合肥大學
HEFEI UNIVERSITY

Programming with Python

17. Listen

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Dies ist ein Kurs über das Programmieren mit der Programmiersprache Python an der Universität Hefei (合肥大学).

Die Webseite mit dem Lehrmaterial dieses Kurses ist https://thomasweise.github.io/programmingWithPython (siehe auch den QR-Kode unten rechts). Dort können Sie das Kursbuch (in Englisch) und diese Slides finden. Das Repository mit den Beispielprogrammen in Python finden Sie unter https://github.com/thomasWeise/programmingWithPythonCode.

Outline

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- Wir fangen mit Listen an.

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Beispiele

Type Hints, Listen erstellen, Elemente anhängen, verbinden, und indizieren

- Listenvariablen werden mit dem Type Hint `list[elementTyp]` annotiert, wobei `elementType` der Datentyp für die Elemente ist[6].

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↓ python3 lists_1.py ↓

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There now are 4 fruits: ['apple', 'pear', 'orange', 'cherry']
The vegetables are: ['onion', 'potato', 'leek'].
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len(food) = 7
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Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `a in lst` ist `True`, wenn Element `a` in Liste `lst` auftaucht.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `a in lst` ist `True`, wenn Element `a` in Liste `lst` auftaucht.
- `a not in lst` ist `True`, wenn Element `a` *nicht* in Liste `lst` auftaucht.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `a in lst` ist `True`, wenn Element `a` in Liste `lst` auftaucht.
- `a not in lst` ist `True`, wenn Element `a` *nicht* in Liste `lst` auftaucht.
- `lst.insert(i, e)` fügt Element `e` an Index `i` in Liste `lst` ein.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `a in lst` ist `True`, wenn Element `a` in Liste `lst` auftaucht.
- `a not in lst` ist `True`, wenn Element `a` *nicht* in Liste `lst` auftaucht.
- `lst.insert(i, e)` fügt Element `e` an Index `i` in Liste `lst` ein.
- `lst.removee` löscht Element `e` aus der Liste `lst`.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `a in lst` ist `True`, wenn Element `a` in Liste `lst` auftaucht.
- `a not in lst` ist `True`, wenn Element `a` *nicht* in Liste `lst` auftaucht.
- `lst.insert(i, e)` fügt Element `e` an Index `i` in Liste `lst` ein.
- `lst.removee` löscht Element `e` aus der Liste `lst`.
- `lst.sort()` sortiert die Liste `lst`.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `a not in lst` ist `True`, wenn Element `a` *nicht* in Liste `lst` auftaucht.
- `lst.insert(i, e)` fügt Element `e` an Index `i` in Liste `lst` ein.
- `lst.removee` löscht Element `e` aus der Liste `lst`.
- `lst.sort()` sortiert die Liste `lst`.
- `lst.reverse()` kehrt die Reihenfolge der Elemente in Liste `lst` um.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `lst.insert(i, e)` fügt Element `e` an Index `i` in Liste `lst` ein.
- `lst.removee` löscht Element `e` aus der Liste `lst`.
- `lst.sort()` sortiert die Liste `lst`.
- `lst.reverse()` kehrt die Reihenfolge der Elemente in Liste `lst` um.
- `list(cont)` erstelle eine neue Liste mit dem Inhalt des Kontainers `cont`.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `lst.removee` löscht Element `e` aus der Liste `lst`.
- `lst.sort()` sortiert die Liste `lst`.
- `lst.reverse()` kehrt die Reihenfolge der Elemente in Liste `lst` um.
- `list(cont)` erstelle eine neue Liste mit dem Inhalt des Kontainers `cont`.
- `==`, `!=`, `is` und `is not` funktionieren auch mit Listen.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `lst.removee` löscht Element `e` aus der Liste `lst`.
- `lst.sort()` sortiert die Liste `lst`.
- `lst.reverse()` kehrt die Reihenfolge der Elemente in Liste `lst` um.
- `list(cont)` erstelle eine neue Liste mit dem Inhalt des Kontainers `cont`.
- `==`, `!=`, `is` und `is not` funktionieren auch mit Listen.

```python
"""An example of creating, modifying, sorting, and copying lists."""

numbers: list[int] = [1, 7, 56, 2, 4]  # Create the list.
print(f"The numbers are: {numbers}.")  # Print the list.

print(f"is 7 in the list: {7 in numbers}")  # Check if 7 is in the list.
print(f"is 2 NOT in the list: {2 not in numbers}")  # the opposite check
print(f"7 ist at index {numbers.index(7)}.")  # Search for number 7.
print(f"2 ist at index {numbers.index(2)}.")  # Search for number 2.

numbers.insert(2, 12)  # Insert the number 12 at index 2...
print(f"After inserting 12, the numbers are: {numbers}.")  # and print.

numbers.remove(56)  # Remove the number 56 from the list.
print(f"After removing 56, numbers are: {numbers}.")  # Print the list.

numbers.sort()  # Sort the list `numbers` in place.
print(f"The sorted numbers are: {numbers}.")  # Print the list.

numbers.reverse()  # Reverse the order of the list elements.
print(f"The reversed numbers are: {numbers}.")  # And print the list.

cpy: list[int] = list(numbers)  # Create a copy of the list `numbers`.
print(f"cpy == numbers: {cpy == numbers}.")  # Indeed, `cpy == numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # No, `cpy is not numbers`.

del cpy[0]  # We change `cpy`, but `numbers` remains unchanged.
print(f"cpy == numbers: {cpy == numbers}.")  # Now, `cpy != numbers`.
print(f"cpy is numbers: {cpy is numbers}.")  # And `cpy is not numbers`.
print(f"cpy is not numbers: {cpy is not numbers}.")  # indeed, it is not
```

↓ python3 lists_2.py ↓

```
The numbers are: [1, 7, 56, 2, 4].
is 7 in the list: True
is 2 NOT in the list: False
7 ist at index 1.
2 ist at index 3.
After inserting 12, the numbers are: [1, 7, 12, 56, 2, 4].
After removing 56, numbers are: [1, 7, 12, 2, 4].
The sorted numbers are: [1, 2, 4, 7, 12].
The reversed numbers are: [12, 7, 4, 2, 1].
cpy == numbers: True.
cpy is numbers: False.
cpy == numbers: False.
cpy is numbers: False.
cpy is not numbers: True.
```

Suchen, einfügen, löschen, sortieren, kopieren und vergleichen

- `lst.removee` löscht Element `e` aus der Liste `lst`.
- `lst.sort()` sortiert die Liste `lst`.
- `lst.reverse()` kehrt die Reihenfolge der Elemente in Liste `lst` um.
- `list(cont)` erstelle eine neue Liste mit dem Inhalt des Kontainers `cont`.
- `==`, `!=`, `is` und `is not` funktionieren auch mit Listen.

```
1  The numbers are: [1, 7, 56, 2, 4].
2  is 7 in the list: True
3  is 2 NOT in the list: False
4  7 ist at index 1.
5  2 ist at index 3.
6  After inserting 12, the numbers are: [1, 7, 12, 56, 2, 4].
7  After removing 56, numbers are: [1, 7, 12, 2, 4].
8  The sorted numbers are: [1, 2, 4, 7, 12].
9  The reversed numbers are: [12, 7, 4, 2, 1].
10 cpy == numbers: True.
11 cpy is numbers: False.
12 cpy == numbers: False.
13 cpy is numbers: False.
14 cpy is not numbers: True.
```

Konkatenation, Addition, Multiplikation, Slices, und auspacken

- Die Addition `lst1 + lst2` von zwei Listen `lst1` und `lst2` erzeugt eine neue Liste mit den Elementen von `lst1` gefolgt von den Elementen von `lst2`.

```python
"""An example of more operations with lists."""

lst1: list[int] = [1, 2, 3, 4]  # create first list
lst2: list[int] = [5, 6, 7]  # create second list
lst3: list[int] = lst1 + lst2  # lst3 = concatenation of lst1 and lst2.
print(f"lst3 = lst1 + lst2 == {lst3}")  # [1, 2, 3, 4, 5, 6, 7]

lst4: list[int] = lst2 * 3  # lst4 = lst2, repeated three times.
print(f"lst4 = lst2 * 3 == {lst4}")  # [5, 6, 7, 5, 6, 7, 5, 6, 7]

lst5: list[int] = lst4[2:-2]  # lst5 = lst4 from index 2 to 3rd from end
print(f"lst5 = lst4[2:-2] == {lst5}")  # [7, 5, 6, 7, 5]

lst6: list[int] = lst4[1::2]  # start at index 1, take every 2nd element
print(f"lst6 = lst4[1::2] == {lst6}")  # [6, 5, 7, 6]

# Start copying lst4 at last element, move backwards take every 2nd
# element, and stop right before index=3.
lst7: list[int] = lst4[-1:3:-2]
print(f"lst7 = lst4[-1:3:-2] == {lst7}")  # [7, 5, 6]

lst7[1] = 12  # Modify the slice lst7 originally from lst4.
print(f"{lst4 = }, {lst7 = }")  # Shows that lst4 remains unchanged.

a, b, c = lst2  # store the three elements of lst2 into variables
print(f"{a = }, {b = }, {c = }")  # a=5, b=6, c=7
```

Konkatenation, Addition, Multiplikation, Slices, und auspacken

- Die Addition `lst1 + lst2` von zwei Listen `lst1` und `lst2` erzeugt eine neue Liste mit den Elementen von `lst1` gefolgt von den Elementen von `lst2`.
- Die Multiplikation `lst * i` der Liste `lst` mit dem `int` `i` erzeugt eine neue Liste, in der die Elemente von `lst` `i`-Mal hintereinander vorkommen.

```python
"""An example of more operations with lists."""

lst1: list[int] = [1, 2, 3, 4]  # create first list
lst2: list[int] = [5, 6, 7]  # create second list
lst3: list[int] = lst1 + lst2  # lst3 = concatenation of lst1 and lst2.
print(f"lst3 = lst1 + lst2 == {lst3}")  # [1, 2, 3, 4, 5, 6, 7]

lst4: list[int] = lst2 * 3  # lst4 = lst2, repeated three times.
print(f"lst4 = lst2 * 3 == {lst4}")  # [5, 6, 7, 5, 6, 7, 5, 6, 7]

lst5: list[int] = lst4[2:-2]  # lst5 = lst4 from index 2 to 3rd from end
print(f"lst5 = lst4[2:-2] == {lst5}")  # [7, 5, 6, 7, 5]

lst6: list[int] = lst4[1::2]  # start at index 1, take every 2nd element
print(f"lst6 = lst4[1::2] == {lst6}")  # [6, 5, 7, 6]

# Start copying lst4 at last element, move backwards take every 2nd
# element, and stop right before index=3.
lst7: list[int] = lst4[-1:3:-2]
print(f"lst7 = lst4[-1:3:-2] == {lst7}")  # [7, 5, 6]

lst7[1] = 12  # Modify the slice lst7 originally from lst4.
print(f"{lst4 = }, {lst7 = }")  # Shows that lst4 remains unchanged.

a, b, c = lst2  # store the three elements of lst2 into variables
print(f"{a = }, {b = }, {c = }")  # a=5, b=6, c=7
```

Konkatenation, Addition, Multiplikation, Slices, und auspacken

- Die Addition `lst1 + lst2` von zwei Listen `lst1` und `lst2` erzeugt eine neue Liste mit den Elementen von `lst1` gefolgt von den Elementen von `lst2`.
- Die Multiplikation `lst * i` der Liste `lst` mit dem `int` `i` erzeugt eine neue Liste, in der die Elemente von `lst` `i`-Mal hintereinander vorkommen.
- Listen können genauso ge-sliced werden wie Strings[12].

```python
"""An example of more operations with lists."""

lst1: list[int] = [1, 2, 3, 4]  # create first list
lst2: list[int] = [5, 6, 7]  # create second list
lst3: list[int] = lst1 + lst2  # lst3 = concatenation of lst1 and lst2.
print(f"lst3 = lst1 + lst2 == {lst3}")  # [1, 2, 3, 4, 5, 6, 7]

lst4: list[int] = lst2 * 3  # lst4 = lst2, repeated three times.
print(f"lst4 = lst2 * 3 == {lst4}")  # [5, 6, 7, 5, 6, 7, 5, 6, 7]

lst5: list[int] = lst4[2:-2]  # lst5 = lst4 from index 2 to 3rd from end
print(f"lst5 = lst4[2:-2] == {lst5}")  # [7, 5, 6, 7, 5]

lst6: list[int] = lst4[1::2]  # start at index 1, take every 2nd element
print(f"lst6 = lst4[1::2] == {lst6}")  # [6, 5, 7, 6]

# Start copying lst4 at last element, move backwards take every 2nd
# element, and stop right before index=3.
lst7: list[int] = lst4[-1:3:-2]
print(f"lst7 = lst4[-1:3:-2] == {lst7}")  # [7, 5, 6]

lst7[1] = 12  # Modify the slice lst7 originally from lst4.
print(f"{lst4 = }, {lst7 = }")  # Shows that lst4 remains unchanged.

a, b, c = lst2  # store the three elements of lst2 into variables
print(f"{a = }, {b = }, {c = }")  # a=5, b=6, c=7
```

Konkatenation, Addition, Multiplikation, Slices, und auspacken

- Die Multiplikation `lst * i` der Liste `lst` mit dem `int` `i` erzeugt eine neue Liste, in der die Elemente von `lst` `i`-Mal hintereinander vorkommen.
- Listen können genauso ge-sliced werden wie Strings[12].
- Listen-Slices sind immer neue Listen. Sie können unabhängig von der Originalliste verändert werden.

```python
"""An example of more operations with lists."""

lst1: list[int] = [1, 2, 3, 4]  # create first list
lst2: list[int] = [5, 6, 7]  # create second list
lst3: list[int] = lst1 + lst2  # lst3 = concatenation of lst1 and lst2.
print(f"lst3 = lst1 + lst2 == {lst3}")  # [1, 2, 3, 4, 5, 6, 7]

lst4: list[int] = lst2 * 3  # lst4 = lst2, repeated three times.
print(f"lst4 = lst2 * 3 == {lst4}")  # [5, 6, 7, 5, 6, 7, 5, 6, 7]

lst5: list[int] = lst4[2:-2]  # lst5 = lst4 from index 2 to 3rd from end
print(f"lst5 = lst4[2:-2] == {lst5}")  # [7, 5, 6, 7, 5]

lst6: list[int] = lst4[1::2]  # start at index 1, take every 2nd element
print(f"lst6 = lst4[1::2] == {lst6}")  # [6, 5, 7, 6]

# Start copying lst4 at last element, move backwards take every 2nd
# element, and stop right before index=3.
lst7: list[int] = lst4[-1:3:-2]
print(f"lst7 = lst4[-1:3:-2] == {lst7}")  # [7, 5, 6]

lst7[1] = 12  # Modify the slice lst7 originally from lst4.
print(f"{lst4 = }, {lst7 = }")  # Shows that lst4 remains unchanged.

a, b, c = lst2  # store the three elements of lst2 into variables
print(f"{a = }, {b = }, {c = }")  # a=5, b=6, c=7
```

Konkatenation, Addition, Multiplikation, Slices, und auspacken

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```python
"""An example of more operations with lists."""

lst1: list[int] = [1, 2, 3, 4]  # create first list
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lst3: list[int] = lst1 + lst2  # lst3 = concatenation of lst1 and lst2.
print(f"lst3 = lst1 + lst2 == {lst3}")  # [1, 2, 3, 4, 5, 6, 7]

lst4: list[int] = lst2 * 3  # lst4 = lst2, repeated three times.
print(f"lst4 = lst2 * 3 == {lst4}")  # [5, 6, 7, 5, 6, 7, 5, 6, 7]

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print(f"lst5 = lst4[2:-2] == {lst5}")  # [7, 5, 6, 7, 5]

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lst4: list[int] = lst2 * 3  # lst4 = lst2, repeated three times.
print(f"lst4 = lst2 * 3 == {lst4}")  # [5, 6, 7, 5, 6, 7, 5, 6, 7]

lst5: list[int] = lst4[2:-2]  # lst5 = lst4 from index 2 to 3rd from end
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print(f"{a = }, {b = }, {c = }")  # a=5, b=6, c=7
```

↓ python3 lists_3.py ↓

```
lst3 = lst1 + lst2 == [1, 2, 3, 4, 5, 6, 7]
lst4 = lst2 * 3 == [5, 6, 7, 5, 6, 7, 5, 6, 7]
lst5 = lst4[2:-2] == [7, 5, 6, 7, 5]
lst6 = lst4[1::2] == [6, 5, 7, 6]
lst7 = lst4[-1:3:-2] == [7, 5, 6]
lst4 = [5, 6, 7, 5, 6, 7, 5, 6, 7], lst7 = [7, 12, 6]
a = 5, b = 6, c = 7
```

Konkatenation, Addition, Multiplikation, Slices, und auspacken

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```
1 lst3 = lst1 + lst2 == [1, 2, 3, 4, 5, 6, 7]
2 lst4 = lst2 * 3 == [5, 6, 7, 5, 6, 7, 5, 6, 7]
3 lst5 = lst4[2:-2] == [7, 5, 6, 7, 5]
4 lst6 = lst4[1::2] == [6, 5, 7, 6]
5 lst7 = lst4[-1:3:-2] == [7, 5, 6]
6 lst4 = [5, 6, 7, 5, 6, 7, 5, 6, 7], lst7 = [7, 12, 6]
7 a = 5, b = 6, c = 7
```

Zusammenfassung

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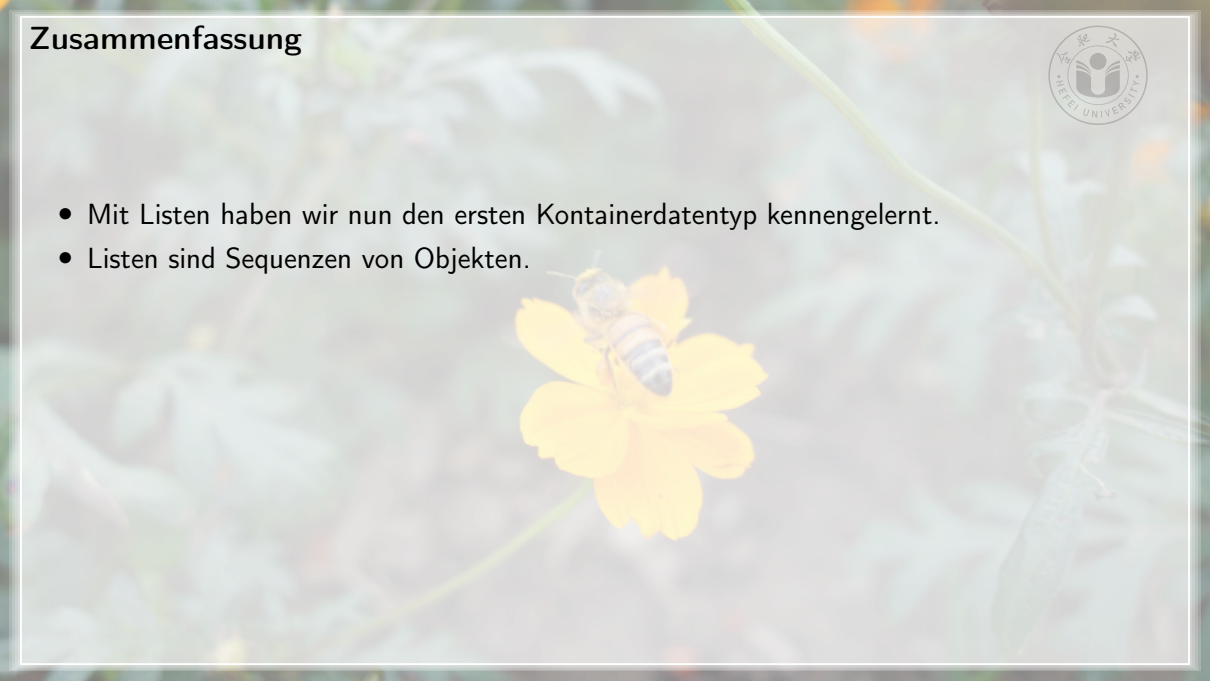
- Mit Listen haben wir nun den ersten Kontainerdatentyp kennengelernt.

Zusammenfassung



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- Listenvariablen sollten mit Type Hints annotiert werden.
- Listen können genau wie Zeichenketten (Strings) indiziert werden.
- Listen sind ein wichtiges Werkzeug, um dynamisch veränderliche Kollektionen von Objekten zu verarbeiten.

谢谢您们！

Thank you!

Vielen Dank!

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Glossary (in English) I

Git is a distributed Version Control Systems (VCS) which allows multiple users to work on the same code while preserving the history of the code changes[13,17]. Learn more at `https://git-scm.com`.

GitHub is a website where software projects can be hosted and managed via the Git VCS[11,17]. Learn more at `https://github.com`.

literal A literal is a specific concrete value, something that is written down as-is[8,16]. In Python, for example, `"abc"` is a string literal, `5` is an integer literal, and `23.3` is a `float` literal. In contrast, `sin(3)` is not a literal. Also, while `5` is an integer literal, if we create a variable `a = 5` then `a` is not a literal either (it is a variable). Hence, literals are values that the Python interpreter reads directly from the source code and creates as objects in memory. They are not something that is the result from a computation or the result of a variable lookup. Python supports some type hints for literals, including the type `LiteralString` for string literals and the type `Literal[xyz]` for arbitrary literals `xyz`.

Mypy is a static type checking tool for Python[9] that makes use of type hints. Learn more at `https://github.com/python/mypy` and in[19].

Python The Python programming language[4,7,10,19], i.e., what you will learn about in our book[19]. Learn more at `https://python.org`.

type hint are annotations that help programmers and static code analysis tools such as Mypy to better understand what type a variable or function parameter is supposed to be[5,18]. Python is a dynamically typed programming language where you do not need to specify the type of, e.g., a variable. This creates problems for code analysis, both automated as well as manual: For example, it may not always be clear whether a variable or function parameter should be an integer or floating point number. The annotations allow us to explicitly state which type is expected. They are *ignored* during the program execution. They are a basically a piece of documentation.

VCS A *Version Control System* is a software which allows you to manage and preserve the historical development of your program code[17]. A distributed VCS allows multiple users to work on the same code and upload their changes to the server, which then preserves the change history. The most popular distributed VCS is Git.