Rich Detail Range (RDR): Redefining Perceptual Picture Quality in the Era of AI Displays

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***Abstract*—** Recent advances in display hardware have significantly outpaced improvements in content delivery, particularly in bandwidth-constrained streaming environments. As a result, modern display systems increasingly rely on AI-based enhancement techniques such as super-resolution, motion interpolation, and reconstruction to bridge the gap between content quality and display capability. While existing quality frameworks — most notably High Dynamic Range (HDR)—successfully describe luminance, contrast, and color volume, they do not adequately capture whether reconstructed visual details remain perceptually stable, structurally coherent, or credible to human observers. In this paper, we introduce Rich Detail Range (RDR) as a descriptive perceptual concept for discussing picture quality in AI-enhanced display pipelines. RDR characterizes the perceived richness, integrity, and fidelity of visual details across spatial, temporal, and structural dimensions, with an emphasis on content-aware processing. RDR is not proposed as a standard, algorithm, or evaluation metric, but rather as a conceptual framework intended to complement existing quality dimensions and support clearer discussion of emerging perceptual challenges in modern display systems.

***Keywords*—** *RDR, Rich Detail Range, HDR, High Dynamic Range, Display technology, AI*

I. Introduction

Display technology has entered a new phase of development. Over the past decade, increases in panel resolution, refresh rate, and peak brightness have been dramatic, while content delivery—especially in streaming and ad-supported scenarios—remains constrained by resolution, bitrate, and latency. This mismatch has fundamentally altered the role of the display system: instead of passively rendering pixels, displays increasingly infer and reconstruct visual information through AI-driven processing.

Under these conditions, picture quality can no longer be fully explained by signal fidelity alone. The perceptual outcome depends on how enhancement algorithms interpret content, reconstruct missing details, and maintain temporal and structural consistency across frames. This shift motivates the need for new descriptive concepts that extend beyond traditional signal-based metrics.

II. Limitations of Existing Picture Quality Frameworks

High Dynamic Range (HDR) [1-5] has successfully standardized how the industry discusses luminance, contrast, and color volume. These dimensions remain essential components of visual quality. However, HDR does not address a growing class of perceptual artifacts introduced by AI-enhanced processing pipelines.

In practice, a display may be fully HDR-capable yet still deliver unsatisfactory perceived quality when:

- fine details fluctuate or "crawl" across frames,
- reconstructed textures lack structural consistency,
- motion trajectories appear unstable or implausible,
- AI-generated details conflict with scene semantics.

Such artifacts are difficult to describe using traditional metrics, yet they strongly influence viewer perception. What is missing is a way to discuss detail richness and perceptual fidelity under reconstruction, rather than brightness or color reproduction alone.

III. From Signal Fidelity to Content Understanding

Traditional picture quality optimization assumes that visual fidelity begins with received pixels. Enhancement decisions are typically applied uniformly based on signal characteristics such as noise level or resolution.

In AI-enhanced display systems, this assumption no longer holds. Effective enhancement requires awareness of:

- scene structure and object boundaries,
- motion types and trajectories,
- texture versus noise characteristics,
- temporal continuity across frames.

Without such understanding, enhancement becomes guesswork—often producing visually sharp but perceptually unstable or incoherent results. This observation leads to a fundamental shift: **Perceptual picture quality begins with content understanding, not signal processing alone.**

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IV. Rich Detail Range (RDR)

Rich Detail Range (RDR) describes the perceived richness and fidelity of visual details across spatial, temporal, and structural dimensions of displayed content. It focuses on how convincingly fine details, textures, edges, and motion structures are:

- preserved or reconstructed,
- aligned with scene geometry,
- consistent over time,
- and perceived by human observers.

RDR is particularly relevant in scenarios where content is enhanced or reconstructed by AI-driven processes.

What RDR Is Not

To avoid ambiguity, RDR is explicitly not:

- a brightness or contrast metric,
- a replacement for HDR or color standards,
- a specific algorithm or processing technique,
- a certification, rating, or product designation.

RDR is introduced as a conceptual and perceptual framework, intended to evolve through shared understanding rather than centralized control.

V. RDR and HDR: Complementary Dimensions

HDR and RDR address different aspects of visual quality. HDR describes how bright, dark, and colorful an image can be, while RDR describes how rich, stable, and credible its details appear, especially under reconstruction.

A display can excel at HDR while still exhibiting poor RDR when reconstructed details lack coherence or temporal stability. In this sense, RDR complements HDR by addressing perceptual dimensions that arise in AI-enhanced pipelines.

VI. Metadata and System Coordination

Once content understanding is achieved, it must be made actionable across the display pipeline. In this context, metadata can serve as a general mechanism for externalizing content-aware insights so that different processing stages can coordinate their actions.

Metadata is not discussed here as a fixed format or standard, but as a conceptual bridge between content analysis and perceptual outcome. RDR does not prescribe how such metadata should be represented, encoded, or transmitted, and multiple approaches may coexist depending on system architecture and constraints.

VII. A New Picture Quality Perspective

Taken together, RDR reflects a broader shift in how picture quality is conceptualized:

> **Understand the content → guide enhancement decisions → render perceptually credible results**

Under real-world constraints, increasing data volume alone is insufficient. Perceptual quality increasingly depends on how well systems understand and respect the content they enhance.

VIII. Discussion and Outlook

RDR is proposed as a shared language for discussing perceptual picture quality in AI-enhanced display systems. By focusing on detail richness, temporal stability, and structural coherence, RDR highlights challenges that are not fully addressed by existing frameworks.

Future work may explore perceptual studies, system-level implications, and complementary representations that further clarify how content understanding influences visual experience. RDR is intended as a starting point for discussion rather than a definitive specification.

IX. Conclusion

This paper introduces Rich Detail Range (RDR) as a descriptive perceptual concept for reframing picture quality in modern display systems. As AI-driven enhancement becomes central to visual pipelines, RDR provides a vocabulary for discussing whether reconstructed details remain perceptually credible and structurally faithful. By complementing existing quality dimensions, RDR supports clearer analysis of emerging challenges in AI-enhanced visual experiences.

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