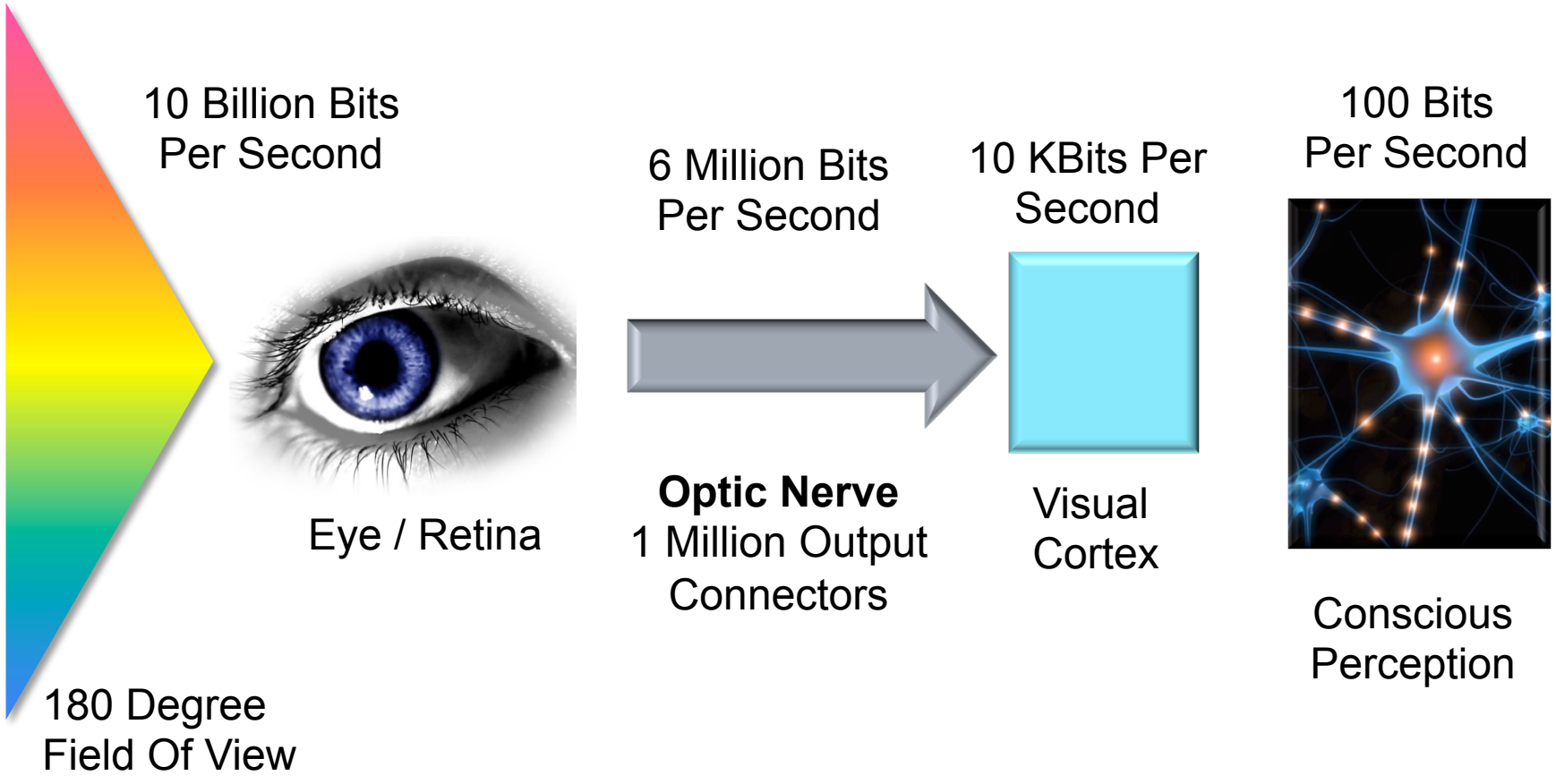
Tektronix

QC Testing using Artificial Intelligence

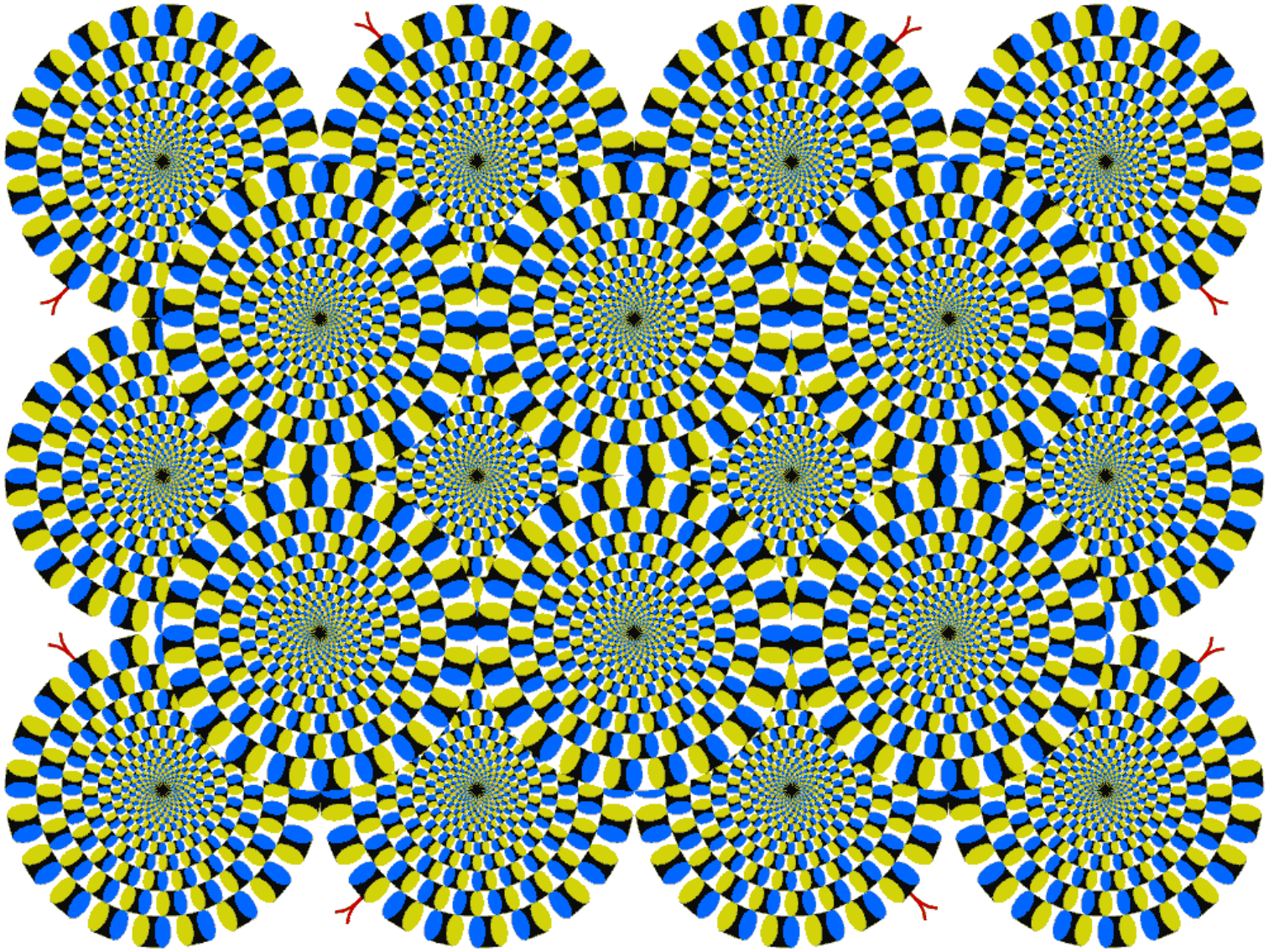
Visual Perception: Block Diagram



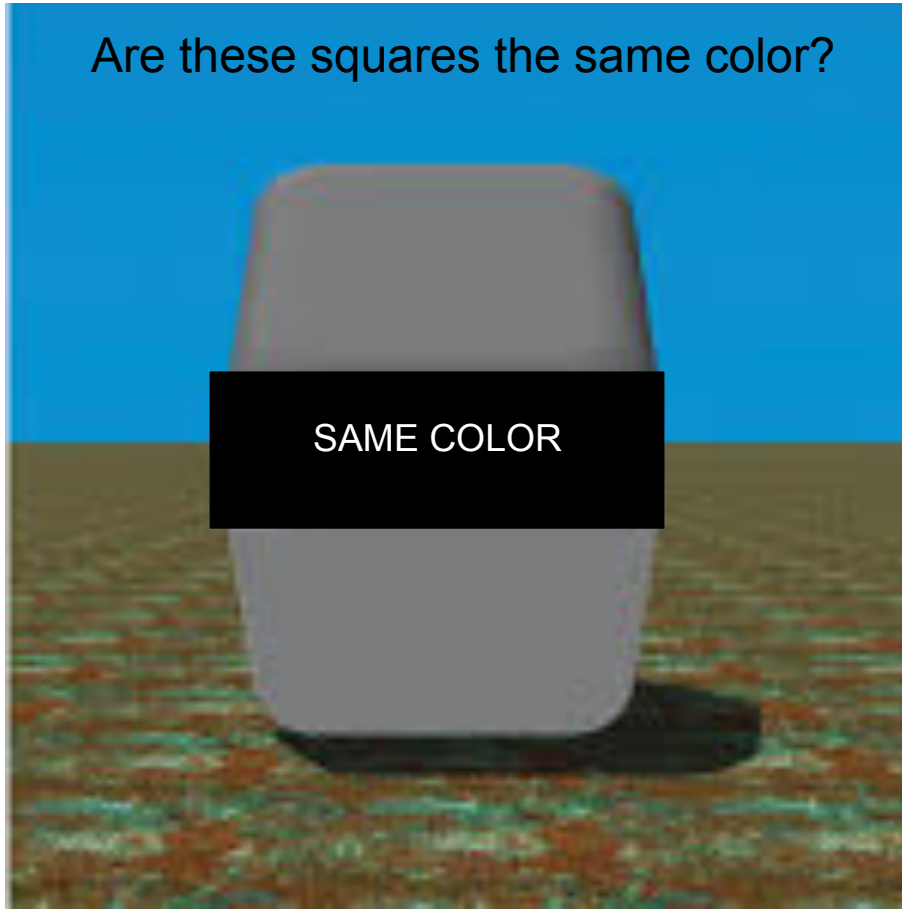
Visual Perception Major Factors - Simplified

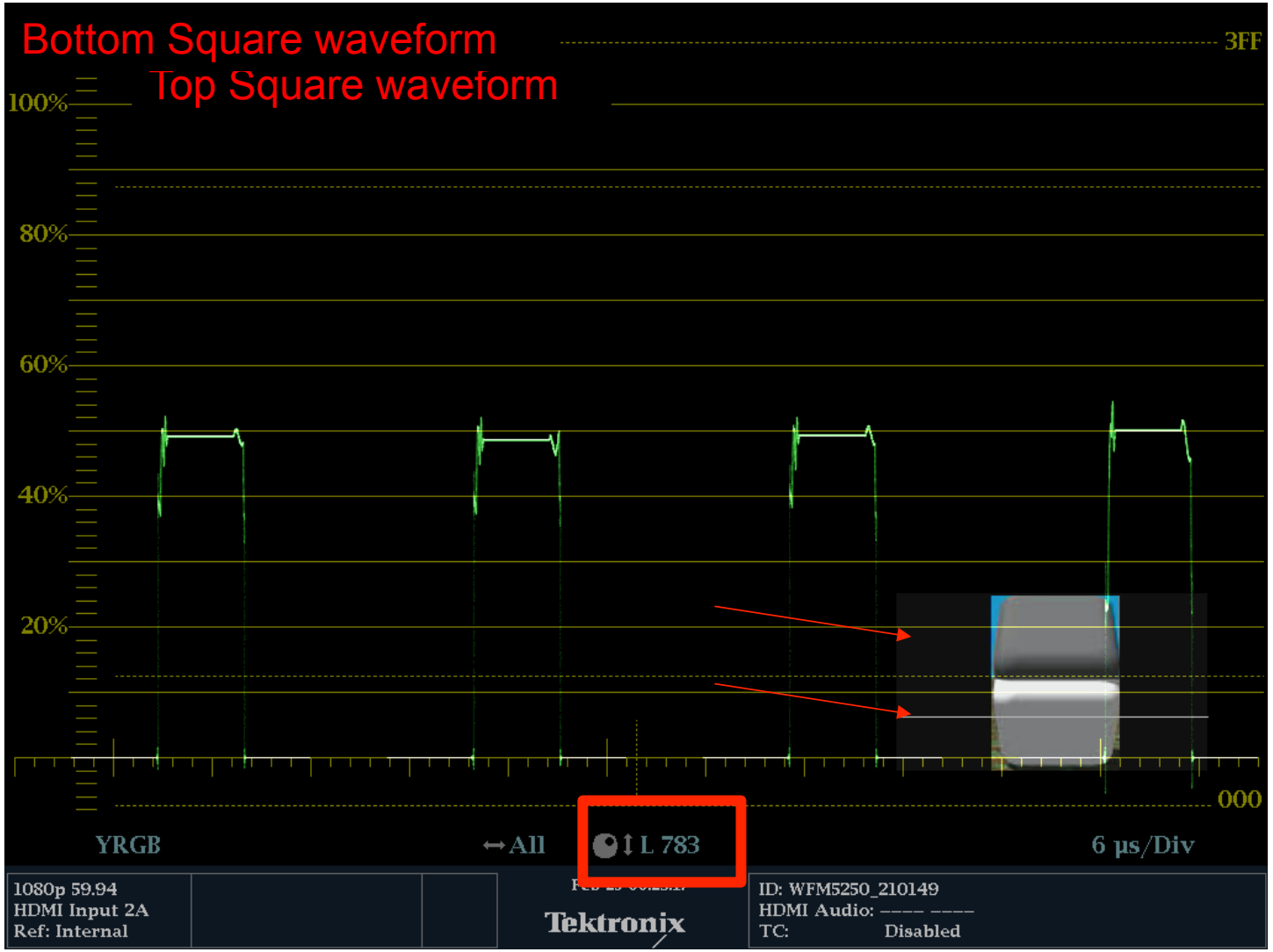
- Eye Movement
  - Constant Subtle Tracking
- Receptor Persistence and Sensitivity
  - Maximize Contrast to detect changes in illumination and color
- Conditioned Experience
  - Personal Knowledge of Objects and Conditions

Visual Perception: Persistence of Vison

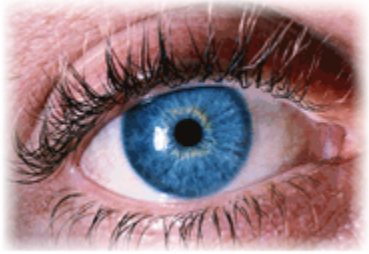


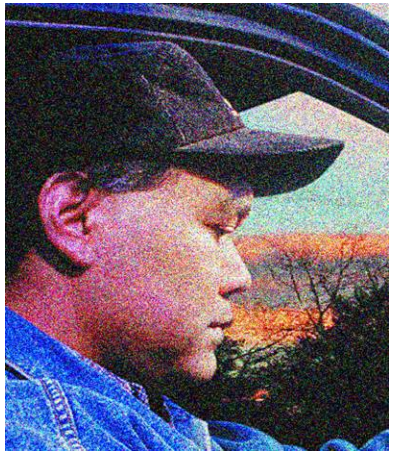
Can you trust your eyes?





Human Vision Models – Types of defects

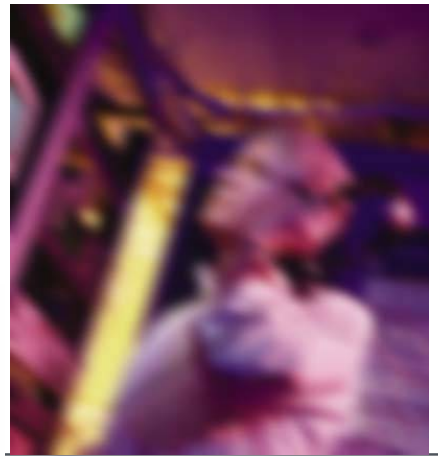




NOISE

Blockiness

Blur



Mean Opinion Score (MOS) Method Human

- **Step 1 -** Show the test audience the best-case training clip
  - This is generally the original unimpaired video clip
- **Step 2 -** Show the test audience the worst-case training clip
  - This is generally the most heavily-impaired version of the reference clip that you will ever ask this test audience to evaluate
- **Step 3 -** Show the test audience any number of video clips and ask them to evaluate each on a scale of 1 to 5
  - These video clips are often, but not always, the same content as the best and worst case but with varying degrees of impairment
  - MOS of 1 = As bad as the worst-case training clip
  - MOS of 5 = As good as the best-case training clip
- **Step 4 -** Calculate the mean average of all viewers' scores for each test clip to produce a final MOS score

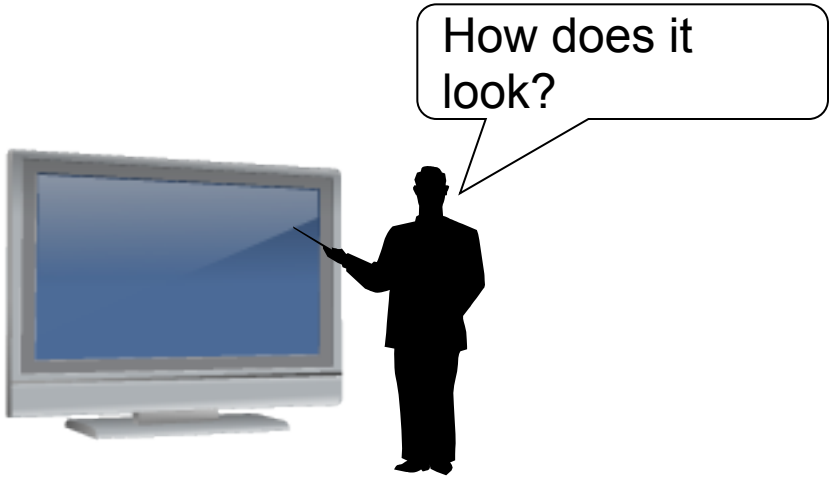
Mean Opinion Score

WHAT IS MOS?

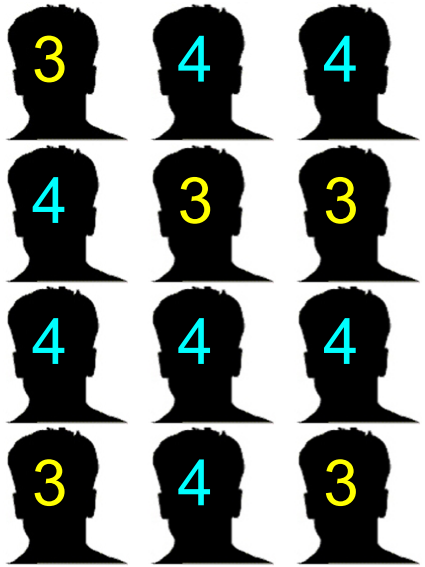
- Arithmetic mean over single ratings performed by human subjects for a given stimulus in a subjective quality evaluation test

Rating	Label
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

MOS Example



Rating	Label
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

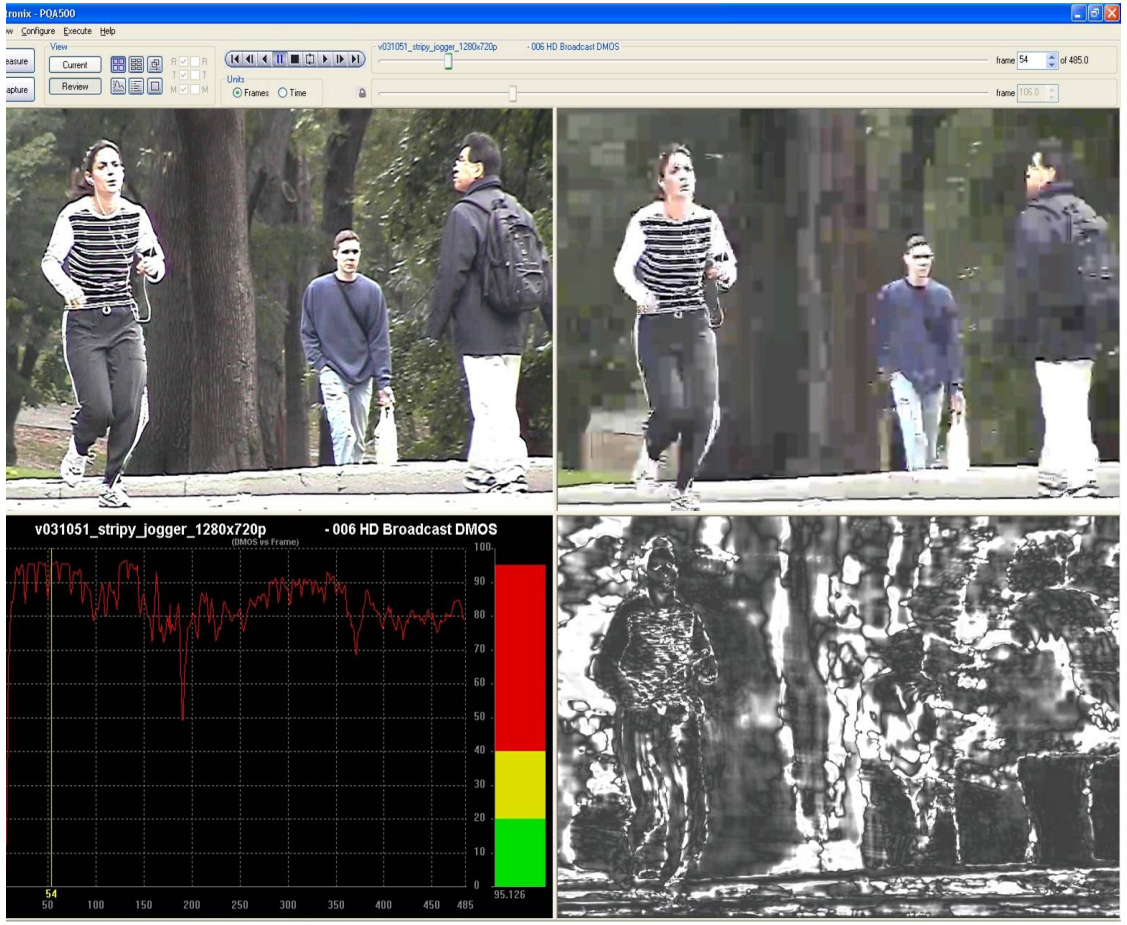


$$\frac{5 \times 3\text{'s} + 7 \times 4\text{'s}}{12} = 3.58$$

This is your final MOS score

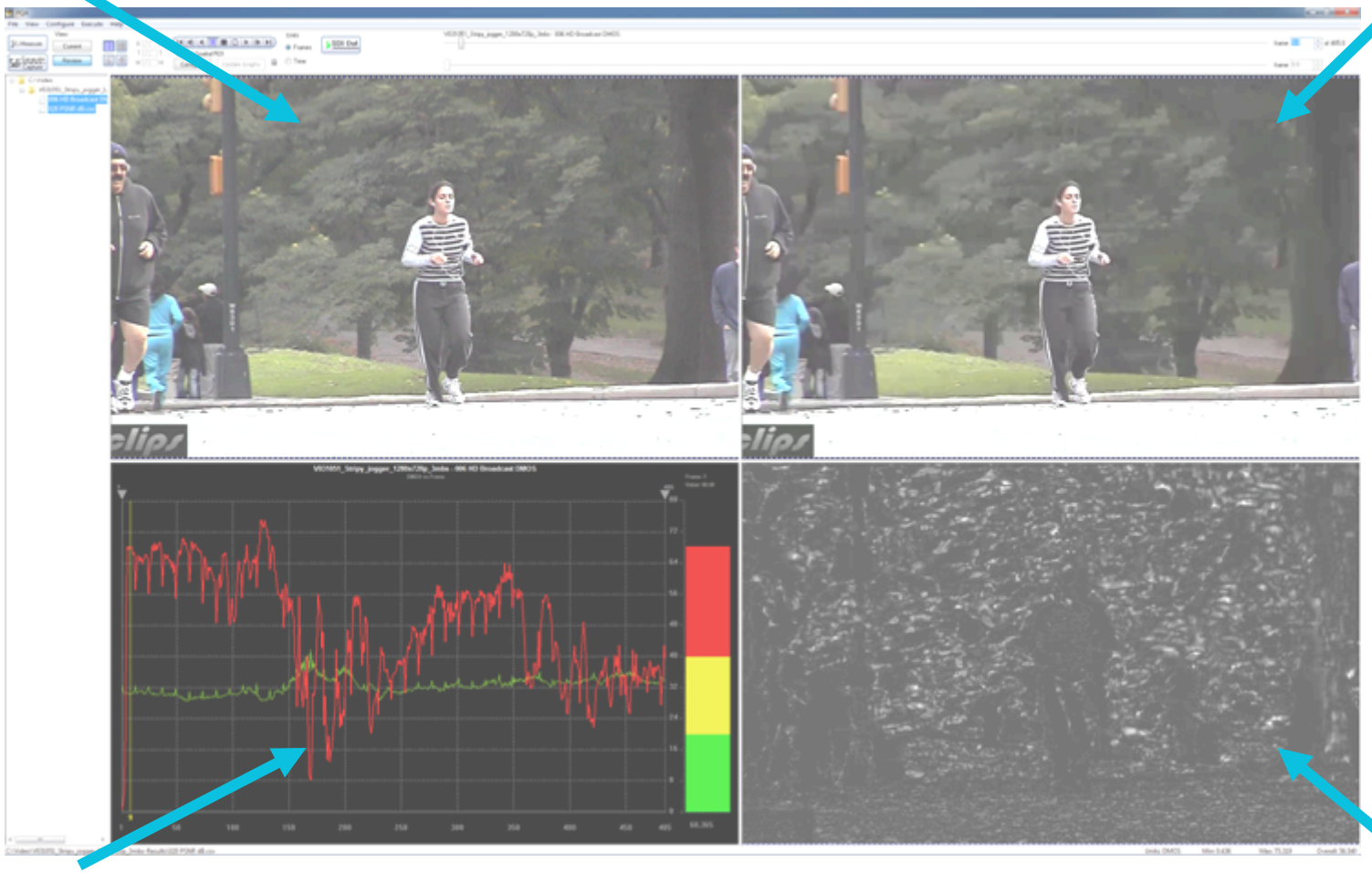
PQA500 Picture Quality Analysis

- Fast, Accurate, Repeatable, Objective Picture quality measurement
- Picture quality measurement based on Human Vision System Model.
  - DMOS & PQR
- Picture quality comparison across different resolutions and frame rates
  - HD, SD, CIF
- Attention/Artifact weighted measurement
- Automatic temporal and spatial alignment

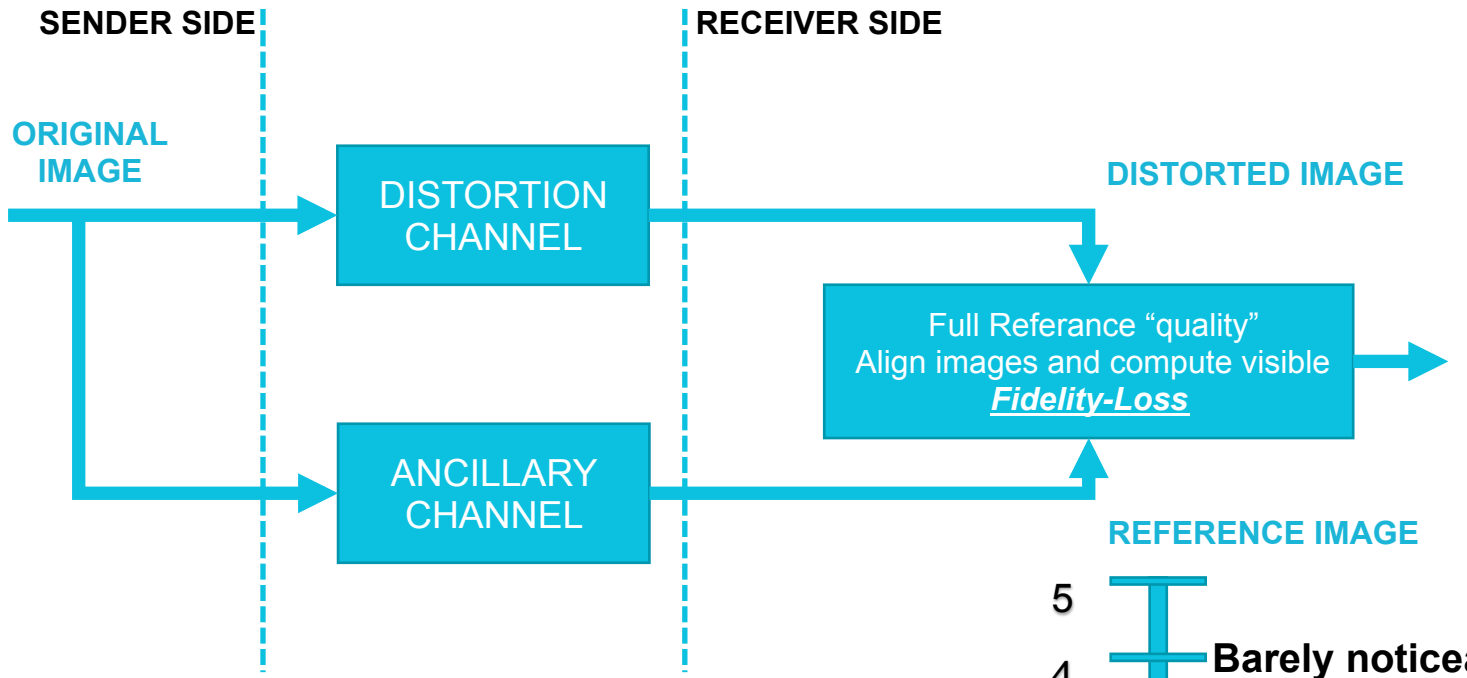


Full-Reference Picture Quality Measurements

PQA



Full-Reference PQ Measurement



PQA600 Patents

US 8,229,229 Systems and methods for predicting video location of attention focus probability trajectories due to distractions

US 8,754,988 , 8,963,998 Full reference system for predicting subjective quality of 3D video

US 6,975,776 Predicting human vision perception and perceptual difference

US 6,941,017 Temporal processing for real-time human vision system behavior modeling

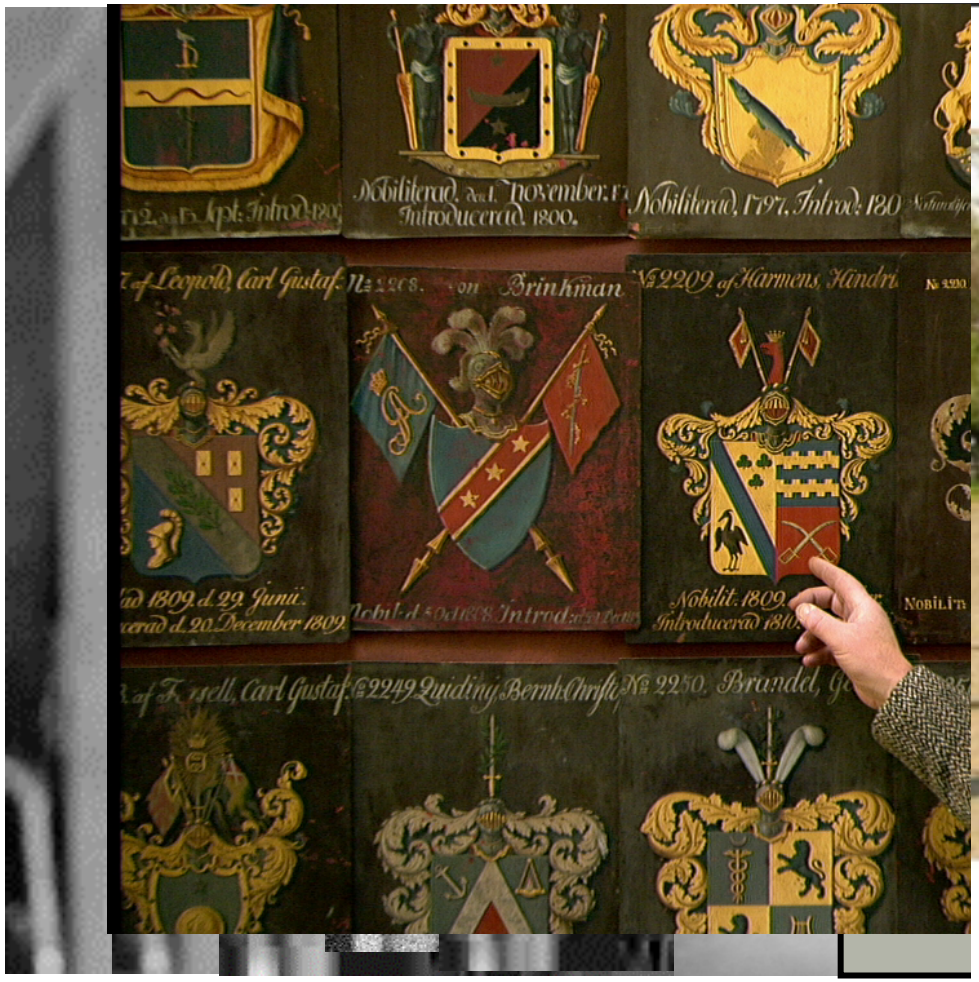
US 6,678,424 Real-time human vision system behavioral modeling

The New Way of Evaluating Video Quality

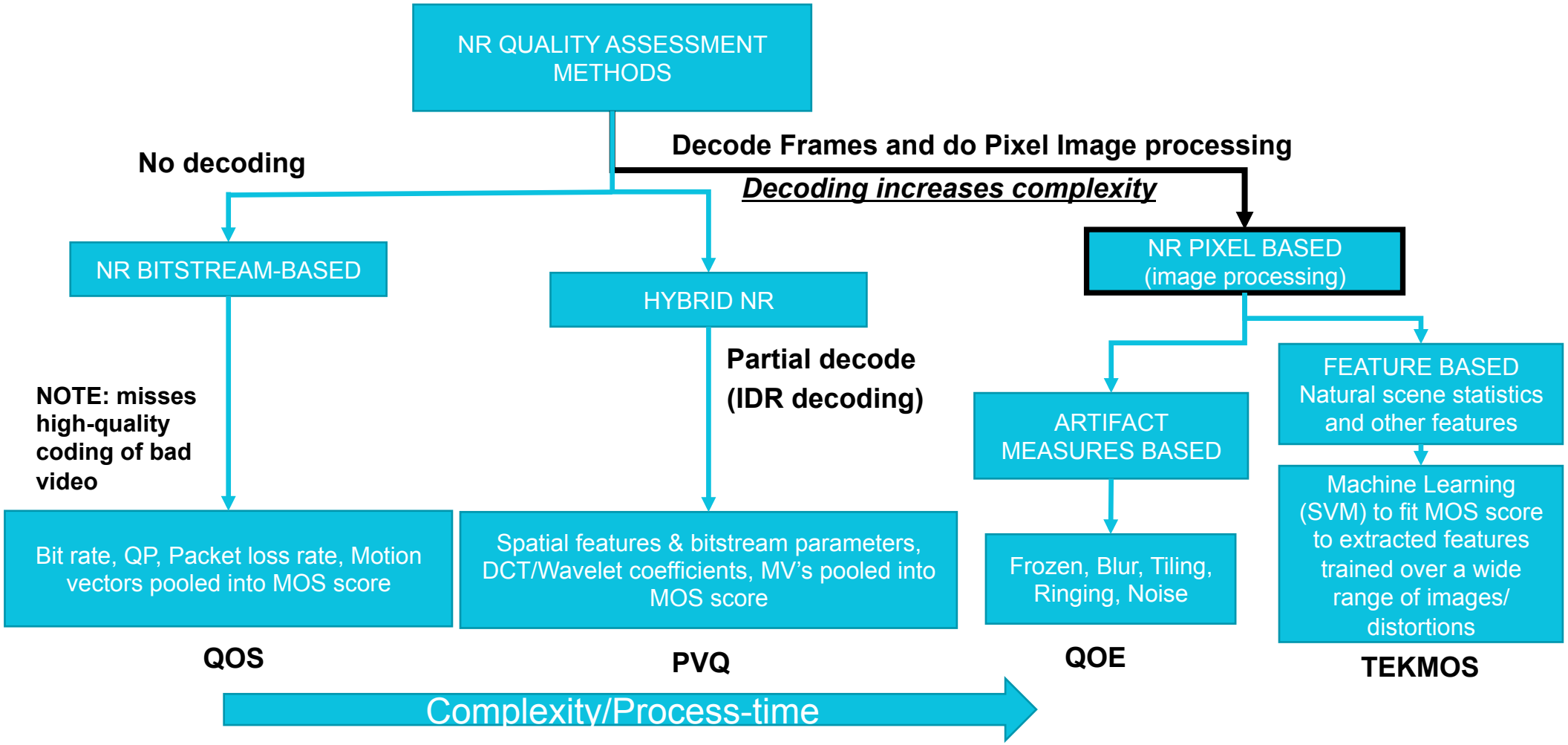
No Reference Picture Quality Measurements

- **Single ended** MOS score typically running in **real-time** but **difficult to correlate** with subjective score
- **Difficult to extract parameters** from image well correlated to **subjective assessment on their own**
- **No temporal or spatial alignment needed.** Operate on multiple image quality scales or formats
- **No secondary path needed**

No-Reference MOS Scoring Test



No-Reference (blind) PQ Measurements



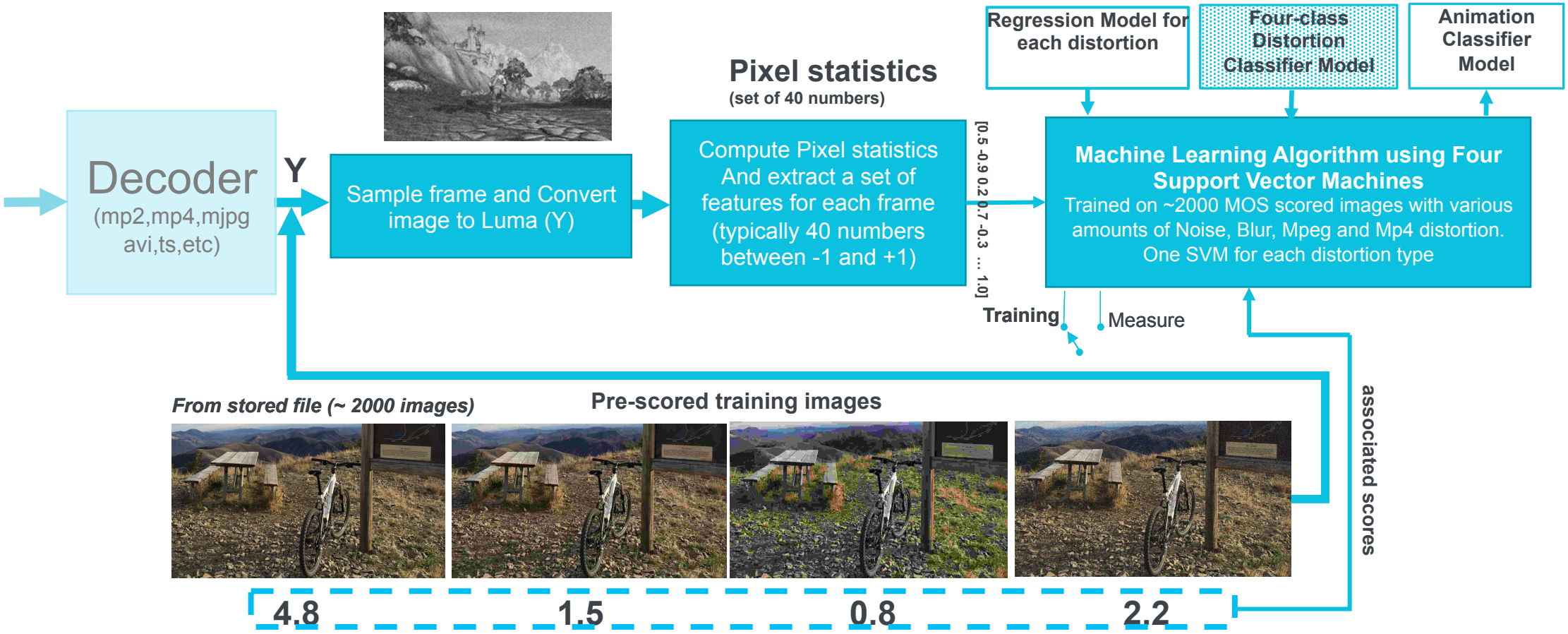
TekMOS

PROPRIETARY TEKTRONIX MEASUREMENT

- Non-Reference Picture Quality metric
  - Single-ended measurement
  - Can be performed on file-based content or live signals equally well
- ***Training Mode*** used by Tektronix engineering to build a model from an image library, scored with and without various distortions
- ***Measurement Mode*** used in product implementations to compute score for arbitrary input images

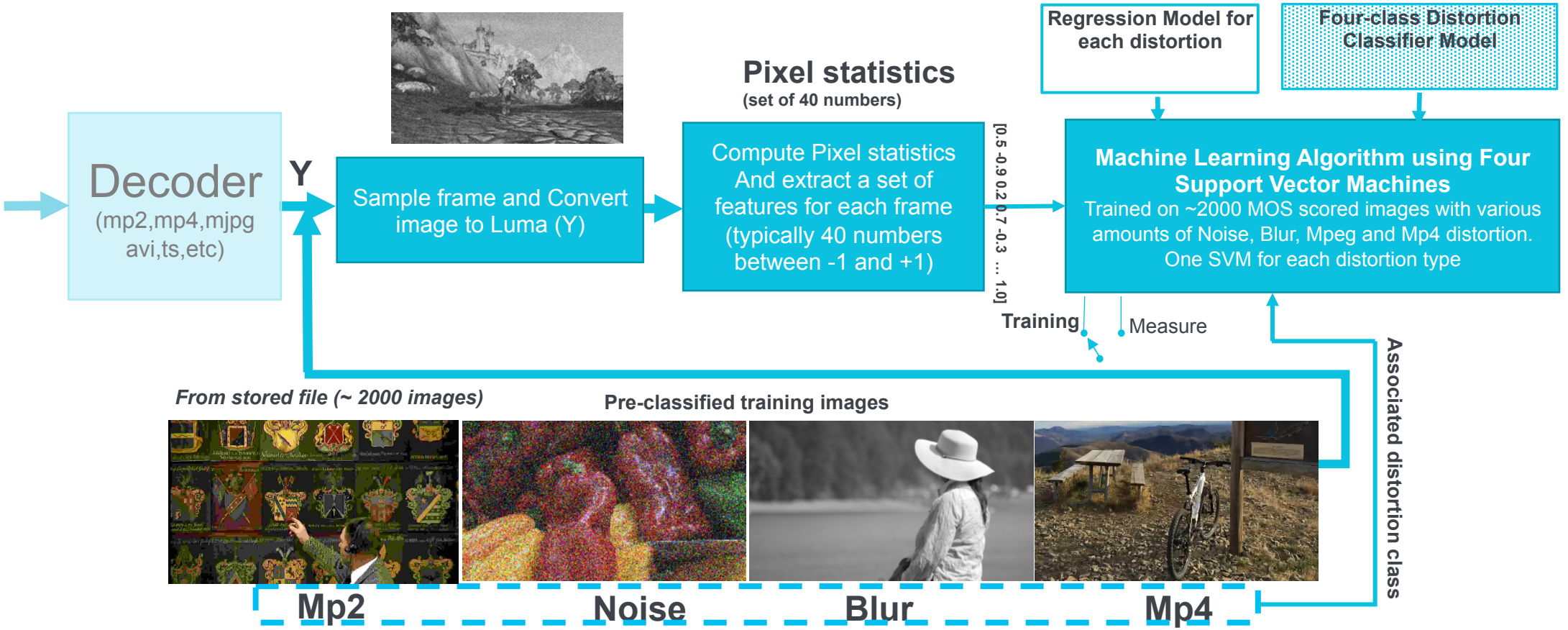
TekMOS Block Diagram

TRAINING MODE TO CREATE REGRESSION MODEL



TekMOS Block Diagram

TRAINING MODE FOR DISTORSION CLASSIFICATION



TekMOS Block Diagram

MEASUREMENT MODE

Grab sample frame
(IDR frame MP4)

Luma only

Compressed stream (mp4, mp2, j2k,etc)

Decoder
(mp2,mp4,j2k,avi ,ts,etc)

Sample frame and Convert image to Luma (Y)

Pixel statistics
(set of 40 numbers)

Compute Pixel statistics And extract a set of features for each frame (typically 40 numbers between -1 and +1)

[0.5 -0.9 0.2 0.7 -0.3 ... 1.0]

10
25
40
8

SVM Model for each distortion (0..100)

MP2 (0.02)
Noise (.08)
MP4 (0.80)
Blur (0.10)

Four-class Distortion Classifier Model

1=animation
0=not animation

Binary Animation Classifier Model

Machine Learning Algorithm using Four Support Vector Machines
Trained on ~2000 MOS scored images with various amounts of Noise, Blur, Mpeg and Mp4 distortion. One SVM for each distortion type

Training

Measure

Distortion Probabilities

[0.02,0.08,0.80,0.10]

SVM scores [10,25,40,8]

(Distortion Probabilities)

(Regression Scores for each Distortion)

Overall score= [0.02 0.08 0.80 0.1] * [10 25 40 8] = 35;

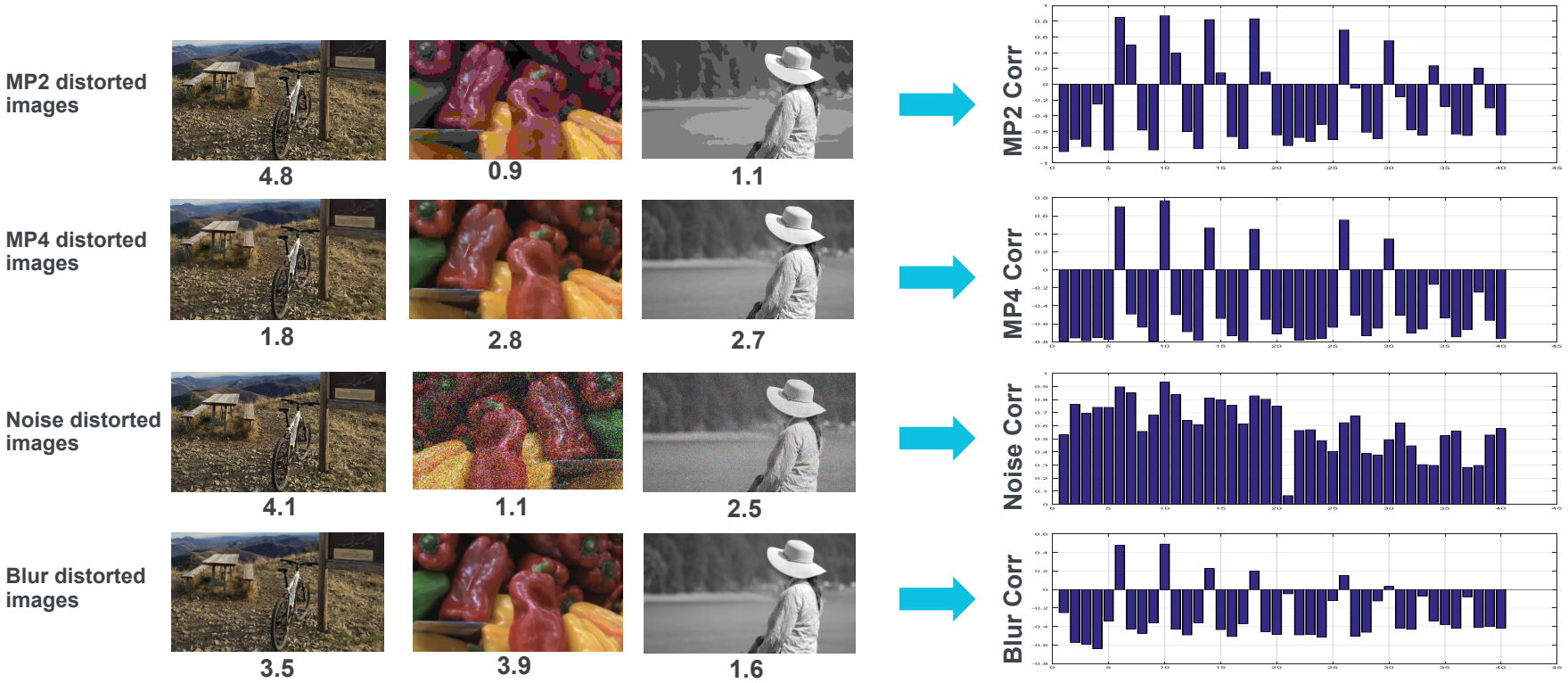
(vector dot product)

MOS = (100-35)/20 = 3.25 mp4 (not animation)

SVM = Support Vector Machine

Distortion Classes

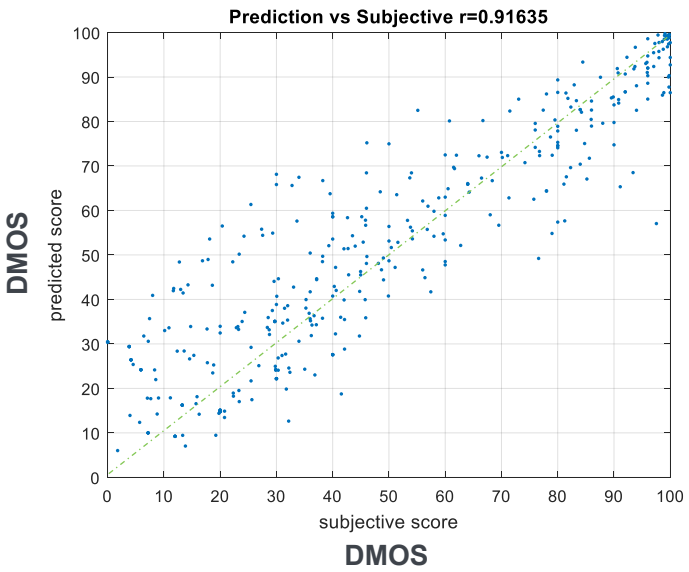
FEATURE-TO-SCORE CORRELATIONS

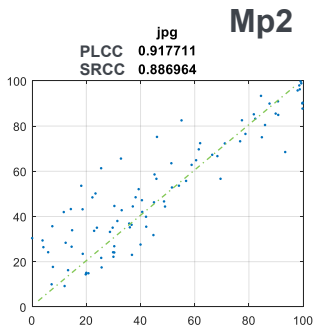


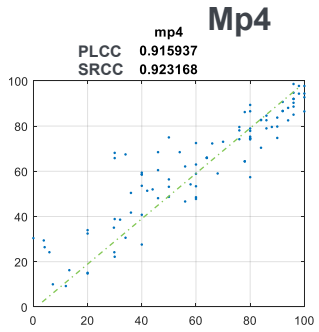
SVM = Support Vector Machine

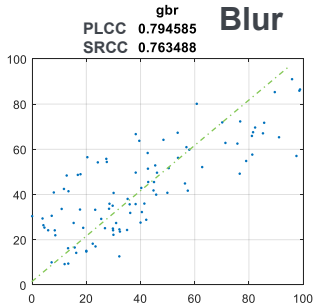
TekMOS Test Scoring Results (392 test images)

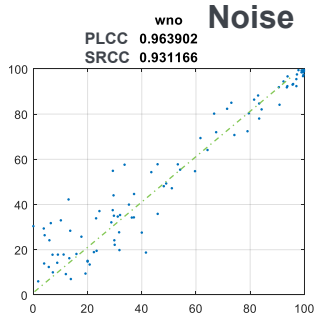
OVERALL SCORE CORRELATION AND CORRELATION BY DISTORTION CLASS

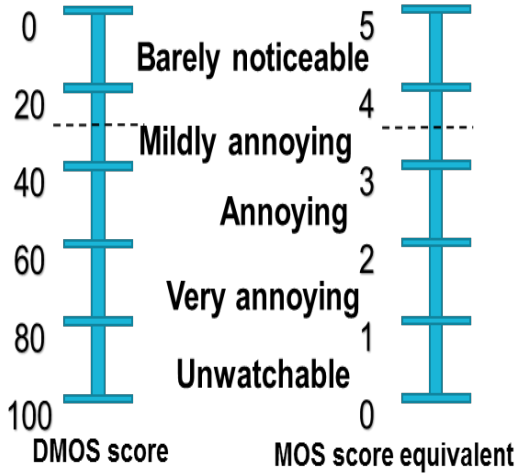












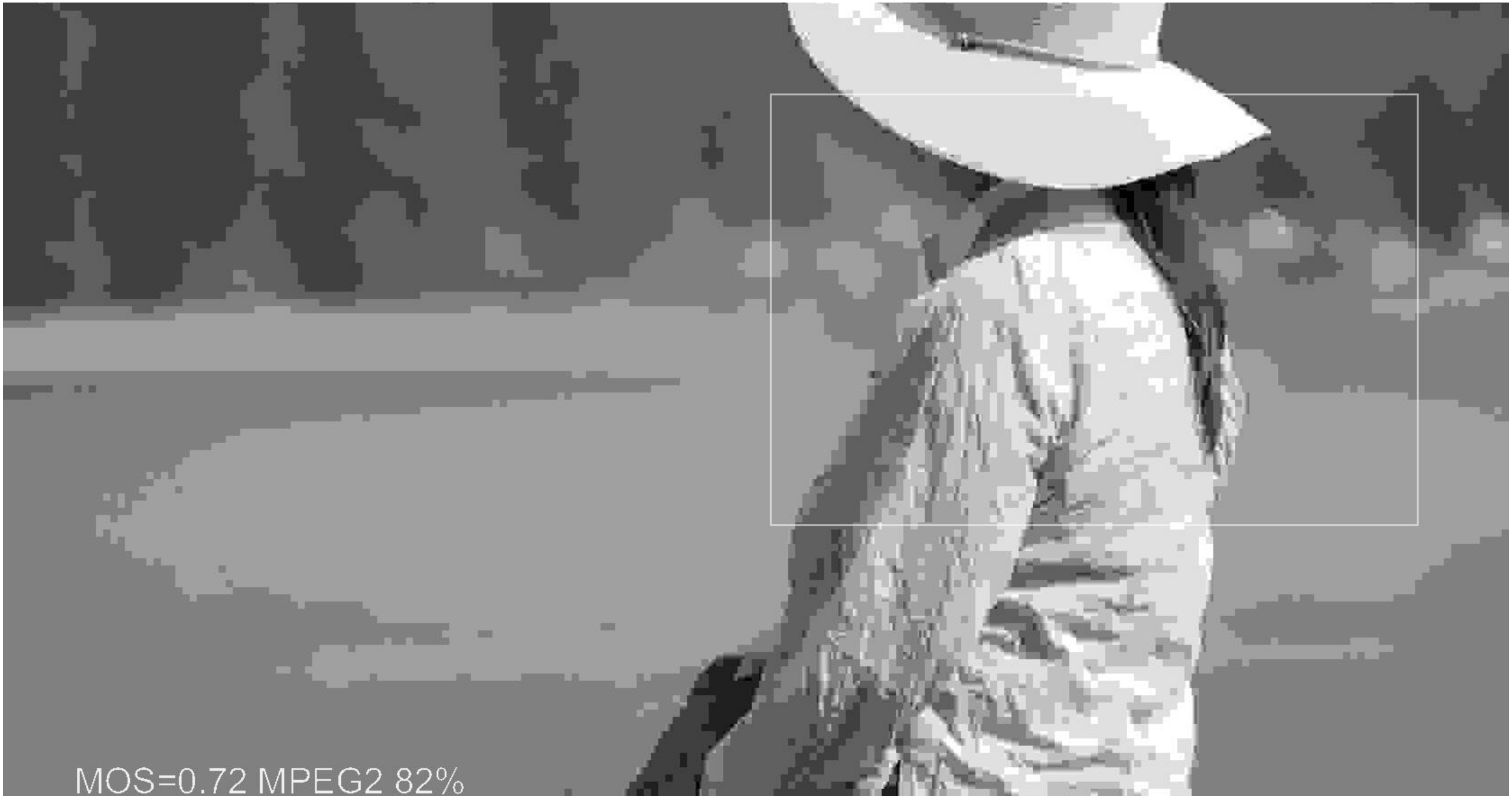
Total, Distortion-weighted Correlation:
PLCC= 92%
SRCC=91%
Sigma=9.6 (~0.5 MOS)

MOS=4.3 BLUR 74%

MOS=2.9 BLUR 91%

MOS=3.1 MPEG2 85%

MOS=2 MPEG2 84%


MOS=0.72 MPEG2 82%

MOS=2.6 NOISE 97%

MOS=1.4 NOISE 90%

Measurement Enhancements

TEMPORAL DECAY FILTER

- **Very short durations** of a few contiguous frames of lower quality are not typically noticed
- **Temporal decay filter** acts like a RC filter similar to a PPM meter with an exponential decay
  - Adjustable time-constant (0 to 20 seconds)
- If the sequence of **low-quality frames persist**, then the score settles to the low value as set by the time constant thereby **lowering the overall average** score for the clip

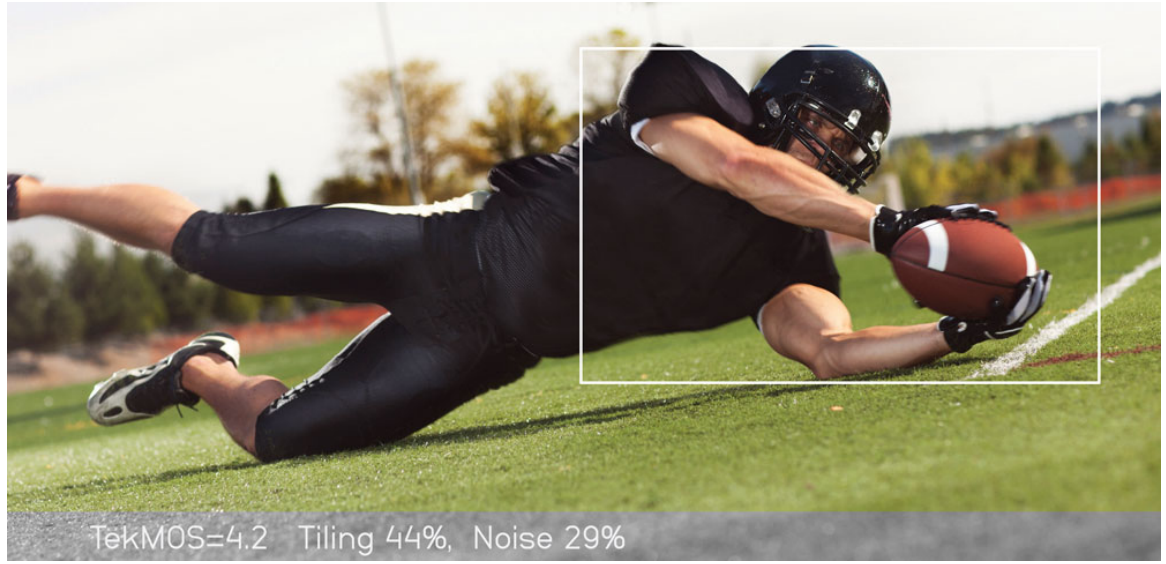
Measurement Enhancements

REGION OF INTEREST

- Detect and grade only the region with highest amount of details in the frame

TekMOS machine learning picture quality

No-reference measurement enables operations monitoring at scale

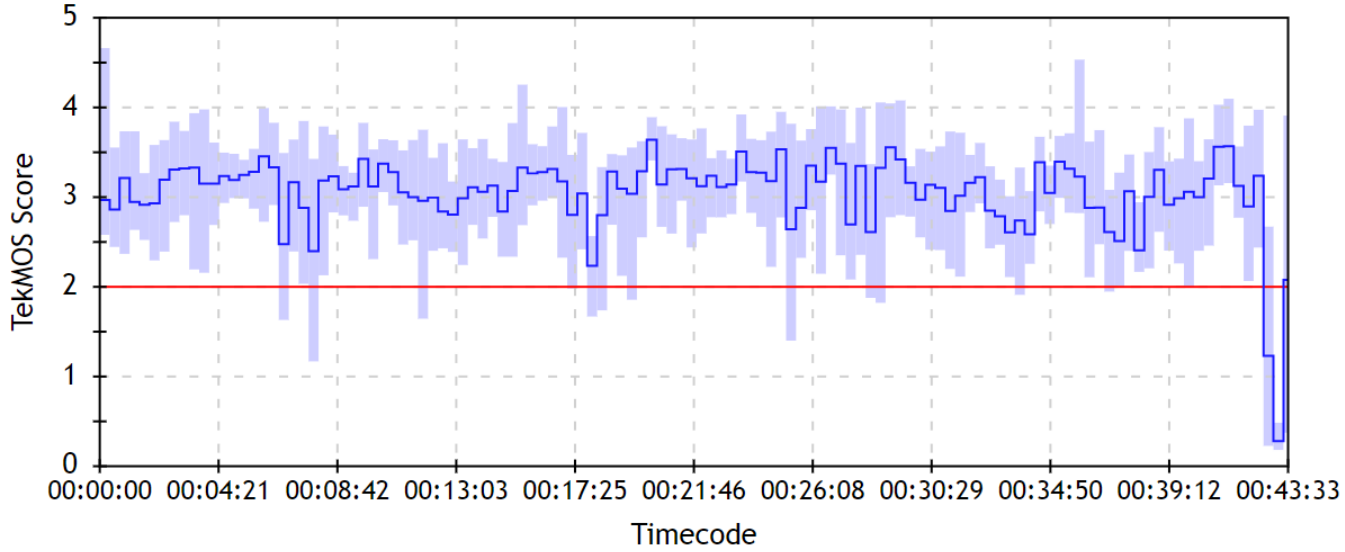


- Live and VOD
- Single view of TekMOS, QoS, and QoE with Reason Codes
- Machine learning non-reference with good correlation to human score
- Practical for multi-stream monitoring applications
- Detects source & encoding degradations
- Adjustable threshold alerts

Measurement Results

TEKMOS GRAPH

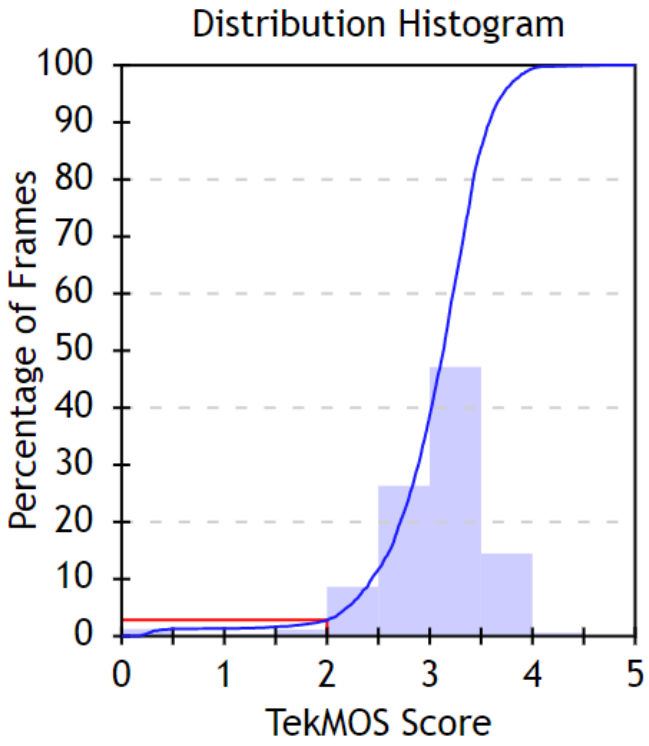
- Displays TekMOS scores for entire video stream in one graph
- Divides play duration into ~120 time segments
  - Light colored bars represent minimum & maximum TekMOS scores
  - Darker line represents average TekMOS score per segment



Measurement Results

DISTRIBUTION HISTOGRAM

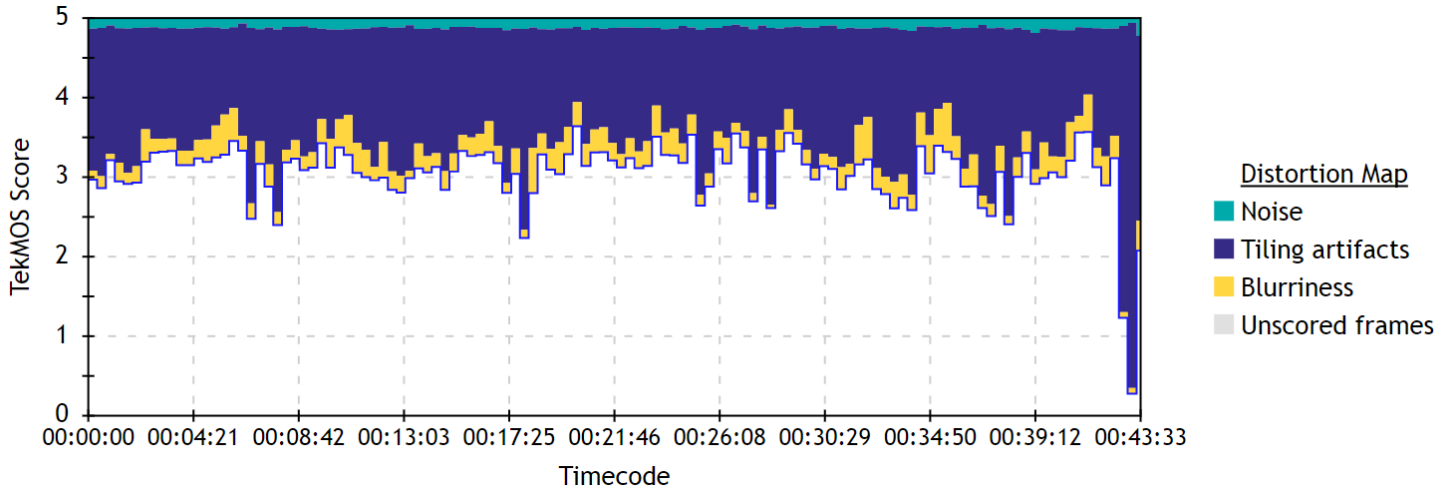
- Helps the user determine their desired template threshold values
- Light colored bars show percentage of scores in each “bucket” (0.5 score resolution)
- Darker line shows the cumulative percentage of frames worse than a specific score
- Red lines intersect for the Program Threshold



Measurement Results

DISTORTION MAP

- Colored bands in the “negative space” between 5.0 and the measured TekMOS score shows the probability that the score is caused by one of four distortion classes
- Vertically aligned with TekMOS avg/min/max graph to help isolate locations and determine the underlying reasons



Tek Mos Machine Learning NR (blind) PQ

ADVANTAGES OF MACHINE LEARNING APPROACH TO PQ

- Can be trained for **any distortion type in any combination**
- Can be used as Classifier to estimate **Distortion Type** as well as **MOS score**
- Each training creates a model for the SVM. User can select different models based on preferences of scoring criticality.
- Possible to allow **customer training to create custom models** from private set of images with customer preferred subjective scoring.
- Can be **easily re-trained to create models** that focus on particular current or future compression distortions

TEKMOS & PQA

COMPLEMENTARY TOOLSETS

	TEKMOS	PQA
Type of Measurement	No-Reference	Full-Reference
Result	MOS – 5 to 1	DMOS 0 to 100
Method	Machine Learning	Human Vision System
Performance	Faster than Real-time at 1080p	5-10X Real-time at 1080p
Optimal Use cases	Operational Monitoring “does the quality level meet expectations over time?”	Encoder/Decoder Evaluation “are these components fully optimized?”

Thank You