Homework nr. 1 - data visualization (deadline 25/10/2018)

In short, the main task is to download data on theses defended at CTU from the Internet, store them in pandas Data Frame and then visualize some hidden information.

> The instructions are not given in details: It is up to you to come up with ideas on how to fulfill the particular tasks as best you can. Thinking of how to visualize the data is an important part of data visualization! ;)

What are you supposed to do:

1. Browse the web https://dspace.cvut.cz/?locale-attribute=en (https://dspace.cvut.cz/?locale-attribute=en) and find out how to download data on Bachelor and Master theses.
2. Download or scrape the data such that for each thesis you know the following:
   - Faculty name, department name, thesis title, thesis type (bachelor/master), supervisor name, reviewer name, year (or date) of the defence, study programme and discipline, link to a webpage with details.
3. Store these data in one *csv* file (should be handed in along with this notebook).
4. Use tools available for Python to plot charts and tables to visualize/display this information:
   - Number of defended theses per year for CTU/Faculties. Distinguish the type of thesis.
   - Find the departments/study programmes/supervisors/reviewers with highest numbers of thesis and come up with some nice plots and tables to depict their numbers.
   - Mean/median/minimum/maximum number of supervised theses per year for faculties.
   - Number (or fraction) of theses supervised by people with various degrees (Bc./Ing./Ph.D./ ...).

If you do all this properly, you will obtain 6 points

To earn **extra two points** you can do some of these:

- Use http://beakerx.com (http://beakerx.com) to make your notebook interactive in a meaningful way.
- Come up with some other reasonable and interesting views of data.
- Use your data to create an interactive webpage (HTML + JavaScript).

Comments

- Please follow the instructions from https://courses.fit.cvut.cz/MI-PDD/homeworks/index.html (https://courses.fit.cvut.cz/MI-PDD/homeworks/index.html).
- If the reviewing teacher is not satisfied, he can give you another chance to rework your homework and to obtain more points.

Solution

Data downloading

- Data are download from page dspace, where can be list all uploaded work on CTU.
- Data for each work can be download as table on work url (https://dspace.cvut.cz/handle/10467/78315?show=full (https://dspace.cvut.cz/handle/10467/78315?show=full))
- Data is in multiple languages. The language preference with downloaded files (Bachelor, Master, ...) can be specified.
- In script I download master's and bachelor's thesis and want data in english if possible, but if not get czech.
- In data table from dspace are not save faculty name and people's degrees.
- Faculty name are parse from page navigation in every work own page.
- Degree for supervisors and rereviewers can be dowload from (https://usermap.cvut.cz/ (https://usermap.cvut.cz/))
    - There is some problems. UserMap are genereted by js script and can't be dowload by html get.
    - So, for download degrees of supervisor and rereviewers need selenium and Chrome driver for generating pages. This generating pages take some time. For this reason, I have enclosed the csv file with downloaded data.
- While downloading are data flush to csv every downloaded page with works. This prevent lost data when run raise exception.
- Data are save in works.csv with head of csv (,acceptedDate,author,department,discipline,faculty,issued,language,programme, rewiever,rewiever_degree,subject,supervisor,supervisor_degree,title,type,uri)

In [8]:

```
# Imports for downloading

import pandas as pd
import requests
from bs4 import BeautifulSoup
import time
import os.path
```

In [9]:

```python
from selenium import webdriver
# Problem when getting people from users.cvut.cz Ajax rendering.
# For get people -> need Chrome webdriver and it is take more time to get All
# Function to get degrees of people
class People():

    def __init__(self):
        self.driver = webdriver.Chrome()
        self.people = {}

    def end(self):
        self.driver.quit()

    "Get degree from user whichc work on faculty. Cache users for not download mre tha one."
    def getDegree(self, name, faculty):
        try:
            item = (name, faculty)
            if item in self.people:
                return self.people[item]

            self.driver.get("https://usermap.cvut.cz/search?query=" + name);
            for element in self.driver.find_elements_by_id(
                "search-results-table")[0].find_element_by_tag_name(
                "tbody").find_elements_by_tag_name("tr"):

                names = element.find_element_by_tag_name("a").text
                fac = element.find_element_by_tag_name("abbr").get_attribute("title").split("-")[0].strip()
                if faculty == fac:
                    splitName = names.split(",")
                    degrees = ", ".join(splitName[len(name.split(" ")):])
                    self.people[(name, faculty)] = degrees
                    return degrees
        except Exception:
            return None
        return None
```

In [ ]:

```
# Download data - It may take a several minutes.
#                 You can edit the number of pages downloaded.
#                 Work is being rolled down from the newest.


# Main dpace url for find BP, DP
urlMain = 'https://dspace.cvut.cz{}'
# Url with search form
urlDist = '/discover'
# Data for specific page to download
data = {
    'rpp' : '100',
    'etal' : '0',
    'group_by' : 'none',
    'page' : '0',
    'sort_by' : 'dc.date.issued_dt',
    'order' : 'desc'}

#Prefered lang
pref_lang = "eng"
#Download degrees from usemap -> need chrome driver for render javascript
 to download.
dPeople = True
work_get = {"bachelor thesis", "master's thesis", 'bakalářská práce', 'di
plomová práce'}

# Need
newColumns = {'dc.contributor.advisor' : 'supervisor' , 'dc.contributor.a
uthor' : 'author',
                 'dc.identifier.uri' : 'uri', 'dc.date.issued' : 'issued'
,
       'dc.language.iso' : 'language', 'dc.subject' : 'subject', 'dc.titl
e' : 'title', 'dc.type' : 'type',
       'dc.date.accepted' : 'acceptedDate', 'dc.contributor.referee' :'re
wiever',
       'theses.degree.discipline' : 'discipline', 'theses.degree.grantor'
 : 'department',
       'theses.degree.programme' : 'programme'}

if dPeople: people = People()
# Group columns by language spec and keep one of want language or if not
 exist keep another one.
# Keep only one column in prefer language
def manageColumns(df):
    mp={}
    rem_flag = False
    for number, lang in enumerate(df[2]):
        if df[0][number] not in mp:
            mp[df[0][number]] = []
        mp[df[0][number]].append((lang, number))
    for i in mp.copy():
        if len(mp[i])> 1:
            for j in mp[i]:
                if j[0] == pref_lang:
                    mp[i].remove(j)
                    rem_flag = True
                    break
            if not rem_flag:
                mp[i].pop(0)
        else:
            del mp[i]
    for i in mp:
        for j in mp[i]:
            df = df.drop(j[1], axis=0)
    return df

# Extract nice data frame from one work html page to table
def parseDataFromHtmlTablePage(pageText):
    ldf = pd.read_html(pageText.text,header = None, flavor = 'bs4')
    df = ldf[0]
    df = manageColumns(df)
    df = df.transpose()
    df.columns = df.iloc[0]
    if ("dc.type" not in df.columns):
        print("Not specific type.")
        return pd.DataFrame()
    df = df.drop(0, axis = 0)
    df = df.drop(2, axis = 0)

    if (str(df['dc.type'][1]).lower() not in work_get):
        return pd.DataFrame()

    for i in newColumns:
        if i not in df.columns:
            df[i]=None
    for i in df.columns:
        if i not in newColumns:
            df = df.drop(i, axis=1)

    df.rename(columns=newColumns, inplace=True)

    # Data which are not on dspace page
    df["faculty"] = BeautifulSoup(pageText.text, "html.parser").find_all(
"ul",
                        {"class": "breadcrumb hidden-xs"})[0].find_all("l
i")[1].get_text().strip()
    if dPeople:
        try:
            df["supervisor_degree"] = people.getDegree(df['supervisor'][1
], df['faculty'][1])
        except Exception:
            df["supervisor_degree"] = None
        try:
            df["rewiever_degree"] = people.getDegree(df['rewiever'][1], d
f['faculty'][1])
        except Exception:
            df["rewiever_degree"] = None
    return df

# Data frame with all data
data_all = pd.DataFrame(columns = ['supervisor', 'author', 'issued', 'ur
i', 'language', 'subject', 'title', 'type',
                  'acceptedDate', 'rewiever', 'discipline', 'department',
                                   'programme', 'faculty', 'supervisor_degree', 'rewiever_degree'])

firstPage = requests.get(urlMain.format(urlDist), data)
soup = BeautifulSoup(firstPage.text, "html.parser")
pages = int(soup.find("li", {"class": "last-page-link"}).find("a").get_text())
print("Download first page. Pages with works:", pages, flush=True)

sumTime = 0
file = 'tmp.csv'
# from page
fromPage = 150
# go over all pages
for pg in range(fromPage, pages+1):

    data['page'] = pg
    page = requests.get(urlMain.format(urlDist), data)
    soup = BeautifulSoup(page.text, "html.parser")

    # go over all items on page
    t1 = time.time()
    for i in soup.findAll("div", {"class": "row ds-artifact-item "}):
        one = requests.get(urlMain.format(i.find("a").get("href")), {'show' : 'full'})
        if one.status_code != 200:
            print("Cant reach the work page. Continue..")
            continue

        df = parseDataFromHtmlTablePage(one)
        if df.shape[0] == 0:
            continue
        if data_all.shape[0] == 0:
            data_all = df.copy()
        else:
            data_all = pd.concat([data_all,df], ignore_index=True, sort=False)

    if data_all.shape[0] == 0:
            continue
    # Get lower type and convert date in Data Frame
    data_all['type'] = data_all['type'].str.lower()

    #data_all['acceptedDate'] =  pd.to_datetime(data_all['acceptedDate'], format='%Y-%m-%d')

    #Count time and print download pages.
    #After 100 download flush dataframe to csv.
    #To prevent program die.
    sumTime += time.time()-t1

    print("Page:", pg, "/", pages, flush=True)
    print(sumTime, pg, flush=True)
    if os.path.isfile(file):
        data_all = data_all.reindex(sorted(data_all.columns), axis=1)
        data_all.to_csv(file, mode='a', sep=',', header=False)
    else:
        data_all = data_all.reindex(sorted(data_all.columns), axis=1)
        data_all.to_csv(file, mode='a', sep=',', header=True)

    data_all = data_all.iloc[0:0]

    print("Remaining :", (sumTime/(pg+1-fromPage))*(pages-pg), flush=True
)

if dPeople: people.end()
```

Data visualization

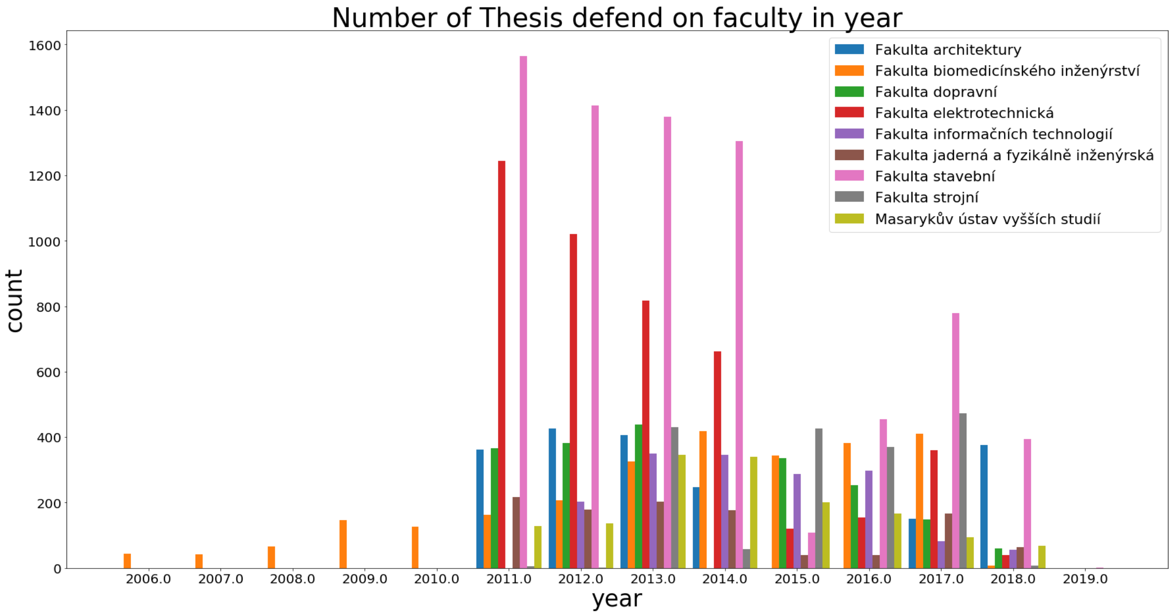
The data visualization is divided into 4 parts, according to the input

In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import sklearn as skit
import seaborn as sns
from IPython.display import display, Markdown, Latex

RAW_DATA = pd.read_csv('works.csv', index_col=0).reset_index(drop=True)
RAW_DATA['acceptedDate'] =  pd.to_datetime(RAW_DATA['acceptedDate'], form
at='%Y-%m-%d')
RAW_DATA['issued'] =  pd.to_datetime(RAW_DATA['issued'], format='%Y-%m-%d
')
RAW_DATA['type'] = RAW_DATA['type'].str.replace('bakalářská práce','bache
lor thesis')
RAW_DATA['type'] = RAW_DATA['type'].str.replace('diplomová práce',"maste
r's thesis")
RAW_DATA['year'] = RAW_DATA['acceptedDate'].map(lambda x: x.year)
```

In [9]:

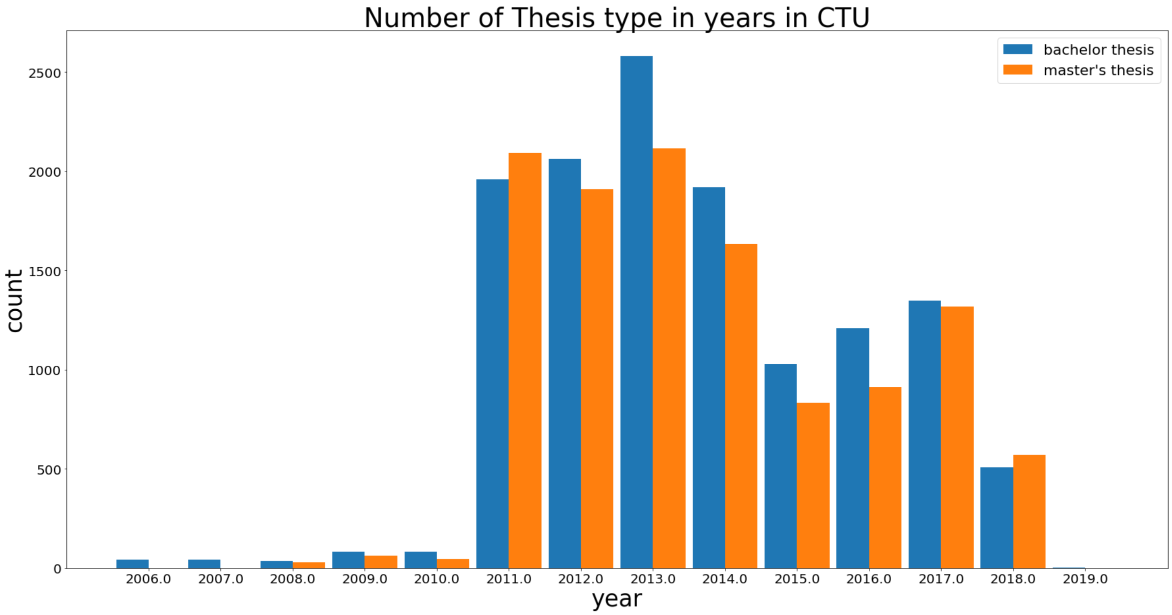
```
dataCVUT = RAW_DATA.copy()
#group by year and faculty

def groupedBoxPlot(boxLb, xLb, ttl):
    df1 = pd.DataFrame({'count' : dataCVUT.groupby([xLb, boxLb
                                    ]).size().sort_values(ascending=False
)}).reset_index()

    #create subplots
    fig, ax = plt.subplots(figsize=(30,15))
    plt.ylabel("count", size = 35)
    plt.xlabel(xLb, size = 35)
    plt.rc('axes',labelsize=30, titlesize=30)
    #x
    ind = sorted(df1[xLb].unique())
    #bar
    fac = sorted(df1[boxLb].unique())

    magicNumber = float(0.90/len(fac)) # the width of the bars
    startNumber = float(-1*(0.90/2)) #distribute bars near the year

    pp = []
    for f in fac:
        # Get data by faculty
        df = df1.loc[df1[boxLb] == f, [xLb, 'count']].sort_values(by = xL
b, ascending=True)
        # Add year which are not in faculty. Fill with 0
        for yr in ind:
            if yr not in df[xLb].tolist():
                df = df.append(pd.DataFrame([[yr, 0]], columns=[xLb, 'cou
nt']), ignore_index=True)
        # List from sorted years with count
        df = df.sort_values(by = xLb, ascending=True)["count"].tolist()
        # Create bars shifted by number which distributed around the year
        pp.append(ax.bar([x+startNumber+magicNumber/2 for x in ind], df,
magicNumber))
        startNumber += magicNumber

    ax.set_title(ttl, size = 40)
    ax.set_xticks([x for x in ind])
    plt.xticks(fontsize=20)
    plt.yticks(fontsize=20)
    ax.set_xticklabels(ind)

    ax.legend([x[0] for x in pp], fac, fontsize = 22)
    ax.autoscale_view()
    plt.show()
    display(Markdown("Only head of table for graph. It is too large. The
 table may be scaled up or exported to csv."))
    display(df1.sort_values(by=boxLb).sort_values(by=xLb).head(10))

groupedBoxPlot('faculty', 'year', 'Number of Thesis defend on faculty in
 year')
display(Markdown('The first graph shows that complete data has been found
 on the dspace site since 2011.'))
display(Markdown('Data from previous years may be listed but, for exampl
e, they miss parameter'))
display(Markdown('defend_date or the data are not listed at all. It is in
teresting to notice the'))
display(Markdown('appearance of the defended works of our faculty in 201
2.'))

groupedBoxPlot('type', 'year', 'Number of Thesis type in years in CTU')
display(Markdown('#### Number of thesis defend on faculty, diveded into m
aster and bachelor.'))
boxLb = 'type'
xLb = 'faculty'
df1 = pd.DataFrame({'count' : dataCVUT.groupby([xLb, boxLb]).size().sort_
values(ascending=False)}).reset_index()
display(df1.sort_values(by=boxLb).sort_values(by=xLb))
```



Only head of table for graph. It is too large. The table may be scaled up or exported to csv.

	year	faculty	count
64	2006.0	Fakulta biomedicínského inženýrství	43
65	2007.0	Fakulta biomedicínského inženýrství	42
59	2008.0	Fakulta biomedicínského inženýrství	67
50	2009.0	Fakulta biomedicínského inženýrství	146
53	2010.0	Fakulta biomedicínského inženýrství	127
23	2011.0	Fakulta dopravní	366
4	2011.0	Fakulta elektrotechnická	1245
37	2011.0	Fakulta jaderná a fyzikálně inženýrská	218
46	2011.0	Fakulta biomedicínského inženýrství	162
0	2011.0	Fakulta stavební	1564

The first graph shows that complete data has been found on the dspace site since 2011. Data from previous years may be listed but, for example, they miss parameter defend_date or the data are not listed at all. It is interesting to notice the appearance of the defended works of our faculty in 2012.



Only head of table for graph. It is too large. The table may be scaled up or exported to csv.

	year	type	count
20	2006.0	bachelor thesis	43
21	2007.0	bachelor thesis	42
22	2008.0	bachelor thesis	37
23	2008.0	master's thesis	30
16	2009.0	bachelor thesis	83
18	2009.0	master's thesis	63
17	2010.0	bachelor thesis	82
19	2010.0	master's thesis	45
4	2011.0	bachelor thesis	1959
2	2011.0	master's thesis	2092

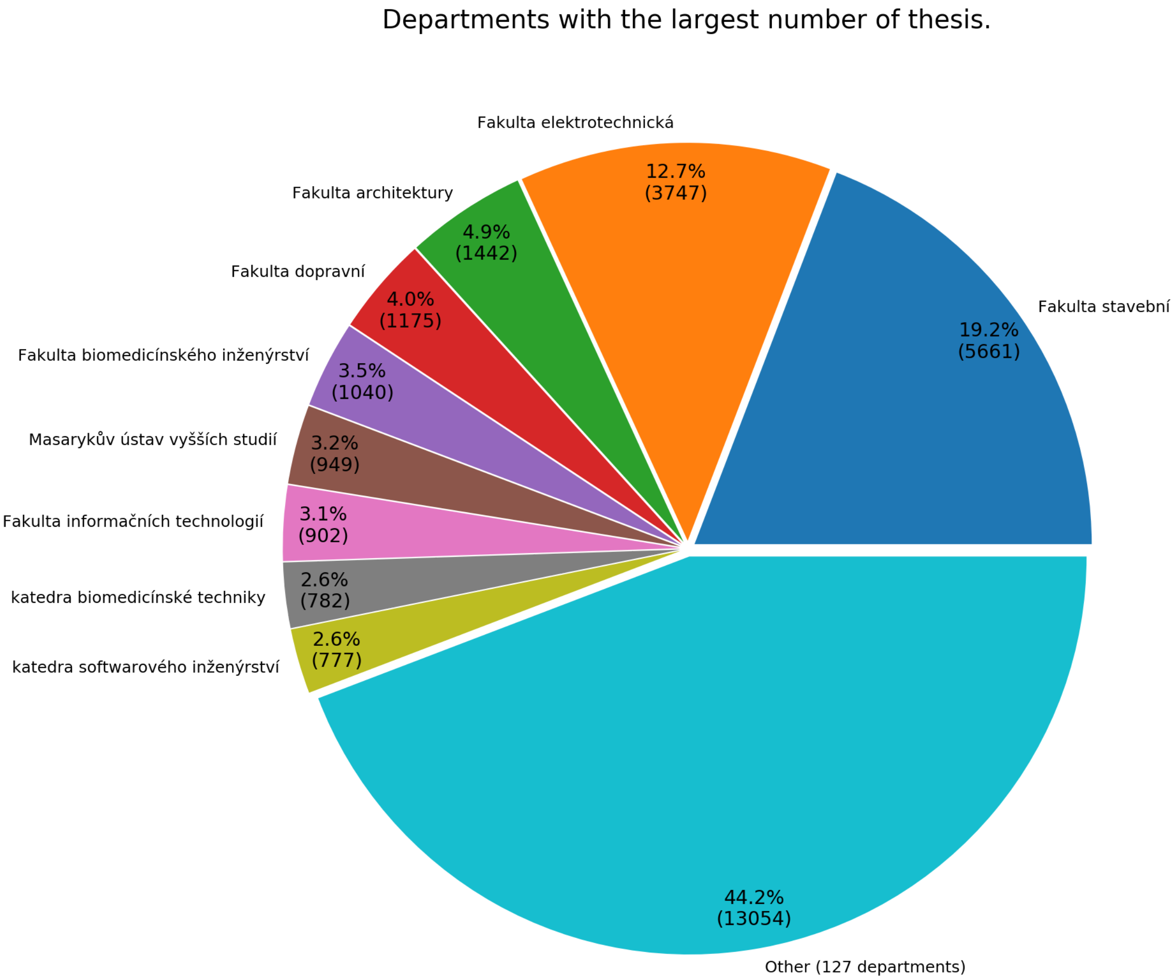
Number of thesis defend on faculty, diveded into master and bachelor.

	faculty	type	count
9	Fakulta architektury	master's thesis	1096
11	Fakulta architektury	bachelor thesis	1014
4	Fakulta biomedicínského inženýrství	bachelor thesis	1662
10	Fakulta biomedicínského inženýrství	master's thesis	1035
12	Fakulta dopravní	bachelor thesis	1005
8	Fakulta dopravní	master's thesis	1152
3	Fakulta elektrotechnická	bachelor thesis	2724
2	Fakulta elektrotechnická	master's thesis	3135
5	Fakulta informačních technologií	bachelor thesis	1400
14	Fakulta informačních technologií	master's thesis	874
17	Fakulta jaderná a fyzikálně inženýrská	master's thesis	481
16	Fakulta jaderná a fyzikálně inženýrská	bachelor thesis	607
0	Fakulta stavební	master's thesis	4326
1	Fakulta stavební	bachelor thesis	4156
13	Fakulta strojní	master's thesis	917
7	Fakulta strojní	bachelor thesis	1159
6	Masarykův ústav vyšších studií	bachelor thesis	1352
15	Masarykův ústav vyšších studií	master's thesis	662

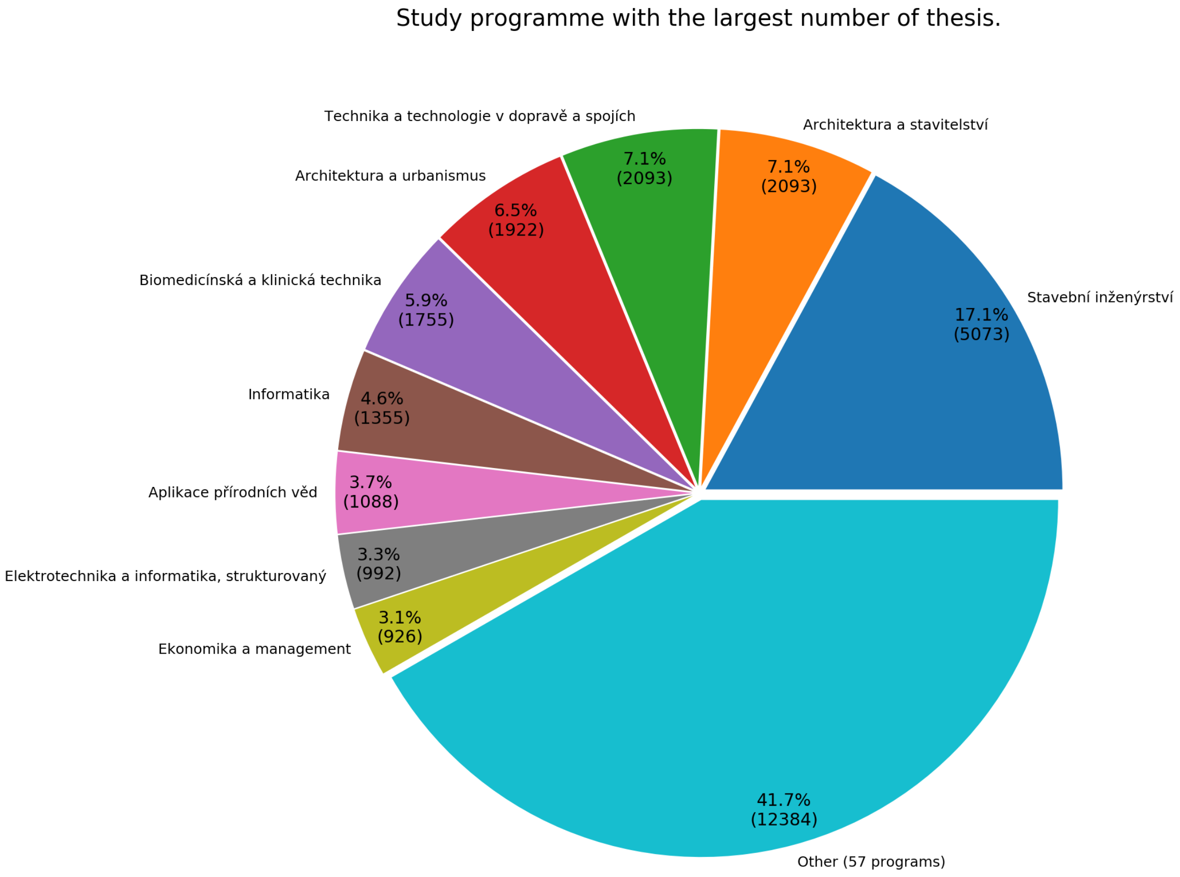
In [30]:

```
dataCVUT = RAW_DATA.copy()

def func(pct, allvals):
    absolute = int(pct/100.*np.sum(allvals))
    return "{:.1f}%\n({:d})".format(pct, absolute)

def pieChart(sizes, labels, title, rotation):

    plt.rc('axes',labelsize=20, titlesize=30)
    fig1, ax1 = plt.subplots(figsize=(25,30))
    patches, texts, autotexts = ax1.pie(sizes, labels=labels, autopct=lambda pct: func(pct, sizes),
        startangle=rotation, textprops={'fontsize': 30}, pctdistance=0.9, labeldistance=1.05, explode=len(sizes)*[0.02])
    for i in texts:
        i.set_fontsize(25)
    ax1.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.
    ax1.set_title(title, size = 40)

    plt.show()


def pieChartFromDataFrame(dataFrame, groupBy, otherName, numberOfPieces, title, rotation=0):
    dataFrame = pd.DataFrame({'count' : dataCVUT.groupby([groupBy]).size().sort_values(ascending=False)}).reset_index()
    tmp = dataFrame.loc[numberOfPieces:,:].sum()
    tmp[groupBy] = "Other (" + str(dataFrame.loc[:,:].count()['count']) + " " + otherName + ")"
    dataFrame = pd.concat([dataFrame.loc[:numberOfPieces,:],pd.DataFrame(tmp).transpose()], sort=False)

    labels = dataFrame[groupBy]
    sizes = dataFrame['count']

    explode = [0] * len(labels)

    pieChart(sizes, labels,title, rotation )
    display(dataFrame)


pieChartFromDataFrame(dataCVUT, 'department', "departments", 8,
                      "Departments with the largest number of thesis.")


pieChartFromDataFrame(dataCVUT, 'programme', "programs", 8,
                      "Study programme with the largest number of thesis.")

numberOfPieces = 10
display(Markdown("#### Supervisors programme with the largest number of thesis."))

dataFrame = pd.DataFrame({'count' : dataCVUT.groupby(['supervisor']).size().sort_values(ascending=False)}).reset_index()
```

```
tmp = dataFrame.loc[numberOfPieces:,:].sum()
tmp['supervisor'] = "Other (" + str(dataFrame.loc[:,:].count()['count'])
+ " " + 'supervisors' + ")"
dataFrame = pd.concat([dataFrame.loc[:numberOfPieces,:],pd.DataFrame(tmp)
.transpose()], sort=False)
dataFrame['percent'] = (dataFrame['count'] / dataFrame['count'].sum())*10
0.
display(dataFrame)
display(Markdown("#### Reviewers with the largest number of thesis."))
dataFrame = pd.DataFrame({'count' : dataCVUT.groupby(['rewiever']).size()
.sort_values(ascending=False)}).reset_index()
tmp = dataFrame.loc[numberOfPieces:,:].sum()
tmp['rewiever'] = "Other (" + str(dataFrame.loc[:,:].count()['count']) +
" " + 'reviewers' + ")"
dataFrame = pd.concat([dataFrame.loc[:numberOfPieces,:],pd.DataFrame(tmp)
.transpose()], sort=False)
dataFrame['percent'] = (dataFrame['count'] / dataFrame['count'].sum())*10
0.
display(dataFrame)
```



	department	count
0	Fakulta stavební	5662
1	Fakulta elektrotechnická	3747
2	Fakulta architektury	1443
3	Fakulta dopravní	1176
4	Fakulta biomedicínského inženýrství	1041
5	Masarykův ústav vyšších studií	949
6	Fakulta informačních technologií	902
7	katedra biomedicínské techniky	782
8	katedra softwarového inženýrství	778
0	Other (127 departments)	13055



	programme	count
0	Stavební inženýrství	5073
1	Architektura a stavitelství	2094
2	Technika a technologie v dopravě a spojích	2093
3	Architektura a urbanismus	1922
4	Biomedicínská a klinická technika	1756
5	Informatika	1355
6	Aplikace přírodních věd	1088
7	Elektrotechnika a informatika, strukturovaný	992
8	Ekonomika a management	927
0	Other (57 programs)	12384

Supervisors programme with the largest number of thesis.

	supervisor	count	percent
0	Náplava Pavel	184	0.637782
1	Kuklíková Anna	129	0.44714
2	Svoboda Pavel	113	0.391681
3	Chludil Jiří	107	0.370884
4	Pospíchal Václav	107	0.370884
5	Šestáková Irena	103	0.357019
6	Šimeček Ivan	102	0.353553
7	Jandera Michal	98	0.339688
8	Knytl Luboš	94	0.325823
9	Lédl Petr	93	0.322357
10	Svoboda Emanuel	93	0.322357
0	Other (3342 supervisors)	27627	95.7608

Reviewers with the largest number of thesis.

	rewiever	count	percent
0	Kordík Pavel	86	0.405374
1	Šimeček Ivan	79	0.372378
2	Chludil Jiří	75	0.353523
3	Škorňová Eva	67	0.315814
4	Cupal Libor	65	0.306387
5	Valenta Michal	64	0.301673
6	Kubr Jan	60	0.282819
7	Krejčí Pavel	60	0.282819
8	Náhlík Josef	59	0.278105
9	Kudrna Valdemar	52	0.24511
10	Macek Ondřej	49	0.230969
0	Other (6781 reviewers)	20499	96.625

In [6]:

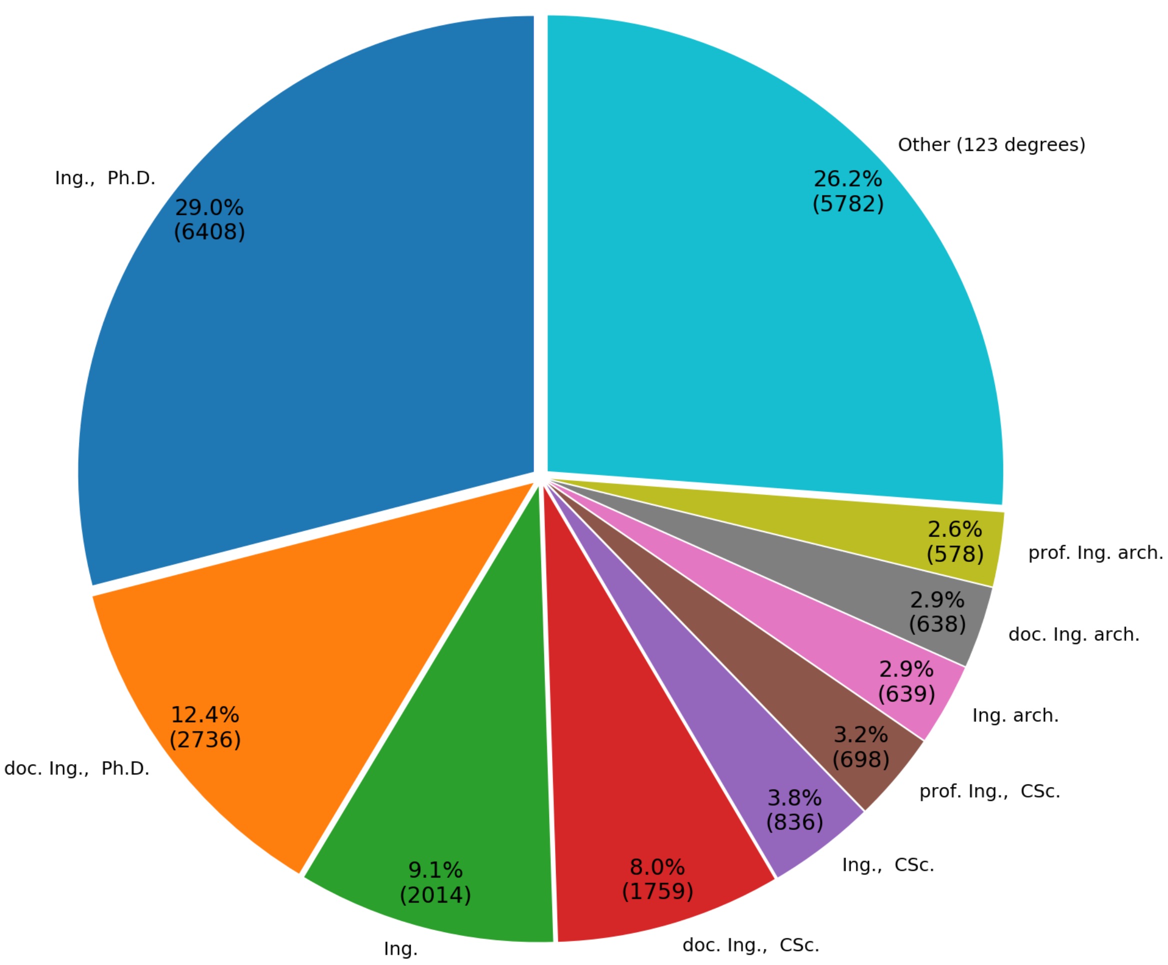
```
dataCVUT = RAW_DATA.copy()
df1 = pd.DataFrame({'count' : dataCVUT.groupby(['year', 'faculty'
                                ]).size().sort_values(ascending=False)}).
reset_index()

years = sorted(df1['year'].unique())
facs = sorted(df1['faculty'].unique())
data = pd.DataFrame(columns = sorted(df1['faculty'].unique()))
for y in years:
    tmp = df1.loc[df1['year'] == y, ['faculty', 'count']].sort_values(by
= 'faculty', ascending=True)
    tmp.index = tmp['faculty']
    tmp = tmp.drop('faculty', axis=1).transpose()
    tmp.index = [y]
    data = pd.concat([data,tmp], sort=False)

for f in facs:
    data[f]  = pd.to_numeric(data[f], errors='ignore')

display(Markdown('#### Mean/median(50%)/minimum/maximum number of supervi
sed theses per year for faculties.'))
display(data.transpose().reindex(sorted(years), axis=1).describe().loc[[
'mean', '50%', 'min', 'max']])
```

Mean/median(50%)/minimum/maximum number of supervised theses per year for faculties.

	2006.0	2007.0	2008.0	2009.0	2010.0	2011.0	2012.0	2013.0	2014.0	2
mean	43.0	42.0	67.0	146.0	127.0	506.375	441.111111	521.777778	444.5	23
50%	43.0	42.0	67.0	146.0	127.0	290.500	207.000000	406.000000	343.0	24
min	43.0	42.0	67.0	146.0	127.0	5.000	2.000000	203.000000	58.0	4
max	43.0	42.0	67.0	146.0	127.0	1564.000	1413.000000	1380.000000	1305.0	42

In [31]:

```
dataCVUT = RAW_DATA.copy()


pieChartFromDataFrame(dataCVUT, 'supervisor_degree', "degrees", 8,
                      "Number of theses supervised by people with various degrees.", 90)
```



Number of theses supervised by people with various degrees.

	supervisor_degree	count
0	Ing., Ph.D.	6408
1	doc. Ing., Ph.D.	2736
2	Ing.	2014
3	doc. Ing., CSc.	1759
4	Ing., CSc.	837
5	prof. Ing., CSc.	698
6	Ing. arch.	640
7	doc. Ing. arch.	638
8	prof. Ing. arch.	579
0	Other (123 degrees)	5782

In [ ]: