61A Lecture 25

Announcements

Pairs Review

Pairs and Lists

In the late 1950s, computer scientists used confusing names

- **cons:** Two-argument procedure that creates a pair
- **car:** Procedure that returns the first element of a pair
- **cdr:** Procedure that returns the second element of a pair
- **nil:** The empty list

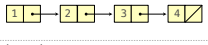
(cons 1 2)

(cons 2 nil)

- A (non-empty) list in Scheme is a pair in which the second element is **nil** or a Scheme list
- **Important!** Scheme lists are written in parentheses separated by spaces
- A dotted list has some value for the second element of the last pair that is not a list

```
> (cons 1 (cons 2 nil))
(1 2)
> (define x (cons 1 2))
> x
(1 . 2)
> (car x)
1
> (cdr x)
2
> (cons 1 (cons 2 (cons 3 (cons 4 nil))))
(1 2 3 4)
```

Not a well-formed list!



(Demo)

Exceptions

Today's Topic: Handling Errors

Sometimes, computer programs behave in non-standard ways

- A function receives an argument value of an improper type
- Some resource (such as a file) is not available
- A network connection is lost in the middle of data transmission

Grace Hopper's Notebook, 1947, Moth found in a Mark II Computer

Exceptions

A built-in mechanism in a programming language to declare and respond to exceptional conditions

Python raises an exception whenever an error occurs

Exceptions can be handled by the program, preventing the interpreter from halting

Unhandled exceptions will cause Python to halt execution and print a stack trace

Mastering exceptions:

Exceptions are objects! They have classes with constructors.

They enable non-local continuations of control

If **f** calls **g** and **g** calls **h**, exceptions can shift control from **h** to **f** without waiting for **g** to return.

(Exception handling tends to be slow.)

Raising Exceptions

Assert Statements

Assert statements raise an exception of type AssertionError

assert <expression>, <string>

Assertions are designed to be used liberally. They can be ignored to increase efficiency by running Python with the "-O" flag; "O" stands for optimized

python3 -O

Whether assertions are enabled is governed by a bool __debug__

(Demo)

Raise Statements

Exceptions are raised with a raise statement

raise <expression>

<expression> must evaluate to a subclass of BaseException or an instance of one

Exceptions are constructed like any other object. E.g., TypeError('Bad argument!')

TypeError -- A function was passed the wrong number/type of argument

NameError -- A name wasn't found

KeyError -- A key wasn't found in a dictionary

RuntimeError -- Catch-all for troubles during interpretation

(Demo)

Try Statements

Try Statements

Try statements handle exceptions

```
try:
    <try suite>
except <exception class> as <name>:
    <except suite>
...
```

Execution rule:

The <try suite> is executed first

If, during the course of executing the <try suite>,
an exception is raised that is not handled otherwise, and

If the class of the exception inherits from <exception class>, then

The <except suite> is executed, with <name> bound to the exception

Handling Exceptions

Exception handling can prevent a program from terminating

```
>>> try:
        x = 1/0
    except ZeroDivisionError as e:
        print('handling a', type(e))
        x = 0

handling a <class 'ZeroDivisionError'>
>>> x
0
```

Multiple try statements: Control jumps to the except suite of the most recent try statement that handles that type of exception

(Demo)

WWPD: What Would Python Display?

How will the Python interpreter respond?

```
def invert(x):
    inverse = 1/x  # Raises a ZeroDivisionError if x is 0
    print('Never printed if x is 0')
    return inverse

def invert_safe(x):
    try:
        return invert(x)
    except ZeroDivisionError as e:
        return str(e)
```

```
>>> invert_safe(1/0)
>>> try:
...     invert_safe(0)
... except ZeroDivisionError as e:
...     print('Hello!')
>>> inverrrrt_safe(1/0)
```

Example: Reduce

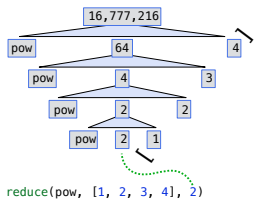
Reducing a Sequence to a Value

```
def reduce(f, s, initial):
    """Combine elements of s pairwise using f, starting with initial.

    E.g., reduce(mul, [2, 4, 8], 1) is equivalent to mul(mul(mul(1, 2), 4), 8).

    >>> reduce(mul, [2, 4, 8], 1)
    64
    """
```

f is ...
  a two-argument function
s is ...
  a sequence of values that can be the second argument
initial is ...
  a value that can be the first argument



(Demo)

Sierpinski's Triangle

(Demo)