Super-fun with First-class Shapes in Quil

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Where are we from?

UMM is a small liberal arts campus of UMN located 3 hours driving from Minneapolis/St.Paul.

What are we working on?

Specific goal: developing Clojure-based introductory CS course (*ClojurEd project*).
General goal: making Clojure more accessible to beginners and those with no Java background.
What does this include?

1. Beginner-friendly error messages.
2. Libraries and tools that allow beginners to explore functional approaches, recursion, and abstraction.
3. Integration into a beginner-friendly IDE.

What are we working on?

Developing Clojure-based introductory CS course (*ClojurEd project*).
General goal: making Clojure more accessible to beginners and those with no Java background.
What does this include?

1. Beginner-friendly error messages.
2. **Libraries and tools that allow beginners to explore functional approaches, recursion, and abstraction: graphical library.**
3. Integration into a beginner-friendly IDE.

Summer project 2015.

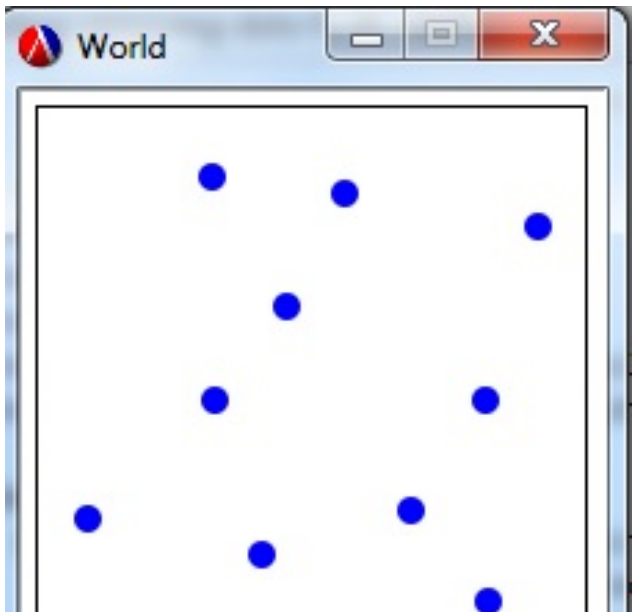
Beginner-friendly graphical library

Inspiration: Racket "universe" package http://racket-lang.org/

- Separation of Model, View, Control (MVC)
- Functional implementation of MVC: world state, functions:
  old world state $\rightarrow$ new world state
  world state $\rightarrow$ image
- First-class shapes (circles, rectangles, user-added jpegs, etc) not attached to any position
- Functions to combine simpler shapes into complex shapes: `above`, `beside`, `overlay`, `scale`...

Beginner-friendly graphical library: MVC

```
(define (main duration)
  (big-bang '() ; starts with an empty list of positions.
   [to-draw display-dots] ;draw dots on canvas
   [on-tick do-nothing 1 duration] ;dots don't move w/time
   [on-mouse add-or-remove-dot])) ;click handling
```



Beginner-friendly graphical library: first-class shapes

```
(define dot (circle 10 "solid" "blue"))

;; display-dots: list of positions  -> image
(define (display-dots lop)
  (cond [(empty? lop) blank-scene]
        [else (place-image dot
                           (posn-x (first lop))
                           (posn-y (first lop))
                           (display-dots (rest lop)))]))

;; add-or-remove-dot: list of positions,
;; coordinates of click -> list of positions
.........
```

Odds and ends (not an actual slide)

Elena: Don't forget:

1. Mention Racket influence
2. Mention the author of Quil fun mode
3. Mention Tom Hall EuroClojure 2014

Shapes as First Class Objects

```
Thomas:  like racket.  Wanted to have shape object.
collage style.
```

- Racket-style implementation of shapes
- Shapes are treated as objects, modified through functions
- Shapes hold their specifications for drawing
- Easy to redraw wherever needed
- Easier to understand conceptually for students

Simple Shapes

Thomas: create shape template, then reuse when needed. Quil does it this way (ex)

- Quil shapes live in the draw function
- Quil shapes are functions to draw the shape

```
(defn draw-state [state]
  (q/background 100)
  (q/fill 0 255 0)
  (q/rect 300 300 100 200))
```

Our Shapes

Thomas: We do it this way (ex). Uses draw function.

- Our shapes are defined once and reused when needed
- Our shapes are drawn through the draw-shape (or ds) function

```
(def green-rectangle
  (create-rect 100 200 :green))

(defn draw-state [state]
  (q/background 100)
  (ds green-rectangle 300 300))
```

Creating a Collage

Thomas: We do it this way (ex). Uses draw function.

- Functional Quil uses paintbrush approach
- Our firstclass-shapes use collage approach

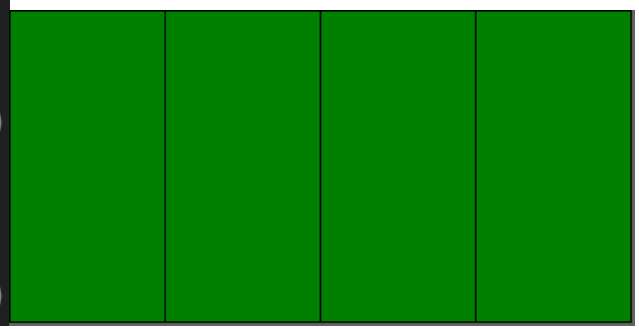
Thomas: Talk about mvc differences here, get Elena to word it

Complex Shapes

Thomas: creating complex shapes. deconstructable.

- Complex shapes are a collection of simple shapes
- Each simple shape holds their individual offsets
- Methods are used to create complex shapes from simple ones

```
(def green-rects
  (beside green-rectangle
          green-rectangle
          green-rectangle
          green-rectangle))

(defn draw-state [state]
  (q/background 100)
  (ds green-rects 300 300))
```

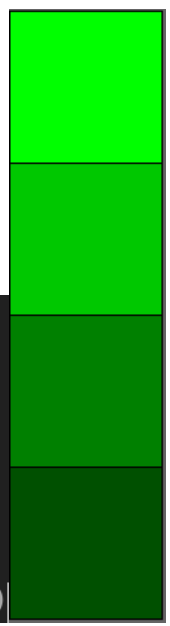


Above and Beside

Thomas: show above and beside (ex)

- Complex shapes are constructed through calling above or beside
- Can use reduce and map

```
(def green-scale-rects
  (above lime-green-rectangle
         light-green-rectangle
         green-rectangle
         dark-green-rectangle))

(defn draw-state [state]
  (q/background 100)
  (ds green-scale-rects 500 500))
```

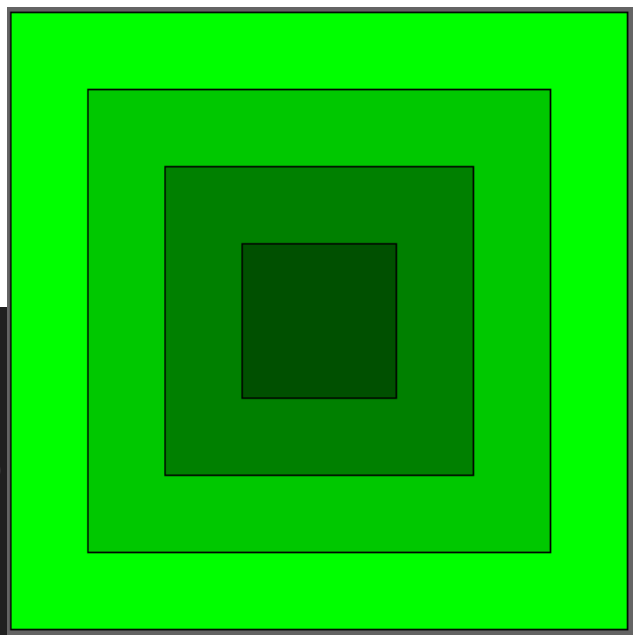


Overlay

Ryan: show overlay

- Complex shapes are also constructed through overlay

```
(def green-hole
  (overlay dark-green-rectangle
           green-rectangle
           light-green-rectangle
           lime-green-rectangle))

(defn draw-state [state]
  (q/background 100)
  (ds green-hole 500 500))
```



Align

Ryan: beside align overlay align etc. (ex)

- An align version of overlay, above, and beside exist

```
(def green-lean-right
  (above-align :right
               dark-green-rectangle
               green-rectangle
               light-green-rectangle
               lime-green-rectangle))

(defn draw-state [state]
  (q/background 255)
  (ds green-lean-right 500 500))
```

```
(def green-hill
  (beside-align :bottom
                dark-green-rectangle
                green-rectangle
                light-green-rectangle
                lime-green-rectangle))

(defn draw-state [state]
  (q/background 255)
  (ds green-hill 500 500))
```

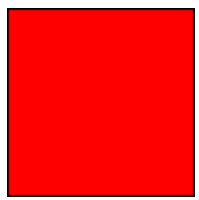
```
(def green-align-bottom-right
  (overlay-align :bottom :right
                 dark-green-rectangle
                 green-rectangle
                 light-green-rectangle
                 lime-green-rectangle))

(defn draw-state [state]
  (q/background 255)
  (ds green-align-bottom-right 500 500))
```

Rotation and Scaling

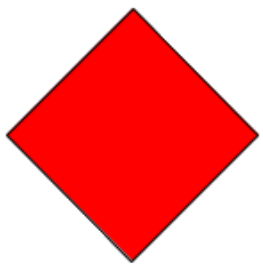
- You can modify the size and orientation of the shape

```
(rotate-shape red-square 45)
```

```
(scale-shape red-square 2 2)
```



```
(rotate-shape (scale-shape red-square 2 2) 45)
```



Images

Thomas: images treated like shapes. Rotate, applying most of the functions.

- images can be rotated and scaled similar to shapes

```
(def cool-picture
  (create-picture "/src/images/elena.png"))

(scale-shape cool-picture 2 2)

(defn draw-state [state]
  (q/background 255)
  (ds cool-picture 500 500))
```

Thomas: Put Beach example here

Simple Shape Structure

Ryan: Explain how the shape structure is set up.

- As a data structure, simple shapes are hash's
- Shapes hold a variety of information within them

```
{:w w
 :h h
 :tw w
 :th h
 :dx 0
 :dy 0
 :angle 0
 :ds (fn [x y pict wid hei cs angle]
       (if (> (count colors) 0)
         (apply f-fill colors)
         (no-fill))
       (with-translation [x y]
         (with-rotation [(/ (* PI angle) 180)] (f-rect 0 0 wid hei)))
       (no-fill))}
```

Complex Shape Structure

`Ryan: Explain the complex shape structure`

- Complex shapes are vectors of shapes
- Each shape knows its position from the core of the shape
- This allows for a 'deconstructable' complex shape

`Thomas: explode example here`

Draw-Shape Structure

`Ryan: Explain how the draw-shape function works.`

- Draw-shape calls the internal Quil draw function within the shape object
- Draw-shape also works on image objects

```
(rect-mode :center)
(image-mode :center)
(if (not (vector? shape))
  ((:ds shape) x y (:rp shape) (:w shape) (:h shape) (current-stroke) (:angle shape))
  (doall (map #((:ds %) (+ x (:dx %)) (+ y (:dy %)) (:rp %) (:w %) (:h %) (current-stroke) (:angle %)) shape)))
```

Future Work

- Fill out more functionality
  - Rotate more complex shapes
  - Pixel-detail Overlay and Overlay-Align
  - More seamless integration with Quil fun-mode
- Open Source the project `Elena: Done?`
- Integrate a Clojure sound library

Acknowledgments

`Elena: Need proper acknowledgments and logos; also probably thank Cognitect and other conj sponsors for providing an opportunity to talk` Our research was sponsored by:

- HHMI
- LSAMP

Thank you!
Any questions?