

# Measuring Image Quality

Heath Nielson

# Measuring Quality

What

- Identify and measure attributes of an image that can be used to determine whether the perceived quality meets the expectations of the organization.

# Measuring Quality

## Why

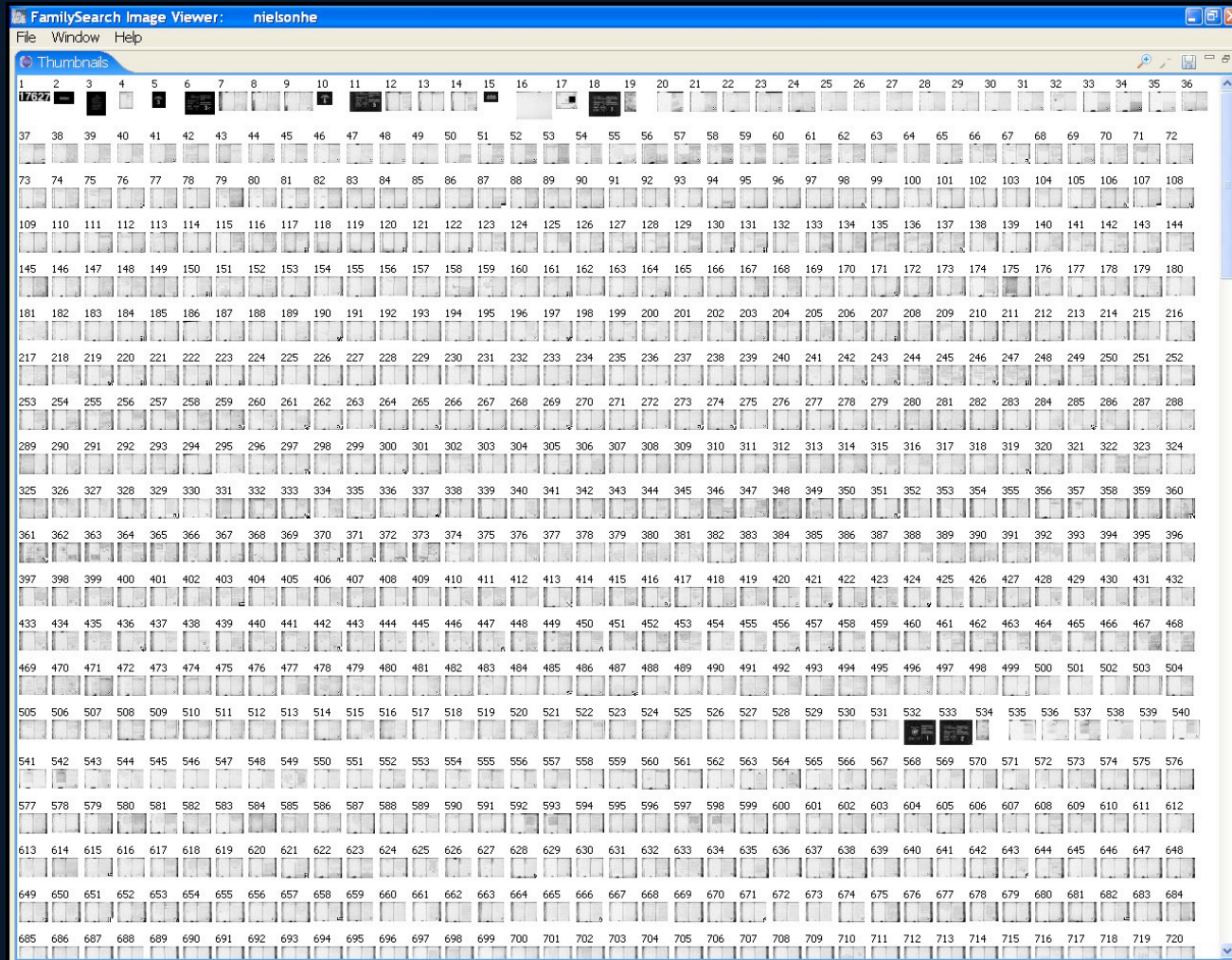
- Should be part of any document processing system
- Guarantee consistency
- Useful for identifying upstream process problems
  - Manual
  - Automated

# Measuring Quality

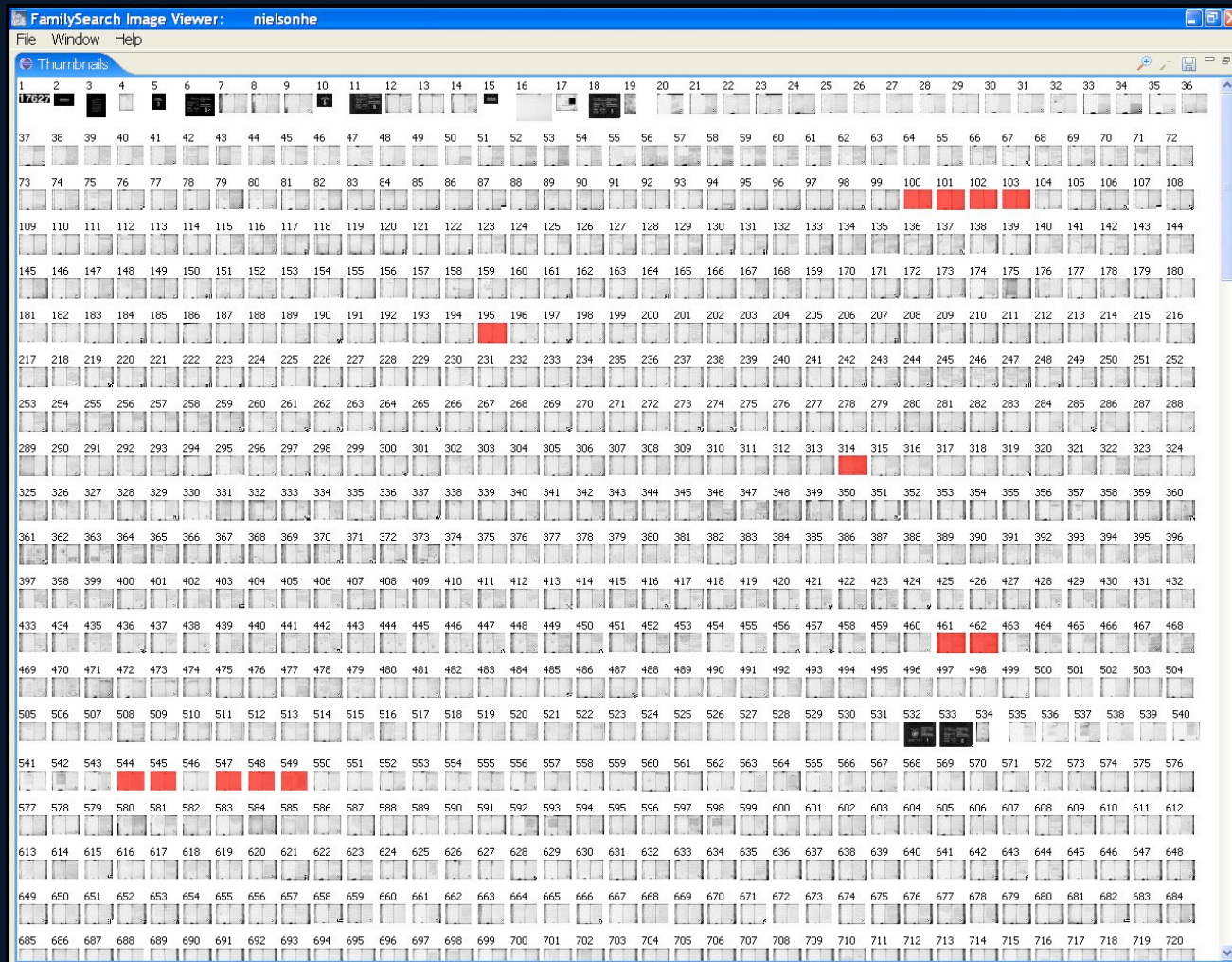
How

- Subjective
  - Easy to do
  - Not always predictable nor consistent
- Objective
  - Predictable and consistent
  - Hard to measure

# Audit Brute Force



# Audit Exception Based



# Contributing factors affecting quality

- State of original document
- Digitization
  - Resolution
  - Lighting
  - Exposure
  - Focus
- Post-processing
  - Rotation
  - Cropping
  - Contrast enhancement
  - Lossy compression

# Quality Standards

DIRT (Digital Image Research Team)

- Composed of operational and development personnel
- Identify image attributes affecting quality
- Provide, where possible, metrics to measure those attributes
- Determine acceptable ranges for attributes
- Provide tools and training to facilitate consistent quality



# Quality Standards

## DIRT Specification

- Defines image attributes and desirable values for each
  - Tonal Range
  - Tonal Resolution
  - Even Exposure
  - Spatial Resolution
  - Contrast
  - Colorspace
  - Focus
  - Blur
  - File format
  - File name
  - Dimensions
  - Size
  - Complete Capture
  - Orientation
  - Skew
  - Fixity

# Subjective Evaluation

- Direct Numerical Category Scaling
  - Subjects classify images into a number of categories
  - Usually use a numerical scale e.g. (1=Bad, 5=Good)
  - Subjects tend to use separate internal scales
    - Different “types” of images
    - Different types of distortion
- Functional Measurement Theory
  - Compares image qualities
  - Subjects indicate which image is preferred
  - More evaluations required
    - Each sampled image must be compared with every other sampled image

# Subjective Evaluation

## Jpeg Compression

- Sample images
  - Randomly selected
  - Includes image from both scanned microfilm and camera capture
  - Each image compressed at several predetermined settings
  - The original, uncompressed image is also included
- Images were presented randomly
- About 10% of the time a previously evaluated image is presented for reevaluation
- Each image was evaluated by 3 different subjects

# Subjective Evaluation

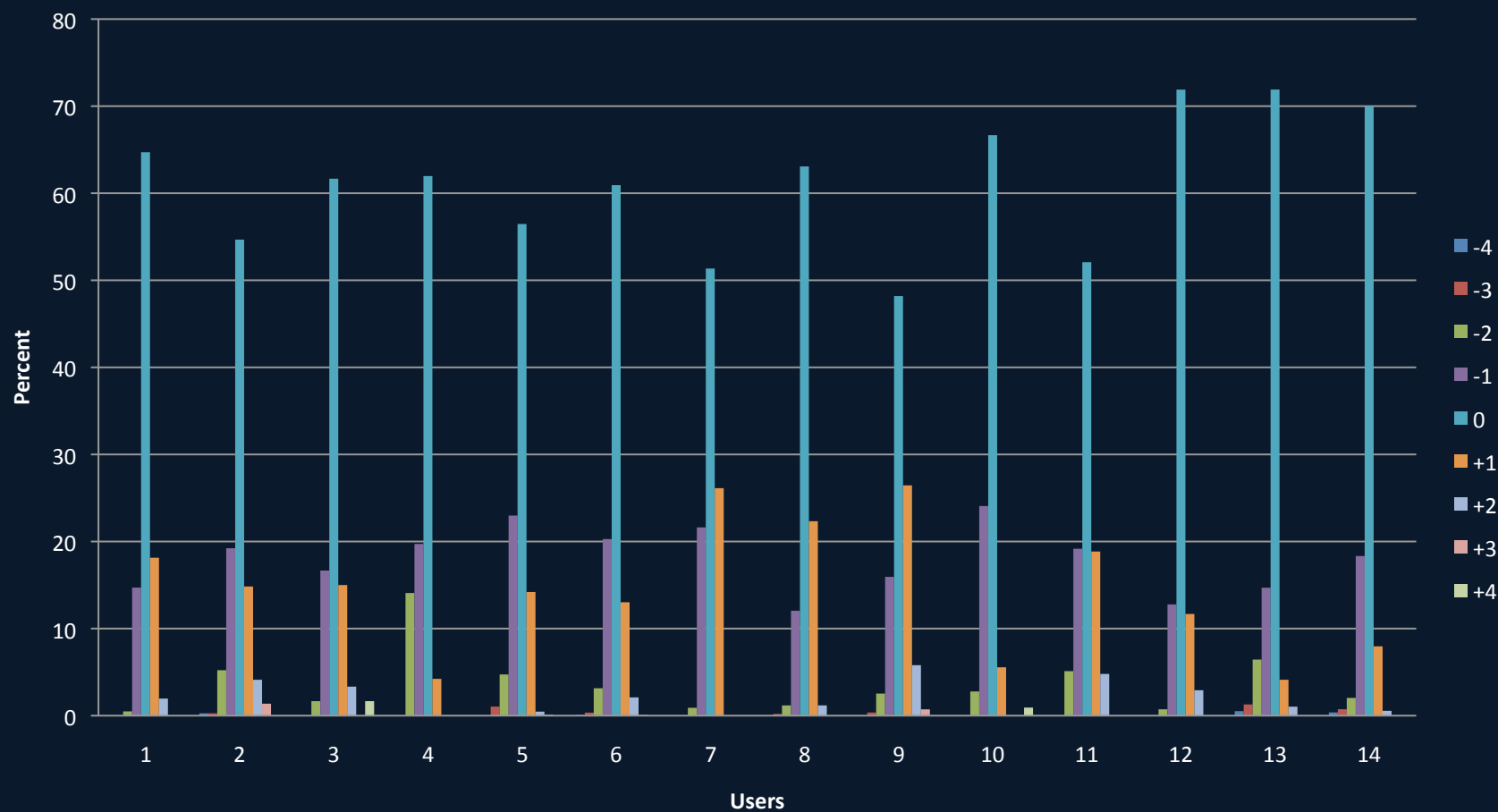
## Jpeg Compression

- Direct category scaling method
  - Asked to classify images on a scale of 1-5
- Zoom image 1-100%
- Pan around
- No time limit
- No calibration of monitors or ambient light



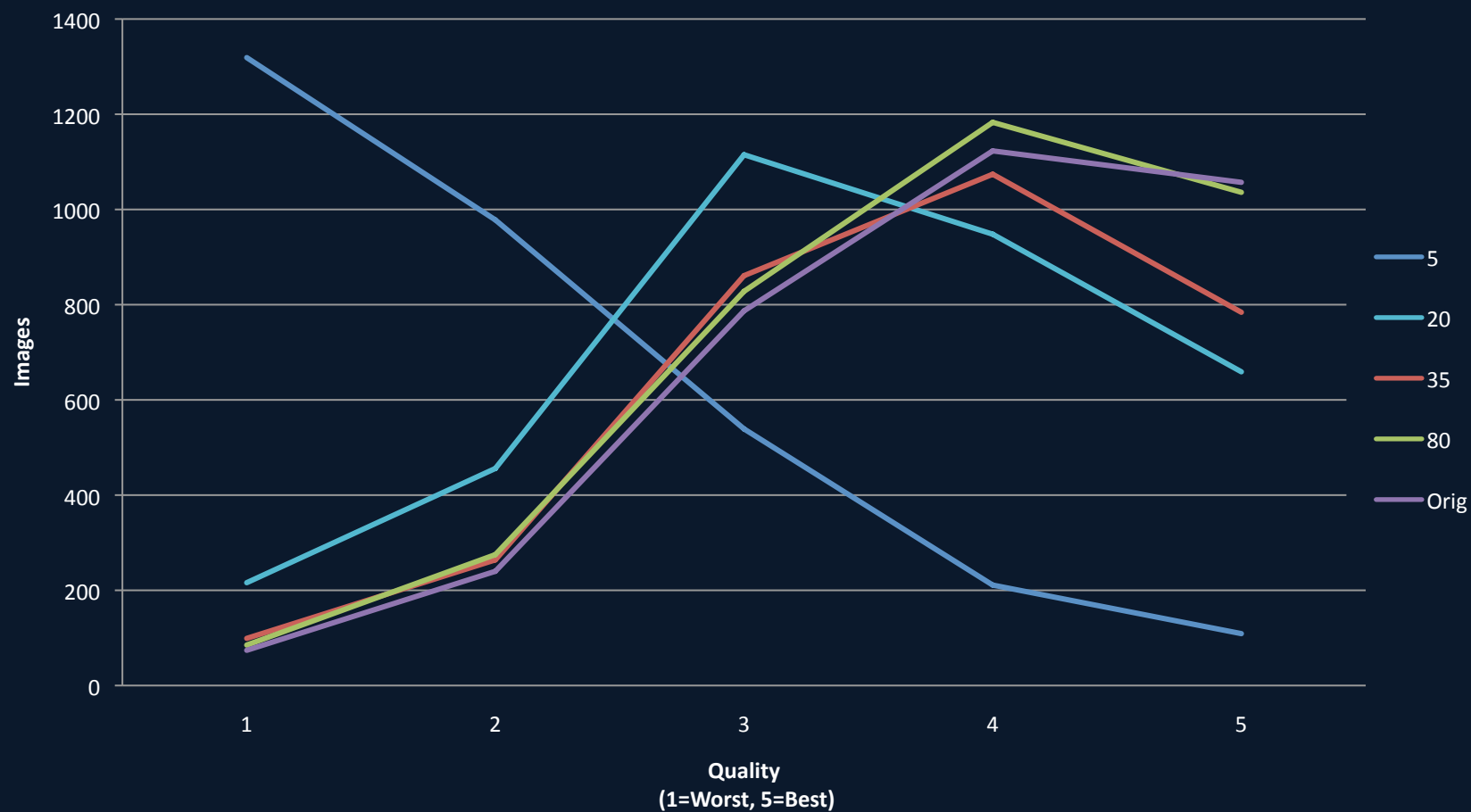
# Subjective Evaluation

## Consistency



# Subjective Evaluation

Raw scores



# Objective Measures

- No-Reference
  - No reference image available
  - “Blind” reference
- Reduced-Reference
  - Set of extracted features from reference image are used
- Full-Reference
  - A complete reference image is available



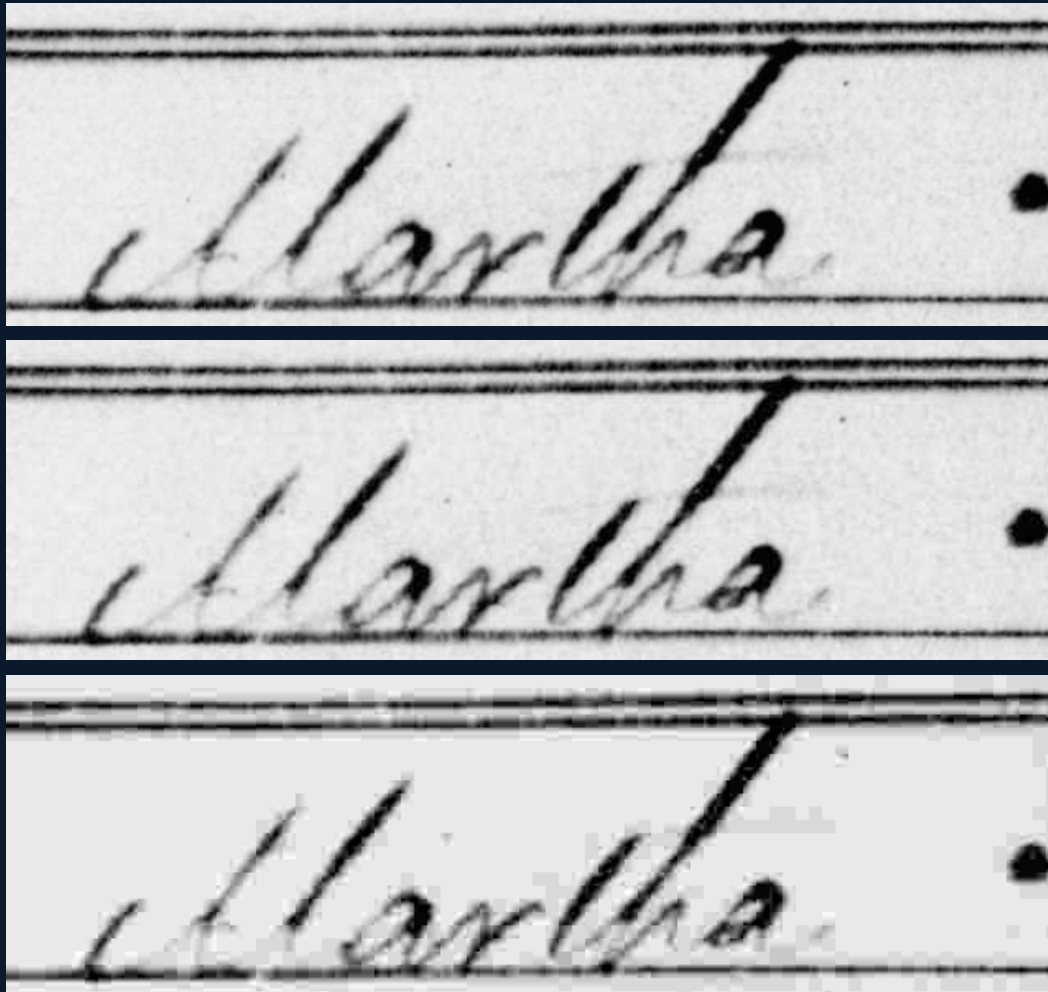
# MSE

- Measures how much something changed but not how important that change is
- Ranges from 0 (exactly the same) to infinity

$$MSE(\hat{\theta}) = E[(\hat{\theta} - \theta)^2]$$

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} (I(i, j) - K(i, j))^2$$

# MSE



JPEG Quality

80

4.6

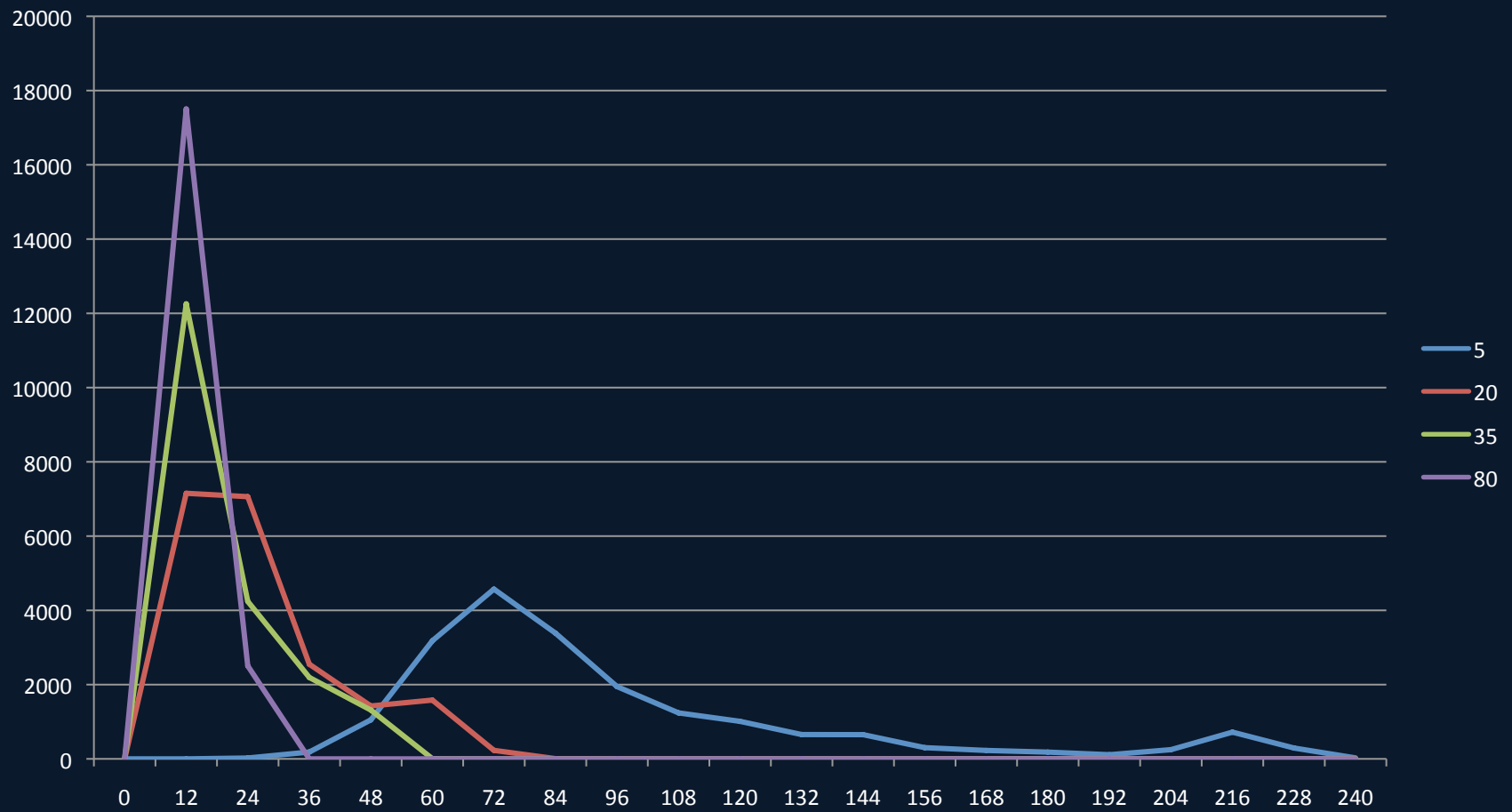
35

15.1

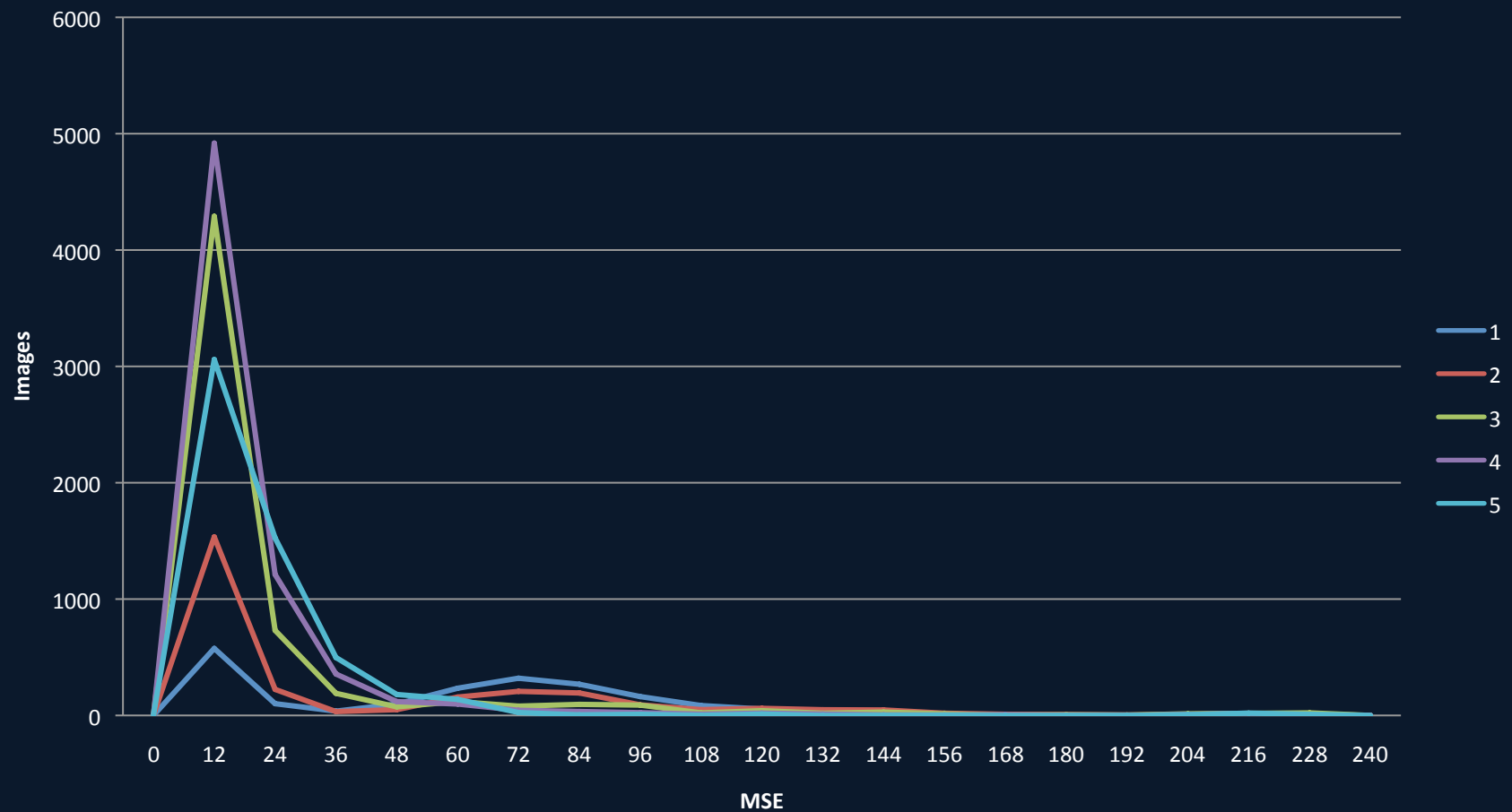
5

111.2

# MSE



# MSE vs. User Evaluation

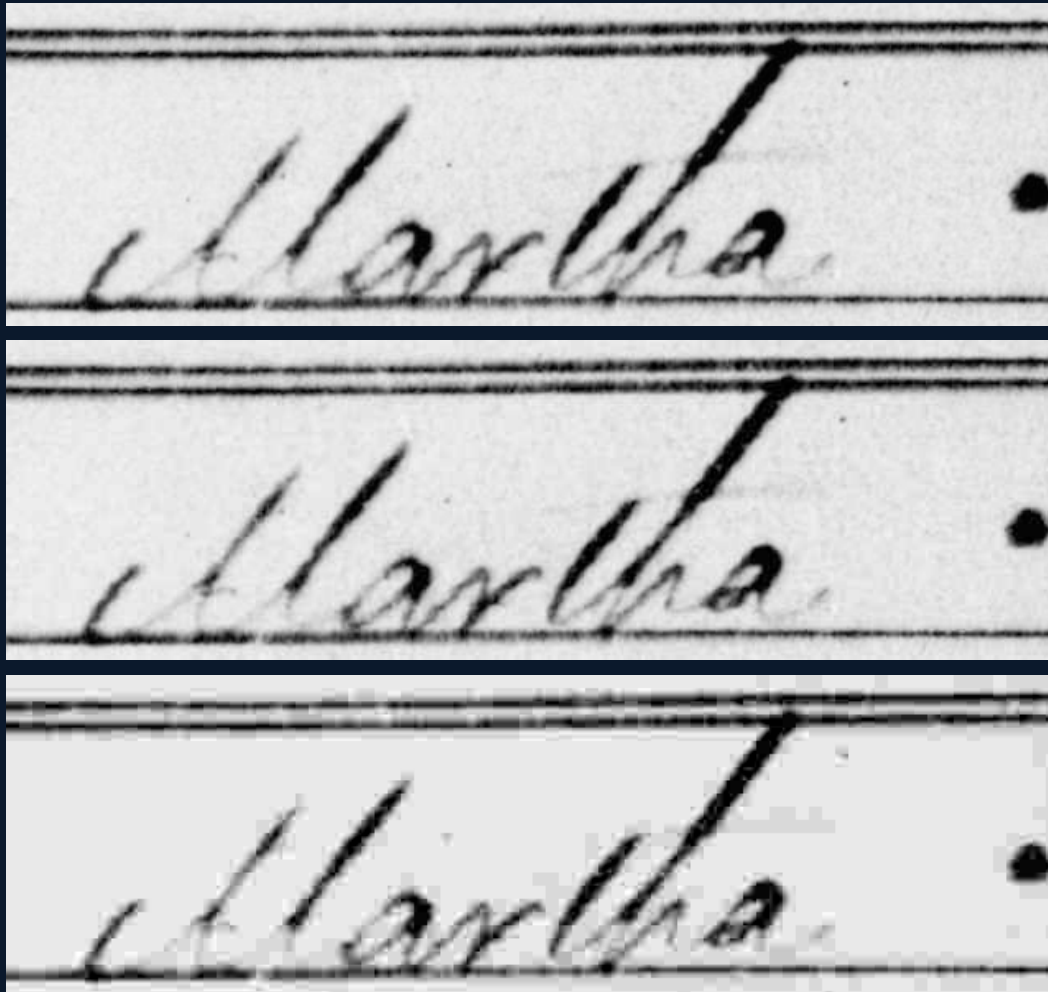


# PSNR

- Ratio between the maximum possible power and the power of corrupting noise introduced by compression
- Measured using the logarithmic decibel scale
- Higher values, better quality
- Typical values 30-50db

$$PSNR = 20 \cdot \log_{10} \left( \frac{MAX}{\sqrt{MSE}} \right)$$

# PSNR



JPEG Quality

80

41.5

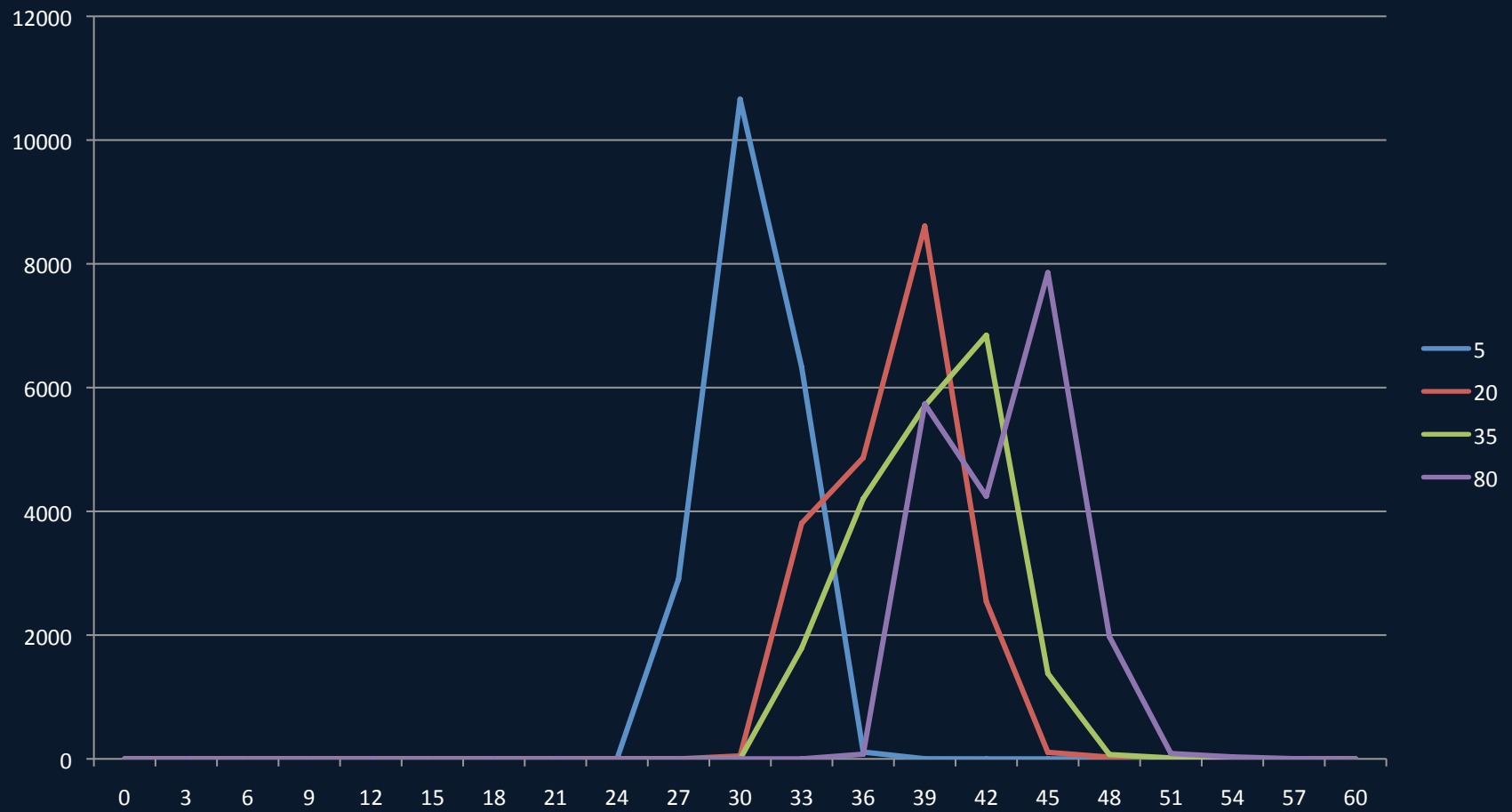
35

36.4

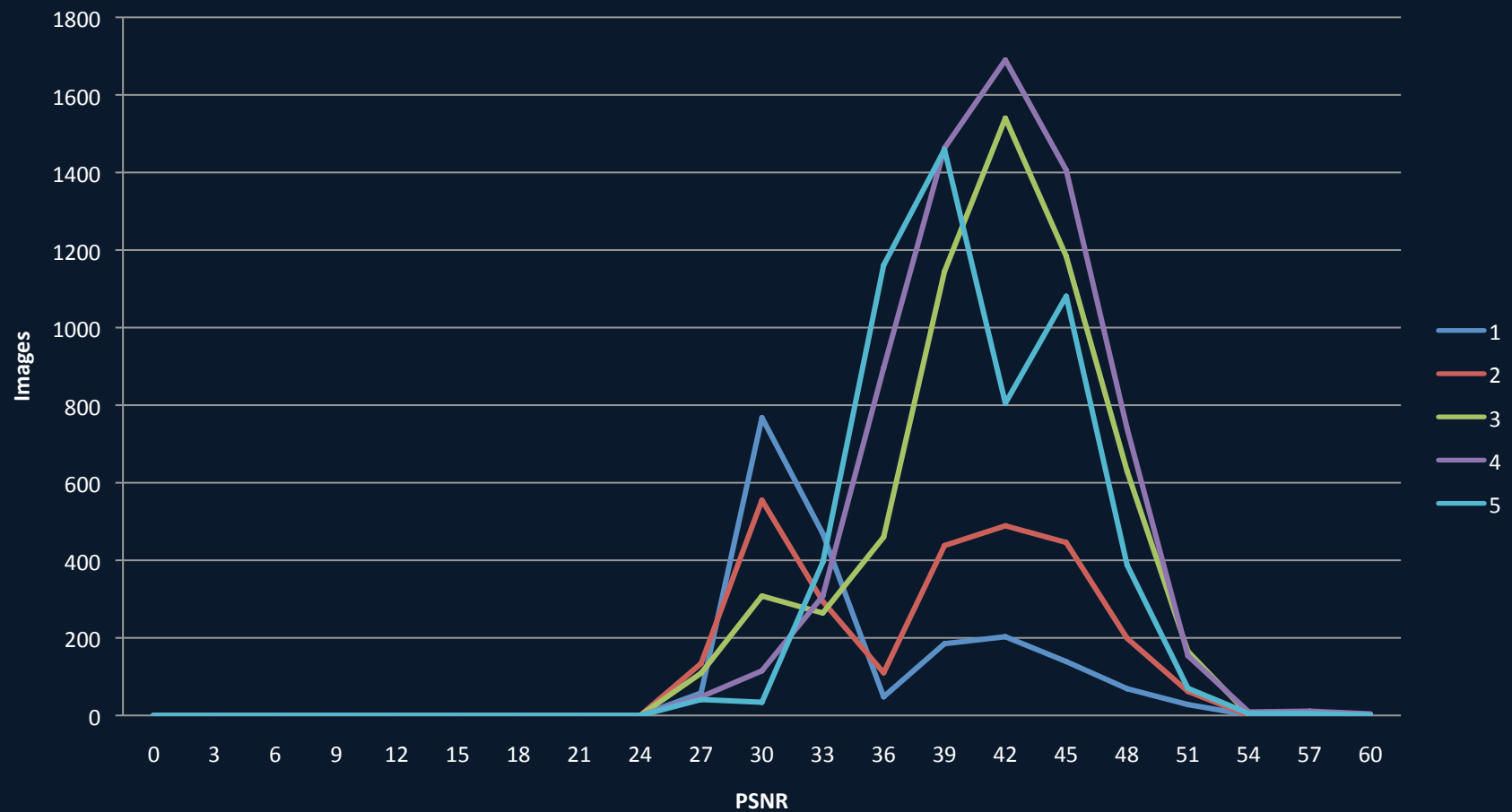
5

27.7

# PSNR



# PSNR vs User Evaluation





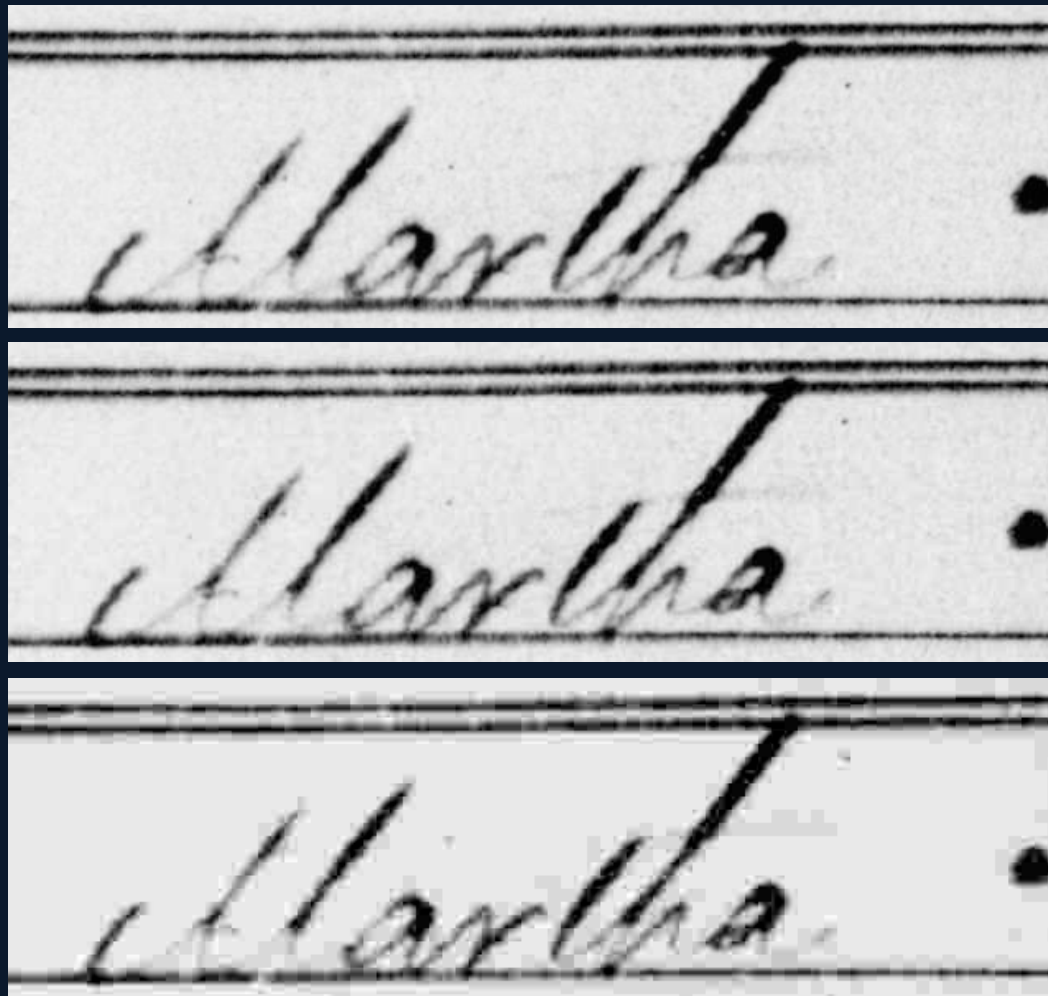
# Universal Quality Index

- Proposed by Wang and Bovik (2002)

$$Q = \frac{4\sigma_{xy}\bar{x}\bar{y}}{(\sigma_x^2 + \sigma_y^2)[(\bar{x})^2 + (\bar{y})^2]}$$

- Attempts to measure:
  - Loss of correlation
  - Luminance distortion
  - Contrast distortion

# Universal Quality Index



JPEG Quality

80

0.943

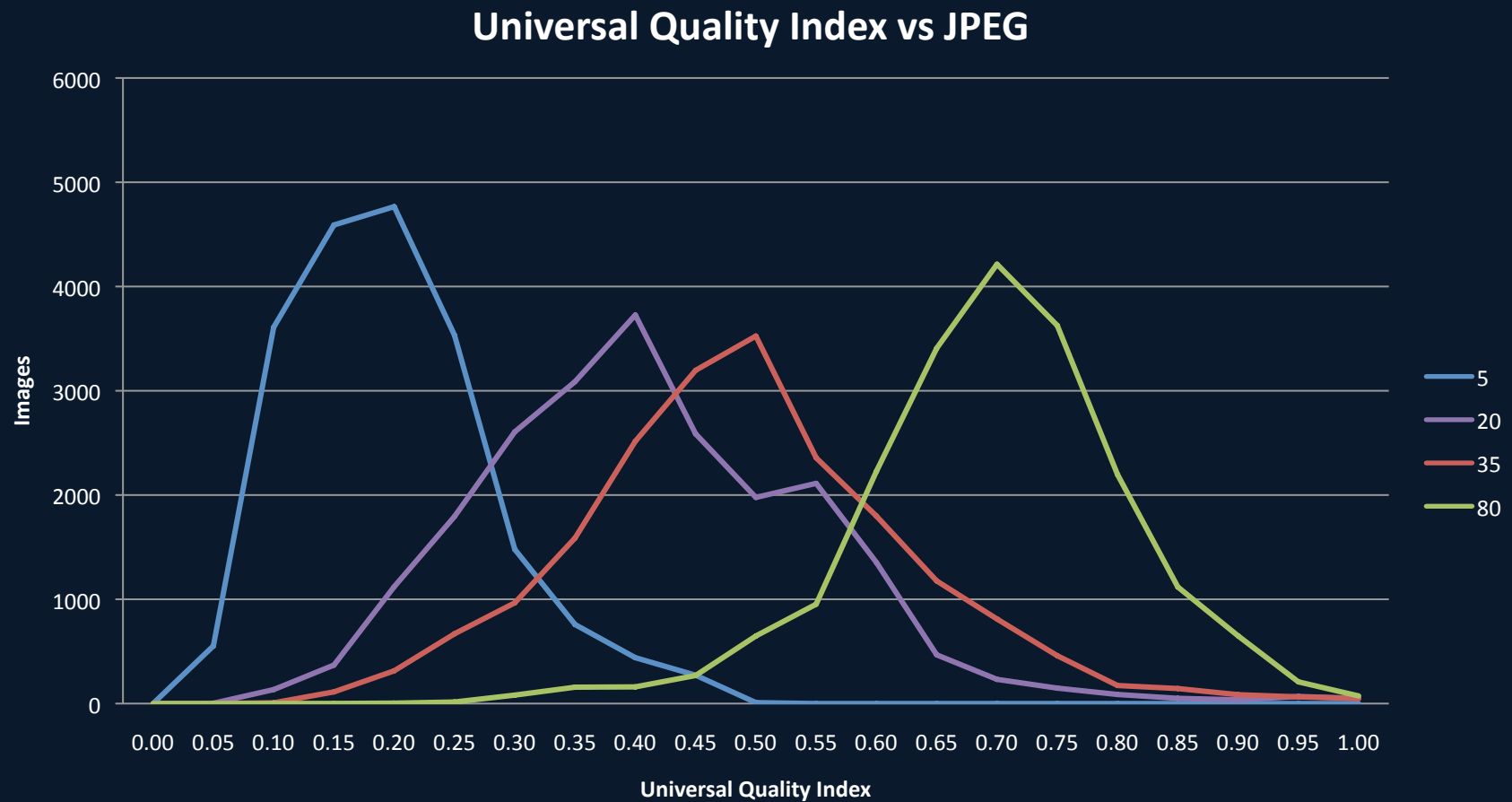
35

0.821

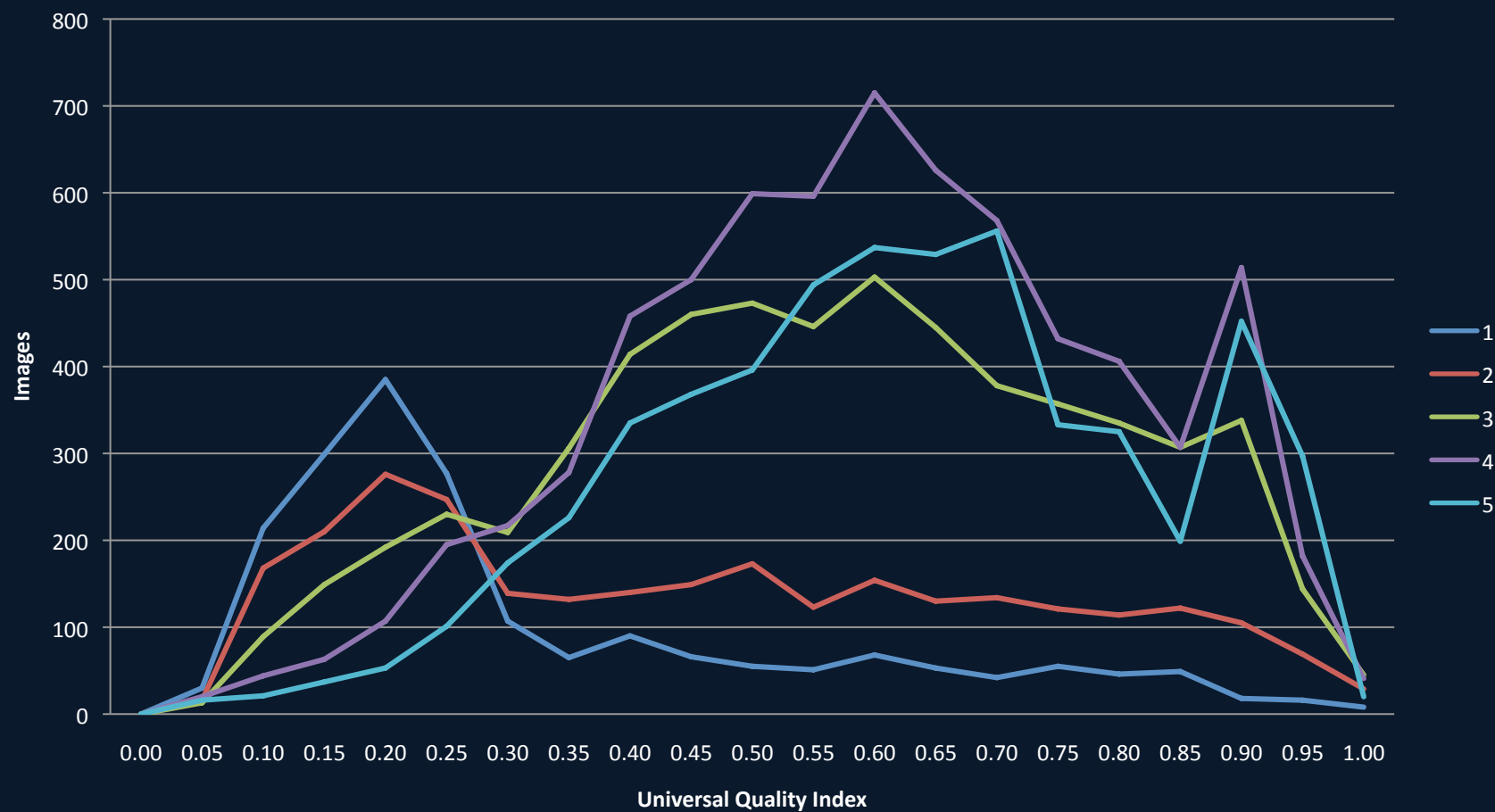
5

0.428

# Universal Quality Index vs JPEG



# UQI vs. User Evaluation



# Conclusion

- Refine subjective results
- Correlate subject results to objective
  - Evaluate other published quality metrics
  - Define our own