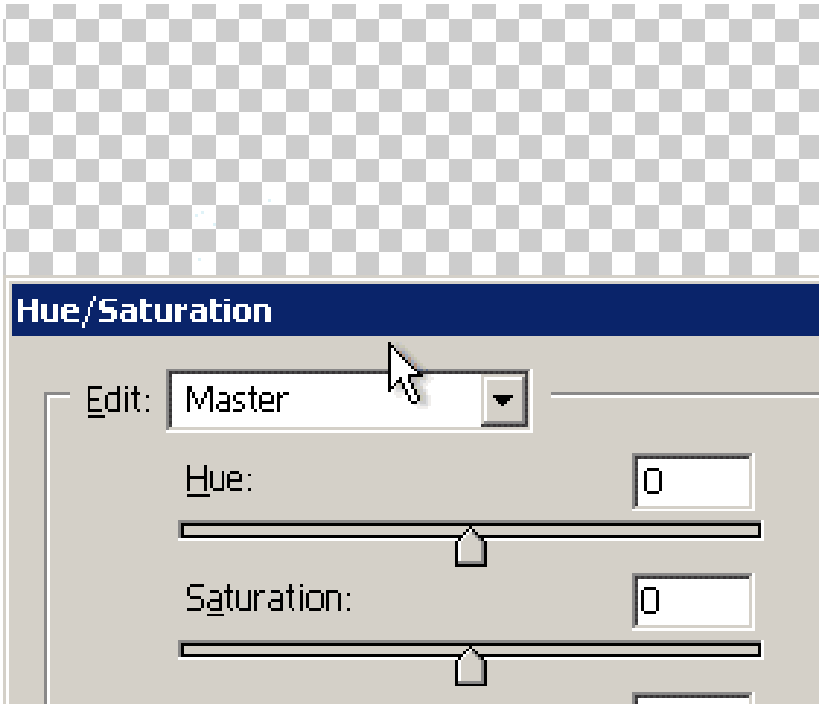
Introduction to Informatics

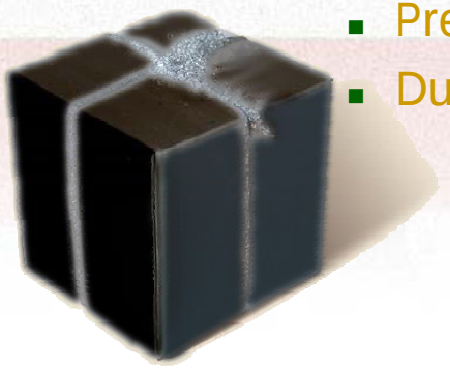
Lecture 11: Encoding Multimedia Data



Luis M.Rocha and Santiago Schnell

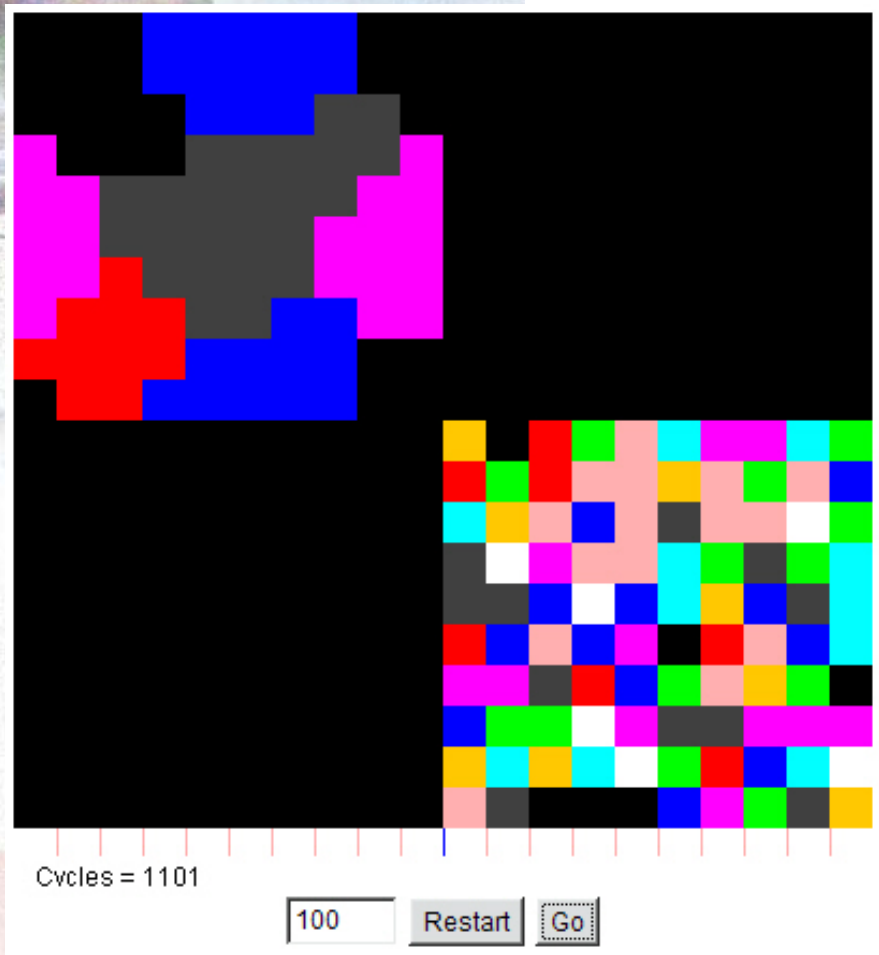
Individual assignment

- Individual Project
  - 1st installment
    - Presented: February 1st
    - Due: February 9th
  - 2nd Installment
    - Presented: February 15th
    - Due: March: 2nd
  - 3rd Installment
    - Presented: March 8th
    - Due: March 30th
  - 4th Installment
    - Presented: April 5th
    - Due: April 20th



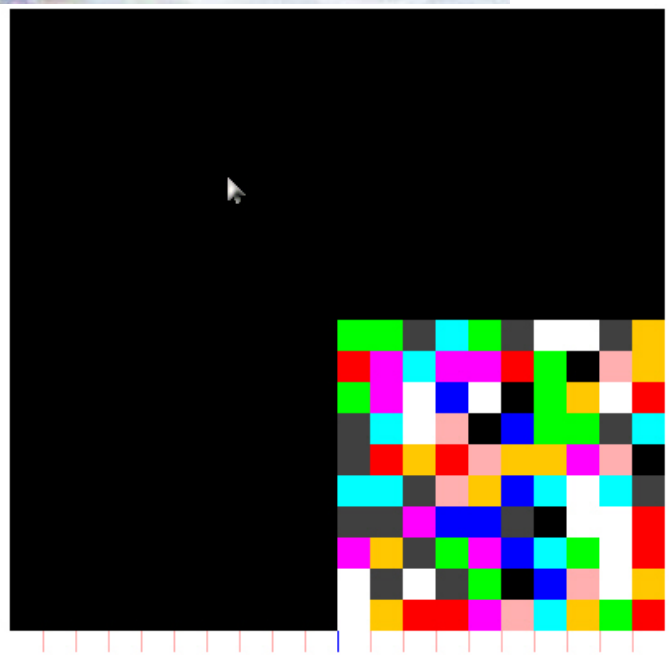
The Black Box

Individual Assignment



- Analysis and Observations
  - 400 cells (20x20)
    - 4 quadrants of 100 cells (10x10)
  - 10 colors
    - Red, blue, green, orange, purple, cyan, pink, grey, white, and black.
      - Ahmed Kambal, Clliff Taylor (11), Anna wong(8),Samuel Ritter,Anup Sarode, John Oglesby, Donald Peek
  - Black “death” in bottom left quadrant:
    - usually 600-800 cycles
      - Jeffery Randall
    - About 700 cycles
      - James Waugh
    - 421 lowest number of cycles observed to blackout
      - Ahmed Kambal
  - Bottom right quadrant does not become fixed
    - All colors keep appearing randomly
      - Jacob Marsh (2 Million)
      - Marc Epstein (500,000)
  - Top right quadrant after freezing
    - Black cells with blotches of green
    - Same number of colors as when it started
    - Five colors spread through the quadrant
    - All black

Assignment I.



More Observations

- Top left quadrant after freezing
  - blocks of 3 or 4 colors arranged like a jigsaw puzzle
- only once in a two hour period all quadrants blacked out except TR
  - Ahmed Kambal (it can happen! Donald Peek)
- Restarts with window hopping or scrolling
- Input = 0
  - shows grid
  - Bonnie Seacott

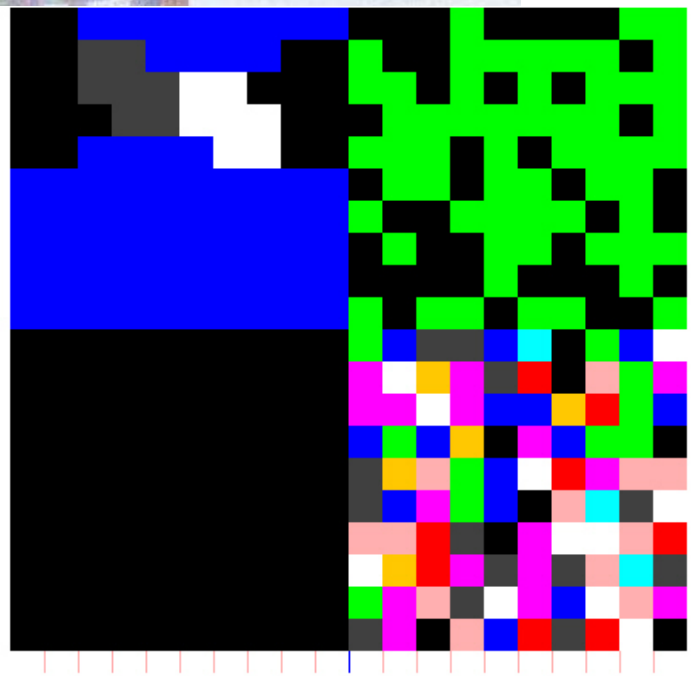
Donald Peek

- Observed how many quadrants turn black (1,2 or 3)
  - 20 Trials
  - Each having 1500 iterations or cycles
    - 1 quadrant: In 18/20 trials
    - 2 quadrants: In 2/20 trials
    - 3 blocks: In 0/20 trials

Anna Wong

- "When I put 1 in the box, about 6 of the little squares change colors at different parts of the matrix."
  - Is this True?

Individual Assignment

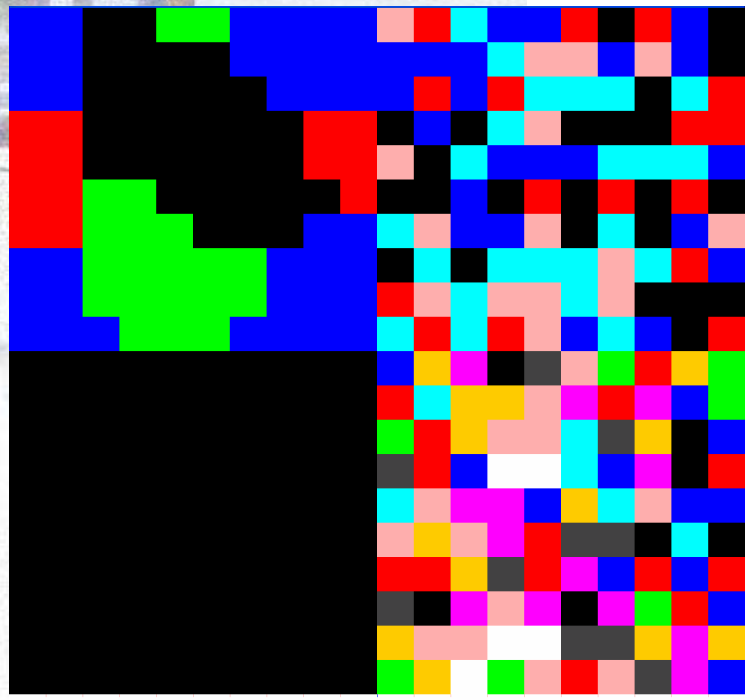


- Hypotheses
  - Each quadrant is doing something on its own
    - Since the quadrants are programmed, they must be following a pattern
      - Kael Andrew Kanczuzewski
  - In three out of the four quadrants, cells are moving towards a “fixed” state
    - After the four quadrants are discernable fewer cells change color per cycle
      - Marcus Bigbee
    - the more cycles that are run, the more the complexity of the image presented decreases. This is because the number of differently colored boxes is reduced as more cycles are run.
      - Allen Shyu
  - In the bottom-left quadrant, once a cell turns black it causes others to die too
    - It’s the black boxes that kill almost as if they are acting as a virus.
      - Cliff Taylor
    - It’s like the small black are spreading to all the other colored squares turning them black almost like a disease. The black squares change squares that are touching them.
      - Marcus Bigbee

Need to be tested!

With logic!

Individual Assignment

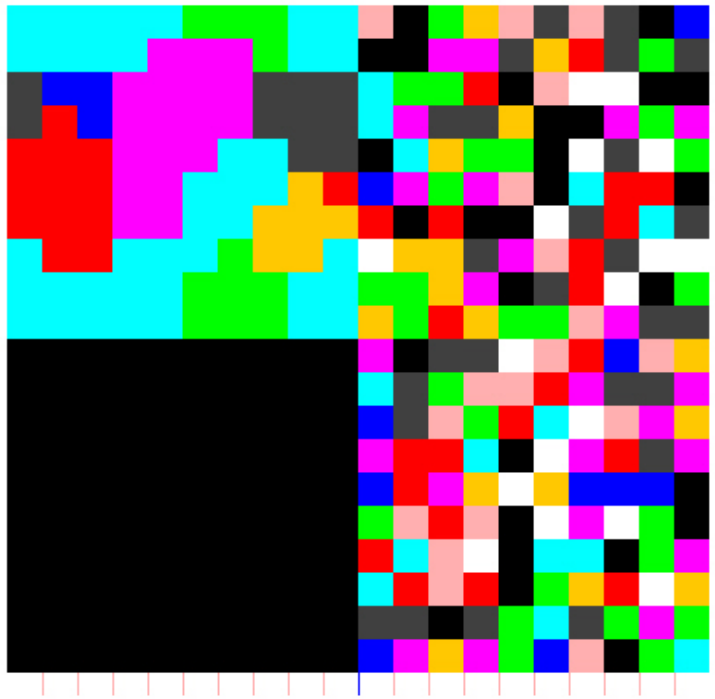


Need to be tested!

With logic!

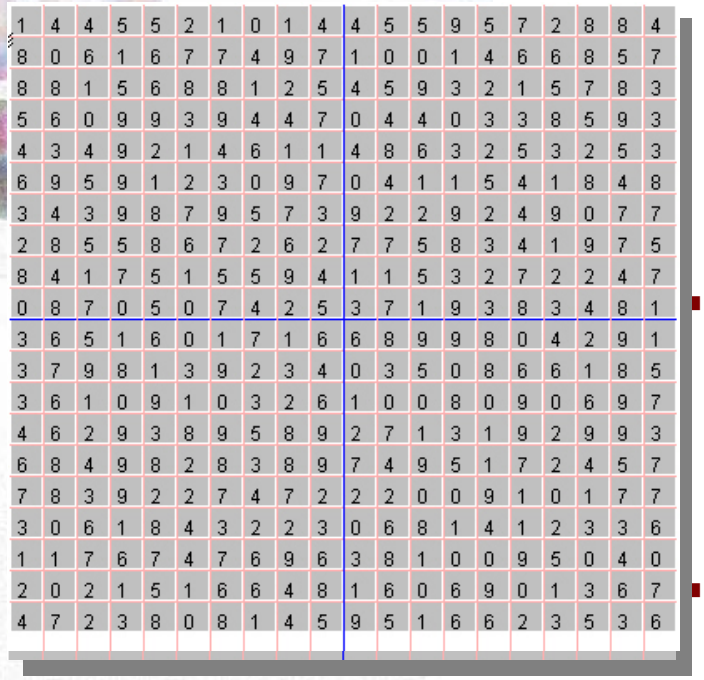
- More Hypotheses...
  - Each color must be represented a fixed number of times ?
    - A certain percentage for each color is allowed in the grid, once that percentage is satisfied then, it stops, and/or only allows for a certain amount of that color to be represented
      - Anup Sarode
    - This hypothesis is falsified by Donald Peek's observation in which in 2/20 cases he found half of the black box to be completely black
  - Deterministic or probabilistic?
    - depends on the colors and where they are when the box is restarted. I believe that once you hit restart and the boxes "randomize" the box already has pre-determined what will happen to the box as a whole.
      - Donald Peek
    - Probabilistic equation
      - Ahmed Kambal, John Oglesby
  - Kael Andrew Kanczuzewski
    - The top left quadrant shows some sort of aggregation?
      - 1-3 different colors dominate the screen
      - Certain colors take over others colors; if a very specific case happens then only black will remain.

Individual Assignment



- Models
  - Black “death”, disease spread
    - Once it is black it stays that way
    - Some sort of epidemic or viral spreading
      - Cliff Taylor, Marc Epstein, Craig Bauer (and others)
  - Image decoder/processor
    - Allen Shyu, Anna Wong
  - It could be modeling the life of a species in different parts of the world and some parts become endangered or extinct.
    - Andrew James
  - It could be the spread of information which brings communities of people into more modern times. However as more and more people obtain and understand the information, other areas eventually progress as well. However, a quarter of the people can never understand the information and keep changing their ideas but never get the full picture.
    - Craig Phillip

Individual Assignment



- Encoding!!
  - A model that represents the black box

A – B – C –D – E
/ / / / /
B - B - D - E - A
/ / / / /
B - B – E - A - B
/ / / / /
B – B – A – B – B

    - Craig Phillip Bauer
  - Another One

B=black G=green R= red Bl=blue

G---R---Bl---B
R---B
Bl---R---G---R---Bl---G---R---B

    - Andrew Philbrick
  - If we assigned each color a number we might be able to model this experiment a little better.
    - John Oglesby
- Other Ideas
  - Focus on a quadrant
  - Focus on a single cell
  - Collect relationships
    - What always happens or tends to happen?

Individual assignment

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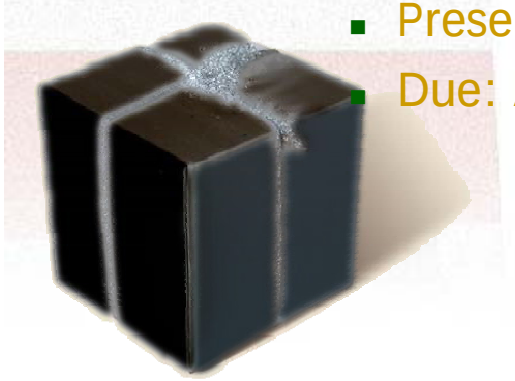


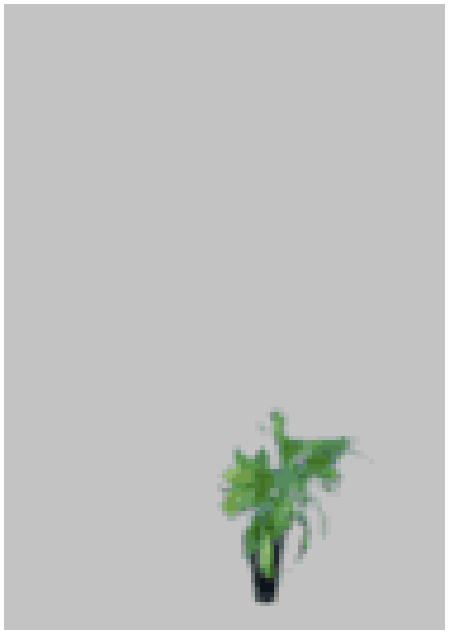
The Black Box

Luis M.Rocha and Santiago Schnell

Readings until now

- Lecture notes
  - Posted online @ http://informatics.indiana.edu/rocha/i101
    - *The Nature of Information*
    - *Technology*
    - *Modeling the World*
  - @ *infoport*
  - From course package
    - Von Baeyer, H.C. [2004]. *Information: The New Language of Science*. Harvard University Press.
      - Chapters 1, 4 (pages 1-12)
    - From Andy Clark's book "*Natural-Born Cyborgs*"
      - Chapters 2 and 6 (pages 19 - 67)
    - From Irv Englander's book "*The Architecture of Computer Hardware and Systems Software*"
      - Chapter 3: Data Formats (pp. 70-86)

Assignment Situation

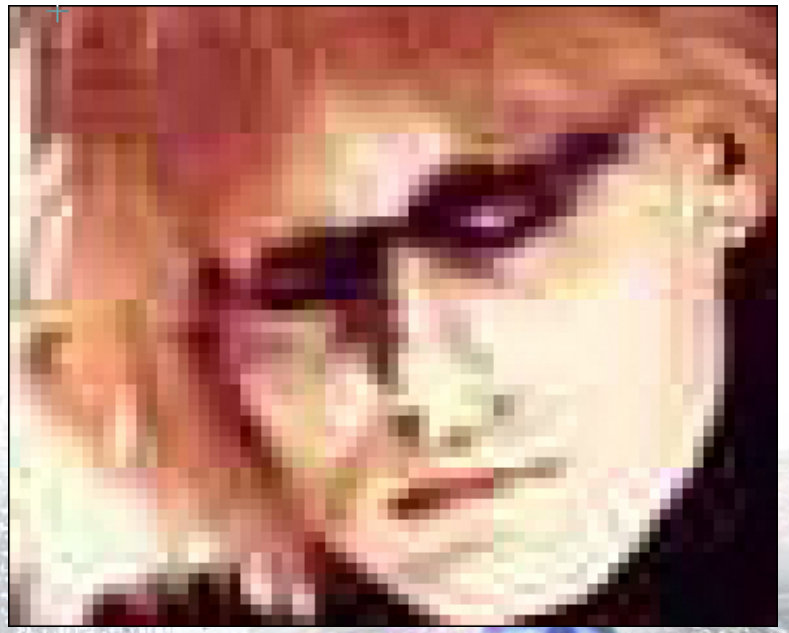


- Labs
  - Past
    - Lab 1: Blogs
      - Closed (Friday, January 19): Grades Posted
    - Lab 2: Basic HTML
      - Closed (Wednesday, January 31): Grades Posted
    - Lab 3: Advanced HTML: Cascading Style Sheets
      - Closed (Friday, February 2): Grades Posted
    - Lab 4: More HTML and CSS
      - Closed (Friday, February 9): being graded
    - Lab 5: Introduction to Operating Systems: Unix
      - Due Friday, February 16
  - Next: Lab 6
    - More Unix and FTP
      - Due Friday, February 23
- Assignments
  - Individual
    - First installment
      - Closed: February 9: Being Graded
  - Group Project
    - First installment
      - Presented: February 20, Due: March 9th
- Midterm Exam
  - March 1st (Thursday)

Encoding the World

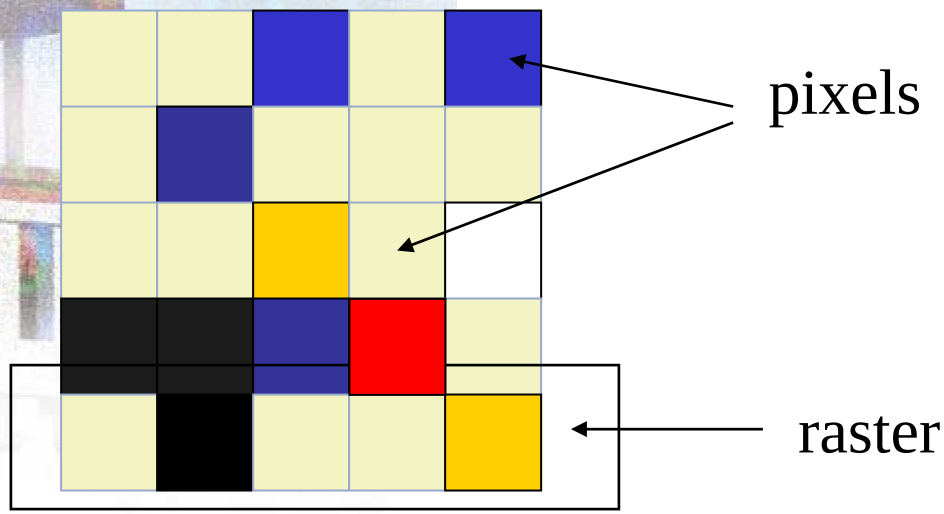
- What is multimedia?
  - Images
    - BMP, GIF, TIFF, PNG, Postscript, JPEG, SWF, SVG
  - Sound
    - WAV, MP3, MIDI, WMA, AAC, Audible
  - Video
    - MPEG-2, AVI, WMV, Quicktime
- How do we encode multimedia?
  - What symbol system to use?

Bitmap or Raster Images



Pixels: picture elements

Bitmap Image



- Representation of a two-dimensional image as a finite set of digital values
- Picture elements or ***pixels***
  - **Resolution:** number of pixels in an image
    - 1024 x 768
  - Each defined by one or more numbers
    - Color, intensity

2^{24} (about 16 million)

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
1	1	0	0	1	0	0	1

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
1	1	0	0	1	0	0	1

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
1	1	0	0	1	0	0	1

RGB: 3 Bytes, one for each primary colors: Red, Green, and Blue: *16,777,216* colors total

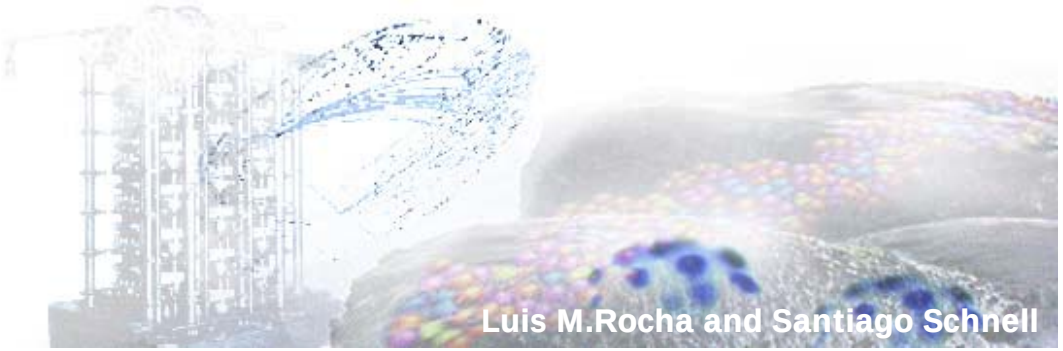
Adapted from Cathy Wyss (I308)

RGB Colors

- Black #000000
- White #FFFFFF
- Grey #555555
- Red #FF0000
- Orange #FF8800
- Purple #880088

- 3 Bytes, one for each primary color
  - 24 bits
  - Red, Green, and Blue
    - 16,777,216 colors total
  - Web colors are RGB values (Hexadecimal format)
    - AliceBlue #F0F8FF
    - Azure #F0FFFF
    - Beige #F5F5DC
    - Bisque #FFE4C4
    - Black #000000
    - Blue #0000FF

Adapted from Cathy Wyss (I308)



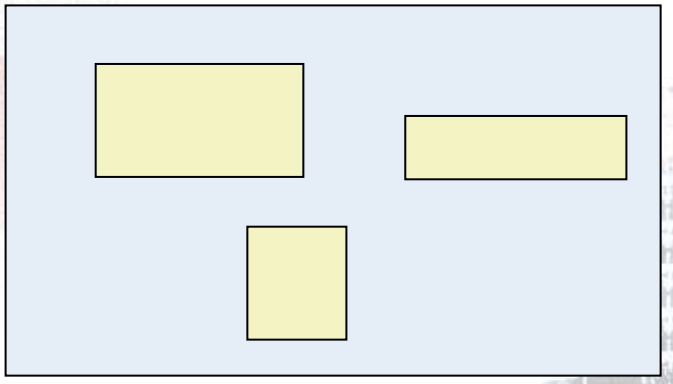
Graphics Interchange Format

- Developed by CompuServe in 1987 (GIF87a)
  - Developed to facilitate exchange across computing platforms
  - Allows transparency
  - GIF89a
    - 1989: allows animated GIF images
- Uses LZW (Lempel-Ziv-Welch) data compression
  - More efficient than plain bitmaps
  - Large images downloaded quicker
  - Lossless compression
  - 256 colors only
  - Patent owned by Unisys until 2003
    - Compuserve did not know that LZW was covered by a patent.
    - Before 1994, Unisys was not aware that GIF used LZW.
  - Builds a dictionary of previously seen strings in the information being compressed.
    - The dictionary does not have to be transmitted

http://sheepfilms.co.uk

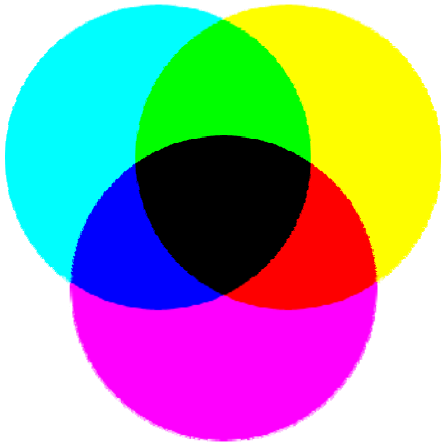
GIF File Structure

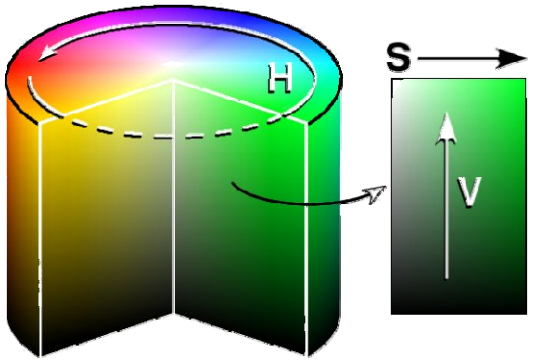
- Screen descriptor
  - Defines image resolution and color depth, followed by an optional global color map (palette).
- One or more image descriptors follow
  - Data chunks within GIF that contain actual image data
  - A rectangular part of the complete image
- GIF89a extension blocks were introduced
  - Used to store text comments or other additional information. Some of these extension blocks can be used to tell decoder software to delay the decoding of subsequent image descriptors. That's how GIF can be used to store animations.

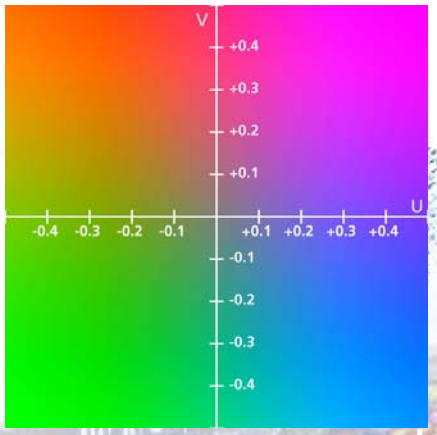


Other Color Spaces

- CMY (CMYK)
  - Mixes pigments of the following colors in order to make other colors:
    - C=Cyan (opposite of red, absorbs)
    - M=Magenta (opposite of Green)
    - Y=Yellow (opposite of Blue)
    - K=Key (black).
  - Subtractive
    - From White
    - Objects absorb some of the white light, and reflect the color we see
  - Printers
- HSV
  - Hue, Saturation, Value or Brigthness
  - Intuitive, easy to convert to RGB
  - Closest to human perception
- YUB
  - Luminance and Chrominance
    - Used by PAL and NTSC
  - Performs better under compression
  - Close to human perception
  - Easy to convert to RGB



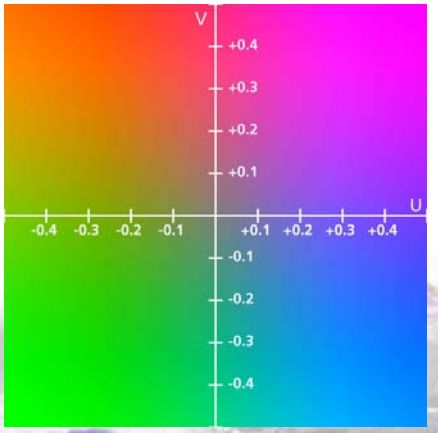




Y=0.5

Joint Photographic Experts Group (JPEG)

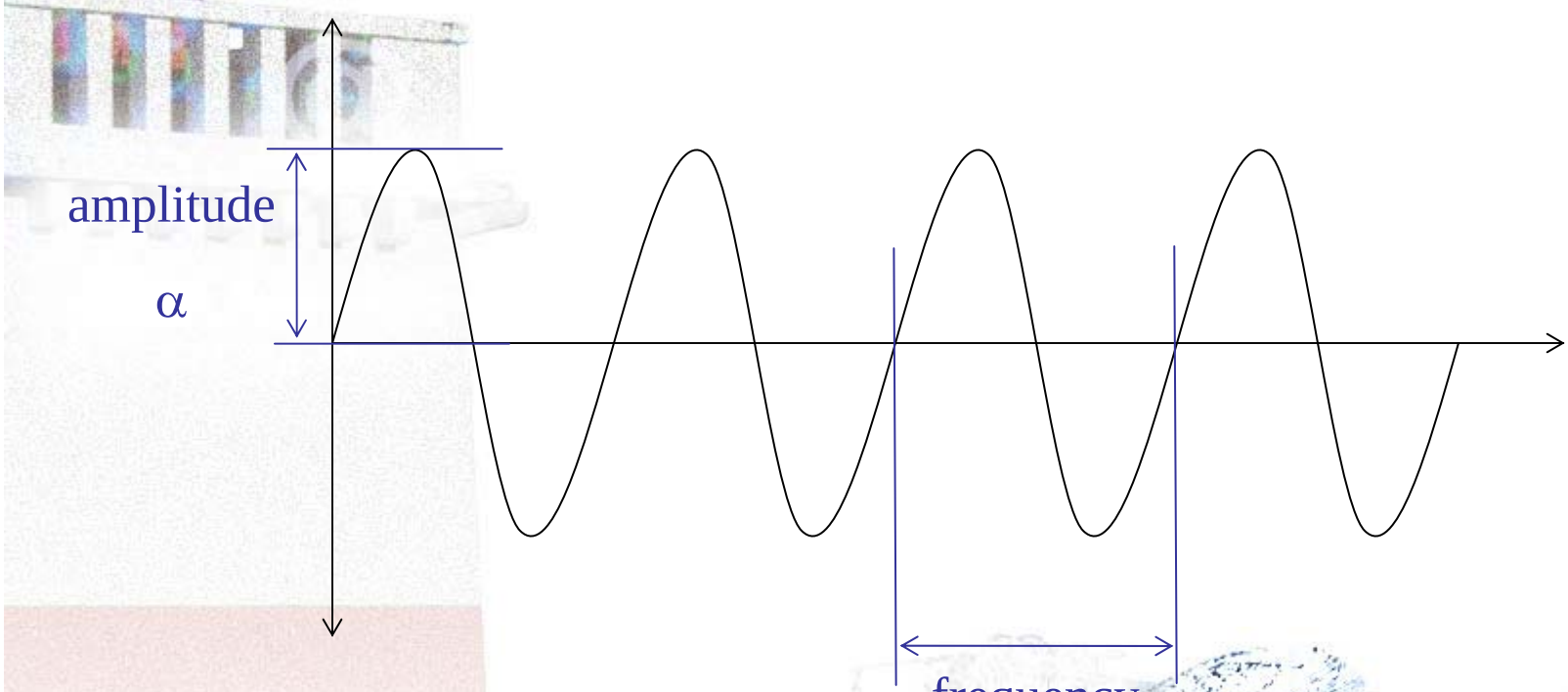
- Compression Algorithm
  - GIF uses only 265 colors
  - JPEG allows more 16 million colors!
  - Lossy compression
    - Can reduce image resolution, particularly for sharp edges and lines
  - Better for photos
    - GIF is better for line drawings and simple images
- Converts RGB to YUV
  - Color space used in the PAL system of television broadcasting
  - Y = luminance component (the brightness)
    - Y = R + G + B
  - U and V are the chrominance (color) components.
    - U = B-Y and then scaling
    - V =R-Y and then scaling by a different factor
  - Reduces high frequency brightness variation



Y=0.5

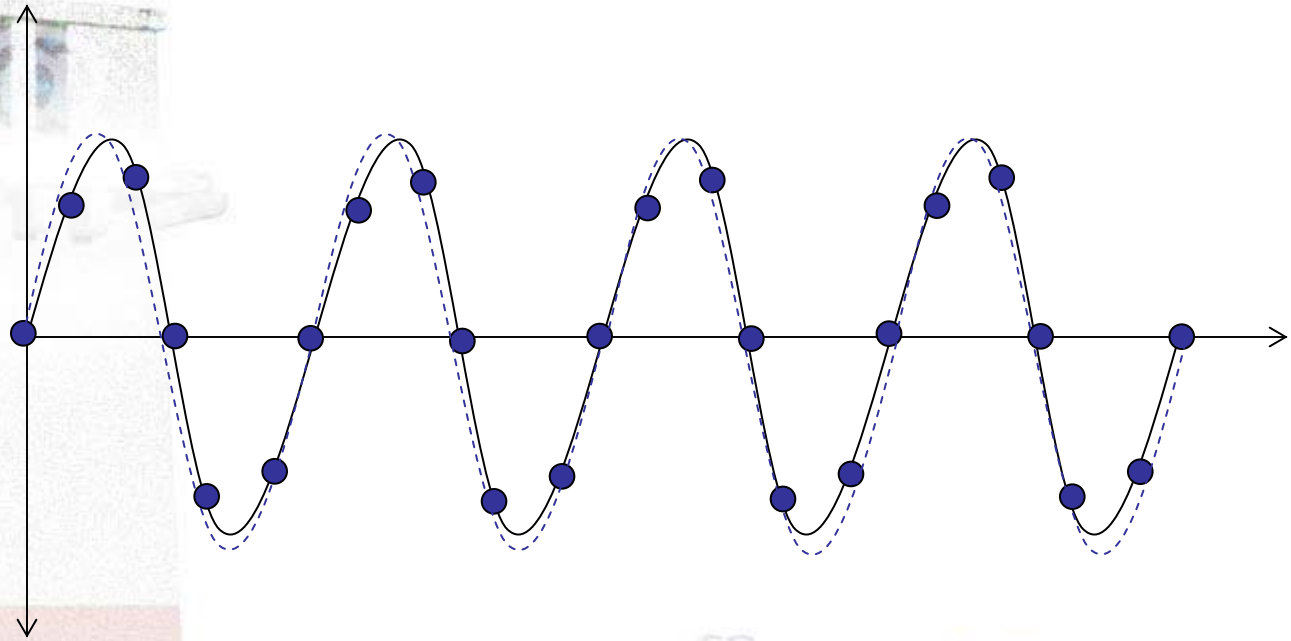

Worth1000.com
Luis M.Rocha and Santiago Schnell

Audio Data



Adapted from Cathy Wyss (I308)

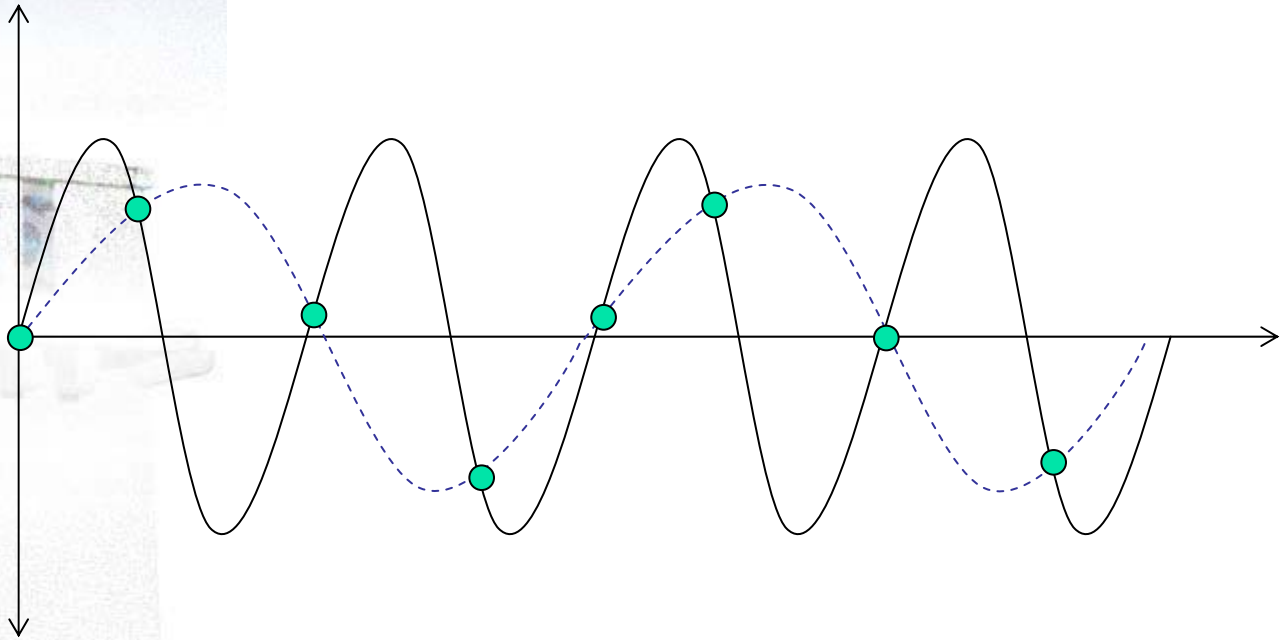
Sampling



Adapted from Cathy Wyss (I308)

Sampling

Sampling rate must be > 2ν (*Nyquist frequency*)



Human ear: 20 – 20,000 Hz

Sampling points **encoded** as a series of integers, plus information about the data such as amplitude, sampling frequency, number of samples

Adapted from Cathy Wyss (I308)

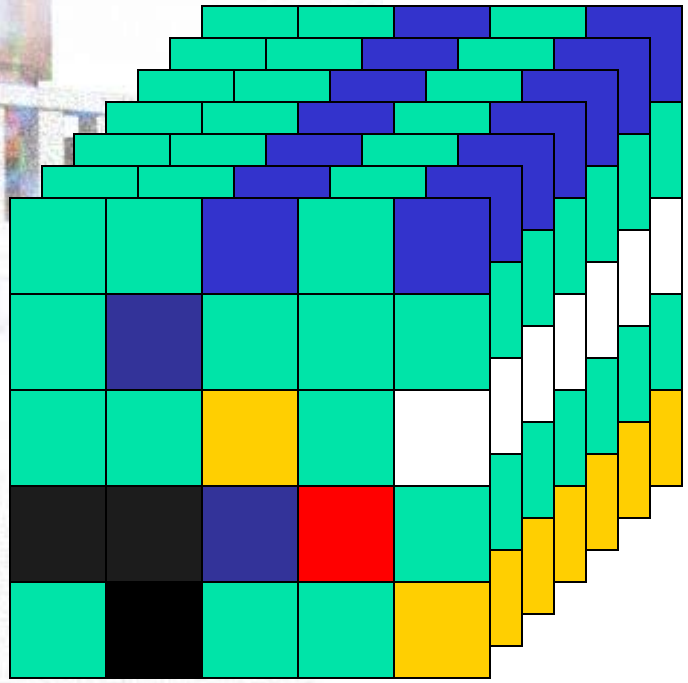
Compressing Audio

- Lossless data compression
  - Eliminates redundancy
    - E.g. Zip archives
  - Up to ~ 50%
- Lossy Data Compression
  - The restored data is degraded, but “close enough”
  - Up to ~ 95% or more
  - Mp3: *MPEG-1/2 Audio Layer 3*
    - Developed in Europe (Fraunhofer Society)
    - Uses a hybrid transform from a time to a frequency domain
    - 112...128 kbit/s, compression 10:1...12:1
    - excellent at 224...320 kbit/s, very good at 192...224 kbit/s, good at 128...192 kbit/s

Encoding Music

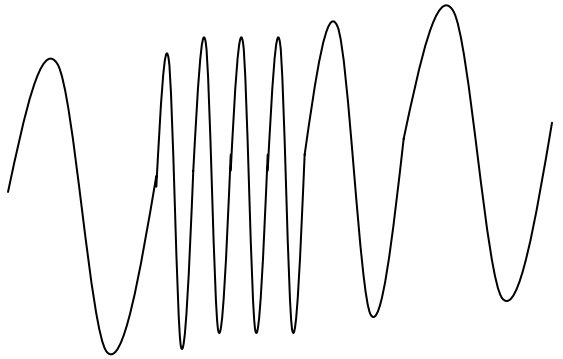
- Musical Instrument Digital Interface (MIDI)
  - Encodes information about music and instruments for exchange among musical instruments (1983)
  - Allows computers, synthesizers, sound cards and drum machines to control one another, and to exchange system information.
  - Very compact, but can be slow because it is serial
- Does not encode sound, but notation and other machine codes
- Music Informatics
  - Eric Isaacson, Christ Raphael, Peter Todd
  - Music Information Technology Group
    - http://theory.music.indiana.edu/mit/

Video



frames

+



sound

Adapted from Cathy Wyss (I308)

Video

- Data is the same as image and audio, but in huge amounts!
  - Resolution 640 x 480 pixel in RGB true color (16 million colors) at a ***frame rate*** of 30 frames per second
    - 640 x 480 x 3 bytes x 30 fmps = 27.56 Mbytes per second!
  - MPEG-2 is a compression algorithm
    - 30-40 Mbytes per minute
    - Used in DVDs with some modification and in HDTV
  - Real Video, Quicktime, WMF, Indeo

Next Class!

- Topics
  - Classical Logic
- Readings for Next week
  - @ *infoport*
    - Read data encoding resources at Infoport!!
  - From course package
    - Klir, J.G., U. St. Clair, and B.Yuan [1997]. Fuzzy Set Theory: foundations and Applications. Prentice Hall
      - Chapter 2: Classical Logic (pp. 87-98)
- Lab 6
  - More Unix and FTP