Structures and All That

September 25, 2019

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We can get you prepared for the 31st century
With advanced programming and quad rendering
And Java plus plus plus scripting language
We offer advanced job placement assistance"

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- Whereas with "or" we would check which kind of data we would have and then use a computation specific to that data, with products we can directly project out data.
- Let's say that in Java that you have some person class with a first and last name represented as strings.
- It is easy to define a method that returns the person's full name by concatenating the first and last name.

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- We can represent a grid with one number in the same sense that we can simulate a 10x10 2D array with a 100 element array.

Structs Make Things Easier

Personally, I like doing things the easy way.

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def first_name(tup):
  return tup[0]
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- So Python gives classes (or named tuples) as a way to more easily define such structured data.

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- We will return to discussing lists in more detail later, since they are *extremely* important.
- But for now, remember that we wanted to avoid the inconveniences given by using other existing data types to represent some piece of compound data!

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(check-expect (distance-to-0 (point 0 5)) 5)
(check-expect (distance-to-0 (point 7 0)) 7)
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(define (distance-to-0 ap)
  (sqrt
    (+ (sqr (point-x ap))
       (sqr (point-y ap)))))
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  2. One selector per field, which extracts the value of the field from a structure instance; and
  3. One structure predicate, which, like ordinary predicates, distinguishes instances from all other kinds of values.

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2. The selectors per field are `(point-x point-val)` and `(point-y point-val)`. The general form of a selector for a specific field is `(struct-name-field-name val)`
3. A predicate for checking types is automatically created, for example: `(point? point-val)` and in general a predicate `struct?` is created.

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- You guys should be able to think of many more examples.

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- Let's first consider defining a 2D vector struct as follows: `(struct vector [delta-x delta-y])`
- Now, we can represent a ball as a point (which only has positive components) and a vector (which can have negative components): `(struct 2D-ball position vec)`

Other Representations

Our 2D Ball struct has nested occurrences of other structs. This is a natural thing, and even recursive descriptions of data are natural, i.e. linked lists and binary trees. But we can also consider using a *flat representation* for our 2D Ball, which doesn't nest structs.

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- Let's talk about defining data definitions for structs. We must specify the form of the struct and the types of its field and provide an interpretation of what each of the fields represents. Here's how we do this for our point struct:

Other Representations

Our 2D Ball struct has nested occurrences of other structs. This is a natural thing, and even recursive descriptions of data are natural, i.e. linked lists and binary trees. But we can also consider using a *flat representation* for our 2D Ball, which doesn't nest structs.

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- Let's talk about defining data definitions for structs. We must specify the form of the struct and the types of its field and provide an interpretation of what each of the fields represents. Here's how we do this for our point struct:

```
(define-struct point [x y])
; A Point is a structure:
;    (point Number Number)
; interpretation a point x pixels from left, y from top
```

-

Structs and Program Design

Now we need to consider designing programs using structs.
Sample Problem Your team is designing an interactive game program that moves a red dot across a image canvas and allows players to use the mouse to reset the dot. Here is how far you got together:

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```
(define MTS (empty-scene 100 100))
(define DOT (circle 3 "solid" "red"))

; A Point represents the state of the world.

; Point -> Point
(define (main p0)
  (big-bang p0
    [on-tick x+]
    [on-mouse reset-dot]
    [to-draw scene+dot]))
```

Designing scene+dot

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  ```
  (check-expect (scene+dot (point 10 20))
                (place-image DOT 10 20 MTS))
  (check-expect (scene+dot (point 88 73))
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  ```

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- Testing this is uninteresting, so let's consider if we were asked to define the `x+` function, which takes in a Point and returns a new Point with an x-coordinate that is 3 units further to the right of the old point.

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- To take inventory we project out the x and y fields from our point, as usual:

```
(define (x+ p) (... (point-x p) ... (point-y p) ...))
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  (point (+ (point-x p) 3) (point-y p)))
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- If we had more fields than y, we simply are projecting out the old field as an argument when creating the new struct value.
- This adds a lot of boilerplate code...

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We might want to define a function, `point-set-x` which takes in a point and a value and produces a new point where the x-coordinate is the given value and the y-coordinate is taken from the old point.

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- `point-set-x` is known as a *functional setter*, similar to a more traditional setter in languages like Java.
- However, defining an update operation on a complicated structure can get very complicated, and we can get around this uses *lenses* (we may discuss this later in the course).