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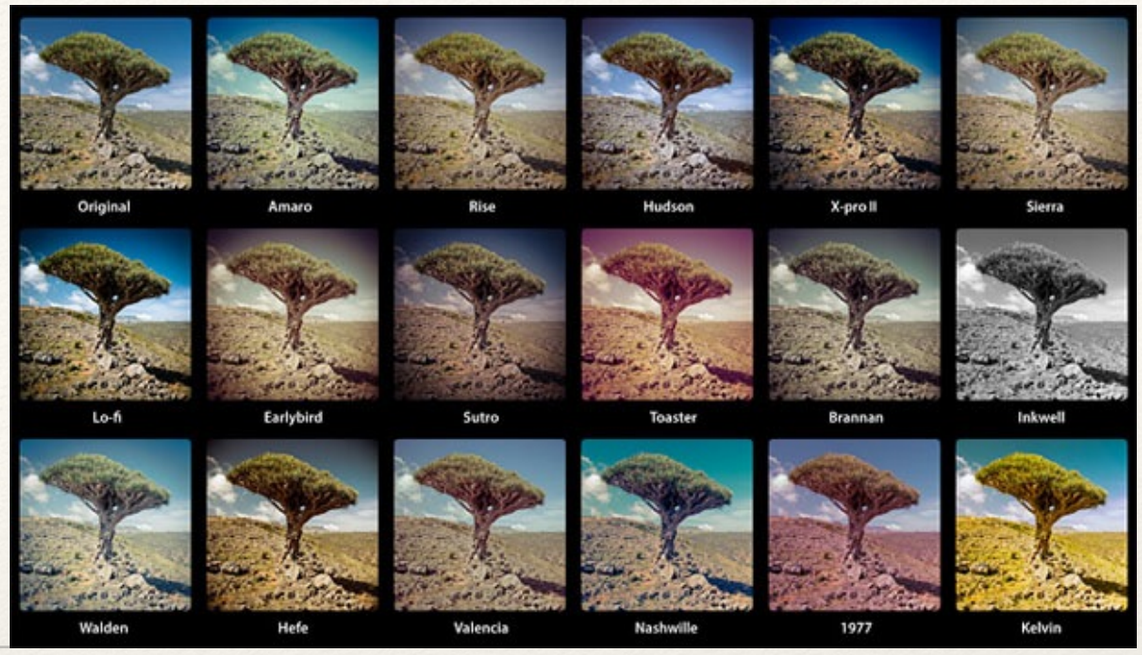

Image Manipulation: Pixel Traversal

Elements of Graphics
CS324e

Digital Images

- Bits are binary (0 or 1)
- Pixels are composed of bits
  - Bits-per-pixel determine the range of color
- Images are composed of pixels

Image Buffers

- Screen pixel data is stored in an array
- This array (or image buffer) allows us to access per-pixel information

How the pixels look:

0	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24

How the pixels are stored:

0	1	2	3	4	5	6	7	8	9	.	.	.		

Images in Processing

- Image buffers are stored in the `PImage` data type
- `PImage` allows for loading and displaying image data
- Some image manipulation:
  - Size
  - Position
  - Opacity
  - Tint
- To display: `image(PImage img, float x, float y, float width, float height)`

Loading and Displaying Images

```
PImage img;

void setup() {

   size(100, 100);

   img = loadImage(“foo.png”);

}

void draw() {

   image(img, 0, 0); //Note: we must load an
image before displaying it!

}
```

Fitting Processing Window to Image Size

```
void setup() {
  surface.setResizable(true);

  img = loadImage(“foo.png”);

  surface.setSize(img.width, img.height);
}
```

Changing Individual Pixels

- `loadPixels()` and `updatePixels()` should be called *before* and *after* pixel manipulation respectively
  - `loadPixels()` allows us to **read** from the pixel data
  - `updatePixels()` **writes** any changes back to the pixel data
  - Calls not necessary for every Operating System, but *may not work without them*
- `PImage.pixels` array stores each pixel as a `color`
  - Access the color of the pixel at `index` in `PImage img`:
  - `color c = img.pixels[index];`

Consider…

- How can we access every pixel in an image?
- How can we access every pixel by its (x, y) value?
  - Hint: remember this layout!

How the pixels look:

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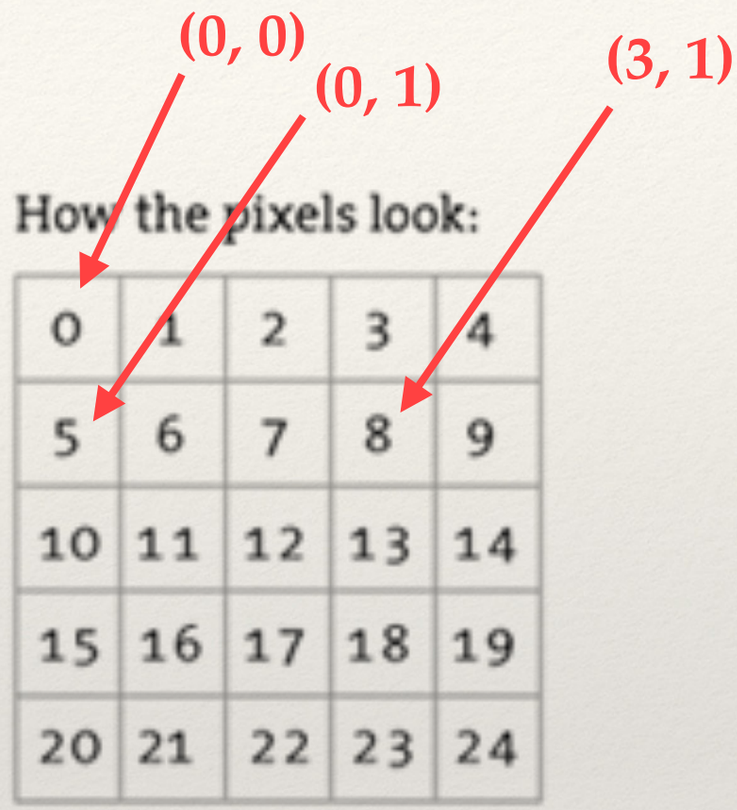
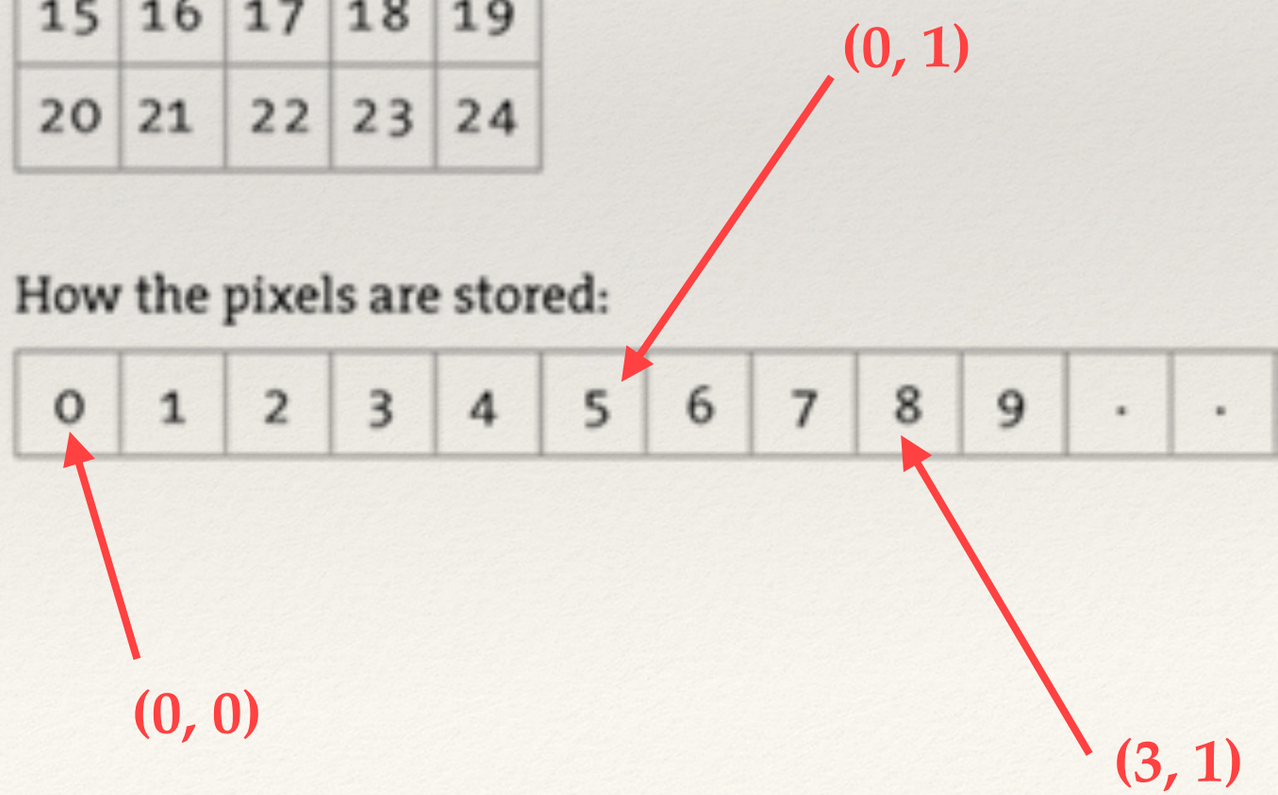
How the pixels are stored:

0	1	2	3	4	5	6	7	8	9	·	·	·		

Accessing by (x, y) Coordinates

- We will perform a *stride* into the 1D array to know which **row** (e.g. **y value**) we are currently looking for
- Once we get to the correct row, we can use the **column** (e.g. **x value**) to find the final placement of the index into the 1D array
- To do this, we must know the image width
  - row * imageWidth = index of row in the 1D array
  - Then add in the column value





Traversing an Image Buffer

```
//access img's pixels
img.loadPixels();
for (int x = 0; x < img.width; x++) {
   for (int y = 0; y < img.height; y++) {
      //access pixel at index and set c to its value
      int index = x + y*img.width;
      color c = img.pixels[index];
   }
}
//update any modifications to img's pixels
img.updatePixels();
```

Tint

- `tint()` modifies the color of the displayed images
- `noTint()` disables `tint()` modifications

```
void draw() {
  tint(0, 153, 204);
  image(img, 0, 0);
  noTint();
  image(img, 50, 50);
}
```

Creating Tint Example

Hands-on: Creating Tint

- Today's activity:

    1. **Re-create** Processing's `tint` functionality using a method you create (i.e. **do not use** the existing tint function)

        1. This method can take RBG/color data like the Processing `tint` method does

        2. You may want to make your `tint` method to be "per image" rather than "per screen" — to do this, your method should also have an argument for the `PImage` you will tint