UMassAmherst | Manning College of Information & Computer Sciences

Programming Methodology

Lab 2: Type Signatures and More Higher-order Functions

Wednesday February 11, 2025

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Weekly Lab Agenda

- Go over reminders/goals
- Review past material
- Work in groups of 2-3 to solve a few exercises.
    - Please sit with your group from last week.
- Discussion leaders will walk around and answer questions.
- Solutions to exercises will be reviewed as a class.
- Attendance will be taken at the end.

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Reminders

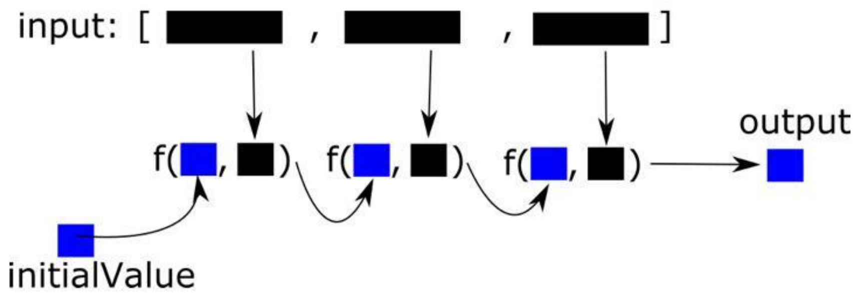
- Homework 2 is due Tonight (2/11) at 11:59pm.
    - Come to office hours for help!
- If you need to miss lab and have a valid reason according to the syllabus (medical, other personal) please fill out the lab excusal form on Canvas before the start time of your lab.
    - Waking up late or the bus being late are NOT valid reasons to miss lab.
- Submit what you have at the end of lab to Gradescope. If you miss many submissions to Gradescope, we may penalize your lab grade.

Today’s Goals

- Practice with more higher-order functions
- Practice writing correct type signatures

Review of Reduce

```
function reduce<T, U>(
    a: T[],
    f: (acc: U, e: T) => U,
    init: U
): U {
    let result = init;
    for (let i = 0; i < a.length; ++i) {
        result = f(result, a[i]);
    }
    return result;
}
```



Reduce is used to combine array elements with the same function.

Example: Find the product of all elements of an array a = [3, 2, 6, 2, 2, 0]

```
a.reduce((prod, e) => prod * e, 1);
```

Exercise 1: Reduce

Write a function **`countBlue`** that takes in an array **`arr: Color[]`** and returns the number of pixels that are "mainly blue".

A color is "mainly blue" if the blue value is at least twice the red value and at least twice the green value. Recall that the color format is **`[R,G,B]`**.

Can you solve the same problem for a 2D array of type **`Color[][]`** ?

Solution 1: Reduce

```
const isBlue = (c: Color) => c[2] >= 2*c[0] && c[2] >= 2*c[1];

function countBlue(r: Color[]): number {
   return r.reduce((acc, c) => isBlue(c) ? acc + 1 : acc, 0);
}

function countBlue2D(m: Color[][]): number {
   return m.reduce((acc, r) => acc + countBlue(r), 0);
}
```

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Review of Type Signatures

We can infer types based on the operations done on values

```
// f(x: number, y: number): number     or  f: (number, number) => number
function f(x, y) {
  return x + (2*y);
  // product with y: y is number, x and result is number
}
```

Sometimes, we have several possibilities

```
// g: (number, number) => number    or    g: (string, string) => string
function g(x, y) { return x + y; }  // + can be string concatenation

// h(a: string): boolean   or   h<T>(a: T[]): boolean
function h(a) { return a.length > 5; } // both strings & arrays have length
```

The array could have any element type. We call T a **type variable.**
This lets us write **generic functions.**

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Exercise 2: More Reduce

Write a function **`atLeastHalf`** that takes in an array **`arr`** and a function **`func`**, which can be applied to an element of **`arr`** to produce a boolean.

The function should return **`true`** if **`func`** returns **`true`** for at least half of the array elements and **`false`** otherwise.

You will need to complete type signature for this function.

Use **`reduce`**.

Bonus: how could you implement this function without **`reduce`**?

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Solution 2: More Reduce

```
function countIf<T>(a: T[], func: (x: T) => boolean): number {
    return a.reduce((count, elem) => {
        return func(elem) ? count + 1 : count;
    }, 0);
}

function atLeastHalf<T>(a: T[], func: (x: T) => boolean): boolean {
    return countIf(a, func) >= a.length / 2;
}
```

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Solution 2 Bonus: Using Filter

```
function countIf<T>(a: T[], func: (x: T) => boolean): number {
    return a.filter(func).length;
}

function atLeastHalf<T>(a: T[], func: (x: T) => boolean): boolean {
    return countIf(a, func) >= a.length / 2;
}
```