Australian National University

COMP1730/COMP6730
Programming for Scientists

Dictionaries and sets

Announcements

- Homework 5 is due this Sunday (11:55pm).
- Homework 5 will be marked in the labs next week.
- Drop-in labs on Tuesday and Wednesday evening.
- Major assignment will be released on Monday.
- Practice labs - Monday 10-12, 4-6 in N114.

Lecture outline

- Mappings: the `dict` type.
- Sets: the `set` type.

Mappings

- A *mapping* (a.k.a. *dictionary*) stores key–value pairs; each key stored in the mapping has exactly one value. A key may be any type of constant (immutable) value.
- Examples of use:
  - Storing a look-up index (e.g., a contact list).
  - Organising data with “complex” labels (like a multi-dimensional table).
  - Storing solutions to subproblems in a dynamic programming algorithm.

* What you can do with a mapping:
  - Create a new, empty mapping.
  - Store a value with a key.
  - Check if a given key stored in the mapping?
  - Look up the value stored for a given key.
  - Remove a key.
  - Enumerate keys, values, or key–value pairs.
* Key lookup is (amortised) constant time.

python's `dict` type

* Create a new dictionary:

```
>>> adict = {}
>>> adict = dict()
>>> adict = { (2015,12) : 33.4,
              (2016,6) : 148.3 }
>>> adict = { "be" : 2, "can" : 3 }
```

  – Dictionary (and set!) literals are written with curly brackets ({ and }).
  – The literal can contain *`key : value`* pairs, which become the initial contents.

- Key exists in dictionary:

```
>>> key in adict
```

- Look-up and storing values:

```
>>> adict = { "be" : 2, "can" : 1 }
>>> adict["can"]
1
>>> adict["now"] = 2
>>> adict[3] = "yet"
```

  - To index a value, write the key in square brackets after the dictionary expression.
  - Assigning to a dictionary index expression adds or updates the key.

* `dict` is a mutable type.
  – Like lists, arrays.
* Keys must be *immutable* $^{(\star)}$.

```
>>> alist = [1,0]
>>> adict = { alist :  2 }
TypeError: unhashable type: 'list'
```

* A dictionary can contain a mix of key types.
* Stored values can be of any type.

- Removing keys:
  - `del` *`adict`*`[`*`key`*`]`
    Removes *`key`* from *`adict`*.
  - *`adict`*`.pop(`*`key`*`)`
    Removes *`key`* from *`adict`* and returns the associated value.
  - *`adict`*`.popitem()`
    Removes an arbitrary `(`*`key`*`, `*`value`*`)` pair and returns it.
- `del` and `pop` cause a runtime error if *`key`* is not in dictionary; `popitem` if it is empty.

Iteration over dictionaries

- `adict.keys()`, `adict.values()`, and `adict.items()` return *views* of the keys, values and key–value pairs.
- Views are iterable, but *not* sequences.

```
for item in adict.items():
    the_key = item[0]
    the_value = item[1]
    print(the_key, ':', the_value)
```

Programming problem(s)

- Counting frequency of items:
  - words in a file (or web page);
  - (combinations of) values in a data table.
- Building a Markov model (over text, for example).
- Cross-referencing data tables with common keys.

Sets

- A *set* is an unordered collection of (immutable) values without duplicates.
- Like a dictionary with only keys (no values).
- What you can do with a set:
  - Create a new set (empty or from an iterable).
  - Add or remove values.
  - Is a given element in the set? (membership).
  - Mathematical operators: union, intersection, difference (note: not complement!).
  - Enumerate values.

python's `set` type

- Set literals are written with `{ .. }`, but with elements only, not key–value pairs:

```
>>> aset = { 1, ’c’, (2.5, ’b’) }
```

- `{ }` creates an empty dictionary, not a set!
- A set can be created from any iterable:

```
>>> aset = set("AGATGATT")
>>> aset
{’T’, ’A’, ’G’}
```

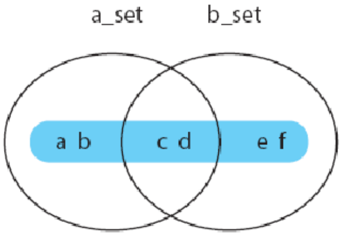
  - No duplicate elements in the set.
  - No order of elements in the set.

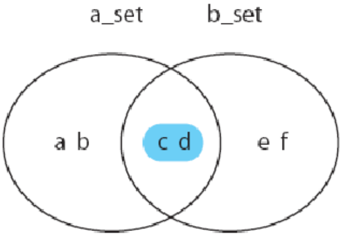
Set operators

`elem in aset`	membership ($e \in A$)
`aset.issubset(bset)`	subset ($A \subseteq B$)
`aset | bset`	union ($A \cup B$)
`aset & bset`	intersection ($A \cap B$)
`aset - bset`	difference ($A \setminus B$, $A - B$)
`aset ^ bset`	symmetric difference

- Set operators return a new result set, and do not modify the operands.
- Also exist as methods (`aset.union(bset)`, `aset.intersection(bset)`, etc).

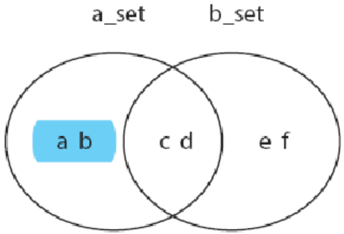
* The union of `a_set` and `b_set` is the set of all elements that are in `a_set`, in `b_set`, or in both.
* The intersection of `a_set` and `b_set` is the set of elements that are in both `a_set` and `b_set`.



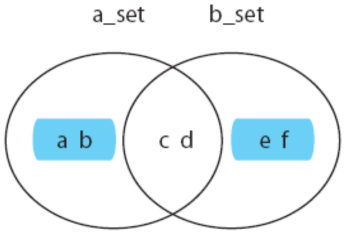


(Images from Punch & Enbody)

* The difference of `a_set` and `b_set` is the set of elements in `a_set` that are not in `b_set`.

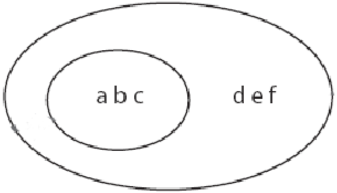


* The symmetric difference of `a_set` and `b_set` is the set of elements that are in either but not in both.



(Images from Punch & Enbody)

- `a_set` is a subset of `b_set` iff every element in `a_set` is also in `b_set`.
- $A \subseteq B$ iff $A \cap B = A$.

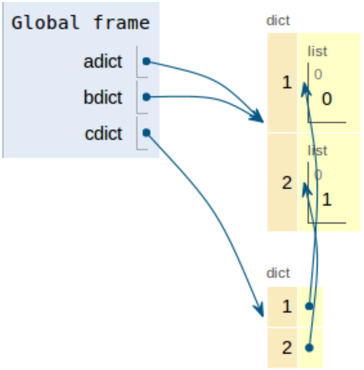


(Image from Punch & Enbody)

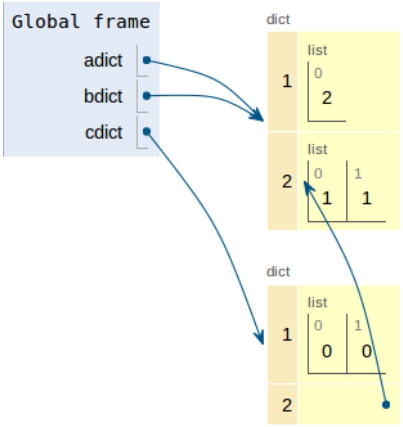
Copying

- Dictionaries and sets are mutable objects.
- Like lists, dictionaries and sets store *references* to values.
- `dict.copy()` and `set.copy()` create a *shallow* copy of the dictionary or set.
  - New dictionary / set, but containing references to the same values.
  - Dictionary keys and set elements are immutable, so shared references do not matter.
  - Values stored in a dictionary can be mutable.

```
adict = {1:[0],2:[1]}
bdict = adict
cdict = adict.copy()
bdict[1] = [2]
cdict[1] = [0, 0]
adict[2].append(1)
```



```
adict = {1:[0],2:[1]}
bdict = adict
cdict = adict.copy()
bdict[1] = [2]
cdict[1] = [0, 0]
adict[2].append(1)
```



Programming problem: Frequent words

- Read in a text file.
- Print the words in order from most common to least common.