Exercise 2

10/6/2023

100/100 Points

Attempt 1

Review Feedback
10/6/2023

Attempt 1 Score:
100/100

View feedback

Unlimited Attempts Allowed
10/8/2023

Details

In this assignment, you will experiment with generating images using the iterated image functions. Throughout the assignment, you will:

- Practice writing functions withnames (e.g. *named functions*) and without names (e.g. *anonymous functions*)
- Practice the process of *abstraction* by relying on your work from Exercise 1
- Practice translating mathematical expressions into code

Introduction

One of the core principles in computer science is **abstraction**–masking the "details" of how something works and instead just assuming that it works the way someone says it does. We've actually done quite a bit of this already; now we're just giving it a name. For example, we don't know *exactly* how `circle` produces a circle. We just know that if we give it the inputs it asks for, that it does *something* that makes a circle of that type appear.

> Why is abstraction important? Well here's a farfetched example…
>
> > Imagine you're in charge of a company that designs air planes. How do you think your boss would react if you designed a plane that could fly from O'Hare to JFK in New York one single time before having to be replaced? Your passengers get on the plane, fly to New York, and then that plane is toast–a completely one-off machine. Now surely you see a problem here. No one is going to want to buy your plane if it can only be used once. So you decide to redesign it so it's reusuable…but now it's only usable between O'Hare and JFK. It can't fly to any other airports… Still no one wants to buy your plane. Is the market rigged? Or is the product you've designed too limited? You go back and redo your design so that the plane is capabable of lots reuse **and** it can be flown to any destination less than 2000 miles away. Now your planes are flying off the shelves. This example, though ridiculous, is a demonstration of the process of abstraction. Your first design worked, but only a single time. Then you refined it so that it could be re-used. Then you refined it even further so that it could be re-used *across a variety of contexts*. When we write programs **we are (usually) not trying to design software that can only be used once for one specific thing**. Instead we are aiming to build **powerful** and **flexible** computational machines that can handle a variety of inputs. That way, we can start to *think with our machine in mind* (i.e. we know how this part of the task can be solved because our program can solve it) and move on to other and/or larger tasks.

This assignment will give you practice with the process of abstracting programs. You'll begin by writing very basic code, then gradually building up layers of abstraction to:

- mask complexity
- minimize repetition
- and write *reusable* and *generalizable* patterns.

We've also provided a **library file** called `iterated-images.rkt`. This file holds definitions of several functions you'll need to use during this assignment. We call it a library file, because using it is just like checking a reference book from a library. You don't have to look at the code in this file, but you do need to make sure that both files (`exercise_2.rkt` and `iterated-images.rkt`) are in the same folder on your computer.

Exercise 2 Starter Files (https://bain-cs111.github.io/course-files/exercises/exercise_2_template.zip)

> *Note:* Like the last assignment, we've tried hard to provide instructions for those who have a hard time seeing colors. Please let us know if any of the questions cause you issues.

Getting Started

Start by opening the `exercise_2.rkt` file. At the top of the definitions file you'll see two `require` statements. Each asks Dr Racket to **import** or load some external libraries (just like checking out a book from a real library):

```
(require 2htdp/image)
(require "./iterated-images.rkt")
```

> **Reminder**
> These files are provided in the `zip` file. You have to extract that zip file before editing. On a Mac double click on the `zip` file to expand. On **Windows** (https://support.microsoft.com/en-us/windows/zip-and-unzip-files-8d28fa72-f2f9-712f-67df-f80cf89fd4e5#:~:text=To%20unzip%20a%20single%20file,and%20then%20follow%20the%20instructions.) and **Chrome** (https://www.lifewire.com/how-to-zip-unzip-files-on-chromebook-4799535) computers, for some reason they allow you to open these files in what's called `read-only` mode (in the bottom right hand corner of DrRacket will be a yellow box that says `Read Only`). Don't do that! Instead, first extract all the files into your `cs111` folder and THEN start working.

> *Pro-tip 1*: do not MOVE an already open file. If you open a file in DrRacket (or any app) and THEN move the file in your operating system, the app doesn't know the file was moved. It will assume you want to save it in the older folder.

The first line should look familiar, it loads the `image` library from our auxillary textbook "**H**ow **t**o **D**esign **P**rograms (**2**E)." The second line asks DrRacket to load in the library we provided in your homework download. The `./` says "please look in the same folder as the file we're currently editing" while the second part is the name of the file to load. We've written the `require` commands for you for this assignment but you will need to understand how they're importing code for future assignments.

When you run the file for the first time, a window will pop up saying that all of your tests failed. Don't panic. You haven't programmed anything yet! If you look through the test window, you'll see that a number of different named tests failed. For now, you can close the test report window and carry on but this window gives you important information as to *why* each test failed.

> **If you get an error message about not being able to load** `iterated-images.rkt` First, check to see that `iterated-images.rkt` and your `exercise_2.rkt` file are in the same folder on your computer. Second, make sure that the file you have open is actually the one you intended to open (close DrRacket then re-open your exercise 1 file.) Third, if you're on a Mac, you may have gotten a popup asking for permission to access a folder on your computer. If you said no… then DrRacket can't read your file. You can fix it by going to System Settings (or System Preferences), selecting the Privacy & Security tab, looking for the `Files and Folders` option, and checking all of the options under `DrRacket`.

The starter code contains a series of **unit tests**: pieces of the program that test your code against sets of expected results. When you run your code by clicking the "Run" button or Ctrl + R (Cmd + R on Mac), DrRacket will run the tests and generate a report of what tests succeeded and failed. If any tests failed, they'll pop up in a window. Read the windov to see what happened, **do not just close it!** To troubleshoot your output, you'll need to compare your image results to the expected results.

To experiment with this assignment, you have two options.

Option 1

You can work directly in the Definitions Window. Whenever you want to test what you've written, just run the file, which will generate a testing report in a popup window.

> **Tip**: If you want to work on one part of the homework at a time, select any tests you don't want to run, and click Racket > Comment Out With semicolons (`;`). Racket ignores anything that comes after a semicolon when it runs your program, so you won't get notified if those tests fail. When you're ready to tackle those parts of the assignment, highlight the commented-out region and click Racket > Uncomment to restore the code. **Don't forget to uncomment and run all your tests before you submit**.

Option 2

Alternatively, you can work in the the Read/Evaluate/Print Loop (from now on, we'll call it the **REPL**), aka the Interactions Window. The REPL is nice for fiddling with your code without having to continually re-run the file, and you can hit Ctrl+Up to repeat your previous command if you want to make adjustments. Keep doing this until you get the result you're looking for. Once you're satisfied with your results, paste your code into the Definitions Window in the appropriate place.

If there's an error in your code in the Definitions Window then nothing from the Definitions Window will work in the Interactions Window until you fix the error and hit the Run button again. For example all of the `iterated-*` functions from our `iterated-images` library won't be there! So it's usually best to write one function at a time and test each one as your write it rather than writing all of it at once and then start trying to fix it.

> **Tip**: It's almost NEVER a good idea to tackle "all" of something at once when it comes to programming. Instead, make small subgoals for yourself and attack each subgoal first. For example, remember in Exercise 0 when we made a circle overlaid on another circle? Sure, you could tackle that all at once. But you could also create small subgoals like 1. create a small red circle; 2. create a large blue circle; 3. overlay red circle on top of blue circle. That way, if you run into an issue in any one particular sub goal, you know it's due to something in that specific section of your program.

Part 1: Iterative Expressions

In this section, we'll use three iterator functions: `iterated-overlay`, `iterated-beside`, and `iterated-below`. We covered these functions in class, but if you need a refresher on how iterators work, look it up in the Help Desk by right-clicking on `iterated-images` in the require statement at the top of the file. Or checkout Monday's lecture slides and recording.

For this part of the homework, we've provided placeholders or **stubs** for your code. Just look for the line that says something like:

```
(define question-1 "fill this in")
```

and replace the `string` "fill this in" with your answer. This will allow the tests to find your code.

Question 1: A Simple Bullseye

Use `overlay` to generate a `"purple"` bullseye consisting of five concentric circles. The smallest circle should have a radius of 10, and the largest should have a radius of 50. The circles should be an even distance apart.

Part B

Now use iterated-overlay to generate an image identical to your result from Part (a). Remember that iterators begin counting at 0, not 1, which means you may need to adjust your math slightly to avoid creating a circle with zero radius. If you're getting something like the figure below, that's probably what's happening to you:

The tiny dot in the middle of this circle is a circle of radius 0. We don't want that

---

Question 2: A Row of Rectangles

Use `iterated-beside` to generate a row of eight `"purple"` rectangles. The heights of all the rectangles should be 50. The widths should range from 10 to 80.

Question 3: A Simple Flower

Use `iterated-overlay` to generate a flower. You will need to use five ellipses defined as follows:

```
(ellipse 100 25 "solid" "blue")
```

> Hint: look up the help desk documentation for the `rotate` function. Remember that there are 360 degrees in a circle, and you're dividing these by five ellipses.

Representing colors with RGB(A)

Like we explored last week, colors can also be represented in a format called **RGB**. The exact details of **how RGB works (https://en.wikipedia.org/wiki/RGB_color_model)** are beyond the scope of this course, but you can think of a color as a list of three values between 0 and 255, each member of which corresponds to the amount of red, green, and blue light it contains.

Here are some example RGB values:

- `"blue"` is (0 0 255). Notice that this color has zero red light, zero green light, and full blue light.
- `"black"` is (0 0 0). This color has zero red, green, and blue light.
- `"white"` is (255 255 255). This color has the maximum amount of light of red, green, and blue light.

In Racket, we denote RGB colors with the color function:

```
;; color : number number number -> color
(color red-light  green-light  blue-light)
```

where each of `red-light`, etc. is a number between 0 and 255. So we can replace `"blue"` with `(color 0 0 255)` as demonstrated by the following REPL session:

```
> (circle 25 "solid" "blue")
```

```
> (circle 25 "solid" (color 0 0 255))
```

Returning to the flower you wrote in the previous question, change the color `"blue"` in the ellipse definition to `(color 0 0`

Since we can represent colors numerically, we can also use simple math to *change* colors. For example, increasing a color's red-light value by 150 will make it 150 units more red:

```
> (square 50 "solid"
         (color 0 0 255))
```

```
> (square 50 "solid"
         (color 150 0 255))
```

We can also control the **opacity** of a color by adding a fourth number, known as the **alpha value**. The alpha value is a number between 0 (completely transparent) and 255 (completely opaque). Once you add an alpha value to an RGB color, you're using the **RGBA format** (the A stands for "alpha").

```
> (square 50 "solid"
         (color 0 0 255 0))

> (square 50 "solid"
         (color 0 0 255 128))
```

```
> (square 50 "solid"
         (color 0 0 255 255))
```

Note that the Racket `color` function takes either three or four numbers. If you only supply three, Racket assumes you want a fully opaque color, so the alpha value will **default** to 255.

Question 4: A Colorful flower

Use `iterated-overlay` to generate a colorful flower. This flower should be identical to the previous one, except the ellipses should be colored accordingly:

- The first ellipse produced by `iterated-overlay` should be perfectly green, i.e. `(color 0 255 0)`.
- Each successive ellipse should be 25 units more blue and 25 units less green than the previous ellipse.

> **Hint**: You must use `iterated-overlay` for this question. You can start by copying your solution from Question 3, then modifying the part of the code responsible for the color of the ellipse on each iteration.

The `interpolate-colors` function

Manually calculating RGB shade differences can be, well…annoying. Since the disciplinary purpose of computer science is to help programmers be productive once to enable future laziness, we now introduce a new function called `interpolate colors`, which provides a much easier way to blend two colors:

```
;; interpolate-colors : color color number -> color
(interpolate-colors color-1 color-2 fraction)
```

where the `fraction` is a number between 0 and 1, which denotes how much to blend the two colors. Using a `fraction` of 0 just returns *color-1*, and a `fraction` of 1 just returns *color-2*.

> **Important Note**: `interpolate-colors` *does not support* `string` *colors.* Instead, it expects color objects which you can create using the `color` or `make-color` functions described above and in the lecture slides.

Just as `iterated-overlay` abstracts away the tedium of calling `overlay` with ten basically identical circles `interpolate`

Question 5: A Fancy Flower

Use `iterated-overlay` and `interpolate-colors` to generate a fancy flower. This flower should be similar to the previous one, except that each ellipse should have an alpha value of 100, meaning that the colors of the different ellipses will blend with the colors below them. Remember that alpha is the fourth argument to the `color` function!

You must use `interpolate-colors` in your implementation, starting with `red` and ending with `green`. Remember that iteration starts at 0, so if you call an iterator `n` times, the final iteration will be `n-1`. You may need to adjust your math to make sure the fifth iteration is completely green.

Since debugging colors is difficult with reduced opacity, we have provided a completely opaque test image for you to use Search for the line

```
;; (define q5-colors )
```

Start by writing your answer to use an alpha value of 255 and see if you can make it look like this image. Once it does, then change it to use an alpha value of 100 and it should look like the real image.

Part 2: Function Abstractions

Now that you're familiar with the abstractions provided by the `iterated` library, we can start abstracting even more. In this section, you will write reusable functions to generate images from some template, but with even more flexibility.

Whenever you write a function, you should start by writing two comments: a **signature** and a **purpose statement**.

- The **signature** defines the *name* of the function, then a colon (`:`), its input arguments in order, an arrow (`->`), and then the type of **return value** (or output). It should almost read as an icebreaker statement for the function: "Hello, my name is doubler and I expect one number and then give you back a number."
- The **purpose statement** is a brief human-readable description of what the function does.

Here's what that looks like in practice:

```
;; doubler : number -> number
;; Takes a number and multiplies it by two
(define doubler
  (lambda (n)
    (* 2 n)))
```

Remember, any line that begins with a semi-colon is a **comment** which means it's just a note to the programmer that the computer ignores.

In this assignment, we've provided you with signatures and purpose statements for the first few functions you need to define. *Whenever signatures or purpose statements are not provided, you are required to write your own.*

Reminder: Functions vs. Expressions

In Part 1, your answers (e.g. `question-1` and so on) were **expressions** formed by calling other functions. They all simplified to images.

In Part 2, your answers will be `functions` formed using `lambda`.

The following table gives examples of the difference between functions and expressions:

Expressions and Functions

x+1	g(x)=x+1
g(3)	h(x)=g(x)
`(circle 50 "solid" a-color)`	`(lambda (a-color) (circle 50 "solid" a-color))`
`(iterated-overlay (lambda (n) (square n "solid" "blue")) 5)`	`(lambda (number-of-iterations) (iterated-overlay (lambda (n) (square n "solid" "blue")) number-of-iterations))`

One way to summarize the difference is that expressions can be *simplified* to a concrete value of some kind, whereas functions have missing information (the arguments) which need to be filled in before we can simplify. When a function is called with that information, we can plug in the missing information and simplify.

Question 6: Paint Palettes

Write a function called `palette` that takes three arguments:

1. A start color,
2. An end color, and
3. A number of squares to generate.

`palette` should return a single `image`, consisting of a row of 50x50 squares. The number of squares to generate is given by `num-squares`, the third function argument.

The leftmost square should have color `color-1`, and the rightmost square should have color `color-2`. The squares in between should evenly interpolate between the two colors. Again, remember that iteration starts at 0 and ends at `n - 1`.

Here's a starter (mmm…now I want a piece of sourdough bread) for your function defintion:

```
;; palette: color color number -> image
;; returns a single image, consisting of a row of 50x50 squares
;; the number of squares to generate is given by num-squares
(define palette
  (lambda (color-1 color-2 num-squares)
    ...))
```

Calling `(palette (color 0 0 0) (color 255 255 255) 2)` should produce a row consisting of two squares, one completely black and one completely white. If you have difficulty solving this problem, look back at all the functions you have used before. You can use as many of them as you want to solve this problem.

Question 7: Paint Grids

Using the `palette` function, you wrote in Question 6, write a function called `palette-grid` which takes four arguments:

1. A start color
2. An end color
3. A row count
4. A column count

`palette-grid` should return an `image`, a grid with `num-rows` rows and `num-cols` columns. Each grid cell should be a 50x50 square.

- Each row should interpolate evenly between the leftmost and rightmost color, like before.
- Each column should interpolate between the topmost color, and black: `(color 0 0 0)`. However, the last column

You must use the `palette` function you wrote in Question 6.

Here's another starter for you:

```
;; palette-grid : color color number, number -> image
;; create a grid of interpolated colors
(define palette-grid
  (lambda (color-1 color-2 num-rows num-cols)
    ...))
```

> **Hint**: experiment with the function `iterated-above`. Its signature is identical to `iterated-beside`.

Question 8: Bullseye Revisited

Recall that in Question 1, you wrote two equivalent expressions to generate a bullseye consisting of 5 rings with an outer radius of 50. Wouldn't it be great if we could generalize this template to create bullseyes with any radius size and number of rings? Of course it would be! Rhetorical questions are so great. Well, the great news is that's exactly what you're going to do next!

Write a function called `bullseye/simple` which takes three arguments:

1. A number of rings
2. A radius
3. A color

`bullseye/simple` should return an image of a bullseye with the specified number of rings. The outermost circle should have the specified radius. The lines of the bullseye should be the given color.

In contrast to previous functions, you must:

1. Write your own signature, purpose statement, and definition for `bullseye/simple` (see Questions 6 & 7 in the starter code for signature and purpose examples), and
2. Convert the two images provided in the `.rkt` file into test cases; that is make your own calls to `check-expect` that compare the value for a call for `bullseye/simple` to the image provided.

We've provided one complete test case to start you off. Specifically, calling

```
(bullseye/simple 5 50 "purple")
```

should produce a bullseye identical to your answer for both parts of Question 1. Compare your code for Questions 1(a), 1(b), and 8, and notice the increasing generalization.

Question 9: Colorful Bullseye

Write a function called `bullseye/color` which takes four arguments:

1. A number of rings
2. A radius
3. An inner color
4. An outer color

`bullseye/color` should return an image of a bullseye with the specified number of rings. The outermost circle should have the specified radius. The innermost ring should have a color given by the third argument, and the outermost ring should have a color given by the fourth argument. The intermediate rings should interpolate evenly between the two colors. While you can't reuse the `bullseye/simple` function here, you should use its implementation for inspiration.

Again, you must write your own function signature, purpose (see Questions 6 & 7 in the starter code for signature and

Double Checking Your Work

Before turning your assignment in, **run the file one last time** to make sure that it runs properly and doesn't generate any exceptions, and all the provided tests pass. Keep in mind that **we will be generating DIFFERENT images using your functions** to see if they work the way the assignment specifies. You will only submit your RKT file, not the `iterated-images.rkt` file – in this class you will NEVER submit anything than your work to Canvas.

> *Pro-tip 1*: do not MOVE an already open file. If you open a file in DrRacket (or any app) and THEN move the file in your operating system, the app doesn't know the file was moved. It will assume you want to save it in the older folder.

> *Pro-tip 2*: do not submit a file that you currently have open. Instead, finish your work then close DrRacket. That way, there's no possible way to submit an older file.

> *Pro-tip 3*: do not have multiple versions of the same file. It just makes it harder for you to keep track of what's what.

> *Pro-tip 4*: worried you didn't submit the right file? It takes seconds to check! Once you've successfuly submitted on Cavnas, just download the file you just submitted by clicking on the link Canvas provides. Then open that file in DrRacket. Is it the right one? If so, you're good to go! If you want to RUN the file inside your downloads folder, keep in mind you would need to copy the `iterated-images.rkt` file into your Downloads folder as well.

Submitting to Canvas

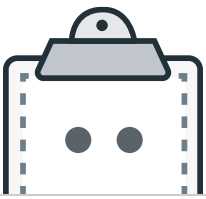
Questions about submitting to Canvas? About DrRacket features? Checkout our FAQ pages:

- **DrRacket Cheat Sheet (https://canvas.northwestern.edu/courses/201068/pages/drracket-cheatsheet)**
- **Checking for Runtime and Syntax Errors (https://canvas.northwestern.edu/courses/201068/pages/checking-for-syntax-or-runtime-errors-in-racket)**
- **Submission and Grading FAQ (https://canvas.northwestern.edu/courses/201068/pages/exercise-submission-+-grading-faq)**
- **Autograder FAQ (https://canvas.northwestern.edu/courses/201068/pages/autograder-and-submission-faq)**

Remember, **close DrRacket before you submit** to ensure that you've saved your latest work. The Automated Type Checker (ConnorBot) will post its results of its type checks and the built-in `check-expect`s every 30 minutes. If you get an unexpected failure, it may be because you submitted the wrong file.

Late Penalty Waiver

Remember, the deadline for submitting this waiver is 24 hours before the DUE AT time on Canvas.



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