Developing a Graphical Library for a Clojure-based Introductory CS Course

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Outline

1. Introduction to the project
2. Goals and setup for an introductory course
3. Developing a Clojure graphical library
4. Our graphical library
5. Conclusions and future work
The Project

- Contributing to ClojureEd on adapting to Clojure for an introductory course
- Objective is to develop a graphical library for Clojure
- We hope this graphical library can be useful for the introductory course
- Work in progress
Introduction to Clojure

- Developed by Rich Hickey in 2007
- Functional programming language in the Lisp family
- Runs on the JVM
- Immutable data structures and first class functions
- Data structures such as lists, vectors, hashmaps
Students are not expected to have prior programming knowledge

The course currently utilizes Racket to help teach key concepts

Racket is a functional language similar to Clojure

Functional languages help students learn concepts like recursion and higher order functions

The course makes use of Racket’s graphical library
Racket graphical library game example
Benefits and limitations of Clojure

Benefits:
- Gaining traction in the industry
- Offers better parallel processing
- Integration with Java

Limitations:
- Unintuitive error messages
- Lacks a graphical library
- Lack of an IDE suitable for beginner CS students
Clojure Syntax

- Prefix notation
  \((\text{name of function} \ \text{argument 1} \ \text{argument 2} \ \ldots)\)
  \((+ 2 2)\)
  \(\rightarrow 4\)

- Defn
  \((\text{defn square}[x] (* x x))\)

- Anonymous functions
  \((fn [x] (* x x))\)

- First class functions
  \((\text{map square} [1 2 3 4])\)
  \(\rightarrow [1 4 9 16]\)

- Hashmaps
  \(){:a 1 :b 2 :c 3\}
Introduction to functional approaches

- Stylistic choice for programming
- Immutable data types
- Less dependency on order
- First class functions
Requirements for a graphical library

- Reinforce functional approaches from Clojure
- Accessible to introductory students
- Implement Model-view-controller (MVC) similar to Racket’s graphical library
  - Checkers example
Overview of Quil

- Open source graphical library for Clojure
- Provides functionality suitable for introductory-level projects
- Built on top of Java Swing
- Continuously being developed
Developing programs with Quil

- Defsketch
- Works using frames and frame rate
- Draws in layers
- Supports input from keyboard and mouse

(defsketch example
 :title "Example"
 :setup setup-example
 :draw draw-example
 :size [400 300])
Example of a Quil program

Example Code:

```clojure
(defn setup-example []
  (frame-rate 1)
  (background 200))

(defn draw-example []
  (ellipse
   (random (width))
   (random (height))
   100 100))
```

Our Image
Issues with Quil

- Imperative approaches
  - Often requires direct manipulation of state
  - Dependencies on order
  - Inconsistent with introductory course goals

- Underdocumented API
Development of the graphical library

- Abstracted over Quil’s functions
  - Defsketch
  - Shapes
  - Colors
  - Text
- Handling state in a functional approach
  - Models MVC
How our graphical library works

- Separates handling of state
  - MVC
  - update
  - display
An example made using our graphical library

(def states
  {:snake [450 450 450 470 450 490 450 510],
   :snake-head [450 450],
   :food [150 150],
   :snake-direction "north", :score 0})

(def updates
  {:setup-drawing setup
   :snake update-snake
   :food update-food})

(def display-order
  [draw-canvas draw-food draw-snake])
Snake Example
Differences in handling state in Racket

Racket gives entire state to user

- Entire State
  - Stored Data as State Handled by Racket
  - State Broken Down by User and Updated
    - Snake
    - Food
    - Score
  - State Reassembled by User and Returned
    - Entire State
Our system breaks state down for the user

- Stored Data Handled by Graphical Library
  - Data for Snake
  - Data for Food
  - Data for Score

- User Provided Function to Update State
  - Function to Update Snake
  - Function to Update Food
  - Function to Update Score

- Updated State is Stored by Graphical Library
  - Data for Snake
  - Data for Food
  - Data for Score
Conclusions

- Good start for abstracting over Quil’s functions
- More functional approach
- Graphical library shows promise
Future Work

- This is still work in progress
- Create our own macro to abstract over defsketch
- Abstract over more functions in Quil
- Develop an API with examples for students
Selected references:

- Quil https://github.com/quil/quil
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