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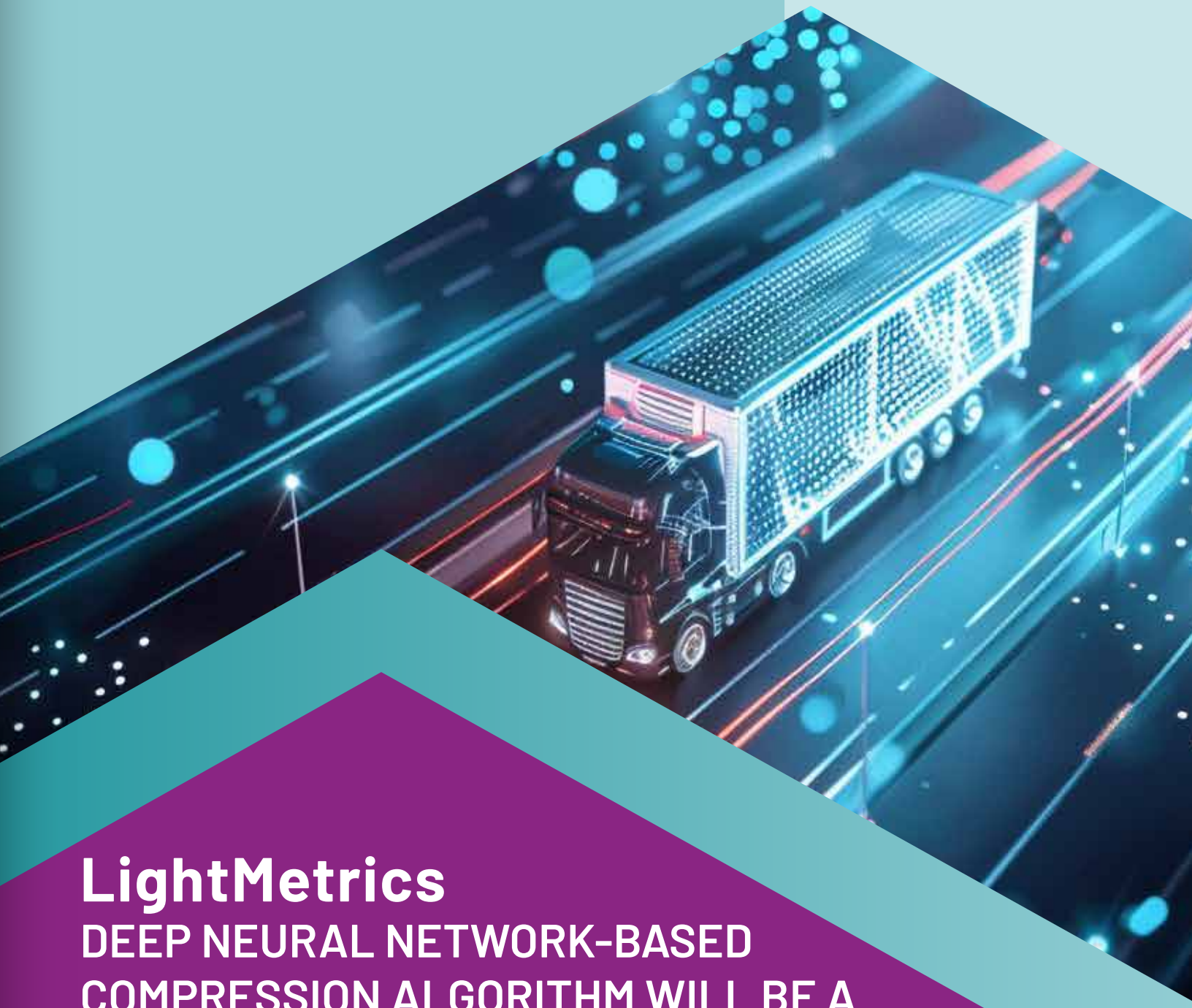


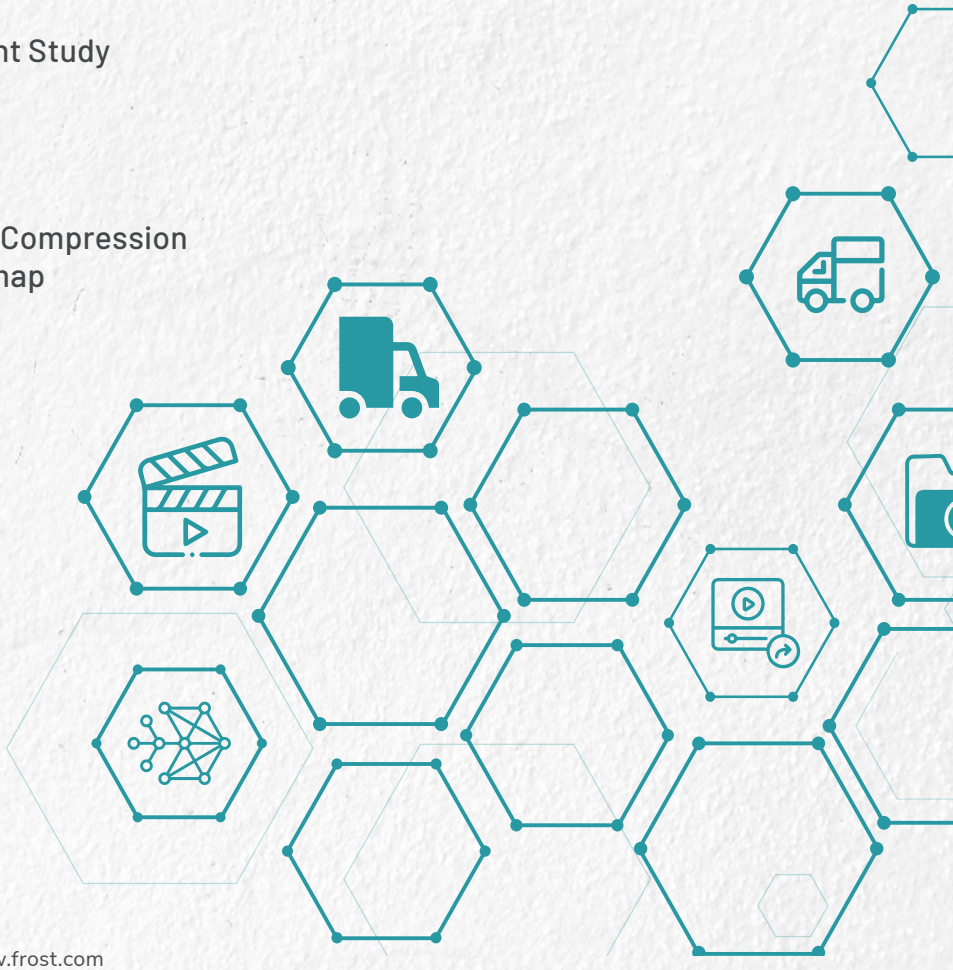
LightMetrics

DEEP NEURAL NETWORK-BASED COMPRESSION ALGORITHM WILL BE A GAMECHANGER IN VIDEO TELEMATICS

By Mugundhan Deenadayalan

FROST & SULLIVAN WHITEPAPER

CONTENTS



Status Quo of Commercial Video Systems

Two critical expectations from video safety systems in any commercial vehicle fleet include:

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Crash reduction is achieved through driver monitoring, real-time in-cabin alerts, coaching, and AI-driven adaptive coaching workflows tailored to individual driving styles and patterns.

On-demand video retrieval makes video footage quickly and efficiently available when needed to exonerate the driver and protect the fleet.

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LightMetrics excels in these two key areas, offering strong differentiation by driver coaching (in-cabin, offline and app) and video retrieval workflows.

On-demand video is a key component of video safety systems and serves as the primary value proposition for fleets and drivers. This offers the highest ROI for fleets during safety events, accidents, or insurance claims. From a fleet's perspective, there are two important factors associated with video retrieval:

Duration of video storage—The more hours that can be stored, the better. Most dash cameras can store 50 to 100 hours of video without significant quality loss.

Ease of video retrieval—Retrieving short video snippets based on inaccurate information regarding time or place is very frustrating.

Despite the clear benefits and high ROI of on-demand video, video telematics industry leaders have innovated minimally in this area over the past two decades in favor of other application areas and features.

Challenges in Video Retrieval

Video evidence of crashes and disputes is increasingly important in the commercial trucking industry due to the high insurance claims that often result. According to the Federal Motor Carrier Safety Administration's last published report on Large Truck and Bus Crash Facts in 2021, there were about 4,800 fatal crashes involving large trucks in the United States. Of that figure, FMCSA estimates that about 71% of large-truck crashes occur due to driver distraction. As of 2023, the average US truck accident settlement amount was $73,109, and the highest US truck accident settlement cost was more than $80 million.

The availability of video speeds up the investigation process in a crash or a dispute—it helps exonerate drivers and fleets, saves the insurance company (and the fleet) money, and prevents fraud due to exaggerated claims. While the video telematics industry began using on-demand video for exoneration use cases decades ago, little has been done to address the industry's issues. These include:

Limited Duration Video

Modern video telematics systems store video locally and make it available for retrieval on demand. Typically, 128GB storage is available, which provides for 50 hours of driving if road and driver-facing videos are saved. More hours can be added by reducing the bit rate but increasing the duration significantly sacrifices video quality (resolution).. Increasing storage on the cameras will help, but the accompanying increase in camera cost makes this unviable for many businesses.

Higher Data Upload Charges

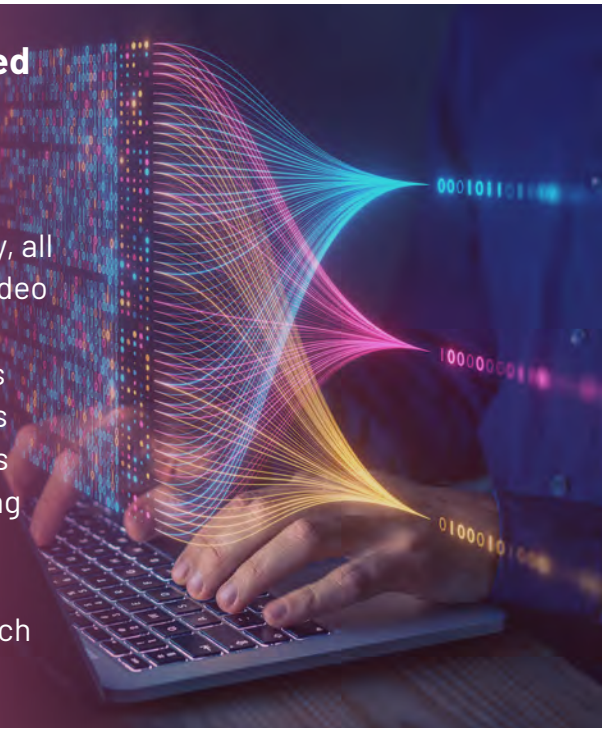
Connectivity is a significant recurring cost for telematics service providers (TSPs), fleet management companies, and commercial vehicle OEMs providing video telematics. Video telematics with AI captures risky driving and uploads video snippets to the cloud. In advanced markets where video telematics adoption is higher, 1GB of data per month costs approximately $6. Whenever the fleet requests video on-demand, that adds to the data usage. Many solution providers impose strict rate limits on how many videos a fleet can access in a month to restrict costs. This adversely affects the user experience (UX).

Longer Video Retrieval/Wait Times

While video telematics system capabilities have advanced significantly, such as detecting risky driving using AI, on-demand video retrieval still suffers from the same wait time issues it did decades ago. When there is an undetected sideswipe and a video is needed, it is unlikely that the exact time or location is known. Given the high cost of data and the time it takes to upload large video snippets, most video telematics systems require the fleet to request a 1- to 3-minute-long video snippet. A fleet makes one request and waits anxiously for the video to be uploaded, only to find that the video snippet does not have the moment of interest. They make more requests and wait—the more the video requests, the longer it takes to upload all the video files. This leads to a lot of frustration and anxiety for fleet managers who are under tremendous pressure to obtain the video and take the next steps. Ideally, a fleet should have a deterministic way of getting the video for the incident they need.

Video Compression Techniques Remain Unchanged

For a long time now, H.264/MPEG4 has been the industry default when it comes to video compression. This is due to multiple factors—all major chipset vendors support this encoding with hardware acceleration and, more importantly, all important browsers support decoding the H.264 stream. Video has so much spatial and temporal redundancy that without compression algorithms, transmitting it over any network is impossible. The reason proprietary compression algorithms have not become popular is similarly two-fold. First, there is no built-in hardware acceleration process, and implementing video encoding into software is extremely complex from a computational viewpoint. Second, any proprietary compression format will not be supported by browsers, which is the medium most people use to play videos.



Breaking New Ground in Video Telematics

Given the importance of driver exoneration for fleets, LightMetrics focused on the most crucial aspect of exoneration—the duration of video that can be saved on a camera. Dashcam videos are very similar in terms of the content, the scene is always a road and a driver in the cabin. Given the relatively well-defined data distribution, a targeted video compression algorithm will likely compress video better than a generic codec like H.264. However, the huge challenges of not having hardware acceleration and browsers not playing proprietary formats remain. So, LightMetrics identified two key problems that need to be solved to break new ground in on-demand video, the highest ROI feature in video telematics.

1. Develop a new compression algorithm
2. Overcome the lack of hardware acceleration for a new compression algorithm

Neural Network-based Video Compression (NNVC)

To achieve this, LightMetrics leveraged neural networks and related machine learning (ML) techniques to enhance video compression for video telematics. Conventional video encoding involves no learning from the data. With neural networks, LightMetrics leveraged big data from their video telematics deployments to learn optimal representations for the video signals from a compression perspective. While the journey from a lab concept to a viable algorithm was challenging, the outsized benefits for fleets were the motivation the team needed.

At a conceptual level, it is straightforward: video exhibits spatio-temporal redundancies that traditional video coding exploits to compress the signal without an appreciable loss in subjective and objective quality. The new representation that is learned by the neural network exhibits similar properties. Tools and processing techniques for exploiting temporal redundancy, such as motion estimation, motion prediction in various modes, differential coding, and entropy coding, were adapted to deliver a compressed video stream.

Hardware Acceleration

Most modern chipsets have hardware acceleration for popular video compression techniques like H.264. Without hardware acceleration, one would have to compress video using software running on the CPU. This is usually infeasible on most chipsets because the CPU resources are needed elsewhere and constantly loading the CPU causes overheating, which leads to other undesirable downstream issues.

Because most modern chipsets have digital signal processing (DSP) and graphics processing units (GPUs) with libraries to accelerate neural network inference, LightMetrics was able to leverage those resources to perform compression using neural networks on the device even though proprietary compression algorithms cannot be hardware accelerated in general. In doing so, LightMetrics used AI to solve the oldest and most important problem of fleets - exoneration using video telematics on commodity hardware (i.e., hardware without very powerful GPUs and DSPs). With LightMetrics able to do more with less, the other challenge of limited computational bandwidth on cameras can now also be optimized using the same neural network.

AI and ML have ushered in a new revolution in video telematics with the ability to reliably and accurately detect risky driving behaviors, and LightMetrics used this to break new ground and compress video more efficiently with its NNVC algorithm.

Solution Focus—LightMetrics' Neural Network-based Video Compression (NNVC)

LightMetrics has been at the forefront of AI innovation in video telematics since 2015, catering to industry-leading TSPs and video telematics vendors while gaining extensive expertise in AI and ML technologies. The company invested significantly in R&D for AI, ML, and video analysis and developed NNVC to efficiently convert video on the edge in the camera into a form requiring significantly fewer bits for transfer and storage.

Algorithm Architecture

From an architectural perspective, any video compression needs hardware acceleration. LightMetrics' neural network uses an algorithm with the GPU or DSP present on most chipsets to run inference on incoming frames. This makes video processing extremely efficient compared to running it on CPUs. For chipsets without GPU or DSP resources, a lightweight neural network can be run on the CPU—the only difference between the two is the degree of compression possible.

The incoming video frames are processed either a frame at a time (e.g., with a convolutional neural net) or as multiple frames (e.g., a neural network with recurrent connections) to leverage the temporal redundancy. Leveraging temporal redundancy significantly improves the compression and the reconstruction quality. The neural network's output is an embedding vector—a set of numbers representing the encoded scene.

Conventional video codec post-processing techniques, like quantization and lossless compression techniques, are applied on top of the embeddings and the resulting data is transmitted over a chosen channel (e.g., wireless).

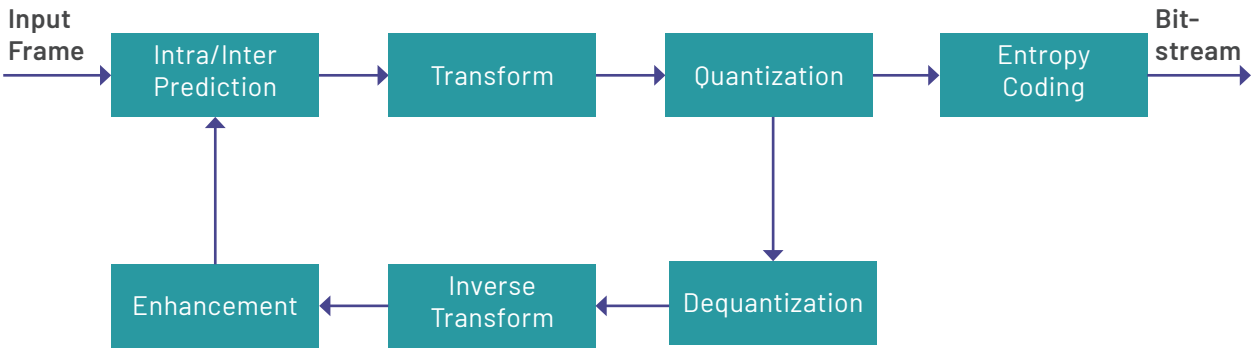
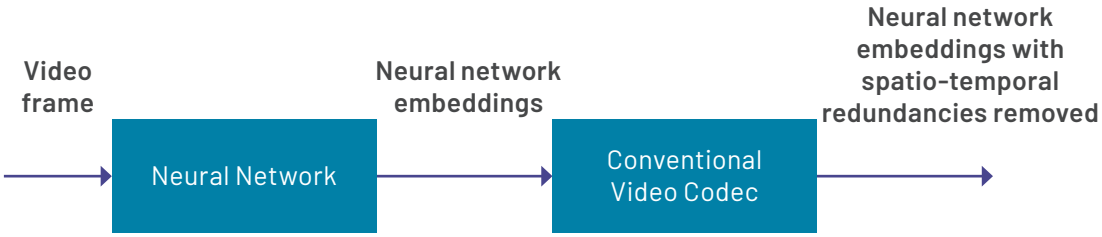


FIGURE 1: A Conventional Video Compression Algorithm

Figure 1 shows a conventional video codec, such as H.264. Note that many processing steps are designed to effectively remove spatio-temporal redundancies, thus compressing the video efficiently.

Figure 2 below shows the proposed approach using a neural network.



The neural network inference is done on the CPU/GPU/DSP, depending on the resource availability. The output from the neural network can be processed by a separate block designed to further reduce redundancies in the data for transmission. A preferred implementation method is to use conventional video compression techniques on the neural network's output. This can leverage the video codec acceleration hardware on chipsets, providing excellent compression overall without loading the device computationally.

After encoding the frames using a neural network, the compressed video undergoes post-processing on the edge before being uploaded to the cloud. This process achieves compression rates approximately 3 to 5 times better than standard H.264/AVC and is twice as efficient as H.265/HEVC compression. However, the novel video representation created by the deep neural network (DNN) cannot be played directly in browsers. It must be decoded through a proprietary neural network in the cloud, where the information is transcoded into standard H.264 format. The resulting H.264 videos are then stored and made accessible via cloud APIs, enabling playback on standard browsers and devices .

When a fleet manager requests a video snippet from a specific vehicle at a particular date and time, the request is made through a user dashboard or through an API. The dashboard then sends a notification to the camera, prompting it to check if the requested video is available. If the requested video is available, the camera uploads the footage in the proprietary format to the cloud.

This proprietary format ensures optimal compression and storage efficiency, though it cannot be played by regular video players. Once uploaded to the cloud, the video is transcoded to the H.264 format, making it compatible with playback in a standard web browser. The user can then access and play the requested video on the dashboard. The original video, saved in its proprietary format, remains stored on the camera. While conventional video players cannot directly access it, this format helps maintain footage integrity and security while optimizing storage and data transfer processes.

This workflow framework effectively addresses all previously mentioned challenges and delivers significantly improved compression and video representation through the power of AI and neural networks technology.

Value Proposition to Customers (TSP, OEM, Fleets)

Longer Video Storage

LightMetrics' proprietary compression (NNVC) offers substantial benefits, revolutionizing video telematics for TSPs, OEMs, and fleets. The algorithm can compress video 3 to 5 times smaller than H.264. For fleets, this means instead of having a few days of storage in a 128GB SD card, they can now have nearly a month's driving stored on the same SD card. With typical settings for 720p video, the storage goes from 50 hours (road and driver views) on a 128GB SD card to approximately 150 to 250 hours, depending on the bitrate used. From an insurance provider's perspective and fighting fraudulent claims, NNVC is a quantum leap in the right direction—especially since this works with existing storage or SD cards via a software update.

Faster Video Retrieval

In the event an unfortunate crash is reported to the fleet, the fleet personnel are under a lot of pressure to quickly understand what happened and possibly join the investigation to work towards fleet exoneration or a quick settlement. Often, fleets are frustrated with having to wait for videos after a request has been made. With the video being compressed better, the file sizes are significantly smaller (3 to 5 times), and this means that the internet upload process and delivery to the fleet is faster. Nearly all video telematics solutions limit the duration of an on-demand video request for the same reason (a large file size that takes a long time to upload), but a file size significantly reduced by NNVC accommodates longer duration video snippets to help localize what happened faster. Therefore, in addition to storing videos for a longer duration, the NNVC algorithm improves the UX for the fleet via faster retrieval times.

Significant Reduction in Data Costs

The compression algorithm significantly reduces data costs associated with video telematics, cutting them by over 50% on average. In context, US data costs typically run around $6 per GB, but the algorithm's efficiency can save approximately $3 per GB. Having good unit economics for all entities in the value chain is crucial if video telematics has to be more widely adopted. LightMetrics innovates not only for the fleets but also for their OEM and TSP partners. As video telematics becomes more widespread, industry stakeholders can leverage the NNVC algorithm to unlock substantial economic advantages.

Reduced Total Cost Of Operation (TCO)

The key value proposition for fleets is reducing the total cost of operation (TCO) and the streamlined management of exoneration scenarios. LightMetrics' compression technology empowers fleet managers with efficient, cost-effective, reliable video storage and retrieval solutions.

The extended storage means greater protection for the fleet against fraudulent claims, engineered crashes, unfair accusations, and nuclear verdicts. The lower data costs in offering video telematics to fleets mean better unit economics for OEM and TSP partners of LightMetrics.

Given the information and context video offers, the extended storage and efficiencies provide fleets greater visibility and control over their operations. This can translate into more proactive maintenance through vehicle video surveillance and can enhance driver performance monitoring through extended driver-facing dashcam recordings. It can also improve vehicle and driver safety measures, contributing to higher operational efficiency and reduced TCO.

Overall Competitive Edge as LightMetrics Partner

The company's exclusive focus on serving TSPs and OEMs using a B2B model positions its proprietary compression algorithm as a strategic advantage for partners and their customers (the fleets). By adopting LightMetrics' RideView video telematics, TSPs and OEMs can differentiate where it matters the most to fleets. This differentiation plays a pivotal role in customer retention and acquisition. In addition to enabling faster video retrieval for fleets and contributing to a better UX, NNVC helps TSPs and OEMs reduce data costs, significantly improving their unit economics.

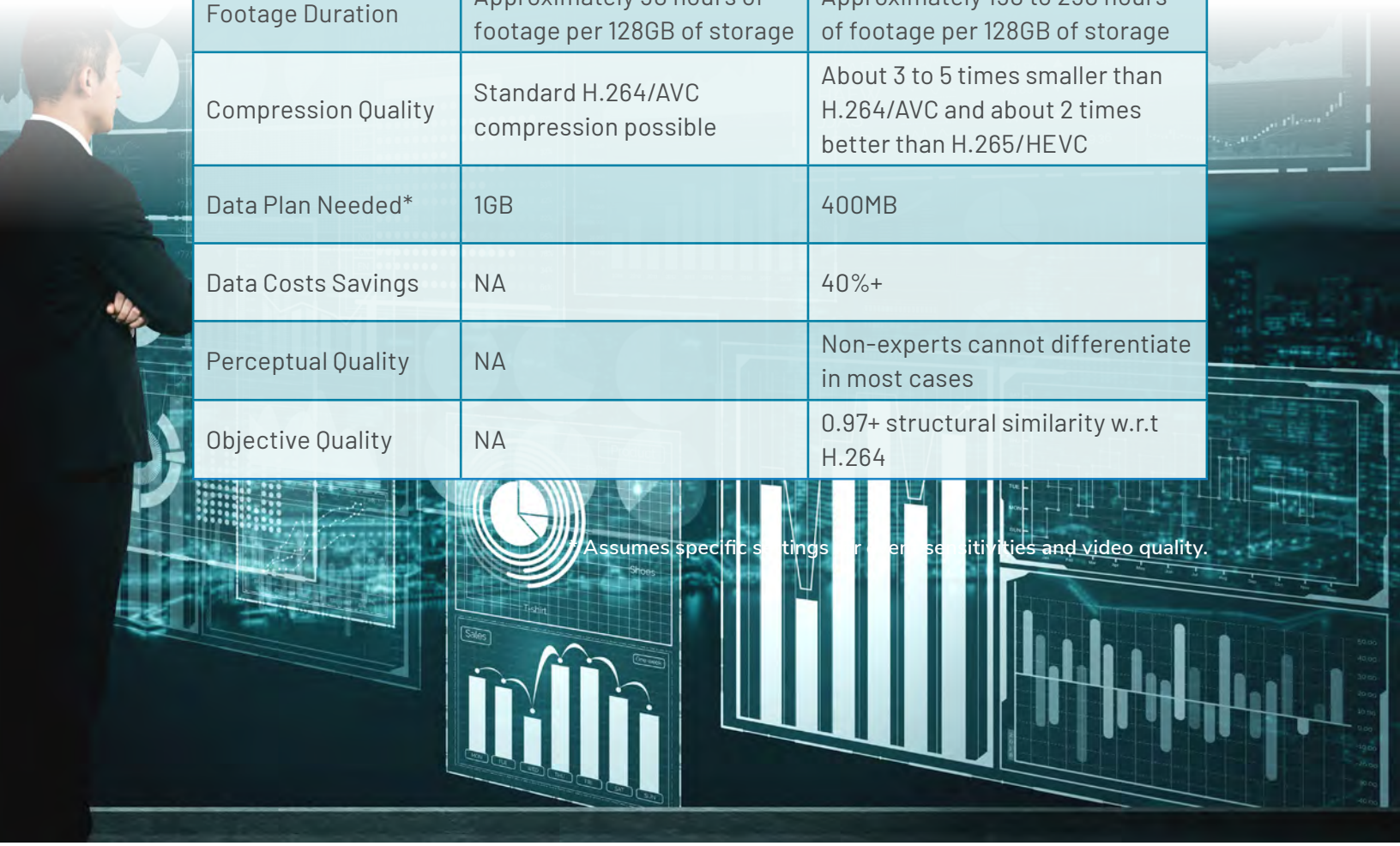
LightMetrics' proprietary DNN-based video compression algorithm marks a significant advancement in video telematics. The video telematics feature with the highest ROI is the on-demand video retrieval as it can be used for exoneration. Advancing the state of the art in what matters the most to fleets not only provides greater protection and a better UX, but also offers tangible economic benefits to TSPs. By capitalizing on this technology, industry stakeholders can position themselves for success in the rapidly evolving video telematics landscape.

Technical Comparison & Competitive Leverage

Comparison of Conventional Video Compression vs. LightMetrics Video Compression

Attribute	Conventional Video Compression	LightMetrics Video Compression
Compression Technique	Inter-frame compression	Neural net works based compression
Codec Type	H.264/AVC	Proprietary format
AI Use in Video Signal Processing	Compression is generic and does not learn from or get better with data	Compression uses AI that learns from and can get better with data
Hardware Acceleration	Built-in chipsets	Accelerated by GPU or DSP hardware
Footage Duration	Approximately 50 hours of footage per 128GB of storage	Approximately 150 to 250 hours of footage per 128GB of storage
Compression Quality	Standard H.264/AVC compression possible	About 3 to 5 times smaller than H.264/AVC and about 2 times better than H.265/HEVC
Data Plan Needed*	1GB	400MB
Data Costs Savings	NA	40%+
Perceptual Quality	NA	Non-experts cannot differentiate in most cases
Objective Quality	NA	0.97+ structural similarity w.r.t H.264

*Assumes specific settings for camera sensitivities and video quality.



Subjective Quality Assessment Study

To evaluate the perceptual quality of the LightMetrics' NNVC algorithm compared to the widely used H.264 codec, a subjective quality assessment was conducted that aimed to determine the extent to which expert viewers could distinguish between video sequences encoded using the two methods.

The study involved 49 engineers who were selected based on their extensive expertise in video quality and codec analysis, ensuring high reliability in the assessment. Participants reviewed 10 video sequences encoded using both H.264 and NNVC algorithms in a side-by-side comparison format. To mitigate bias, the order of presentation (i.e., whether H.264 or NNVC appeared first) was randomized. There were a total of 490 subjective evaluations, and participants were instructed to select the sequence they preferred based on subjective quality.

The results of the subjective evaluation revealed that in approximately 70% of the comparisons (335 opinions), participants reported no discernible difference between the H.264 and NNVC encoded sequences. Among the remaining 30%, preferences were evenly split: 15% of the time participants preferred the H.264 encoded sequence, and 15% of the time participants favored the NNVC sequence.

The findings suggest that even among expert viewers, the perceptual quality of the NNVC algorithm is nearly indistinguishable from the baseline H.264 codec. Consequently, NNVC can be considered a viable alternative to H.264 for applications where perceptual quality is critical.

Response	Felt both baseline and NNVC were similar	Preferred baseline H.264	Picked NNVC
Number of opinions	335	77	78
Percentage	68.37%	15.71%	15.92%

Data Usage Statistics

Over a two-week period, mobile data usage was analyzed within a small fleet of five vehicles. The analysis compared data consumption across two intervals, ensuring that the distances covered were equal and that the number of risky driving events remained consistent, as the same drivers and vehicles were involved. The results indicated that mobile data usage for uploading event-triggered videos was significantly lower when using NNVC. On average, data consumption per event video was reduced by 40% using NNVC compared to traditional methods.

Attribute	H.264	NNVC
Miles driven	1,000	1,022
Events created	51	55
Data used	256MB	112MB
Data used per event	5.02MB	2.04MB

Neural Network-based Video Compression (NNVC) Availability and Roadmap

LightMetrics' NNVC technology is now available for partners to test, with full deployment planned for Q4, 2024. Currently, the technology supports road and driver camera views, which constitute the majority of video telematics deployments worldwide. Key upcoming features on the roadmap include support for additional camera types beyond road and driver views, customizable resolutions and video settings, and the integration of live streaming capabilities.

Key Takeaways

- **On-demand Video as a Key ROI Driver:** On-demand video retrieval is the most significant ROI driver in video telematics. The ability to access video footage that is weeks old is invaluable for fleets aiming to protect themselves against false claims.
- **Superior Compression with NNVC:** NNVC offers 3 to 5 times better compression than traditional methods, enabling the storage of 150 to 250 hours of video on a 128GB SD card compared to the usual 50 hours.
- **Cost-efficiency and Enhanced User Experience:** NNVC's superior compression leads to reduced mobile data usage and lower costs. For fleets, smaller video files improve user experience by enabling faster access to on-demand videos and by allowing for longer video requests—beyond the typical three minutes—when investigating incidents like crashes.
- **Innovative Solution for Fleet Exoneration:** NNVC is a groundbreaking technology in the video telematics industry, representing a significant advancement in addressing driver and fleet exoneration.

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