

LIBSSM

Large Imaging with BeamSplitter Sensor Matrices

conceptual design & illustrations.

Jijo. 2 August 2018

The author is a filmmaker who has done many technological innovations.
For details, visit www.navodayastudio.com

A beam splitter is an optical device that splits a beam of light in two.

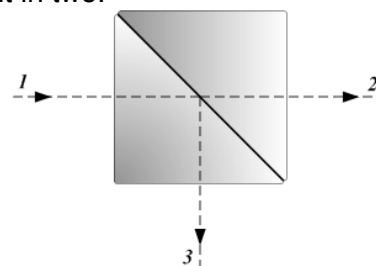
Schematic illustration of a beam splitter cube.

1 - Incident light

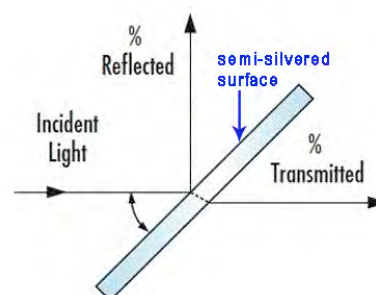
2 - 50% Transmitted light

3 - 50% Reflected light

In practice, the reflective layer absorbs some light.



Another way is to use a half-silvered mirror (dichroic optical coating on optically clear glass plate).



https://en.wikipedia.org/wiki/Beam_splitter

In motion picture cinematography at least, with individual lenses you cannot capture segments of one large subject and then optically/ digitally combine them into a single image sequence. Because, in their optical qualities - lens aberration for instance, no two lenses are identical.

The major shortcoming of the *CINERAMA* process (1952) was not that multiple projectors couldn't be aligned to project segments of an image seamlessly ... but that, separate shooting lenses could never be aligned to take in segments of a subject seamlessly.

This is to answer the question - *Why Beamsplitters?*

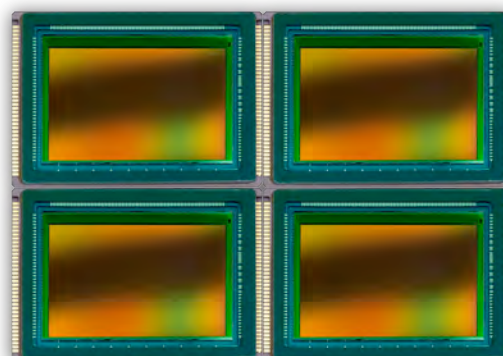
Today, Digital Cinema Projectors can be aligned pixel-to-pixel, seamlessly. But not the shooting lenses.

Hence, outlined here is a concept for splitting a **Very Large Image** - with beamsplitters, and using array of sensors to capture segments of that image onto computers.

Arraying of sensors adjacent to each other doesn't help. For, when placed close together, the sensors don't join seamlessly. Such arraying is possible for digital photography of images in astronomy. But for cinema ... well, we have an example in Cinerama. Hence the need for alternate images for adjacent sensors.



Four quadrants taken with lens array (simulated).



Array of CMOS when placed side by side.

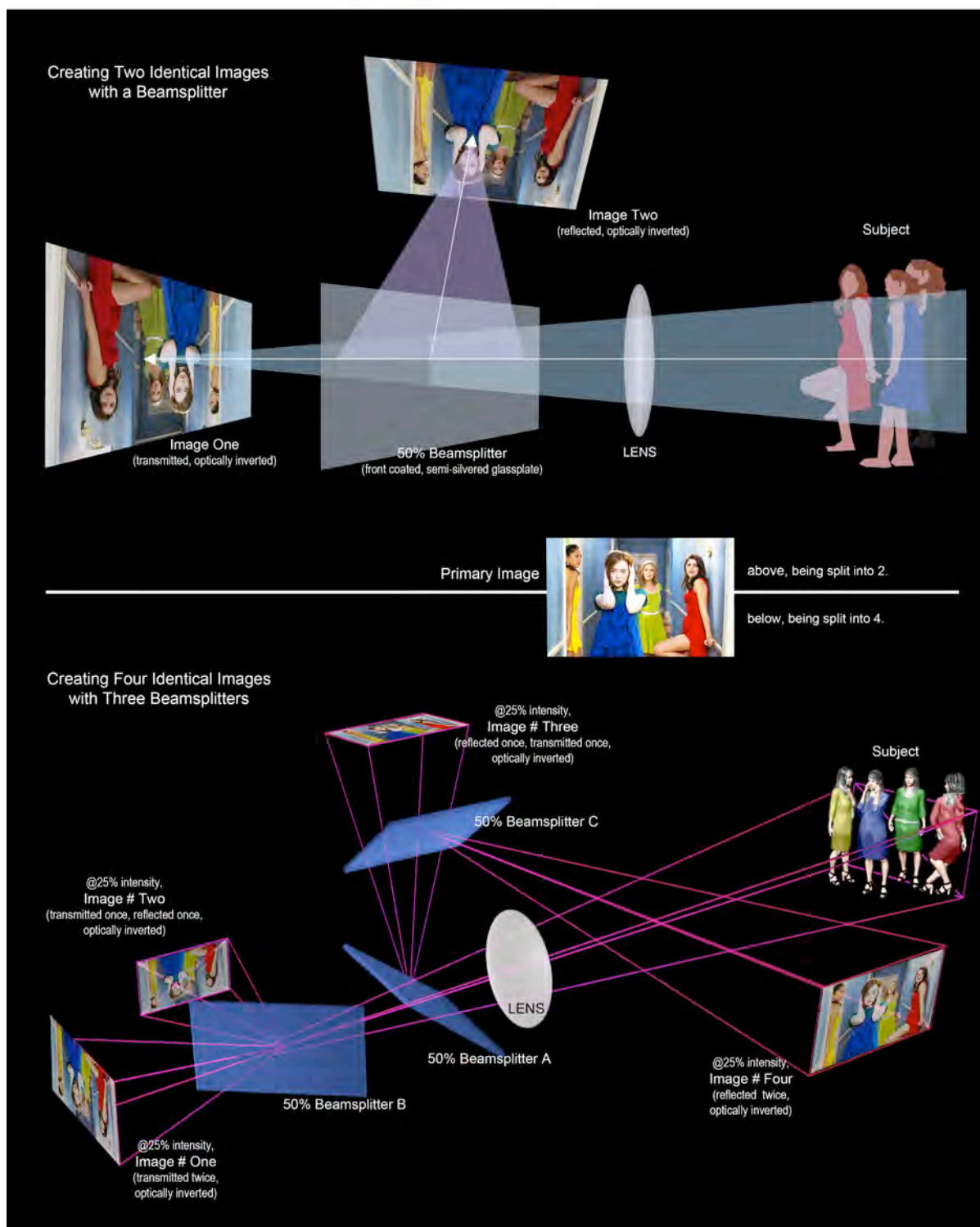


Image courtesy, film *La La Land* (2016)

Once you have four identical images, you can divide them into 4 segments with

(A) 2 X 2 matrix

or a maximum of 16 segments with

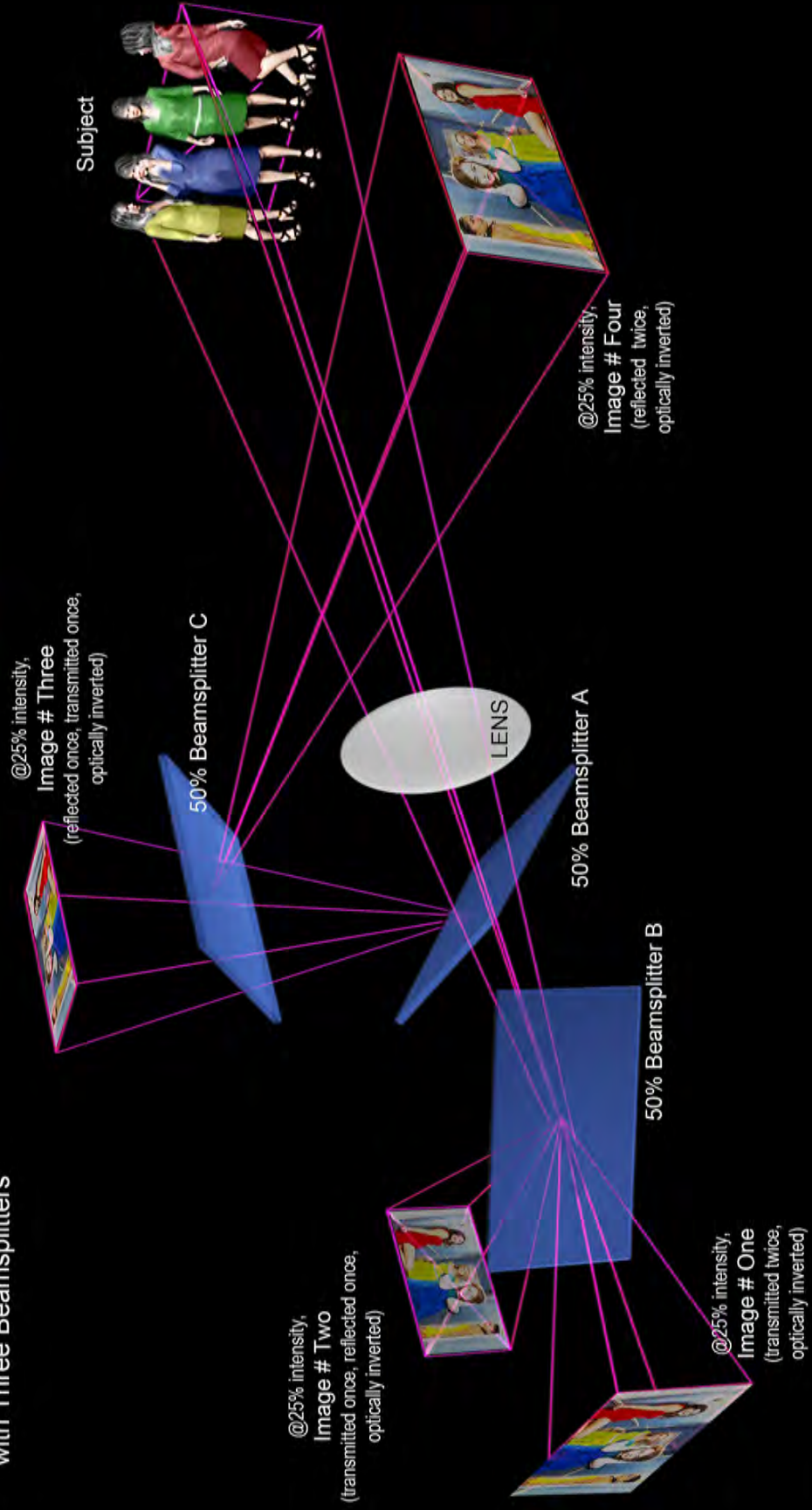
(B) 4 X 4 matrix.



Primary Image

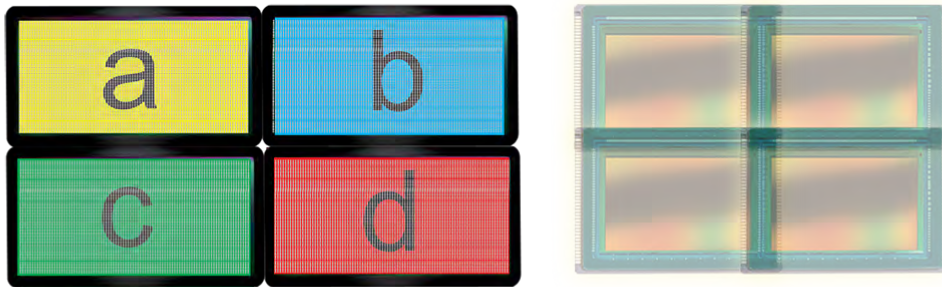
being split into 4.

Creating Four Identical Images with Three Beam Splitters



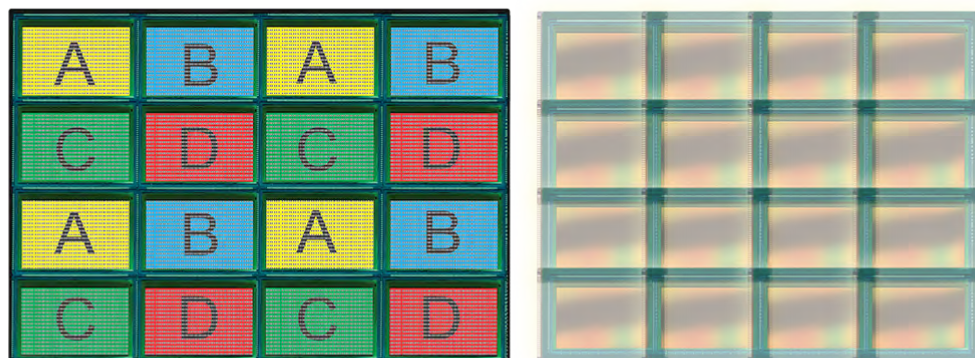
Dividing four identical images into 4 segments with

(A) 2 X 2 matrix



or a maximum of 16 segments with

(B) 4 X 4 matrix.



2 X 2 MATRIX

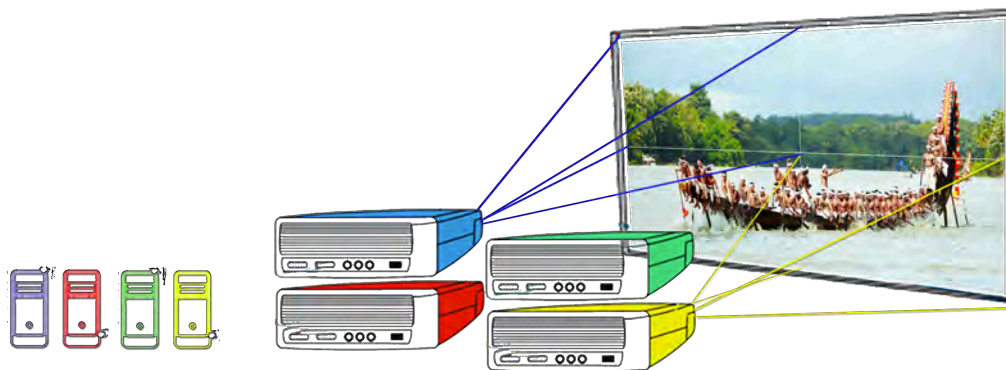
When stitched together, the image would be about **3 times the resolution** of 65mm (5 perf.) film image.

Which would make this about the same as Imax (15 perf.) film.

And about 7.5 times the resolution of 35mm (full aperture) film.



To add dynamism to this large image, recording the images in 3D with a High Frame Rate (60fps) Architecture should also be considered. For such a scenario, it may require coupled drives with banks of servers sharing a master clock.



Now to 4 X 4 matrices ...

4 X 4 MATRIX

Sensors - 4 numbers of A, 4 numbers of B,
4 numbers of C and 4 numbers of D

A total of 16 RED Dragon (6K) 35 mm.

Each of Size 30.72mm X 5.8mm. Resolution 6144 X 3160

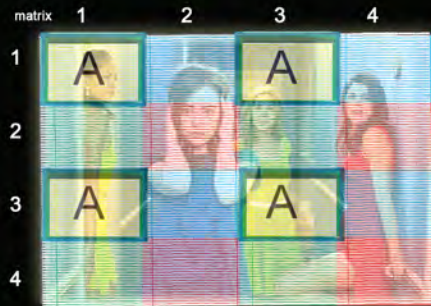
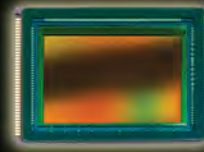


Image One

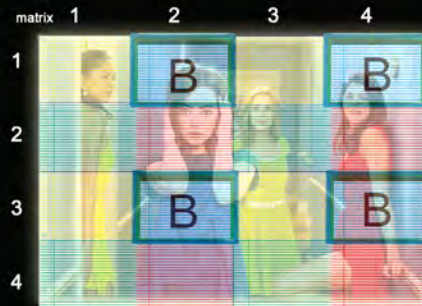


Image Two

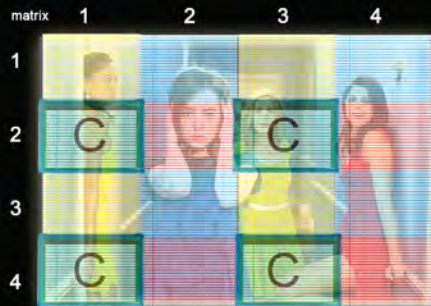


Image Three

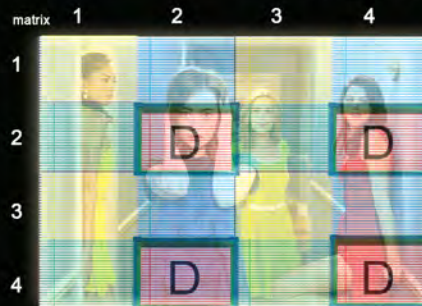
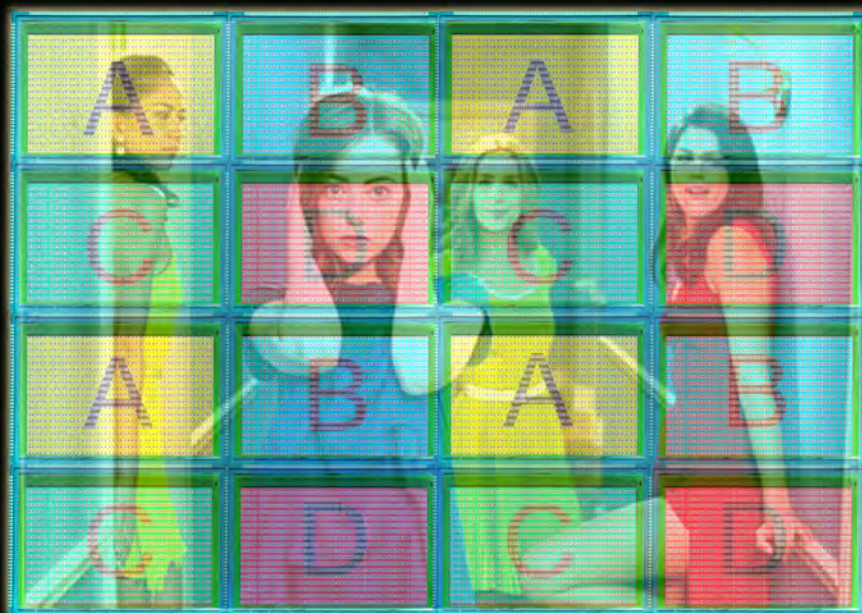


Image Four

In effect, a 4 X 4 matrix (16 numbers) of
RED Dragon (6K) Sensors

Each of Size: 30.72mm x 15.8mm Resolution: 6144 x 3160

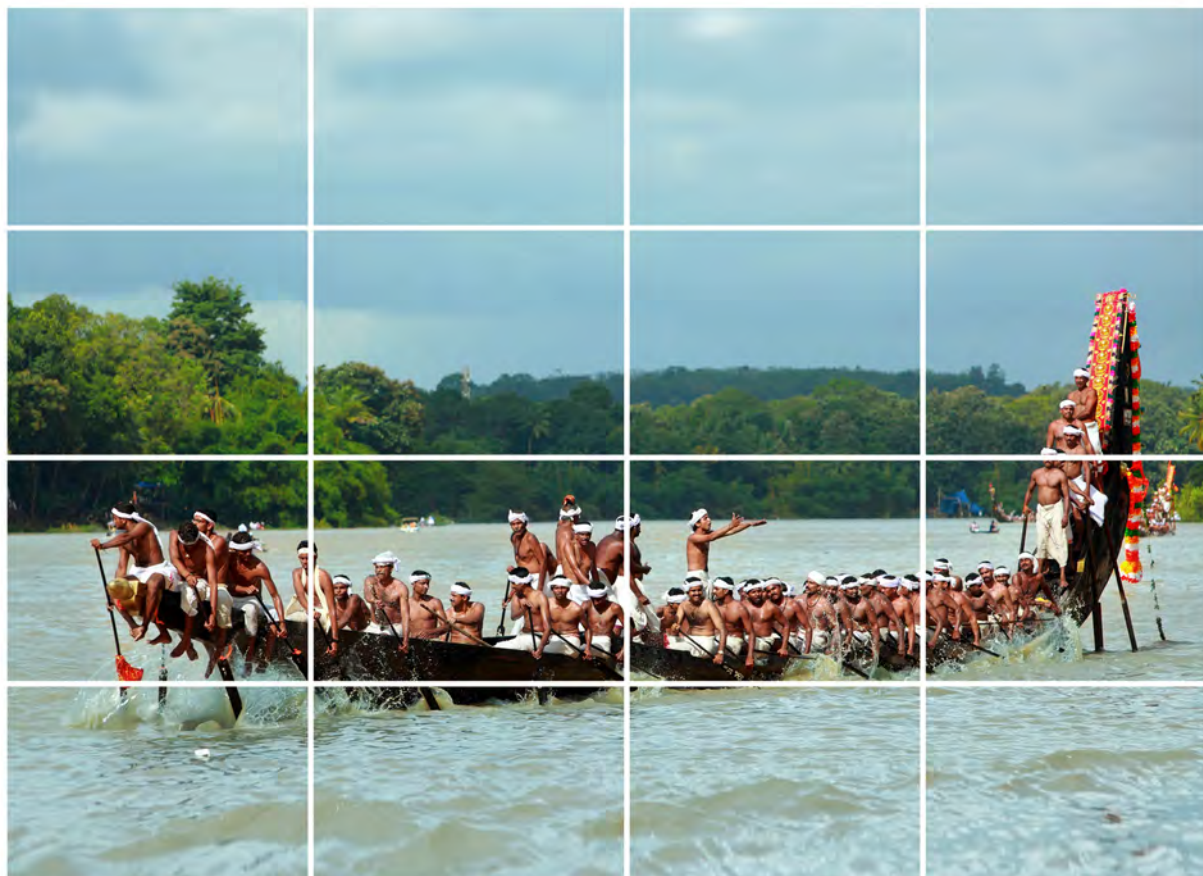
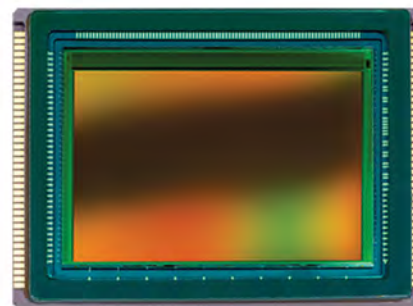


4 X 4 MATRIX

When stitched together, the image would have **16 times the resolution** of 35mm (full aperture) film image.

In comparison, an Imax (15 perf.) film image has 7.5 times the resolution of 35mm.

And, a 65mm (5 perf.) film image has 2.5 times the resolution of 35mm.



This Large Digital Imaging could find use in different applications. Once the images from the matrix have been stitched into a single image sequence, the play-out could be in any format. HD, Digital Cinema for Theaters ... even special venues of Mammoth Screen sizes where segments of the image are seamlessly played from multiple Digital Cinema Projectors. That should make this a hit with VR Themed Rides.

Jijo.

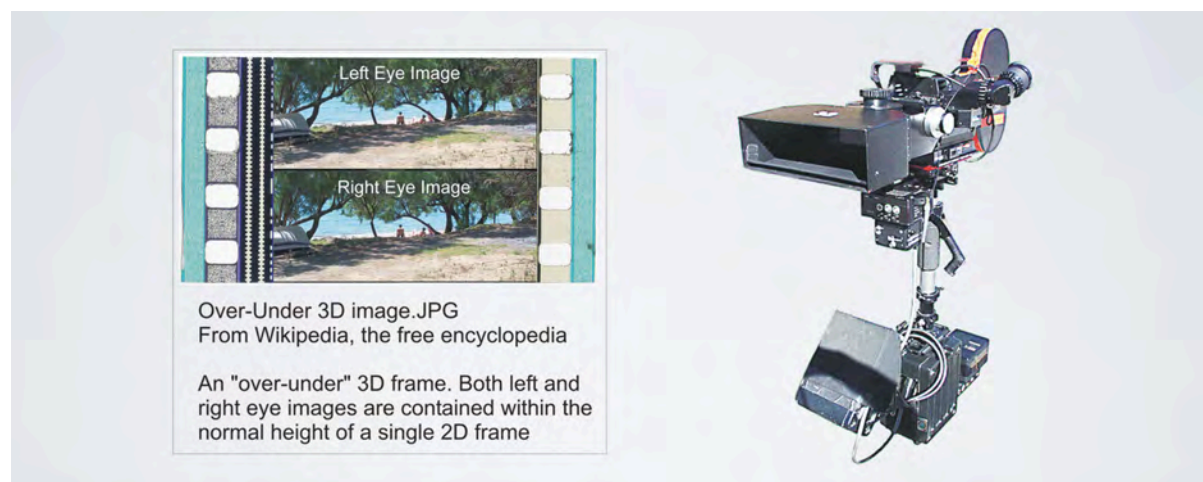
Navodaya Studio, Kakkanad, Kochi.

2 August 2018

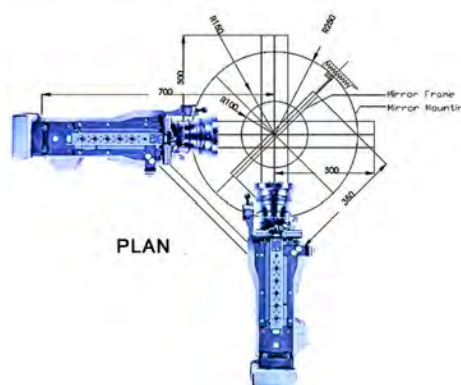
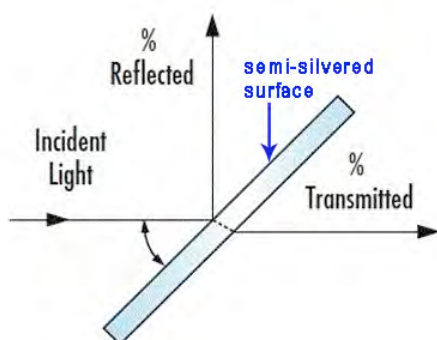
Afterword

(Instead of a rambling preamble, better I thought a rambling postamble).

The thought process – (1) Large Image Format, (2) High Frame Rate and (3) High Dynamic Range – all of them for Digital 3D Imaging – started developing in my mind on that day in August 2001 when my colleague Senthil Kumar of Real Image suggested that my brother Jose should make his proposed 3D film - *Magic Magic* (2003), in Digital Cinema format. But, it would have taken at least one more year to see a DCP encoding process which Senthil was developing. Since Jose couldn't wait, my brother went ahead to shoot the film in 35mm cinematographic format with Arriflex cameras and Stereovision lenses. And his film *Magic Magic* (2003) was released with film prints during the summer of 2003. The procedure was exactly as we had followed over the previous 2 decades – making and exhibiting 3D films with the infrastructure we had developed for *My Dear Kuttichathan* (1994).



Senthil went ahead to develop the Qube Cinema Projection system – which changed not only theatrical exhibition - but eventually filmmaking itself, when RED Cameras replaced ARRI cameras to become the workhorse of the industry. Meanwhile, with the team at Kishkinta Amusement park, I on my part developed a Digital 3D System (2004) for shooting and exhibiting 3D snippets of 10 minutes durations at Kishkinta.



We used to say that if my brother Jose had waited, he could have become **the first digital 3D feature filmmaker** ... a honor that went to James Cameron when he made *Avatar* (2010). Now, before I come to what we fell short in achieving our ambitions in 2004 (which, with this article, I intent to accomplish now) I should mention for Digital 3D Imaging why I opted for the 'beam splitter'.

Beamsplitter is as old as the earliest 18th century optical device for measuring the speed of light. And this principle was used in making the first 3D films of the 1950s. The very same beamsplitter has today (in 2018) yet again become the film industry standard for shooting state-of-the-art live 3D productions.

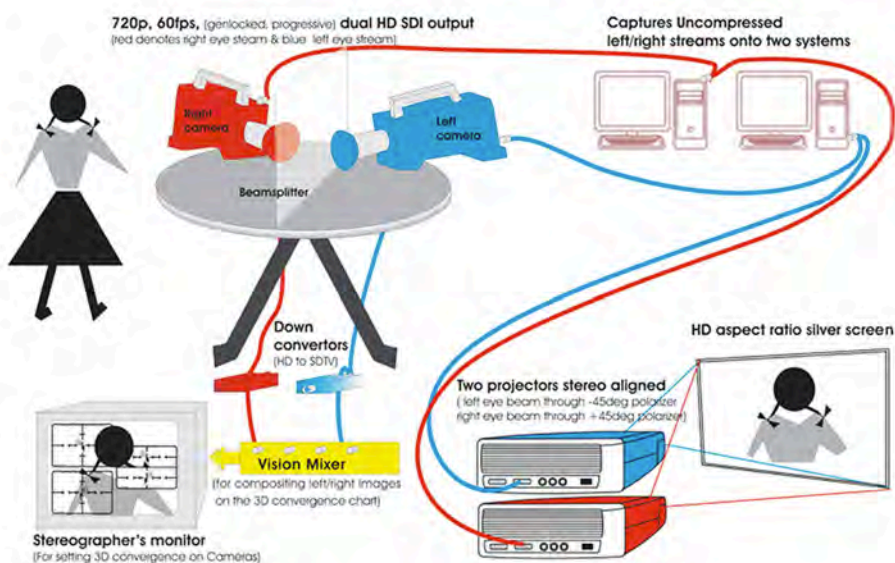
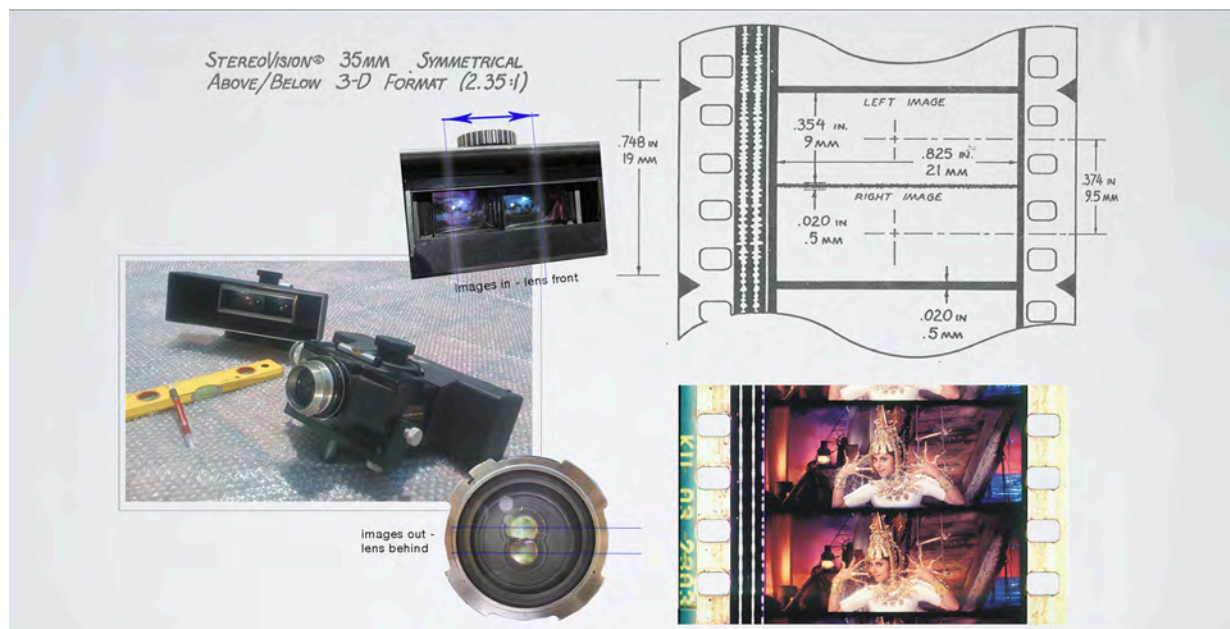


illustration by Narayana Moorthy.
Kishkinta. 2004.

In 2004, Senthil and his Joint Director at ReallImage - Jayendra, were keen on putting Chris Condon's lenses on a digital camera so as to follow the Stereovision architecture – locked left eye/right eye frames, all the way from camera shoot to theatre exhibition.

A Stereovision 3D lens has dual optics within (as in a pair of human eyes - 2.5 inches apart). With prisms, the two images (one for the right eye, one for the left) are stacked one above the other, and cast onto the 35mm film gate.



I had two problems there.

ONE - In year 2004, the number of pixels even on the best of digital sensors bestowed much less image resolution than that of a 16mm film frame!

TWO - Even by year 2008, the sensor of the digital cinema camera was small that it would not cover the image circle of 35mm Stereovision lenses. (In fact, Jainul - our self-taught 3D wizkid and Balaji - our Digital Cinema guru, tested our patience by trying to adapt the

Stereovision PL lens mount to lock with the digital camera ... only to realize that the RED digital camera sensor, as claimed, was not as big as the 35mm film size 24.89 X 18.67. No wonder, the pair of stereo images got cropped – asymmetrically!

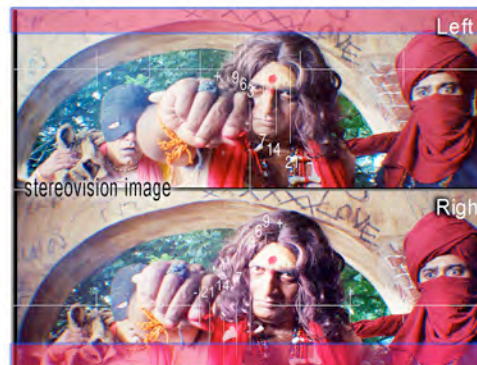
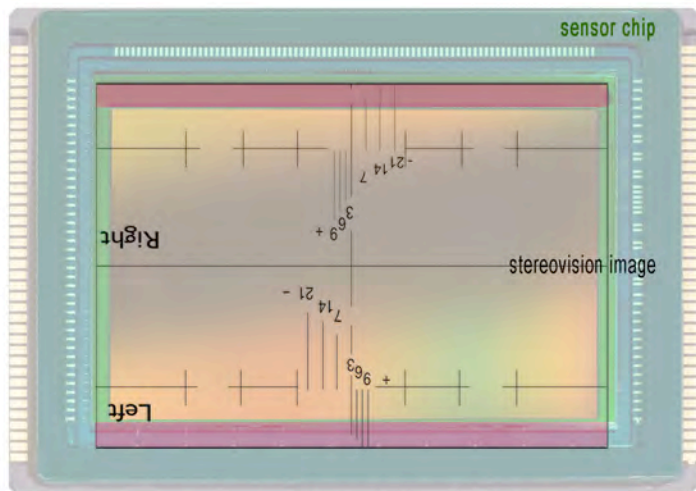
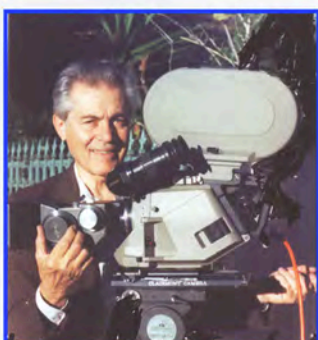


Image areas are lost at the bottom of the right-eye image and at the top of the left-eye image... asymmetrically.

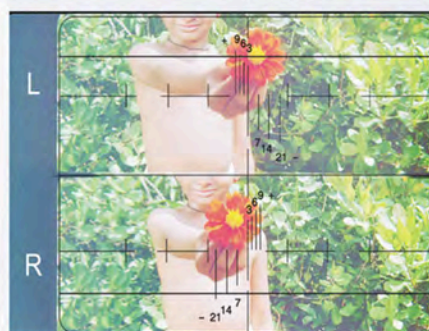
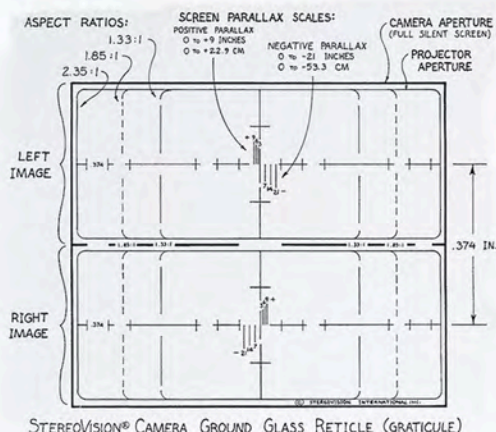
Yet, seeing a bright future in taking Chris's ingenious 3D imaging technique right into the emerging digital era, I asked Chris Condon whether he could change the design for a smaller image plane? ... re-center the top/bottom images for the sensor area?



CHRIS J CONDON
(1923 - 2010)
Optical Engineer
Designer/Founder
of
Century Precision Optics
Co. - North Hollywood, CA
Author
American Cinematography
Manual, 1963
A New Large Format 70mm
10P65 Camera Design,
SMPTE, 1988



John Rupkalvis
stereo reticle
for 35mm over/ under
symmetric imaging



In answer, the once celebrated optical engineer of Hollywood came out with a tirade against everything video and digital. He still swore by film chemistry. Alas I realized, yet again, that yesterday's harbinger has become today's retarder! I was half expecting this. For, during the past few years when we had done S3D Imaging with computer graphics (3DMax, Maya and Autodesk Inferno softwares), Chris was almost dismissive about the efforts.

When we developed a computer reticule to measure Z-axis – i.e; a template to enumerate spatial separation between objects in a given stereo image pair, John Rupkalvis – who had designed the 3D camera viewfinder reticule, was enthusiastic. But John was vary of Chris Condon, his mentor.

My solution was to use two digital cameras on a beamsplitter rig. The same method used during 3D's advent in 1950s. One sensor for each eye would provide double the resolution.

Dual stream Digital 3D Imaging (2004)

3D Rig - MRT Prototype Ark of the Covenant

Design by RealFun & Fabrication by SICCO Engineering, Chennai.



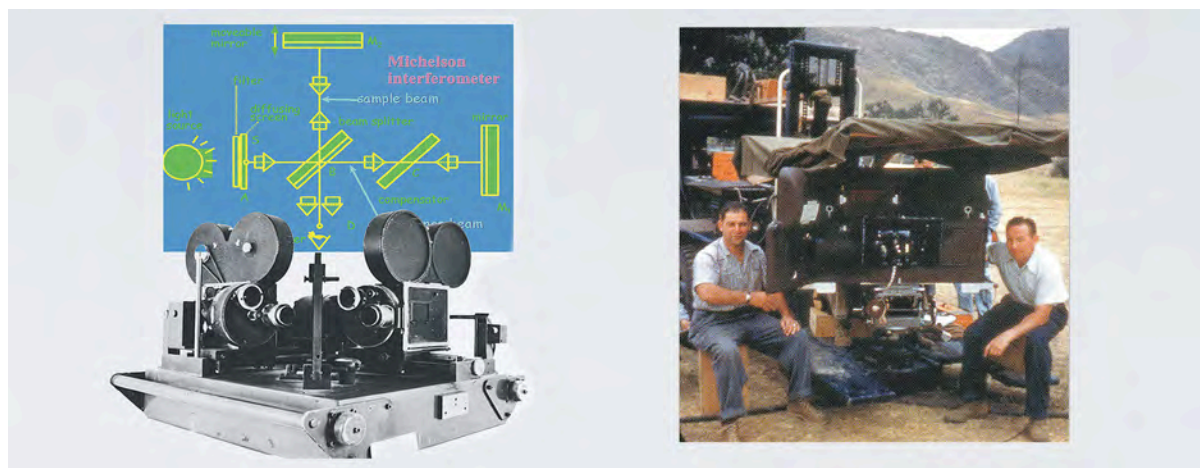
The implications?

Let me list the pros and cons.

In the 1950s, the main problems they had encountered for such a 'paired-image capturing' were as below.

1. The dual-camera bulk.

But today, void of mechanical components, digital cameras are way smaller than film cameras.



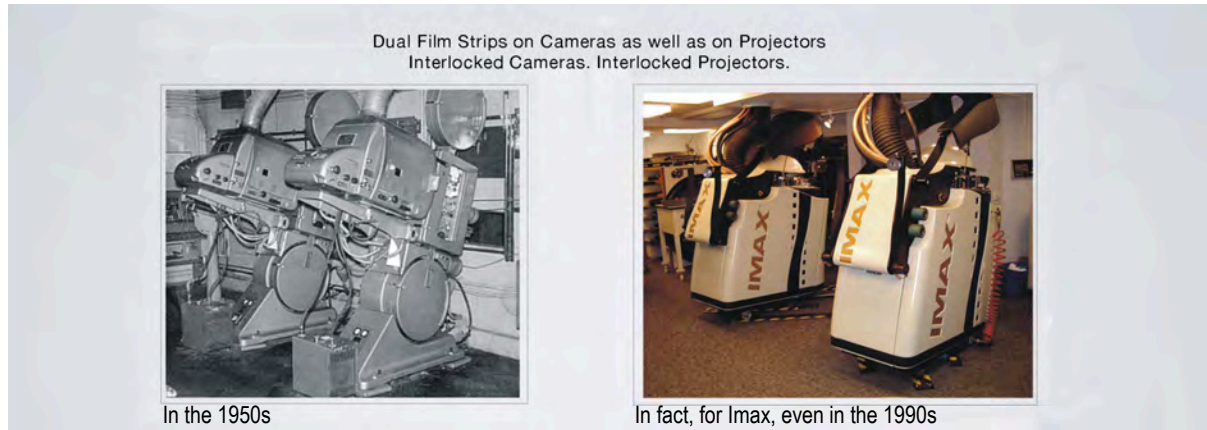
2. The reflected (right eye) image had to be optically flopped in a film lab printer.

But with computers today, an image flop can be done live!

And today, if you mount the beamsplitter glass plate vertical with the right eye camera on top and inverted, then your image has corrected itself. What more? ... even the rig assembly's footprint becomes smaller!

3. Keeping the two film strips from slipping and thereby preventing the image pair from getting mis-aligned was a matter of grave concern.

None of this is of problem today. For, throughout the entire process chain, digital images are tagged and handled by the computer.



Whereas, the projection of Stereovision single-strip 3D film is done by converging the top/bottom - lefteye/righteye images onto the silver screen with a split/ prism lens in front of the projector.



Yet, there are surely two advantages in using a paired-lens Stereovision architecture.

- (1) Theoretically speaking, Stereovision lenses can go onto *any camera* – film, digital or video.
- (2) By using Stereovision lenses, no bulky rig or special dual-camera support systems such as crane, jib, camera car, etc. need be resorted to.

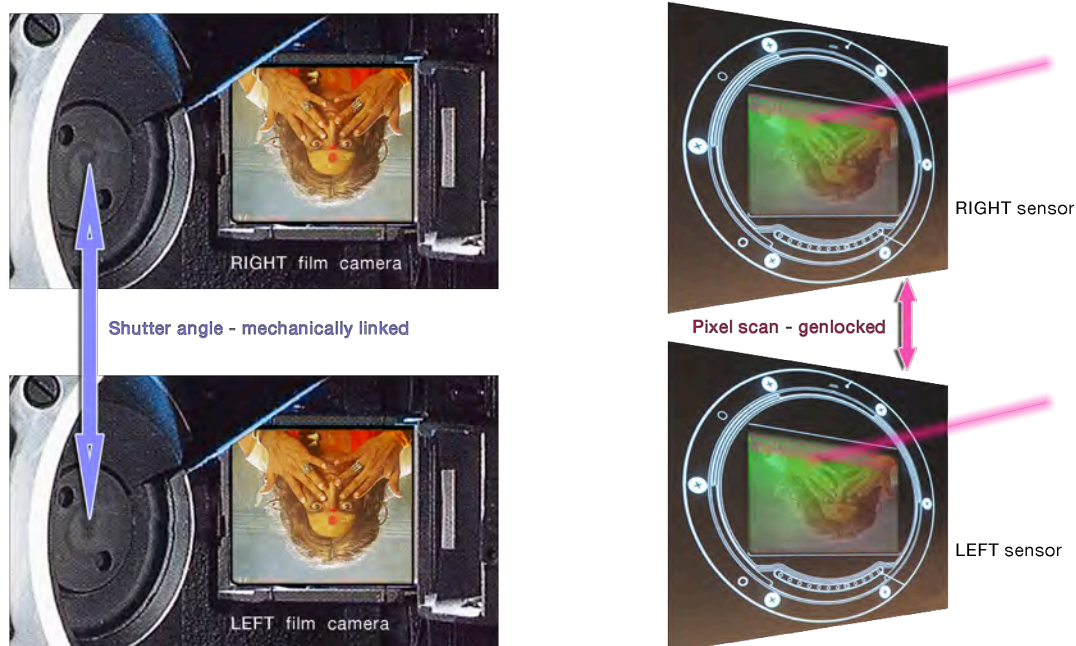
Hence Senthil and Balaji pitched for Stereovision architecture. While Jayendra, Jainul and myself opted for the two advantages (mentioned below) in using dual-camera.

And, the majority won.

- (1) The image quality for digital was undergoing quantum leaps. That meant, the quality of lenses and the number of lens brands were proliferating. With Chris having stopped hand-grinding lenses at his Burbank shop, the quality of Stereovision lenses was of no match to the brilliance of Zeiss, Cooke or Arri lenses. So, such professional lenses - used in pairs - would offer much better quality images than the Stereovision dual lens.

(2) A 3D rig is cumbersome, agreed. But on a 3D rig, the introcular distance between the eyes can be varied. It is a great boon for stereography - especially when CG and green-screen matting are considered. And today, with camera and lens metadata, all variables can be tracked and controlled.

Only one additional rule has to be included (along with traditional 3D cinematography principles) when pairing digital cameras for 3D imaging. The paired cameras have to be gen-locked. They should be slaved to a single source - preferably a master external clock. Also, if the screening happens to be with dual servers and dual projectors, it is to be ascertained that the left/right image pairs are always in absolute synch. For that, the digital servers should share the same clock and the digital projectors should be gen-locked. (This practice of additional image stability goes back to the pin-registration on film cameras and sometimes even pin-registering the film projectors!)



Now, even if the dual cameras (and projectors) are matched 100% identical, they are bound to have unmatched menu settings. It is also probable that the software/ firmware of the cameras would be running different versions of their OS and hence could be in variance to one another. It has to be ascertained that all OS and apps. in the dual systems are identical. Settings (shutter, LUT, etc.) should be reverted to default mode and then programmed afresh - identically. Any external devices (like a blackburst generator) if connected, it has to have dual outputs running into both cameras. If not, then two identical devices of identical settings are to be used.

One other suggestion I had made was to use high frame rate – for photography as well as for projection. Historically speaking, for cinema, when it was first devised at the beginning of the 20th century, the image capturing rate of 24 frames-per-second happened to fall short for human persistence of vision. An image flicker is just about getting avoided at 24fps. Hence, I suggested 60 frames per second. Because, 60fps is where 24fps, 25fps and 30fps non-drop would agree with each other. (Not that it matters much these days). But the important point was, Intamin and Showscan – firms who provided special venue presentations at amusement centers and fairgrounds – shot and projected their 65mm 2D films at 60 frames per second ... providing distinct and sharp images. Utilizing high frame rate and high resolution for 3D would give extraordinary results.

In 2004 we did shoot at 60 fps with Panasonic Varicam. Ideally, still higher frame rates have to be available (as in Phantom cameras) so that slow-motion cinematography is possible.

Digital 3D Cinema Projection (2004)

Two projectors stereo aligned
(left eye beam through -45deg polarizer
right eye beam through +45deg polarizer)

Encoded MPEG2 @ 45Mbps per eye videostream.
DLP Projectors SLMR6 BARCO stereo-aligned.

Projection Lenses TLP 1.6

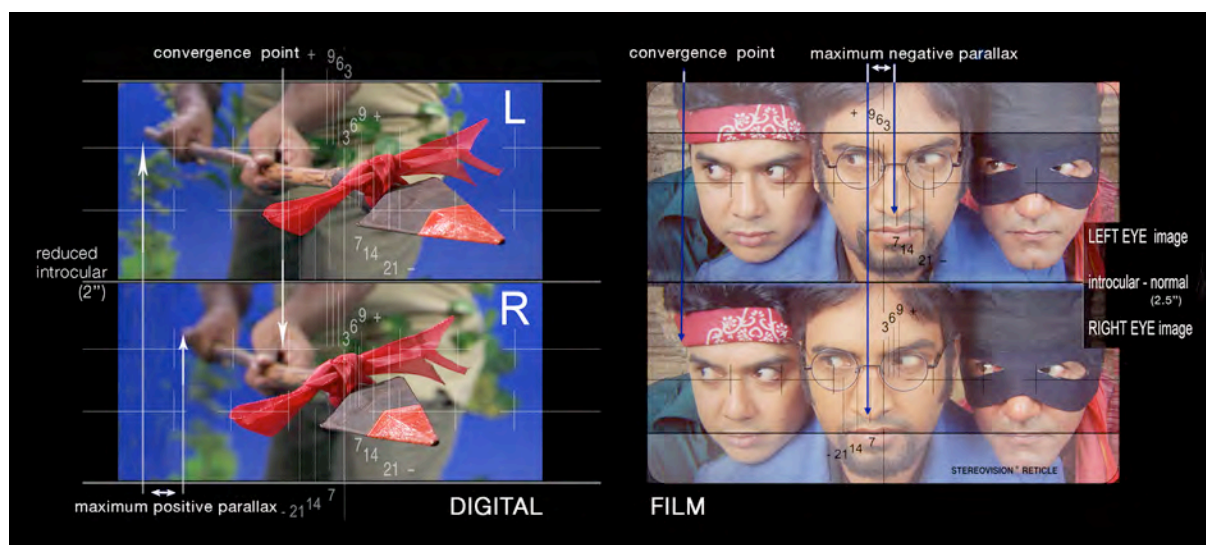
Twin Qubes Synch locked

Digital Video Output:	DVI standard
UI Monitor Output:	HDSI Interface optional
Audio Output:	15-pin D-sub VGA connector (monitor optional)
	25-pin D-sub Connector Analog Audio Output
	S/PDIF Digital Audio Output
Video Compression:	MPEG-2 4:2:0 & 4:2:2
	Windows Media 9 4.2.0
Video Resolution:	Variable from SD PAL/NTSC to HD 1080P
	2048x1080 resolution supported over DVI
Frame Rates:	23.97, 24, 25, 29.97, 30, 50, 59.94 & 60 fps

Senthil, citing the low refreshment rate of the optical chip, was not keen on high frame rates. But come NAB 2014, he did agree that the filmmaking trend was changing to high frame rate image capture. Reallmage themselves have started promoting it.

On my suggestion of how to achieve large image capture with beamsplitters, Balaji suggested the same technique to make HDR (high dynamic range imaging done in still photography) also be made possible in cinematography. He was badgering Jayendra to do the film *180* (2011) in HDR. I suppose unavailability of beamsplitter rigs deterred the attempt.

Given below is a Digital Vs. Film interocular comparison.



On the topic of our past attempts on 3D and Large Format Imaging, one more point I should be mentioning here. Alan Bartly - the tech wizard of Kodambakkom cinema, did attempt to modify one of our Stereovision lenses to shoot Digital. And it was he who said that its optical quality won't suit the stark reality of Digital.

In 2010, Alan tried to array digital sensors for making the concept of LIBSSM work. But those days we never had many such spare sensors around. Hence we gave up. Today, after searching the web for sensor chip arraying, I am surprised that till now no one has considered this idea. The display technology is now at the threshold of huge flat projection screens. And that is where large image fields would be necessary.

Meanwhile, ...

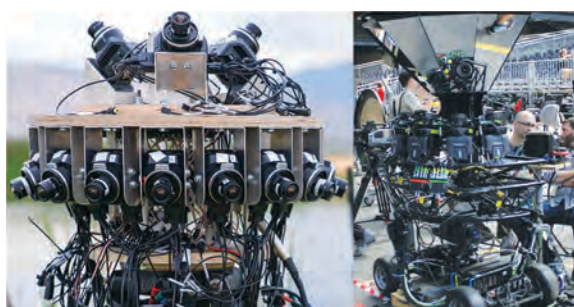
Present day standard
3D Rig



Dual 3D Lenses (4K + 4K)
for 8K Sony Digital Projector



... and the proliferation of
all kinds of Rigs



And also,

NEWS "To fend off Netflix, movie theaters try 3-screen immersion"



In this photo taken on Thursday, Aug. 9, 2018, a trailer shows a car speeding through traffic as part of a demonstration for ScreenX at Cineworld in London. Sit at the back of the movie

theater, and it's possible to see the appeal of ScreenX, the latest attempt to drag film lovers off the sofa and away from Netflix. Instead of one screen, there are three, creating a 270-degree view meant to add to the immersive experience you can't get from the home TV. (AP Photo/Robert Stevens)

Hence all the more, the case for **Large Imaging with BeamSplitter Sensor Matrices**.

CONCLUDED.

Reference

Manual of Stereoscopic Cinematography
by John A Rupkalvis and Christopher J Condon
Stereovision, Burbank. 1985.

Foundations of the Stereoscopic Cinema: A Study in Depth
by Lenny Lipton
Van Nostrand Reinhold, 1982 ISBN 0442247249, 9780442247249