

SSIMPLUS[®] and PSNR: A Comparison

It's not how many bad pixels you have, it's which pixels.

Getting with the times

For over 60 years, the mean squared error (MSE) has been the dominant quantitative performance metric in the field of signal processing¹.

It is used to assess signal quality and fidelity, compare competing methods of signal processing, and serves as the near-ubiquitous tool of choice for design engineers who optimize signal processing algorithms².

However, the limitations of the PSNR metric render it insufficient for the demands of the 21st century video industry.

Blind spots inherent to how the metric functions have been overcome by more sophisticated approaches to measuring signal fidelity and quality, such as the SSIMPLUS[®] Viewer Score.

$$MSE = \frac{\sum_{w,h} [I_1(w,h) - I_2(w,h)]^2}{W * H}$$

$$PSNR = 10 \log_{10} \left(\frac{\max(I)^2}{MSE} \right)$$

The Promise and Peril of PSNR

Design engineers who specialize in signal processing optimization use PSNR for a reason.

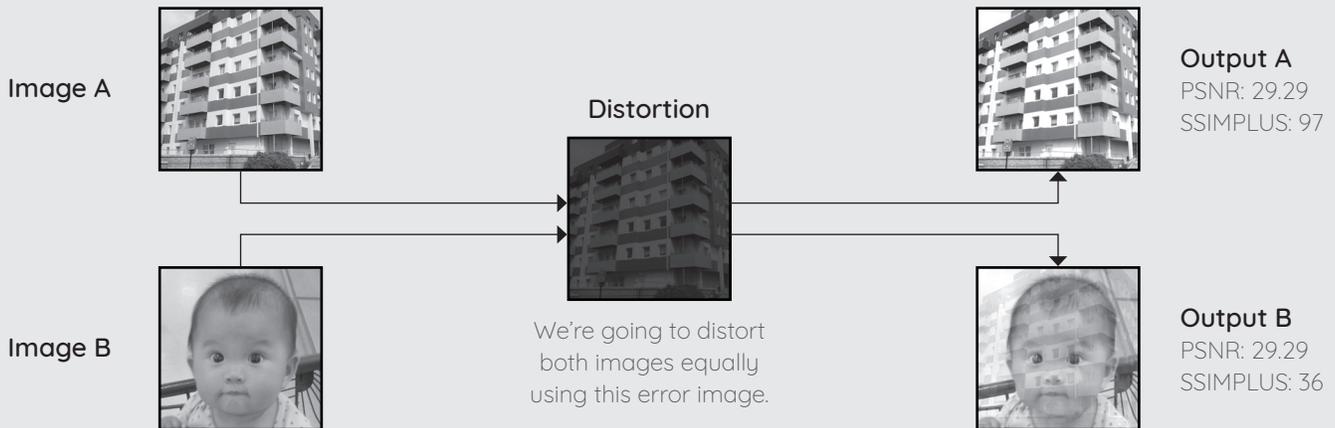
With all of these benefits, it seems like a no-brainer to use the PSNR metric to measure the quality degradation of video files through encoding. The problem is that as PSNR attempts to compute signal fidelity by comparing sets of pixels before and after a transformation, it has no sense of which pixels are most valuable. The blind spot of PSNR is the human visual system.

- ① The algorithm itself is simple. In video signal processing, it compares pixels from pristine and corrupted signals and computes the difference.
- ② It is easy to use and inexpensive to compute. The MSE can be evaluated at each sample independent of every other, which is very important for the adoption of optimization.
- ③ It is very useful for comparing and optimizing signals, and is therefore used conventionally in many signal processing applications: filter design, signal compression and reconstruction, etc.

¹Mean squared error: Love it or leave it? A new look at signal fidelity measures. <https://ieeexplore.ieee.org/abstract/document/4775883>

²Z Wang, AC Bovik—IEEE signal processing magazine, 2009

Consider these two images



To the human eye, they look very different in how they've been distorted. But according to the PSNR metric both of these images are equally distorted. They share an identical PSNR of 29.29, corresponding to the fact that the images were distorted by identical pixels in the error image. Their SSIMPLUS Viewer Scores are 97 for Output A and 36 for Output B, because the SSIMPLUS metric recognized the more dramatic distortion of Output B.

This kind of error arises when you try to measure video quality by blindly comparing pixels; you track changes but lose context. Because they were distorted by an identical error image, PSNR thinks they are identically distorted. The eye says anything but.

The SSIMPLUS Solution

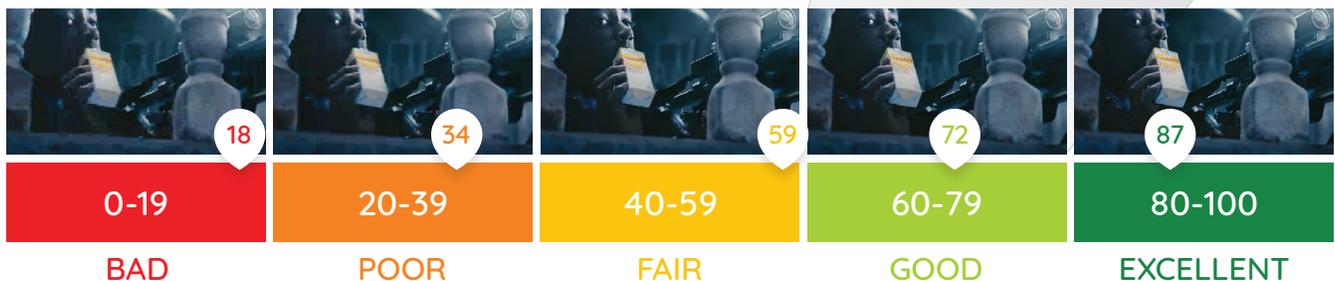
While you won't see failures as dramatic as the above in the field, the example demonstrates that there are impairments seriously impacting viewer experience that PSNR will not catch. SSIMPLUS, a video quality metric developed by the creators of Structural Similarity (SSIM), is designed to address these concerns by taking the human visual system into account when measuring quality.

By watching video files in the same way a human being would—for instance by placing greater value on the pixels of an expressive face than of a background cloud—SSIMPLUS generates a Viewer Score that correlates 90% with the Mean Opinion Score (MOS) of human subjects.³ This human-centric approach has proven to have numerous benefits beyond automatically detecting problematic edge cases like the above.

>90%
MACHINE TO HUMAN
CORRELATION



HOW OUR SOFTWARE SEES THE DEGRADATION
NARROW IT DOWN TO THE PIXEL LEVEL

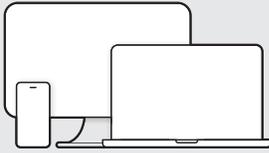


³<https://ece.uwaterloo.ca/~z70wang/research/ssimplus/>



A Sample of Use Cases for SSIMPLUS

① Cross-resolution



Compressing a video file is an inherently destructive process. High frequency pixels are stripped from the file to move them more quickly around the world, and when those pixels are removed there is no lossless way to get them back. In order to measure the quality of video files up and down the encoding ladder to the source file, PSNR scales the compressed file to compare. This approach introduces artifacts to the file that can render quality measurements inaccurate. Because of the way SSIMPLUS watches video files in order to compare them, it is capable of measuring quality degradation across different bitrates and resolutions without scaling by the user. In practice, this means SSIMPLUS can use encoding ladders in a far more sophisticated way, serving customers the most bandwidth-inexpensive file that will still please the eye.

For example, the PSNR metric may demand a higher bitrate file based on its calculation of MSE for a streaming soccer match to a mobile device. SSIMPLUS—which understands that the file is being viewed on a six inch smartphone screen and that the viewer will focus on the ball and players rather than the textures of the crowd—will only demand the more bitrate-expensive file when the lower quality file produces impairments the viewer will notice. This results in significant bandwidth savings.

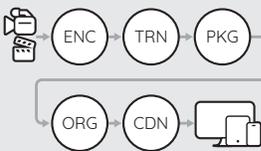
② Human Memory



PSNR works on a frame-by-frame basis, comparing pixels one-to-one before and after a given transformation and giving a score to each frame without any regard for the fluctuations in the video quality over time. But the human visual system does not work this way. When comparing two files frame-by-frame, PSNR gives equal weight to each frame and score despite the effect that frame has on the human memory.

Because SSIMPLUS watches the video the same way a human being would, it will detect impairments and take into account their effect on our overall experience. Thus, SSIMPLUS will assign a failing score to files that frustrate the viewer, even if individual frames are OK. PSNR totally disregards this aspect of the human visual system.

③ Delivery chain inspection



Impairments can arise at multiple points in your delivery chain. Encoding, transcoding, transmission... All of these processes can lead to noticeable problems with the video that reaches the customer. Without insight into the quality of a file throughout the chain, it's impossible to know where and when the issue arose.

The SSIMPLUS suite of measurement tools are designed to inspect quality at every step in your delivery chain, alerting you to issues wherever they arise. This not only prevents poor quality video from reaching customers, it allows you to evaluate your tech stack in a granular way. Is your packager consistently distorting your video? SSIMPLUS will give you the answer and help you solve persistent problems and improve video quality for customers.



“PSNR and MSE are image metrics, not designed for video and not designed for multiple resolutions’ analysis like you see in a typical encoding ladder. They quantify the difference between the original and compressed frame, but they do not incorporate how a human might perceive that difference, how a human perceives the errors.”

—Jan Ozer, Streaming Learning Center

*Quote from Bitmovin Webinar on Video Quality, Nov 13, 2019

Bring the accuracy of 100,000 human views to every stage of the video workflow

A scalable metric is required across all aspects. Level up your existing video quality metrics with SSIMPLUS and account for impact of transformations on perceptual video quality.

	VMAF based	SSIM based	PSNR based	+ SSIMPLUS® Viewer Score
ACROSS CONTENT TYPES	~ Partial	✗ No	✗ No	✓ Yes. One score across all types of content
ACROSS RESOLUTIONS	✗ No	✗ No	✗ No	✓ Yes
ACROSS FRAME-RATES	✗ No	✗ No	✗ No	✓ Yes
ACROSS DYNAMIC RANGES	✗ No	✗ No	✗ No	✓ Yes
ACROSS BITRATE TO LINEAR QUALITY SCALE	~ Not linear	~ Not linear	~ Not linear	✓ Yes
ACROSS ENCODER STANDARDS	✗ No	~ Image based	~ Image based	✓ Yes
ACROSS PLAYBACK DEVICES	✗ No	✗ No	✗ No	✓ Yes. One score across all devices.
AGAINST SUBJECTIVE VIEWERS	✗ No	✗ No	✗ No	✓ >100,000 actual human views
SAMPLE DURATION	~ VOD only	~ Sample	✓ Continuous	✓ Continuous Live & VOD; Faster than real-time.
DEPLOYMENT SOLUTION	~ Algorithm	✓ Hardware/ Software	✓ Hardware	✓ Software platform

A Paradigm Shift

These are just a few salient examples of the benefits offered by SSIMPLUS, but the true benefits are too numerous to list. Simply put, SSIMPLUS is an unprecedented way to technologically inspect video; an algorithm that can watch video like a human being. Valuable new features that arise from this paradigm shift are still being discovered as the metric grows in adoption and its uses become clear.

Reach out to us at info@ssimwave.com to learn how the SSIMPLUS metric can guard your viewers against frustrating experiences. **Stop bad video in its tracks.**