

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

3D Systems Corporation et al.,

Petitioner

v.

Intrepid Automation, Inc.,
Patent Owner.

Inter Partes Review (IPR) Proceeding Number: 2025-01241
U.S. Patent No. 11,014,301

Exhibit Number: **Exhibit 1032 for Petitioner**

Exhibit Title: Excerpts of Rebuttal Report of William J. Allen Intrepid Automation, Inc. v. 3D Systems Corporation et al, Dkt. 27-5, 24-cv-02262-AGS-DDL (SDCA)

Date of Filing: June 15, 2026

Filed By: Petitioner 3D Systems Corporation et al.,

Description of Exhibit: Rebuttal Report of William J. Allen cited in Petitioner's Reply of U.S. Patent No. 11,014,301

Exhibit 4

Rebuttal Report of William J. Allen
3D Systems v. Wynne et al
December 15, 2023

I. Introduction

My name is William J. Allen. I have been retained by the law firm of Smith, Gambrell & Russell, LLP and Defendants Intrepid Automation, Ben Wynne, Chris Tanner, Jamie Etcheson, Robert Mueller, and Ivan Chousal to provide expert analysis and testimony in connection with the above-captioned litigation. Specifically with respect to this report, I have been asked to provide an assessment of certain portions of the reports of Robert Zubrickie and Richard Greene submitted in connection with this case. I may be asked to comment on other reports submitted by 3DS's experts.

Qualifications

I graduated from Purdue University in 1982 with a Bachelor of Science degree in Computer Science. I spent over 30 years working at Hewlett-Packard, including the HP Labs, focusing predominantly on imaging and printing technology. I was the first technologist promoted to HP Fellow in HP's printing business. From 2001-2006, I was Chief Scientist for Hewlett-Packard's Digital Projection Display business.

More recently, I served as Fellow, Global Innovation Team at Iron Mountain, where I was responsible for image quality and integrity on Iron Mountain's recently announced digital pathology on demand service. I resigned my position from Iron Mountain in early November 2023.

I am a named inventor on over 90 United States patents and patent applications, many of which are related to digital projection and digital imaging. I am also named inventor on patents and/or patent applications specifically related to 3D printing. Among other things, I am the primary inventor of wobulation, which is an inexpensive way to double the resolution of projected images without increasing the size of the spatial light modulator (e.g., the Digital Light Processing or DLP chip). Put generally, wobulation, a form of pixel shifting, works by projecting multiple image sub-frames upon a surface with each projected sub-frame's pixels shifted slightly (i.e., less than a pixel) relative to pixels in other projected sub-frames. The resulting multi-sub-frame image has higher resolution than any of the constituent sub-frames. The sub-frames can be projected sequentially from a single

In opining, Mr. Greene does not identify any alleged trade secrets with sufficient particularity to separate them from known concepts in the digital display and projection community. Mr. Greene does nothing more than state – with citation only to 3DS’s interrogatory responses – a number of general concepts, all of which have been discussed extensively in patents and other publications, and all of which have been known and regularly used in the digital display and projection community before 2017. Mr. Greene does not state a specific technique, method, or algorithm for combining these known concepts.

a. Edge Blending / Pixel Blending / Image Blending / Stitching

From usage in Mr. Greene’s report, and my professional experience, all of these terms below refer to the management of projected light (including UV radiation), to appropriately blend projected images, in areas where light from more than one projector lands on a *target area*:

- Edge blending
- Pixel blending
- Image blending
- Stitching

In the case of stereolithography, *target areas* are on a surface of the pool of resin in the printer’s vat (top surface), or the printer’s resin container (bottom surface). The target area in visible image projection is often a reflective projection screen (front projection applications), or a translucent projection screen (rear projection applications). As set forth above, the problems and edge-blending solutions are the same regardless of the target area.

Here I list many references to the terms above, to show how they are used interchangeably in Mr. Greene’s report:

- Paragraph 30 references: “...edge blending of multi-projectors systems...” and “...a portfolio of edge blending techniques...”
- Paragraph 32 states, “...blend the images of multiple projectors a needed.”
- Paragraph 33 states, “...and blending of the individual sub-images associated with composite image for a 3D print job.”
- Paragraph 38 discusses “blending” and “...“image blending” for multiple projector systems in a 3D printer,”

- In Paragraph 40, Mr. Greene informs the reader that “stitch[ing]” is a form of “image blending.”
- In Paragraph 124, Mr. Green writes, “...to successfully blend overlapping edges.” Under a document sub-section titled, “Projector Overlap and Edge Blending / Calibration.”

Please assume all further references, in this document, to any of the terms itemized above are essentially interchangeable.¹

Edge blending has been well-known in multi-projector systems for decades, for example in:

- Zijian Song, Guanghong Gong, Zhanpeng Huang, Liang Han and Ying Ding, "A new edge blending paradigm for multi-projector tiled display wall," *2010 International Conference on Computer Application and System Modeling (ICCASM 2010)*, Taiyuan, 2010, pp. V5-349-V5-352, doi: 10.1109/ICCASM.2010.5620133. <https://ieeexplore.ieee.org/abstract/document/5620133> (the “Song Publication”)
- Brown, Matthew, and David G. Lowe. "Automatic panoramic image stitching using invariant features." *International journal of computer vision*, 74 (2007): 59-73.
- US patent 7,079,157 (the “157 patent”), “Matching the edges of multiple overlapping screen images,” granted 18-Jul-06, filed by Sun Microsystems, Inc, inventor: Michael F. Deering.
- US patent 6,456,339 (the “339 patent”), “Super-resolution display,” granted 24-Sep-02, filed by Massachusetts Institute of Technology, inventors: Rajeev J. Suranti, and Thomas F. Knight, Jr.

Song’s 2010 publication specifically addresses edge blending in multi-projector tiled displays. The abstract of the Song publication is included here in its entirety (*italics added*):

¹ “Edge blending bars” refers to a technique used to manage overlapping projected images, where the overlapping areas often are in the shape of elongated rectangles or “bars.” “Edge blending bars” are addressed independently farther below.

Multi-projector tiled display wall has been widely used in various applications such as simulation, entertainment. Edge blending, which is the core technology for multi-projector [sic] tiled display wall, is improving by and by over ten years. But there are still some problems not resolved. Focus on optimizing edge blending and achieving perfect visual effect, we propose a new edge blending paradigm for the first time, which based on *spline interpolation*. We present that *any couple of curves which can make the overlapped region be visual seamless could be the proper function model for edge blending*. Because any discrete curve can be described by points, so we can use a group of control points to create the curve for edge blending, which is calculated through real-time spline interpolation. Comparing to the previous paradigm, our new paradigm is much more universal and flexible. Furthermore, it can realize perfect visual seamless edge blending and cost much less time than any method.

The abstract above notes that edge blending problem was being addressed for over ten years prior to the Song document's 2010 publication date (i.e., edge blending was being addressed since at least 2000). Importantly, Song's publication notes "any couple of curves" could be the proper function model for edge blending, provided they produce a "visual seamless" effect. Visual seamlessness is achieved by precise control of irradiance in regions of the projected pattern that are addressed by two or more projectors.

The Brown and Lowe publication describes, in detail with equations and example images, an automatic image stitching algorithm. The first part of the paper deals with finding the same features in multiple photos so they can be aligned when overlapping. This allows a large panorama style image to be created. Later, *Section 6 Gain Compensation*, deals with gain (pixel intensity) compensation. Next, *Section 7 Multi-Band Blending*, handles visible artifacts remaining at edges after gain compensation.

The '157 patent addresses many issues associated with multi-projection systems. The abstract of the '157 patent is included here in its entirety (*italics added*):

A graphics system comprises pixel calculation units and a sample buffer which stores a two-dimensional field of samples. Each pixel calculation unit selects positions in the two-dimensional field at which pixel values (e.g. red, green, blue) are computed. The pixel computation positions are selected to compensate for image distortions introduced by a display device and/or display surface. *Non-uniformities in a viewer's perceived intensity distribution*

from a display surface (e.g. hot spots, overlap brightness) are corrected by appropriately scaling pixel values prior to transmission to display devices. Two or more sets of pixel calculation units driving two or more display devices adjust their respective pixel computation centers to align the edges of two or more displayed images. Physical barriers prevent light spillage at the interface between any two of the display images. Separate pixel computation positions may be used for distinct colors to compensate for color distortions.

As the '157 patent explains, it has long been a common practice to, in parallel, address many challenges in projection systems by employing broadly-capable technical approaches. The Background/Summary section states (*italics added*), in part:

Thus, a system and method is desired for providing improved display capabilities including *improved edge blending, hotspot correction, edge matching, distortion correction, and chromatic distortion compensation* in a system having a super-sampled sample buffer.

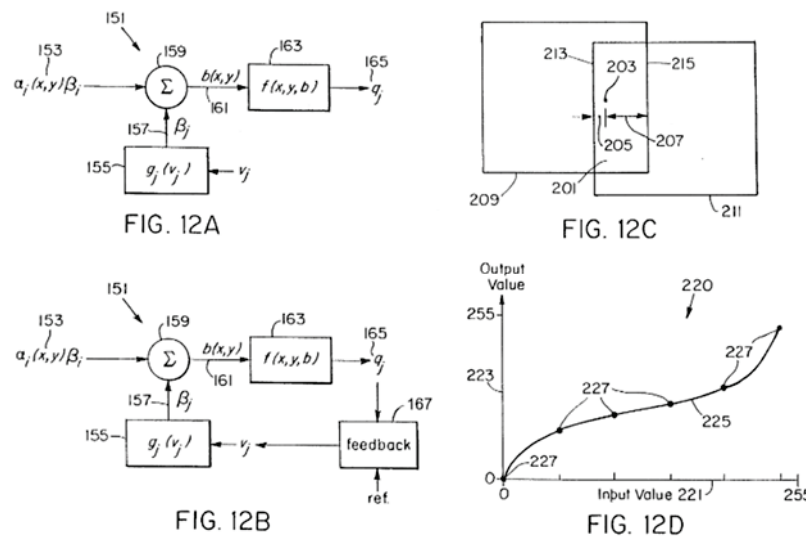
U.S. Patent No. 7,079,157 (issued Jul. 18, 2006) Col. 8:25-29.

The '339 patent provides a highly detailed description of a camera-based technique that corrects for many types of distortion and blends images from plural projectors. The '339 patent's abstract is included here in its entirety (*italics added*):

A super-resolution display derives a map by selectively driving the display while sensing the display output. A stored pixel correction function based on the mapping is applied to pixel data corresponding to the images to be displayed, and the display is driven from the corrected or modified pixel data. This can be used to *correct many types of distortion* and to *blend images from plural projectors*. Pixel data is stored in a frame buffer, and the pixel correction function is applied to the pixel data between the frame buffer and the display, or alternatively, the pixel correction function is applied first, and corrected pixel data is stored in the frame buffer. The display is then driven from the corrected pixel data. In a preferred embodiment, the display comprises a plurality of projectors. The pixel correction function corrects for misalignment of projected overlapping pixel arrays and blends the overlapping projection regions. In another embodiment, the projected images from plural projectors completely overlap, and the projectors have a small fill factor, resulting in a very- high-resolution display. A single projector embodiment corrects for imperfections across the display. The correction

functions are derived by composing a screen to sensor mapping with projector to sensor mappings. These mappings are established by optically sensing physical or projected test charts. Preferably, the optical sensor comprises at least one camera, such as a CCD camera. Alternatively, the optical sensor may comprise a pair of orthogonal linear sensor arrays.

To illustrate the level of detail of the disclosure of the '339 patent, Figures 12 A-D from the '339 patent are included below:



Figures 12 A-D from US 6,456,339

The above patents are selected examples of projection display edge blending solutions from over a decade ago. There are many other examples; searching patents and applications on the USPTO website for “projection AND display AND (edge ADJ blending)” resulted in over 100 matches with publication dates earlier than 2016.

It is my opinion that, in his report, Mr. Greene neither describes in meaningful detail, nor separates the referenced 3DS edge blending techniques from general knowledge, or specific knowledge of those skilled in edge blending of multi-projector systems. Practitioners within the digital display and projection community would be well-familiar with the concept of edge-blending, and they would have access to prior art patents and publications that disclose edge-blending generally, as well as providing specific methods, techniques, and algorithms that would enable one to perform edge-blending.

b. Edge Blending Bars

An “edge blending bar” is just a name for using one or more edge-blending techniques in an area of overlap in two or more sub-images. “Edge blending,” in the context of a multi-projector system, describes the process or technique of managing areas of the composite projected image that are addressed by more than one projected image. These are the “overlap” areas.

If the overlapping projected images are rectangular, then the overlap areas will generally be rectangular in shape. In other words, the overlap areas will be shaped like bars, hence “edge-blending bars.”

It should be noted that there is nothing technologically significant about the *phrase* “edge blending bars.” Although older patents and published papers do not use those exact words when referring to “edge blending”, “pixel blending”, “image blending”, or “stitching”, they are referring to the same thing – a zone of overlap in which one or more various edge-blending functions are performed. In fact, I have reviewed the deposition transcript of 3DS’s 30(b)(6) designee Scott Turner in which he acknowledges that “blending bars” is a coined name for a known concept:

Q. Blending bars, is that something that was known as of August 2017 in the general projector -- projection and display community?

A. · I believe the term "blending bars" came out of a document written and authored by Robert Mueller that is -- was provided in the interrogatories. · I can go refresh my recollection if you would like me to, but that's my recollection before I start that process. · And it was disclosed and provided in response to Interrogatory 3 from Chousal.

Q. · Blending bars is a name, though. · But the concept of blending bars, was that something that was known?

A. I -- I don't know if it was coined by Robert or if it's a term he used from display and projection, which would not -- neither one would surprise me.

Q. · Can you explain what blending bars are?

A. · My understanding of it, as I sit here today, is it's the area where the two projectors actually overlap, and it is in the shape of a rectangle.

Q · And you agree with me that in the display and projection community, the overlap between two projectors is something that's -- there's been overlapping projectors for years, correct?

A · Yes · Creating composite images using multiple projectors has been done in display preceding its use in photopolymer printing as far as I know.

Q · And one way to do it -- the use of a single composite image based on multiple projectors would be to overlap the two subimages; is that correct?

A · Yes · Typically there is an overlap required due to the distortions of the field of view of individual projectors.

Q · And that overlap could be rectangle --rectangular · Is that correct?

A · If it -- if it's a -- two well calibrated projectors, it will be rectangular · If it's not, it would be trapezoidal.

Oct. 17, 2023 Turner 30(b)(6) Dep. at 101:11-103:8.

Relevant patents referenced in Mr. Greene's report:

- US patent 10,723,078 (the '078 patent), "Method of aligning pixelated light engines," granted 28-Jul-20, filed 28-Sep-17 by 3D Systems Inc, inventor: Guthrie Cooper
- US patent 10,773,510 (the '510 patent), "Scalable and fast three dimensional printing system," granted 15-Sep-20, filed 6-Feb-17 by 3D Systems Inc, inventors: Ben Wynne, and Robert Mueller.
- One of the prior art references in the '510 patent is US patent application 12/273,428 ("the '428 application", US 2010/0125356, issued on 4-Mar-14 as US 8,666,142, "the '142 patent"), "System and method for manufacturing," filed on 18-Nov-2008, by Global Filtration Systems Inc, and invented by Axelandr Shkolnik, and Ali El-Siblani.

Mr. Greene points to discussions regarding zones of overlap and specific figures in the '078 Patent, and '510 Patent, owned by 3DS and pointing to apparent similarity to the discussion of edge-blending bars found in Intrepid's U.S. Patent No. 10,780,640 (the "'640 Patent). Mr. Greene, however, fails to assess whether the concept of zones of overlap for edge-blending already existed as known concepts prior to the priority date of 3DS patent applications. This failure is surprising given the testimony from 3DS's corporate designee that edge-blending within rectangular

zones of overlap was a known concept in projection before 3DS started using it. Oct. 17, 2023 Turner 30(b)(6) Dep. at 101:11-103:8. Mr. Greene states in his Exhibit 2 that he considered Mr. Turner's testimony; however, he does not address it here.

I agree with Mr. Turner that the use of blending bars was known long before the Individual Defendants worked at 3DS.

Edge-blending bars are discussed in the '428 application, which is prior art to 3DS's '078 Patent, to 3DS's '510 Patent, and to Intrepid's '640 Patent. In fact, the '428 application is cited on the face of 3DS's '510 Patent as having been cited by the Examiner during patent prosecution. The '428 application discloses a multi-projector solution for stereolithographic processes that can employ DLP technology. It includes calibrating to correct geometric distortions of pattern generators (projectors), as set forth in the below citations to the specification.

“The manufacture of parts may be based on various technologies including photopolymer using light or laser curing methods. Secondary curing may take place with exposure to, for example, ultraviolet (UV) light. A process to convert a computer aided design (CAD) data to a data model suitable for rapid manufacturing may be used to produce data suitable for constructing the component. Then, a pattern generator may be used to construct the part. An example of a pattern generator may include the use of DLP (Digital Light Processing technology) from Texas Instruments...” Background/Summary [0005].

Geometric calibration and correction is explained in the '428 specification, for example in the Brief Description of the Drawings section, “FIG. 1AA is an example of a self-calibrating/self-correcting rapid manufacture machine where the pattern generators are mounted downwardly for direct projection and the imager is mounted to the side.” Description [0004] Fig. 1AA from the '428 application is included below in this report.

Management of overlapping projected regions is covered in the '428 specification, and geometric distortion correction, is also in the '428 specification. Both are discussed at Description [0249] which is included here in its entirety (*italics added*):

In general, pattern generator calibration patterns 612, 614 are located within the extents of outer perimeter 340 (the calibrated region associated with imager 106). Although both calibration patterns 612, 614 are shown here to demonstrate exaggerated pincushion distortion, their imaging regions are *overlapping along their common border, and allow for the*

calibration/correction methods described herein to adjust their patterns accordingly. The outer boundary of each calibration patterns 612, 614 are located within outer perimeter 340 and thus, can be viewed by imager 106. Imager 106, having been calibrated separately (e.g., by imager calibration method 1100; see FIG. 1B) provides precise and compensated information to controller 120 regarding the patterns generated. *In order to transform the pincushioned output of pattern generators 102, 104 to a more usable output, pattern correction methods 620 (e.g., see above FIGS. 1C-1G) are used to compensate the patterns 132, 134 prior to generation by pattern generators 102, 104.*

Additionally, Fig. 3 in the ‘157 patent, granted in 2006 to Sun Microsystems, (referenced above) is a now-familiar diagram used to explain overlap regions in a 4-projector system.

U.S. Patent Jul. 18, 2006 Sheet 3 of 52 US 7,079,157 B2

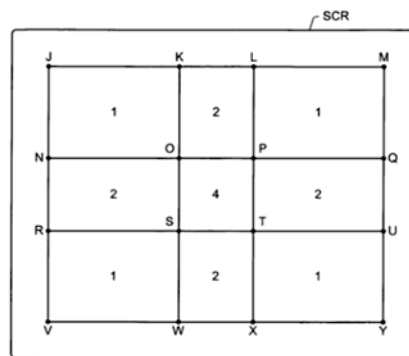


FIG. 3

Fig. 3 from US 7,079,157

The following text shows how the ‘157 patent defines the overlap regions and the need to control intensity (irradiance) in the overlap regions (*italics added*):

The overlap-brightness problem exists when any number of projected images are overlapped. For example, FIG. 3 illustrates the overlapping of four projected images generated by four projection devices in a “two by two” configuration. One of the projected images is represented by rectangle JLTR.

The other three projected images have the same size as rectangle JLTR and are displaced to the three remaining corners M, V and Y. *Exactly two of the projected images overlap in regions KLPO, NOSR, STXW and PQUT*, and thus, these regions may exhibit a light intensity which is double that of the non-overlap regions JKON, LMQP, RSWV and TUYX. All *four projected images overlap in the center region OPST*, and thus, the center region may exhibit a light intensity which is four times larger than the intensity of the non-overlap regions.

U.S. Patent No. 7,079,157 (issued Jul. 18, 2006) Col. 1:62-Col. 2:9.

3DS's '078 patent is about aligning multiple projectors with overlapping "build fields." A build field is the roughly rectangular area on the liquid resin that is addressed (projected onto) by a single projector. Fig. 2 in the '078 patent shows overlapping build fields, and names various parts of "...a build plane 6 formed by the action of four light engines 4A, 4B, 4C, and 4D." Description [0026].

U.S. Patent Jul. 28, 2020 Sheet 2 of 7 US 10,723,071

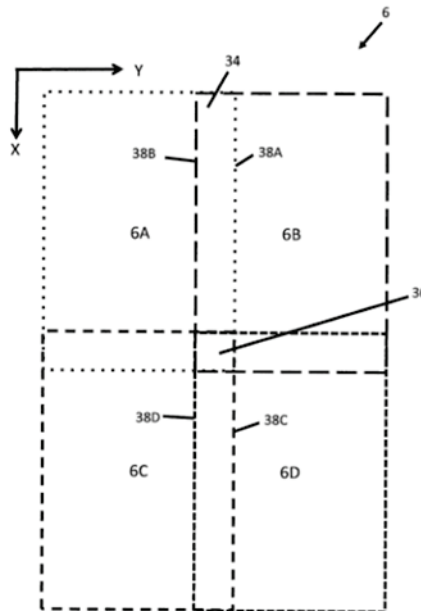


FIG. 2

Fig. 2 from US 10,723,027.

In Fig. 2 above, **34** is defined as an “overlap zone,” and there are 4 overlap zones depicted. **36** is defined as a “central overlap zone.” The ‘078 3DS patent does not explain how curing UV light intensity is managed in bar-shaped overlap zones **34**, or in the square shaped central overlap zone **36**. Neither the word “bar” nor the word “blend” appears in the ‘078 patent.

The ‘510 3DS patent has a similar diagram to ‘078’s Fig. 2. In the ‘510 patent this diagram appears as Fig. 8.

U.S. Patent Sep. 15, 2020 Sheet 7 of 9 US 10,773,510 B2

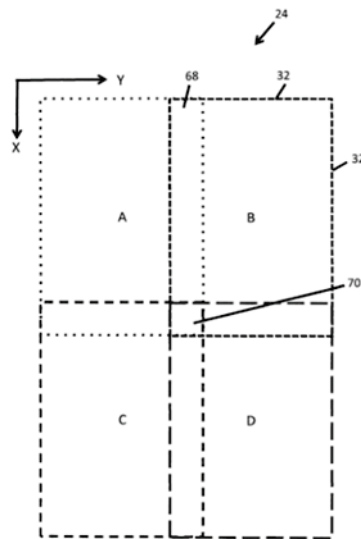


FIG. 8

Fig. 8 from US 10,773,510.

In Fig. 8 above, **68** is defined as “zone of overlap,” and there are 4 of them depicted. **70** is defined as a “build field portion...over which all four build fields A, B, C, and D overlap.”

The ‘510 3DS patent does not explain how curing UV light intensity is managed in bar-shaped zones of overlap **68**, or in the square shaped central build field portion where all four build fields overlap **70**. Neither the word “bar” nor the word “blend” appears in the ‘510 patent.

The disclosure in Sun Microsystems '157 patent, including Fig. 3 which "illustrates the overlapping of four images generated by four projection devices", describes what is referred to in Mr. Greene's report as: "blending bars," "overlaps," "overlapping regions," and "overlapping edges," among other terms. The '157 patent's treatment of overlapping projected images is at the same, if not greater level of specificity, as treatment of the same in the 3DS patents cited in Mr. Greene's Report.

The '157 patent describes the overlap regions and explains the problem, that the light intensity in the overlap regions is greater than the intensity in the non-overlap regions. What neither Mr. Greene, nor the cited 3DS patents, do is provide any specific methods, techniques or algorithms to manage projected image blending in the overlap regions, rendering uniform the intensity of the light across overlap and non-overlap areas. This lack of explanation is in contrast to the '157 patent, the '339 patent, the Song publication, and the Brown publication that describe a number of possible solutions, including management of blending in overlap regions taking into account a subsequent gamma correction in the digital image processing pipeline (the '157 patent).

It is my opinion that Mr. Greene neither describes in meaningful detail; nor separates the alleged 3DS's approach to blending bars from general knowledge in the digital display and projection community, or specific knowledge of those skilled in the calibration and design of multi-projector systems. Practitioners within the digital display and projection community would be well-familiar with the concept (if not the name) of blending bars, and they would have access to prior art patents and publications that disclose blending bars / zones of overlap generally, as well as providing specific methods, techniques, and algorithms that would enable one to perform edge-blending within the zones of overlap in a multi-projector system.

c. Calibration and Geometric Alignment

In Mr. Greene's report, Paragraph 31 references: "algorithms and methods that comprise calibration...of multiple images of multi-projector 3D printers, all of which vary energy when transitioning from one projector to another." I will note here, the specific problem of managing electromagnetic (photonic, be it infrared, visible, or ultra-violet light) energy, in transition areas on a surface where photons from more than one projector impinge, is common to tiled visible-light images (patterns) projected onto screens for human viewing, and to tiled projected ultra-violet light patterns projected onto resin pools for 3D object fabrication.

The relevant definition of the verb *calibrate*, as used in this context, can be found in <https://www.merriam-webster.com/>, “to adjust precisely for a particular function”. Calibration typically requires some form of measurement to determine the amount, or degree, of adjustment that is necessary.

Calibration and geometric alignment has been well-known in multi-projector systems for decades, for example in:

- I. Garcia-Dorado and J. Cooperstock, "Fully automatic multi-projector calibration with an uncalibrated camera," *CVPR 2011 WORKSHOPS*, Colorado Springs, CO, USA, 2011, pp. 29-36, doi: 10.1109/CVPRW.2011.5981726. (<https://ieeexplore.ieee.org/abstract/document/5981726>). (the “Garcia-Dorado” Publication)
- US patent 7,443,364 (the ‘364 patent), “Projection of overlapping sub-frames onto a surface,” granted 20-Oct-08, filed by Hewlett Packard Development Co LP, inventors: Niranjana Damara-Venkata, Nelson Liang An Chang, and William J. Allen.
- US patent 7,907,792 (the ‘792 patent), “Blend maps for rendering an image frame,” granted 15-Mar-2007, filed by Hewlett Packard Development Co LP, inventor: Michael Harville.

The Garcia-Dorado publication addresses challenges of manual calibration with a fully automatic multi-projector solution. The Garcia-Dorado publication’s abstract is included here in its entirety (*italics added*):

Multiple video projectors can be used to provide a seamless, undistorted image or video over one or more display surfaces. Correct rendering requires calibration of the projectors with respect to these surface(s) and an efficient mechanism to distribute and warp the frame buffer data to the projectors. Typically, the *calibration process* involves some degree of manual intervention or embedding of optical sensors in the display surface itself, neither of which is practical for general deployment by non-technical users. We show that an effective result can in fact be achieved without such intervention or hardware augmentation, allowing for a *fully automatic multi-projector calibration* that requires nothing more than a low-cost uncalibrated camera and the placement of paper markers to delimit the boundaries of the desired display region. *Both geometric and intensity calibration* are

performed by projection of gray-coded binary patterns, observed by the camera. Finally, the frame buffer contents for display are distributed in real time by a remote desktop transport to multiple rendering machines, connected to the various projectors.

The Garcia-Dorado publication discusses difficulties with manual calibration, including the problems it presents to non-technical users and operators, and it proposes a fully automatic multi-projector calibration approach. The solution manages both geometric and intensity (irradiance) calibration. It explains employing a camera to assist with automation of the calibration process. The Garcia-Dorado Publication describes multiple problems associated with multi-projector displays (geometric calibration and intensity calibration in this case) being addressed in parallel by one solution.

The '364 patent addresses calibration, and improvement of pixel resolution, in regions where light from more than one projector impinges.

The Detailed Description of the '364 patent is states, in part, (*italics added*):

In one embodiment, display system 100 includes a camera 122 and *a calibration unit 124*, which are used in one form of the invention to *automatically determine a geometric mapping* between each projector 112 and the reference projector 118, as described in further detail below with reference to FIGS. 2A-2C and 3.

U.S. Patent No. 7,443,364 (issued Oct. 28, 2008) Col. 3:52-57.

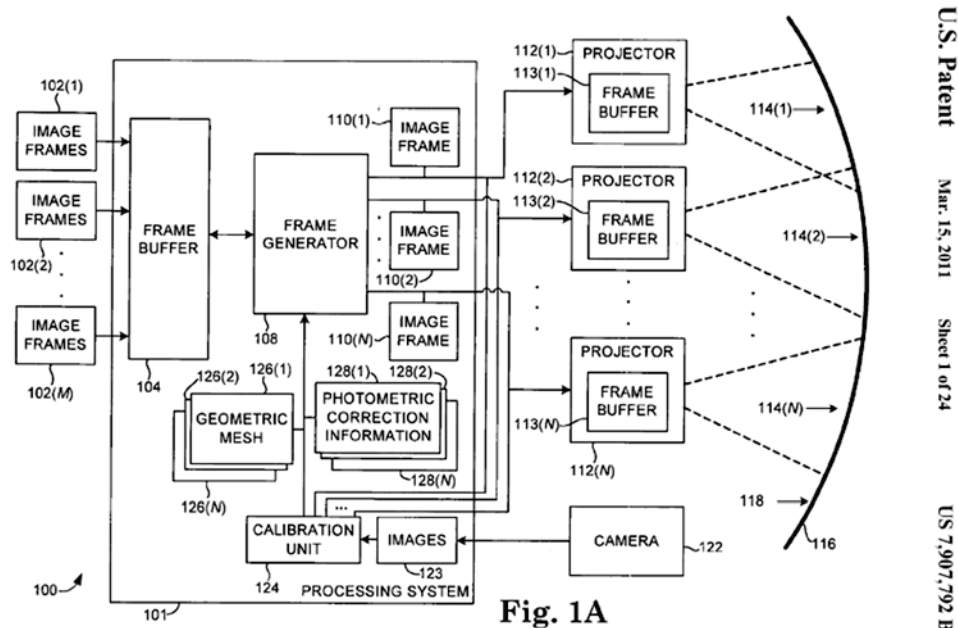
The '792 patent's invention addresses both calibration and correction of geometric problems and calibration and correction of photometric problems in multi-projector systems. The abstract of the '792 patent is included here in its entirety (*italics added*):

A method performed by a processing system includes determining at least first and second distances between a first pixel location having a first pixel value in a first image frame and first and second edges of the first image frame, respectively, and determining a first factor that is proportional to a first product of the first and the second distances and configured to attenuate the first pixel value in response to the first pixel value being displayed by a *first*

projector on a display screen such that the first pixel value overlaps with a second pixel value displayed by a *second projector*.

The word “calibration” appears in the ‘792 patent 187 times. One section of the specification is dedicated to “Geometric Calibration and Correction for Displayed Images,” beginning at Description Paragraph 49. Another section of the specification is dedicated to “Photometric Calibration and Correction of Displayed Images,” beginning at Description Paragraph 117.

The solution is described in a high level of detail. It is applicable to curved projection surfaces, which are more challenging than planar-surface multi-projection embodiments. Fig. 1A from the ‘792 patent illustrates a multi-projector system, projecting onto a curved surface, as well as details of a solution embodiment.



U.S. Patent Mar. 15, 2011 Sheet 1 of 24 US 7,907,792 B2

Figure 1A from US 7,907,792

It is my opinion that Mr. Greene neither describes in meaningful detail; nor separates the alleged 3DS calibration and geometric alignment techniques from general

knowledge in the digital display and projection community, or specific knowledge of those skilled in the calibration of multi-projector systems. Mr. Greene does not even identify whether the claimed calibration and geometric alignment techniques, methods and algorithms enable fully-automated calibration.

Practitioners within the digital display and projection community would be well-familiar with the concept of calibration and geometric alignment, and would have access to prior art patents and publications that disclose calibration and geometric alignment generally, as well as providing specific methods, techniques, and algorithms that would enable one to perform calibration and geometric alignment, including fully-automated calibration and geometric alignment.

d. Warp Correction

Mr. Greene's report mentions "warp correction," in Paragraph 31. Warp correction refers to geometric displacement of pixels from their intended location, for example keystone distortion, barrel distortion, and pin cushion distortion; see visual examples in Fig. 5A, Fig 5B, and Fig. 5C from the '428 application (below). Warp correction has been well-known in multi-projector systems for many years. 3DS acknowledges that it did not invent warp correction. Oct. 17, 2023 Turner 30(b)(6) Dep. 136:9-138:8. 3DS also acknowledges that the concept of using warp correction in connection with stereolithography is not a trade secret. *Id.*

Public disclosures of warp correction included at least the following sources:

- The '792 patent referenced above;
- A publicly available projector image processing chip, the Pixelworks PW610 "Digital Projection Post-Processor," available in 2008. See the Pixelworks press release dated 7-Jan-08, which can be found here: <https://pixelworks.gcs-web.com/node/7566/pdf>
- M. Harville, B. Culbertson, I. Sobel, D. Gelb, A. Fitzhugh and D. Tanguay, "Practical Methods for Geometric and Photometric Correction of Tiled Projector," *2006 Conference on Computer Vision and Pattern Recognition Workshop (CVPRW'06)*, New York, NY, USA, 2006, pp. 5-5, doi: 10.1109/CVPRW.2006.161. (the "Harville Publication").

The '792 patent (referenced above) address warp correction. The Detailed Description that patent states, in part, (*italics added*):

FIG. 1D is a schematic diagram illustrating the projection of images 114(1) through 114(6) onto non-planar developable display surface 116 with

geometric and photometric correction. By applying geometric correction as described in Section II below, frame generator 108 *unwarps*, spatially aligns, and crops images 114(1) through 114(6) to minimize distortion in the display of images 114(1) through 114(6) on display surface 116. Frame generator 108 also spatially aligns images 114(1) through 114(6) as shown in FIG. 1D.

U.S. Patent No. 7,907,792 (issued Mar. 15, 2011) Col. 6:27-35.

Figure 1C and Figure 1D, from the '792 patent, illustrate the warping problem that is corrected by the invention. Note the individually projected images 114 are all warped in Figure 1C, where they are projected on to a curved screen surface. In the depicted example, six projected images, not all the same size, are corrected.

Figure 1D shows how the six unwarped corrected images 114 appear on the curved screen.

The techniques in the '792 patent can be applied to correct warped images, from multiple projectors, that are projected onto a planar surface; from paragraph 32, "Display surface 116 includes any suitable surface configured to display images 114."

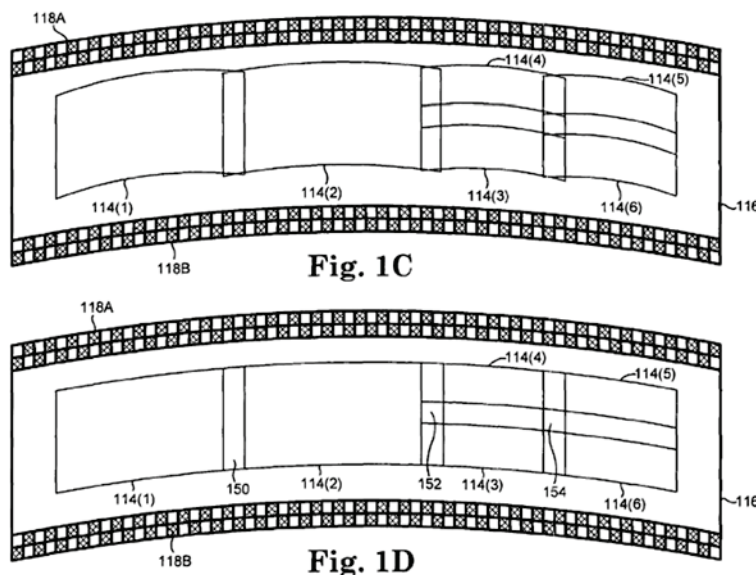


Figure 1C and Figure 1D from US 7,907,792

U.S. Patent Mar. 15, 2011 Sheet 2 of 24 US 7,907,792 B2

Pixelworks makes image processing chips for digital projectors and displays. In their January 7, 2008 press release, they tout their PW610 Digital Projection Post-Processor chip. :

The PW610 is powered by Pixelworks' ARK Engine(TM) technology, which uses a 12-bit image path to correct off-axis, or "keystone" image projection with unparalleled accuracy and speed. An advanced memory architecture enables 30 degree simultaneous *horizontal and vertical keystone correction* at Full-HD resolution of 1080p. Resolutions up to SXGA go even further with 45 degree simultaneous H/V *keystone correction*. ARK Engine technology also supports *pin cushion correction and barrel distortion correction* at all resolutions.

Off-axis ("keystone") image projection distortion, pin cushion distortion correction, and barrel distortion correction, are all forms of warp correction. Warp correction for projectors is a historic need, and back in 2008 Pixelworks integrated multiple forms of warp correction in their dedicated projection display image processing chip, the PW610.

Both geometric correction, including correcting warp, and photometric correction (irradiance correction) of tiled projector displays are addressed in the Harville publication.

The authors solve the correction problem, for multi-projector systems, on curved display surfaces. They deal with distortions caused by projector optics. Their solution is applicable to the simpler case of planar surfaces. They also explain how their solution can efficiently be implemented on a GPU. In addition, they present a solution for photometric (color and intensity) correction, that is applied in parallel with their geometric correction solution. Here is the abstract, in its entirety (*italics added*):

We describe a novel, practical method to create largescale, immersive displays by tiling multiple projectors on curved screens. Calibration is performed automatically with imagery from a single uncalibrated camera, without requiring knowledge of the 3D screen shape. Composition of 2D-mesh-based coordinate mappings, from screen-to-camera and from camera-to-projectors, allows *image distortions imposed by the screen curvature and camera and projector lenses to be geometrically corrected* together in a single non-parametric framework. For screens that are developable surfaces, we show that the screen-to-camera mapping can be determined without some of

the complication of prior methods, resulting in a display on which imagery is undistorted, as if physically attached like wallpaper. We also develop a method of photometric calibration that unifies the geometric blending, brightness scaling, and black level offset maps of prior approaches. The functional form of the geometric blending is novel in itself. The resulting method is more tolerant of geometric correction imprecision, so that visual artifacts are significantly reduced at projector edges and overlap regions. Our efficient *GPU-based* implementation enables a single PC to render multiple high-resolution video streams simultaneously at frame rate to arbitrary screen locations, leaving the CPU largely free to do video decompression and other processing.

It is my opinion that Mr. Greene does not describe in meaningful detail how 3DS's claimed multi-projection and calibration trade secret utilizes warp correction. He does not separate the alleged 3DS warp correction techniques from general knowledge in the digital display and projection community, or from specific knowledge of those skilled in the calibration of multi-projector systems. Practitioners within the digital display and projection community would be well-familiar with the concept of warp correction, and would have access to prior art patents and publications that disclose warp correction generally as well as providing specific methods, techniques, and algorithms that would enable one to perform warp correction.

e. Irradiance / Irradiance Uniformity / Irradiance Characterization

Irradiance is the radiant flux (power from impinging photons) incident on a unit area of a surface. It is measured in W/m^2 (watts per square meter). This is an important parameter to control, at high spatial resolution, over the surface of the resin pool. Delivering a known irradiance level, to an area, for a determined amount of time, allows a curing energy (energy = power * time) dose to be administered, to that area, according to a prescribed quantity.

In visual image projection systems, irradiance directly affects the perceived brightness of the projected image, on a pixel-by-pixel basis. Methods to control irradiance are necessary to produce images with good quality. Extensive irradiance control methods for multi-projector visual imaging systems have been developed and employed for years. For visible images, irradiance correction and irradiance uniformity correction may be referred to as photometric control or photometric correction. These same visible-image irradiance control techniques are applicable to

spatial irradiance control of UV-based multi-projector systems used in stereolithographic applications.

One way of controlling irradiance is through the use of an "irradiance mask," which is typically a 2-D data array of irradiance control (adjustment) values. For example, array elements in an irradiance mask might have a 1:1 correspondence with pixels in the image from one projector. The irradiance mask element values could be binary, either 0 or 1. The irradiance mask elements could be used to disable (turn off) an arbitrary set of projected pixels used to cure a layer in an object being built up by a stereolithographic device. In a more general form, the irradiance mask values could range between 0.0 and 1.0, and be used to independently attenuate intensity of each projected pixel used to cure a layer in an object as it is built. *See* October 17, 2023 Turner 30(b)(6) Dep. at 50:18-24 ("an irradiance mask is a calculated bitmap that you apply in your control system"). 3DS acknowledges that it did not invent the concept of irradiance uniformity or irradiance masking. *Id.* at 61:1-20. 3DS concedes that third-party supplier Young Optics provides an irradiance mask with its off-the-shelf projectors that it sells. *Id.* at 60:16-25. Mr. Greene does not cite Turner's testimony on this point, nor does he identify a special 3DS-specific irradiance mask or irradiance uniformity method, technique or algorithm.

The Harville publication (referenced above) describes photometric correction in multi-projector systems.

The '157 patent (referenced above) addresses "Non-uniformities in a viewer's perceived intensity distribution from a display surface (e.g. hot spots, overlap brightness)." This means it teaches one how to address non-uniformities in irradiance delivered by a UV projection system onto the surface of liquid photopolymeric resin.

Of relevance is US patent 9,497,447 (the '447 patent), "System and method for color and intensity calibrating of a display system for practical usage," granted 15-Nov-16, filed by Scalable Display Technologies Inc, inventors: Paul E. Green, Rajeev J. Surati, Kevin Amaratunga, and Samson J. Timoner.

The '447 patent's abstract is included here in its entirety (*italics added*):

The invention provides a system and method that allows for the *calibration of color and intensity in a display system* in a manner that is practical for the user, and handling obscuring factors, giving the user the ability to make intelligent trade-offs, and making it possible to quickly and efficiently re-

compute a correction. More generally, correction and adjustment of intensity and color non-uniformities, and *using optical sensor feedback* to detect and correct for those changes is contemplated. This includes, but is not limited to, showing very bright images and very dark images. This invention further provides methods for making a practical system for the user, including a method of calculating corrections, dealing with obscuring factors that can affect the calculation process, providing information to allow users to make decisions on how to make trade-offs on the quality factors of the display, and allowing fast re-calculation of intensity corrections when re-calibrating.

The '447 patent's invention works, in part, by iterative convergence of projected images, measured by a camera-based feedback system, in order to mitigate spatial intensity variations in the projected image. The system works with multi-projector systems. A general system diagram is provided in Figure 2 of the patent:

In Paragraph 32 of Mr. Greene's report, irradiance characterization is defined as follows:

Irradiance Characterization generally ensures, for example, that each projector presents the appropriate irradiance characteristic for a particular location in the print area.

The '447 patent discloses irradiance characterization as defined by Mr. Greene. The '447 patent discloses an approach that calibrates intensity in a display system, and uses optical sensor feedback to detect and correct for those changes. In a projection display system, intensity of image pixels is the direct result of the projected irradiance impinging on each pixel location on a surface. Such calibrations and corrections can be used to ensure that each projector, in a multi-projector system, delivers appropriate irradiance for a particular location in the print area. This can be done over the life of the system, thereby addressing an irradiance management concern expressed in Mr. Greene's report in Paragraph 31.

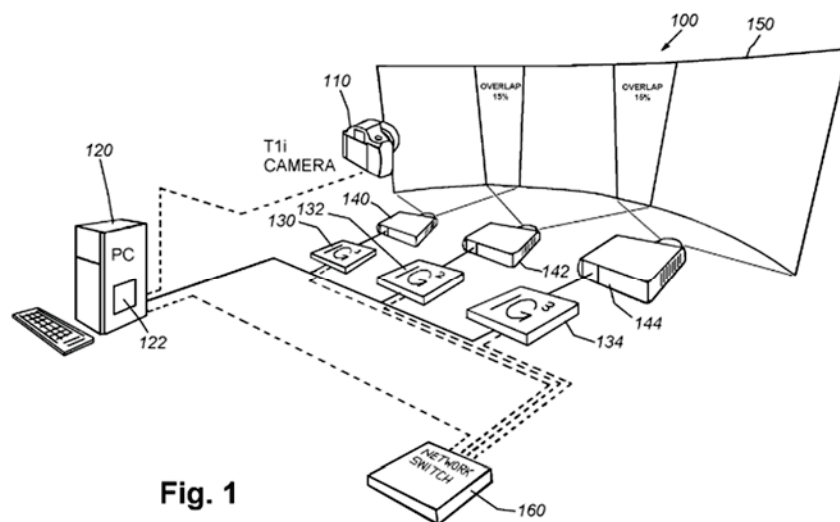


Fig. 1

U.S. Patent

Nov. 15, 2016

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US 9,497,447 B2

Figure 1 from US 9,497, 447

The '157 patent, referenced above, also manages non-uniformities in pixel intensity (irradiance), by appropriately scaling pixel values prior to transmission to display devices. This management can be done over the life of the device.

It is my opinion that Mr. Greene neither describes in meaningful detail, nor separates the alleged 3DS irradiance / irradiance uniformity / irradiance characterization from general knowledge in the digital display and projection community, or specific knowledge of those skilled in the calibration multi-projector systems. Practitioners within the digital display and projection community would be well-familiar with the concept of irradiance / irradiance uniformity / irradiance characterization, and would have access to prior art patents and publications that disclose irradiance / irradiance uniformity / irradiance characterization generally as well as providing specific methods, techniques, and algorithms that would enable one to perform irradiance / irradiance uniformity / irradiance characterization.

f. Gamma / Gamma Correction / Gamma Adjustment

Gamma correction refers to adjusting image intensity based on a gamma function (a type of exponential function). Gamma correction has been around for a very long time in image signal processing. The US Federal Communications Commission

approved the NTSC color television standard in 1953. That standard included processing of video signals with a gamma function. This adjustment can be done on an entire image uniformly applying a single gamma function. It can be done with independent gamma functions for each color channel (e.g., red, green, and blue) in an image. And it can be applied individually to each pixel in a digital image.

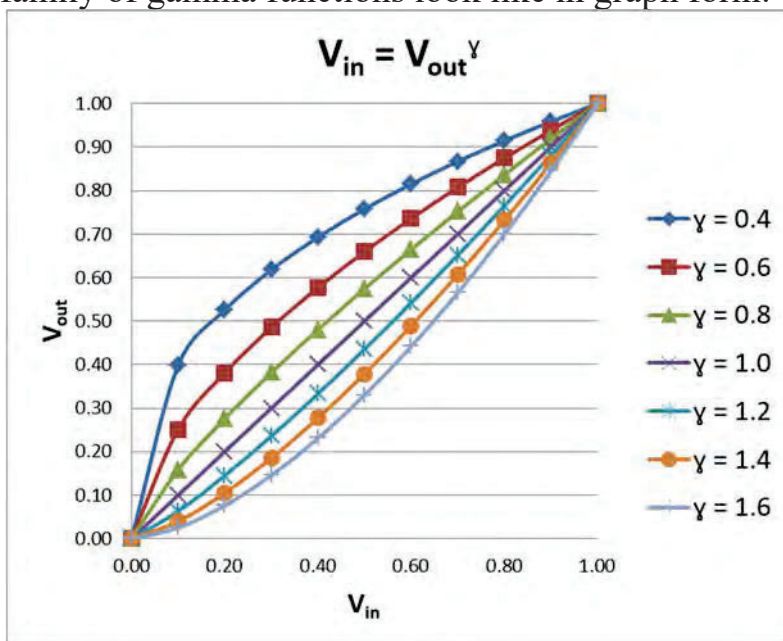
Gamma correction is applying a gamma function to achieve a desired result. Frequently an image, or an image signal, is characterized and analyzed in order to determine a desired gamma correction.

The common form of the gamma function is:

$$V_{\text{out}} = V_{\text{in}}^{\gamma}$$

Where V_{out} and V_{in} are each on the range [0.0, 1.0]. The output V_{out} , is the input V_{in} raised to the power of gamma (Greek letter γ).

Here is what a family of gamma functions look like in graph form:



Family of gamma functions in graph form

As shown above, the gamma function is simply a mathematical exponential relationship between two ranges of numbers, an input range and an output range. In the particular example above, the minimum input (0.0 above) maps to the same value for output (again 0.0). And the maximum input (1.0 above) maps to the same value for output (1.0).

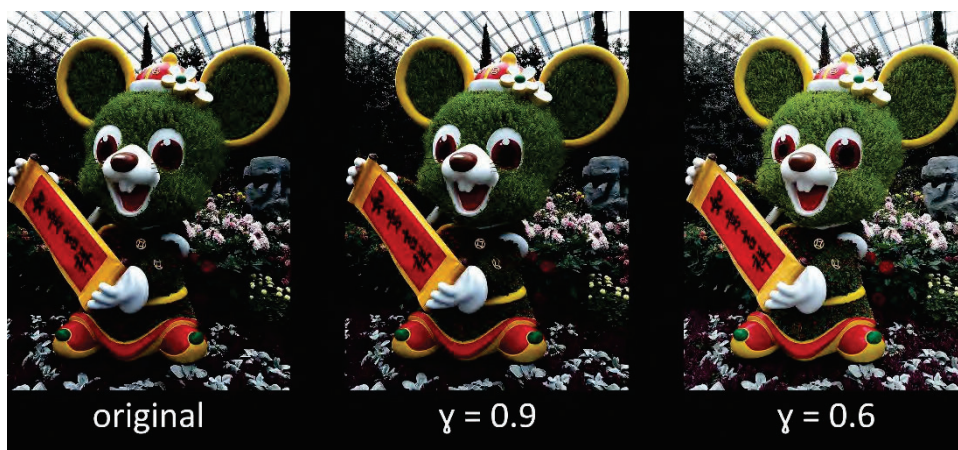
In many physical systems, there is a similar relationship between two parameters. For example, aerodynamic drag force on a moving automobile is proportional to the square of the vehicle's velocity...this can be thought of as a gamma value of 2.0.

One could use a gamma-type function to map required horsepower to expected speed of a car. It takes about four times more horsepower to propel a car at 100 miles/hour than it does to propel the same car at 50 miles/hour.

Note: frequently the term “gamma” is used to describe a function that is similar to the idealized mathematical exponential gamma function. An engineer might talk about, or implement, “gamma correction” by mapping input values (uncorrected) to output values (corrected) with an arbitrary 1-dimensional function, or even a look up table (LUT).

In display and hardcopy imaging systems, it is important to produce images that people perceive as having “good image quality.” Often adjusting digital values of image data, before sending that data to a printer or display, is necessary. It turns out that the basic gamma function, as shown above, frequently is sufficient to allow an image to be significantly improved.

Below is an example of an original image, and two adjusted versions, each with a different gamma adjustment (correction) applied. The original is too dark. An adjustment with $\gamma = 0.6$ improves the image significantly. The examples were created using the built-in gamma function in Adobe Photoshop.



Example of applying different gamma adjustments (corrections) to an image.

If a display were too dark, adjusting with a gamma value less than 1.0 would lighten the image. Choosing the correct gamma value results in a better-looking image.

Gamma characterization and adjustment, or compensation, for multi-projector imaging systems, has been well known for decades, for example in:

- US patent 7,215,362 (the ‘362 patent), “Auto-calibration of multi-projector systems,” granted 8-May-07, filed by Fraunhofer Gesellschaft zur Forderung der Angewandten Forschung eV, inventor: Stefan Klose.
- US patent 7,270,426 (the ‘426 patent), “Multi-projection display and projector,” granted 18-Sep-05, filed by Seiko Epson Corp, inventor: Yasunaga Miyazawa.

In August of 1991, HP introduced the HP Deskwriter 500C, HP’s first color consumer inkjet printer. I was responsible for the color image processing software for that printer. I used a common lookup table to make printed images look good...neither too dark nor too light. This is documented in the August 1992 HP Journal article, “HP DeskWriter C Printer Driver Development,” by William J. Allen, Toni D. Courville, and Stephen O. Miller: <https://www.hpl.hp.com/hpjournal/pdfs/IssuePDFs/1992-08.pdf>. From page 101, “A one-dimensional correction function is independently applied to each primary before it is halftoned.” From page 101, “A one-dimensional correction function is independently applied to each primary before it is halftoned.”

On page 102, the HP Journal article explains characterizing the printer, by printing and measuring sample output. Characterizing digital printing and projection devices, and using those characterizations to modify control signals to improve output quality, has been a well-documented industry practice for decades.

3DS acknowledges that it did not invent the concept of gamma correction, which was a well-known concept in the projection and display community as of August 2017. Oct. 17, 2023 Turner 30(b)(6) Dep. 88:13-89:7,

Gamma in DLP Projection-based Stereolithographic Devices

In stereolithographic systems, UV light is used to cure resin. The depth of resin that is cured by UV light exposure is not linear, instead it generally follows a gamma curve. So doubling the amount of light energy delivered to a small area of resin does not double the depth of resin cured. Accordingly, it can be useful to build in a gamma

correction, altering the input data by a gamma function, before sending adjusted data to the SLA devices projection imaging system.

To effectively implement gamma correction in the context of stereolithography, it is important to understand some basic resin chemistry. There are a number of excellent technical reference books on stereolithography that provide the necessary information, including one in particular by a former 3DS scientist:

Jacobs, Paul Francis. *Rapid prototyping & manufacturing: fundamentals of stereolithography*. Society of Manufacturing Engineers, 1992.

Chapter 2 is titled *Basic Polymer Chemistry*, and it explains both the chemistry of the liquid photopolymeric resins used in stereolithography, as well as how they are cured by ultraviolet (actinic) light that is used to irradiate liquid resin in order to provoke the curing chemical reaction.

Here are formal definitions of some units used in the book:

Irradiance is a measure of the power, delivered by photons, to an area of a surface. Common units are watts per square meter (W/m^2) and milliwatts per square centimeter (mW/cm^2). Resin is irradiated with curing light for a period of time.

Time is measured in seconds (s) or milliseconds (ms).

Exposure is the total energy delivered to an area, and it is irradiance multiplied by the time duration over which that level of irradiance was delivered. Common units are joules per square meter (J/m^2) and millijoules per square centimeter (mJ/cm^2).

Distance (e.g., depth), in the US is frequently measured in mils. 1 mil = 1/1000 inch.

Jacobs' book explains in detail how cure depth of resin is related to the exposure level of the resin to light. In his example, he uses light from a laser. The source of curing light, whether it be a laser or DLP-based projector, is not a key factor. The key factor is the exposure delivered by the light source. Here is a graph of *Cure depth (mils) vs. Exposure (mJ/cm^2)* from page 35 of Jacobs' book:

mentioned.

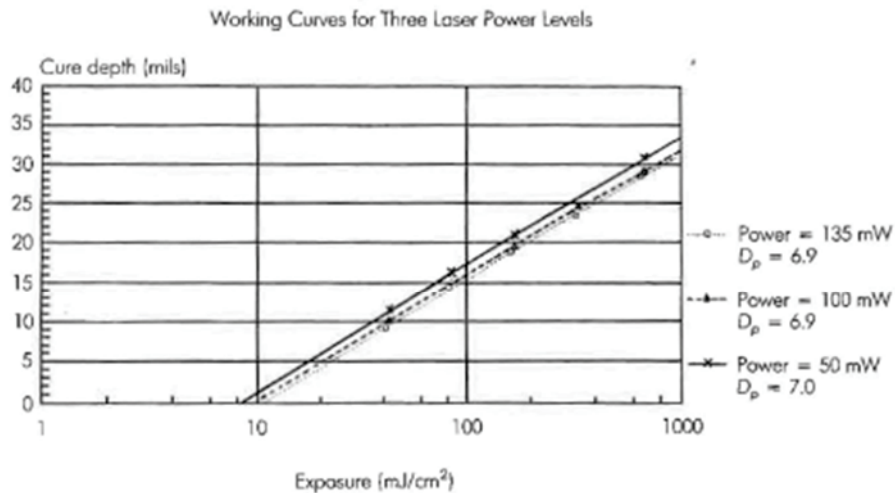


Figure 2-3. Working curves for Cibatool XB 5131 at three argon-ion laser power levels.

Figure 2-3 from Rapid Prototyping & Manufacturing by Paul Jacobs.

One sees that larger exposure values result in larger cure depths. Cure depth, per Jacobs' book, can be measured with a micrometer. The graph also shows the cure depth vs exposure values vary somewhat when different power lasers are used.

The graph above is plotted on log-log axes. This means straight lines on that log-log graph will plot as the familiar gamma curves (as illustrated above: *Family of gamma functions in graph form*) on a graph with linear axes.

The key point made in Jacobs' book is: cure depth has a gamma-curve relationship to exposure. Therefore, it is advantageous to have a gamma compensation capability in the digital signal processing chain of a stereolithographic system. Fortunately, gamma compensation is well understood, and has common in imaging systems for many decades.

Different resins have different curing responses to the amount of UV energy, and/or the wavelength of UV energy, delivered to a small area of resin. The sensitivity of a resin can be characterized, as suggested by Jacobs, by measuring the cure depth over a variety of exposure conditions by varying irradiance and time. In 3DS_01870 (2nd slide of a 26-Oct-16 presentation titled "Rafiki (6-Pack) TRL's Priority List," there is a bullet under "Materials" reading, "365 nm wavelength compatible material testing on-going (Marty)." I believe this is an indication that 3DS was characterizing

the performance of a particular resin/projection engine pair as suggested by Dr. Jacobs.

Different gamma-style compensation functions can be derived, and selected for use, depending on the resin in the printer, and characteristics of the printer's UV illumination. This makes it possible to send a data file to the printer that, for example, does not depend on the resin in the vat. The printer can be programmed to select the appropriate gamma-style compensation function in order to produce results consistently across a variety of resin types.

Actual compensation functions may not exactly be exponential gamma functions. Still, those compensation functions are often called "gamma" functions or "gamma" compensations. The key point is: "gamma-ish" compensation functions are used in many systems, including 2D hardcopy printers, classic CRT displays, and stereolithographic 3D printers.

DLP-based projectors have virtually perfect abilities to deliver output intensity (irradiance on a pixel basis), as a function of input pixel value, by duty cycle modulation of each pixel's associated DLP micromirror. This means it is possible to input an arbitrary curve for the input to out mapping, and have the device respond as desired. This curve can be employed as a "look up table," in which, for each possible pixel digital input value, a corresponding adjusted value (representing output intensity of that pixel) is defined. In this manner a gamma function type mapping can be defined between input pixel values and projected pixel intensities. The lookup table approach supports mapping via arbitrary functions, of which gamma functions are a set.

In some cases, it may be desirable to individually adjust the projected intensity of each projected pixel. This adjustment may be according to a gamma function, or another function that accomplishes desired system goals. If standard projection image processing chips, such as those supplied by Texas Instruments (supplier of DLP projection technology components), or Pixelworks, are not capable of implementing such mappings on a per pixel basis, well-known image processing techniques can be implemented in software, or in GPUs, to adjust digital intensity values for pixels on an individual basis.

Like other items discussed above, gamma adjustment and compensation, in projection systems, has long been accomplished via publicly available chips. For example, the 2008 Pixelworks press release noted above states the PW610 chip

manages gamma with, “a 1024 point output gamma table ensures signal compatibility and color correction for any projection display.”

This means the chip has a look up table with 1024 entries. 1024 is 2^{10} , which means the table is indexed by 10-bit binary values. Input pixels can be represented as 10-bit numbers. For each possible input pixel value, the table holds a corresponding adjusted value. The adjusted values can correspond to a gamma function. It is common for these types of lookup tables to allow arbitrary values to be loaded, enabling them to represent arbitrary functions, including linear scaling and sigmoid functions.

A number of the patents cited above provide further explanation of gamma corrections. The ‘362 patent states, “The definitely calculated blending value is stored both in the left and the right blending image--depending on the starting and final points of the scan line. Due to the different start and final values (the starting point in the left partial image corresponds to the final value in the right partial image), a so-called cross fade with integrated gamma correction is created.”

U.S. Patent No. 7,215,362 (issued May 8, 2007) Col. 7:4-10.

This description is explaining how both a smooth cross fade, across a region of overlapping light from more than one projector, is managed. The invention not only manages a smooth control of irradiance (“so-called cross fade”), it also manages the adjusted pixel values in the overlapping region, taking into account downstream (occurring after the cross fade adjustment in the digital signal processing chain) gamma corrections that normally are independently managed in each projector.

From the ‘426 patent, Description paragraph 70:

“FIG. 8(A) shows a relationship between a pixel value of certain color and an output value from the projector, wherein, when RGB colors are expressed by 8 bits, the pixel value in a color takes a value 0-255. Because γ -correction has been done in each projector PJa, PJb, the relationship between pixel value and output value is given as in FIG. 8(A). Accordingly, when taking such γ -correction into consideration, there is an actual need to correct the pixel value by use of such a function as in FIGS. 8(B) and 8(C), in order to provide an output value of 1 from the projectors PJa, PJb to the overlap.”

Figure 8 from the '426 patent is below. Fig. 8A shows a gamma function, similar to the one shown above in graphical form. There are two projectors involved, projecting images that overlap slightly. Each projector has a gamma function applied to its output. The patent explains how to modify pixel values, for each projector in the overlapping region, so the resulting composite image has appropriate irradiance (visual brightness) across the entire area covered by the two projected images.

In Fig. 8CB, one sees that the rightmost pixel values for "PJ_a" (projector A) are modified according to a sigmoid (s-shaped) curve. In Fig. 8C, the leftmost pixel values for "PJ_b" (projector B) are modified according to a different sigmoid curve. The corrections in Fig. 8B and Fig. 8C deliver appropriate irradiance, in regions where two projectors, each with a gamma function applied to its output, produce overlapping output images.

Also note the sigmoid (s-shaped) blending curves shown in Fig. 7C and Fig. 7D of the '426 patent. Blending curves can have arbitrary shapes, including linear (straight line), and sigmoid.

Interestingly, in 3DS_013873, a slide titled "Starting Provisional Invention Disclosure Process," from the 26-Oct-16 "Rafiki (6-Pack) TRL's Priority List" presentation noted previously, one of the bullets reads, "Sigmoid projector blending for 3D printing." This indicates that 3DS felt there was novelty in using sigmoid curves for blending projected images, and had started work toward a patent on that concept. It is not clear to me how 3DS would have been able to overcome prior art related to sigmoid curves and blending edges of projected images.

U.S. Patent Sep. 18, 2007 Sheet 7 of 17 US 7,270,426 B2

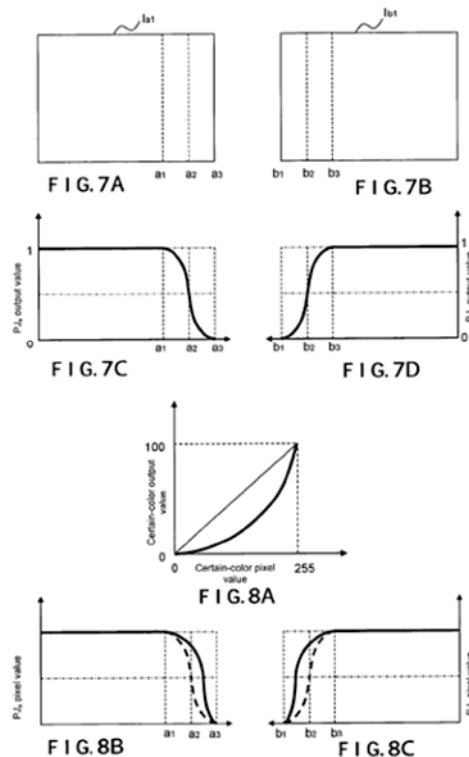
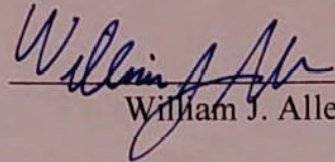


Figure 7 and Figure 8 from US 7,270,426

It is my opinion that Mr. Greene neither describes in meaningful detail, nor separates the alleged 3DS's approach to gamma correction / gamma adjustment from general knowledge in the digital display and projection community, or specific knowledge of those skilled in the calibration and design of multi-projector systems. Practitioners within the digital display and projection community would be well-familiar with the concept of gamma correction / gamma adjustment and would have access to prior art patents and publications that disclose gamma correction / gamma adjustment generally as well as providing specific methods, techniques, and algorithms that would enable one to perform gamma correction / gamma adjustment.²

² Nowhere in Mr. Greene's report can I find an explanation of how gamma compensation is implemented in any of 3DS's stereolithographic devices, let alone a specific method, technique or algorithm that is separable from what is known in the digital projection and display community regarding gamma correction / gamma adjustment. Additionally, neither 3DS's '510 patent nor '078 patent mentions "gamma", nor do they explain how gamma compensation would be implemented in a device.

December 15, 2023

 15-DEC-23
William J. Allen