Outline of the Lecture

- Image Processing Toolbox (IPT--Matlab).
- Reading Images.
- Displaying Images

**Image Processing Toolbox (IPT)**

(Matlab)

- **IPT** is a collection of functions that extend the capability of the Matlab numeric computing environment and support a wide range of image processing including:
  - Spatial image transformation.
  - Morphological operations.
  - Neighborhood and block operations.
  - Linear filtering and filter design.
  - Transform.
  - Image enhancement and analysis.
  - Deblurring.
  - Region of interest operations.

Coordinate Conventions:

- The result of **sampling** and **quantization** is a **matrix of real numbers**; two ways are used to represent the digital image:
  - **First convention**: this convention is frequently used in image processing books, in which,
    - The image origin is defined to be at \((x, y) = (0,0)\), the next coordinate value along the first row of the image is \((x, y) = (0,1)\).
    - \(x\) ranges from 0 to \(M - 1\) and \(y\) ranges from 0 to \(N - 1\) in integer increment.
  - **Second convention**: this convention is used in IPT Matlab toolbox, the notation \((r,c)\) to indicate rows and columns.
    - The origin of the coordinate system is at \((r,c) = (1,1)\).
    - \(r\) ranges from 1 to \(M\) and \(c\) ranges from 1 to \(N\) in integer increment.

• IPT documentation refers to the coordinates as **pixel** coordinates or **spatial** coordinates.

**Matrix notation of the digital image**:

- Representations of digital image functions:
  
  **1. Image processing books matrix representation.**

\[
 f(x, y) = \begin{bmatrix}
 f(0,0) & f(0,1) & \cdots & f(0,N-1) \\
 f(1,0) & f(1,1) & \cdots & f(1,N-1) \\
 \vdots & \vdots & \ddots & \vdots \\
 f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1)
\end{bmatrix}
\]
2. Matlab matrix representation

\[
f(r, c) = \begin{bmatrix}
    f(1,1) & f(1,2) & \ldots & f(1,N) \\
    f(2,1) & f(2,2) & \ldots & f(2,N) \\
    \vdots & \vdots & \ddots & \vdots \\
    f(M,1) & f(M,2) & \ldots & f(M,N)
\end{bmatrix}
\]

- The two representations are equal except for the shift in origin.
- The notation \( f(p, q) \) denotes the element located in row \( p \) and column \( q \).
- \( 1 \times N \) matrix is called a row vector.
- \( M \times 1 \) matrix is called a column vector.
- \( 1 \times 1 \) matrix is scalar.
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Reading Images

- To read an image, use the `imread` command, whose syntax is:
  
  \[ I = \text{imread ('filename')} \]

- This command reads and stores the image in an array \( I \).

  `'filename'` - string containing the complete name (path) of the image file including extension.

Example:

\[
\begin{align*}
>> f &= \text{imread('chestxray.jpg')}; \\
& \quad \text{reads the jpg image ‘chestxray’ into image array.} \\
>> I &= \text{imread(pout.tif')}; \\
& \quad \text{reads and stores the image in an array } I.
\end{align*}
\]

`whos` command:

- `whos` command is used to get information about variable in the workspace.

\[
\begin{align*}
>> \text{whos}
\end{align*}
\]

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Bytes</th>
<th>Class</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>291x240</td>
<td>69840</td>
<td>uint8</td>
<td>-----------</td>
</tr>
</tbody>
</table>

`size` command:

- Function `size` gives the row and column dimensions of an image:

\[
\begin{align*}
>> \text{size(f)}; \\
& \quad \text{ans} = \\
& \quad \quad 1024 \quad 1024
\end{align*}
\]

\[
\begin{align*}
>> [M \quad N] &= \text{size(f)};
\end{align*}
\]

- This syntax returns the number of rows (M) and the number of columns (N) in the image.

- The following table summarizes some ways to get information about an image. These are not specific to the Image Processing Toolbox.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>whos</code></td>
<td>To get information about size, type, and bytes, of all variables.</td>
</tr>
<tr>
<td><code>whos I</code></td>
<td>For information about an image stored in I.</td>
</tr>
<tr>
<td><code>size(I)</code></td>
<td>To get the size of the image stored in I.</td>
</tr>
<tr>
<td><code>class(I)</code></td>
<td>To get type of data stored in I.</td>
</tr>
</tbody>
</table>

Displaying Images

- To display an image, the `imshow` function is used, which has the basic syntax:

  a) `imshow f,G`  
  f- an image, G- the number of intensity levels used to display the image, if G is omitted, it defaults to 256 levels.

  b) `imshow f, [low high]`

  ✓ Displays as **black** all values **less than or equal to low**.
  ✓ Displays as **white** all values **greater than or equal to high**.
  ✓ The values in between are displayed using the default number of levels.

  c) `imshow f,[ ]`
Sets variable \textbf{low} to the \textbf{minimum} value of array \textit{f} and \textbf{high} to its \textbf{maximum} value. This form is useful for images with \textbf{low dynamic range}.

\textbf{pixval} command:

- \textbf{Pixval} is used to display the intensity values of individual pixel \textbf{interactively}: Moving the cursor, the coordinates of the cursor position and the corresponding intensity values are shown.
- \textbf{Pixval} displays \textbf{Red, Green, blue} components, when the image is \textbf{color}.
- If the left button on the mouse is \textbf{clicked} and then held pressed, \textbf{pixval} displays the \textbf{Euclidean distance} between the initial and current cursor location, the syntax is:\textbf{pixval}

\textbf{Example 1}

\begin{verbatim}
>> f = imread ('rose_512.tif'); % read from disk an image
>> whos f % extract basic information about the image
>> imshow (f) % display the image.
• If another image, \textit{g}, is displayed using \textbf{imshow}, Matlab replaces the image in the screen with the new image.
>> figure, imshow (g) % keep the first image and %output a second image.
>> imshow (f), imshow (g) % display both images
\end{verbatim}

\textbf{Example 2}

- Suppose that we read an image \textit{h} and find that using \textbf{imshow (h)} produces the image that has a \textbf{low dynamic range}, to correct:

\begin{verbatim}
>> Imshow (h, [ ]) % improve the image h.
• There are a series of photos that come as part of the image processing toolkit. To get the list of images and credits, you can type:
>> help imdemos
• If you want to view any of these photos, you can use the \textbf{imshow}, which opens a separate window displaying the image. For instance:
\begin{verbatim}
>> imshow('football.jpg');
>> imshow('coins.png');
>> imshow('autumn.tif');
>> imshow('board.tif');
\end{verbatim}
\end{verbatim}