Objectives

- Exception Handling
- Searching

EXCEPTION HANDLING

Runtime Errors: Exceptions

- "Raised" at runtime
- A signal that something "ain't quite right"
  - Something has occurred that can't be easily handled using typical Python structures
- When an exception is raised
  - Program execution stops
  - Python prints out the ***traceback***
    - A report of the function calls made in your code to reach this point

Example Traceback

```
$ python yearborn.py
This program determines your birth year
given your age and the current year

Enter your age: seven
Traceback (most recent call last):
  File "/Users/sprenkles/Box/CSCI111/inclass/24-dictionaries/yearborn.py",
  line 31, in <module>
    main()
  File "/Users/sprenkles/Box/CSCI111/inclass/24-dictionaries/yearborn.py",
  line 12, in main
    age = int(input("Enter your age: "))
ValueError: invalid literal for int() with base 10: 'seven'
```

Shows the problem (`ValueError`) and
the line where the error occurred and the execution path to get there
→ called `main` on line 31, error is on line 12 in `main`

Handling Exceptions

- Using try/except statements
- Syntax:

```
try:
        <body>
except [<errorType>] :
        <handler>
```

Optional: use this to handle specific error types appropriately

- Example:

`try` body: Typical behavior/ No errors

```
try:
    age = int(input("Enter your age: "))
    currentyear = int(input("Enter the current year: "))
except:
    print("Error: Your input was not in the correct form.")
    print("Enter integers for your age and the current year")
    sys.exit(1)
```

yearborn.py

Exception-Specific Handling

- Using try/except statements
- Syntax:

```
try:
        <body>
except [<errorType>] :
        <handler>
```

Optional: use this to handle specific error types appropriately

- Example:

```
try:
    age = int(input("Enter your age: "))
    currentyear = int(input("Enter the current year: "))
except ValueError:
    print("Error: Your input was not in the correct form.")
    print("Enter integers for your age and the current year")
    sys.exit(1)
```

yearborn2.py

Discussion: `sys.exit([status])`

- What is `sys.exit([status])`?
  - A way to exit the program
- Where does it come from?
  - The `sys` module; need to import
  - `import sys`

```
exit(...)
        exit([status])

    Exit the interpreter by raising SystemExit(status).
    If the status is omitted or None, it defaults to zero (i.e., success).
    If the status is an integer, it will be used as the system exit status.
    If it is another kind of object, it will be printed and the system
    exit status will be one (i.e., failure).
```

Examples of Types of Exceptions

- IndexError
  - When index is not found in the sequence
- KeyError
  - When a key is not found in the dictionary
- IOError:
  - FileNotFoundError: File doesn't exist
  - PermissionError: Don't have permission to read/write file

Exception Handling

```
try:
    inFile = open(infileName, "r")
    # typically, would process file here…
    inFile.close()
except IOError as exc :
    print("Error reading \"" + infileName + "\".")
    # could be a variety of different problems,
    # so print out the exception and its type
    print(exc)
    print(type(exc))
    sys.exit(1)
```

- Exceptions are *objects*
- We can get more information about the exception by printing them out

file_handle.py

Best Practices

- Prevent errors as best you can
  - Example: use `if` statements to verify data
    - Confirm key is in the dictionary before trying to access
- For errors you can't prevent, *handle* them!
  - Example: We can check if a file exists before trying to read it BUT between the check and actually reading the file, the file could be deleted from the system!

Review

- We discussed two different search techniques:
  - What were they?
  - How do they compare?
  - What are their pros and cons?

- Continue working on the problem we ended with (implementing the second search technique)

Review: Search Using `in` Review

- Iterates through a list, checking if the element is found
- Known as ***linear search***
- **Implementation:**

```
def linearSearch(searchlist, key):
    for elem in searchlist:
        if elem == key:
            return True
    return False
```

value	8	5	3	7
pos	0	1	2	3

What are the strengths and weaknesses of implementing search this way?

Review: Linear Search

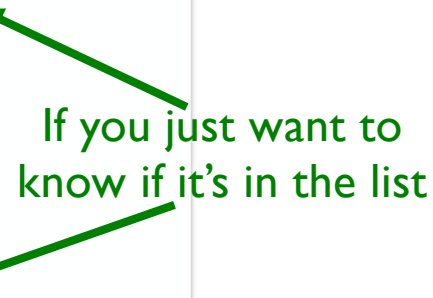
- **Overview**: Iterates through a list, checking if the element is found
- **Benefits:**
  - Works on *any* list
- **Drawbacks**:
  - **Slow**, on average: needs to check each element of list if the element is not in the list

Review: Binary Search: Eliminate Half the Possibilities

- Repeat until find value (or looked through all values)
  - Guess middle *value* of possibilities
    - (*not* middle *position*)
  - If match, found!
  - Otherwise, find out too high or too low
  - Modify your possibilities
    - Eliminate the possibilities from your number and higher/lower, as appropriate
- Known as **Binary Search**

Binary Search Implementation

```
def search(searchlist, key):
    low=0
    high = len(searchlist)-1
    while low <= high :
        mid = (low+high)//2
        if searchlist[mid] == key:
            return mid    # return True
        elif key > searchlist[mid]:
            low = mid+1
        else:
            high = mid-1
    return -1    # return False
```



Binary Search

- Example of a ***Divide and Conquer*** algorithm
  - Break into smaller pieces that you can solve
- Benefits:
  - Faster to find elements (especially with larger lists)
- Drawbacks:
  - Requires that data can be compared
    - `__lt__, __eq__` methods implemented by the class (or another solution)
  - List **must** be sorted before searching
    - Takes time to sort

Key Questions in Computer Science

- How can we efficiently organize data?
- How can we efficiently search for data, given various constraints?
  - Example: data may or may not be sortable
- What are the tradeoffs?

Empirical Study of Search Techniques

Goal: Determine which technique is better under various circumstances

- How long does it take to find various keys?
  - **Measure** by the number of comparisons
  - Vary the size of the list and the keys
  - What are good tests for the lists and the keys?

Empirical Study of Search Techniques

- Analyzing Results …
  - By how much did the number of comparisons for *linear search* vary?
  - By how much did the number of comparisons for *binary search* vary?
- What conclusions can you draw from these results?

`search_compare.py`

Search Strategies Summary

- Which search strategy should I use under the following circumstances?
  - I have a short list
  - I have a long list
  - I have a long sorted list

Search Strategies Summary

- Which search strategy should I use under the following circumstances?
  - I have a short list
    - How short? How many searches? Linear (`in`)
  - I have a long list
    - Linear (`in`) - because don't know if in order, comparable
    - Alternatively, may want to sort the list and *then* perform binary search, if sorting first won't be more effort than just searching.
  - I have a long sorted list
    - Binary

Extensions to Search

In InstaFace, we want to find *people* who have a certain name.

Consider what happens when **`searchlist`** is a list of *Persons* and key is a name (a `str`)

We want to find a `Person` whose name matches the key and return the *Person*

List of Person objects

0	1	2	3	4
Person Id:“1” “Gal”	Person Id:“2” “Scarlett”	Person Id:“3” “Tom”	Person Id: “4” “Ben”	Person Id: “5” “Samuel”

Example: looking for a person with the name “Tom”…

List of Person objects

0	1	2	3	4
Person Id:“1” “Gal”	Person Id:“2” “Scarlett”	Person Id:“3” “Tom”	Person Id: “4” “Ben”	Person Id: “5” “Samuel”

0	1	2	3	4
Person Id: “4” “Ben”	Person Id: “1” “Gal”	Person Id:“5” “Samuel”	Person Id:“2” “Scarlett”	Person Id:“3” “Tom”

Sorted by name, e.g., `personList.sort(key=Person.getName)`

Extensions to Solution

```
def search(searchlist, key):
    low=0
    high = len(searchlist)-1
    while low <= high :
        mid = (low+high)//2
        if searchlist[mid] == key:
            return mid
        elif key > searchlist[mid]:
            # look in upper half
            low = mid+1
        else:
            # look in lower half
            high = mid-1
    return -1
```

Consider what happens when **`searchlist`** is a list of *Persons* sorted by name, ***`key`*** is a ***`str`*** representing a name

Goal: return a Person object with that name (key)

0	1	2	3	4
Person Id: "4" "Ben"	Person Id: "1" "Gal"	Person Id:"5" "Samuel"	Person Id:"2" "Scarlett"	Person Id:"3" "Tom"

Extensions to Solution

```
def search(searchlist, key):
    low=0
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    return -1
```

Consider what happens when **`searchlist`** is a list of *Persons* sorted by name, ***`key`*** is a ***`str`*** representing a name
Goal: return a Person object with that name (key)

What can we do to make search results more intuitive?

0	1	2	3	4
Person Id: "4" "Ben"	Person Id: "1" "Gal"	Person Id:"5" "Samuel"	Person Id:"2" "Scarlett"	Person Id:"3" "Tom"

Summary of Extensions to Solution

- Check the *name* of the `Person` at the midpoint
- Represent, handle when no `Person` matches
- What could we do if more than one person has that name?

- Note: we're not implementing "name contains"
  - How could we implement that?

Looking Ahead

- Lab 11