

# Developing a Forensic Image Examination Quality Rating Metric

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Charles Fenimore & Wo Chang

[fenimore@nist.gov](mailto:fenimore@nist.gov)

[wchang@nist.gov](mailto:wchang@nist.gov)

01-301-975-2428

# The Challenge

**Forensic imagery as stills or CCTV is constantly captured for expert examination in support of public safety. Often, it is “from the wild” without fine control of illumination, position, attitude, or obscuration of persons, vehicles etc. Data volumes are huge; quality (and hence utility) unknown.**

An FBI DVD, “Caught on Camera”, addresses some of the quality issues.



# Photographic comparison and content analysis tasks on imagery “in the wild”

Lighting dramatically affects quality for facial comparison task  
Localize measurement of quality factors: resolution,



# The Challenge

**The image examiner's knowledge and judgment is essential in law enforcement forensics – frequently with computational assist.**

- Automatic methods read license plates, do biometric-based ID, or other well-defined tasks but generally requires high quality imagery.
- The examiner may find unique image elements to solve a case; see LA arson bomber or Germantown, Maryland, 7-11 flash mob



# Quality of CCTV images – a use case

**CCTV imagery ‘from the wild’ can have highly variable quality depending on:**

- illumination,
- camera resolution, distance to target, focus, other acquisition parameters,
- scene effects, obscuration, object motion, etc.

**Quality metric to:**

- semi-automate image selection or prioritization
- quality rating defined by examination potential of imagery.

**Hypothesis: Forensics can benefit from application of the National Image Interpretability Rating Scale methodology (NIIRS) to law enforcement needs.**

# Outline

## 1. The National Imagery Interpretability Rating Scale (NIIRS)

- measures the quality of an image as *interpretability* or *intelligence potential* for use by a trained image analyst.
- Assigns rating to tasks and images. Simple model predicts image rating based on image and target specific parameters.
- High level of agreement among trained image analysts on image quality rating.

## 2. Metric development for a forensic image examination rating scale (FIERS):

- Images
- quality factors
- Modeling
- assessment.

# Surveillance image interpretation



## Rating level 5:

Detect open bay doors of vehicle storage buildings

## Rating Level 6:

Identify automobiles as sedans or station wagons.

## Rating level 7:

Detect individual steps on stairway.

## Rating Level 8:

Identify grill detailing and/or the license plate on a passenger/truck type vehicle



# National Imagery Interpretability Rating Scale (NIIRS)

- Measures image *interpretability* or *intelligence potential* of an image to an analyst.
- Mapped images and interpretation tasks to a scale, 1 – 9 (and up)
  - Higher NIIRS level interpretation tasks are more demanding
  - Task are structured: detect /distinguish between/ identify

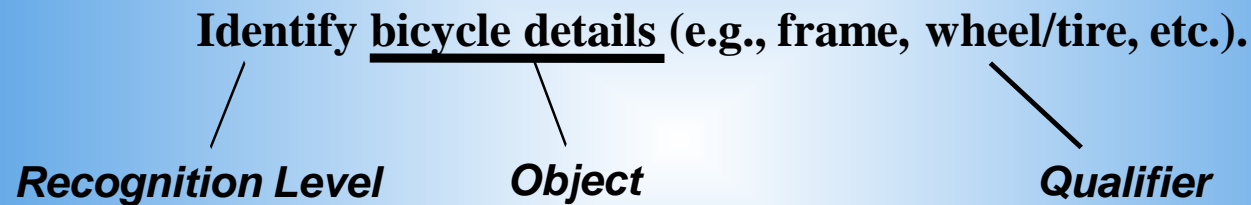


Image quality equation maps acquisition parameters to scale level

$$\text{Quality} = F(\text{resolution at object, edge blur, SNR, edge overshoot})$$

where  $F$  is log-linear

Supports reliability measurement for quality rating, system design and image collection planning



# Civil interpretation tasks for forensic image exam scale development

<b>Interpretation Tasks (Criteria)</b>	<b>NIIRS Rating</b>
<b>Identify individual bunches of pine needles.</b>	<b>9</b>
<b>Identify tree species based on leaf size and shape.</b>	<b>8.4</b>
<b>Identify facial features on an individual (i.e., at least partial discrimination of some facial features).</b>	<b>8.2</b>
<b>Identify windshield wipers on a vehicle.</b>	<b>8</b>
<b>Identify grill detailing and/or the license plate on a passenger/truck type vehicle.</b>	<b>8</b>
<b>Detect outside rearview mirrors on passenger cars.</b>	<b>7.7</b>
<b>Identify bicycle details (e.g., frame, wheel/tire, etc.).</b>	<b>7.7</b>
<b>Identify limbs (arms, legs) on an individual.</b>	<b>7.3</b>
<b>Detect small road signs (e.g., stop, yield, speed limit) in an urban area.</b>	<b>6.6</b>
<b>Detect individuals, when not in a group</b>	<b>6.2</b>

# Forensic image Examination Rating Scale (FIERS) development

- Implemented Civil NIIRS quality model. Exercise model.

## Still Image General Quality Equation (GIQE)

$$Q = c_0 + c_1 \log_{10} (TSD) + c_2 \log_{10} (RER) + c_3 G / SNR + c_4 H \quad (1)$$

**Q** = NIIRS quality measure for a deployed imaging system,

**TSD** = target sampled distance, pixel spacing projected to the target,

**RER** = relative edge response (slope of the normalized edge response measured between two points one-half pixels on opposing sides of an edge.)

**SNR** = signal to noise ratio [5, p. 306],

**G** = noise gain arising from modulation transfer function compensation (MTFC) In the absence of compensation, **G** = 1.

**H** = edge overshoot is the height of edge overshoot on the normalized edge response. **H** arises from modulation transfer function compensation.

See Leachtenauer, JC and Driggs, RG, Surveillance and Reconnaissance Imaging Systems, Artech, Boston, [2001]

# FIERS Quality Model Implementation

FIERS\_Q - Forensic Image Examination Rating Scale - Quality Metric

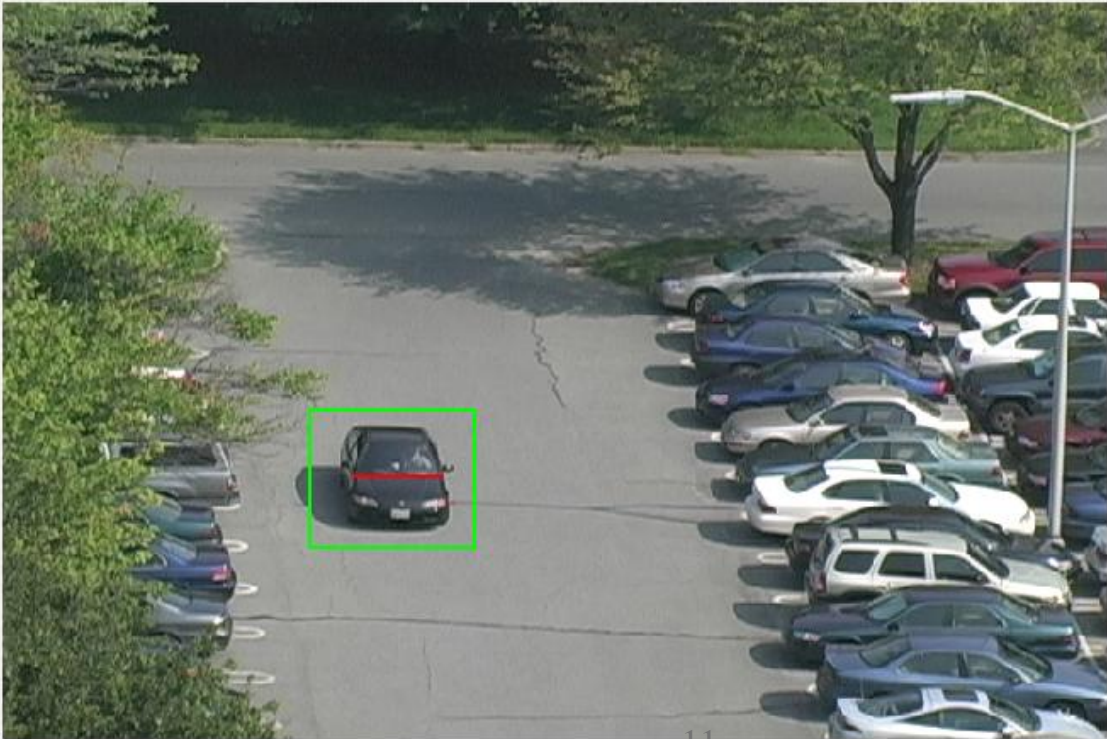
File

Step 1: Select image to rate, or Browse & Select.

Directory: C:\Users\fenimore\Documents\MATLAB\FIERS\NISTAdminRoof\_01\ **Browse**

Image: rfa225closeG1.png

Quality Rating: Q = 9.51, TSD = 1.1, RER = 0.589, DynRng = 206, Noise = 1.4, L\_inch = 64, L\_pix = 60



11

gy

The image shows a screenshot of a software application window titled 'FIERS\_Q - Forensic Image Examination Rating Scale - Quality Metric'. The window has a 'File' menu and a toolbar with icons for zooming, panning, and other image manipulation tools. A yellow highlighted box contains the text 'Step 1: Select image to rate, or Browse & Select.' Below this, there is a 'Directory' field with the path 'C:\Users\fenimore\Documents\MATLAB\FIERS\NISTAdminRoof\_01\' and a 'Browse' button. An 'Image' dropdown menu shows 'rfa225closeG1.png'. At the bottom of the interface, a 'Quality Rating' section displays several metrics: Q = 9.51, TSD = 1.1, RER = 0.589, DynRng = 206, Noise = 1.4, L\_inch = 64, and L\_pix = 60. The main area of the window displays an aerial photograph of a parking lot. A dark-colored car in the center of the lot is enclosed in a green rectangular box, and a red horizontal line is drawn across the front of the car. The number '11' is visible at the bottom center of the image, and a small 'gy' logo is in the bottom right corner.

# Forensic image Examination Rating Scale (FIERS) development

- Implemented Civil NIIRS quality model. Initially compare Quality model scores on images with published task scores.
- Formal evaluation of imagery and tasks await institutional approval.
- NIST is interested in working with practitioners; participation is essential to FIERS development. Interpretation tasks must be domain specific.

# NIST CCTV Image Collection

High definition collection for NIIRS scale development.



**Interpretation Task**

<b>Civil NIIRS</b>	<b>Image Rating</b>
------------------------	-------------------------

**Identify grill detailing and/or the license plate on a vehicle.**

**8**

**7.9**

**Detect small road signs (e.g., stop, yield, speed) in urban area.**

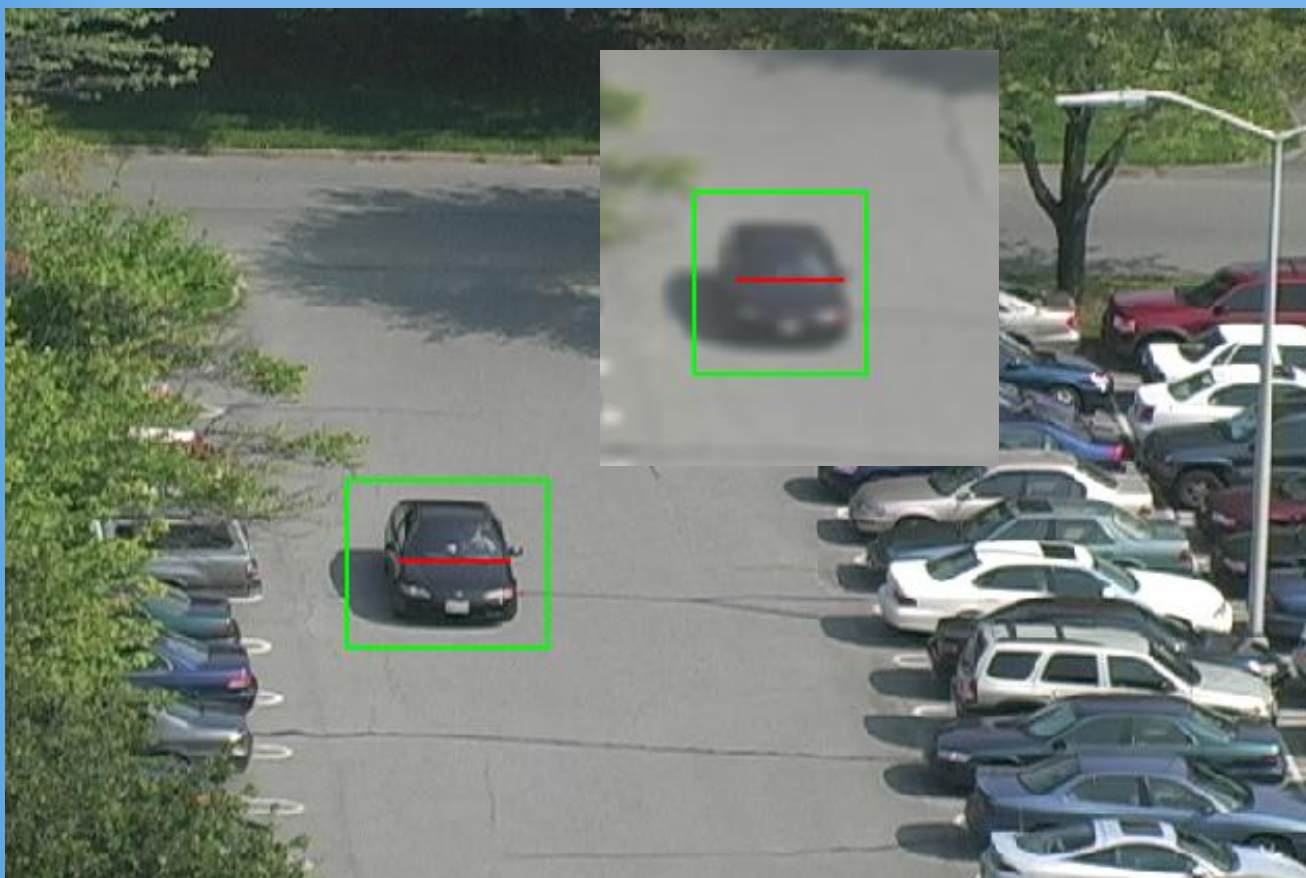
**6.6**

**6.55**



# NIST CCTV Image Collection

High definition collection for NIIRS scale development.



## Interpretation Task

Identify grill detailing and/or the license plate on a vehicle.

Detect outside rearview mirrors on passenger cars.

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Civil  
NIIRS

8

7.7

Image  
Rating

9.5

7.8

# NIST CCTV Image Collection

High definition collection for NIIRS scale development.



**Interpretation Task**

**Civil  
NIIRS**

**Image  
Rating**

**Identify facial features on an individual  
(i.e., at least partial discrimination of some facial features).**

**8.2**

**10.3**

**Identify limbs (arms, legs) on an individual.**

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**7.3**

**8.3**



# Imagery sources for FIERs, forensic image examination rating scale development

## Imagery: current sources ‘from the wild’

- Scripted: iLIDS, future collections
- Scripted NIST Biometrics collections.
- Modified (corrupted/meliorated) images – blurring or noise added/filtered to mimic imagery ‘in the wild’
- Synthetic (faces from the British Home Office, NIST ++ )
- Imagery from the wild, available to practitioners

# Conclusions: Forensic image scale development

- We have taken initial steps to assess the applicability of an image interpretation quality model; need a more formal eval.
- It remains to determine forensics-specific tasks, to incorporate other aspects of forensics work flow, and to build an optimal forensic image quality model.
- We are working with 2 forensic practitioners and invite you to view a demo of the FIERS implementation at the break.
- Potential payoffs for forensic science:
  - quantify image quality requirements
  - potential for automated ratings of large image collections, could support prioritized image examination
  - reliability measures for forensic examination process
  - quantify value of images as evidence (pathology). The capability to quantify examination potential of any image, may reduce the risk of conflicting expert testimony.