

## Introduction to Image Processing

Cmput306

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## Image Processing: What is it?

- How to represent, store and display images.
- How images are captured
- Image transforms
- Image filtering, enhancement and restoration
- Image compression

## Related Computation with images:

1. Improving or changing images and movies (image and video processing)
2. analyzing images and movies (computer vision)
3. Finding desired images or movies (image indexing and databases)
4. Acting based on visual information (robotics, vision based HCI)
5. Generating images and movies (graphics and animation)
6. Any others????

## Image Processing: **NOT!**

“How can I use Corel PhotoPaint™ to turn the sky green?”



## Image Processing: NOT!

## Image Processing: NOT!



Champion **TUROK®: DINOSAUR HUNTER** player, "Gramps," recommends Intense 3D Voodoo

## Image representation

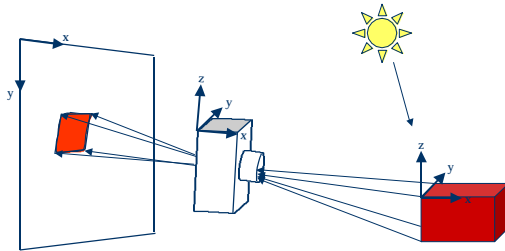
000 007 073 038 055 076 008 050 074 004 043 046 006 050 023  
047 109 107 110 107 110 110 120 120 124 124 124 124 124 123  
047 125 130 130 127 121 117 142 131 133 134 141 140 144 135  
051 139 143 139 147 134 140 009 127 144 139 144 130 181 149  
004 136 181 148 147 138 003 001 004 009 138 146 161 161 136  
043 144 145 139 134 171 124 191 047 030 171 145 175 144 163  
025 161 174 170 147 049 200 193 110 009 100 130 173 171 171  
011 091 181 185 177 028 078 060 041 006 073 180 167 204 121  
017 091 004 008 004 013 190 184 139 024 000 004 113 137 124  
005 006 077 070 001 011 111 171 071 004 030 07 000 003  
013 008 074 039 027 037 141 129 002 028 033 011 072 079 005  
012 045 002 011 012 010 000 007 011 022 027 006 078 071 008  
011 037 004 004 001 026 025 000 006 006 023 071 070 000 000  
011 000 077 007 007 003 004 147 140 030 023 007 045 076 007  
012 049 076 039 030 028 174 197 182 000 021 021 121 141 002  
013 039 111 072 020 078 200 211 182 061 049 030 043 000 106  
007 025 027 002 027 101 180 120 100 004 016 011 017 023 001  
011 061 072 010 027 014 000 006 002 027 045 011 016 042 044  
014 041 047 011 010 000 000 010 024 007 016 041 013 030 027  
013 093 106 017 010 027 030 042 012 001 043 013 014 020 027  
019 040 029 023 018 024 011 020 011 010 026 017 012 017 014  
027 042 100 040 010 010 011 011 010 000 017 000 027 013  
027 028 018 030 020 012 017 010 000 011 007 015 008 010 024  
017 018 008 010 011 010 010 000 000 011 007 010 005  
022 013 037 043 126 123 122 000 005 008 007 010 010 011 008  
018 008 000 010 023 003 100 120 005 012 011 010 010 000 006  
017 010 010 007 007 014 100 118 007 016 011 010 005 000 006  
013 010 012 014 002 076 037 011 019 024 020 000 003 013 004  
018 010 008 011 010 010 010 011 011 007 008 007 000 010 003  
011 000 010 010 011 011 014 000 008 007 005 005 000 000 002  
014 007 000 011 007 010 000 007 000 007 001 000 007 003  
000 011 013 010 011 017 017 010 010 011 011 011 011 000 005  
007 007 073 010 010 010 000 000 074 004 043 006 000 030 023  
002 181 174 172 107 049 200 193 110 009 100 130 173 171 171



## Image representation and display: Perceptual /= numerical

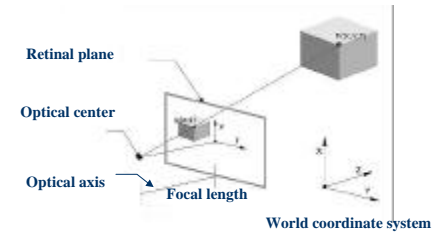


## How the 3D physical world is captured on a 2D image plane

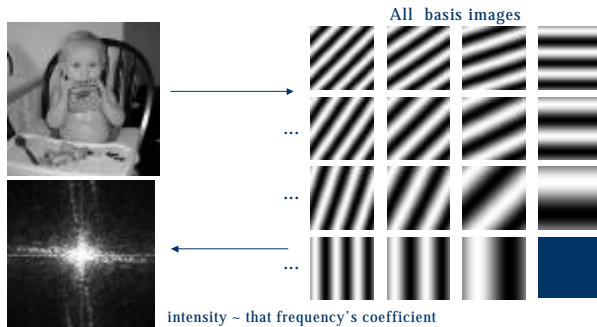


## How the 3D physical world is captured on a 2D image plane

Pinhole camera model



## Fourier transform:



## Mathematically: Discrete FT in matrix form

$$\begin{bmatrix} F(0) \\ F(2) \\ \vdots \\ F(N-1) \end{bmatrix} = \frac{1}{\sqrt{N}} \begin{bmatrix} 1 & 1 & \cdots & 1 \\ 1 & e^{\frac{j2\pi}{N}} & \cdots & e^{\frac{j2\pi(N-1)}{N}} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & e^{\frac{j2\pi(N-1)}{N}} & \cdots & e^{\frac{j2\pi(N-1)^2}{N}} \end{bmatrix} \begin{bmatrix} f(0) \\ f(2) \\ \vdots \\ f(N-1) \end{bmatrix}$$

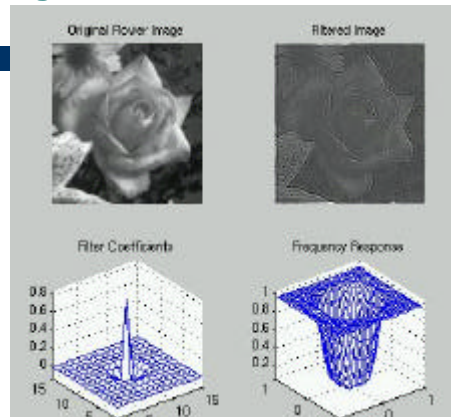
$$F(\mathbf{u}) = \frac{1}{\sqrt{N}} \sum_{x=0}^{N-1} f(x) e^{-\frac{j2\pi ux}{N}}$$

• Note:  $u=A\mathbf{x}$  form!

Inverse:  $A^T$ \*

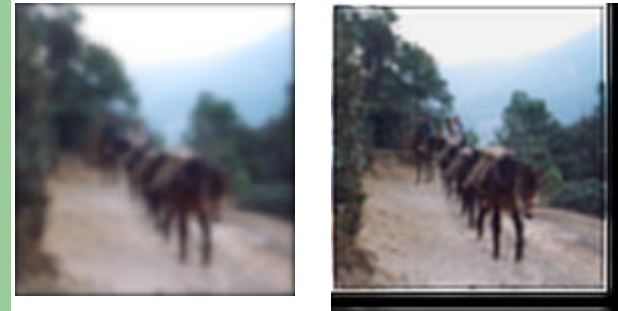
## Filtering: High Pass

- Sharp cutoff frequency
- Why is filtered image so dark??

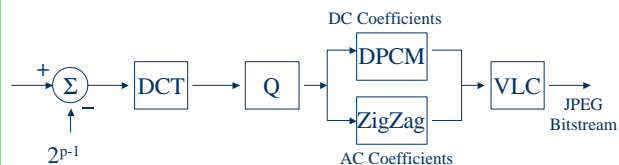


## Example: F-t based restoration

- Unfocused image
- Restored image

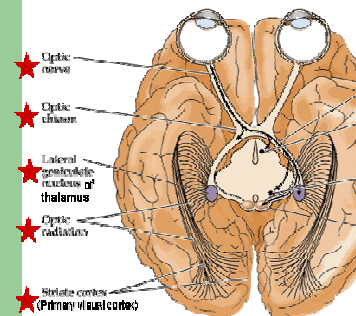


## Image Compression: jpeg



- 8x8 DCT transform (as defined in the previous lecture)
- Q: Quantization of DCT coefficients
- Predictive coding (DC) or Zig-Zag scan (AC) of Quantized DCT coefficients
- Variable length coding of the quantized AC and DC coefficients
- Decoding performs operations in reverse

## Biological Image Processing



- Eye transforms light into nerve impulses
- Optic chiasm splits left and right visual fields
- LGN: Exact function unknown. May have to do with stereo.
- V1 (Striate cortex) performs spatial filtering / coordinate transforms

## Outlook: Visual Computing



## Administrativa

- Text: Gonzalez and Woods "Digital Image Processing" + on-line material provided.
- Homework: 4 labs and exercises.
  - 45% of grade
- Exams:
  - Midterm 20%,
  - Final 35%

## Administrativa

- Instructor: Martin Jagersand
  - Email: [c306@ugrad.cs.ualberta.ca](mailto:c306@ugrad.cs.ualberta.ca)
  - Office hours M,W after class.
- TAs:
  - Keith Yerex, [keith@cs.ualberta.ca](mailto:keith@cs.ualberta.ca)
  - Neil Birkbeck, [birkbeck@cs.ualberta.ca](mailto:birkbeck@cs.ualberta.ca)
  - Aloak Kapoor, [aloak@cs.ualberta.ca](mailto:aloak@cs.ualberta.ca)
- Course newsgroup: c306
- Course WWW pages:
  - [ugweb.cs.ualberta.ca/~c306](http://ugweb.cs.ualberta.ca/~c306)

## Labs and Exercises

- Practical labs will use Matlab and digital video  
(No scheduled labs in the first week)
- Location: CSC building, advanced syst lab  
(You can also access matlab on ohaton)
- Theoretical exercises of math type.  
(Brush up on linear algebra, calculus and statistics)