II. Basic Concepts in Display Systems

1. Display

- any system through which (________) is conveyed to people through (________) means

- A book, a painting, or a sign could all be considered “display systems”

- (________) refers to any information which is being conveyed visually.
2. Basic components of a display system

1. Image source
2. Image processing
3. Image storage and transmission
4. Image display
5. Viewer
(1) **An image source**

- might be a real object viewed by an image transducer, a computer program, or a spoken words ....

(2) **Image processing and rendering**

- The basic information from the source **must be processed** in some manner before being delivered to the rest of the display system, and then **must be put into a form** which is suitable for the intended display device.

* rendering: refer to the process of finally changing the image information into the form required by the display
(3) **Image storage, compositing, and transmission**

- digital memory, video tape storage,…

- The image storage portion of the display system may be used simply to delay the delivery of the image information to the viewer, but it may also be an important factor in the image processing and rendering step, and shared by that portion of the system.

- The storage portion also composites multiple sources into the final single image which will be seen by the viewer.

- The composited image must be delivered to the viewer via a transmission channel.
(4) **The display**

• translate the image information between the format in which it is stored and the format used by the display device

(5) **The viewer**

• The viewer is in reality the single most important factor in determining the performance requirements and other factors that define the rest of the system.

• It is of utmost importance to keep in mind that any display system ultimately relies on, and is limited by, the needs and limitations of human vision.

“Display systems are a ( ) interface.”
3. Imaging Concepts

What do we mean by “image” in the first place?

In what form should we expect it to be?

How much information will there be?

At what rate must the image information be conveyed?
“Image” simply means “what people see”.

- Humans see the world in color, can discern motion, in three dimensions.

- Three-dimensional information comes from having two “image receptors” (eyes), each of which actually only captures a two-dimensional view of the world. We gain information about the third dimension through comparing these two views. → The definition of image might be “a two-dimensional visual representation”.

- We draw a distinction between image and reality. The image is not the real object. It contains only the information relating to the appearance of the object.
3.1 Vector-scan and raster-scan systems

(1) vector-scan displays

• Creating a picture through ( ) which come together to form recognizable representations of shapes, objects, and so forth.

• We might create a two-dimensional coordinate system, and order the machine to create the image as follows:
  (a) Draw a red line from point (2,4) to point (4,4)
  (b) Draw a red line from point (2,4) to point (2,0)
  (c) Draw a red line from point (2,2) to point (3,2)

• examples: classical mechanical plotter, analog oscilloscope
(2) Mosaic formation

• Creating a picture through ( ) of pure color next to each other to form the desired shape or pattern.

• We might create a two-dimensional coordinate system, and order the machine to create the image as follows:
  (a) Place a blue tile at (4,3)
  (b) Place a blue tile at (3,2)
  (c) Place a green tile at (1,5)…

• This mosaic formation is actually the basis behind practically all electronic imaging and display systems in use today.
  (1) Information about the image is taken at a number of regularly spaced sampling points
  (2) This information may be processed, translated,… until finally sent to a display.
  (3) Display creates the desired output through controlling each of a regular array of points or cells making up the display’s screen.
• “picture element”, individual elements in the display device which make up the final displayed image

• has a fixed size, shape, and other restrictions

* image credit: [색채과학] (박승옥 외, 국제), p. 96
For each location within the 2-D image space to receive a pixel information, we specify a starting point – the first tile to be placed – and then to proceed through the array in a predefined, regular manner. In a rectangular coordinate system, an obvious method is to proceed by sampling each location in a row, and through each row in turn. Almost every display system in use today employs raster scanning. One pass through the full array is generally referred to as a ( ).

**Raster-scanned image**
3.2 Spatial formats vs. resolution

(1) Format (Spatial format)

• refers to the overall “size” of the image, in terms of the number of pixels horizontally and vertically covered by the defined image space.

• (Ex) 1024 x 768 : 1024 samples(pixels) per horizontal row, or line 768 pixels in each vertical column of the array of pixels [ Full HD ] 1920 x 1080 ~ 2 millions (82” LCD TV)

(2) Resolution

• refers to the amount of details which can be resolved in an image or by an imaging system

• expressed in terms of the number of basic image elements per a definite physical distance

• (Ex) dots per inch,
<table>
<thead>
<tr>
<th>화면비율</th>
<th>표준</th>
<th>해상도 (가로 x 세로)</th>
<th>Dot 수</th>
<th>Pixel 수</th>
<th>Gate 선택시간</th>
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<tbody>
<tr>
<td></td>
<td>q-VGA</td>
<td>320 x 240</td>
<td>76,800</td>
<td>230,400</td>
<td>69 µs</td>
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<tr>
<td>4:3</td>
<td>VGA</td>
<td>640 x 480</td>
<td>307,200</td>
<td>921,600</td>
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<td>SVGA</td>
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<td>SXGA+</td>
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<td></td>
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<td></td>
<td>QUXGA</td>
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<td>7,680,000</td>
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<td>Wide SXGA+</td>
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- **Ultra Definition**
  - SEC: 82”, (3840 x 2160), 120 Hz
  - Sharp: 64” DID, (4096 x 2160)
  - CPT: 56” U(3840x2160)
3.3 Moving images; frame rates

- Representing motion in the images can be done by simply re-drawing the moving objects within the image, but most often it is simply assumed that motion will be portrayed by replacing the entire image, at regular intervals, with a new image.

- Motion pictures operate by showing a sequence of what are basically still photographs, and relying on the eye/brain system to interpret this as a convincing representation of smooth motion.

- **Frame**: each individual image in the series
  
  **[cf] field**: sub-frame component

- **Frame rate**: the rate at which they are displayed
  
  **update rate**: how rapidly new images can be provided to or created in the frame buffer

  **refresh rate**: how rapidly new images are actually produced on the screen of the display device
• The complete visual experience we receive from a display system comprises a regular three-dimensional array of samples in both time and space.

• Various difficulties and artifacts may be produced through the nature of the sampling methodology itself.

“We are almost always in display dealing with a series of samples rather than continuous data.”
3.4 Three-dimensional imaging

- At the very least, rendering images in three dimensions, i.e., keeping track of 3-D spatial relationship when creating images via computer, has been used for many years.

- pixel → (volume pixel)
4. Transmitting the Image Information

• The data capacity required of the interface in a raster-scan system:

  (1) the amount of information contained in each sample, or pixel, normally stated in bits → at least 8 bits, more often as much as 24-32 bits

  (2) the number of samples in each image transmitted, i.e., the number of pixels per frame or field
      (ex) 1024x768 → 786,432 pixels

  (3) The field or frame rate required → typically tens of frames per second

  (4) Any overhead or “dead time” required by the display → refers to any limitations on the amount of time which can be devoted to the transmission of valid image data

      [Example] 1024x768 pixels, frame rate of 75 frames/s, 24 bits/pixel, 25% of the available time to be “lost” to overhead requirements