Plan for October 19-23

- Review Catchup and Midterm and Future
  - Make sure everyone understand options
- Review Assignment 5, Word Games
  - APIs, Global Variables, Interactive Games
- Images, tuples, RGB color model
  - Ready for lab, next assignment, and next set of APTs

Near-term Administrivia and Due Dates

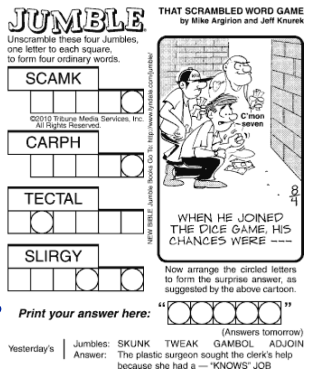
- Midterm regrade:
  - Review rubric, ask Prof in your section
- Mastery APTs for mid-term catchup
  - October 23 and October 30
- Programming Assignments: Four left
  - 10/29, 11/5, 11/19, 12/3
- APTs and APT Quizzes
  - Quizzes: 11/2, 11/16, 11/30 (moved by one week)
- Midterm exam and final
  - November 12, December 9 and 13

Jumble Review from Last Week

http://www.jumble.com

Use this problem to think about word games

- Human approach
  - What do you do?
- Computational method?
  - Cheating or insight?


JUMBLE THAT SCRAMBLED WORD GAME by Mike Argirion and Jeff Knurek

Unscramble these four Jumbles, one letter to each square, to form four ordinary words.

SCAMK

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CARPH

TECTAL

SLIRGY

NEW BIBLE Jumble Books Go To: http://www.tyndale.com/jumble/

Now arrange the circled letters to form the surprise answer, as suggested by the above cartoon.

Print your answer here: “ ”

(Answers tomorrow)

Yesterday's | Jumbles: SKUNK TWEAK GAMBOL ADJOIN
Answer: The plastic surgeon sought the clerk's help because she had a — “KNOWS” JOB

Review Jumble Programming Concepts

- When you run the program it starts in __main__, see Jumble.py for details
  - This is how Python works, boilerplate code
  - Global variables accessed in this section
- What's the variable *words* at beginning?
  - Global variable. Accessible in *every function* in the module (global required for modifying)
  - Used sparingly often useful in a small module
  - Abused, can lead to hard to maintain code

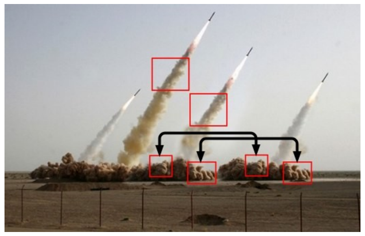
Questions About Assignment 5

http://bit.ly/101fall15-oct20-1

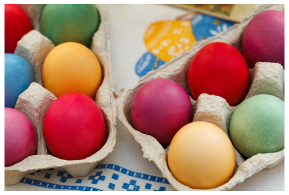
After this: image processing

Image Processing

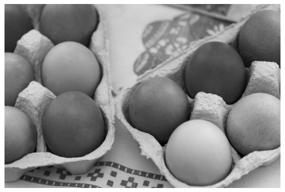
- What's real, what's Photoshopped
  - http://bit.ly/1Kj0Kn6 from 2008
  - Learn more at http://bit.ly/1Psi0hG, we'll do very basic stuff in class and lab, next assignment too!



Example: convert color to gray scale



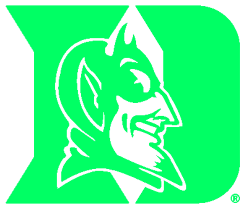
Process each pixel
Convert to gray



Example: convert blue to green

Process each pixel
Convert blue ones to green

Is this like red-eye removal?



Need new concepts and Image library

- Red, Green, Blue color model
  - Triples of (R,G,B) are processed as Python tuples.
  - *Let's study tuples!*
- Images can be very big, what's 4K display?
  - 4,096 x 2,160 = 8,847,360 pixels, 8Mb at least
  - Creating huge lists takes up memory
  - Sometimes only need one pixel at-a-time
  - *Let's study generators!*

Need new concepts and Image library

- Red, Green, Blue color model
  - Additive model, each pixel specified by (r,g,b) triple, values of each between 0-255
  - https://en.wikipedia.org/wiki/RGB_color_model
  - White is (255,255,255) and Black is (0,0,0)
- Images stored as sequence of (r,g,b) tuples, typically with more data/information too
  - 256 values, represented as 8 bits, $2^8 = 256$
  - 32 bits per pixel (with alpha channel)
  - In Python we can largely ignore these details!

Image library: Two ways to get pixels

- Each pixel is a *tuple* in both models
  - Like a list, indexable, but *immutable*
  - `pix = (255,0,0)`
    - What is `pix`?, `pix[0]`? What is `pix[5]`?
- Invert a pixel: by subscript or named tuple
  - Access by assignment to variables!

```
npx = (255-pix[0],255-pix[1],255-pix[2])
```

```
(r,g,b) = pix
npx = (255-r,255-g,255-b)
```

Let's look at GrayScale.py

- Key features we see
  - Import Image library, use API by example
  - Image.open creates an image object
- Image functions for Image object im
  - `im.show()`, displays image on screen
  - `im.save("xy")`, saves with filename
  - `im.copy()`, returns image that's a copy
  - `im.load()`, [x,y] indexable pixel collection
  - `im.getdata()`, iterable pixel collection
- Let's look at two ways to process pixels!

Image Library: open, modify, save

- `Image.open` can open most image files
  - .png, .jpg, .gif, and more
  - Returns an image object, so store in variable of type Image instance
  - Get pixels with `im.getdata()` or `im.load()`
- `Image.new` can create a new image, specify color model "RGB" and size of image
  - Add pixels with `im.putdata()`
- These belong to Image package

`im.getdata()`, accessing pixels

- Returns something *like* a list
  - Use: `for pix in im.getdata():`
  - Generates pixels on-the-fly, can't slice or index unless you use `list(im.getdata())`
  - Structure is called a Python generator!
  - Saves on storing all pixels in memory if only accessed one-at-a-time
- See usage in GrayScale.py, note how used in list comprehension, like a list!

Alternate : Still Tuples and Pixels

- The `im.getdata()` function returns list-like iterable
  - Can use in list comprehension, see code
  - Use `.putdata()` to store again in image

```
pixels = [makeGray(pix) for pix in im.getdata()]
```

```
def makeGray(pixel):
    r,g,b = pixel
    gray = (r+g+b)/3
    return (gray,gray,gray)
```

Making Tuples and Generators

- Overuse and abuse of parentheses
  - To create a tuple, use parentheses

```
for pix in im.getdata():
    (r,g,b) = pix
    npx = (255-r,255-g,255-b)
```

  - To create a generator use parentheses as though creating a list comprehension!

```
[2*n for n in range(10000)]
(2*n for n in range(10000))
```

- See this in PyDev console

Questions about Image Code

http://bit.ly/101fall15-oct20-2

`im.load()`, accessing pixels

- Returns something that can be indexed [x,y]
  - Only useful for accessing pixels by x,y coords
- Object returned by `im.load()` is …
  - Use pix[x,y] to read and write pixel values
- Note: this is NOT a generator

```
pix = im.load()
tup = pix[0,0]
pix[1,1] = (255,255,0)
```