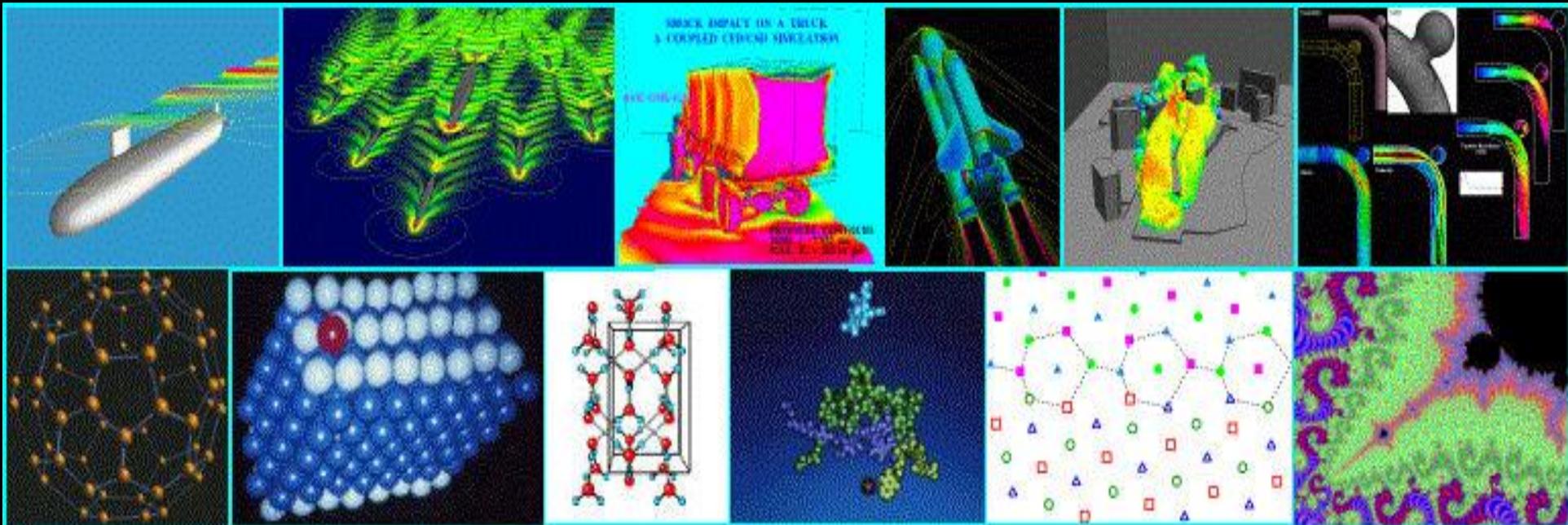


Computing for Scientists

Visualization (VIS)

(Nov. 12, 2013 – Dec. 05, 2013)



Jie Zhang

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CDS 130 - 001
Fall, 2013

Where are we now?

The Tool: MATLAB (remaining chapters)

- **CHAPTER 8:** Matrices (Arrays) and Matrix Operations
- **CHAPTER 9:** Iteration II: Double Nested FOR Loops (DNFL)
- **CHAPTER 10:** Conditionals: IF Statements

Section 0: Introduction & Syllabus

Section 1. Computer Fundamentals

Section 2. Scientific Simulation

Section 3. Visualization

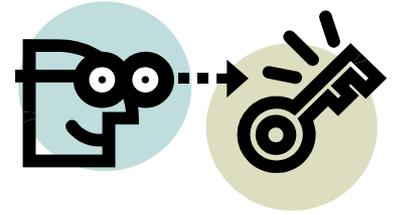


We are here!

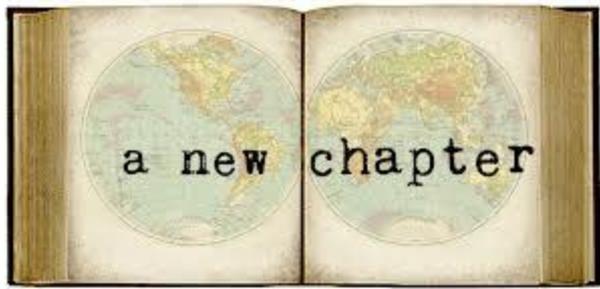
Section 4: Data Analysis (not covered)

Section 5: Ethics

Visualization (VIS)



- 1. Introduction**
- 2. Image as a 2-D Array**
- 3. Color and Colormap**



Section 3

Chapter 1

Introduction

(Nov. 12, 2013)

Picture

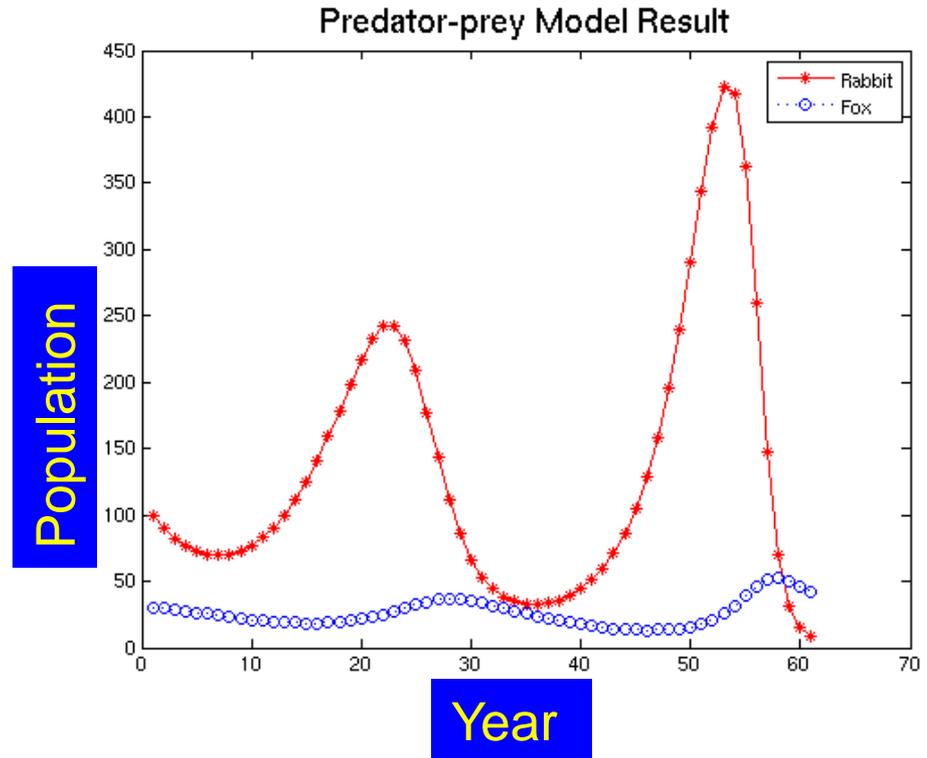
**A Picture Is Worth a
Thousand Words**



**Cave Painting: the
dawn of civilization**

The Line Plot

```
R =  
Column 1 through 6:  
 1.0000e+002  1.1000e+002  1.1220e+002  1.0031e+002  7.0900e+001  3.3228e+001  
Columns 7 through 12:  
 8.5422e+000  1.6068e+000  4.0460e-001  1.4088e-001  6.2192e-002  3.2757e-002  
Columns 13 through 18:  
 1.9778e-002  1.3317e-002  9.7999e-003  7.7643e-003  6.5455e-003  5.8170e-003  
Columns 19 through 24:  
 5.4088e-003  5.2294e-003  5.2301e-003  5.3876e-003  5.6952e-003  6.1587e-003  
Columns 25 through 30:  
 6.7945e-003  7.6296e-003  8.7024e-003  1.0065e-002  1.1785e-002  1.3950e-002  
Columns 31 through 36:  
 1.6676e-002  2.0109e-002  2.4438e-002  2.9905e-002  3.6824e-002  4.5595e-002  
Columns 37 through 41:  
 5.6737e-002  7.0917e-002  8.8995e-002  1.1208e-001  1.4161e-001  
F =  
Columns 1 through 7:  
 20.0000  28.0000  40.6000  59.3166  83.1342  104.2920  111.1898  
Columns 8 through 14:  
 104.8199  95.1801  85.8546  77.3296  69.6207  62.6700  56.4092
```



Numeric output of the
Predator-Prey Model

The line plot of the
Predator-Prey Model

**A graph is worth a
thousand numbers**

2-D Data and 3-D data

0.0001	0.0002	0.0004	0.0008	0.0016	0.0031	0.0064	0.0128	0.0256	0.0512	0.1024	0.2048	0.4096	0.8192	1.6384	3.2768	6.5536	13.1072	26.2144	52.4288	104.8576	209.7152	419.4304	838.8608	1677.7216	3355.4432	6710.8864	13421.7728	26843.5456	53687.0912	107374.1824	214748.3648	429496.7296	858993.4592	1717986.9184	3435973.8368	6871947.6736	13743895.3472	27487790.6944	54975581.3888	109951162.7776	219902325.5552	439804651.1104	879609302.2208	1759218604.4416	3518437208.8832	7036874417.7664	14073748835.5328	28147497671.0656	56294995342.1312	112589990684.2624	225179981368.5248	450359962737.0496	900719925474.0992	1801439850948.1984	3602879701896.3968	7205759403792.7936	14411518807585.5872	28823037615171.1744	57646075230342.3488	115292150460684.6976	230584300921369.3952	461168601842738.7904	922337203685477.5808	1844674407370955.1616	3689348814741910.3232	7378697629483820.6464	14757395258967641.2928	29514790517935282.5856	59029581035870565.1152	118059162071741130.2304	236118324143482260.4608	472236648286964520.9216	944473296573929041.8432	1888946593147858083.6864	3777893186295716166.3728	7555786372591435332.7456	15111572745182870665.4912	30223145490365741330.9824	60446290980731482661.9648	120892581961462924673.9296	241785163922825849347.8592	483570327845651698695.7184	967140655691303397391.4368	1934281311382606794782.8736	3868562622765213989565.7472	7737125245530427979131.4944	15474250491060855958262.9888	30948500982121711916525.9776	6189700196424342383311.9552	12379400392848684766623.9104	24758800785697369533248.8208	49517601571394739066496.6416	990352031427894781329923.2832	198070406285578956265985.5664	39614081257117791247197197.1328	79228162514235583474395394.2656	158456325028435168948790788.5312	316912650056870337897581577.0624	6338253001137407177951631554.1248	12676506002274814355913263108.2496	25353012004549628711826626216.4992	5070602400909925742373253243.9984	10141204801819851484746064887.9968	20282409603639702974893213775.9936	4056481920727940594978736751.9872	81129638414558811899774735023.9744	162259276829117637999748470047.9488	324518553658235275999488940095.8976	649037107316471551998977880191.7952	1298074214632423103997957760383.5904	2596148429264846207995915520767.1808	5192296858529692415991831041534.3616	10384593717259384231983662083068.7232	20769187434518768463967324161336.4464	41538374869037536927334828322672.8928	83076749738075073854666645245345.7856	16615349947615014770933329049070.5712	33230699895230029541866658098141.1424	66461399790460059083733316182282.2848	13292279958092001816746662436456.5696	26584559916184003633493324736912.1392	53169119832368007266886849473824.2784	106338239664736014537773698947648.5568	21267647932947202907553739795299.1136	425352958658944058151074755915598.2272	85070591731788811632214151183117196.4544	17014118346357363264222822362739.9088	34028236692714726528445644725479.8176	68056473385429453056891288450959.6352	136112946770848906113778177370191.2704	27222589353169781222557555440398.5408	54445178706339562445115115110796.0816	1088903574127191244902221103915592.1632	21778071482543824898044222078395.3264	43556142964087647796088444444751.6528	87112285928175295592177388889503.3056	17422451836635059114435437477776.6112	34844903673270118228888755555552.2224	69689807346540236457777511111104.4448	13937961469080447311555522222220.8896	27875922938160894622111111111111.7792	55751845876321789242222222222222.15584	11150369172643357848444444444444.31168	22300738345286715796888888888888.62336	44601476690573431593777777777776.12472	89202953381146863117755555555552.24944	178405906762293723715511111111104.49888	356811813524587447431111111111108.99776	713623627049174894862222222222217.99552	142724725409834978972444444444435.99104	285449450819669957954888888888871.98208	570898901639339915909777777777743.96416	114179780327867983919555555555587.92832	228359560655735967831111111111175.85664	45671912131147193566222222222235.71328	91343824262294387132444444444471.42656	18268764452458874468488888888894.85312	36537528904917748937777777777789.70624	73075057809835497875555555555579.41248	146150115619675957711111111111158.82496	29230023139135191542222222222236.64992	58460046278270383084444444444473.29984	11692009256554076616888888888894.59968	23384018513108153333777777777789.19936	46768037026216306675555555555578.39872	93536074052432613351111111111156.79744	18707214810486522702222222222231.59488	37414429620973045404444444444463.18976	74828859241946090808888888888926.37952	14965771848392181617777777777785.15904	29931543696784323235555555555570.31808	59863087393768646471111111111140.63616	119726174787537292822222222222281.27232	239452349575074565644444444444162.54464	478904699150148911111111111111325.08928	95780939830029782222222222222265.17856	191561877660195764444444444444130.35712	38312375532039152888888888888926.71424	7662475106407830577777777777785.42848	15324950212015661555555555555570.85696	30649900424031323111111111111141.71392	61299800848062646222222222222283.42784	122599607361252892444444444444166.85568	24519921472250578488888888888933.71136	4903984294450115777777777777787.42272	9807968588900231555555555555574.84544	19615937177800461111111111111149.69088	3923187435560092222222222222239.38176	7846374871120184444444444444478.76352	15692749542240368888888888888956.52704	3138549908448073777777777777793.05408	6277099816896147555555555555586.10816	12554199633792295111111111111172.21632	2510839926758459222222222222244.43264	5021679853516918444444444444488.86528	1004335970703783688888888888897.73056	2008671941407567377777777777794.46112	4017343882815134755555555555588.92224	8034687765630269511111111111177.84448	1606937553126053922222222222235.68896	3213875106252107844444444444471.37792	642775021250421568888888888894.75584	1285550042500843137777777777789.51168	2571100085001686275555555555579.02336	5142200170003372551111111111158.04672	1028440034000714510222222222236.09344	205688006800142902044444444472.18688	411376013600285804088888888894.37376	8227520272005716081777777777788.74752	1645504054401143216555555555577.49504	3291008108802286433111111111154.99008	658201621760457286222222222239.98016	1316403243520915724444444444479.96032	263280648704183144888888888895.92064	526561297408366289777777777791.84128	1053122594816324797555555555583.68256	2106245189632649595111111111167.36512	421249037926529919022222222234.73024	842498075853059838044444444469.46048	168499615111619176088888888898.92096	336999230223239352177777777797.84192	673998460446478704355555555595.68384	1347996920892777408711111111191.36768	2695993841785554817444444444182.73536	539198768357110963888888888964.71072	107839753671421927777777777799.42144	215679507342845555555555555598.84288	431359014685691111111111111197.68576	86271802937138222222222222239.37152	172543605874264444444444444478.74304	3450872117484888888888888895.48608	6901744234969777777777777790.97216	13803484679939555555555555581.94432	27606969359879111111111111163.88864	5521393871975822222222222232.77728	11042787549516444444444444485.55456	2208557509903288888888888897.108912	4417115019806577777777777794.217824	8834230039613155555555555588.435648	17668460779226311111111111176.871296	3533692155845262222222222233.742592	7067384311690524444444444467.485184	1413476862338104888888888894.970368	2826953724680089777777777799.940736	5653907449360179555555555599.881472	11307814898720359111111111199.762944	2261562979744071822222222239.525888	4523125959488143644444444479.051776	904625191897632728888888898.103552	1809250383795265457777777796.207104	3618500767590530915555555592.414208	7237001535181061831111111184.828416	1447400307176212362222222236.656832	289480061432242472444444473.313664	578960122864484944888888896.627328	1157920245288969897777777793.254656	2315840490577939795555555586.509312	4631680981155879591111111173.018624	926336196231175918222222236.037248	185267239462235184444444472.074496	370534478924471368888888894.148992	741068957848942737777777798.297984	1482137917497885475555555596.595968	2964275834995770951111111193.191936	592855166999154190222222236.383872	118571033999828838044444472.767744	237142067999657676888888895.535488	474284135999315353777777791.070976	948568271998630707555555582.141952	1897136543997261415111111164.283904	379427308799452283022222232.567808	75885461759890456604444465.135616	151770923519780913208888890.271632	3035418470395618241777777780.543264	607083694079123648355555560.108528	1214167388158247366711111120.217056	242833477637647473344444440.434112	485666955275294946688888880.868224	971333910550589893777777780.736448	194266780110117978755555560.472896	388533560220235957511111120.945792	777067120440471915022222241.891584	155413424080094383044444483.783168	31082684816018876608888896.766336	621653696320377532177777783.532672	124330739264075506435555567.065344	2486614785281510128711111134.130688	49732295705630202574444428.261376	99464591411260405148888856.522752	198929182822420810287777783.045504	397858365644841602175555567.091008	795716731289683204351111134.181016	159543346257936640870222241.362032	31908669251587321714444482.724064	63817338503174643528888865.448128	127634671003492870577777780.896256	255269342006985741155555561.792512	510538684013971423111111131.585024	10210773680279428462222242.170048	20421547360558856944444484.340096	4084309472111771388888868.680192	8168618944223542777777787.360384	1633723788844708555555574.720768	3267447577689417111111134.441536	653489515537883422222248.883072	1306979031075766844444497.766144	261395806215153368888895.532288	5227916124303067377777781.064576	1045583224660613555555562.129112	2091166449321227111111134.221824	418233289864245422222248.443648	836466579728490844444496.887296	1672933159456881711111134.774592	334586631857376342222249.549184	669173263714752684444499.098368	1338346467429505377777780.196736	2676692934859010755555560.393472	5353385869718021511111130.786944	107067717397000432222241.573888	214135434794000864444483.147776	428270869588001728888866.295552	8565417391760034577777781.191104	1713083579152007155555562.382208	342616715830401411111134.764416	68523343166080282222249.528832	137046682332160564444499.057664	274093364664321128888898.115328	548186729328642257777781.030656	1096373458657244515555562.061312	21927469173144890222241.122624	438549383462897804444482.245248	87709876692579560888864.490496	1754197533851591217777780.980992	3508395067703182435555561.961984	7016790135406364871111133.923968	140335802740127297444487.847936	280671605480254594888895.695872	5613432109605091897777781.391744	1122686421921018395555562.783488	2245372843842036791111134.566976	449074568768407358222249.133952	898149137536814716444498.267904	179629827507362942888896.535808	359259655014725885555561.071616	718519310029451771111134.113232	143703862005891354222249.226464	287407724011782708444498.452928	574815448023565416888896.905856	1149630880071130837777781.811712	2299261760042216675555563.623424	4598523520084433351111134.246848
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Cognition Visualization

Visualization is a cognitive process performed by humans in forming a mental image of a domain space



Human Cognition

- **Most effective way human takes in information, digest information, making decision, and being creative.**
- **The most important among the five senses**

What is Scientific Visualization

Scientific visualization is an interdisciplinary branch of science primarily concerned with the visualization of three dimensional phenomena (meteorological, medical, biological etc) where the emphasis is on realistic rendering of volumes, surfaces, illumination sources with a dynamic (time) component.

Friendly (2008), also

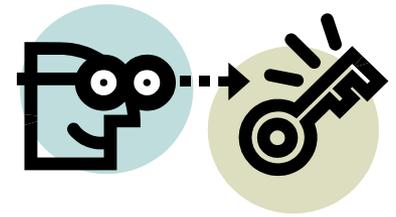
http://en.wikipedia.org/wiki/Scientific_visualization



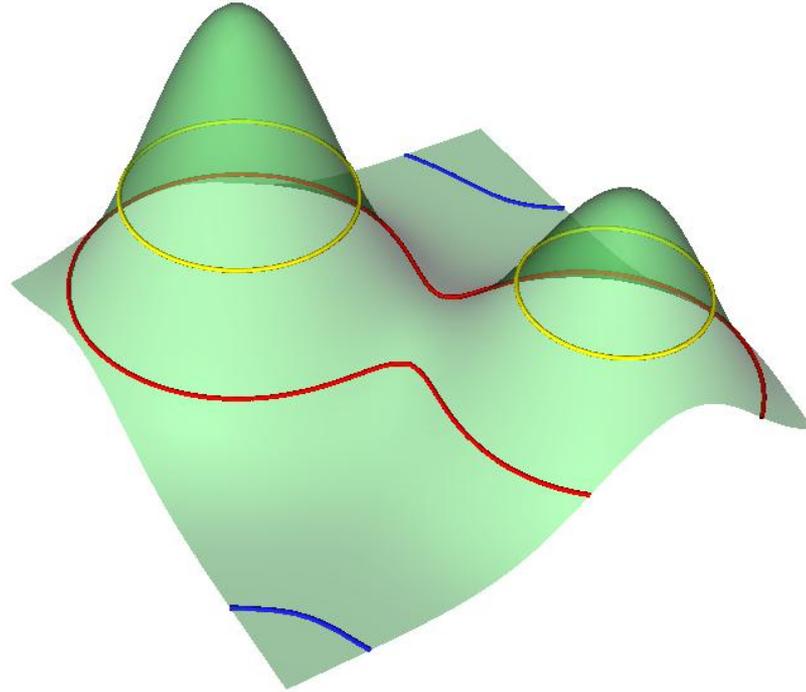
At Information
Age

Goals of Scientific Visualization

- **Provide scientific insight**
- **Effective communication**

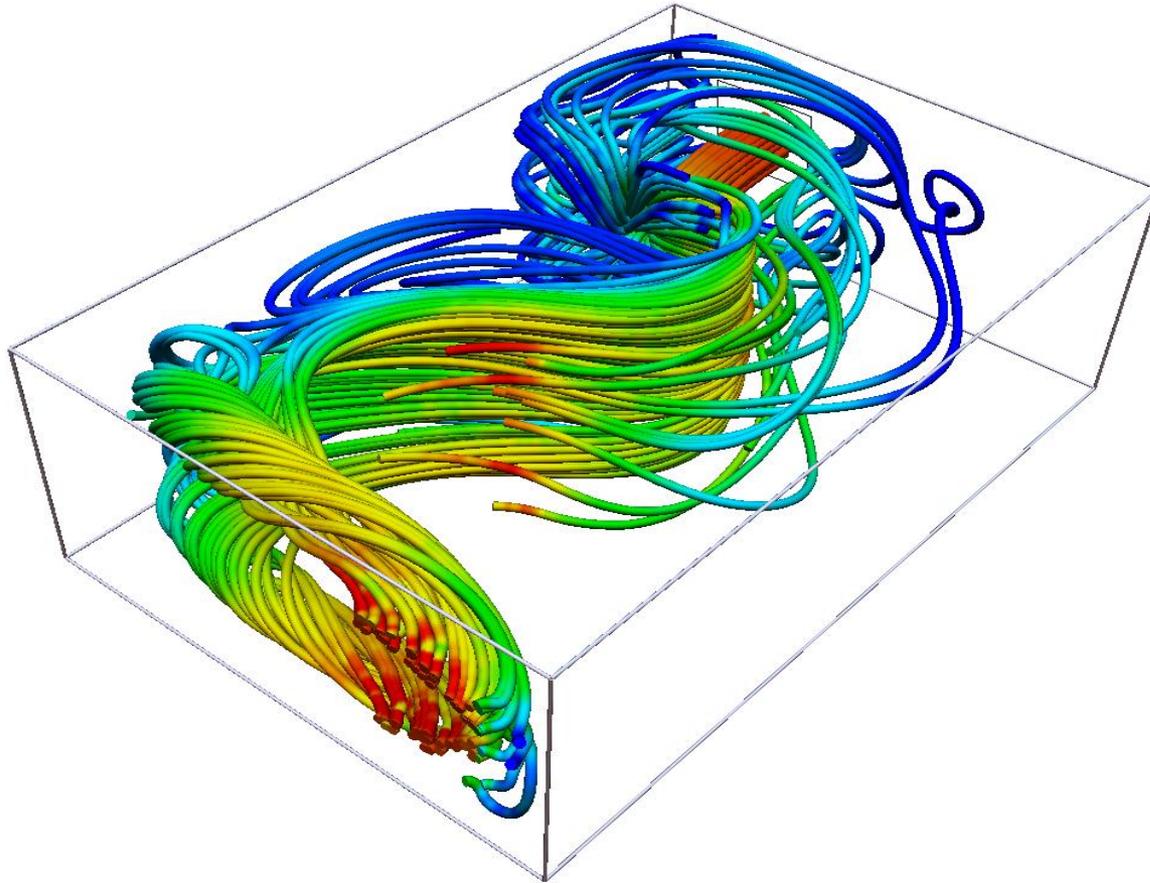


Example: Scalar Data



- Height plot of a 2-D data, and the contour lines
- In topology, the data are of 2-D: a curved surface
- The data are mapped into 3-D geometric space in computer memory
- The data are then rendered onto a 2-D visual plane on a screen

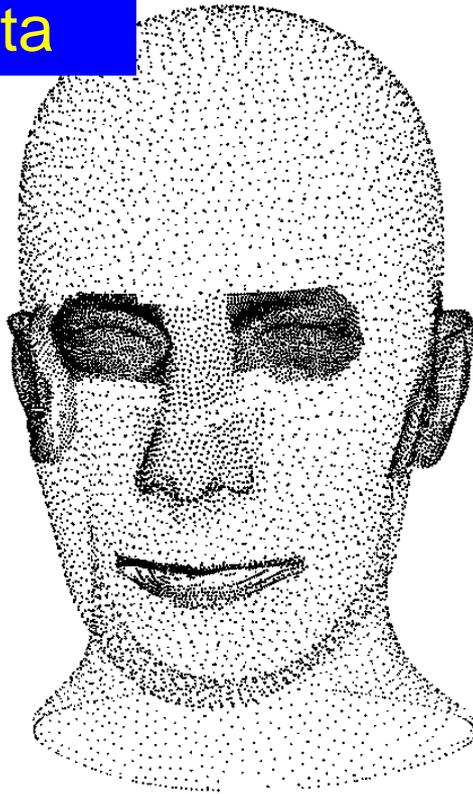
Example: Vector Data



Stream tubes: show how water flows through a box with an inlet at the top-right and an outlet at the lower-left of the box; the data are (1) 3-D volume, (2) vector

Example: Unstructured Data

Sampled data



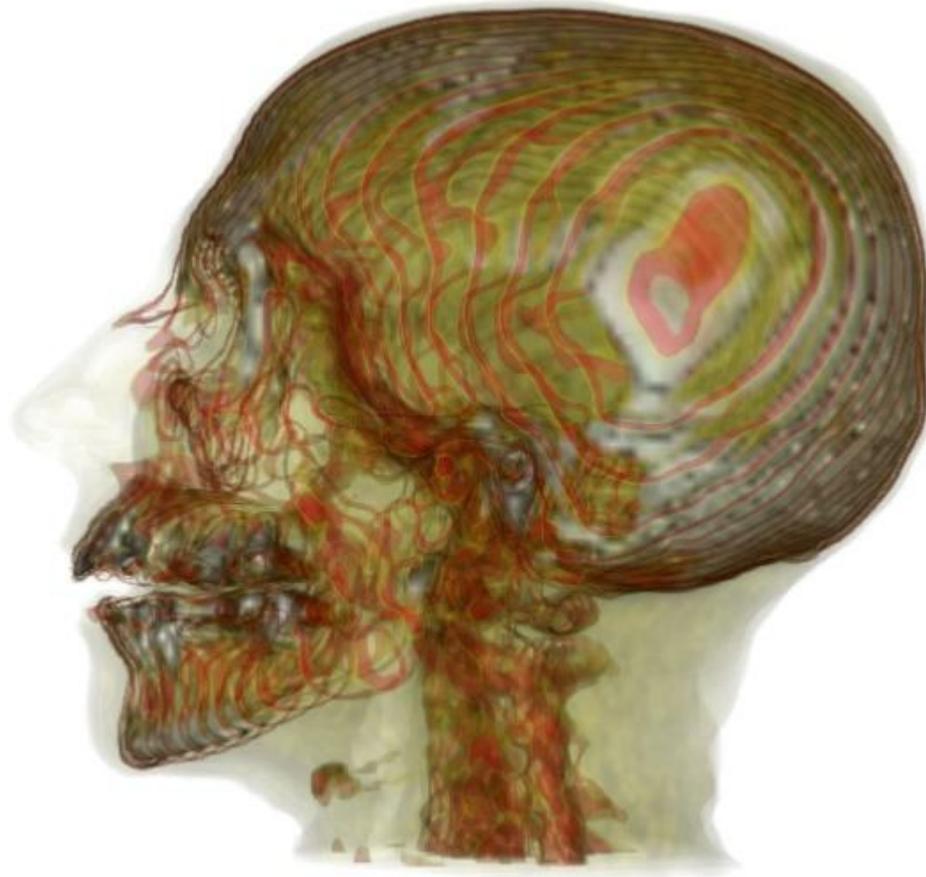
Rendered data



Scattered Point Cloud and Surface Reconstruction.

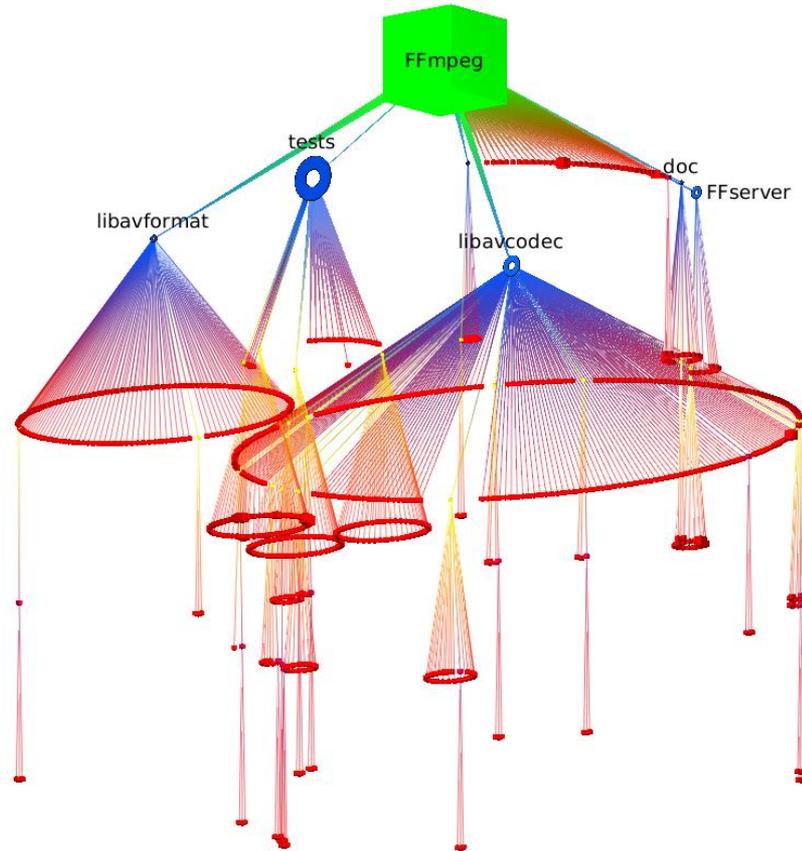
The data are a set of sampled data points in 3-D space, and the distribution of data is unstructured; need to reconstruct the surface from the scattered points

Example: Volume Visualization



3-D data of human head. Instead of showing a subset (e.g, a slice as in CT images), the whole 3-D data are shown at once using the technique of Opacity Transfer Function

Example: Information Visu.



- The file system of FFmpeg, a popular software package for encoding audio and video data into digital format
- Information, such as name and address, can not be interpolated; the visualization focuses on the relations.

An attempt at visualizing the Fourth Dimension: Take a point, stretch it into a line, curl it into a circle, twist it into a sphere, and punch through the sphere.

--Albert Einstein--

Difficulty in visualizing the fourth dimension



(Nov. 12, 2013 Stops Here)

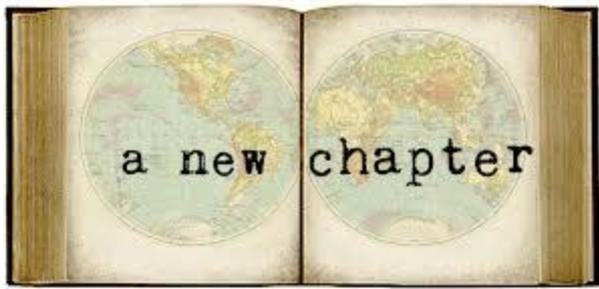


(Dec. 03, 2013 Starts Here)

Review: IF and DNFL

Question: What final value of `a` is printed out?

```
a = 0;
c = 0;
for m = 1:3
    for n = 1:3
        if (m <= n)
            c = c + 1;
        end
        if (c > a)
            a = a + 1;
        end
    end
end
a
```



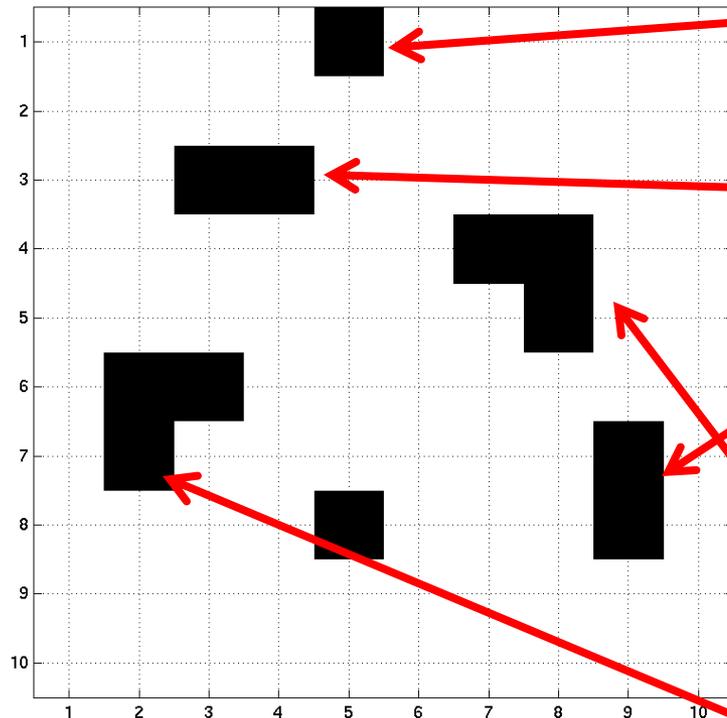
Section 3 Chapter 2

Image As a 2-D Array

(Dec. 03, 2013)

Exercise: Tumor Finder

- Implement a MATLAB program to find tumors in an X-ray image, a 10 X 10 2-D array, or 100 pixels.
- A positive pixel has a value of 1, indicated by black
- A negative pixel has a value of 0, indicated by white



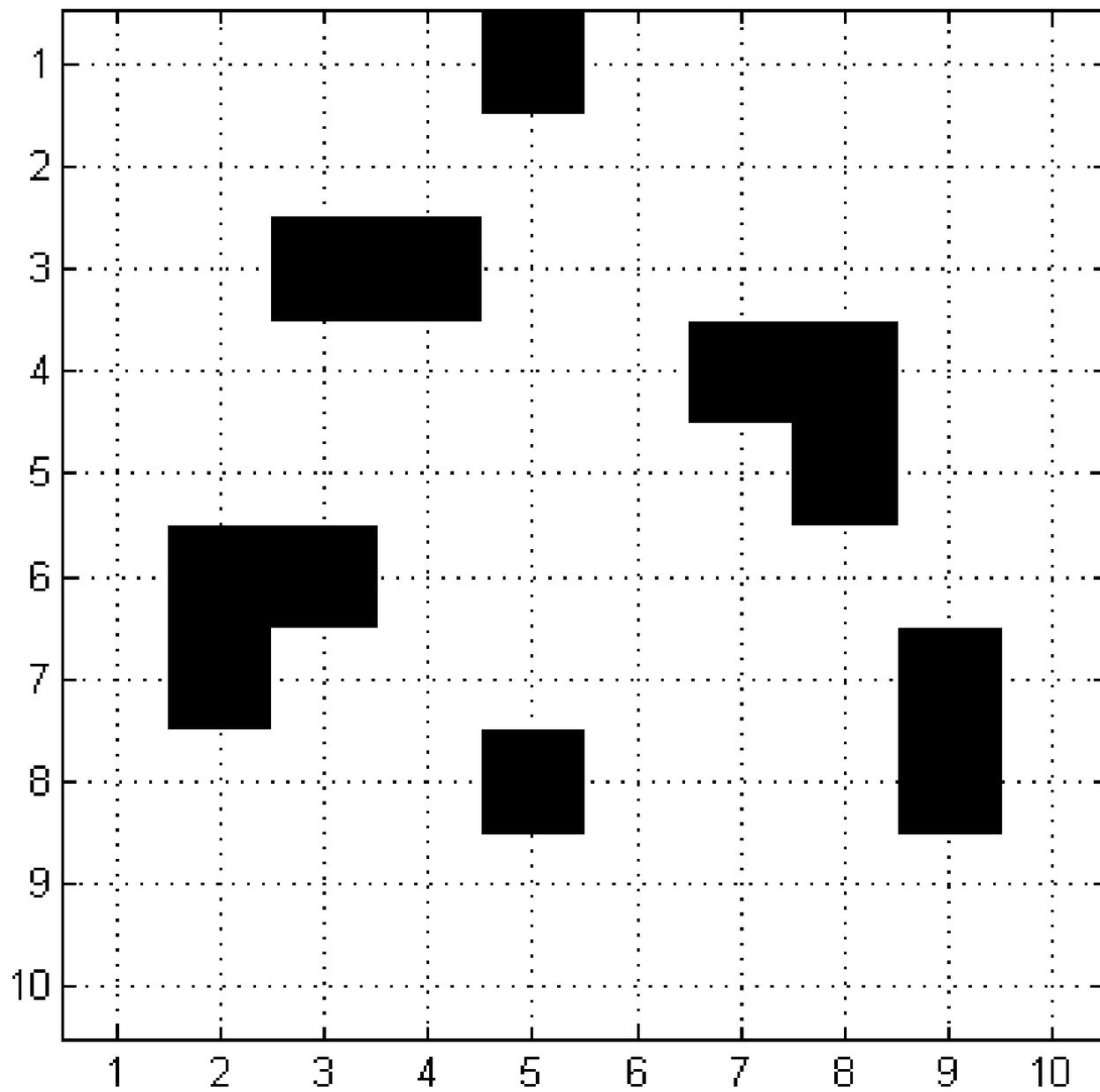
Isolated single pixel :
noisy feature

Isolated two-in-row :
benign tumor

Isolated two-in-column :
benign tumor

Right Bend :
malignant tumor

Left Bend :
malignant tumor



Exercise: Tumor Finder

- **How the image is created (“tumor1.m”)**

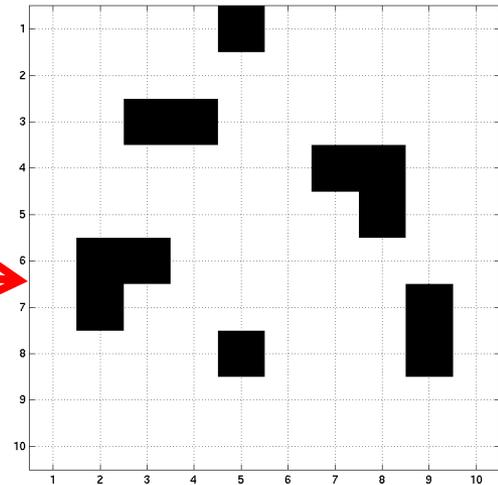
```
tum(10,10)=0 %initiate the tumor variable
tum(1,5)=1   %define a noise feature
tum(8,5)=1   %define another noise featurer
tum(3,3)=1   %define a benign tumor
tum(3,4)=1
tum(7,9)=1   %define a begin tumor
tum(8,9)=1
tum(6,2)=1   %define a malignant tumor (left bend)
tum(6,3)=1
tum(7,2)=1
tum(4,7)=1   %define another malignant tumor (right bend)
tum(4,8)=1
tum(5,8)=1

mycolormap=[1,1,1;0,0,0] %define a color map
colormap(mycolormap)     %call my color map
imagesc(tum)             %show the image of the 2-D data
axis square              %square axis
grid on                  %show data grid
set(gca,'XTick',[1:10],'YTick',[1:10])
```

Exercise: Tumor Finder

```
0 0 0 0 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 1 0 0
0 0 0 0 0 0 0 1 0 0
0 1 1 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0 1 0
0 0 0 0 1 0 0 0 1 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
```

2-D data



Image

In real applications, the doctor takes the digital image, and analyze it.

Exercise: Tumor Finder

Question:

Use a MATLAB program to find how many positive pixels (with value of 1) in the image?

To save your time

- (1) Download the “tumor1.m” file from class website at
- (2) Open this file in MATLAB, and add additional program code to it

Algorithm: (scan the image, count all positive pixels)

For all (i,j)

count `image(i,j) == 1`

Exercise: Tumor Finder

Answer:

```
-----  
%count how many positive pixels in the image (2-D array)  
count_pos=0;  
for i=[1:10]  
    for j=[1:10]  
        if (tum(i,j) == 1)  
            count_pos=count_pos+1;  
        end  
    end  
end  
  
disp('Number of Positive Pixels=')  
count_pos  
-----
```

Exercise: Tumor Finder

Question:

Use a MATLAB program to find how many two-in-row in the image?

Algorithm:

For all (i,j)

count $\text{image}(i,j) == 1$ and $\text{image}(i,j+1) == 1$

Exercise: Tumor Finder

Answer:

```
-----  
%count how many two-in-row  
count_two_row=0;  
for i=[1:10]  
    for j=[1:9]  
        if (tum(i,j) == 1 && tum(i,j+1)==1)  
            count_two_row=count_two_row+1;  
        end  
    end  
end  
  
disp('Number of two-in-row=')  
count_two_row  
-----
```

Exercise: Tumor Finder

Question:

Use a MATLAB program to find how many two-in-column in the image?

Algorithm:

For all (i,j)

count $\text{image}(i,j) == 1$ and $\text{image}(i+1,j) == 1$

Exercise: Tumor Finder

Answer:

```
-----  
%count how many two-in-column  
count_two_col=0;  
for i=[1:9]  
    for j=[1:10]  
        if (tum(i,j) == 1 && tum(i+1,j)==1)  
            count_two_col=count_two_col+1;  
        end  
    end  
end  
  
disp('Number of two-in-col=')  
count_two_col  
-----
```

Exercise: Tumor Finder

Question:

Use a MATLAB program to find how many left bend in the image?

Algorithm:

For all (i,j)

count $\text{image}(i,j) == 1$ and $\text{image}(i,j+1) == 1$ and $\text{image}(i+1,j) == 1$

Exercise: Tumor Finder

Answer:

```
-----  
%count how many left bend  
count_left_bend=0;  
for i=[1:9]  
    for j=[1:9]  
        if (tum(i,j) == 1 && tum(i,j+1)==1 && tum(i+1,j)==1)  
            count_left_bend=count_left_bend+1;  
        end  
    end  
end  
  
disp('Number of left_bend=')  
count_left_bend  
-----
```

Exercise: Tumor Finder

Question:

Use a MATLAB program to find how many right bend in the image?

Algorithm:

For all (i,j)

count $\text{image}(i,j) == 1$ and $\text{image}(i,j+1) == 1$ and
 $\text{image}(i+1,j+1) == 1$

Exercise: Tumor Finder

Answer:

```
-----  
%count how many right bend  
count_right_bend=0;  
for i=[1:9]  
    for j=[1:9]  
        if (tum(i,j) == 1 && tum(i,j+1)==1 && tum(i+1,j+1)==1)  
            count_right_bend=count_right_bend+1;  
        end  
    end  
end  
  
disp('Number of right_bend=')  
count_right_bend  
-----
```

Exercise: Tumor Finder

Question:

Use a MATLAB program to find how many malignant tumors in the image?

Algorithm:

Number of Left Bend + Number of Right Bend

Exercise: Tumor Finder

Answer:

```
-----  
%find the number of malignant tumors  
    count_malig=count_left_bend + count_right_bend;  
    disp('Number of malignant tumors=')  
    count_malig  
-----
```

Exercise: Tumor Finder

Question:

Use a MATLAB program to find how many benign tumors in the image?

Algorithm:

Number of Two-in-row + Number of Two-in-column – Number of Malignant Tumor X 2

Exercise: Tumor Finder

Answer:

```
-----  
count_benign=count_two_row + count_two_col -  
    count_malig*2;
```

```
disp('Number of benign tumors=')  
count_benign
```

```
-----
```

Exercise: Tumor Finder

Refer to “tumor2.m” for the final program



The End of Chapter 2



**(December 03, 2013 Stops
Here)**



**(December 05, 2013 Starts
Here)**



Section 3

Chapter 3

Color and Colormap

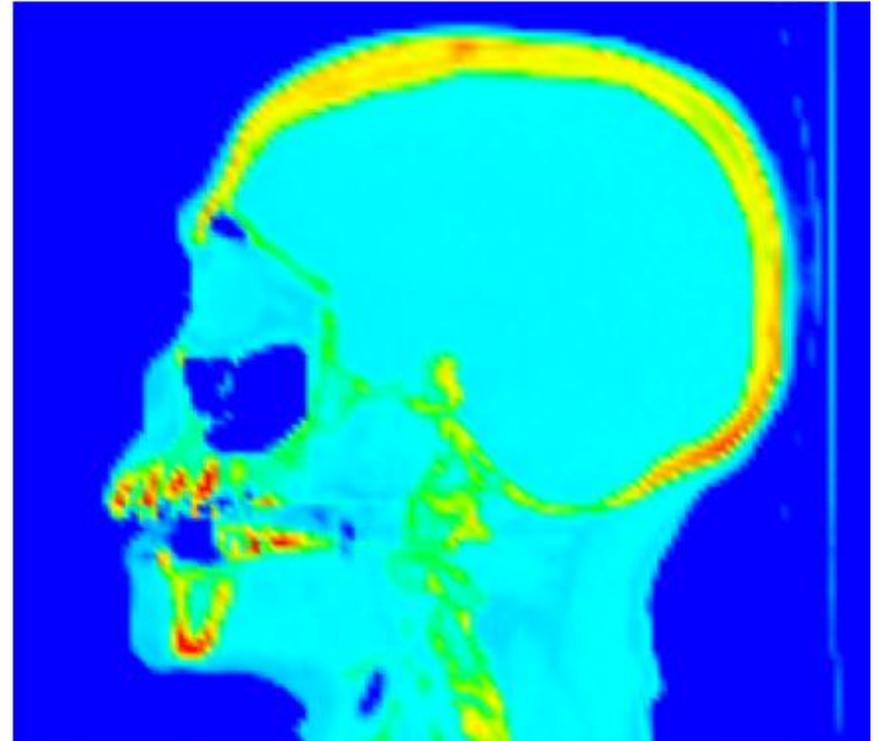
(Dec. 05, 2013)

Colormap



a)

Gray-scale Colormap



b)

Rainbow Colormap

Color

Question:

Do scientific data have intrinsic colors?

For example, hourly temperature reading at Fairfax?

For example, wind speed in a tornado?

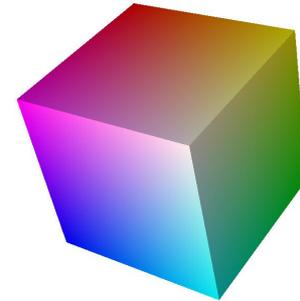
Color

Answer:

- Most scientific data concern about value, strength, or intensity. They have no color
- Color in scientific images are called pseudo-color, which use the color in the visualization as a cue to indicate the value of the data
- For example, red for high temperature, and blue for low temperature

Computer Color

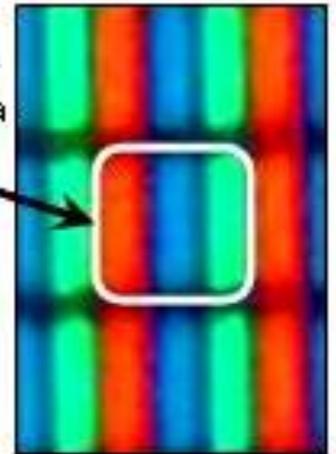
- A special type of vector with dimension $c=3$
 - The value of a color = (R, G, B)
- RGB system: convenient for computer
 - R: red
 - G: green
 - B: blue
- HSV system: intuitive for human
 - H: Hue (the color, from red to blue)
 - S: Saturation (purity of the color, or how much is mixed with white)
 - V: Value (the brightness)



Computer Color

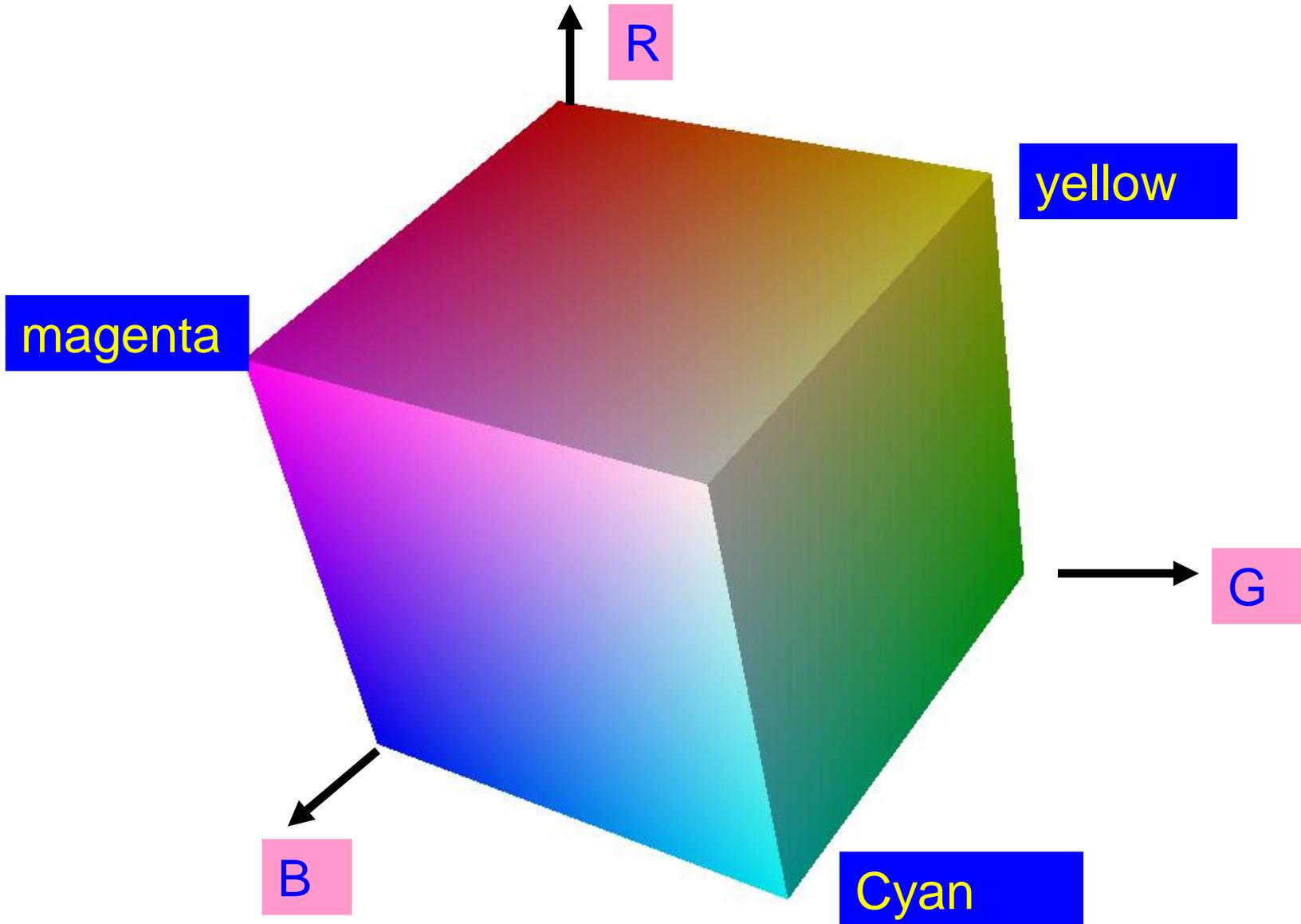
- A pixel of a LCD monitor contains three sub-pixels: R, G, B
- Each sub-pixel displays the intensity of one primary color
- Modern LCD monitor uses 1 Byte or 8 bits to determine the intensity of the primary color
 - Each primary color has 255 intensity levels
- The number of colors of a LCD monitor
= $255 \text{ (red)} \times 255 \text{ (green)} \times 255 \text{ (blue)}$
= 16,581,375
Or 16 million different colors
- The monitor shows true color
 - Human eyes discern 10 million color

The red, blue
and green sub-
pixels forming a
color pixel



Close-up of an
LCD display panel

RGB Cube



RGB System

- Every color is represented as a mix of “pure” red, green and blue colors in different amount
- Equal amounts of the three colors give gray shades
- RGB cube
 - main diagonal line connecting the points $(0,0,0)$ and $(1,1,1)$ is the locus of all the grayscale value
- Color $(0,0,0)$: dark
- Color $(1,1,1)$: white
- Color $(0.5,0.5,0.5)$: gray level between dark and white
- Color $(1,0,0)$: Red
- Color $(0,1,0)$: Green
- Color $(1,1,0)$: ?
- $(1,0,1)$: ?
- $(0,1,1)$: ?

IMAGE method

How to visualize a 2-D data as an image?
-Use “imagesc” method in Matlab

Question: Visualize the following 2-D array

```
myimage = [1  0  1  0  1;  
           0  1  0  1  0;  
           1  0  1  0  1;  
           0  1  0  1  0;  
           1  0  1  0  1]
```

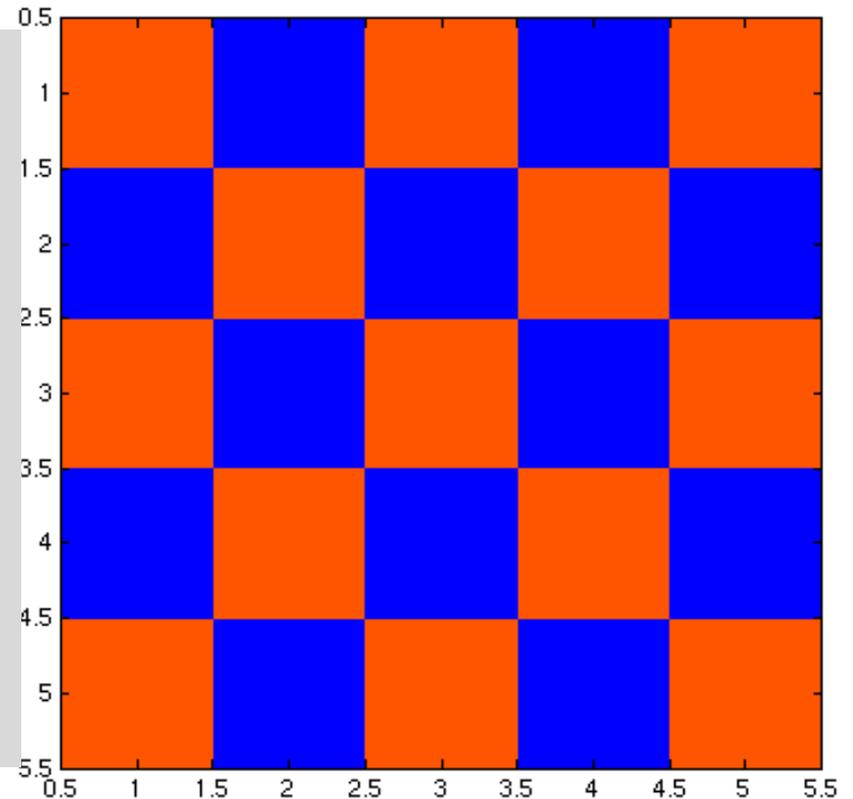
IMAGE method – “imagesc”

Answer:

```
myimage = [1  0  1  0  1;  
           0  1  0  1  0;  
           1  0  1  0  1;  
           0  1  0  1  0;  
           1  0  1  0  1]
```

```
%visualize the 2-D data array  
imagesc(myimage)
```

```
%make the image in a square shape  
Axis square
```



Colormap method – "colormap"

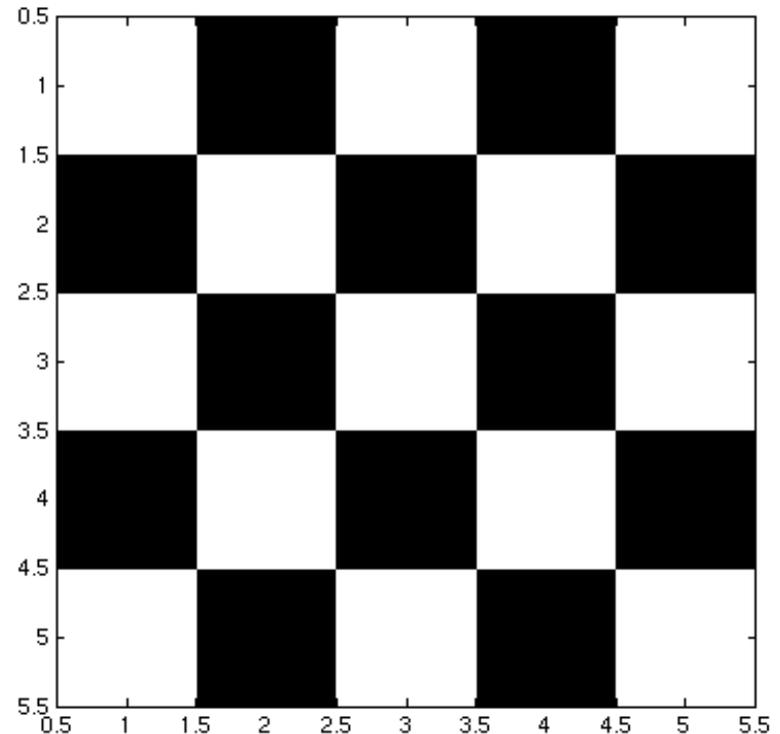
How to change the color to black and white?

Answer:

```
%define a colormap with only  
two colors
```

```
mycolormap=[0,0,0; 1,1,1]
```

```
colormap(mycolormap)
```



Colormap method – "colormap"

Question:

For the colormap defined below:

```
>mycolormap = [ 0, 0, 0;  
                0.5, 0.5, 0.5;  
                1 1 1;  
                1 0 0;  
                1 1 0;  
                0 0 1]
```

How many colors in total are defined in mycolormap? What are these colors?

Colormap method – "colormap"

Answer:

Six colors in total. They are (1) black, (2) gray, (3) white, (4) red, (5) magenta, and (6) blue, respectively.



The End of Chapter 3



The End of Section 3:

Visualization

(Dec. 05, 2013 ends Here)