# 4 Arrays and Images

1. Make the following array, and display it with the function show on isrb.

```
w=[
[0,1,1,1,1,1],
[0,1,0,0,0,1],
[0,1,0,1,0,1],
[0,1,1,1,0,1],
[0,1,0,0,0,1],
]
```

2. We can draw a color image using the function show. Below is an example of a $2 \times 3 \times 3$ array.

```
d=[[[0,0,0],[0,1,0],[0,0,1]],
[[1,0,0],[1,1,0],[1,0,1]],
[[0,0,0],[0,1,0],[0,0,1]],
[[1,0,0],[1,1,0],[1,0,1]]]
```

   Perform show(d) on isrb. Each entry of d has three values, which represent Red, Green, and Blue, respectively.

3. Using show, draw simple national flags with colored image. For example,

| Green | White | Red |
|---|---|---|

Table 1: Italy

| Green | White | Orange |
|---|---|---|

Table 2: Ireland

| Red |
|---|
| White |
| Blue |

Table 3: Italy

   Note that we can use the following table

| Color | Green | White | Red | Orange | Blue |
|---|---|---|---|---|---|
| Red | 0 | 1 | 1 | 1 | 0 |
| Green | 0.6 | 1 | 0 | 0.4 | 0.2 |
| Blue | 0 | 1 | 0 | 0 | 0.6 |

4. Solve the following.(You can refer to the sources on ITC-LMS)

   (a) Define a function make1d(n) that makes a 1-dimensional array with size n each of whose entry is 0.

   (b) Define a function make2d(h,w) that makes a 2-dimensional array with h rows and w columns each of whose entry is 0.

(c) Define a function make2d_color(h,w) that makes an h×w×3 array each of whose entry is 0.

5. Define a function gradation(n) in gradation.rb that makes a one-dimensional array with size n whose ith value is equal to $i/n$.

   Hint: Change some lines in make1d so that we can assign a value using i in each iteration.

6. Let $\mathrm{i} = \sqrt{-1}$. We represent a complex number $x + y\mathrm{i}$ as an array of length two. For example, a=[1,2] means $1 + 2\mathrm{i}$.

   (a) Define a function add(a,b) that returns the sum of two complex numbers $a$ and $b$. The returned value is also an array of length two.

   (b) Define a function mult(a,b) that returns the product of two complex numbers $a$ and $b$.

   (c) Define a function abs(a) that returns the absolute value of a complex number $a$.

   (d) Define a function div(a) that returns the result when we divide $a$ by $b$.

7. Let $a$ be a one-dimensional array with size $n$. We regard it as a vector of order $n$.

   (a) Define a function vec_mult(a,b) that returns the (inner) product $a^\top b$ of $a$ and $b$.

   (b) Define a function vec_norm(a) that returns the norm of $a$, that is, $\sqrt{a^\top a}$.

8. Let a and b be two two-dimensional arrays with size $n \times n$. We consider a and b as matrices. You can use the functions in the last problem.

   (a) Define a function mat_add(a,b) that returns the sum of a and b.

   (b) Define a function mat_mult(a,b) that returns the product of a and b.

9. (a) Make a function length3(a,x) that computes the number of elements around the xth element in a, that is,

$$\mathsf{length3}(\mathsf{a},\mathsf{x}) = \begin{cases} 3 & \text{if } 0 < x < \ell - 1 \\ 1 & \text{if } x = 0 \text{ and } \ell = 1 \\ 2 & \text{if } \ell > 1 \text{ and } (x = 0 \text{ or } \ell - 1) \\ 0 & \text{otherwise} \end{cases}$$

   where $\ell$ is the length of the array a. Note that the indices of a start from 0 to $\ell - 1$.

   (b) Make a function array_average3(a,x) that computes the average of the elements around the xth element in a. For example, array_average3(a,2) is equal to (a[1]+a[2]+a[3])/3 if the length of a is at least 4, and array_average3(a,0) is equal to (a[0]+a[1])/2.

(c) Make image_average9(image,x,y) that computes the average of the elements around the xth element in a 2-dimensional array image. For example, image_average3(a,0,0) is equal to (a[0][0]+a[0][1]+a[1][0]+a[1][1])/4, and if x,y are not on the "boundaries", the value is the average of the 9 elements around a[x][y] with a[x][y] itself.

10. We can make an image by modifying another image. For example, we can make a gray image(array) s brighter by replacing each entry $b$ with $(b+1)/2$. Thus, it is realized by making a new array img with the same size as s, and defining img[y][x]=(s[y][x]+1)*0.5 as the brightness of the (x,y) coordinate.

    Define the following functions and apply them to your image.

    (a) a function brighter(img) that makes a given image img brighter.

    (b) a function blend(img1, img2) that blends two images img1 and img2, where "blend" means to take the average of the two values of img1 and img2 at the same coordinates.

    (c) a function blur(img) that "average" the image img using the function image_average9 in the previous problem.

11. Compare the outputs of the following two programs. (See also Appendix in lecture slides)

```
a = Array.new(2)
b = Array.new(2)
for i in 0..1
    b[i] = a
    for j in 0..1
        b[i][j] = i
    end
end
b
```

```
b = Array.new(2)
for i in 0..1
   b[i] = Array.new(2)
   for j in 0..1
        b[i][j] = i
    end
end
b
```

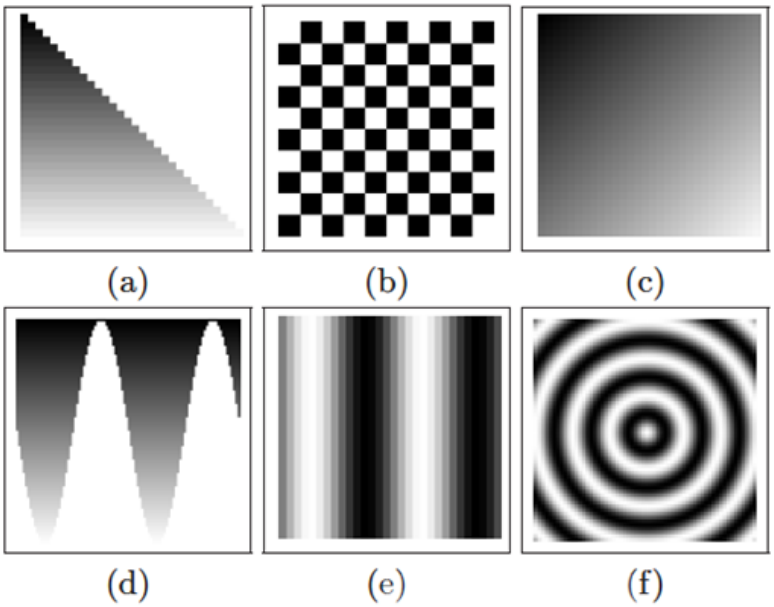
12. Compare the outputs of the following two functions. (See also Appendix in lecture slides)

```
def inc1(b)
  n = b.length()

  for i in 0..n-1
        b[i] = b[i]+1
  end
  b
end
```

```
def plus1(b)
   n = b.length()
   c = Array.new(n)
   for i in 0..n-1
      c[i] = b[i]+1
   end
   c
end
```

13. Make functions that generate the following images.


(a)
(b)
(c)
(d)
(e)
(f)