Lecture 11, 19 September 2024

- Recursive definition of factorial
- Add diagnostic `print()` to trace recursive calls

In [1]:
```
def fact(n):
    print("evaluating factorial of",n)
    if n == 1:
        return(1)
    else:
        return(n*fact(n-1))
```

In [2]:
```
fact(8)
```

```
evaluating factorial of 8
evaluating factorial of 7
evaluating factorial of 6
evaluating factorial of 5
evaluating factorial of 4
evaluating factorial of 3
evaluating factorial of 2
evaluating factorial of 1
```

Out[2]:
```
40320
```

- A negative argument creates an unending sequence of recursive calls
- Python has a built in `recursion limit` to abort such cases
  - This limit may deny some legitimate computation -- for instance `factorial(3000)` will also abort
  - We will see later that we can increase this limit

In [3]:
```
fact(-1)
```

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---------------------------------------------------------------------------
RecursionError                            Traceback (most recent call last)
Cell In[3], line 1
----> 1 fact(-1)

Cell In[1], line 6, in fact(n)
      4     return(1)
      5 else:
----> 6     return(n*fact(n-1))

Cell In[1], line 6, in fact(n)
      4     return(1)
      5 else:
----> 6     return(n*fact(n-1))

    [... skipping similar frames: fact at line 6 (2966 times)]

Cell In[1], line 6, in fact(n)
      4     return(1)
      5 else:
----> 6     return(n*fact(n-1))

Cell In[1], line 2, in fact(n)
      1 def fact(n):
----> 2     print("evaluating factorial of",n)
      3     if n == 1:
      4         return(1)

File ~/python-venv/venv/lib/python3.11/site-packages/ipykernel/iostream.py:681, in OutStream.write(self, string)
    678     msg = "I/O operation on closed file"
    679     raise ValueError(msg)
--> 681 is_child = not self._is_master_process()
    682 # only touch the buffer in the IO thread to avoid races
    683 with self._buffer_lock:

File ~/python-venv/venv/lib/python3.11/site-packages/ipykernel/iostream.py:551, in OutStream._is_master_process
(self)
    550 def _is_master_process(self):
--> 551     return os.getpid() == self._master_pid

RecursionError: maximum recursion depth exceeded while calling a Python object
```

- We can also induct on the structure of a datastructure
- We can break up a list into the first element (the *head*) and the rest (the *tail*) as a smaller list
- Here is a recursive definition of `len()`

In [4]:
```
def mylen(l):
    print("Call with",l)
    if l == []:
        return(0)
    else:
        return(1+mylen(l[1:]))
```

In [5]:
```
mylen([7,18,2,-1,3])
```

```
Call with [7, 18, 2, -1, 3]
Call with [18, 2, -1, 3]
Call with [2, -1, 3]
Call with [-1, 3]
Call with [3]
Call with []
```

Out[5]: 5

- A similar definition for `sum()`

In [6]:
```
def mysum(l):
    print("Call with",l)
    if l == []:
        return(0)
    else:
        return(l[0]+mysum(l[1:]))
```

In [7]:
```
mysum([7,18,2,-1,3])
```

```
Call with [7, 18, 2, -1, 3]
Call with [18, 2, -1, 3]
Call with [2, -1, 3]
Call with [-1, 3]
Call with [3]
Call with []
```

Out[7]: 29

- Insert a value `v` into a list `l` sorted in ascending order

In [8]:
```
def sortedinsert(l,v):
    if v < l[0]:
        return([v]+l)
    else:
        return(l[:1] + sortedinsert(l[1:],v))
```

In [9]:
```
sortedinsert(list(range(1,20,2)),14)
```

Out[9]: [1, 3, 5, 7, 9, 11, 13, 14, 15, 17, 19]

- The built in recursion limit causes this function to fail on moderate size lists

In [10]:
```
sortedinsert(list(range(3000)),3000)
```

```
---------------------------------------------------------------------------
RecursionError                            Traceback (most recent call last)
Cell In[10], line 1
----> 1 sortedinsert(list(range(3000)),3000)

Cell In[8], line 5, in sortedinsert(l, v)
      3     return([v]+l)
      4 else:
----> 5     return(l[:1] + sortedinsert(l[1:],v))

Cell In[8], line 5, in sortedinsert(l, v)
      3     return([v]+l)
      4 else:
----> 5     return(l[:1] + sortedinsert(l[1:],v))

    [... skipping similar frames: sortedinsert at line 5 (2970 times)]

Cell In[8], line 5, in sortedinsert(l, v)
      3     return([v]+l)
      4 else:
----> 5     return(l[:1] + sortedinsert(l[1:],v))

RecursionError: maximum recursion depth exceeded
```