Understanding Megapixel Camera Technology for Network Video Surveillance Systems

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Introduction

(1) 3 MP Camera Covers an Area 9X as Large as (1) VGA Camera

Megapixel = Reduce Cameras

1.3 Mega = 4 VGA

3 Mega > 9 VGA

640 480

1,280 1,536

VGA 1.3 Megapixel

2,048
Today’s Discussion

Camera Specifications
- Imager types and sizes
- Resolution
  - Pixels
  - Lines of Resolution
- Pixel count expressed as Megapixel
- Understanding Megapixel lenses and optics

Megapixel Camera Myths & Hype

Megapixel Camera Applications
- Surveillance goals
- Where and when to deploy Megapixel Cameras
  - How to calculate camera requirements
  - Costs and ROI to deploy Megapixel Cameras
  - Other considerations

Network Transport of Megapixel Video Information
- Compression Methods
- Transport Protocols
- Bandwidth Considerations
- Physical Infrastructure Considerations

Summary
Camera Specifications

Anatomy of a Typical Network Camera
Imager Types and Sizes: CCD (Charge Coupled Devices)

The “Simple” Explanation

- Sensors are Made up of Photo Reactive ‘PIXELS’ or Picture Elements
- Light Causes a Charge to Build up on Each PIXEL Proportional to Light Intensity
- Control Circuit Sends Accumulated Charge to ‘Charge Amplifier’
- Charge Amplifier Converts Charge to Sequential Analog Signal
Imager Types and Sizes: CMOS
(Complimentary Metal Oxide Semi-Conductor)

The “Simple” Explanation

- Sensor is comprised of Photo Detector ‘PIXELS’ or Picture Elements
- Photo Detector sends signal to CMOS Transistors
- Signal is read at the output of one of the transistors
- Other Transistors buffer and reset the Photo Detector
Most Common Imager Sizes

Field of View: Effects of Imager Size

1/3” Imager

Both with 12mm Lenses

1/4” Imager
Resolution

• What Determines Camera Resolution?
  – Scanning Area or Number of Pixels on Imager
  – Type of Scan
    • Interlace or Progressive Scan
Pixels

What is a Pixel?

**Definition:** In digital imaging, a **pixel** (or picture element) is a single point in a raster image. The pixel is the smallest addressable screen element, it is the smallest unit of picture which can be controlled. Each pixel has its own address. The address of a pixel corresponds to its coordinates. Pixels are normally arranged in a 2-dimensional grid, and are often represented using dots or squares. Each pixel is a sample of an original image, where more samples typically provide more-accurate representations of the original. The intensity of each pixel is variable. In color image systems, a color is typically represented by three or four component intensities such as red, green, and blue, or cyan, magenta, yellow, and black.

Resolution: Scanning Area and Pixels

Scanning Area refers to the number of pixels on the imager

Megapixel – 1280 x 960 (1.3M)
Resolution: Scanning Area and Pixels

Scanning Area refers to the number of pixels on the imager

Megapixel – 1280 x 960 (1.3M)
Progressive vs. Interlace Scan

Progressive

Interlace
Resolution: Lines of Resolution

EIA 1956 Resolution Chart
Resolution: Lines of Resolution

ISO 12233 Resolution Chart
Pixel Count Expressed as Megapixel

Common Megapixel Formats:

<table>
<thead>
<tr>
<th>Megapixel</th>
<th>Resolution</th>
<th>Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3 MP</td>
<td>1280 x 960</td>
<td>1,228,800</td>
</tr>
<tr>
<td>2.0 MP</td>
<td>1600 x 1200</td>
<td>1,920,000</td>
</tr>
<tr>
<td>3.1 MP</td>
<td>2048 x 1536</td>
<td>3,145,728</td>
</tr>
</tbody>
</table>
### What About ‘High Definition’ HD?

<table>
<thead>
<tr>
<th>HD Format</th>
<th>Resolution</th>
<th>Pixels</th>
<th>Megapixel</th>
</tr>
</thead>
<tbody>
<tr>
<td>720 p</td>
<td>1280 x 720</td>
<td>921,600</td>
<td>1 MP</td>
</tr>
<tr>
<td>1080 i or p</td>
<td>1920 x 1080</td>
<td>2,073,600</td>
<td>2.1 MP</td>
</tr>
</tbody>
</table>

- HD is a Picture Format; combination of Aspect Ratio, and Pixels
  - Just Because a Camera is HD it Doesn’t Mean it produces a Better Image or is Higher in Quality
- A 3.1 MP Camera has a Resolution of 2048 x 1536 or 3,145,728 Pixels
  - A 3.1 MP Camera has a Higher Resolution than “Full HD”
Resolution Selection Chart

VGA vs. Megapixel

Megapixel

VGA
VGA vs. Megapixel

VGA

Megapixel
1.3 Megapixel Camera
3 Megapixel Camera
1.3 vs. 3 Megapixel Camera (4X) Zoom Comparison

1.3 Megapixel Camera

3 Megapixel Camera
Understanding Megapixel Lenses and Optics

Diagram showing the relationship between the object, lens, and image sensor with dimensions labeled as follows:
- Object: H 480mm, V 330mm
- Lens: D 2500mm
- Image Sensor: h 6.4mm, v 4.8mm

The diagram also indicates a 1/2 inch format.
Fujinon Standard for CCTV Megapixel Lenses

- Fujinon Standard for CCTV Megapixel Lenses
- 1/3” 1.3Mega Nyquist Frequency
- Spacial Frequency (lp/mm)
- M TF (%)
- Competitor Mega Pixel Lens
- Fujinon Mega Pixel Lens
- Fujinon Standard Lens

Diagram:
- Zone 1
  - F:Open
  - 1.3Mega

- Zone 2
  - F:2.8
  - 0.4Mega
  - 1.3Mega

- Fujinon Megapixel Lens
  - 3Mega
  - 1.3Mega
  - 3Mega
3 Megapixel Camera
2 Megapixel Camera
3 Megapixel Camera

Crisp and clear image for entire picture.
Megapixel Camera Myths & Hype
Myths and Hype # 1 – More Pixels = Better Picture Quality

3 Megapixel Camera

Resolution is not enough for actual use, even a 5MP will be restricted by the lack of optical accuracy

VGA Resolution – Replace multiple VGA cameras with 3MP

TVL of Resolution of Camera Determines Megapixel Picture Quality, not Number of Pixels

Must use a Resolution Chart to Compare Cameras
Any Camera Regardless of Resolution Will Cover this Area. Viewing Area is Determined by the Site Survey & Lens Selection, not the Camera Type!

Myths & Hype #2 – (1) 3MP = (9) VGA Cameras, Etc.

2,048

1,536

Here We See the Claim that (1) 3 Megapixel Camera Replaces (9) VGA Cameras But Does Anyone ACTUALLY Use (1) camera for any of these VGA Views? So, we are simply ENHANCING the resolution available for this view.
Myths & Hype #3 – Megapixel Cameras Perform Better in Low Light

1.3 Megapixel Camera
- High Sensitivity
- Low noise

2 Megapixel Camera
- Poor color

3 Megapixel Camera
- Low Sensitivity

3 Megapixel Camera
- Black level is too high
Myths & Hype #4 – Megapixel Provides Better Color Reproduction and Visibility

1.3 Megapixel Camera
- High Visibility
- High Performance of Color Reproduction

2 Megapixel Camera
- Poor Visibility
- Poor Color Reproduction

3 Megapixel Camera
- Poor Visibility
- Poor Color Reproduction

3 Megapixel Camera
- Poor Visibility
- Poor Color Reproduction
Myths & Hype # 5 - All Pixels are Created Equal

Pixels vary by Manufacturer and are also Affected by:

- Signal to Noise Ratio
- Imager Size & Type
- Sensitivity
- Lenses

Megapixel Cameras can be Great, but make sure the Increase in Pixels Justifies the Additional Bandwidth and Storage Required
Myths & Hype # 5 - All Pixels are Created Equal

Model A
Resolution : VGA

Model B
Resolution : VGA
Megapixel Camera Applications

• License Plate Recognition

• Casinos & Gaming

• Point of Sale-Cash Denominations

• Any Application Requiring High Detail or Wide Field of View
Surveillance Goals

- What is the Value of the Asset to Protect?
- What is the Risk to be Mitigated?
- How will the Video Surveillance System be Used?
  - For Observation
  - Forensic Review
  - Identification
UK Home Office Guidelines for CCTV

- Monitoring an Area, a Person Should Appear at Least 5% of Screen Height
- Detection of Intruders Into an Area, Persons Should be at Least 10% of Screen Height
- Recognition of a Known Individual, Persons Should be 50% of Screen Height
- Identify an Unknown Person, Present an Image at 120% (knees to head)
- The Standard Height for a Person that these Standards are Based on is 1.6m (5’ 4”)

Note: These guidelines do not take into consideration the resolution of the camera
Interpolation of UK guidelines for Higher Resolution

Example:

50% of screen height for a 640 x 480 camera
Target occupies 240 pixels high.

Assume 6 foot high person 240/6 = 40 pixels per foot
# How to Calculate Camera Requirements

Table 5.9

<table>
<thead>
<tr>
<th>Surveillance Video Function</th>
<th>Resolution (Pixels per foot)</th>
<th>Horizontal Resolution (Pixels)</th>
<th>Vertical Resolution (Pixels)</th>
<th>Maximum Horizontal Field of View (Feet)</th>
<th>Maximum Vertical Field of View (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>20</td>
<td>640</td>
<td>480</td>
<td>32</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>1024</td>
<td>768</td>
<td>51</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>1280</td>
<td>960</td>
<td>64</td>
<td>48</td>
</tr>
<tr>
<td>Forensic review</td>
<td>40</td>
<td>640</td>
<td>480</td>
<td>16</td>
<td>12</td>
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<tr>
<td></td>
<td>40</td>
<td>1280</td>
<td>960</td>
<td>32</td>
<td>24</td>
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<tr>
<td>Recognition</td>
<td>80</td>
<td>640</td>
<td>480</td>
<td>8</td>
<td>6</td>
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<tr>
<td></td>
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<td>1024</td>
<td>768</td>
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<td>10</td>
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<tr>
<td></td>
<td>80</td>
<td>1280</td>
<td>960</td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

These are guidelines alone, and Table 5.8 must be used together with this to achieve an accurate resolution measurement.

Source: BICSI ESS Manual 2nd Edition
Visual Acuity – Pixels on Target
Visual Acuity – Pixels on Target

600 Pixels on Target
Visual Acuity – Pixels on Target

100 Pixels on Target
Megapixel Cameras Cover More Area, Fewer Cameras are required!

- We have all heard today that a 1.3 MP Camera has 4x the coverage of a VGA camera. Thus, We Should be Able to Replace (4) VGA Cameras With (1) 1.3 MP Camera
  - Or 9 VGA = (1) 3.1 MP
  - Less cabling, less power, etc…. Let’s see….  

- What about the following considerations:
  - Will you really use a 1.3 MP Camera to Cover the same Area as 4 VGA Cameras?
  - MP Cameras Cost More, Require Special Lenses
  - Higher the Pixel Count the Larger the File Size
    - Larger Storage Requirements
  - Higher Bandwidth Requirements
    - May Need to Upgrade Existing Infrastructure to Accommodate
  - The 1:4 or the 1:9 MP:VGA Camera Ratios In Reality don’t apply
    - A 1:2 or 1:4 MP:VGA Camera Ratio is More Realistic

- Consider All Factors of System Deployment when Developing an ROI Model, not Just Quantity of Cameras
Other Megapixel Considerations

• Megapixel Cameras are Harder to Focus
  – Focus Depth gets Shallower as Pixel Count Increases

• The Larger the Imager, the More Light can Impinge upon the Imager
  – Higher the Pixel Count the Larger the Imager Should Be

• The Higher the Pixel Count, the Smaller the Pixel
  – Thus, as pixel count increases, less light hits each pixel and the more noise is created
  – Megapixel Cameras will Perform Poorer than Lower Pixel Count Cameras in Low Light Conditions
Network Transport of Megapixel Information

Methods for Encoding Video for IP Transmission

• Intra-Frame
  – JPEG, JPEG2000
  – Codes a Single Image on a Standalone Basis

• Inter-Frame
  – MPEG1, 2, 4, H.261, H.263, H.264/AVC (also known as MPEG4 Part 10)
  – Utilizes Motion Compensation; Takes Advantage of Redundancy Between Nearby Video Frames
  – Based on Motion Vectors that Predict Frame content; Uses Blocks Drawn from One or More Nearby Frames
Network Transport of Megapixel Information

Intra-Frame vs. Inter-Frame

Intra-Frame
Ex: M-JPEG

Inter-Frame
Ex: MPEG-4
MPEG-4 Encoding Details

- **Encoding Frames**
  - **I-Frames (Intra-Frames)**
    - Completely Self-Contained/Do Not reference Other Frames
  - **P-frames**
    - References the Previous Frame for Image Data
    - Each Macroblock of P-frames can be Encoded Independently
    - P-Frames Use Similarities from Subsequent frames; Are Significantly Smaller than I-Frames
  - **B-Frames are Called Key Frames**
    - "Bidirectional" Frames – Frames that Reference Both Prior and Sequential Frames
Using Encoded Megapixel Video
Storing and Recording Encoded Megapixel Video

**Software Based Recording Solutions**
- Software Loads on End User Windows based PCs
- End User can Provide and Maintain hardware
- Failure of PC Running Software may Cause Loss of Data

**Embedded Real-Time Operating System (RTOS) Appliance DVRs**
- Appliance Dedicated to Recording and Storing Video
- Hardware Provided by Manufacturer
- Not Dependent on Third Party OS and Drivers
- Usually Do Not require licenses or Keys
- Typically Managed by PC Based Software

**Software as a Service (SaaS)**
- Users Purchase “Subscription” to Site Hosting Service
Transport Protocols

- **UDP – User Datagram Protocol**
  - Fast Data Transfer
  - No Packet Sequencing
    - Packets Lost – Gone Forever
  - MPEG4/H.264

- **TCP – Transmission Control Protocol**
  - Ordered Packets
  - MJPEG
  - Packets Sequencing
    - Packets Lost - Retransmission
  - Slower Data Transfer
Unicast vs. Multicast Transmission

**Unicast**
- MPEG4
- Limited # of Users
- Frame Rate May Drop/# Users

**Multicast**
- MPEG4: Unlimited Clients
- Bandwidth is Fixed Regardless of # of Clients
- Network Replicates Data
Bandwidth Considerations

Network Design Steps

1. Plan Network Topology
2. Calculate Maximum Bandwidth for each Camera (Based on Resolution, Compression and Frame rate)
3. Calculate Maximum Bandwidth for each Client (PC)
4. Study Bandwidth Allocation
5. Evaluate Network Device Performance (Capability of Transmission Packet, Function)
1. Plan Network Topology
2. Calculate Maximum Bandwidth for each Camera

3. Calculate Maximum Bandwidth for each Client (PC)
4. Study Bandwidth Allocation

Check for Bottlenecks and Optimize Distribution of Network Load

5. Evaluate Network Device Performance
   (Capability of Transmission Packet, Function)
Physical Infrastructure Considerations

Infrastructure Components
Infrastructure Components
Infrastructure Components

NETWORK CAMERAS

NETWORK VIDEO RECORDER

WAN ROUTER

Format Conversion Server

WAN

NETWORK SWITCH

WORKSTATIONS
IP-Based Centralized Recording System
IP-Based Distributed Recording System
In Summary . . .

• Megapixel Cameras can be Used to Replace VGA Cameras in Certain Applications
  – Select Camera type According to Surveillance Goals and Applications
  – Take the Camera for a “Test Drive” if Possible

• Be Wary of the Marketing Hype; Know the Basics

• Consider all System Factors when Developing an ROI Model for Megapixel Camera Deployment, Not Just Quantity of Cameras

• Match Video Surveillance System with Network Protocols

• Achieve a Convergence of Intelligent and Professional Imaging over Networks
Questions?
Comments!
Ideas?
Thank You!

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