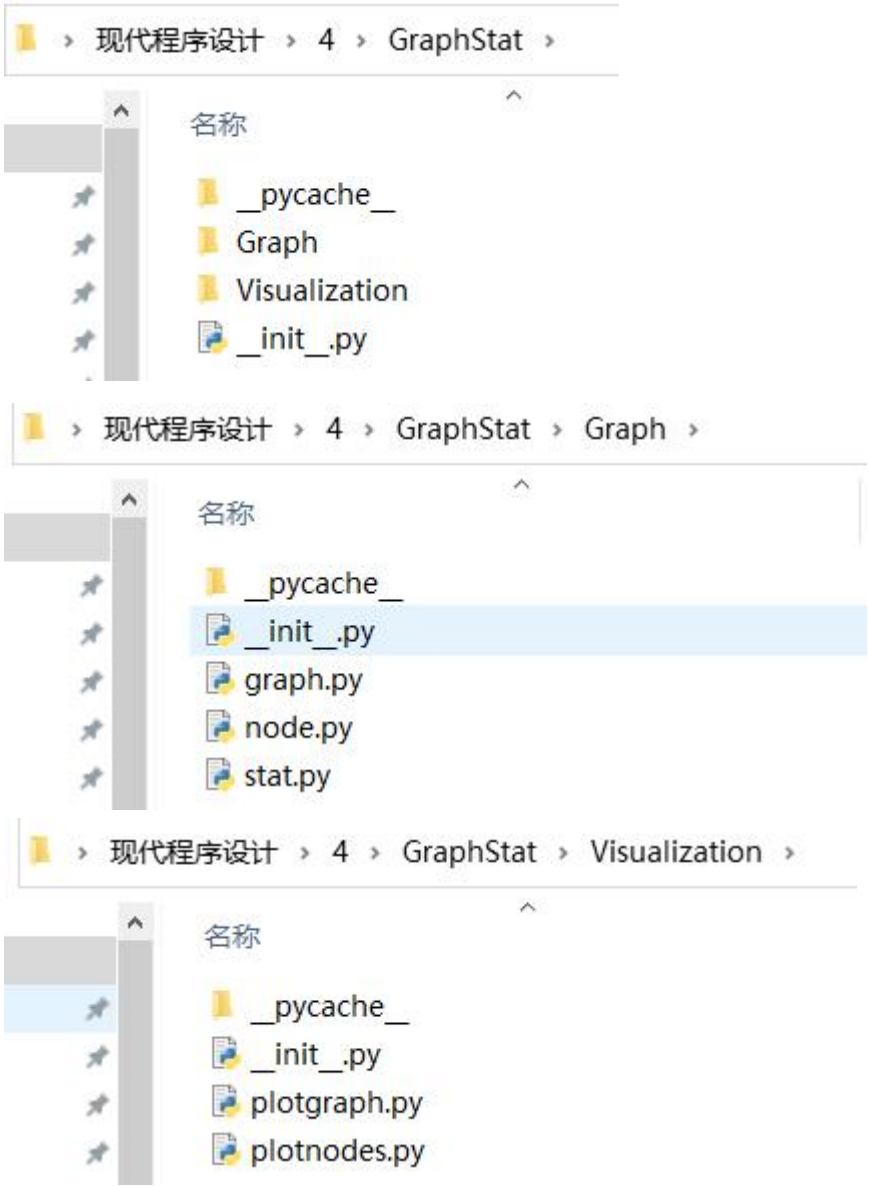
1. 首先建立包，分为图像信息处理和可视化两部分，如下图



2.

（1）节点信息处理

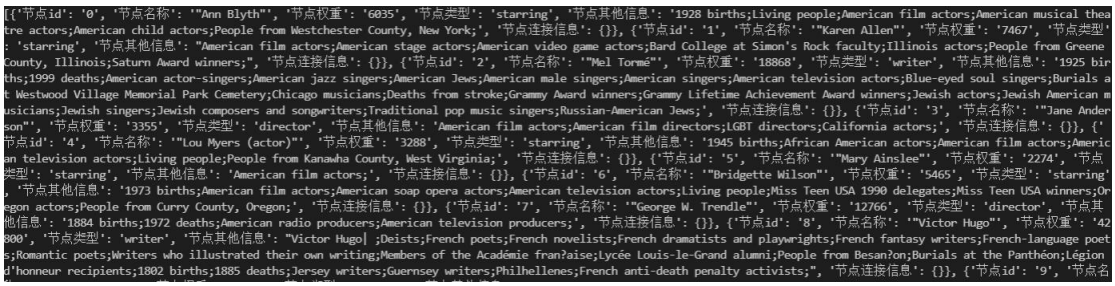
利用字典，将节点的属性储存在字典中，每个字典是一个节点，将所有的节点以列表的形式储存，实现函数：init_node（）

C: > Users > 86186 > Desktop > 现代程序设计 > 4 > GraphStat > Graph > node.py > init_node

```python

def init_node(filepath):
    res=[]
    with open(filepath,'r',encoding="utf-8") as f:
        for line in f.readlines():
            if line == "*Vertices 34282\n":
                continue
            elif line =="*Edges\n":
                break
            else:
                dict={}
                infor=list(line.strip().split('\t'))
                dict["节点id"]=infor[0]
                dict["节点名称"]=infor[1]
                dict["节点权重"]=infor[2]
                dict["节点类型"]=infor[3]
                dict["节点其他信息"]=infor[4]
                dict["节点连接信息"]={}
                res.append(dict)
    return res
```

调用部分结果：

```python
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)
print(nodelist)
```



[{'节点id': '0', '节点名称': '"Ann Blyth"', '节点权重': '6035', '节点类型': 'starring', '节点其他信息': '1928 births;Living people;American film actors;American musical theatre actors;American child actors;People from Westchester County, New York;', '节点连接信息': {}}, {'节点id': '1', '节点名称': '"Karen Allen"', '节点权重': '7467', '节点类型': 'starring', '节点其他信息': "American film actors;American stage actors;American video game actors;Bard College at Simon's Rock faculty;Illinois actors;People from Greene County, Illinois;Saturn Award winners;", '节点连接信息': {}}, {'节点id': '2', '节点名称': '"Mel Tormé"', '节点权重': '18868', '节点类型': 'writer', '节点其他信息': '1925 births;1999 deaths;American actor-singers;American jazz singers;American Jews;American male singers;American singers;American television actors;Blue-eyed soul singers;Burials at Westwood Village Memorial Park Cemetery;Chicago musicians;Deaths from stroke;Grammy Award winners;Grammy Lifetime Achievement Award winners;Jewish actors;Jewish American musicians;Jewish singers;Jewish composers and songwriters;Traditional pop music singers;Russian-American Jews;', '节点连接信息': {}}, {'节点id': '3', '节点名称': '"Jane Anderson"', '节点权重': '3355', '节点类型': 'director', '节点其他信息': 'American film actors;American film directors;LGBT directors;California actors;', '节点连接信息': {}}, {'节点id': '4', '节点名称': '"Lou Myers (actor)"', '节点权重': '3288', '节点类型': 'starring', '节点其他信息': '1945 births;African American actors;American film actors;American television actors;Living people;People from Kanawha County, West Virginia;', '节点连接信息': {}}, {'节点id': '5', '节点名称': '"Mary Ainslee"', '节点权重': '2274', '节点类型': 'starring', '节点其他信息': 'American film actors;', '节点连接信息': {}}, {'节点id': '6', '节点名称': '"Bridgette Wilson"', '节点权重': '5465', '节点类型': 'starring', '节点其他信息': '1973 births;American film actors;American soap opera actors;American television actors;Living people;Miss Teen USA 1990 delegates;Miss Teen USA winners;Oregon actors;People from Curry County, Oregon;', '节点连接信息': {}}, {'节点id': '7', '节点名称': '"George W. Trendle"', '节点权重': '12766', '节点类型': 'director', '节点其他信息': '1884 births;1972 deaths;American radio producers;American television producers;', '节点连接信息': {}}, {'节点id': '8', '节点名称': '"Victor Hugo"', '节点权重': '42800', '节点类型': 'writer', '节点其他信息': "Victor Hugo| ;Deists;French poets;French novelists;French dramatists and playwrights;French fantasy writers;French-language poets;Romantic poets;Writers who illustrated their own writing;Members of the Académie fran?aise;Lycée Louis-le-Grand alumni;People from Besan?on;Burials at the Panthéon;Légion d'honneur recipients;1802 births;1885 deaths;Jersey writers;Guernsey writers;Philhellenes;French anti-death penalty activists;", '节点连接信息': {}}, {'节点id': '9', '节点名

（2）节点信息输出

利用字典和 format 函数，将节点信息输出，实现函数：print_node（）

调用部分结果如下：

```python
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)
node.print_node(nodelist)
```

```
id:9520
name:"Arthur J. Nascarella"
weigh:1877
nodetype:starring
otherinformation:American film actors;American television actors;Living people;New York City Police Department officers;Year of birth missing (living people);United States M
arines;
id:9521
name:"Alan Davies"
weigh:8701
nodetype:starring
otherinformation:1966 births;Old Bancroftians;Alumni of the University of Kent;English comedians;English actors;English radio personalities;Living people;People from Loughto
n;English atheists;QI;
id:9522
name:"Arsinée Khanjian"
weigh:3278
nodetype:starring
otherinformation:1958 births|Khanjian, Arsinée;Lebanese Armenians;Armenian Canadians|Khanjian, Arsinée;Armenian people;Canadian film actors|Khanjian, Arsinée;Lebanese Canadi
ans;Gemini Award winners|Khanjian, Arsinée;Genie Award winners for Best Actress|Khanjian, Arsinée;Lebanese immigrants to Canada|Khanjian, Arsinee;Living people|Khanjian, Ars
inée;People from Beirut|Khanjian;
```

3. 图的信息处理

（1） 初始化边信息，将边的信息以列表形式储存

C: > Users > 86186 > Desktop > 现代程序设计 > 4 > GraphStat > Graph > graph.py > ...

```python
import json
def init_edge(filepath):
    mark=0
    with open(filepath,'r',encoding="utf-8") as f:
        mid=[]
        for line in f.readlines():
            if line == "*Edges\n":
                mark = 1
            elif mark == 1:
                mid.append(list(line.strip().split('\t')))

    return mid
```

运行结果：

```
PS C:\Users\86186\Desktop\现代程序设计\第2次>  c:; cd 'c:\Users\86186\Desktop\现代程序设计\第2次'; & 'C:\Users\86186\AppData\Local\Programs\Python\Python37\python.exe' 'c:\U
sers\86186\.vscode\extensions\ms-python.python-2021.10.1336267007\pythonFiles\lib\python\debugpy\launcher' '13709' '--' 'c:\Users\86186\Desktop\现代程序设计\4\图的建立与可视
化.py'
[['0', '4221', '1'], ['0', '4390', '1'], ['0', '2664', '1'], ['0', '6885', '1'], ['0', '989', '1'], ['0', '7387', '1'], ['1', '11814', '1'], ['1', '3869', '1'], ['1', '11348
', '1'], ['1', '9023', '1'], ['1', '7353', '1'], ['1', '11190', '1'], ['1', '13214', '1'], ['1', '4562', '1'], ['1', '5465', '1'], ['1', '6106', '1'], ['1', '7922', '1'], ['
1', '13175', '1'], ['1', '11814', '1'], ['2', '14185', '1'], ['2', '6938', '1'], ['2', '6938', '1'], ['2', '6255', '1'], ['2', '6826', '1'], ['2', '10597', '1'], ['2', '1870
', '1'], ['2', '6172', '1'], ['2', '15364', '1'], ['2', '12753', '1'], ['2', '6938', '1'], ['2', '15364', '1'], ['2', '4388', '1'], ['2', '5924', '1'], ['2', '16173', '1'],
['2', '3898', '1'], ['3', '12931', '1'], ['3', '11371', '1'], ['3', '2748', '1'], ['3', '12206', '1'], ['3', '2498', '1'], ['5', '10462', '1'], ['6', '1985', '1'], ['6', '10
341', '1'], ['6', '12388', '1'], ['6', '8410', '1'], ['7', '6466', '1'], ['10', '12853', '1'], ['11', '6513', '1'], ['12', '4599', '1'], ['13', '5279', '1'], ['13', '7705',
'1'], ['13', '1121', '1'], ['13', '11326', '1'], ['14', '14271', '1'], ['15', '3685', '1'], ['15', '5696', '1'], ['15', '1426', '1'], ['15', '15551', '1'], ['15', '5758', '1
'], ['15', '3685', '1'], ['15', '6327', '1'], ['15', '12835', '1'], ['17', '4063', '1'], ['17', '11576', '1'], ['17', '9090', '1'], ['18', '11926', '1'], ['19', '12669', '1
'], ['20', '5002', '1'], ['20', '5196', '1'], ['20', '10246', '1'], ['20', '15689', '1'], ['20', '2502', '1'], ['20', '7007', '1'], ['20', '15815', '1'], ['20', '7723', '1'],
 ['20', '8559', '1'], ['20', '4891', '1'], ['21', '2507', '1'], ['21', '7232', '1'], ['22', '13393', '1'], ['22', '837', '1'], ['22', '242', '1'], ['24', '1168', '1'], ['24
', '992', '1'], ['24', '6718', '1'], ['24', '2007', '1'], ['24', '10653', '1'], ['24', '10403', '1'], ['24', '1980', '1'], ['24', '10511', '1'], ['24', '13170', '1'], ['24',
'15719', '1'], ['24', '9859', '1'], ['24', '9859', '1'], ['24', '10511', '1'], ['24', '10278', '1'], ['24', '14077', '1'], ['24', '3070', '1'], ['24', '10511', '1'], ['27',
'14857', '1'], ['28', '10014', '1'], ['28', '9336', '1'], ['28', '7375', '1'], ['28', '5234', '1'], ['29', '11118', '1'], ['29', '1555', '1'], ['29', '5012', '1'], ['29', '1
1046', '1'], ['31', '5151', '1'], ['31', '5837', '1'], ['31', '382', '1'], ['31', '7868', '1'], ['31', '2360', '1'], ['31', '7868', '1'], ['34', '7663', '1'], ['34', '4580',
 '1'], ['34', '8659', '1'], ['34', '9565', '1'], ['34', '1696', '1'], ['34', '7182', '1'], ['34', '300', '1'], ['34', '14658', '1'], ['34', '4186', '1'], ['34', '4295', '1']
, ['34', '14337', '1'], ['34', '873', '1'], ['34', '2979', '1'], ['34', '15390', '1'], ['34', '11904', '1'], ['34', '873', '1'], ['34', '4598', '1'], ['34', '14898', '1'], [
'34', '14356', '1'], ['34', '11533', '1'], ['34', '2055', '1'], ['34', '3807', '1'], ['36', '13529', '1'], ['36', '14623', '1'], ['36', '9468', '1'], ['36', '7827', '1'], ['
36', '14080', '1'], ['36', '14691', '1'], ['36', '10536', '1'], ['36', '9468', '1'], ['36', '6561', '1'], ['36', '13529', '1'], ['36', '9821', '1'], ['36', '8309', '1'], ['3
```

（2） 去掉重复边，计算权重，同时将节点信息和边信息整合在字典中，每个节点增加一个“邻居节点”的属性，以字典方式储存，键为与该节点相邻的节点，值为这两点形成的边的权重。

```python
def init_graph(nodelist,edgelist):
    for i in range(len(edgelist)):

        if edgelist[i][1] in nodelist[int(edgelist[i][0])]["节点连接信息"].keys():
            nodelist[int(edgelist[i][0])]["节点连接信息"][edgelist[i][1]] += 1
        else:
            nodelist[int(edgelist[i][0])]["节点连接信息"][edgelist[i][1]] = 1

    return nodelist
```

运行结果：

C: > Users > 86186 > Desktop > 现代程序设计 > 4 > 图的建立与可视化.py > ...

```python
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)


edgelist=graph.init_edge(filepath)

graphlist=graph.init_graph(nodelist,edgelist)
print(graphlist)
```

```
PS C:\Users\86186\Desktop\现代程序设计\第2次> c:; cd 'c:\Users\86186\Desktop\现代程序设计\第2次'; & 'C:\Users\86186\AppData\Local\Programs\Python\Python37\python.exe' 'c:\Users\86186\.vscode\extensions\ms-python.python-2021.10.1336267007\pythonFiles\lib\python\debugpy\launcher' '13848' '--' 'c:\Users\86186\Desktop\现代程序设计\4\图的建立与可视化.py'
[{'节点id': '0', '节点名称': '"Ann Blyth"', '节点权重': '6035', '节点类型': 'starring', '节点其他信息': '1928 births;Living people;American film actors;American musical theatre actors;American child actors;People from Westchester County, New York;', '节点连接信息': {'4221': 1, '4390': 1, '2664': 1, '6885': 1, '989': 1, '7387': 1}}, {'节点id': '1', '节点名称': '"Karen Allen"', '节点权重': '7467', '节点类型': 'starring', '节点其他信息': "American film actors;American stage actors;American video game actors;Bard College at Simon's Rock faculty;Illinois actors;People from Greene County, Illinois;Saturn Award winners;", '节点连接信息': {'11814': 2, '3869': 1, '11348': 1, '9023': 1, '7353': 1, '11190': 1, '13214': 1, '4562': 1, '5465': 1, '6106': 1, '7922': 1, '13175': 1}}, {'节点id': '2', '节点名称': '"Mel Tormé"', '节点权重': '18868', '节点类型': 'writer',
```

（3） 图信息的序列化储存和反序列化加载

为了方便图信息的储存，设计序列化函数

```python
def save_graph(graphlist):
    return json.dumps(graphlist)

def load_graph(graphlist):
    return json.loads(graphlist)
```

4. 图的信息统计

（1） 计算图的平均度

平均度为所有节点度之和除以节点个数，而所有节点度之和等于边的数量的 2 倍，由此可以计算平均度

```
def cal_graphavg(graphlist,edgelist):
    count = len(graphlist)
    edge =2* len(edgelist)
    avg = edge/count
    return avg
```

运行结果：

```
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)


edgelist=graph.init_edge(filepath)

graphlist=graph.init_graph(nodelist,edgelist)
print(stat.cal_graphavg(graphlist,edgelist))
```

```
PS C:\Users\86186\D
sers\86186\.vscode\
化.py'
8.308899454540152
```

（2） 获取节点的类型分布，单个节点以字典形式储存，所有节点以列表形式输出

```
def typestat(graphlist):
    res=[]
    for i in range(len(graphlist)):
        resdict = {}
        resdict["节点id"] = graphlist[i]["节点id"]
        resdict["节点名称"] = graphlist[i]["节点名称"]
        resdict["节点类型"] = graphlist[i]["节点类型"]
        res.append(resdict)
    return res
```

运行结果：

```
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)


edgelist=graph.init_edge(filepath)

graphlist=graph.init_graph(nodelist,edgelist)
print(stat.typestat(graphlist))
```

```
化.py'
[{'节点id': '0', '节点名称': '"Ann Blyth"', '节点类型': 'starring'}, {'节点id': '1', '节点名称': '"Karen Allen"', '节点类型': 'starring'}, {'节点id': '2', '节点名称': '"Mel Tormé"', '节点类型': 'writer'}, {'节点id': '3', '节点名称': '"Jane Anderson"', '节点类型': 'director'}, {'节点id': '4', '节点名称': '"Lou Myers (actor)"', '节点类型': 'starring'}, {'节点id': '5', '节点名称': '"Mary Ainslee"', '节点类型': 'starring'}, {'节点id': '6', '节点名称': '"Bridgette Wilson"', '节点类型': 'starring'}, {'节点id': '7', '节点名称': '"George W. Trendle"', '节点类型': 'director'}, {'节点id': '8', '节点名称': '"Victor Hugo"', '节点类型': 'writer'}, {'节点id': '9', '节点名称': '"Jeremy Leven"', '节点类型': 'writer'}, {'节点id': '10', '节点名称': '"Rodney Eastman"', '节点类型': 'starring'}, {'节点id': '11', '节点名称': '"David Greig (dramatist)"', '节点类型': 'director'}, {'节点id': '12', '节点名称': '"Emmanuèle Bernheim"', '节点类型': 'writer'}, {'节点id': '13', '节点名称': '"John Michael Higgins"', '节点类型': 'starring'}, {'节点id': '14', '节点名称': '"Tim DeKay"', '节点类型': 'starring'}, {'节点id': '15', '节点名称': '"Jason Miller (playwright)"', '节点类型': 'writer'}, {'节点id': '16', '节点名称': '"D
```

（3） 获取节点的权重分布

```
def weighstat(graphlist):
    res=[]
    for i in range(len(graphlist)):
        resdict = {}
        resdict["节点id"] = graphlist[i]["节点id"]
        resdict["节点名称"] = graphlist[i]["节点名称"]
        resdict["节点权重"] = graphlist[i]["节点权重"]
        res.append(resdict)
    return res
```

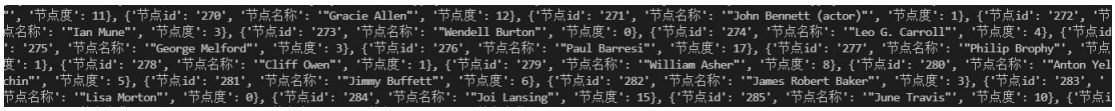
运行结果：

```
重': '6881'}, {'节点id': '130', '节点名称': '"Charles S. Dutton"', '节点权重': '8064'}, {'节点id': '131', '节点名称': '"David Faustino"', '节点权重': '5275'}, {'节点id': '132', '节点名称': '"Rain Phoenix"', '节点权重': '7650'}, {'节点id': '133', '节点名称': '"Victor Rasuk"', '节点权重': '3683'}, {'节点id': '134', '节点名称': '"Luther Vandross"', '节点权重': '26591'}, {'节点id': '135', '节点名称': '"Ralph Meeker"', '节点权重': '5683'}, {'节点id': '136', '节点名称': '"Tony Lip"', '节点权重': '799'}, {'节点id': '137', '节点名称': '"John Heyer"', '节点权重': '17028'}, {'节点id': '138', '节点名称': '"George Kirby"', '节点权重': '3144'}, {'节点id': '139', '节点名称': '"Mark Burton (writer)"', '节点权重': '314'}, {'节点id': '140', '节点名称': '"Doro Merande"', '节点权重': '3839'}, {'节点id': '141', '节点名称': '"Rick Famuyiwa"', '节点权重': '461'}, {'节点id': '142', '节点名称': '"Mira Sorvin
PS C:\Users\86186\Desktop\现代程序设计\第2次>
```

（4） 获取节点的自由度分布

```python
def degreestat(graphlist):
    res=[]
    for i in range(len(graphlist)):
        resdict = {}
        resdict["节点id"] = graphlist[i]["节点id"]
        resdict["节点名称"] = graphlist[i]["节点名称"]
        degree=sum(list(graphlist[i]["节点连接信息"].values()))
        resdict["节点度"] = degree
        res.append(resdict)
    return(res)
```

运行结果：



5. 图的可视化包

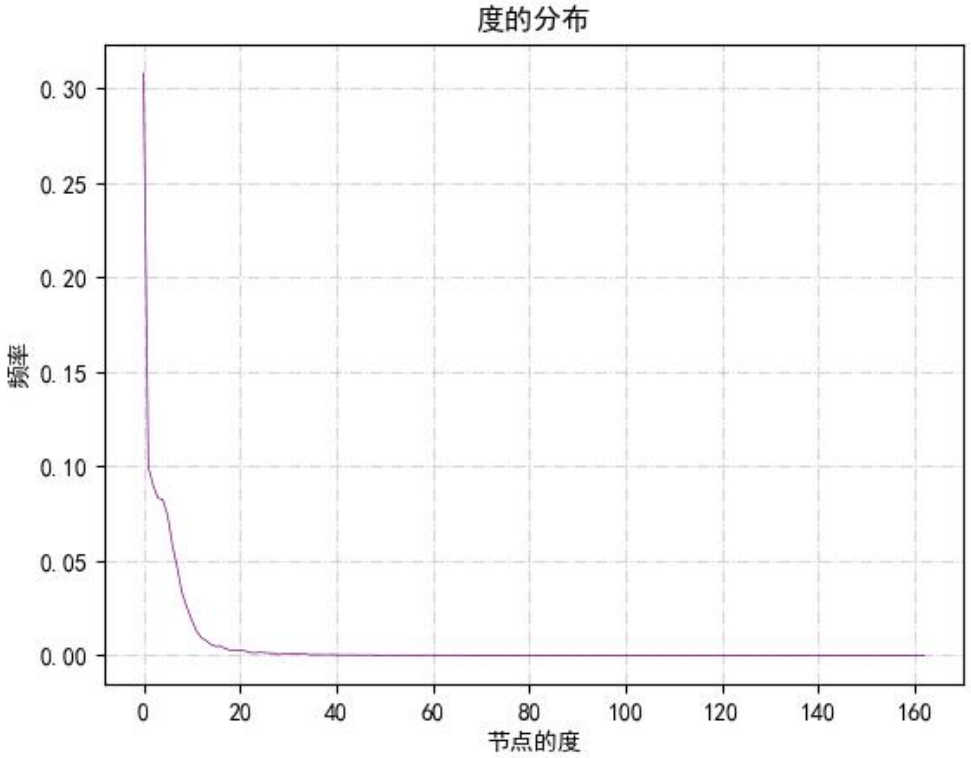
（1） 图的自由度分布可视化

统计每个节点自由度的数量，计算出现的频率，以折线图的形式呈现图的自由度分布

```python
import numpy as np
import matplotlib.pyplot as plt
import networkx as nx

plt.rcParams['font.sans-serif']=['SimHei']
plt.rcParams['axes.unicode_minus'] = False

def plotdegree(degree):
    degreelist=[]
    for i in range(len(degree)):
        degreelist.append(int(degree[i]["节点度"]))
    sumdegree=len(degreelist)
    x=list(set(degreelist))
    y=[]
    for i in x:
        caly=degreelist.count(i)/sumdegree
        y.append(caly)
    x=np.array(x)
    y=np.array(y)
    plt.plot(x,y,ls='-', lw=0.5,  color='purple')
    plt.xlabel("节点的度")
    plt.ylabel("频率")
    plt.title("度的分布")
    plt.grid(alpha=0.5,linestyle='-.')
    plt.show()
```

运行结果:

```python
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)


edgelist=graph.init_edge(filepath)

graphlist=graph.init_graph(nodelist,edgelist)

degree=stat.degreestat(graphlist)
plotgraph.plotdegree(degree)
```



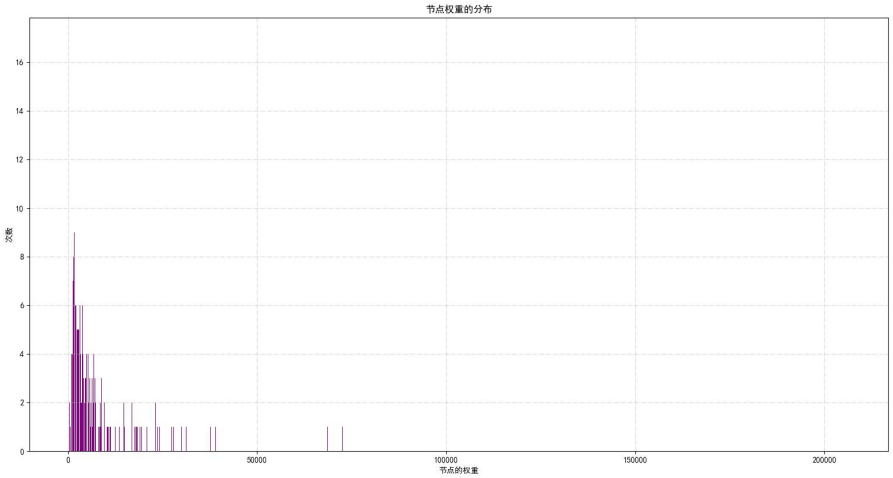
（2） 节点的权重分布可视化

统计不同权重出现的次数，以柱状图的形式呈现结果

```python
import numpy as np
import matplotlib.pyplot as plt

plt.rcParams['font.sans-serif']=['SimHei']
plt.rcParams['axes.unicode_minus'] = False

def plotweigh(weigh):
    weighlist=[]
    for i in range(len(weigh)):
        weighlist.append(int(weigh[i]["节点权重"]))
    x=list(set(weighlist))
    y=[]
    for i in x:
        caly=weighlist.count(i)
        y.append(caly)
    x=np.array(x)
    y=np.array(y)
    print(x,y)
    plt.bar(x,y,color='purple')
    plt.xlabel("节点的权重")
    plt.ylabel("次数")
    plt.title("节点权重的分布")
    plt.grid(alpha=0.5,linestyle='-.')
    plt.show()
```

运行结果:

```python
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)


edgelist=graph.init_edge(filepath)

graphlist=graph.init_graph(nodelist,edgelist)

#degree=stat.degreestat(graphlist)
#plotgraph.plotdegree(degree)
weigh=stat.weighstat(graphlist)
plotnodes.plotweigh(weigh)
```



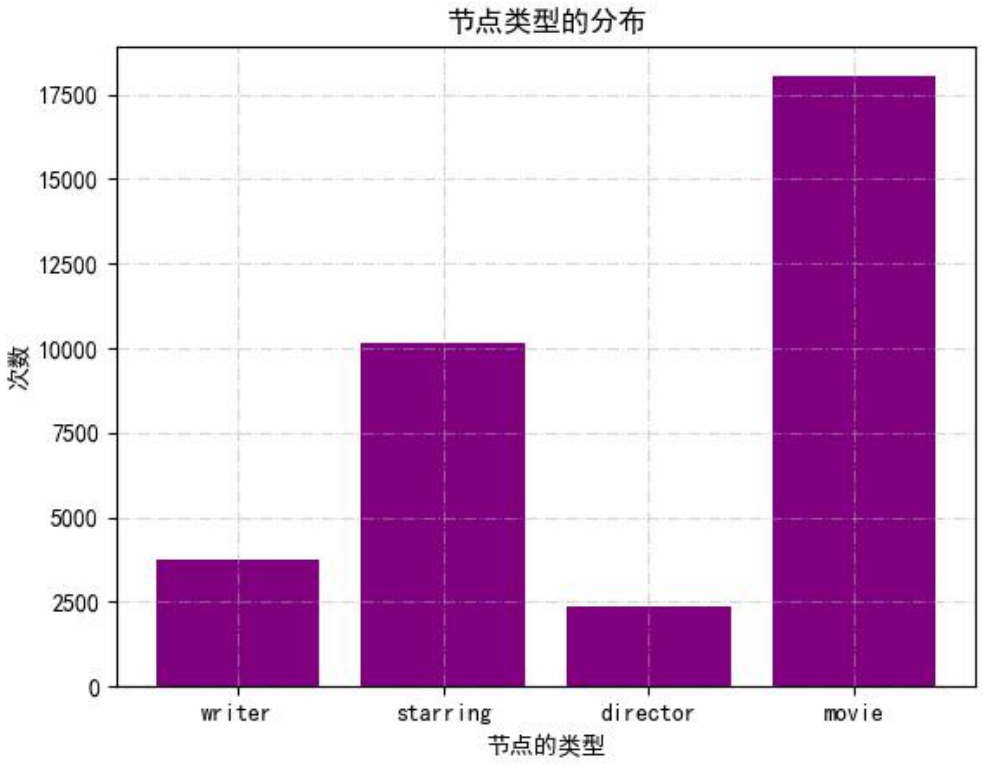
（3） 节点类型分布可视化

统计不同类型节点的数目，以柱状图形式呈现

```
def plottype(type):
    typelist=[]
    for i in range(len(type)):
        typelist.append(type[i]["节点类型"])
    x=["writer","starring","director","movie"]
    y=[]
    for i in x:
        caly=typelist.count(i)
        y.append(caly)
    x=np.array(x)
    y=np.array(y)
    plt.bar(x,y, color='purple')
    plt.xlabel("节点的类型")
    plt.ylabel("次数")
    plt.title("节点类型的分布")
    plt.grid(alpha=0.5,linestyle='-.')
    plt.show()
```

运行结果：

```
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)


edgelist=graph.init_edge(filepath)

graphlist=graph.init_graph(nodelist,edgelist)

#degree=stat.degreestat(graphlist)
#plotgraph.plotdegree(degree)
#weigh=stat.weighstat(graphlist)
#plotnodes.plotweigh(weigh)

type=stat.typestat(graphlist)
plotnodes.plottype(type)
```



6. 利用 networkx 库，画出部分节点之间的网络结构

此处取前 1000 个节点，按照有权无向图画出关系，并且标出节点 id

```
import numpy as np
import matplotlib.pyplot as plt
import networkx as nx
```

```
def plotgraph(filepath):
    mark=0
    with open(filepath,'r',encoding="utf-8") as f:
        mid=[]
        for line in f.readlines():
            if line == "*Edges\n":
                mark = 1
            elif mark == 1:
                mid.append(tuple(map(int,line.strip().split('\t'))))
    G=nx.Graph()
    G.add_weighted_edges_from(mid[:1000])
    nx.draw(G,with_labels=True)
    plt.show()
```

运行结果:

```
from GraphStat.Graph import *
from GraphStat.Visualization import plotgraph
from GraphStat.Visualization import plotnodes
filepath = r"C:\Users\86186\Desktop\现代程序设计\newmovies.txt"

nodelist=node.init_node(filepath)


edgelist=graph.init_edge(filepath)

graphlist=graph.init_graph(nodelist,edgelist)

#degree=stat.degreestat(graphlist)
#plotgraph.plotdegree(degree)
#weigh=stat.weighstat(graphlist)
#plotnodes.plotweigh(weigh)
#type=stat.typestat(graphlist)
#plotnodes.plottype(type)
plotgraph.plotgraph(filepath)
```