

Visual Acuity and Task-Based Video Quality in Public Safety Applications

Joel Dumke

Public Safety Communications Research

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Acknowledgement

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VQiPS

- Video Quality in Public Safety
 - A working group under DHS
 - Practitioners, researchers, industry
 - Hosts annual workshops
 - Always looking for volunteers
 - http://www.pscr.gov/projects/video_quality/vqips/vqip

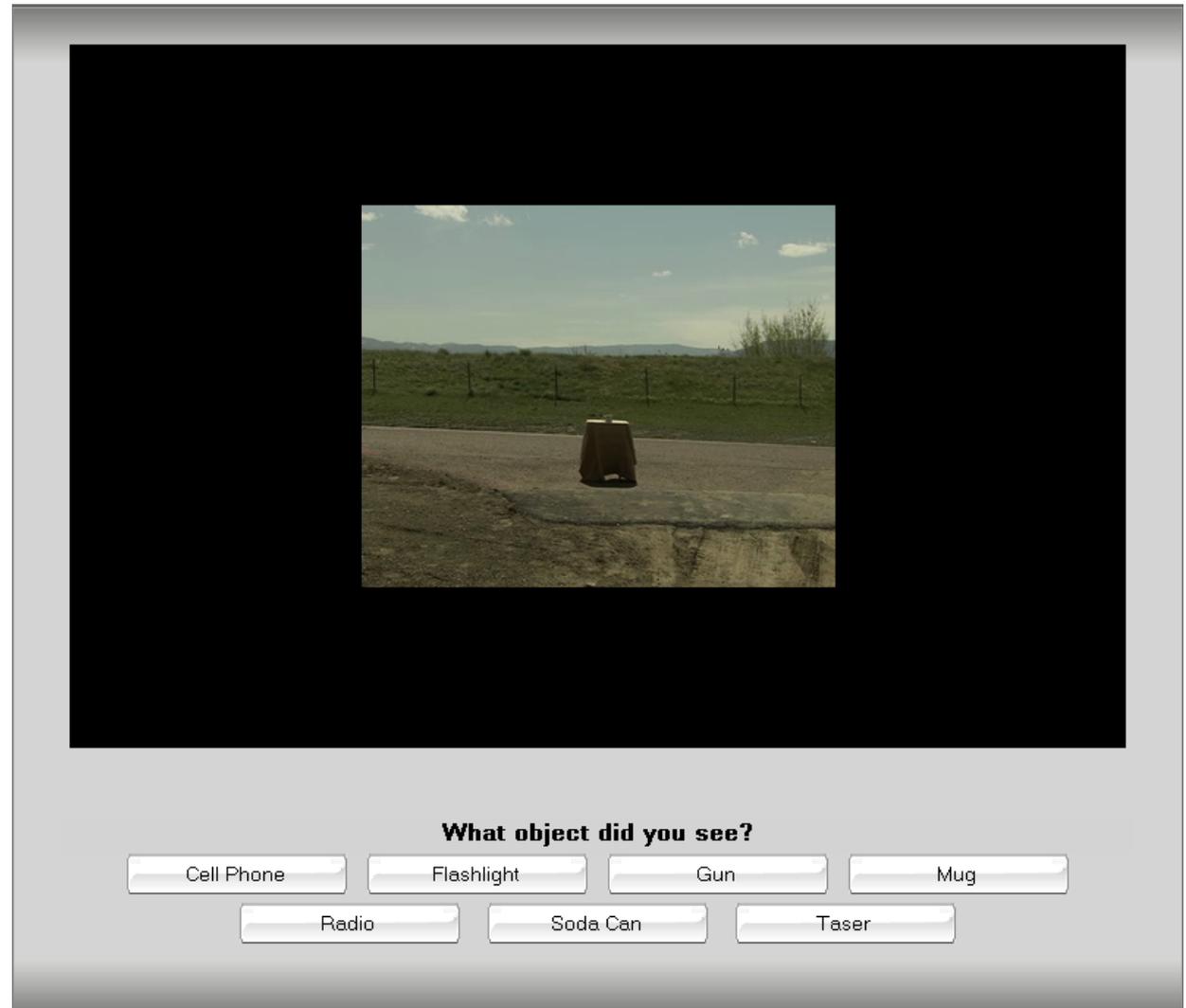


Video Quality

- Our goal is to develop recommendations for public safety practitioners
 - Minimum requirements to meet their needs
- What is quality in public safety applications?
 - MOS is not appropriate for public safety
 - Video must be useful—we have taken a task-based approach
- We wish to avoid specific use cases
 - For efficiency, one set of recommendations should apply to police, fire fighters, EMS, etc.

Example: The Object Recognition Task

- The object recognition task is common across public safety applications
- Forced Choice



What object did you see?

Cell Phone Flashlight Gun Mug

Radio Soda Can Taser

Generalized Use Classes (GUC's)

- Developed by Video Quality in Public Safety (VQiPS) working group
- Three parameters describe scene content
 - Target size: Large or small?
 - Motion: High motion or low motion?
 - Lighting level: Bright, dim or variable?
- Two parameters for how the video is used
 - Usage Timeframe: Live or recorded video?
 - Discrimination Level: Do you need positive ID, characteristics, classification, or just general awareness?

Test Design Problem

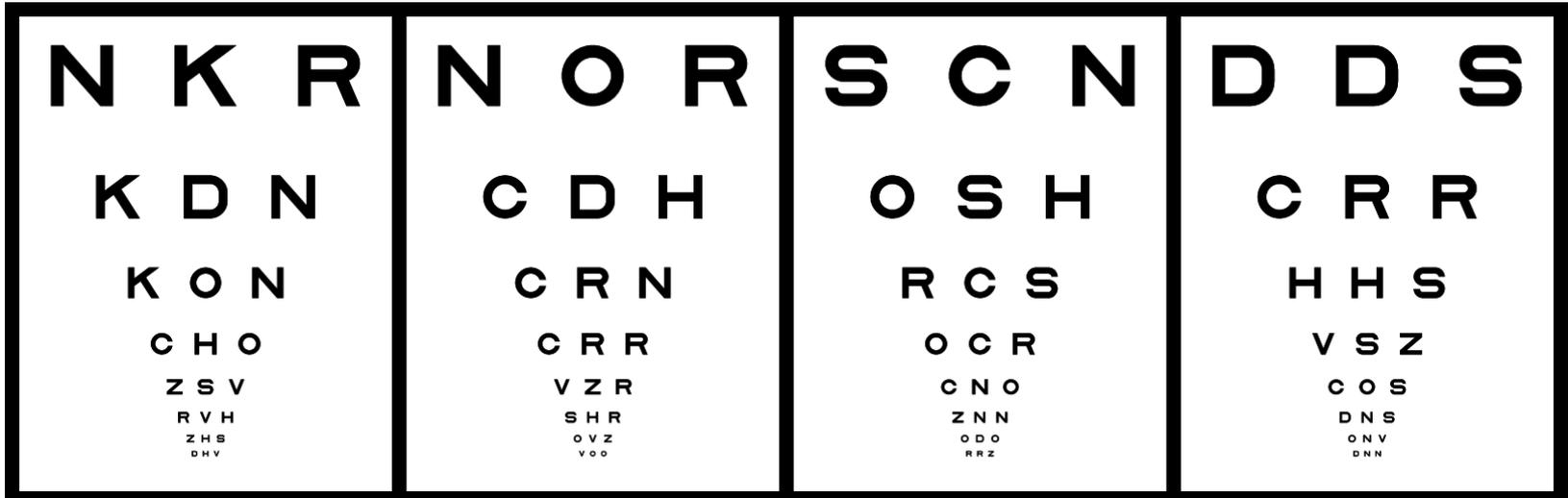
- The scene content and use parameters define 96 different GUC's
- We wish to examine 10 different video systems of varying resolution and bitrate
- The direct approach would require task-based quality assessment under 960 different conditions
 - A prohibitive amount of subjective data

Test Design Solution

- Use a quality metric to separate scene content parameters from use parameters
 - One test measures the quality supplied by each video system applied to each type of scene
 - This test measures performance of the object recognition task in parallel to provide a basis for judging our metric
 - A second test measures the quality required for each desired use (e.g. Positive ID, target classification, etc.)

Visual Acuity

- A metric that incorporates a recognition task
- Can be measured “in the field”
- Determined by the smallest Sloan letters than can be reliably recognized on a reduced LogMAR chart



Test Details

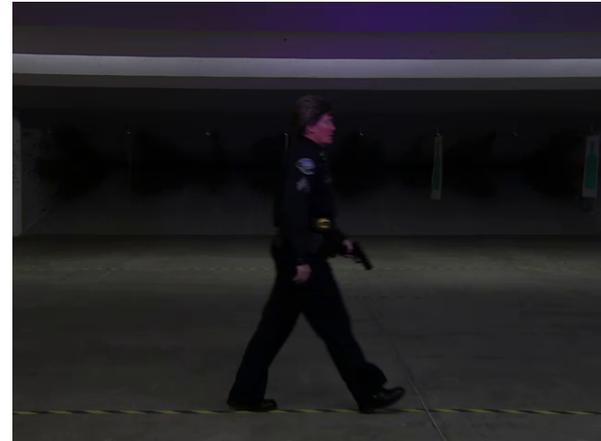
- Scene content parameters
 - Lighting: Outdoor, bright, dim w/ flashing, flashing only
 - Motion: Stationary, walking speed
 - Target Size: Small, large
- Items: Gun, taser, radio, flashlight, cell phone, mug, soda can
- Processing parameters (HRC's)
 - Resolutions: CIF, VGA
 - Bitrates: five choices for each resolution
 - All clips were encoded with H.264, main profile

Lighting Examples

Outdoor



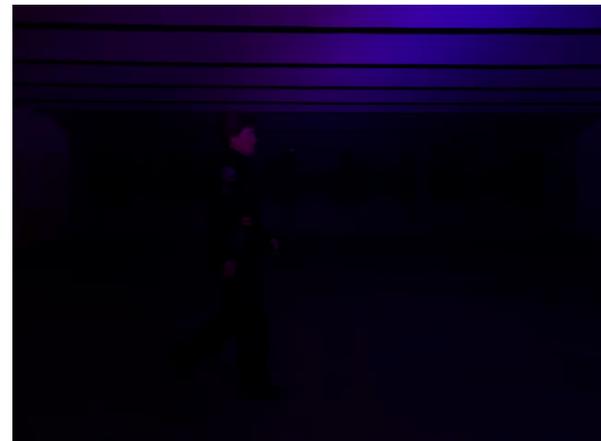
Bright



Dim w/ Flashing



Flashing Only



Motion and Target Size Examples

Walking, Large Target



Walking, Small Target



Stationary, Large Target



More Test Details

- For a given scenario group, scenes were held as constant as possible
 - Only the target object changes
 - Combats memorization
- Acuity charts were synthetically inserted into test sequences
 - Motion and lighting were carefully simulated
- Collected data from 39 viewers
 - Asked to read acuity charts and identify objects for each sequence
- Methods described in ITU-T Recommendation P.912

Test Interface – Visual Acuity

The interface displays a video of a person walking in a field. Overlaid on the left is a visual acuity chart with the following letters:

Z Z O
C Z O
K V H
N V Z
R N V
O S K
O O V
= Z Z

Fill in the chart letters below :

1	Z	Z	O
2	C	Z	O
3	K	V	H
4	N	V	Z
5	R	N	V
6	O	S	K
7	O	O	V
8	X	X	X

Submit

Current video : 2 of 96

Pause Test

Navigation icons: back, stop, forward, full screen

Test Interface – Object Recognition

K R

Z R

H N K

D C O

C V N

D O C

C N O

R C Z

What object did you see?

Cell Phone

Flashlight

Gun

Mug

Radio

Soda Can

Taser

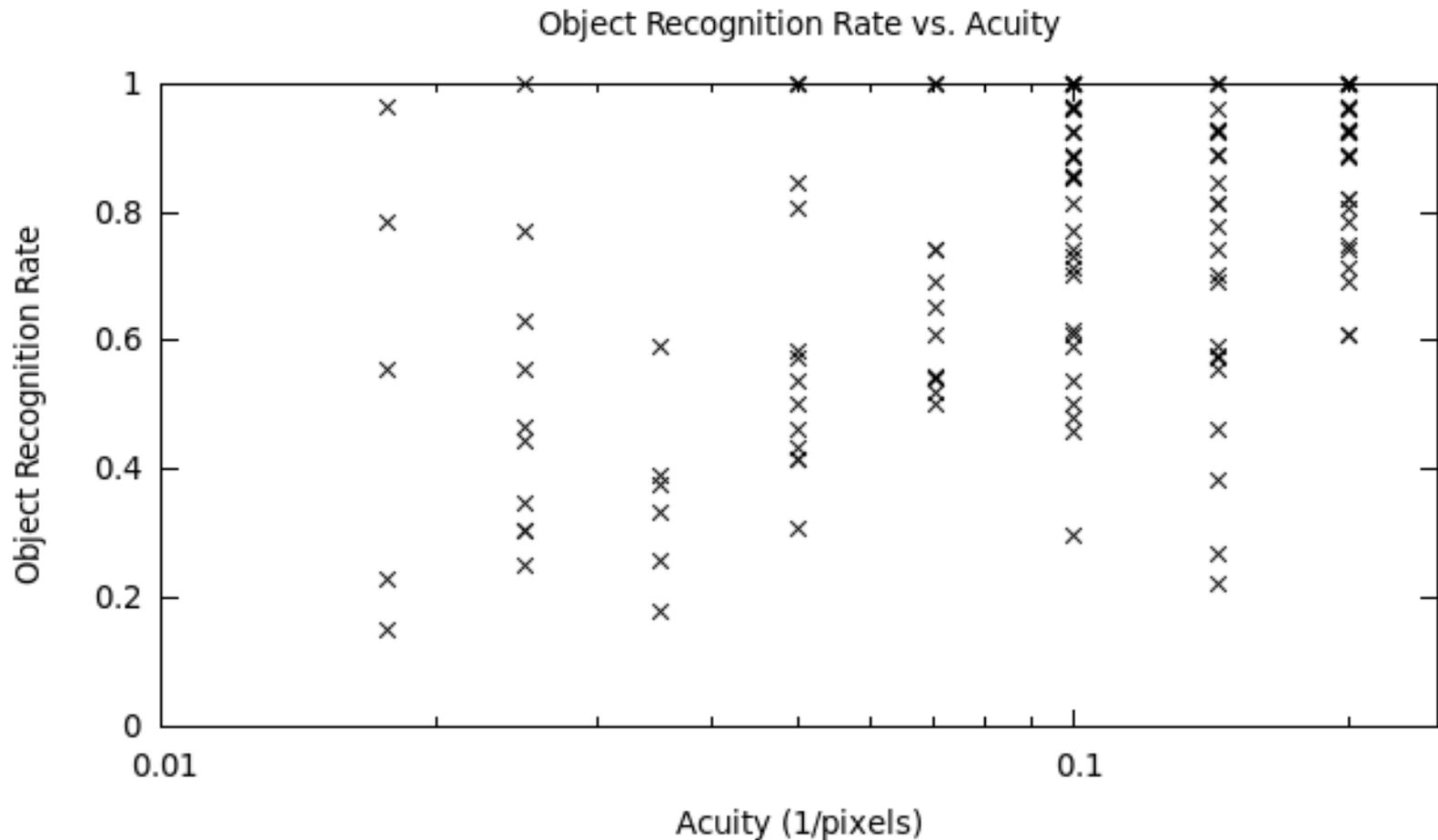
Current video : 4 of 96

Current question : 1 of 1

Pause Test

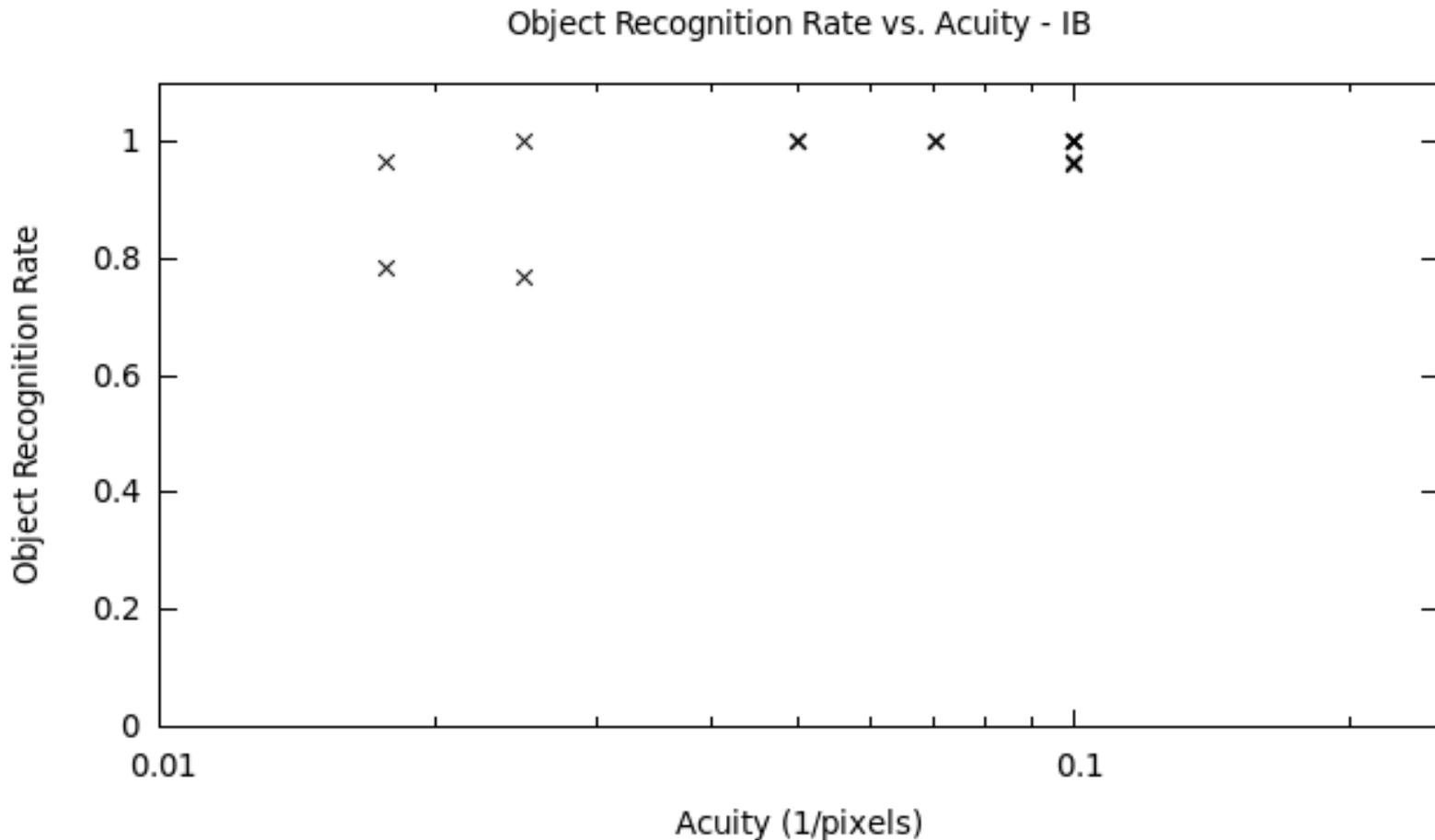
Results

- Viewers were treated as statistically equivalent
- Acuity is the inverse of the height (in pixels) of the smallest characters correctly recognized 90% of the time



Outliers

- Bright light, high motion, large targets
 - Shows low acuity with high recognition rate



Conclusions

- The relationship between acuity and recognition rate varies greatly with target size
 - Intuitively, recognizing a small target should require more acuity
 - We hypothesize that recognizing a small target is a fundamentally different task from recognizing a large target
 - VQiPS should have treated target size as a use parameter rather than a scene content parameter
 - Target size may not be independent from discrimination level
- In other GUC's acuity tracks recognition rate relatively well
 - Especially with low light—lighting parameter dominates

Beyond Object Recognition

- New tasks designed for most recent test

Pause Test

Current video : 2 of 3
Current question : 3 of 4

Recommendations

Scenario	General Elements	Classification	Characteristics (75-percent perfect)	Positive ID (90-percent accuracy)
Bright light, low motion, large target	64 kbps, CIF	64 kbps, CIF	64 kbps, CIF	128 kbps, CIF
Bright light, low motion, small target	128 kbps, VGA	128 kbps, VGA	128 kbps, VGA	128 kbps, VGA
Bright light, high motion, large target	64 kbps, CIF	64 kbps, CIF	128 kbps, CIF	*1024 kbps, CIF
Bright light, high motion, small target	128 kbps, VGA	128 kbps, VGA	128 kbps, VGA	256 kbps, VGA
Dim light, low motion, large target	128 kbps, CIF	128 kbps, CIF	256 kbps, CIF	512 kbps, CIF
Dim light, low motion, small target	256 kbps, VGA	256 kbps, VGA	512 kbps, VGA	512 kbps, VGA
Dim light, high motion, large target	128 kbps, CIF	256 kbps, CIF	512 kbps, CIF	*1024 kbps, CIF
Dim light, high motion, small target	512 kbps, VGA	512 kbps, VGA	1024 kbps, VGA	*2048 kbps, VGA
Variable light, low motion, large target	256 kbps, CIF	512 kbps, CIF	512 kbps, CIF	*1024 kbps, CIF
Variable light, low motion, small target	256 kbps, VGA	1024 kbps, VGA	1024 kbps, VGA	*2048 kbps, VGA
Variable light, high motion, large target	256 kbps, CIF	1025 kbps, CIF	*1024 kbps, CIF	*1024 kbps, CIF
Variable light, high motion, small target	512 kbps, VGA	512 kbps, VGA	*2048 kbps, VGA	*2048 kbps, VGA

Web Tool

- http://www.pscr.gov/outreach/vqips/vqips_guide/rec_tool_vid_reqs.php

Web Tool - Inputs

www.pscr.gov/outreach/vqips/vqips_guide/rec_tool_vid_reqs.php

1. Identify Use Cases 2. Generalize Use Cases into Use Classes 3. Understand System Tasks System Functions 4. Match Use Classes to Equipment Recommendations

Revised May 29, 2012

FEEDBACK

Recommendations Tool for Video Requirements

Use this tool to get recommendations for a single **use case**, or follow the **Generalized Use Class Questionnaire** steps to get recommendations that apply to multiple use cases belonging to one or more **use classes**.

Answer these questions and then click **Get Recommendations**.

Usage Timeframe

Will you use the video for real-time applications or record for later use?

Live or real-time
 Recorded

Discrimination Level

What do you need to recognize a target of interest?

General Elements of the Action
 Target Class Recognition
 Target Class Characteristics
 Target Positive ID

Target Size

How much of the frame does the object or person of interest occupy?

Large
 Small

Motion

How much movement (of the target or the camera) and spatial detail occupies the frame?

High
 Minimal

Lighting Level

Is lighting uniform, or will near-black to daylight ranges occur in the frame?

Constant Lighting - Bright
 Constant Lighting - Dim
 Variable Lighting

Storage Calculator:

How long would you like to store captured video? (days:hours:minutes)

How many cameras are being used?

Web Tool - Outputs

← → ↻ 🏠 www.pscr.gov/outreach/vqips/vqips_guide/rec_tool_vid_reqs.php ☆ 🔔 ☰

Lighting is at a comparatively dim level. (D)
● Variable Lighting

Storage Calculator:
How long would you like to store captured video? (days:hours:minutes)

How many cameras are being used?

Recommendation Key Code: (Rec2LMD)
The recommendation key code provides a simple abbreviation for the video requirements identified by your answers to the preceding questions. The code is a joining of the word, number, or character displayed in parantheses for each answer you chose. Review the description and parantheses content for your answers to decipher the code.

Recommended bit rate: 128 kbps - Total Storage Size: 39.551 GB

Timeframe
Consider Storage
Consider the high storage demands of using a high-resolution camera (good for capturing a high level of detail).

Focus
Focal Length
See [3, 4] for tools to help choose a specific focal length.
Monitor a Room
Consider a lens with a wide angle to monitor large targets in a room. See [3, 4] for tools to help choose a specific focal length.
Monitor an Area of a Room
Consider a lens with a narrower angle to monitor an area of a room. See [3, 4] for tools to help choose a specific focal length.
Wide-Angle Lens
A lens' ability to capture a wide scene is a function of its "focal length," which is measured in millimeters, with smaller focal length lenses capturing wider scenes (but making them appear smaller or farther away). See [3, 4] for tools to help choose a specific focal length.
Wide/Large-Aperture Lens when Light is Dim
The ability of lenses to admit light is measured in f-stops, where smaller numbers indicate lenses that admit more light. A wide-aperture lens allows more light to hit the image sensor. This comes at a cost, however: wide aperture lenses (or lenses using a wide-aperture setting — letting more light come in) have difficulty keeping both near and distant parts of the scene in focus at the same time (a quality known as depth-of-field).

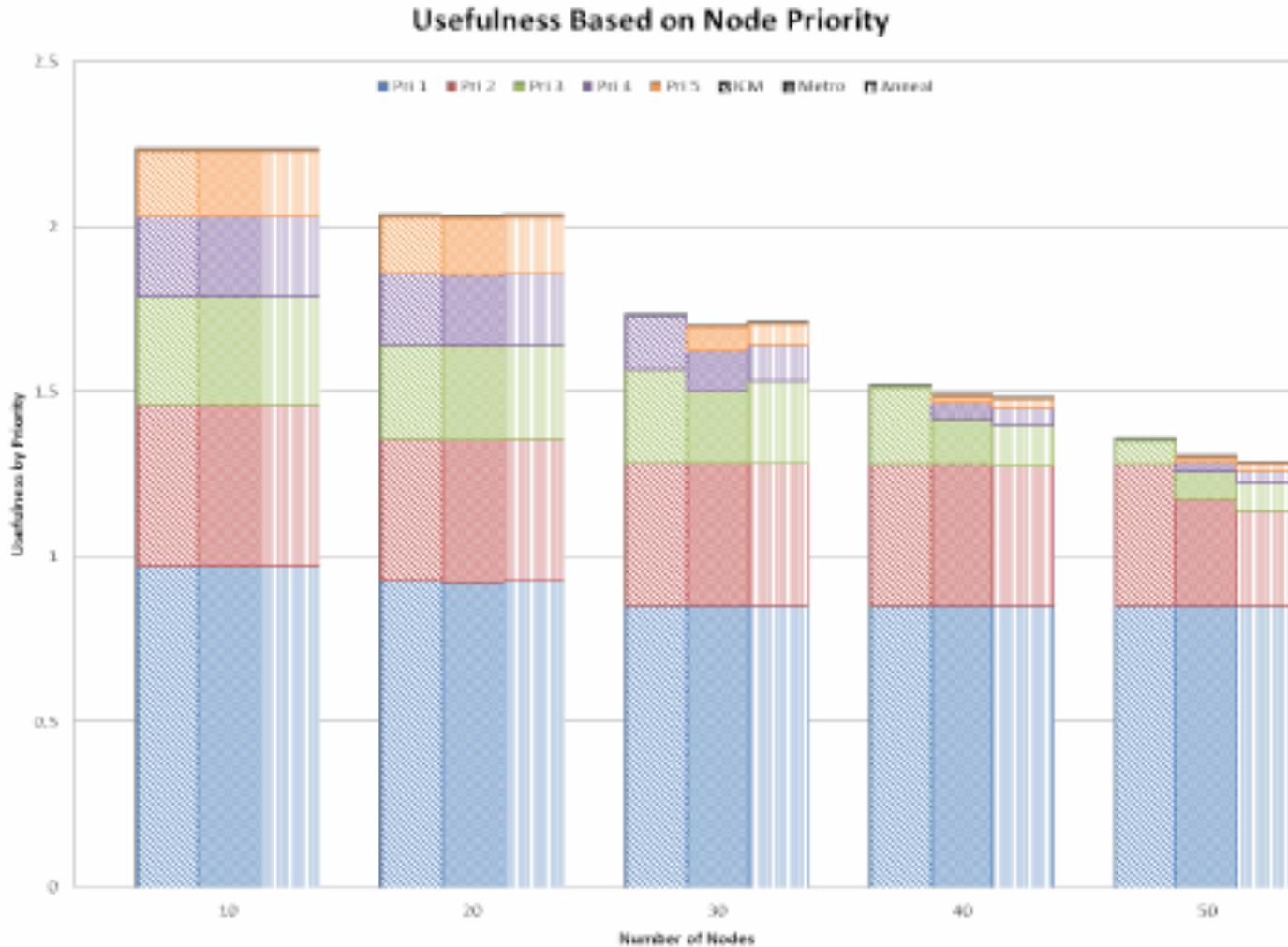
Now What?

- Broadband in public safety makes video more useful than ever
 - But video is still very demanding
- We are now developing a network optimization algorithm for managing multiple video streams over an LTE network with limited resources
 - Requires two major ingredients
 - Relationship between resources and quality
 - An optimization algorithm

Problem Statement

- Goal is to distribute network resources to users in the best way possible.
 - Our research provides a lot of guidance
 - Must be balanced against local priorities
- Studying a variety of optimization algorithms
 - Iterated Conditional Modes (ICM)
 - Simulated annealing
 - Metropolis-Hastings Algorithm

Preliminary Results



Questions?

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