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INTRODUCTION

Stereoscopic 3D HD Represents an opportunity, a blue ocean of possibilities for massive adoption of a radical new way to experience sports, entertainment, videogames and how to learn. There are many challenges from the business, the technical and the user perspectives to this technological evolution step and 3D HD at home will make sense only when the perfect balance to fulfill them all and consensus is achieved. In this document we want to present an overview of the different stages of the 3D ecosystem, the challenges and recommendations of each stage and at then we will explain why we consider the TDVCodec 2D+Delta patented solution to be the answer for this challenges.
MASSIVE ADOPTION OF 3D AT HOME KNOWLEDGBASE
CONTRIBUTION FROM TDVISION SYSTEMS, INC.

CHALLENGES
● Quality (Maintain the highest resolution as possible during the complete 3D ecosystem)
● Mass adoption and fast transition (Market Readiness)
● Low/Zero impact on transition to 3D (Smooth change/upgrade)
● Compatibility for deployment (No impact on digital media deployment pipelines)
● Compatibility with 2D decoding platforms (3D content should not preclude the 2D installed base)
● Compatibility with all existing 3D displays (Allow the user to have freedom of choice for the display of their preference)
● Provide the user with a clear benefit when adopting 3D (No considerable additional cost, no hassle, best 3D experience, great resolution, nothing to lose, everything to gain)
● Maintain integrity of 3D related information over the complete chain.
● Bandwidth optimization (minimize the impact on bandwidth required to achieve high quality 3D HD)

PART I): 3D ECOSYSTEM STAGES

● 3D Content Creation (For reference only)
● Encoding
● Deployment
● Decoding
● Display (For reference only, not within the scope of this group)

1.1) 3D CONTENT CREATION
● Acquisition of content using Stereoscopic Cameras
● Computer Generated content
● 2D to 3D conversion

1.1.1) Acquisition using stereoscopic cameras
When acquiring content with stereoscopic cameras, the content is usually acquired uncompressed in independent left-right stereoscopic pairs. The final content should be at the highest resolution with the Left and Right stereoscopic pairs sequentially named for future reference, possibly in different folders or with a Left/Right identifier.

This real image content may later be edited and possibly embedded with 3D graphics and special effects.

There's a creative issue regarding the use of strictly parallel cameras or cameras with toe-in for real images acquisition, this is a key question for the director and the stereographer.

Key creative question:
● Do you want to use fixed parallax cameras or variable parallax cameras?
● How do you accurately calculate the convergence when shooting real time events? (some examples are focus controlled, manually controlled, estimated convergence, etc.)

If you want to use converged cameras and insert 3D geometry later on in the future then this may lead to a new requirement regarding the storage of this information as metadata on a per frame basis.

1.1.2) Computer generated content
CG animation software renders the Left and the Right perspectives of a 3D environment given a specific dataset of xyz geometry, textures, lights and effects. The final render should be at the highest resolution with the Left and Right stereoscopic pairs sequentially named for future reference, possibly in different folders or with a Left/Right identifier.

It's important to mention that the artistic/creative approach may lead to special effects like hyperstereo or...
reduced stereo at certain shoots. If this 3D content is going to be embedded (for instance, using chroma key perforations) then it is extremely important to match the perspective and the proportions with those of the real image, some metadata in a per-frame basis will be needed.

1.1.3) 2D to 3D conversion
There are several ways to convert from 2D to 3D. One of them leads to a depth map format where information retrieved from temporal-spatial 2D version is created. Very well known issues regarding the transparency and occlusions have been identified regarding this process, since the 3D information was never available. Usually, automatic realtime 2D to 3D conversions don't work fine or yield to visual artifacts that may degrade the overall perception of stereoscopic 3D content, deteriorating by association the concept of digital 3D.

Other off line created 3D conversions are done almost artistically and they yield to a better result. The cost and processing time are two of the main issues associated with this technique, nevertheless, we believe they will soon achieve and create automation tools to improve both aspects.

The final output of 3D content creation stage should always be at the highest resolution as technically possible. Stereoscopic uncompressed format (RAW video) is the main preference among content creators.

1.1.4) Target Viewers (Cinema?, Home?, IMAX?)
If the content is created for the big screen or if it's created for home usage it should address some artistic and technical options based on the targeted audience like:
- Content intended to be presented ONLY at the cinema screen (Current)
- Content intended to be presented ONLY at the home (tbd)
- Content intended to be presented ON EVERY 3D platform (Desirable)
- Content intended to be presented ON A SPECIFIC 3D platform

It's our experience that content originally created for the cinema or IMAX looks fantastic on 3D displays and small projectors like DLP, Horizontal interleaved or dual projectors with small projection screens. We have never observed during all this time any kind of visual artifact in a smaller screen when the content was originally created for the big cinema screen.

1.1.5) Key questions:
- Is there any real difference between the content created for cinema? For IMAX? For Home?
- Should the content store some metadata and information regarding the 3D scenery?
  - If so, Should some kind of perspective vector and xyz information be stored on the content?
  - If so, Should the metadata be purely defined by xyz 3d geometry or by stereoscopic disparity calculation and acquisition?

1.1.6) Comments:
Metadata regarding the 3D scenery is something desirable in order to embed graphics, and MPEG7 and MPEG21 already provide some reference on this regard, it is recommended to read about those standards and take some of the existing references to port them into other compression media standards that may benefit the final output of the stereoscopic content.

1.2) ENCODING
1.2.1) BACKGROUND (2D STATE OF THE ART)
The purpose of encoding Raw Images has always been for practical/optimal deployment using compression techniques, reduce the size (bandwidth) required for deployment while maintaining the quality as high as possible. MPEG2, MPEG4 (H.264, AVC) and VC1 are among the preferred encoding methods. The industry has used MPEG2 for several years now and even when MPEG4 has achieved great levels of quality and higher compression MPEG2 is the most highly adopted encoding method. Until recent years, AVC and VC1 started to gain momentum due to their optimal characteristics, and in the near future, most of the set top box equipments will be based on this formats, and will still provide compatibility backwards with MPEG2 videostreams.
Blu-ray disc is capable to encapsulate on the transport stream MPEG2, AVC and VC1 already.

### 1.2.2) 3D ENCODING
The scope of this stage should be the evaluation of encoding methods to deploy and visualize stereoscopic content. Having a set of Left and Right Raw uncompressed video images as the home master format, provided in the highest quality as possible is the starting point for any 3D encoding method. Regarding the issue about having different releases of the master RAW for cinema or home has to be properly analyzed, calculated and determined as suggested below.

There are two ways to prepare and encode 3D content for deployment:
- Specific Format within a standard 2D frame size
  - Side by Side
  - Upper/lower
  - Line interleaved
  - Frame interleaved
  - Checkerboard
- Use of new formats to deploy 3D (Full 3D)
  - As an independent videostream
  - As auxiliary data
  - As metadata
  - As another video multiplexed on the transport stream

There are only four native display formats
- checkerboard
- line interleaved
- frame sequential
- dual input

The minimum requirements of 3D encoding should be:
- To provide the best quality, as close as possible to the original RAW images
- To provide compatibility with existing infrastructures
- To work with all the existing 3D and 2D displays (past, existing and near future)

Loss is added on every step of the encoding process with respect to the original content, so reducing any loss in resolution is optimal, or, as close as possible to the original resolution, the better.

Evaluation of each method
- Encoded Content Resolution
- Quality Control Test patterns

In order to evaluate the advantages of each method, a matrix for effective resolution as well as quality patterns for evaluation should be created.

H= Horizontal Resolution of RAW video, usually 1920 for home
V= Vertical Resolution of RAW video, usually 1080 for home

### RESOLUTION PER LEFT AND RIGHT FRAME

<table>
<thead>
<tr>
<th>Format</th>
<th>HRes</th>
<th>VRes</th>
<th>Effective Original Area per frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side by Side</td>
<td>H/2</td>
<td>V</td>
<td>50%</td>
</tr>
<tr>
<td>Over/Under</td>
<td>H</td>
<td>V/2</td>
<td>50%</td>
</tr>
<tr>
<td>Line Interleaved</td>
<td>H</td>
<td>V/2</td>
<td>50%</td>
</tr>
<tr>
<td>Checkerboard</td>
<td>H/2</td>
<td>V</td>
<td>50%</td>
</tr>
</tbody>
</table>
No encoding method is lossless, and if on top of any encoding method we decide to cut resolution then the impact is directly related to the final output.

Perceived image quality yields to subjective analysis. Therefore, we suggest to create specific test patterns and perform a systematical mathematic evaluation process with Digital Signal to Noise Ratio, pixel by pixel comparison, percentage of pixels maintained, created, invented, interpolated and missing for each format to provide a more objective result. Then, finally, present the test patterns in comparison with the original Versus encoded-decoded format to the user on an apples to apples comparison.

Basically, there are only two ways to deploy 3D content:
- by Image manipulation (checkerboard, line interleaved, over/under, side by side) image deteriorated.
- by Advanced Digital Encoding enhancement (no image deterioration)

CROSS PLATFORM CASES
Also, given the fact that multiple video displays should be fed with 3D content, it's important to think about the possible trans-3d-format or cross-platform impact the content may suffer. For example:
- Presenting a checkerboard encoded frame into a line interleaved display
- Presenting a Side by Side encoded frame into a checkerboard display

This cross-platform analysis shows that content will be then, again, deteriorated going far away from the original content, accumulating loss and degrading the quality of the content.

There is analysis of the pixel interpolation, the diamond and the Quinconx, and how they achieve to trick the eye providing "no visual difference". For this case we use the very well known science articles Fovea characteristics, the number of cone receptors for color, and the 100s of millions of luma rods, and the maximum arc-minutes the human eye can really perceive. Then we will see that given a the right tools, patterns and comparison images, the human eye can really tell when interpolation has been applied or not (See Interpolation definition).

Comments and suggestions to determine if a cinema version and a home version are needed:
- Calculate the user perspectives in vectors and angles regarding the target field of view and the stereo effect used to create the content
- Perform a test on using 3D content created for the Cinema and playback on existing all stereoscopic displays, try to find the difference.
- Cinema content may be stored in a different color space (P3 versus REC-709)

CREATIVE DECISIONS
- Content: To have a Cinema Release independent of a Home Release regarding stereo separation and effects, may make much business sense to use the same release.
- Content: To have the screen as the maximum convergence point or have negative convergence (exaggerated effect) may create some undesirable effects.
- Content: To use fixed parallel cameras or not, makes it easier but the result could be different.
- Content: To use the Right or the Left camera view as the 2D version may be convenient for business.
- Content: To add/remove the floating window, to remove/add elements within the scene or not.
- Content: To create content with negative parallax or not.
1.3) DEPLOYMENT

Minimum requirements for Deployment of 3D content to the home

1.3.1) Should be compatible with all the existing broadcast infrastructures:
- ATSC Broadcast
- Blu-ray mastering
- DVD mastering
- IPTV deployment
- Satellite
- Cable
- Download

1.3.2) Should support existing characteristics
- Security (HDCP)
- Multiple display formats
- Digital hops
- Bandwidth adjustments

TransCoding

Before transcoding, all the formats need to be understood:

Original 3D HD (100% resolution per eye)

Side by Side in 1 frame, 50% effective frame area
Line interleaved (even lines for one image and odd lines for the other stereoscopic pair) combined to create one frame with interleaved images, 50% effective frame area per eye.

Checkerboard pattern, 50% effective frame area per eye
The loss on each Left/right image by using 50% of the effective frame area shows a clear impact.

The only case to assure that content is properly deployed to every display is using Full Stereo HD 3D:

Full stereo HD 3D

Then we can minimize the impact when transcoding from one encoding format to a specific display (See next section TRANSCODING)
TRANSCODING

When Transcoding or going from one format to another then loss is certainly accumulated.

Transcoding from Side by Side to checkerboard pattern:
• Content is formatted for Side by Side (50% effective area per side)
• Left/Right halves need to be stretched (one out of every other vertical line is missing)
• Each half is then Interpolated (to fill in the gaps, so 50% of the image was invented)
• Checkerboard pattern is then applied, losing 50% of the existing area for each side
• Final output accumulates 2 losses, reducing the original vertical/horizontal effective resolution and yielding to 25% of original pixels, 25% invented and 50% of pixels missing, per each eye.
Transcoding from Side by Side to Horizontal interleaved:

- Content is stretched, one out of every other vertical lines is missing
- Interpolation fills in the gaps
- One out of every other horizontal line is taken from each side
- The full frame with interleaved images is presented on the display.
- Final output accumulates 2 losses, reducing the original vertical/horizontal effective resolution and yielding to 25% of original pixels, 25% invented and 50% of pixels missing, per each eye.
Transcoding from checkerboard pattern to line interleaved:

Loss is clearly accumulated (white pixels are either invented or missing pixels)
Transcoding
Original test pattern:

<table>
<thead>
<tr>
<th>Source</th>
<th>Reconstruction (zoom)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Source" /></td>
<td><img src="image2" alt="Reconstruction" /></td>
</tr>
<tr>
<td><img src="image3" alt="Source" /></td>
<td><img src="image4" alt="Reconstruction" /></td>
</tr>
</tbody>
</table>

From anamorphic side by side

![Side by Side](image5)

![Checkerboard](image6)
From checkerboard full frame.

This reconstruction yields to the best reconstruction (no interpolation, no degradation, no loss in color or resolution)

From 2D plus Delta.

Comments:

- Interpolation works only for solid colors. When dealing with millions of colors, the interpolation severely
deteriorates the quality image

- The test patterns should be done with a colorful image, rather than black and white or solid color test patterns. Using simple solid colors will mislead the final result. Images with high detail like grass, trees and other patterns suffer more degradation than other images. High speed images also suffer from blurry and pixelation when interpolated.
- The best option is to maintain the full information available for reconstruction.

Restoring the image.

When testing the images Vs. the images in a specific format we can clearly observe deterioration or degradation on the image.
For instance. When restoring Checkerboard pattern to Full Frame (Right image in the example)

There is more than a 50% loss with respect to the original image.

No matter what technique is used for interpolation, a given amount of information from a digital frame spread over the larger area of an interpolated file will not look as good as it did at its original size. As a consequence, there is a certain degree of image degradation that results from interpolating an image. lines or curves, that should be smooth, become jagged. Interpolation also causes a loss in Sharpness.

Therefore, the recommendation is to use full 3D HD stereo with an Advanced Coding technique as the delivery format, to avoid the impact of additional losses due to the specific 3D display utilized.

By sending the information with no loss in color, resolution, frame rate or quality we can assure that the final content will not be severely deteriorated.

Now it's just a matter of optimizing the bandwidth and the space used to deploy such 3DHD full stereo content.

Using two independent channels is not effective, therefore, striving for creative ways to encode the Left and Right images into one single videostream using less than 200% the original 2D bandwidth is desired.
1.4) DECODING/RECEPTION

1.4.1) Options for decoding implementation: Once the content has been deployed over existing digital pipelines, the decoding/reception takes place and in order to present 3D images we have the following options:

- External hardware (pass by)
- Internal hardware (inside the TV or inside the Decoder)
- Firmware update to existing devices (Chipsets / STB / Decoders)
- New hardware (updated chipsets)
- Software update/download (PC)

The suggested minimum requirements of any implementation should be:

- Should be compatible with existing installed base of receivers/decoders at least for the 2D version:
  - Existing SetTopBoxes
  - Existing DVD decoders
  - Existing Blu-ray players
  - Existing decoding software

- The decoder should be capable to drive:
  - Existing 2D monitors at the best quality as possible
  - 2D monitors in Anaglyph or ColorCode (Worst case 3D scenario) with the best quality as possible
  - 3D monitors in all the formats at the higher/best resolution as possible

- Any addition in hardware will have its own pros and cons:
  - In the case of external hardware it will represent
    - Additional hassle for the user
    - Additional cost for the box needed in between
  - In the case of internal hardware it will represent
    - An additional cost (implementation, parts, licensing, royalty)
    - Hard solution may lead to several versions, thus, incompatibility, lack of support

- In the case of a firmware update
  - Some devices may not be upgradeable
  - Easy to update

- In the case of a Software update/download
  - Enables the PC platform to be ready for 3D adoption, specially with the digital home, IPTV and media center initiatives
### 1.5) DISPLAY

There are several displays in the market, they all work in a certain native format:

<table>
<thead>
<tr>
<th>Type of native format on the Display</th>
<th>Effective Eye Resolution with respect to original HV resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D</td>
<td>100% Monoscopic</td>
</tr>
<tr>
<td>Line Interleaved</td>
<td>50%L - 50%R</td>
</tr>
<tr>
<td>Checkerboard</td>
<td>50%L - 50%R</td>
</tr>
<tr>
<td>Frame Interleaved</td>
<td>100% L - 100% R (Requires faster refresh rate)</td>
</tr>
<tr>
<td>Full Stereoscopic</td>
<td>100% L - 100% R</td>
</tr>
</tbody>
</table>

The objective of this group should find the way to drive and display all the existing monitors in the market and the near-future monitors. A comparison table is presented here:

<table>
<thead>
<tr>
<th>Input Format</th>
<th>Technology / Received resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D</td>
<td>Full Frame / H,V</td>
</tr>
<tr>
<td>Side by Side</td>
<td>H/2, V</td>
</tr>
<tr>
<td>Over/Under</td>
<td>H, V/2</td>
</tr>
<tr>
<td>Line Interleaved</td>
<td>H, V/2</td>
</tr>
<tr>
<td>Checkerboard</td>
<td>H/2, V</td>
</tr>
<tr>
<td>2D+Depth</td>
<td>Autostereoscopic, H/2 - V</td>
</tr>
<tr>
<td>Frame Interleaved</td>
<td>H, V Frame sequential</td>
</tr>
<tr>
<td>Full Stereoscopic</td>
<td>H, V Simultaneous</td>
</tr>
</tbody>
</table>

Minimum Requirements for the Display stage

- Should support the highest resolution as possible (1080p as of today) for each LR images
- Should not present ghosting when showing 3D
- Should not present crosstalk when showing 3D
- Should not present flicker when showing 3D
- The Display stage should be independent of the encoding stage.
- Should be capable to have a refresh rate of at least 60Hz per eye
- Should be capable to present at least 30fps to each eye
- Should not create any side effects
- Should represent images as close as possible to the original 3D content (no loss in color, quality, resolution)
- Should be a perfect representation of the 3D as originally intended (no loss in depth, no issues with transparencies, no issues with occlusions)
- Should work for 95% of the world population
- Should be perceived with no distortion (autostereoscopic issues, cinema location issues) independently of the location of the user

IMPORTANT NOTICE: Videogame content, techniques, real time calculations, OpenGL and DirectX were been removed from this document since they are out of the scope of this video scope. Nevertheless, they all play a very important part regarding stereoscopic 3D, specially on the visualization stage. Currently, most of the existing game consoles have support for Blu-ray, DVD, IPTV (Networked videostreams) and videoconferencing. This topic should be addressed in the near future on a different task force.
PART 2) TDVISION'S TDVCODEC TECHNOLOGY

Tdvision's TDVCCodec is the way to encode the Left and the Right images in full 3D HD simultaneously while optimizing bandwidth and storing in one single videostream.

The primary videostream presents the full 2D HD version of the content while the stereoscopic pair or Delta is stored in three different methods. All the existing legacy decoders will just ignore the Delta, decoding the primary video as the 2D HD version in full resolution, no loss in color, quality or resolution. The complementary Delta stream is stored in one of the following methods:

2.1) Encoding methods
There are 3 optional encoding methods for the Delta within the TDVCCodec format:
   a) Into the user_data section
   b) as a secondary videostream into the same transport stream or
   c) as a completely independent stream.

The Delta information has 4 variants:
- Full Stereo pair: The complete information with no dependency between the left and the right is stored
- Delta: The different information between the left and the right is stored.
- Optimized delta: The optimized delta (searching horizontally and vertically and storing the optimum redundancy numbers and then obtaining the difference between left and right is stored into the data section.
- Reduced profile
  - Checkerboard: 2D full HD is stored into the primary videostream and the only the necessary information to recreate checkerboard compressed complementary information is stored into as delta
  - Line interleaved: 2D full HD is stored into the primary videostream and the only the necessary information to recreate the reduced line interleaved information is stored as delta
  - 2D plus depth: 2D full HD is stored into the primary videostream and the depth map is stored as Delta
  - Any combination of these methods

2.2) Compatibility
   - 3D HD Content encoded with the TDVCCodec is fully compatible with 2D legacy decoders and “In 3D were available” when TDVision technology is available or implemented for decoding.
   - By using any of the available 3D options, the video stream can be optimized for quality and/or bandwidth.
   - TDVCCodec doesn't present any visual artifacts like the Side by Side and the 2D plus depth counterparts (TDVision does not present occlusion, transparency or depth limitations and is fully compatible with 2D)
   - Implementation requires a relatively simple modification to the firmware and/or our TDVCCodec decoder in software download.
   - Maintains full 3D HD resolution up to 1080p per eye depending on bandwidth availability. No loss in quality or resolution.
   - Provides the best HD quality for both, 3D and 2D formats.

Once a video stream is encoded with TDVision's technology, it can be played back in a normal legacy 2D decoder since the 3D complimentary Delta information will just be discarded at playback time, whereas a new updated decoder will retrieve the 3D information properly.

Depending on the method selected at encoding time, the Right information, Delta information or Stereo Disparity can optimize the bandwidth or the quality, providing up to full HD 3D.

There are no visual artifacts or distortions, since TDVision stores the complete stereoscopic pair and it's reconstructed and decoded as originally captured, no visual artifacts, no detriment, no invented pixels, no
occlusion everything while optimizing bandwidth and quality.

Modifying the firmware by adding our decoding method or using our software decoder is all it takes for the end user to achieve full 3D immersive experience everywhere, basically a simple download or firmware update to modify the way the videostream is created and parsed.

Tdvision solves the main challenges for massive 3D adoption:

- Quality: Maintain Full 1080p per eye, no loss in color, quality or resolution, no interpolation
- Compatibility: With deployment pipelines, with 2D legacy decoders and 2D displays
- Display agnostic: To drive all the existing flavors of 3D displays, and 2D for backwards compatibility
- Bandwidth Optimization: More than 100%, less than 200%
- Massive market adoption: Content, Compatibility and freedom of choice.
2D image

Delta (difference between Left and Right)
The Delta information yields to a high compression due to the high amount of black pixels and the small differences in values from one perspective to another.

The overall implementation of the ecosystem is:

While maintaining compatibility with 2D legacy infrastructures, decoders and displays.

TDVCodec highlights:

- Up to full 1080p per eye
- Best quality in native resolution
- Firmware / Software solution no HW required
- Deployment pipeline compatible
- Display agnostic from 3D HD Cinema @ 1080p per eye down to 2D full HD
- One video stream supports all formats
- The enabler is in the decoder
- Compatible with DOCSIS
- Uses any wrapper and encoding format
- Ready to cover a larger market
- Bandwidth/Quality adjustment
- Beta version ready
- DOCSIS
- MPEG Muxers
- Transport Streams | Program Streams
- MPEG2 | MPEG4 | H.264 | AVC | VC1 | MVC
- DVBS | DVBS2
- Signaling to display over existing HDMI
- All existing 3D displays
- All displays driven at their best native resolution, No interpolation
- 2D displays and even Anaglyph if requested
2.3.1) TERMINOLOGY

Human Stereoscopy
The human capability to perceive simultaneous vision with two eyes, creating a three dimensional experience with depth cues, relative distances perception and volumetric spatial information. Retinal image patterns of the same object are slightly different to the eyes, creating perception into the visual cortex.

Anaglyph
A moving or still picture consisting of two slightly different perspectives of the same subject in contrasting colors that are superimposed in time and space on each other rather than two separate images, producing a three-dimensional effect when viewed through two correspondingly colored filters.

Checkerboard
Left and right stereo images are independently filtered, then sampled in an offset grid pattern. The resulting views are then combined, and appear as a left and right checkerboard pattern in a conventional orthogonal sampled image.

Side by Side
3-D stereoscopic video content is stored in one single frame. Left and Right images are reduced in the horizontal resolution (by removing every other vertical line) by half to fit them one next to each other.

Over/Under (Top/bottom)
3-D stereoscopic video content is stored in one single frame. Left and Right images are reduced by removing every other horizontal lines (reducing vertical resolution by half) to fit them one on top of the other.

Line Interleaved
3-D stereoscopic video content is stored in one single frame. Left images are reduced by removing every even horizontal lines and Right images are reduced by removing every odd horizontal lines. Then the lines are interleaved, leading to a single LR horizontal lines interleaved frame.

Effective Resolution per eye
The final resolution each eye receives on the display stage after encoding, decoding and formatting.

Interpolation
Method of constructing new data points within the range of a discrete set of known data points. Interpolation smoothly blends the color of one pixel into the color of the next adjacent pixel at high levels of zoom. This creates a more organic, but also much blurrier image.

Methods of Interpolation
Nearest Neighbor.
Bilinear.
Bicubic.
Bicubic Smoother.
Stairstep.
Genuine Fractals.
S-Spline algorithm

No matter what technique is used for interpolation, a given amount of information from a digital file spread over the larger area of an interpolated file will not look as good as it did at its original size. As a consequence, there is a certain degree of image degradation that results from interpolating an image. lines or curves, that should be smooth, become jagged. Interpolation Causes a loss in Sharpness.

Eye Convergence
Ability of human eyes to divert eye optical axes horizontally and inwards. The coordinated turning of the eyes
inward to focus on an object at close range.

**Camera Convergence**
To simulate the eye convergence to focus on a specific depth point in space.

**Parallax**
Apparent displacement or difference of orientation of an object viewed along two different lines of sight, and is measured by the angle or semi-angle of inclination between those two lines

**Floating window**
Sidebars added to the stereoscopic content are added to diminish the visual cues that may create visual artifacts by removing depth cues located in the front of the screen (negative parallax)

**Ghosting/Crosstalk**
Visual artifacts caused by stereoscopic information being leaked to the wrong eye. This happens specially at the display stage due to weak polarization, color polarized images or refresh rate not fast enough.

**Hyper Stereo/Hypo Stereo**
Hyper stereo: To increase the IOD beyond the 6.35mm average, creating a giant person perspective effect
Hypo stereo: To reduce the IOD below the 6.35mm average, creating a small person perspective effect

**IOD (Inter Ocular Distance)**
The average distance between the eyes of 6.35mm

**Pseudo stereo**
When images are inverted (Left image going to the Right eye and vice versa)

**REFERENCE**
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