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
UMM’s introductory CS course

- 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**
  
  ```clojure
  (<name of function> <argument 1> <argument 2> ...)
  (+ 2 2)
  -> 4
  
  **Defn**
  
  ```clojure
  (defn square[x] (* x x))
  ```

- **Anonymous functions**
  
  ```clojure
  (fn [x] (* x x))
  ```

- **First class functions**
  
  ```clojure
  (map square [1 2 3 4])
  -> [1 4 9 16]
  ```

- **Hashmaps**
  
  ```clojure
  {: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:

(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

- Stored Data as State Handled by Racket
- Entire State
- State Broken Down by User and Updated
  - Snake
  - Food
  - Score
- State Reassembled by User and Returned
  - Entire State
Diagram of handling state in our graphical library

Our system breaks state down for the user

- Stored Data Handled by Graphical Library: Data for Snake
- User Provided Function to Update State: Function to Update Snake
- Updated State is Stored by Graphical Library: Data for Snake

- Data for Food
- Function to Update Food
- Data for Food

- Data for Score
- Function to Update Score
- 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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