Potential of Motion Imagery Systems

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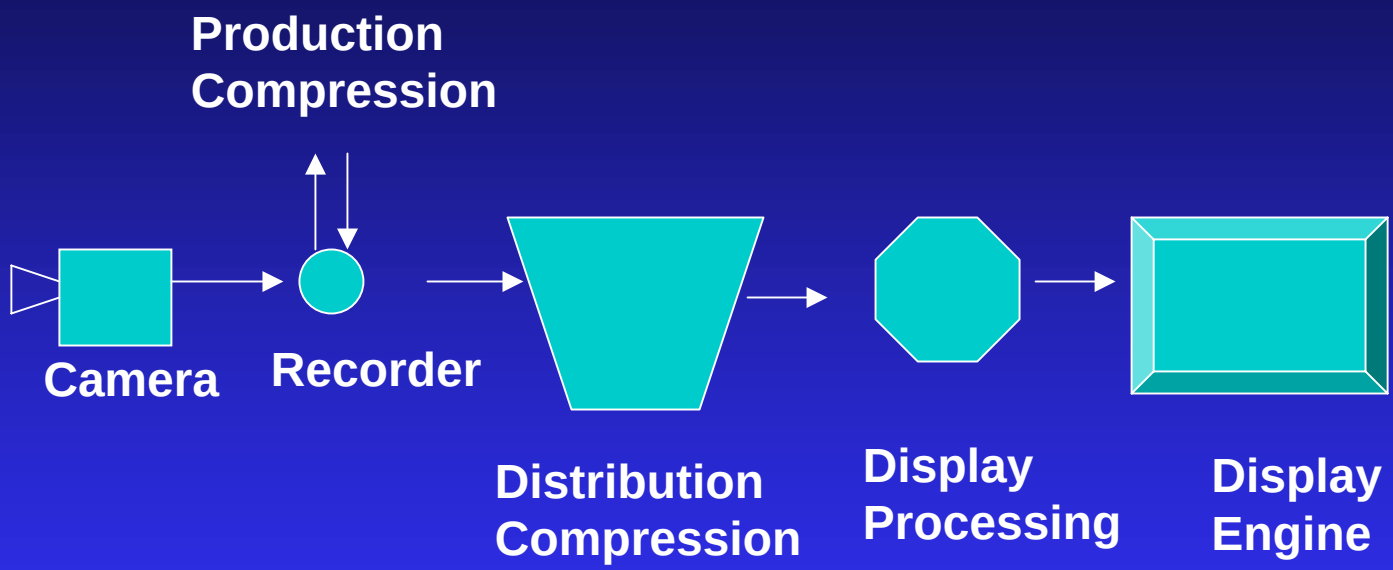
- The Potential
- The Barriers
- The System

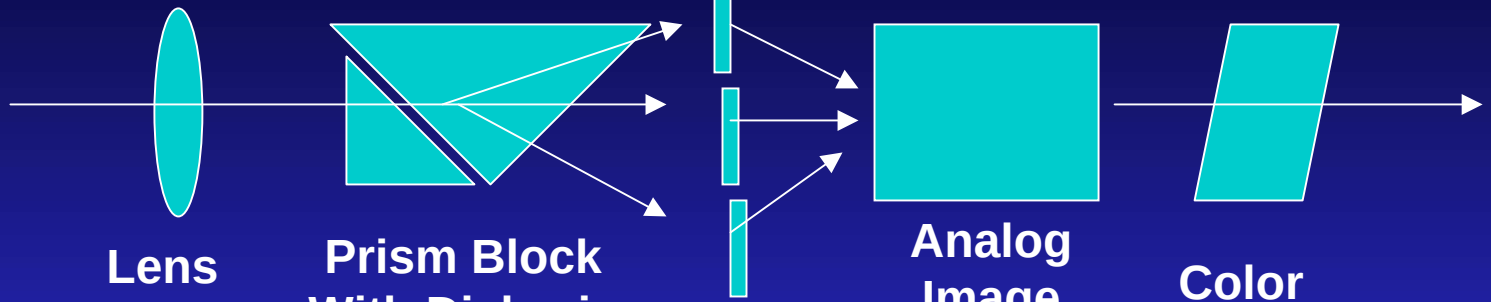
Potential of Motion Imagery Systems

- **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



Optics

Analog Electronics

Digital Electronics

Lens

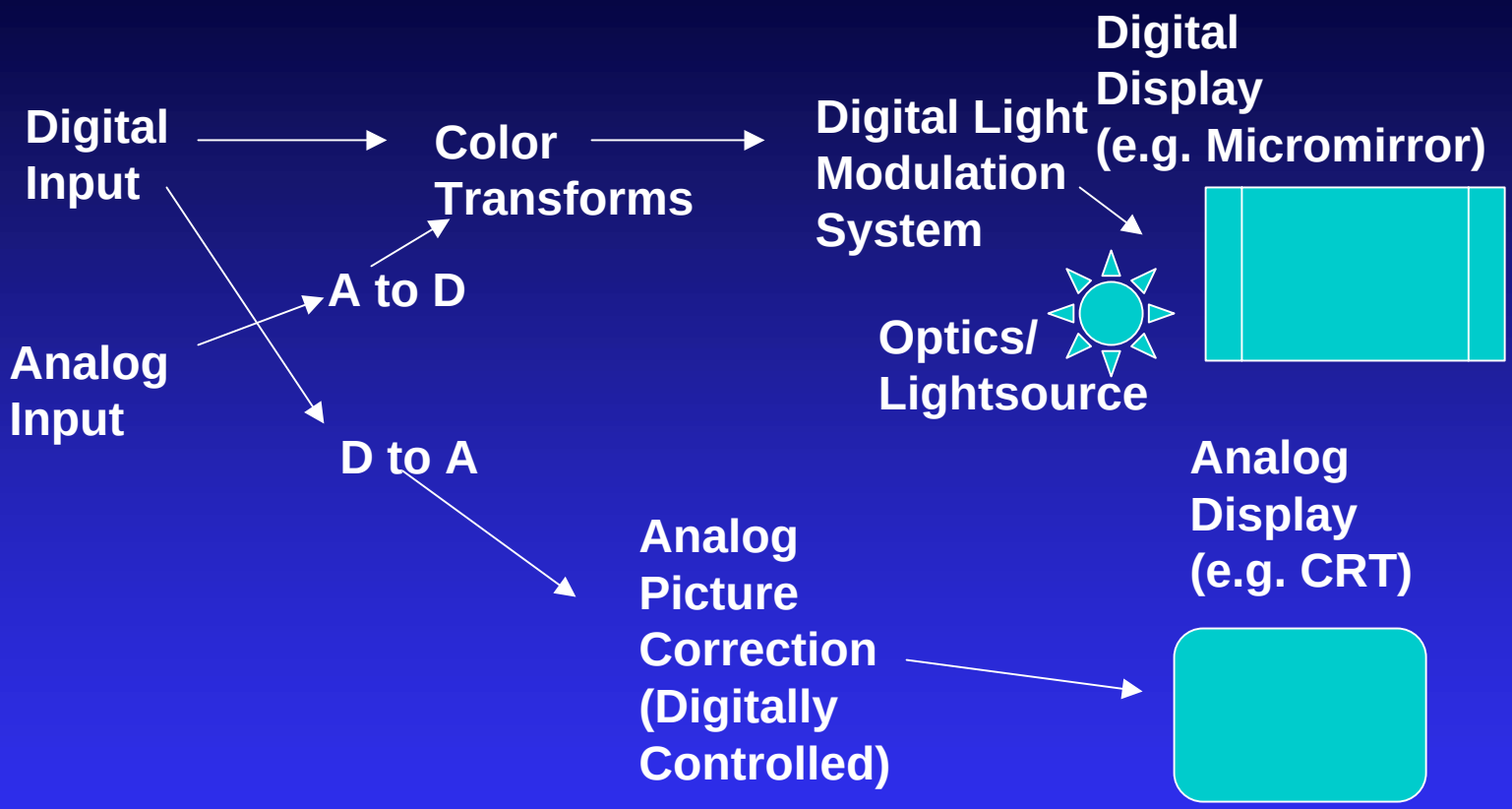
Prism Block With Dichroic Color Separation Filters

Photon/ Electron Sensors (CCD's)

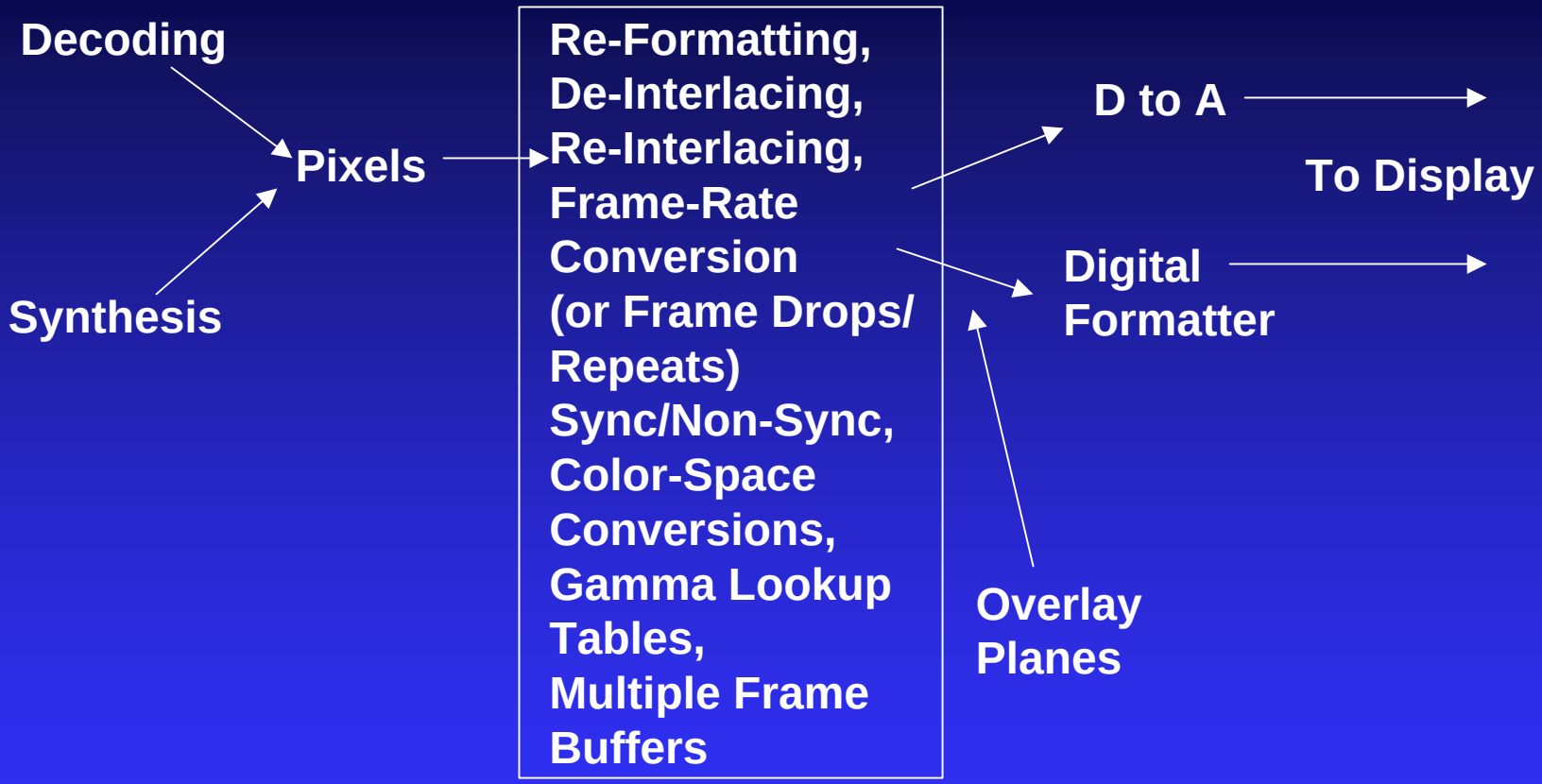
Analog Image Processing + Analog To Digital Converter

Color Processing And Gamma/ Log Conversion + Camera Adjustment, Sharpening, Noise-Reducer, And Compensation System

Displays Are A System



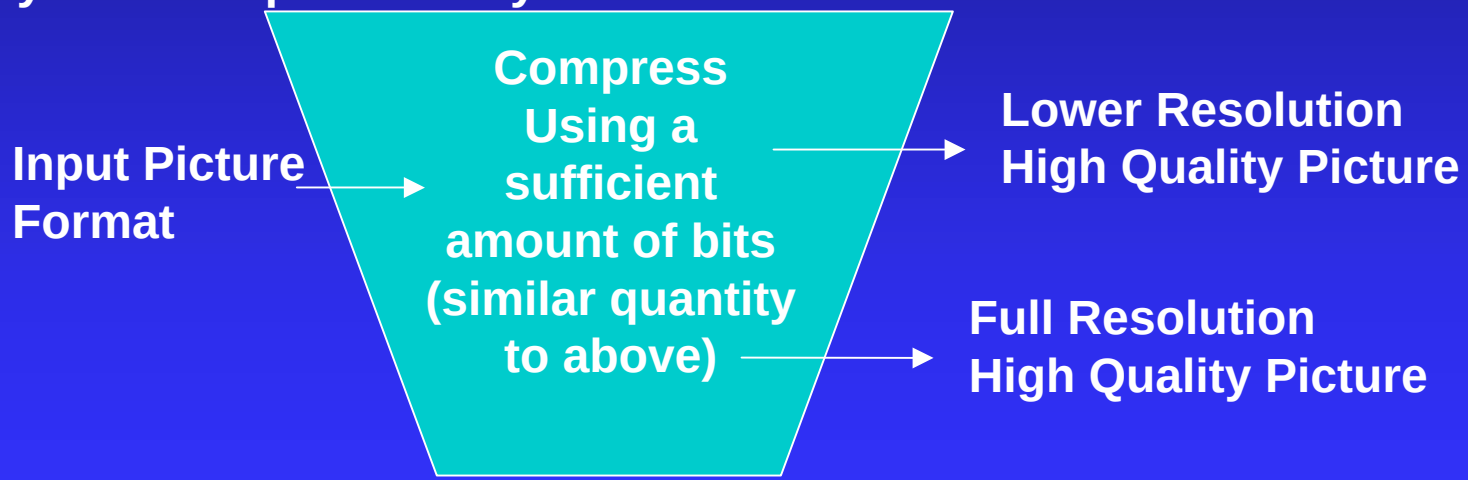
Display Processing Systems As Well



Compression Systems

Most Current Compression Systems:

Layered Compression System:



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

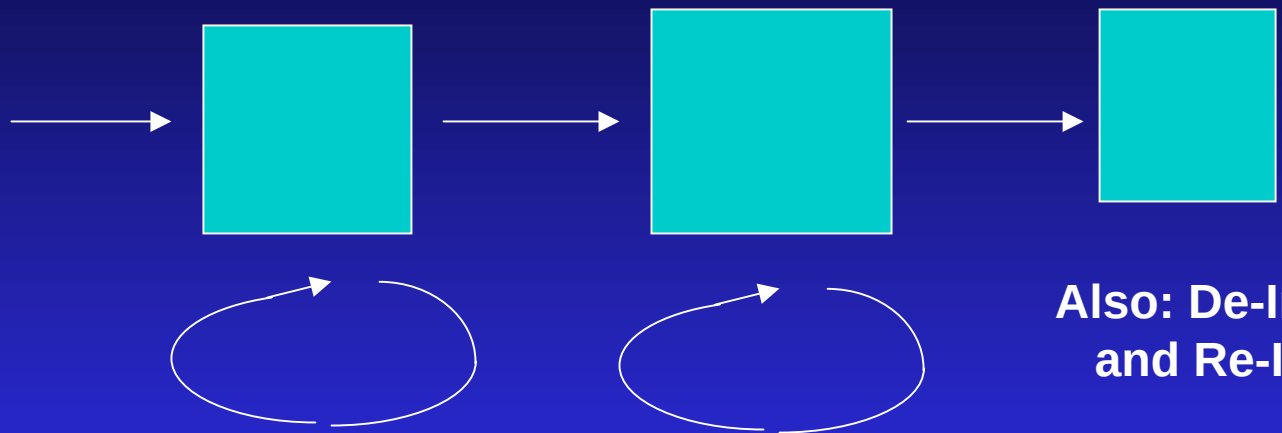
- Interlace
- Concatenated Compression of Insufficient Quality or Inter-Compatibility
- Low Frame Rates (24, 25, 30fps)
- Temporal Undersampling In Camera Sensors
- Insufficient Precision (8 bits) In Computations
- Insufficient Resolution (<1/2 Mpixel)
- Non-Linear Signals With Linear Matrix Operators
- 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

Production Compression

Distribution Codec

Display Reformatting



Also: De-Interlacing
and Re-Interlacing

Multiple
Compressions/
Decompressions

Multiple
Compressions/
Decompressions

Also: Reformatting,
De-Interlacing
Re-Interlacing

Also, Additional Quantization
Error Buildup At Each Step

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
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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