Using Data Types

Outline

Methods

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A method corresponds to a data-type operation

We call (or invoke) a method using a variable name, followed by the dot operator (.), followed by the method name, followed by its arguments separated by commas and enclosed in parentheses

```
>_ ~/workspace/ipp/programs
```

```
>>> import stdio
>>> x, y, z = 200, 300, 600
>>> xbits, ybits, zbits = x.bit_length(), y.bit_length(), z.bit_length()
>>> stdio.writeln(xbits)
8
>>> stdio.writeln(ybits)
9
>>> stdio.writeln(zbits)
10
```

Basic Data Types

Basic Data Types

Methods in the built-in `int` data type

```
>_ ~/workspace/ipp/programs

>>> dir(int)
['bit_length', 'conjugate']
```

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>>> dir(int)
['bit_length', 'conjugate']
```

Methods in the built-in `float` data type

```
>_ ~/workspace/ipp/programs

>>> dir(float)
['as_integer_ratio', 'conjugate', 'fromhex', 'hex', 'is_integer']
```

Basic Data Types

Methods in the built-in `int` data type

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>>> dir(int)
['bit_length', 'conjugate']
```

Methods in the built-in `float` data type

```
>_ ~/workspace/ipp/programs

>>> dir(float)
['as_integer_ratio', 'conjugate', 'fromhex', 'hex', 'is_integer']
```

Methods in the built-in `bool` data type

```
>_ ~/workspace/ipp/programs

>>> dir(bool)
['bit_length', 'conjugate']
```

Basic Data Types

Methods in the built-in `int` data type

```
>_ ~/workspace/ipp/programs

>>> dir(int)
['bit_length', 'conjugate']
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Methods in the built-in `float` data type

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>>> dir(float)
['as_integer_ratio', 'conjugate', 'fromhex', 'hex', 'is_integer']
```

Methods in the built-in `bool` data type

```
>_ ~/workspace/ipp/programs

>>> dir(bool)
['bit_length', 'conjugate']
```

Methods in the built-in `str` data type

```
>_ ~/workspace/ipp/programs

>>> dir(str)
['capitalize', 'center', 'count', 'decode', 'encode', 'endswith', 'expandtabs', 'find', 'format',
'index', 'isalnum', 'isalpha', 'isdigit', 'islower', 'isspace', 'istitle', 'isupper', 'join',
'ljust', 'lower', 'lstrip', 'partition', 'replace', 'rfind', 'rindex', 'rjust', 'rpartition',
'rsplit', 'rstrip', 'split', 'splitlines', 'startswith', 'strip', 'swapcase', 'title', 'translate',
'upper', 'zfill']
```

Basic Data Types

Basic Data Types

Program: `potentialgene.py`

Basic Data Types

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- Command-line input: *dna* (str)

Basic Data Types

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- Command-line input: *dna* (str)
- Standard output: whether *dna* corresponds to a potential gene or not

Basic Data Types

Program: `potentialgene.py`

- Command-line input: *dna* (str)
- Standard output: whether *dna* corresponds to a potential gene or not

```
>_ ~/workspace/ipp/programs
```

```
$ python3 potentialgene.py ATGCGCCTGCGTCTGTACTAG
True
$ python3 potentialgene.py ATGCGCTGCGTCTGTACTAG
False
$
```

Basic Data Types

Basic Data Types

potentialgene.py

```python
import stdio
import sys

def main():
    dna = sys.argv[1]
    stdio.writeln(_isPotentialGene(dna))

def _isPotentialGene(dna):
    ATG = 'ATG'
    TAA, TAG, TGA = 'TAA', 'TAG', 'TGA'
    if len(dna) % 3 != 0:
        return False
    if not dna.startswith(ATG):
        return False
    for i in range(len(dna) - 3):
        if i % 3 == 0:
            codon = dna[i:i + 3]
            if codon == TAA or codon == TAG or codon == TGA:
                return False
    return dna.endswith(TAA) or dna.endswith(TAG) or dna.endswith(TGA)

if __name__ == '__main__':
    main()
```

Collection Data Types

Collection Data Types

Methods in the built-in `list` data type

```
>_ ~/workspace/ipp/programs
```

```
>>> dir(list)
['append', 'count', 'extend', 'index', 'insert', 'pop', 'remove', 'reverse', 'sort']
```

Collection Data Types

Methods in the built-in `list` data type

```
>_ ~/workspace/ipp/programs

>>> dir(list)
['append', 'count', 'extend', 'index', 'insert', 'pop', 'remove', 'reverse',  'sort']
```

Methods in the built-in `tuple` data type

```
>_ ~/workspace/ipp/programs

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Methods in the built-in `tuple` data type

```
>_ ~/workspace/ipp/programs

>>> dir(tuple)
['count', 'index']
```

Methods in the built-in `dict` data type

```
>_ ~/workspace/ipp/programs

>>> dir(dict)
['clear', 'copy', 'fromkeys', 'get', 'items', 'keys', 'pop', 'popitem', 'setdefault', 'update',
 'values']
```

Collection Data Types

Methods in the built-in `list` data type

```
>_ ~/workspace/ipp/programs

>>> dir(list)
['append', 'count', 'extend', 'index', 'insert', 'pop', 'remove', 'reverse',  'sort']
```

Methods in the built-in `tuple` data type

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>>> dir(tuple)
['count', 'index']
```

Methods in the built-in `dict` data type

```
>_ ~/workspace/ipp/programs

>>> dir(dict)
['clear', 'copy', 'fromkeys', 'get', 'items', 'keys', 'pop', 'popitem', 'setdefault', 'update',
 'values']
```

Methods in the built-in `set` data type

```
>_ ~/workspace/ipp/programs

>>> dir(set)
['add', 'clear', 'copy', 'difference', 'difference_update', 'discard', 'intersection',
'intersection_update', 'isdisjoint', 'issubset', 'issuperset', 'pop', 'remove',
'symmetric_difference', 'symmetric_difference_update', 'union', 'update']
```

User-Defined Data Types

User-Defined Data Types

Color	
`Color(r, g, b)`	constructs a new color c with red, green, and blue components r, g, and b, all integers between 0 and 255
`c.getRed()`	returns the red component of c
`c.getGreen()`	returns the green component of c
`c.getBlue()`	returns the blue component of c
`str(c)`	returns a string representation of c

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To create an object of a user-defined data type, we call its constructor, using the name of the data type, followed by the constructor's arguments

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We use a variable name to identify the object to be associated with the method we intend to call

User-Defined Data Types

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In any data-type implementation, it is worthwhile to include an operation that converts an object's value to a string

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We use a variable name to identify the object to be associated with the method we intend to call

In any data-type implementation, it is worthwhile to include an operation that converts an object's value to a string

We use the following form of the `import` statement to import a data type `XYZ` defined in a file `xyz.py`

```
from xyz import XYZ
```

User-Defined Data Types

User-Defined Data Types

Program: `alberssquares.py`

User-Defined Data Types

Program: `alberssquares.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)

User-Defined Data Types

Program: `alberssquares.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)
- Standard draw output: Albers' squares using colors $(r1, g1, b1)$ and $(r2, g2, b2)$

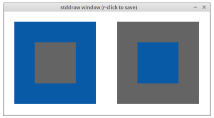
User-Defined Data Types

Program: `albersquares.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)
- Standard draw output: Albers' squares using colors $(r1, g1, b1)$ and $(r2, g2, b2)$

```
>_ ~/workspace/ipp/programs

$ python3 alberssquares.py 9 90 166 100 100 100
```



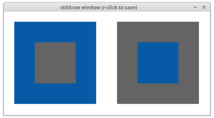
User-Defined Data Types

Program: `alberssquares.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)
- Standard draw output: Albers' squares using colors $(r1, g1, b1)$ and $(r2, g2, b2)$

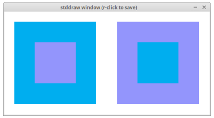
```
>_ ~/workspace/ipp/programs

$ python3 alberssquares.py 9 90 166 100 100 100
```



```
>_ ~/workspace/ipp/programs

$ python3 alberssquares.py 0 174 239 147 149 252
```

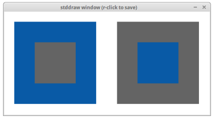


User-Defined Data Types

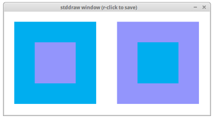
Program: `alberssquares.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)
- Standard draw output: Albers' squares using colors $(r1, g1, b1)$ and $(r2, g2, b2)$

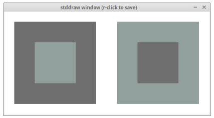
```
>_ ~/workspace/ipp/programs
$ python3 alberssquares.py 9 90 166 100 100 100
```



```
>_ ~/workspace/ipp/programs
$ python3 alberssquares.py 0 174 239 147 149 252
```



```
>_ ~/workspace/ipp/programs
$ python3 alberssquares.py 110 110 110 145 160 156
```



User-Defined Data Types

User-Defined Data Types

alberssquares.py

```
from color import Color
import stddraw
import sys

def main():
    r1 = int(sys.argv[1])
    g1 = int(sys.argv[2])
    b1 = int(sys.argv[3])
    r2 = int(sys.argv[4])
    g2 = int(sys.argv[5])
    b2 = int(sys.argv[6])
    c1 = Color(r1, g1, b1)
    c2 = Color(r2, g2, b2)
    stddraw.setCanvasSize(512, 256)
    stddraw.setYscale(0.25, 0.75)
    stddraw.setPenColor(c1)
    stddraw.filledSquare(0.25, 0.5, 0.2)
    stddraw.setPenColor(c2)
    stddraw.filledSquare(0.25, 0.5, 0.1)
    stddraw.setPenColor(c2)
    stddraw.filledSquare(0.75, 0.5, 0.2)
    stddraw.setPenColor(c1)
    stddraw.filledSquare(0.75, 0.5, 0.1)
    stddraw.show()

if __name__ == '__main__':
    main()
```

User-Defined Data Types

User-Defined Data Types

Program: `luminance.py`

User-Defined Data Types

Program: `luminance.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)

User-Defined Data Types

Program: `luminance.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)
- Standard output: whether the two colors are compatible

User-Defined Data Types

Program: `luminance.py`

- Command-line input: $r1$ (int), $g1$ (int), $b1$ (int), $r2$ (int), $g2$ (int), and $b2$ (int)
- Standard output: whether the two colors are compatible

```
>_ ~/workspace/ipp/programs
```

```
$ python3 luminance.py 0 0 0 0 0 255
(0, 0, 0) compatible with (0, 0, 255)? False
$ python3 luminance.py 0 0 0 255 255 255
(0, 0, 0) compatible with (255, 255, 255)? True
$
```

User-Defined Data Types

User-Defined Data Types

luminance.py

```python
from color import Color
import stdio
import sys

def luminance(c):
    r = c.getRed()
    g = c.getGreen()
    b = c.getBlue()
    if r == g and r == b:
        return r
    return 0.299 * r + 0.587 * g + 0.114 * b

def toGray(c):
    y = int(round(luminance(c)))
    gray = Color(y, y, y)
    return gray

def areCompatible(c1, c2):
    return abs(luminance(c1) - luminance(c2)) >= 128.0

def _main():
    r1 = int(sys.argv[1])
    g1 = int(sys.argv[2])
    b1 = int(sys.argv[3])
    r2 = int(sys.argv[4])
    g2 = int(sys.argv[5])
    b2 = int(sys.argv[6])
    c1 = Color(r1, g1, b1)
    c2 = Color(r2, g2, b2)
    stdio.writeln(str(c1) + ' compatible with ' + str(c2) + '? ' + str(areCompatible(c1, c2)))

if __name__ == '__main__':
    _main()
```

User-Defined Data Types

User-Defined Data Types

Picture	
`Picture(w, h)`	a new *w*-by-*h* picture *pic*
`Picture(filename)`	a new picture *pic* initialized from *filename*
`pic.save(filename)`	save *pic* to *filename*
`pic.width()`	the width of *pic*
`pic.height()`	the height of *pic*
`pic.get(col, row)`	the color of pixel (*col*, *row*) in *pic*
`pic.set(col, row, c)`	set the color of pixel (*col*, *row*) in *pic* to *c*

User-Defined Data Types

User-Defined Data Types

Program: `grayscale.py`

User-Defined Data Types

Program: `grayscale.py`

- Command-line input: *filename* (str)

User-Defined Data Types

Program: `grayscale.py`

- Command-line input: *filename* (str)
- Standard draw output: a gray scale version of the image with the given filename

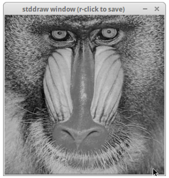
User-Defined Data Types

Program: `grayscale.py`

- Command-line input: *filename* (str)
- Standard draw output: a gray scale version of the image with the given filename

```
>_ ~/workspace/ipp/programs

$ python3 grayscale.py mandril.jpg
```



User-Defined Data Types

User-Defined Data Types

grayscale.py

```python
from picture import Picture
import luminance
import stddraw
import sys

def main():
    filename = sys.argv[1]
    picture = Picture(filename)
    for col in range(picture.width()):
        for row in range(picture.height()):
            pixel = picture.get(col, row)
            gray = luminance.toGray(pixel)
            picture.set(col, row, gray)
    stddraw.setCanvasSize(picture.width(), picture.height())
    stddraw.picture(picture)
    stddraw.show()

if __name__ == '__main__':
    main()
```

User-Defined Data Types

User-Defined Data Types

Program: `fade.py`

User-Defined Data Types

Program: `fade.py`

- Command-line input: *sourceFile* (str), *targetFile* (str), and *n* (int)

User-Defined Data Types

Program: `fade.py`

- Command-line input: *sourceFile* (str), *targetFile* (str), and *n* (int)
- Standard draw output: over the course of *n* frames, gradually replaces the image from *sourceFile* with the image from *targetFile*

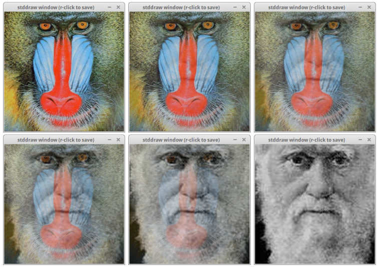
User-Defined Data Types

Program: `fade.py`

- Command-line input: *sourceFile* (str), *targetFile* (str), and *n* (int)
- Standard draw output: over the course of *n* frames, gradually replaces the image from *sourceFile* with the image from *targetFile*

```
>_ ~/workspace/ipp/programs

$ python3 fade.py mandril.jpg darwin.jpg 5
```



User-Defined Data Types

User-Defined Data Types

fade.py

```
from color import Color
from picture import Picture
import stddraw
import sys

def main():
    sourceFile = sys.argv[1]
    targetFile = sys.argv[2]
    n = int(sys.argv[3])
    source = Picture(sourceFile)
    target = Picture(targetFile)
    width = source.width()
    height = source.height()
    stddraw.setCanvasSize(width, height)
    picture = Picture(width, height)
    for i in range(n + 1):
        for col in range(width):
            for row in range(height):
                c0 = source.get(col, row)
                cn = target.get(col, row)
                alpha = i / n
                c = _blend(c0, cn, alpha)
                picture.set(col, row, c)
        stddraw.picture(picture)
        stddraw.show(1)
    stddraw.show()

def _blend(c1, c2, alpha):
    r = (1 - alpha) * c1.getRed() + alpha * c2.getRed()
    g = (1 - alpha) * c1.getGreen() + alpha * c2.getGreen()
    b = (1 - alpha) * c1.getBlue() + alpha * c2.getBlue()
    return Color(int(r), int(g), int(b))

if __name__ == '__main__':
    main()
```

User-Defined Data Types

User-Defined Data Types

InStream	
`InStream(filename)`	a new input stream *in*, initialized from *filename* (defaults to standard input)
`in.isEmpty()`	is *in* empty?
`in.readInt()`	read a token from *in*, and return it as an integer
`in.readString()`	read a token from *in*, and return it as a string

User-Defined Data Types

InStream	
`InStream(filename)`	a new input stream *in*, initialized from *filename* (defaults to standard input)
`in.isEmpty()`	is *in* empty?
`in.readInt()`	read a token from *in*, and return it as an integer
`in.readString()`	read a token from *in*, and return it as a string

OutStream	
`OutStream(filename)`	a new output stream *out* that will write to *filename* (defaults to standard output)
`out.write(x)`	write x to *out*
`out.writeln(x)`	write x to *out*, followed by a newline
`out.writef(fmt, arg1, ...)`	write the arguments $arg_1, \ldots$ to *out* as specified by the format string *fmt*

User-Defined Data Types

User-Defined Data Types

Program: `cat.py`

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- Command-line input: $sys.argv[1 : n-2]$ files or web pages

User-Defined Data Types

Program: `cat.py`

- Command-line input: $sys.argv[1 : n-2]$ files or web pages
- File output: copies them to the file whose name is accepted is $sys.argv[n-1]$

User-Defined Data Types

Program: `cat.py`

- Command-line input: $sys.argv[1:n-2]$ files or web pages
- File output: copies them to the file whose name is accepted is $sys.argv[n-1]$

```
>_ ~/workspace/ipp/programs
```

```
$ cat ../data/in1.txt
This is
$ cat ../data/in2.txt
a tiny
test.
$ python3 cat.py ../data/in1.txt ../data/in2.txt out.txt
$ cat out.txt
This is
a tiny
test.
$
```

User-Defined Data Types

User-Defined Data Types

cat.py

```python
from instream import InStream
from outstream import OutStream
import sys

def main():
    n = len(sys.argv)
    outStream = OutStream(sys.argv[n - 1])
    for i in range(1, n - 1):
        inStream = InStream(sys.argv[i])
        s = inStream.readAll()
        outStream.write(s)

if __name__ == '__main__':
    main()
```

User-Defined Data Types

User-Defined Data Types

Program: `split.py`

User-Defined Data Types

Program: `split.py`

- Command-line input: *filename* (str) and *n* (int)

User-Defined Data Types

Program: `split.py`

- Command-line input: *filename* (str) and *n* (int)
- File output: splits the file whose name is *filename.csv*, by field, into *n* files named *filename*1.*txt*, *filename*2.*txt*, etc

User-Defined Data Types

Program: `split.py`

- Command-line input: *filename* (str) and *n* (int)
- File output: splits the file whose name is *filename.csv*, by field, into *n* files named *filename*1*.txt*, *filename*2*.txt*, etc

```
>_ ~/workspace/ipp/programs
```

```
$ head -5 ../data/ip.csv
www.princeton.edu,128.112.128.15
www.cs.princeton.edu,128.112.136.35
www.math.princeton.edu,128.112.18.11
www.cs.harvard.edu,140.247.50.127
www.harvard.edu,128.103.60.24
$ python3 split.py ../data/ip 2
$ head -5 ../data/ip1.txt
www.princeton.edu
www.cs.princeton.edu
www.math.princeton.edu
www.cs.harvard.edu
www.harvard.edu
$ head -5 ../data/ip2.txt
128.112.128.15
128.112.136.35
128.112.18.11
140.247.50.127
128.103.60.24
$
```

User-Defined Data Types

User-Defined Data Types

split.py

```python
from instream import InStream
from outstream import OutStream
import stdarray
import sys

def main():
    filename = sys.argv[1]
    n = int(sys.argv[2])
    outStreams = stdarray.create1D(n, None)
    for i in range(n):
        outStreams[i] = OutStream(filename + str(i + 1) + '.txt')
    inStream = InStream(filename + '.csv')
    while inStream.hasNextLine():
        line = inStream.readLine()
        fields = line.split(',')
        for i in range(n):
            outStreams[i].writeln(fields[i])

if __name__ == '__main__':
    main()
```