

Super-fun with First-class Shapes in Quil

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Table of contents

- 1 Overview
 - Who we are and why we are here
 - Wish-list for beginner-friendly graphical library
- 2 Clojure first-class shapes
 - Ideas and examples
 - Implementation
- 3 Future work

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 (*ClojureEd 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.

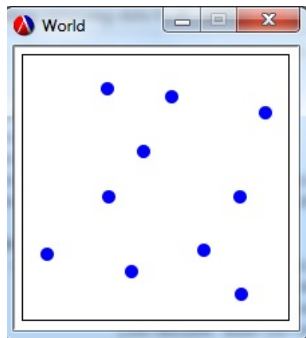
Beginner-friendly graphical library

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
.....
```


World States in Quil

- Using Nikita Beloglazov's Quil fun-mode (functional MVC)
- fun-mode + first class objects = super-fun!
- State as a HashMap

```
(defn setup []  
  (q/frame-rate 60)  
  (q/color-mode :rgb)  
  
  { :screen 0  
    :speed 1  
    :level 1  
    :box-1-points 0  
    :box-2-points 0  
    :box-1-pos { :x 0 :y (- (q/height) 50) }  
    :box-2-pos { :x (- (q/width) 50) :y (- (q/height) 50) }  
    :rocks []  
    :hit-player 0 } )
```

World States in Quil

- Elements of the state modified through functions

```
(defn update-state [state]
  "Takes in the current state and returns the updated state.
  Put functions that change your world state here"

  {:screen 1
   :speed (update-speed state)
   :level (update-level state)
   :box-1-points (update-box-1-points state)
   :box-2-points (update-box-2-points state)
   :box-1-pos (:box-1-pos state)
   :box-2-pos (:box-2-pos state)
   :rocks (update-rocks state)
   :hit-player (hit-player state)})
```

```
(defn update-rocks [state]
  (move-rocks
   (if (spawn-rocks? state)
       (assoc state :rocks (new-rock state))
       state)))

(defn update-speed [state]
  (+ 1 (* 0.1 (quot (max (:box-1-points state)
                          (:box-2-points state)) 50)))))
```

Shapes as First Class Objects

- 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

Creating a Collage

- Functional Quil uses paintbrush approach



- Our firstclass-shapes use collage approach



Simple Shapes

- 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

- Our shapes are defined once in setup 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))
```

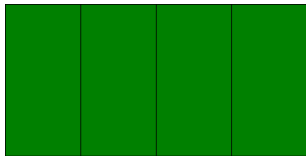


Complex Shapes

- 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

- 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))
```

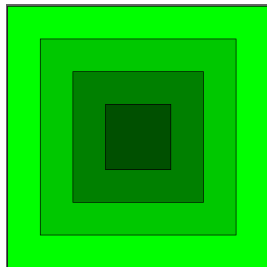


Overlay

- 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

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

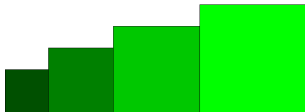
```
(def green-lean-right
  (above-align :right
    dark-green-rectangle
    green-rectangle
    light-green-rectangle
    lime-green-rectangle))

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



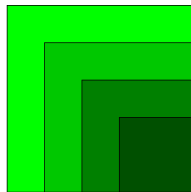
```
(def green-hill
  (beside-align :bottom
    dark-green-rectangle
    green-rectangle
    light-green-rectangle
    lime-green-rectangle))

(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))
```



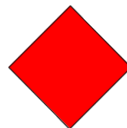
Rotation and Scaling

- You can modify the size and orientation of the shape

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

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

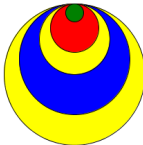
```
(rotate-shape (scale-shape red-square 2 2) 45)
```



Code Comparison

- Strong conceptual differences in code structure

```
(defn draw-state [state]
  (q/background 255)
  (q/fill 255 255 0)
  (q/ellipse 500 500 204 204)
  (q/fill 0 0 255)
  (q/ellipse 500 482 160 160)
  (q/fill 255 255 0)
  (q/ellipse 500 453 102 102)
  (q/fill 255 0 0)
  (q/ellipse 500 437 70 70)
  (q/fill 0 128 0)
  (q/ellipse 500 415 26 26)
  (q/no-fill))
```



```
(defn setup []
  (def green-ring (create-ellipse 26 26 :green))
  (def red-ring (create-ellipse 70 70 :red))
  (def yellow-ring (create-ellipse 102 102 :yellow))
  (def blue-ring (create-ellipse 160 160 :blue))

  (def color-ring
    (overlay-align :top :center
      green-ring
      red-ring
      yellow-ring
      blue-ring
      (scale-shape yellow-ring 2 2)))

  (defn draw-state [state]
    (q/background 255)
    (ds color-ring 500 500))
```

Images

- images can be rotated and scaled similar to shapes



```
(def cool-picture  
  (create-picture "src/images/kappa.png"))  
  
(scale-shape cool-picture 2 2)  
  
(defn draw-state [state]  
  (q/background 255)  
  (ds cool-picture 500 500))
```



Simple Shape Structure

- As a data structure, simple shapes are hashes
- 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

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

Draw-Shape Structure

- 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

- Make it easy to get the color information from shapes (currently color is hard-wired in drawing function).
- Add more functionality
 - Rotate complex shapes
 - Pixel-detail Overlay and Overlay-Align
 - Add support for text, textareas, etc.
 - More seamless integration with Quil fun-mode
- Add examples to the git repo.
- Wish-list: Integrate a Clojure sound library

Where to find it

- Clojars Page <https://clojars.org/org.clojars.quil-firstclass-shapes/firstclasssshapes>
- Github Page
<https://github.com/Clojure-Intro-Course/quil-firstclass-shapes>



Similar Work

Similar (completely independent) work: first-class shapes by Tom Hall, EuroClojure 2014, based on geomlab library.
Used for educational purposes (just like ours).

Acknowledgments

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Clojure/conj sponsors and Cognitect!

Questions?

```
(defn setup []
  (q/frame-rate 60)
  (q/color-mode :rgb)
  (def big-arc (create-arc 200 200 (- (/ q/PI -2) 0.9) (/ q/PI 2) 50))
  (def little-circle (create-ellipse 80 80 255))
  (def small-rect (create-rect 50 50 50))
  (def white-space (create-rect 50 25 255))
  (def big-rect (create-rect 50 60 50))
  (def q-mark (above (overlay-align :bottom :center
                                   big-rect
                                   (overlay
                                    little-circle
                                    big-arc))
                    big-rect
                    white-space
                    small-rect))

  {})

(defn update-state [state] {})

(defn draw-state [state]
  (q/background 255)
  (q/no-stroke)
  (ds q-mark 500 500))
```