Introduction to Programming Language (ITP101)

Debugging

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...So Far & Today...

- Computational Thinking
- Core Python objects
  - Functions
  - Lists
  - Tuples
  - Dictionaries
  - Exceptions

Next...

- Bugs
- Debugging

Brainstorm

1. Bug? Etymology?

2. Some popular bugs you have heard of?

3. Debugging vs Exception handling? The how-to of debugging?

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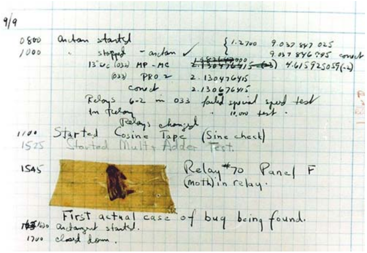
Debugging: The Whats

- The *process* of finding and reducing the number of bugs in a computer program. *Debugger* is the tool used.
- The process of ascertaining why the program is not working.
- Origin: Grace Hopper's moth bug



```
9/9

0800  Arctan started
1000    "    stopped - arctan ✓         { 1.2700   9.037 847 025
                                                 9.037 846 995 conct
       13"uc (032) MP-MC   ~~1.982147000~~
                           ~~2.130476415~~ (-3))  4.615925059(-2)
             (033) PRO 2   2.130476415
                   conct   2.130676415
       Relays 6-2 in 033 failed special speed test
       In relay          .   11,000 test .
             Relays changed
1100  Started Cosine Tape (Sine check)
1525  Started Mult+ Adder Test.
1545                    Relay #70 Panel F
                        (moth) in relay.
          First actual case of bug being found.
1630  arctangent started.
1700  closed down.
```

- Debugging vs exception handling vs testing

Why Debug?

- Errors are inevitable and cost nations billions of $s.

  "Yeah, but I already know exception handling and that should suffice, right?"

- Exception handling ensures that when your program encounters an issue, it will continue to run and provide informative feedback to the user.
- The principle: any erroneous code must be debugged!
- The fact: debugging time $>>$ development time!
  - Debugging large programs can be difficult and frustrating without the skill (of techniques, tools...).
- Debugging skill pays off big time.

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Edsger W. Dijkstra

> *"If debugging is the process of removing software bugs, then programming must be the process of putting them in."*
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Donald Knuth

> *"Beware of bugs in the above code; I have only proved it correct, not tried it."*

Debugging Techniques

Some of them:

1. *Rubber Duck Debugging*

2. *Tracing (a.k.a. Print Debugging)*

   Watching `print` statements (e.g. values of variables)

3. *Post-Mortem Debugging*

   After the program has crashed (e.g. memory/core dump analysis)

4. *Remote Debugging*

Debuggers

- Provide extensive view of the program's execution process.
- Enable a programmer to trace program execution step-by-step and "kill" the bug.
- Can be language-dependent. Some debuggers:

  `pdb` (Python), gdb, `Idb`, visual debuggers (e.g. `MS Visual Studio`), etc

Some features:

- Stepping through the code
- Pausing at some point in the code and resuming (breaking and continuing)
- Stack inspection, etc

Python Debugger (pdb)

- `Pdb` is an interactive debugger that is made available as a module.
- Provides a full-fledged debugging environment with support for:
  - Breakpoints
  - Source code listing
  - Single stepping through source code
  - Stack inspection
  - Post-mortem debugging

  and many more ...
- Can be used in two modes:
  1. Embedding debugging routines in source code
  2. Launching debugger as a script w/out embedding it:

```
python -m pdb <program_name>
```

Pdb: Operations & Commands

First off, import the pdb module.

1) **Setting Breakpoints**

   Program execution pauses at the specified points & tracing begins.

   a. Insert `pdb.set_trace()` where you want tracing to begin.

   b. The `break ("b")` command

Breakpoints

```
b(reak) ([program_name:]lineno | function)
```

Example

```
break myprog.py:3          # break @ line 3 of myprog.py
b myprog.func              # break when func() of myprog.py is called
```

Pdb: Operations & Commands (2)

2) **Displaying the source code** → The `list ("l")` command

3) **Stepping through the code** → The `next ("n")` command

4) **Printing variables' values** → The `print ("p")` command

5) **Continuing program execution** → The `continue ("c")` command

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   - Lets the program continue execution and stop only when a breakpoint is encountered.

Pdb: Operations & Commands (3)

6) **Stepping into functions** → The `step ("s")` command

7) **Continuing until return of functions** → The `return ("r")` command

8) **Restarting the debugged Program** → The `run` or `restart` commands

9) **Getting help** → The `help ("h")` command

10) **Quitting altogether** → The `quit ("q")` command

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