UMass Boston Computer Science

CS450 High Level Languages (section 2)

Functional Progamming vs OOP

Wednesday, December 13, 2023

(last lecture!)

Logistics

- HW 10 out
  - Shapes! Written in OOP-style
  - due: Sun 12/17 11:59 pm EST

(last lecture!)

Last Time

There's Nothing Special About OOP!

- **A typical** (`interface` and `class`es) **OOP program** is **just specific data definition / function design choice!**
  - imposed by the language!

- Data definition:
  - **itemization** of **compound data** …
  - … where **processing functions are grouped with other data fields!**

- Function design:
  - **Function to process this itemization data is split into separate** "`methods`" (one for each kind of item in the itemization)

Last Time

A Simple OO Example: Compare to CS450

Data definition:
Itemization of compound data

```
interface Shape
Image render();
```

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; interp: Represents a shape image
```

```
;; A Circle is a (circ Num Color)
;; fields are radius and color
```

```
;; A Rectangle is a (rect Num Num Color)
;; fields are width, height, color
```

```
class Circle

Num radius;
Color col;

Image render() { // render-circ
  return circ-img ( radius, col );
}
```

itemization item

Compound data fields

```
(struct circ [r col])
```

```
class Rectangle

Num width;    Num height;
Color col;

Image render() {// render-rect
  return rect-img ( width, height, col );
}
```

itemization item

Compound data fields

```
(struct rect [w h col])
```

Last Time

A Simple OO Example: Compare to CS450

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; interp: Represents a shape image
```

```
interface Shape
Image render();
```

```
class Circle

Num radius;
Color col;

Image render() { // render-circ
  return circ-img ( radius, col );
```

```
class Rectangle

Num width;    Num height;
Color col;

Image render() {// render-rect
  return rect-img ( width, height, col );
```

(one cond clause of a) **Shape**-processing function, as a (hidden) field!

```
;; render: Shape -> Image
(define (render sh)
 (cond
[(rect? sh) (render-rect sh)]
[(circ? sh) (render-circ sh)]))
```

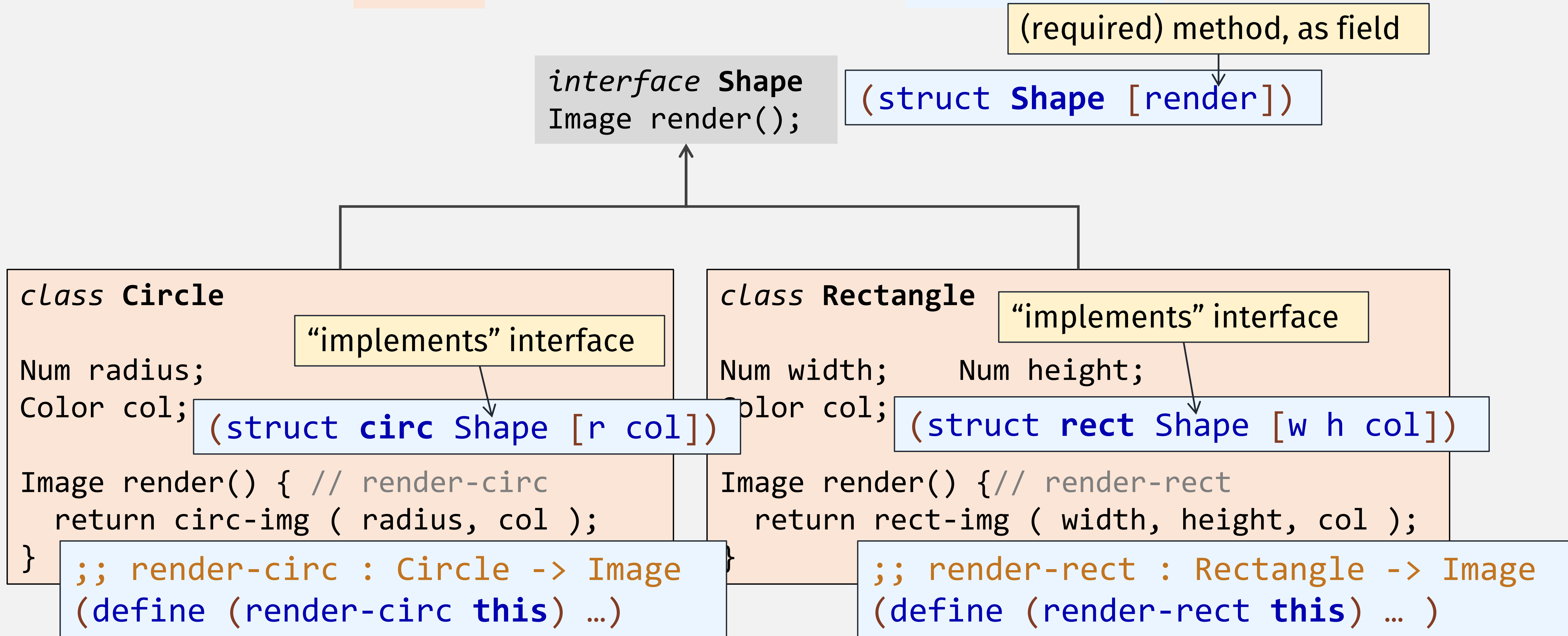
(one cond clause of a) **Shape**-processing function, as a (hidden) field!

In OO langs, this "**dispatch**" function is implicitly written for you

Calls item-specific implementations

Last Time

A Simple OO Example: as structs!



In OO langs, every method implicitly has a class instance arg ("**this**"!)

Last Time

OO-style Constructors … with structs!

```
(struct Shape [render])
```

manually write alternate Shape constructors, with explicit method impls

```
(define (mk-circ r col
                 [circ-render-fn render-circ])
  (circ circ-render-fn r col))
```

default

(method arg optional, with default)

```
(define (mk-rect w h col
                 [rect-render-fn render-rect])
  (rect rect-render-fn w h col))
```

```
(struct circ Shape [r col])
```

```
(struct rect Shape [w h col])
```

```
;; render-circ : Circle -> Image
(define (render-circ this) …)
```

```
;; render-rect : Rectangle -> Image
(define (render-rect this) … )
```

Last Time

OO-style dispatch … with structs!

450-style "dispatch" function

```
;; render : Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]))
```

```
(struct Shape [render])
```

OO-Style "dispatch"

```
;; render : Shape -> Image
(define (render sh)
 ((shape-render sh) sh))
```

```
;; render-circ : Circle -> Image
(define (render-circ this) …)
```

```
;; render-rect : Rectangle -> Image
(define (render-rect this) … )
```

OO vs CS450 Comparison

OO Programming	**CS 450 Design Recipe**
`interface` + `class` imply specific (Itemization-of-compound) Data Def	Explicitly define any kind of Data Def
`class` (compound data) has fields and methods together!	`struct` (compound data) fields typically do not include functions
`class` constructor implicitly adds method impls to created object	data processing function is separate definition
data value to process is implicit method arg	data value to process is explicit function arg
Implicit itemization **dispatch**	Explicit itemization **dispatch** (cond)

OO vs CS450 "OO"-Style Comparison

OO Programming	**CS 450 "OO-style" Design Recipe**
`interface` + `class` imply specific (Itemization-of-compound) Data Def	Explicitly define (itemization-of-compound) Data Def
`class` (compound data) has fields and methods together!	Include methods in `struct` (compound data) fields
`class` constructor implicitly adds method impls to created object	Define additional constructor with explicit method args
data value to process is implicit method arg	data value to process is explicit ~~function~~ "method" arg
Implicit itemization dispatch	Define explicit OO-style dispatch

How to Design … OO-Style Programs

- For **Itemization Data Definition**
  1. List Item Data Defs (and other prev data def parts)
  2. Specify required methods
  3. Define "abstract" struct (with # fields = # of methods)
  4. Define explicit dispatch function(s) (one per method)

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; interp: Represents shape to draw on a canvas
;; Required methods:
;; - render : Shape -> Image
```

```
(struct Shape [render])
```

```
;; render : Shape -> Image
(define (render sh)
 ((shape-render sh) sh))
```

How to Design … OO-Style Programs

```
;; A Rectangle is a:
;; (rect width  : Num
;;       height : Num
;;       color  : Color)
```

```
;; A Circle is a:
;; (circ radius : Num
;;       color  : Color)
```

ata Definition

Defs (and ot

ed methods

ct" struct (w

dispatch fu

```
;; render-circ : Circle -> Image
(define (render-circ this) … )
```

```
;; render-rect : Rectangle -> Image
(define (render-rect this) … )
```

- For **each item**:
  1. Define separate Data def
  2. Define a struct, as substruct of "abstract" struct
  3. Define required methods
  4. Define constructor that includes method impls

```
(define (mk-rect w h col
          [render
           render-rect])
  (rect render w h col))
(define (mk-circ r col)
          [render
           render-circ])
  (circ render r col))
```

```
(struct rect Shape [w h col])
(struct circ Shape [r col])
```

A Simple OO Example: Extensions?

Add a Triangle?

Easy: Just define another class

Add a rotate method?

```
interface Shape
Image render();
```

```
class Circle

Num r;    Color col;

Image render() {
  return circ-img ( r, col );
}
```

```
class Rectangle

Num w;    Num h;    Color col;

Image render() {
  return rect-img ( w, h, col );
}
```

```
class Triangle

Num side1; // …

Image render() {
  return tri-img ( … );
}
```

A Simple OO Example: Extensions?

```
interface Shape
Image render();
Image rotate();
```

Add a rotate method?

Hard!: **must update interface** and **every existing class** (might not have access!)

```
class Circle

Num r;    Color col;

Image render() {
  return circ-img ( r, col );
}

Circle rotate() { … }
```

```
class Rectangle

Num w;    Num h;    Color col;

Image render() {
  return rect-img ( w, h, col );
}

Rectangle rotate() { … }
```

```
class Triangle

Num side1; // …

Image render() {
  return tri-img ( … );
}

Triangle rotate() { … }
```

Shapes, CS450 style

Add a Triangle?

Hard!: must:
- update data def,
- define new struct,
- update every existing "dispatch" function (might not have access!)

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; interp: Represents a shape image
```

```
;; A Rectangle is a (rect Num Num Color)
;; fields are width, height, color
(struct rect [w h col])
;; A Circle is a (circ Num Color)
;; fields are radius and color
(struct circ [r col])
```

```
;; render: Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]))
```

Shapes, CS450 style

Add a Triangle?

Hard!: must:

- update data def,
- define new struct,
- update every existing "dispatch" function (might not have access!)

```
;; render: Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]
  [(tri? sh)  (render-tri sh) ]))
```

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; - Triangle
;; interp: Represents a shape image
```

```
;; A Rectangle is a (rect Num Num Color)
;; fields are width, height, color
(struct rect [w h col])
;; A Circle is a (circ Num Color)
;; fields are radius and color
(struct circ [r col])
;; A Triangle is a (tri … )
;; fields are …
(struct tri [ … ])
```

Shapes, CS450 style

Add a rotate function?

Easy!: Just define another function!

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; interp: Represents a shape image
```

```
;; A Rectangle is a (rect Num Num Color)
;; fields are width, height, color
(struct rect [w h col])
;; A Circle is a (circ Num Color)
;; fields are radius and color
(struct circ [r col])
```

```
;; render: Shape -> Image
(define (render sh)
 (cond
  [(rect? sh) (render-rect sh)]
  [(circ? sh) (render-circ sh)]))
```

```
;; rotate: Shape -> Shape
(define (rotate sh)
 (cond
  [(rect? sh) (rotate-rect sh)]
  [(circ? sh) (rotate-circ sh)]))
```

FP vs OO Comparison

Adding another "item" to itemization, e.g., `Triangle`

- **OO**: *Easy*
  - Just **define another class**
    - Class methods only process that kind of item
    - Implicit "Dispatch" function(s) automatically updated
- **FP**: *Hard*
  - Must **update data def, define another struct**
  - Every explicit "dispatch" function must be manually updated with another cond clause

Adding a new operation for itemization data, e.g., `rotate`

- **OO**: *Hard*
  - Must **update interface, and add new method to every class that implements it**
- **FP**: *Easy*
  - Just **define another function**

A better way? Mixins demo

- A Mixin is a function, whose input and output is a class!

- Available in many languages:
  - RACKET
  - JAVASCRIPT
  - SCALA

- (add-rotate-mixin class-without-rotate) => class-with-rotate

Thank you for a great semester!

- Repo: **cs450f23/lecture28-inclass**
- File: **hw10**-<*your last name*>.rkt

In-class Coding 12/11: work on hw10

Use Racket to create an OO-Style shape drawing …

Recommended (OO-style) struct and data defs

TO implement:
- methods
- constructors (that add methods to struct)
- dispatch fn (one per operation)

```
Shape
Image place-shape( Image canvas );
```

```
(struct Shape [place-method])
(struct rect Shape [w h topleft])
(struct circ Shape [r center])
```

```
Circle

Num r;
Posn center; // center coordinate

// places circle into given canvas
Image place-shape( Image canvas ) {
  return
    place-image( circ-img( r, … ),
                 center
```

```
Rectangle

Num w; Num h;
Posn offset; // topleft corne

// places rect into given can
Image place-shape( Image canv
  return
    place-image ( rect-img(w, h, …)
                  offset
}
```

```
;; A Shape is one of:
;; - Rectangle
;; - Circle
;; Represents:
;;   shape on a canvas
;; methods:
;; - place-shape :
;;   Shape Img -> Img
```

Recommended (additional) functions:

```
;; create-circ: Posn Posn -> Circle
;; Constructs circ from any two coords
(define (create-circ p1 p2) (circ … … ))
```

```
;; create-rect: Posn Posn -> Rectangle
;; Constructs rect from any two coords
(define (create-rect p1 p2) (rect … … … ))
```

Submit your in-class work to github

Thank you for a great semester!