Announcements

- Sign-ups for weekly group tutoring offered by the course tutors have been released!
- Form will close on Saturday, 9/9, at 11:59PM.
- You will receive room and time assignments on Sunday via email.
- Sections will start next week and will be focused on strengthening core concepts.
- More information pinned on Piazza.
CS61B Lecture #7: Object-Based Programming

Basic Idea.

- Function-based programs are organized primarily around the functions (methods, etc.) that do things. Data structures (objects) are considered separate.

- Object-based programs are organized around the types of objects that are used to represent data; methods are grouped by type of object.

- Simple banking-system example:

```
Function-based

account
  deposit
    account

account
  withdraw
    account

Object-based

Account
  deposit
  withdraw
    balance: 1420

Exported methods

Exported field
```
Philosophy

- Idea (from 1970s and before): An abstract data type is
  - a set of possible values (a domain), plus
  - a set of operations on those values (or their containers).

- In IntList, for example, the domain was a set of pairs: (head, tail), where head is an int and tail is a pointer to an IntList.

- The IntList operations consisted only of assigning to and accessing the two fields (head and tail).

- In general, prefer a purely procedural interface, where the functions (methods) do everything—no outside access to fields.

- That way, implementor of a class and its methods has complete control over behavior of instances.

- In Java, the preferred way to write the “operations of a type” is as instance methods.
You Saw It All (Maybe) in CS61A: The Account Class

class Account:
    balance = 0
    def __init__(self, balance0):
        self.balance = balance0
    def deposit(self, amount):
        self.balance += amount
        return self.balance
    def withdraw(self, amount):
        if self.balance < amount:
            raise ValueError("Insufficient funds")
        else:
            self.balance -= amount
        return self.balance

myAccount = Account(1000)
print(myAccount.balance)
myAccount.deposit(100)
myAccount.withdraw(500)

public class Account {
    public int balance;
    public Account(int balance0) {
        balance = balance0;
    }
    public int deposit(int amount) {
        balance += amount; return balance;
    }
    public int withdraw(int amount) {
        if (balance < amount)
            throw new IllegalStateException("Insufficient funds");
        else balance -= amount;
        return balance;
    }
}

Account myAccount = new Account(1000);
print(myAccount.balance)
myAccount.deposit(100);
myAccount.withdraw(500);
You Also Saw It All in CS61AS

```scheme
(define-class (account balance0)
  (instance-vars (balance 0))
  (initialize
   (set! balance balance0)))

(method (deposit amount)
  (set! balance (+ balance amount))
  balance)

(method (withdraw amount)
  (if (< balance amount)
      (error "Insufficient funds")
      (begin
       (set! balance (- balance amount))
       balance)))

(define my-account
  (instantiate account 1000))
(ask my-account 'balance)
(ask my-account 'deposit 100)
(ask my-account 'withdraw 500)
```

```java
public class Account {
  public int balance;
  public Account(int balance0) {
    balance = balance0;
  }
  public int deposit(int amount) {
    balance += amount; return balance;
  }
  public int withdraw(int amount) {
    if (balance < amount)
      throw new IllegalStateException("Insufficient funds");
    else balance -= amount;
    return balance;
  }
}

Account myAccount = new Account(1000);
myAccount.balance
myAccount.deposit(100);
myAccount.withdraw(500);
```
The Pieces

- **Class declaration** defines a *new type of object*, i.e., new type of structured container.

- **Instance variables** such as `balance` are the simple containers within these objects (*fields* or *components*).

- **Instance methods**, such as `deposit` and `withdraw` are like ordinary (static) methods that take an invisible extra parameter (called *this*).

- The **new** operator creates (*instantiates*) new objects, and initializes them using constructors.

- **Constructors** such as the method-like declaration of `Account` are special methods that are used only to initialize new instances. They take their arguments from the **new** expression.

- **Method selection** picks methods to call. For example,

  ```java
  myAccount.deposit(100)
  ```

  tells us to call the method named `deposit` that is defined for the object pointed to by `myAccount`. 
Getter Methods

- Slight problem with Java version of Account: anyone can assign to the balance field

- This reduces the control that the implementor of Account has over possible values of the balance.

- Solution: allow public access only through methods:

  ```java
  public class Account {
    private int balance;
    ...
    public int balance() { return balance; }
    ...
  }
  ```

- Now Account.balance = 1000000 is an error outside Account.

- (OK to use name balance for both the field and the method. Java can tell which is meant by syntax: A.balance vs. A.balance(). However, it’s probably better to choose differing names to avoid confusion.)
• Suppose we want to keep track of the bank’s total funds.
• This number is not associated with any particular Account, but is common to all—it is class-wide.
• In Java, “class-wide” ≡ static

```java
public class Account {
    ...
    private static int funds = 0;
    public int deposit(int amount) {
        balance += amount; funds += amount;
        return balance;
    }
    public static int funds() {
        return funds;
    }
    ...
    // Also change withdraw.
}
```

• From outside, can refer to either Account.funds() or to myAccount.funds() (same thing).
Instance Methods

• Instance method such as

```java
int deposit(int amount) {
    balance += amount; funds += amount;
    return balance;
}
```

behaves sort of like a static method with hidden argument:

```java
static int deposit(final Account this, int amount) {
    this.balance += amount; funds += amount;
    return this.balance;
}
```

• NOTE: Just explanatory: Not real Java (not allowed to declare 'this'). (final is real Java; means “can’t change once set.”)
Calling Instance Method

/** (Fictional) equivalent of deposit instance method. */
static int deposit(final Account this, int amount) {
    this.balance += amount; funds += amount;
    return this.balance;
}

• Likewise, the instance-method call myAccount.deposit(100) is like a call on this fictional static method:

    Account.deposit(myAccount, 100);

• Inside a real instance method, as a convenient abbreviation, one can leave off the leading ‘this.’ on field access or method call if not ambiguous. (Unlike Python)
'Instance' and 'Static' Don't Mix

- Since real static methods don't have the invisible `this` parameter, makes no sense to refer directly to instance variables in them:

```java
public static int badBalance(Account A) {
    int x = A.balance;   // This is OK
    // (A tells us whose balance)
    return balance;     // WRONG! NONSENSE!
    // (Whose balance?)
}
```

- Reference to `balance` here equivalent to `this.balance`,

- But this is meaningless (whose balance?)

- However, it makes perfect sense to access a static (class-wide) field or method in an instance method or constructor, as happened with `funds` in the `deposit` method.

- There's only one of each static field, so don't need to have a 'this' to get it. Can just name the class.
Constructors

- To completely control objects of some class, you must be able to set their initial contents.

- A constructor is a kind of special instance method that is called by the `new` operator right after it creates a new object, as if

\[
\begin{align*}
L = \text{new IntList}(1, \text{null}) &\implies \\
\begin{cases}
\text{tmp} = \text{pointer to 0} \\
\text{tmp.IntList}(1, \text{null}) \\
L = \text{tmp}
\end{cases}
\end{align*}
\]
Multiple Constructors and Default Constructors

• All classes have constructors. In the absence of any explicit constructor, get default constructor, as if you had written:

    public class Foo {
        public Foo() {
        }
    }

• Multiple overloaded constructors possible, and they can use each other (although the syntax is odd):

    public class IntList {
        public IntList(int head, IntList tail) {
            this.head = head; this.tail = tail;
        }

        public IntList(int head) {
            this(head, null); // Calls first constructor.
        }
        ...
    }

Last modified: Fri Sep 8 00:59:28 2017
Constructors and Instance Variables

- Instance variables initializations are moved inside all constructors:

```java
class Foo {
    int x = 5;
    Foo() {
        DoStuff();
    }
}
```

⇐⇒

```java
class Foo {
    int x;
    Foo() {
        x = 5;
        DoStuff();
    }
}
```
## Summary: Java vs. Python

<table>
<thead>
<tr>
<th>Java</th>
<th>Python</th>
</tr>
</thead>
<tbody>
<tr>
<td>class Foo {</td>
<td>class Foo: ...</td>
</tr>
<tr>
<td>int x = ...;</td>
<td>x = ...</td>
</tr>
<tr>
<td>Foo(...)</td>
<td>def <strong>init</strong>(self, ...):</td>
</tr>
<tr>
<td>{ ... }</td>
<td>...</td>
</tr>
<tr>
<td>int f(...)</td>
<td>def f(self, ...):</td>
</tr>
<tr>
<td>{...}</td>
<td>...</td>
</tr>
<tr>
<td>static int y = 21;</td>
<td>y = 21 # Referred to as Foo.y</td>
</tr>
<tr>
<td>static void g(...)</td>
<td>@staticmethod</td>
</tr>
<tr>
<td>{...}</td>
<td>def g(...):</td>
</tr>
<tr>
<td>}</td>
<td>...</td>
</tr>
</tbody>
</table>

aFoo.f(...)  
aFoo.x       
new Foo(...)  
this

---

aFoo.f(...)  
aFoo.x       
new Foo(...)  
self        # (typically)