CS2040S Tutorial 1

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About me

- Year 3 in CS (Interest in Distributed Systems)

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- Did CVWO for the past 2 summers
- Uses Emacs

Now your turn!

- Name
- Interests (Preferably not CS related)
- What was the nicest thing you ate over CNY?

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- CS2040S is intense
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- Prepare for class
- Contribute to class
- I try to respond to emails in like ~24 hours
  - Or you can ping our Telegram group - others probably have the same query!
- I don't want to touch code!

Classes and Objects

- What is a class?

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- What is a class?
- What is an object?

Classes and Objects

```
class Student {
  private String name;

  public Student(String name) {
    this.name = name;
  }
}

Student hans = new Student("Hans");
```

Classes and Objects

```
class Student {
  private static String name;

  public Student(String name) {
    this.name = name;
  }
}

Student hans = new Student("Hans");
```

Classes and Objects

```
class Student {
  private String name;

  public Student(String name) {
    this.name = name;
  }

  private void sayName() {
    System.out.printf("Hi, my name is %s\n", this.name);
  }
}

Student hans = new Student("Hans");
hans.sayName();
```

Java vs Source

Object-orientedness

Everything in Java is an object (well, mostly).

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Immutability

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Higher Order Functions

It's a pain in Java (Covered in CS2030).

Pass by value vs pass-by-reference

```
class X { String n = "hi"; }

void foo(X x) { x.n = "bye"; }

X x = new X();
foo(x);
System.out.println(x.n);
```

Pass by value vs pass-by-reference

```
class X { String n = "hi"; }

void goo(X x) {
  x = new X();
  x.n = "bye";
}

X xx = new X();
goo(xx);
System.out.println(xx.n);
```

Pass by value vs pass-by-reference

```
void hoo(int x) {
  x += 3;
}

int n = 3;
hoo(n);
System.out.println(n);
```

Example 1

```
public static int niceFunction(int n)
{
        for (int i = 0; i < n; i++)
        {
                System.out.println("I am nice!");
        }
        return 42;
}

public static int meanFunction(int n)
{
        if(n == 0) return 0;
        return (2 * meanFunction(n/2) + niceFunction(n));
}

public static int evilFunction(int n)
{
        for(int i = 2; i < n; i *= i){
                System.out.println("To be or not to be");
        }
        return 666;
}
```

Example 2

```
public static int drEvilsRevenge(int n){
        return drEvilRecursion(0, n);
}

public static int drEvilRecursion(int k, int n){
        if(k == n) return 0;
        else {
                return drEvilRecursion(k+1, n)
                     + drEvilRecursion(k+1, n);
        }
}
```

Example 3

```
public static int legendaryFunction(int n){
        int x = 0;
        if(n == 0) return 1;
        for(int i = 0; i < n; i++){
                x += legendaryFunction(n-1);
        }
        return x;
}
```

Example 4

```
// From CS1020
public static int theChosenOne(int n)
{
        int x = 0;
        for (int i = 1; i < n; i *= 3)
        {
                x++;
                for(int j = 0; j < i; j++)
                {
                        x++;
                        for(int k = n-1; k >= 0; k--){
                                x++;
                        }
                        for(int m = n-1; m > 0; m /= 2){
                                x++;
                        }
                }
        }
        return 0;
}
```

When can we use binary search?

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- Can we think of a more general criteria?

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- Increasing/decreasing sequence of numbers
- Can we think of a more general criteria?
- Think about the peakfinding algorithm

A more general criteria

- Given a sequence of elements $E = [e_1, e_2, ..., e_j]$
- Want to find element e^* in E
- We can apply binary search if:
  - $\exists f$, such that $\forall i, f(e_i)$ can tell us:
    - if e_i is e^*, or
    - e^* is in $[e_1, e_2, ...e_{i-1}]$, or
    - e^* is in $[e_{i+1}, e_{i+2}, ...e_j]$

Example: Normal Binary Search

- Find 5 in [1,2,4,5,6,7]
- $E = [1, 2, 4, 5, 6, 7]$
- $f(x) =$
  - found if $x = 5$,
  - search in $[1, 2, ..., x - 1]$ if $x > 5$,
  - search in $[x + 1, x + 2...]$ if $x < 5$

Example: Peakfinding

- Find peak in [1,2,4,5,2,3].

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Example: Peakfinding

- Find peak in [1,2,4,5,2,3].
- $f(x) = ?$
  - $f(x) = \frac{d}{dx}(x)$
  - found if $f(x) = 0$,
  - search in $[1, 2, ..., x - 1]$ if $f(x) < 0$,

Example: Peakfinding

- Find peak in [1,2,4,5,2,3].
- $f(x) = ?$
  - $f(x) = \frac{d}{dx}(x)$
  - found if $f(x) = 0$,
  - search in $[1, 2, ..., x - 1]$ if $f(x) < 0$,
  - search in $[x + 1, x + 2...]$ if $f(x) > 0$

Example: Peakfinding

- Find peak in [1,2,4,5,2,3].
- $f(x) = ?$
  - $f(x) = \frac{d}{dx}(x)$
  - found if $f(x) = 0$,
  - search in $[1, 2, ..., x - 1]$ if $f(x) < 0$,
  - search in $[x + 1, x + 2...]$ if $f(x) > 0$
- $E = ?$

Example: Peakfinding

- Find peak in [1,2,4,5,2,3].
- $f(x) = ?$
  - $f(x) = \frac{d}{dx}(x)$
  - found if $f(x) = 0$,
  - search in $[1, 2, ..., x-1]$ if $f(x) < 0$,
  - search in $[x+1, x+2...]$ if $f(x) > 0$
- $E = ?$
- $E = [[-\infty, 1, 2], [1, 2, 4], [2, 4, 5], [4, 5, 2], [5, 2, 3], [2, 3, \infty]]$

Peakfinding Implementation

- `map(E)` takes $O(n)$

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- `map(E)` takes $O(n)$
- Lazy evaluation
- $f(x)$ is an operation where x is an index perhaps?

Binary search skeleton

```
def binary_search(arr, f):
  mid = len(arr) / 2
  if f(mid) == 0:
    return mid
  if f(mid) == -1:
    # don't actually do this in python
    return binary_search(arr[:mid-1], f)
  else:
    return binary_search(arr[mid+1:], f)
```

- By reducing the algorithm to its simplest elements, we can ease our implementation

Summary

Java

- OOP properties

Binary search

- Removing edge cases
- Abstracting reusable elements

To think about

- Can I use binary search on a sequence with infinite elements?