ETH zürich

Departement Informatik

Programming and Problem-Solving

Reading in data and Sorting 1

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Lists

Advanced Concepts

2-Dimensional Lists

So far lists contain numbers or characters

- Lists can contain lists
- Such **2-dimensional lists** store, e.g., tables and matrices

$$M = \begin{pmatrix} 2 & 0 & 3 & 0 & 6 \\ 3 & 9 & 5 & 1 & 1 \\ 0 & 0 & 7 & 2 & 7 \\ 3 & 9 & 5 & 8 & 0 \\ 8 & 2 & 0 & 3 & 2 \\ 1 & 6 & 5 & 9 & 6 \end{pmatrix}$$

```
M = [ [2, 0, 3, 0, 6],
      [3, 9, 5, 1, 1],
      [0, 0, 7, 2, 7],
      [3, 9, 5, 8, 0],
      [8, 2, 0, 3, 2],
      [1, 6, 5, 9, 6] ]
```

- Accessing line `i` and column `j` with `M[i][j]`

Lists

Reading in Data und Saving it to Lists

Reading in Data

Example: Matrix given in file

- Content of the file is a text
- Matrix stored line by line
- Entries in each line separated by commas
- Entries are to be interpreted as numbers

Three Steps

1. Read in file line by line
2. Extract entries from the lines (separator symbol: comma)
3. Convert each entry to a number

Reading in Data

1. Read in file line by line

```
with open("data.txt") as file:
    lines = file.read().splitlines()
```

- File `data.txt` is opened for the following block of instructions
- Accessible under the name `file`
- `lines = file.read()` stores the whole content of `data.txt` in the variable `lines`
- `lines = file.read().splitlines()` stores the individual lines of `daten.txt` in the list `lines`

Reading in Data: Example

1. Read in file line by line

```
with open("data.txt") as file:
    lines = file.read().splitlines()
```

`data.txt`

```
2, 0, 3, 0, 6
3, 9, 5, 1, 1
0, 0, 7, 2, 7
3, 9, 5, 8, 0
8, 2, 0, 3, 2
1, 6, 5, 9, 6
```

```
lines = [ "2, 0, 3, 0, 6",
          "3, 9, 5, 1, 1",
          "0, 0, 7, 2, 7",
          "3, 9, 5, 8, 0",
          "8, 2, 0, 3, 2",
          "1, 6, 5, 9, 6" ]
```


Reading in Data

2. Extract entries from first line (separator symbol: comma)

```
tmp = lines[0].split(",")
```

```
lines = [ "2, 0, 3, 0, 6",
          "3, 9, 5, 1, 1",
          "0, 0, 7, 2, 7",
          "3, 9, 5, 8, 0",
          "8, 2, 0, 3, 2",
          "1, 6, 5, 9, 6" ]
```

```
tmp = ["2", "0", "3", "0", "6"]
```

Reading in Data

3. Convert each entry to a number

```
data = [0] * len(tmp)
for i in range(0, len(tmp)):
    data[i] = int(tmp[i])
```

```
tmp = ["2", "0", "3", "0", "6"]
```

```
data = [2, 0, 3, 0, 6]
```


Reading in Data: Summary

```
def readfile(filename):

    # Read in file line by line
    with open(filename) as file:
        lines = file.read().splitlines()

    # Extract entries from first line (separator symbol:  comma)
    tmp = lines[0].split(",")

    # Convert each entry to a number
    data = [0] * len(tmp)
    for i in range(0, len(tmp)):
        data[i] = int(tmp[i])

    return data
```


Exercise – Reading in Data

Extend the function so that

- all lines of the file are read and converted
- the content is stored in a 2-dimensional list

```
def readfile(filename):
    with open(filename) as file:
        lines = file.read().splitlines()
    tmp = lines[0].split(",")
    data = [0] * len(tmp)
    for i in range(0, len(tmp)):
        data[i] = int(tmp[i])
    return data
```

Reading in Data

```
def readfile2(filename):
    # Read in file line by line
    with open(filename) as file:
        lines = file.read().splitlines()
    data = []

    # Process all lines successively
    for i in range(0, len(lines)):
        tmp = lines[i].split(",")
        dataline = [0] * len(tmp)
        for j in range(0, len(tmp)):
            dataline[j] = int(tmp[j])
        data.append(dataline)
    return data
```

Data is often supplied as such `csv` files (comma separated values)

Sorting 1

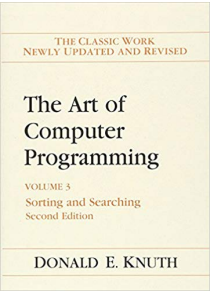
Sorting and Searching

Sorting and Searching

Sorting and searching data are two of the fundamental tasks of computer scientists

Standard reference only deals with these topics

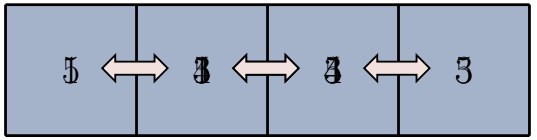
- Given n positive integers
- Specifically, **unsorted** list `data` with `n = len(data)`
- We consider n as input length
- Numbers may appear multiple times
- **Sort** numbers in as little time as possible



Sorting 1

Bubblesort

Bubblesort



Bubblesort

Idea

Sorting by repeatedly finding the maximum

Goal

Sort list `data` with `n` elements, i.e., range $0, \ldots, n-1$

- Find maximum and slide it to the last position
- To this end, iteratively compare neighboring elements
- Maximum travels through list to the last position – like a bubble
- Repeat with range $0, \ldots, n-2$
- Continue until `data` is sorted

Exercise – One Bubble Sequence

Implement one Bubble Sequence

- Run through `data` one time
- Compare neighboring elements
- Swap if the first element is larger
- Maximum bubbles to the right

One Bubble Sequence

One Bubble Sequence in Python

```
data = [6, 22, 61, 1, 89, 31, 9, 10, 76]
n = len(data)

for i in range(0, n-1):
    if data[i] > data[i+1]:
        tmp = data[i]
        data[i] = data[i+1]
        data[i+1] = tmp
```


Exercise – Bubblesort

Implement the complete algorithm

- Iterate bubble sequences
- After ith sequence, the last k elements of `data` are sorted
- Bubble sequences become shorter with each iteration
- To this end, use outer loop

Bubblesort

```
def bubblesort(data):
    n = len(data)
    for d in range(n, 1, -1):
        for i in range(0, d-1):
            if data[i] > data[i+1]:
                tmp = data[i]
                data[i] = data[i+1]
                data[i+1] = tmp
    return data


print(bubblesort([6, 22, 61, 1, 89, 31, 9, 10, 76]))
```


Sorting 1

Minsort

Minsort

Idea

Sorting by repeatedly finding the minimum

- Unlike Bubblesort, we do not compare neighboring elements
- Current minimum is stored
- Each element is compared to it
- If it is smaller, both are swapped
- After one iteration, the minimum is copied to (current) first position
- Continue until `data` is sorted

Minsort

```
def minsort(data):
    n = len(data)
    for current in range(0, n-1):
        minimum = data[current]
        for i in range(current+1, n):
            if data[i] < minimum:
                tmp = data[i]
                data[i] = minimum
                minimum = tmp
        data[current] = minimum
    return data

print(minsort([6, 22, 61, 1, 89, 31, 9, 10, 76]))
```

Sorting 1

Time Complexity of Bubblesort

Time Complexity of Bubblesort

Count comparisons of two numbers

- $n - 1$ comparisons to find maximum
- $n - 2$ comparisons to find second largest element
- ...
- 1 comparison to find smallest element

⇨ $\sum_{i=1}^{n-1} i = (n-1) \cdot n/2 = (n^2 - n)/2$ comparisons in total

⇨ Quadratic number of comparisons

The time complexity of Bubblesort is in $\mathcal{O}(n^2)$

With similar arguments, the time complexity of Minsort is in $\mathcal{O}(n^2)$

Time Complexity of Bubblesort