Finding Red Pixels – Part 2

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CS1114

http://www.cs.cornell.edu/courses/cs1114

Cornell University
Computer Science

Administrivia

- You should all set up your CSUG accounts
- Your card should now unlock Upson 319

Administrivia

- Assignment 1 posted, due Friday, 2/10 by 5pm
  - Look under “Assignments!”
  - You should have seen the post on Piazza
    - If not, let me know
- Quiz 1 on Thursday

Academic Integrity

- You may speak to others about the assignments, but may not take notes
- All code you write must be your own

Administrivia

- Office hours:
  - Prof. Snavely: Th 1:30 – 3pm Upson 4157
  - All other office hours are held in the lab, see staff page for times

Even more compact code

```
D = [ 10 30 40 106 123 8 49 58 112 145 16 53 ]
```

```
D(1)  = D(1) + 20;
D(2)  = D(2) + 20;
D(3)  = D(3) + 20;
D(4)  = D(4) + 20;
D(5)  = D(5) + 20;
D(6)  = D(6) + 20;
D(7)  = D(7) + 20;
D(8)  = D(8) + 20;
D(9)  = D(9) + 20;
D(10) = D(10) + 20;
D(11) = D(11) + 20;
D(12) = D(12) + 20;
```

```
for i = 1:12
    D(i) = D(i) + 20;
end
```

```
D = D + 20;
```

- Special Matlab “Vectorized” code
- Usually much faster than loops
- **But please use for loops for assignment 1**

Why 256 intensity values?

8-bit intensity (2^8 = 256)

5-bit intensity (2^5 = 32)

5-bit intensity with noise

Why 256 intensity values?

4-color CGA display

256-color Amiga display

Today’s (typical) displays:
256 * 256 * 256 = 16,777,216 colors

Counting black pixels

```
function [ nzeros ] = count_zeros(D)
% Counts the number of zeros in a matrix
nzeros = 0;
[nrows,ncols] = size(D);
for row = 1:nrows
    for col = 1:ncols
        if D(row,col) == 0
            nzeros = nzeros + 1;
        end
    end
end
```

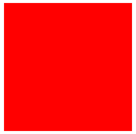
Save in a file named **count_zeros.m**

```
count_zeros([1 3 4 0 2 0])
```

What about red pixels?

 =  +  + 

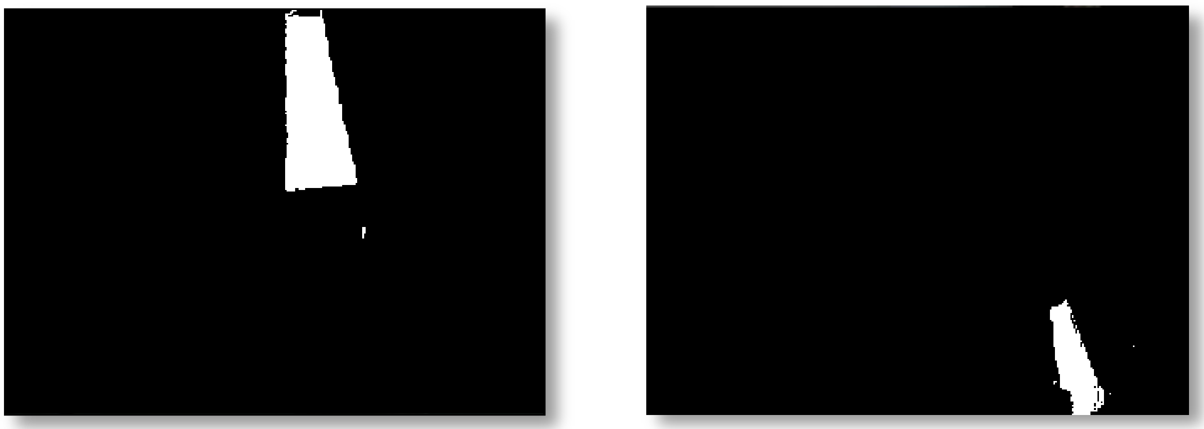
R G B

red(1,1) == 255, green(1,1) == blue(1,1) == 0 → 

red(1,1) == 255, green(1,1) == 255, blue(1,1) == 0 →

Are we done?

binary images



- Assignment 1: come up with a *thresholding* function that returns 1 if a pixel is "reddish", 0 otherwise

Finding the lightstick

- We've answered the question: is there a red light stick?

- But the robot needs to know **where** it is!

Finding the rightmost red pixel

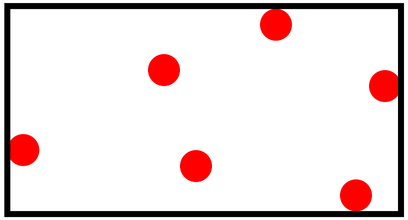
- We can always process the red pixels as we find them:

```
right = 0;
for row = 1:nrows
    for col = 1:ncols
        if red(row,col) == 255
            right = max(right,col);
        end
    end
end
```

Finding the lightstick – Take 1

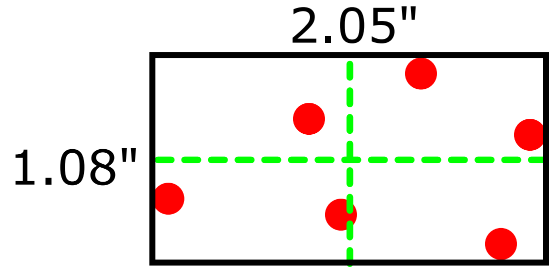
- Compute the bounding box of the red points
- The bounding box of a set of points is the smallest rectangle containing all the points
  - By “rectangle”, I really mean “rectangle aligned with the X,Y axes”

Finding the bounding box



- Each red pixel we find is basically a point
  - It has an X and Y coordinate
  - Column and row
    - Note that Matlab reverses the order

What does this tell us?



Aspect ratio: 2.05/1.08 = 1.9

- Bounding box gives us some information about the lightstick
  - Midpoint → rough location
  - Aspect ratio → rough orientation
  - (aspect ratio = ratio of width to height)

Computing a bounding box

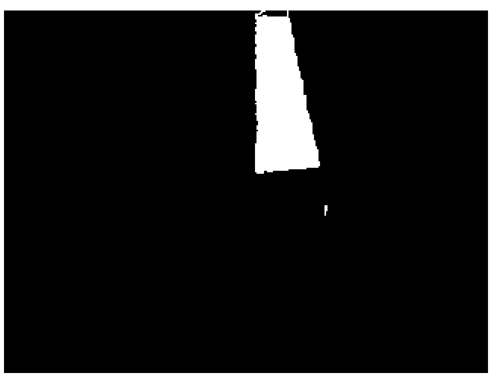
- Two related questions:
  - Is this a good idea? Will it tell us **reliably** where the light stick is located?
  - Can we compute it quickly?

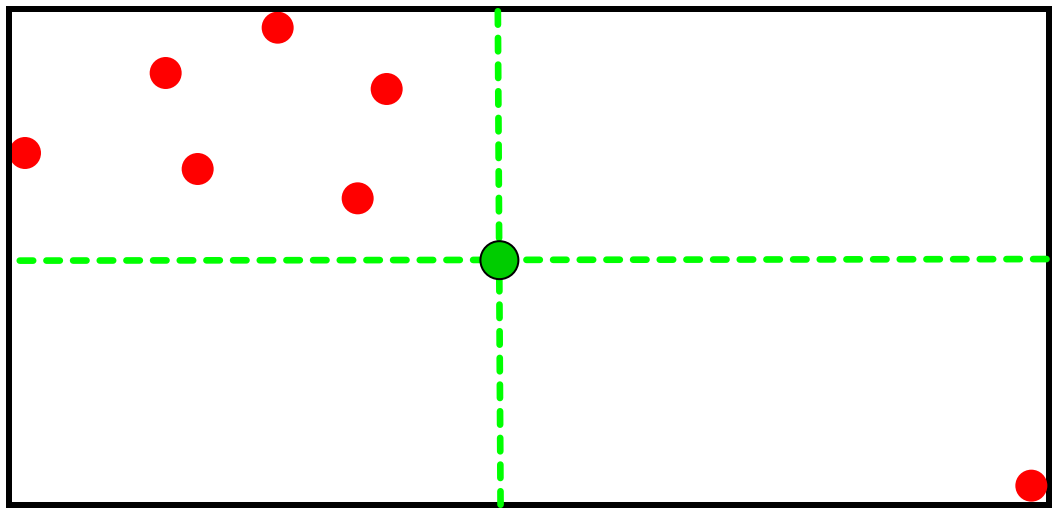
Computing a bounding box

- Lots of CS involves trying to find something that is both useful and efficient
  - To do this well, you need a lot of clever ways to efficiently compute things (i.e., algorithms)
  - We're going to learn a lot of these in CS1114

Beyond the bounding box

- Computing a bounding box isn't hard
  - Hint: the right edge is computed by the code we showed a few slides ago
  - You'll write this and play with it in A2
- Does it work?





Finding the lightstick – Take 2

- How can we make the algorithm more robust?
  - New idea: compute the centroid
- Centroid:

  (average x-coordinate, average y-coordinate)
  - If the points are scattered uniformly, this is the same as the midpoint of the bounding box
  - Average is sometimes called the mean
  - Centroid = center of mass

Computing the centroid?

- We could do everything we want by simply iterating over the image as before
  - Testing each pixel to see if it is red, then doing something to it
- It's often easier to iterate over *just* the red pixels
- To do this, we will use the Matlab function called `find`

The `find` function

img

thresh

X: x-coords of nonzero points

Y: y-coords of nonzero points

Your thresholding function

```
[X,Y] = find(thresh);
```

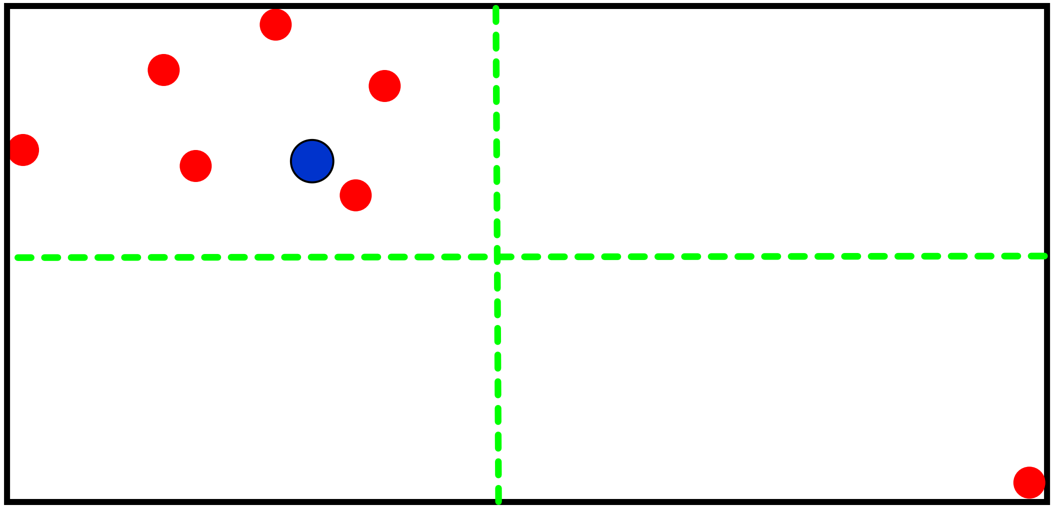
Using find on images

- We can get the x- and y- coordinates of every red pixel using `find`
  - Now all we need to do is to compute the average of these numbers
  - We will leave this as a homework exercise
    - You might have done this in high school

Q: How well does this work?

- A: Still not that well
  - One “bad” red point can mess up the mean
- This is a well-known problem
  - What is the average weight of the people in this kindergarten class photo?

How well does this work?



How can we do better?

- What is the average weight of the people in this kindergarten class photo?

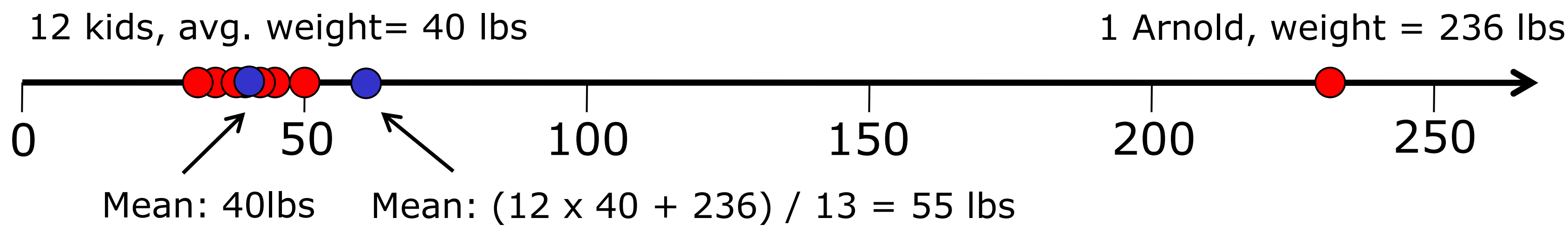
12 kids, avg. weight= 40 lbs

1 Arnold, weight = 236 lbs

Mean: (12 x 40 + 236) / 13 = 55 lbs

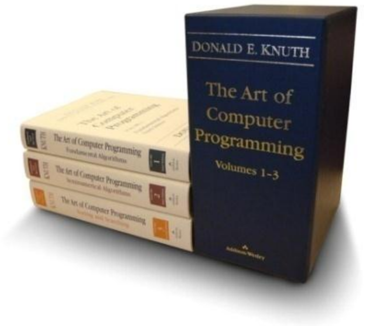
How can we do better?

- Idea: remove maximum value, compute average of the rest



How can we avoid this problem?

- Consider a simple variant of the mean called the "trimmed mean"
  - Simply ignore the largest 5% and the smallest 5% of the values
  - Q: How do we find the largest 5% of the values?



D.E. Knuth, *The Art of Computer Programming*
Chapter 5, pages 1 – 391

Easy to find the maximum element in an array

```
A = [11 18 63 15 22 39 14 503 20];
m = -1;  % Why -1?
for i = 1:length(A)
    if (A(i) > m)
        m = A(i);
    end
end
% At the end of this loop, m contains the
% biggest element of m (in this case, 503)
```

How to get top 5%?

- First, we need to know how many cells we're dealing with
  - Let's say `length(array)` is 100
    - → want to remove top 5
- How do we remove the biggest 5 numbers from an array?

Removing the top 5% -- Take 1

```
% A is a vector of length 100
for i = 1:5
 % 1. Find the maximum element of A
 % 2. Remove it
end
```

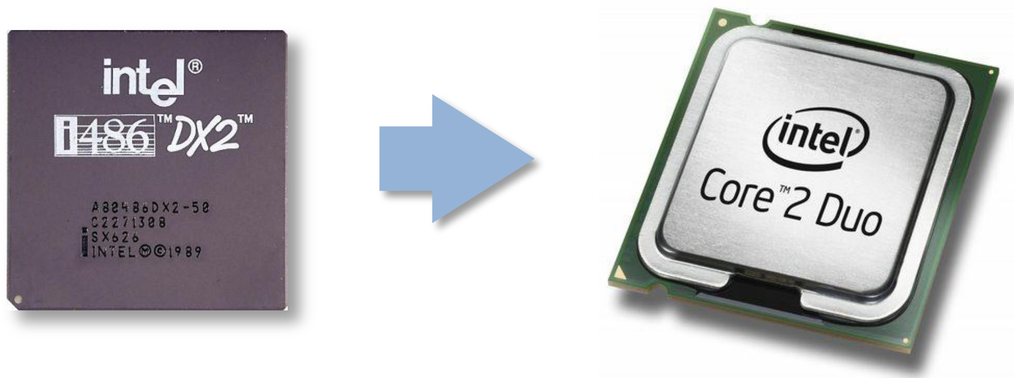
How good is this algorithm?

```
% A is a vector of length 100
for i = 1:5
  % 1. Find the maximum element of A
  % 2. Remove it
end
```

- Is it correct?
- Is it fast?
- Is it *the fastest* way?

How do we define fast?

- It’s fast when `length(A) = 20`
- We can make it faster by upgrading our machine



- So why do we care how fast it is?
- What if `length(A) = 6,706,993,152` ?

How do we define fast?

- We want to think about this issue in a way that doesn’t depend on either:
  A. Getting really lucky input
  B. Happening to have really fast hardware

How fast is our algorithm?

- An elegant answer exists
- You will learn it in later CS courses
  - But I'm going to steal their thunder and explain the basic idea to you here
  - It's called "big-O notation"

- Two basic principles:
  - Think about the average / worst case
    - Don't depend on luck
  - Think in a hardware-independent way
    - Don't depend on Intel!

For next time

- Attend section tomorrow in the lab
- Reminder: Quiz on Thursday, beginning of class