

Potential of Motion Imagery Systems

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The Potential

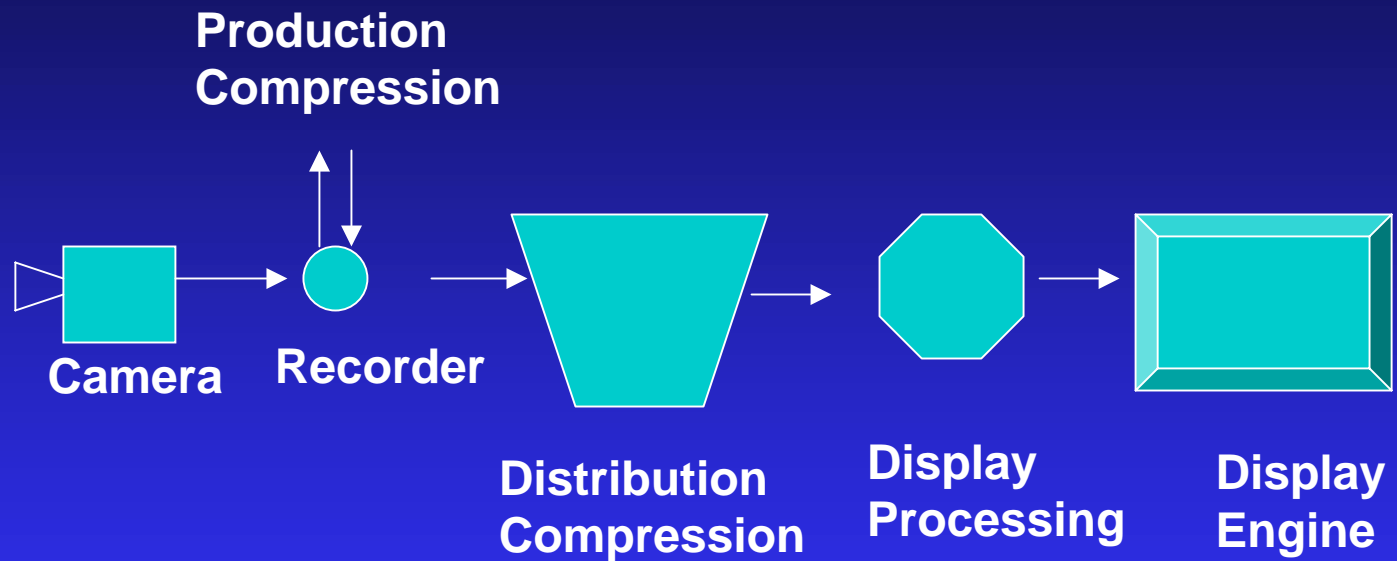
The Barriers

The System

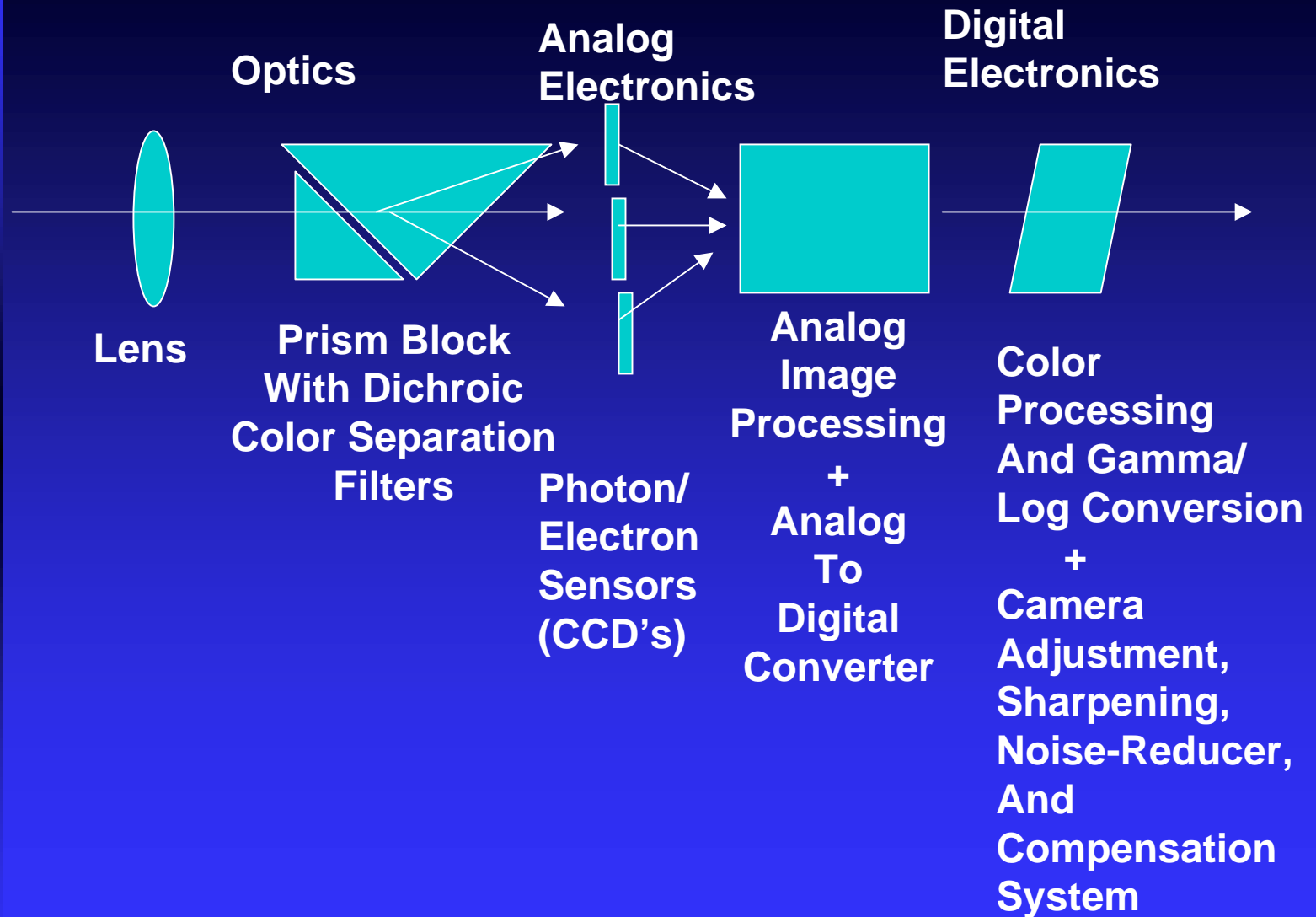
Potential of Motion Imagery Systems

- The presented moving image is only as good as the weakest link
- Analysis, both visual and computational, is most effective if the moving image data is clean
- Typical video systems are highly suboptimal

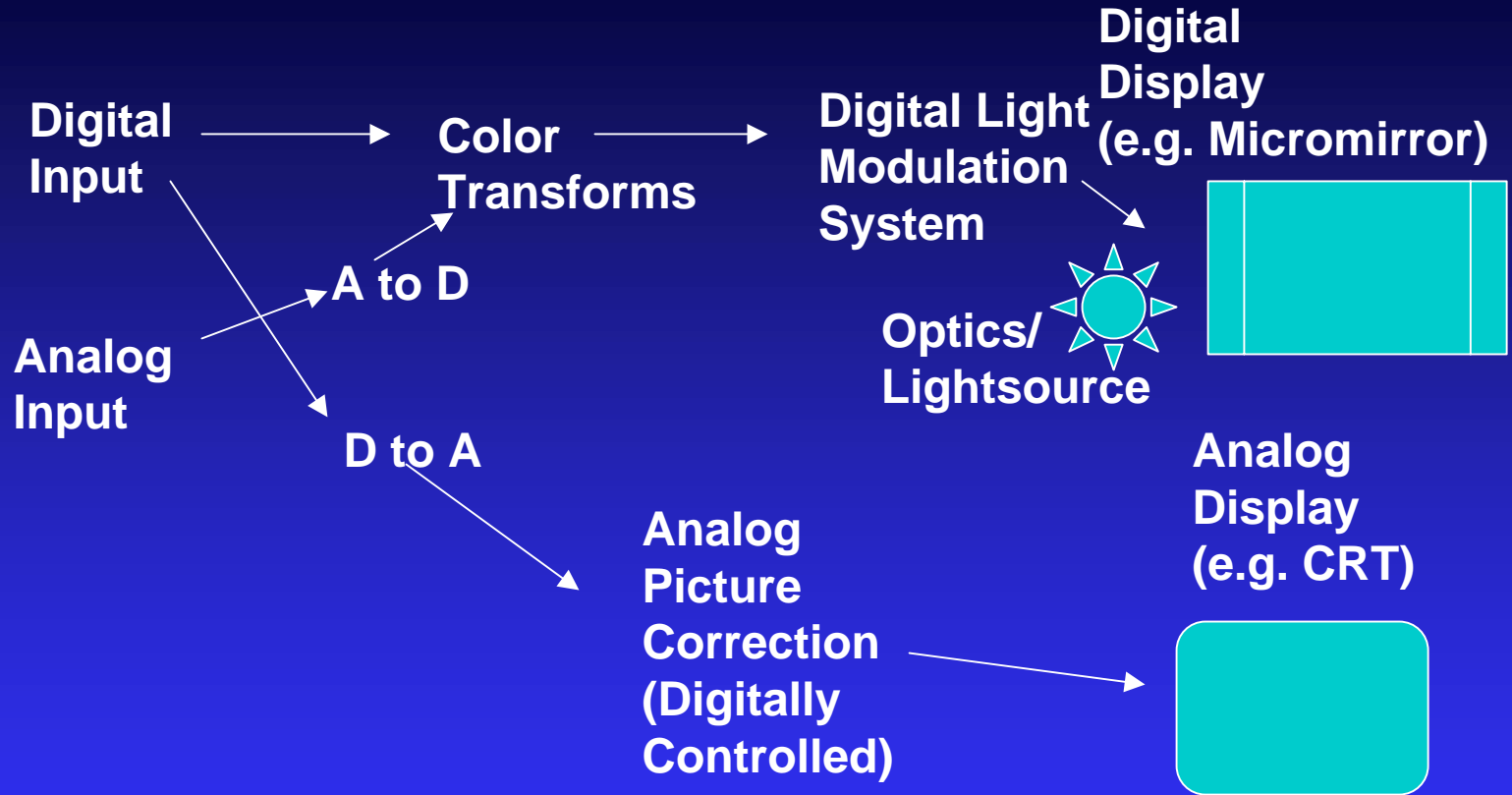
Video As A Complete System



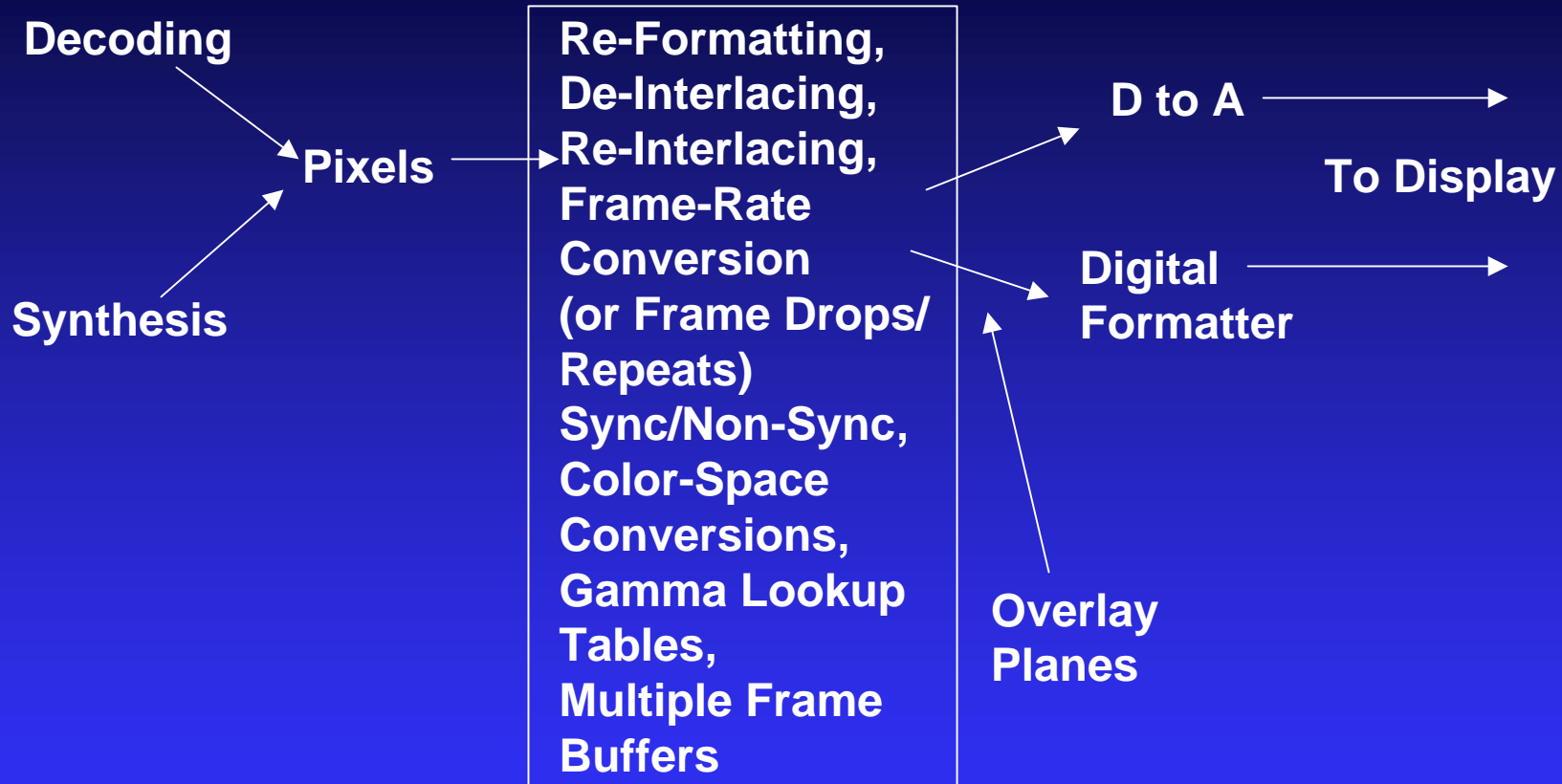
Cameras Are A System



Displays Are A System



Display Processing Systems As Well

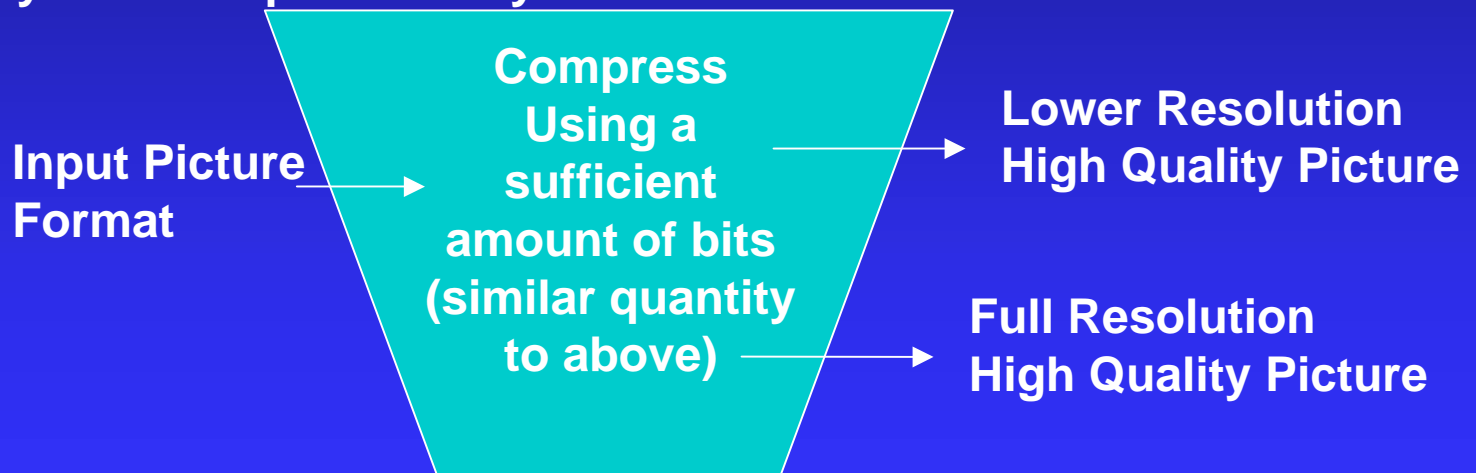


Compression Systems

Most Current Compression Systems:



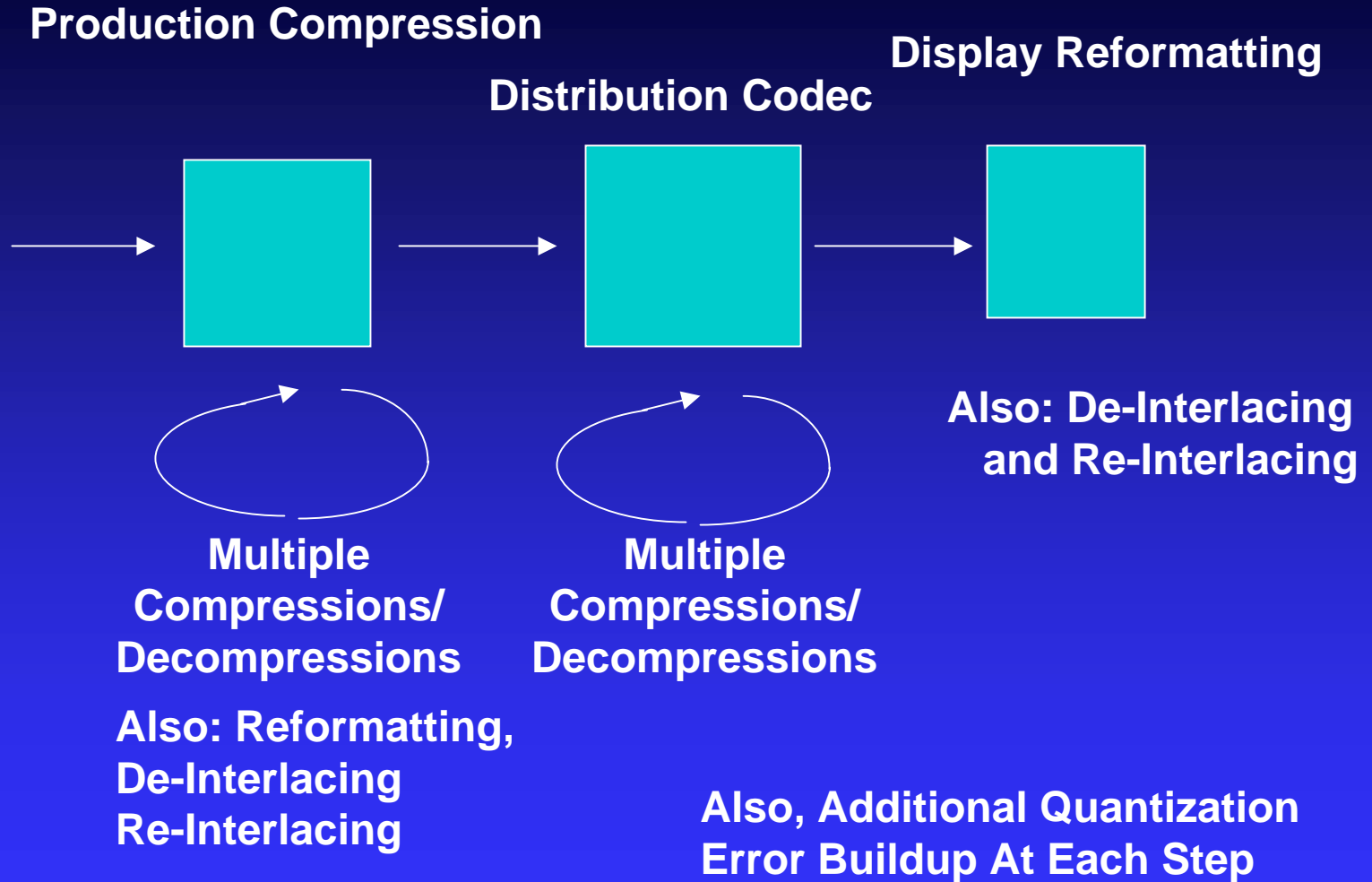
Layered Compression System:



Compromised System-Wide Elements and Practices (from most problematic first)

- **Interlace**
- **Concatenated Compression of Insufficient Quality or Inter-Compatibility**
- **Low Frame Rates (24, 25, 30fps)**
- **Temporal Undersampling In Camera Sensors**
- **Insufficient Precision (8 bits) In Computations**
- **Insufficient Resolution (<1/2 Mpixel)**
- **Non-Linear Signals With Linear Matrix Operators**
- **Re-Formatting and Re-Sizing**
- **Sub-Optimal Digital Filters (often on Non-Linear Signals)**
- **Sensor and Film-Grain Noise**
- **Narrow Gamut Color Primaries**
- **High Ambient Light Viewing (Black Detail Lost)**
- **No White/Neutral Viewing Reference**

Concatenation of Compression Codecs



Quality Criteria For Moving Image Systems and Displays:

- - 30 pixels per viewing degree or greater
 - 10-bits of dynamic range, end-to-end (camera, processing, compression, display processing, and display)
 - Display brightness of 20fl or greater for white
 - Increase to 12 bits as cameras and displays increase their dynamic range and decrease their noise floor
 - When cameras extend their dynamic range, it will be useful to capture a wider range than can be displayed (using a “brightness” adjustment to range between shadow detail and highlight detail during display)

Visual Acuity (Resolution)

- **20-20 Vision can resolve 100 pixels (50 cycles) per degree of viewing angle**
- **Pictures appear sharp beginning at 30 pixels (15 cycles) per deg.**
- **Pictures are noticeably soft (blurry) below 20 pixels (10 cycles)**
- **Thus a display which subtends 40 degrees of viewing angle should have no less than 800 pixels, but preferably 1200 pixels or greater**

The Future Potential Improvements

- **Increasing Frame Rate**
- **Increasing Resolution**
- **Increasing Range of Color**
- **Greater Dynamic Range**
- **Reduced Noise Floor**

Opportunities For Standardization:

- **Interlace**
- **Concatenated Compression of Insufficient Quality or Inter-Compatibility**
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The Potential: No Weak Links

- **Technology exists now that can provide a matched set of system components of uniform high quality**
- **There need be no weakest link**
- **Compression at distribution bit rates can exceed the quality and range of existing cameras and displays**
- **The key building block is digital computation, which enables ever increasing levels of performance**

The Potential: The System Parameters:

- **Interlace fades into history**
- **Higher Frame Rates: 72fps and above**
- **Resolution increases to 1, 2, and 4 MPixels**
- **Wider and more consistent color gamuts**
- **Greatly increased dynamic range (shadows to highlights)**
- **Ever-reducing noise floor, such that noise becomes invisible**
- **Compression using a layered structure for scalability as system parameters improve**

The Potential: Inside The Architecture

- **De-interlacers and frame-rate converters for legacy material**
- **Compression established at the highest quality**
- **Improved temporal sample time in cameras**
- **Greater precision, starting with consistent 10-bits, and increasing from there**
- **Correct linear and non-linear signal processing**
- **Minimized use of re-sizing**
- **Greater sensor sensitivity and range**
- **Wider gamut primaries, perhaps more than three**
- **Increased black to white range in viewing**
- **Established white/neutral viewing reference**

Tonal Distinction and Dynamic Range

- **Current state of the art is 10-bits**
- **The loss in quality of 8 or 9 bits is easily perceived in comparison to 10-bits**
- **This corresponds to about 300:1 dynamic range with 0.6% step size of tonal distinction using a log representation**
- **Human tonal distinction is about 0.25%**
- **Human visual dynamic range exceeds one million to one (white objects in sunlight to moonlit objects)**
- **Human color vision is limited to about a 10,000 to 1 range (color distinction is lost in dim lighting)**
- **10,000:1 at 0.25% will be achieved with 12-bits**