COMP1730/COMP6730
Programming for Scientists

Sequence types

Mid-Semester Exam

* Mid-semester exam: **Wednesday 3 April, 2019.**
  - Two sittings, 6:00pm and 8:00pm.
  - You should receive an email with date, time and location from timetabling.
  - In the CSIT labs.
  - A mix of short answer and programming questions.
  - No permitted materials, but resources available on the lab computers.
* Read information about *deferred assessment* on course assessment page.

Homeworks

* Homework 3 due this Sunday (24 March, 11:55pm).
* Marked on code quality and functionality.
* If it doesn't meet the specification, it won't be marked.
* Discussion in labs next week (Week 5).

Lecture outline

* Sequence data types
* Indexing & slicing
* Sequence operations and functions
* Iteration with `for` loops

Properties of Sequences

* A *sequence* contains zero or more values.
* Each value in a sequence has a *position*, or *index*, ranging from 0 to $n - 1$.
* The *indexing operator* can be applied to all sequence types, and returns the value at a specified position in the sequence.
  - Indexing is done by writing the index in square brackets after the sequence value, like so:

    `sequence[pos]`

Sequence data types

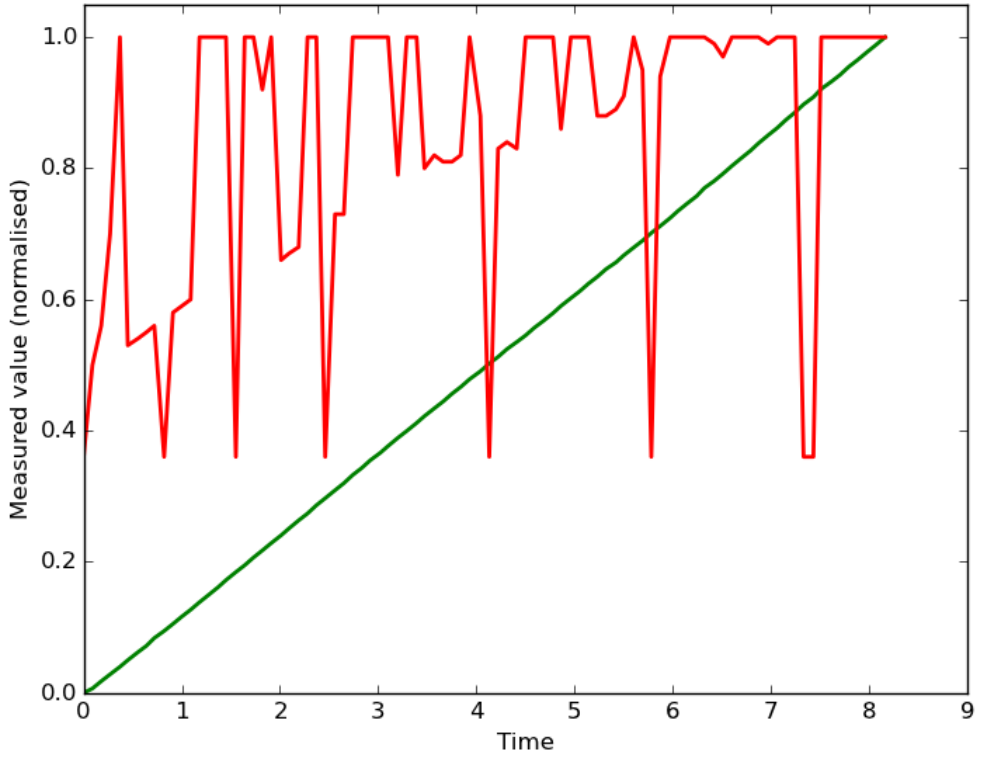
* python has three built-in sequence types:
  - strings (`str`) contain only text;
  - lists (`list`) can contain a mix of value types;
  - tuples (`tuple`) are like lists, but immutable.
* Sequence types provided by other modules:
  - e.g., NumPy arrays (`numpy.ndarray`).

Problem: Sensor modelling

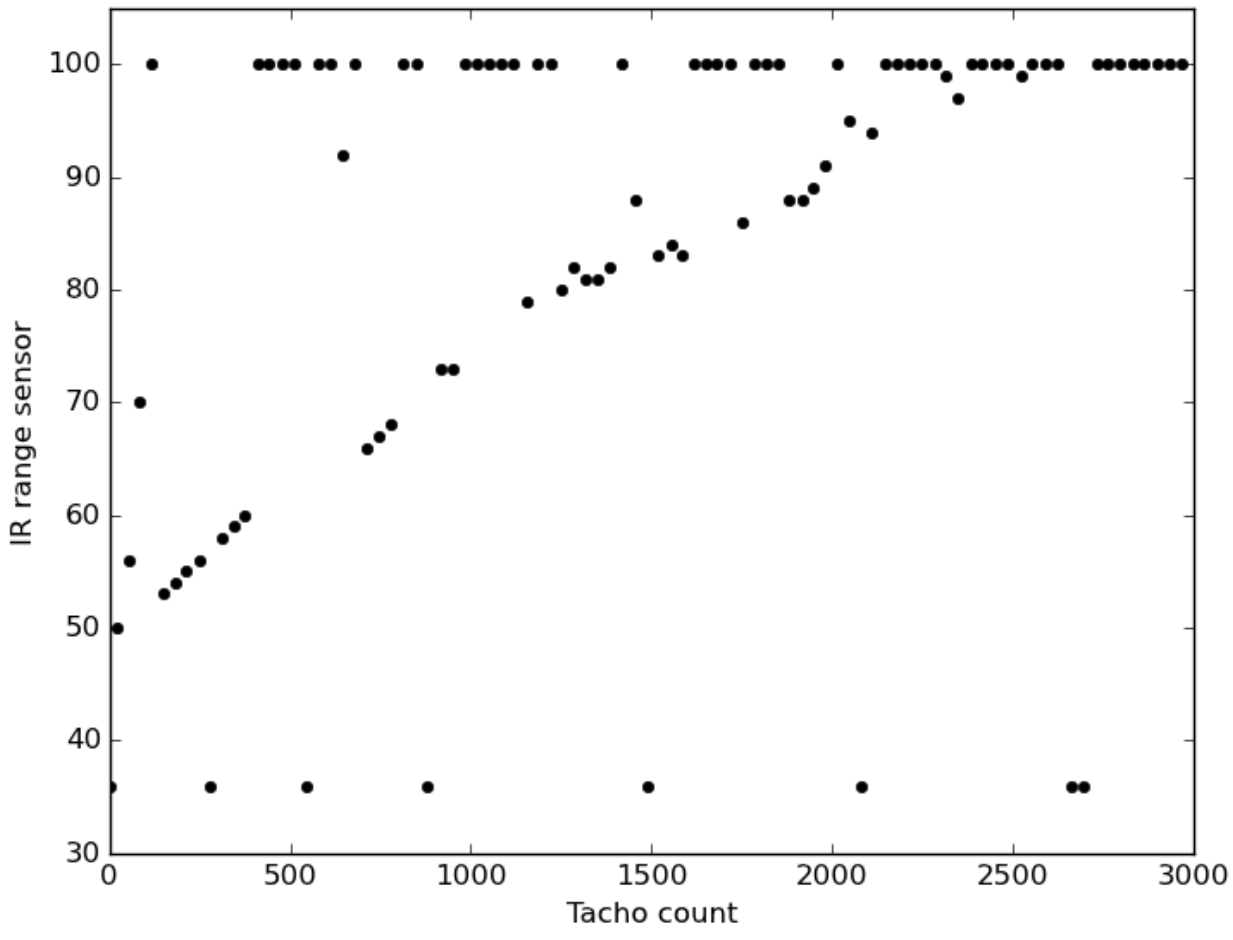
* Time series of two measurements:

* IR sensor (% of range)

* Tachometer ($^1/_{360}$th rev.)



* Is there a linear relation between *x* and *y*?



* Fit a straight line ($y = ax + b$) as close to all of the points as possible.
  - This can be done by solving a least-squares optimisation problem.
  - Simpler idea: Calculate the average slope between pairs of (adjacent) points.
* Need to remove or ignore “outliers”.
* Calculate residuals ($r_i = y_i - (ax_i + b)$) and check if they are normally distributed.

The `list` type

* `list` is python's general sequence type.
* To make a list, write a comma-separated list of elements in square brackets:

```
>>> x = [3.0, 1.5, 0.0, -1.5, -3.0]
>>> x
[3.0, 1.5, 0.0, -1.5, -3.0]
>>> type(x)
<class 'list'>
```

Indexing & length

list:	`3.0`	`1.5`	`0.0`	`-1.5`	`-3.0`
index:	0	1	2	3	4
	-5	-4	-3	-2	-1

* In python, all sequences are indexed from 0.
* The index must be an integer.
* python also allows indexing from the sequence end using negative indices, starting with -1.
* The length of a sequence is the number of elements, *not* the index of the last element.

* Sequence elements are accessed by writing the index in square brackets, `[]`.

```
>>> x = [3.0, 1.5, 0.0, -1.5, -3.0]
>>> x[1]
1.5
>> x[-1]
-3.0
>>> len(x)
5
>>> x[5]
IndexError: list index out of bounds
```

Slicing

* Slicing selects a subsequence of an existing sequence.

  `sequence[`*`start`*`:`*`end`*`:`*`step-size`*`]`

  - *`start`* is the index of the first element in the subsequence.
  - *`end`* is the index of the first element after the end of the subsequence.
  - *`step-size`* allows skipping of elements.

* Slicing works on all built-in sequence types (`list`, `str`, `tuple`) and returns the same type.

Slicing Example

* More on slicing next week.

```
>>> x = [3.0, 1.5, 0.0, -1.5, -3.0]
>>> x[0:3:1]
[3.0, 1.5, 0.0]
>> x[1:5:2]
[1.5, -1.5]
>>> x[2:3:1]
[0.0]
>>> x[3]
0.0
```

Indexing vs Slicing

* Indexing a sequence returns an element.
* The index must be valid (i.e. between 0 and length - 1, or -1 and -length).
* Slicing a sequence returns a subsequence of the same type.
* A slice may contain, 0, 1 or more elements.
* The indexes in a slice do not have to be valid.

Sequence Operations

* The `+` and `*` operators work with sequences.
* `sequence_1 + sequence_2` results in concatenation.

```
my_list_1 = [1, 2, 3]
my_list_2 = [2, 3, 4]
my_list_1 + my_list_2
>>> ...
```

* `sequence * int` results in repetition.

```
my_list_1 = [1, 2, 3]
my_list_1 * 3
>>> ...
```

Functions on Sequences

* There are many built-in functions that operate on sequences:
  - `min` and `max` return the smallest and largest elements in the sequence.
  - `sum` returns the sum of the elements in the sequence.
  - `len` returns the number of elements in the sequence.
  - `sorted` returns a `list` with the elements of the sequence arranged in ascending order.
  - `x in sequence` returns `True` iff `x` is an element of the sequence.

The `for .. in ..` statement

```
for name in expression:
    suite
```

1. Evaluate the expression, to obtain an iterable collection.
   - If value is not iterable: TypeError.
2. For each element *E* in the collection:

2.1 assign *name* the value *E*;

2.2 execute the loop suite.

```
my_list = [2, 3, 5, 7, 11]
for element in my_list:
    print(element * 2)
```

vs.

```
my_list = [2, 3, 5, 7, 11]
i = 0
while i < len(my_list):
    element = my_list[i]
    print(element * 2)
    i = i + 1
```

Iteration over sequences

* Sequences are an instance of the general concept of an *iterable* data type.
  - An iterable type is defined by supporting the `iter()` function.
  - python also has data types that are iterable but not indexable (for example, sets and files).
* The `for .. in ..` statement works on any iterable data type.
  - On sequences, the `for` loop iterates through the elements *in order*.