A

Seminar report

On

Digital Cinema

Submitted in partial fulfillment of the requirement for the award of degree
of Bachelor of Technology in Computer Science

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Preface

I have made this report file on the topic **Digital Cinema** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ……..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Contents

What is a Digital Cinema?

To understand the concept of digital cinemas, we need to understand about the film based cinematography – In a large number of cases (even today), the pictures are shot using analog film based cameras, then converted in to digital format for editing, mixing, re-recording and adding special effects and converted back to analog films for projecting them through the analog film based projectors.

Digital Cinemas use digital processes end to end – right from the capture (digital movies are shot using digital CCD based cameras with high resolution), storage (they are stored in digital tapes, hard disks or flash drives), processing (editing, mixing, re-recording, sound, special effects etc are handled in the digital format), display (digital cinema is displayed using digital projectors which are controlled by industry standard servers with management software in the theatres) and distribution (digital cinema copies are mostly transmitted electronically over the Internet or satellites or even hard disks).

History

Digital media playback of hi-resolution 2K files has at least a 20-year history with early video data storage units (RAIDs) feeding custom frame buffer systems with large memories. Content was usually restricted to several minutes of material. Transfer of content between remote locations was slow and had limited capacity. It wasn't until the late 1990s that feature-length projects could be sent over the 'wire' (Internet or dedicated fiber links).

On October 23, 1998, digital light processing (DLP) projector technology was publicly demonstrated for the first time with the release of *The Last Broadcast*, the first feature-length movie, shot, edited and distributed digitally. In conjunction with Texas Instruments, the movie was publicly demonstrated in five theaters across the United States (Philadelphia, PA, Portland Oregon, Minneapolis Minnesota, Providence Rhode Island and Orlando Florida).

On June 18, 1999, Texas Instrument's *DLP Cinema* projector technology was publicly demonstrated for the second time on four screens in North America (Los Angeles and New York) for the release of Lucasfilm's *Star Wars: Episode I: The Phantom Menace*. Theaters with digital projectors were projecting footage right from Pixar Animation's computers. On January 19, 2000, the Society of Motion Picture and Television Engineers, in North America, initiated the first standards group dedicated towards developing Digital Cinema. On February 2, 2000, Philippe Binant (Gaumont) realized the first digital cinema projection in Europe (Paris) with DLP Cinema technology for the release of *Toy Story II*.

By December 2000, there were 15 digital cinema screens in North America, 11 in Western Europe, 4 in Asia, and 1 in South America.[10] Digital Cinema Initiatives (DCI) was formed in March 2002 as a joint project of many motion picture studios (Disney, Fox, MGM, Paramount, Sony Pictures Entertainment, Universal and Warner Bros. Studios) to develop a system specification for digital cinema.

In April 2004, in cooperation with the American Society of Cinematographers, DCI created standard evaluation material (the ASC/DCI StEM material) for testing of 2K and 4K playback and compression technologies. DCI selected JPEG2000 as the basis for the compression in the system the same year.

In China, an E-Cinema System called "dMs" was established on June 2005, and is used in over 15,000 screens spread across China's 30 provinces. dMS estimates that the system will expand to 40,000 screens in 2009.

2005 the UK Film Council Digital Screen Network launched in the UK by Arts Alliance Media creating a chain of 250 2K digital cinema systems. The roll out was completed in 2006. (Equipment used - Christie CP2000S, NEC NC800C, initially QuVIS Cinema Players which were replaced by Doremi DCP2000's mid way through the roll out in mid 2006). This was the first mass roll out in Europe. All systems were upgrade to the new DCI standard in 2006 using at first the QuVIS Cinema players, and then the Doremi DCP2000 servers which replaced all QuVIS units. Axis IT/Christie Digital also started a roll out in North America.

By mid 2006, about 400 theaters were equipped with 2K digital projectors with the number increasing every month. Several digital 3D films surfaced in 2006 and several prominent filmmakers committed to making their next productions in stereo 3D. VUE West End was one of the first 3D Digital Cinemas along with Odeon Printworks Manchester and VUE Cheshire Oaks with the RealD Inc. equipment installed. All sites supported at the time by Arts Alliance Media. In August 2006, the Malayalam digital movie *Moonnamathoral*, produced by Mrs. Benzy Martin, was distributed via satellite to cinemas, thus becoming the first Indian digital cinema. This was done by Emil and Eric Digital Films, a company based at Thrissur using the end-to-end digital cinema system developed by Singapore-based DG2L Technologies.

In 2007 the UK became home to Europe's first DCI-compliant fully digital multiplex cinemas, Odeon Hatfield and Odeon Surrey Quays (London) with a total of 18 digital screens were launched on Friday 9 February 2007. By March 2007, with the release of Disney's *Meet the Robinsons*, about 600 screens had been equipped with 2K digital projectors that feature Real D Cinema's stereoscopic 3D technology, marketed under the Disney Digital 3-D brand. In June 2007, Arts Alliance Media announced the first European commercial digital cinema Virtual Print Fee (VPF) agreements (with Twentieth Century Fox and Universal Pictures).

As of July 2007, there were some cinemas in Singapore showing digital 4K films to public using Sony 4K digital projectors. They are located at Golden Village Cinema in Vivocity (Hall 11), Eng Wah Cinema in Suntec (Hall 3), Shaw Cinema in Bugis (Hall 1 & 3) and at Cathay Cineplex (Hall 7). In September 2007, Muvico Theaters Rosemont 18 in Rosemont, Illinois became the first theater in North America to have Sony's 4K digital projectors for all 18 screens. In January 2007, "Guru" became the first Indian movie mastered in the DCI compliant Jpeg2000 Interop format and also the first Indian film to be previewed digitally, internationally, at the Elgin Winter Garden in Toronto. "Guru" was digitally mastered at Real Image Media Technologies, India.

In March 2009 AMC Theatres announced that it closed on a $315 million deal with Sony to replace all of its movie projectors with 4K digital projectors starting in the second quarter of 2009 and completing in 2012.

By June 2010, there were close to 16,000 digital cinema screens, with over 5000 of them being stereoscopic setups. Considering an article written by David Hancock, the total number of d-screens worldwide came in at 36,242, up from 16,339 at end 2009 or a growth rate of 121.8 percent during the year. There were 10,083 d-screens in Europe as a whole (28.2 percent of global figure), 16,522 in North America (46.2 percent of global figure) and 7,703 in Asia (21.6 percent of global figure). As regards digital 3D screens, there were a total of 21,936 3D screens, which equals 60.5 percent of all d-screens. This was a rise from the 55 percent in 2009 but is expected to drop slightly in 2011 to 57.5 percent.

By the end of 2012, according to *Screen Digest*, 91.4% of UK screens had been converted to digital and the rest expected to be so by the middle of 2013. Worldwide progress was slower as in some territories, particularly Latin America and Africa, progress was much slower. However almost all screens worldwide were expected to be converted by the end of 2015.

As of 31 March 2015, 38,719 screens (out of a total of 39,789 screens) in the United States have been converted to digital (15,643 of which are 3D capable), 3,007 screens in Canada have been converted (1,382 of which are 3D), and 93,147 screens internationally have been converted (59,350 of which are 3D).

How Digital Cinema Works

In addition to the equipment already found in a film-based movie theatre a DCI-compliant digital cinema screen requires a digital projector and a computer known as a "server".

Movies are supplied to the theatre as a digital file called a Digital Cinema Package (DCP). For a typical feature film this file will be anywhere between 90 and 300GB of data (roughly two to six times the information of a Blu-ray disc) and may arrive as a physical delivery on a conventional computer hard-drive or via satellite or fibre-optic broadband. Currently (Dec 2013) physical deliveries are most common and have become the industry standard. Trailers arrive on a separate hard-drive and range between 200 and 400MB in size.

Regardless of how the DCP arrives it first needs to be copied onto the internal hard-drives of the server, usually via a USB port, a process known as "ingesting". DCPs can be, and in the case of feature films almost always are, encrypted. The necessary decryption keys are supplied separately, usually as email attachments and then "ingested" via USB. Keys are time limited and will expire after the end of the period for which the title has been booked. They are also locked to the hardware (server and projector) that is to screen the film, so if the theatre wishes to move the title to another screen or extend the run a new key must be obtained from the distributor.

The playback of the content is controlled by the server using a "playlist". As the name implies this is a list of all the content that is to be played as part of the performance, the playlist will be created by a member of the theatre's staff using proprietary software that runs on the server. In addition to listing the content to be played the playlist also includes automation cues that allow the playlist to control the projector, the sound system, auditorium lighting, tab curtains and screen masking (if present) etc. The playlist can be started manually, by clicking the "play" button on the server's monitor screen, or automatically at pre-set times.

Technology and Standards

Digital Cinema Initiatives

Digital Cinema Initiatives (DCI), a joint venture of the six major studios, published the first version (V1.0) of a system specification for digital cinema in July 2005. The main declared objectives of the specification was to define a digital cinema system that would *"present a theatrical experience that is better than what one could achieve now with a traditional 35mm Answer Print"*, to provide global standards for interoperability such that any DCI-compliant content could play on any DCI-compliant hardware anywhere in the world and to provide robust protection for the intellectual property of the content providers.

Briefly, the specification calls for picture encoding using the ISO/IEC 15444-1 "JPEG2000" (.j2c) standard and use of the CIE XYZ color space at 12 bits per component encoded with a 2.6 gamma applied at projection. Two levels of resolution for both content and projectors are supported: 2K (2048×1080) or 2.2 MP at 24 or 48 frames per second, and 4K (4096×2160) or 8.85 MP at 24 frames per second. The specification ensures that 2K content can play on 4K projectors and vice-versa. Smaller resolutions in one direction are also supported (the image gets automatically centered). Later versions of the standard added also additional playback rates (like 25 fps in SMPTE mode).

For the sound component of the content the specification provides for up to 16 channels of uncompressed audio using the "Broadcast Wave" (.wav) format at 24 bits and 48 kHz or 96 kHz sampling.

Playback is controlled by an XML-format Composition Playlist, into an MXF-compliant file at a maximum data rate of 250 Mbit/s. Details about encryption, key management, and logging are all discussed in the specification as are the minimum specifications for the projectors employed including the color gamut, the contrast ratio and the brightness of the image. While much of the specification codifies work that had already been ongoing in the Society of Motion Picture and Television Engineers (SMPTE), the specification is important in establishing a content owner framework for the distribution and security of first-release motion picture content.

In addition to DCI's work, the National Association of Theatre Owners (NATO) released its Digital Cinema System Requirements. The document addresses the requirements of digital cinema systems from the operational needs of the exhibitor, focusing on areas not addressed by DCI, including access for the visually impaired and hearing impaired, workflow inside the cinema, and equipment interoperability. In particular, NATO's document details requirements for the Theatre Management System (TMS), the governing software for digital cinema systems within a theatre complex, and provides direction for the development of security key management systems. As with DCI's document, NATO's document is also important to the SMPTE standards effort.

E-Cinema

The Society of Motion Picture and Television Engineers (SMPTE) began work on standards for digital cinema in 2000. It was clear by that point in time that HDTV did not provide a sufficient technological basis for the foundation of digital cinema playback. In Europe, India and Japan however, there is still a significant presence of HDTV for theatrical presentations. Agreements within the ISO standards body have led to these non-compliant systems being referred to as Electronic Cinema Systems (**E-Cinema**).

Digital cinema projectors

Only four manufacturers make DCI-approved digital cinema projectors; these are Sony, Barco, Christie and NEC. Except for Sony, who use their own SXRD technology, all use the Digital Light Processing technology developed by Texas Instruments (TI). Although D-Cinema projectors are similar in principle to digital projectors used in industry, education, and domestic 'home cinemas' they differ in two important respects: first, they must conform to the strict performance requirements of the DCI specification, second, they must incorporate anti-piracy devices intended to protect the content copyright. For these reasons all projectors intended to be sold to theaters for screening current release movies *must* be approved by the DCI before being put on sale. They now pass through a process called CTP (Compliance Test Plan). Because feature films in digital form are encrypted and the decryption keys (KDMs) are locked to the serial number of the server used (linking to both the projector serial number and server is planned in the future), a system will allow playback of a protected feature only with the required KDM.

DLP cinema projectors

Three manufacturers have licensed the DLP cinema technology developed by Texas Instruments (TI): Christie Digital Systems, Barco, and NEC. While NEC is a relative newcomer to Digital Cinema, Christie is the main player in the U.S. and Barco takes the lead in Europe and Asia. DCI-compliant DLP projectors were available in 2K only, but from early 2012, when TI's 4K DLP chip went into full production, DLP projectors have been available in both 2K and 4K versions. Manufacturers of DLP-based cinema projectors can now also offer 4K upgrades to some of the more recent 2K models. Early DLP Cinema projectors, which were deployed primarily in the U.S., used limited 1280×1024 resolution or the equivalent of 1.3 MP (megapixels). Digital Projection Incorporated (DPI) designed and sold a few DLP Cinema units (is8-2K) when TI's 2K technology debuted but then abandoned the D-Cinema market while continuing to offer DLP-based projectors for non-cinema purposes. Although based on the same 2K TI "light engine" as those of the major players they are so rare as to be virtually unknown in the industry. They are still widely used for pre-show advertising but not usually for feature presentations.

TI's technology is based on the use of Digital Micromirror Devices (DMDs). These devices are manufactured from silicon using similar technology to that of computer memory chips. The surface of these devices is covered by a very large number of microscopic mirrors, one for each pixel, so a 2K device has about 2.2 million mirrors and a 4K device about 8.8 million. Each

mirror vibrates several thousand times a second between two positions, in one light from the projector's lamp is reflected towards the screen, in the other away from it. The proportion of the time the mirror is in each position varies according to the required brightness of each pixel.

Three DMD devices are used, one for each of the primary colors. Light from the lamp, usually a Xenon similar to those used in film projectors with a power between 1 kW and 7 kW, is split by colored filters into red, green and blue beams which are directed at the appropriate DMD. The 'forward' reflected beam from the three DMMDs is then re-combined and focused by the lens onto the cinema screen.

Sony SXRD projectors

Alone amongst the manufacturers of DCI-compliant cinema projectors Sony decided to develop its own technology rather than use TI's DLP technology. SXRD projectors have only ever been manufactured in 4K form and, until the launch of the 4K DLP chip by TI, Sony SXRD projectors were the only 4K DCI-compatible projectors on the market. Unlike DLP projectors, however, SXRD projectors do not present the left and right eye images of stereoscopic movies sequentially but use half the available area on the SXRD chip for each eye image. Thus during stereoscopic presentations the SXRD projector functions as a sub 2K projector, the same for HFR 3D Content.

Stereo 3D images

In late 2005, interest in digital 3-D stereoscopic projection led to a new willingness on the part of theaters to co-operate in installing 2K stereo installations to show Disney's *Chicken Little* in 3-D film. Six more digital 3-D movies were released in 2006 and 2007 (including *Beowulf*, *Monster House* and *Meet the Robinsons*). The technology combines a single digital projector fitted with either a polarizing filter (for use with polarized glasses and silver screens), a filter wheel or an emitter for LCD glasses. *RealD* uses a "*ZScreen*" for polarisation and MasterImage uses a filter wheel that changes the polarity of projector's light output several times per second to alternate quickly the left-and-right-eye views. Another system that uses a filter wheel is Dolby 3D. The wheel changes the wavelengths of the colours being displayed, and tinted glasses filter these changes so the incorrect wavelength cannot enter the wrong eye. *XpanD* makes use of an external emitter that sends a signal to the 3D glasses to block out the wrong image from the wrong eye.

Components of Digital Cinema

This article gives a small introduction to some of the individual components that make a Digital Cinema – The Digital Camera, Processing Tools, Content Distribution, Server/Theatre Management and Digital Projectors. As the name suggests, Digital Cinema aims to make all the processes completely digital using the above individual components.

In this near to digital world ruled by the 1's and 0's, the cinema industry has long been ruled by the Analog Film based acquisition, distribution and projection techniques. The purists have been, and still favour films to make and show their cinemas. But all that is changing fast with the introduction of Digital Cinema.

Digital Cinema is not only about digital acquisition, digital mastering, digital distribution and digital projection. Though, that's what we will talk about in this article, Digital Cinema is more about a paradigm shift in the way in which cinema is conceived, shot, processed and shown. The concept that what ever happens in front of the camera being recorded and shown as a cinema is changing. The recorded material becomes just a small portion of what is actually shown in the screen – for example, the background setting/colour can be completely changed or even created in the PC and characters can be introduced in this new setting. Animation and special effects create an alternate reality that may not exist, but still catch the fantasies of the movie audience. Digital cinema can bring even extinct creatures before the screen and give us a perception of them being real.

The digital processing has also been happening with analog films – the video shot by the analog cameras with the films were converted in to digital data for editing, mixing, adding special effects/animations etc and then converted back to analog films for displaying them in the theatres. But now, the entire process is slowly being converted digital end to end. Let us look at the major components that make a Digital Cinema:

Digital Cameras:

Digital cameras can shoot with a resolution of 2k, 3k, 4k and some even higher! Depending on the resolution, the frame rates vary from 20 to 120 fps. Of course, the higher the resolution, lower the possible frame rates. The depth of field is usually equivalent to 35 mm cine lenses. These cameras generally contain more than 10 Mega Pixels and 4k resolution means 4520 x 2540 pixels.

There is also a video preview to enable directors to see the video shot immediately and decide if a change is required in the lighting conditions or a re-shoot is required. There is also an option for direct audio recording with attached external microphones. Digital media connectivity for direct recording is provided with the cameras via USB, HDD, Compact Flash Module, Solid State RAM etc.

The video data is sometimes compressed before transferring it to the attached external media as the storage required is as high as 20GB/min for higher resolutions. RAW data can also be recorded, if required. One striking advantage of certain digital cameras is the ability to upgrade

them indefinitely by replacing the electronics/sensor units, without having to change the peripherals/accessories.

Digital Processing:

Of course, this is the heart of the digital cinema. Once the digital data is shot with the digital cameras, it is much easier to do editing, picture enhancement, colour correction, composting, visual effects, multi-format delivery etc, using digital processes. You can also mix and match formats, frame rates and resolutions much easier with digital cinemas.

Animation and special effects, no need to say, have become the mainstay of many super hit digital cinemas. Interestingly, even the digital re-mastering of classic movies shot with analog films are done using digital processes.

Digital Distribution:

Once the cinema is processed and edited, it is ready to be distributed to the various movie halls. But now, instead of the individual heavy tapes being shipped across the world, the digital data is sent electronically over the Internet, leased lines, satellites and even inexpensive hard-disks and DVD's. This saves time, money and effort. The data is encrypted while sending them across public networks like Internet.

Digital Cinema Servers:

The encrypted data is received and decrypted by the digital cinema servers which are located at the individual cinema halls. It then re-encrypts it and outputs the image data to the digital cinema projector and audio data to the sound processor. The theatre projectors of today support 128 bit AES encryption/decryption for media.

The digital cinema servers generally support the most common JPEG 2000 media playback format for compatibility as required by the DCI multi-vendor Compliance and may optionally support additional formats like MPEG-2 etc. The media block in the server which does the bulk of the work is reprogrammable to accommodate for future developments in image and sound formats. Generally, the industry standard audio/video formats are supported for the output.

The hard disks are generally in the form of an array and they support RAID to ensure redundancy of stored data. All the hard-disks, power supplies, cooling fans etc. are hot swappable. Some of them have a direct fiber termination option for connecting to the network.

The digital cinema projectors can be monitored and upgraded over the network. Some of them even provide a sort of an external remote to control basic functions like Play, Pause, Stop etc. There is an optional theatre management software to enable easy set-up, scheduling and management of multi-screen shows (usually in a multiplex with multiple screens) over the central network so that subsequent manual intervention may not be required.

Digital Cinema Projectors:

These projectors directly accept and play digital format images in high quality. Majority of the digital cinema projectors use DLP – Digital Light Processing technology to project images while some of them might use LCD or some kind of modified LCD crystals for projection. Some projectors come with media block as well which can store/decrypt the digital data.

Common projectors support 2k, 4k resolutions and have a brightness level in excess of 15,000 Lumens. They employ 1.5-7.5W Xenon Lamps (some times two lamps together) as a source of illumination (LED lamps are also getting popular) and the contrast ratio is around 2000:1 which is sufficient to show the minute variations of shades for colours.

The digital cinema projectors support input/output formats according to the DCI standards so that interoperability is not a issue. There are optional lenses to change the throw distances (as they are normally fixed for a particular distance) to adjust according to the theatre conditions. There are even 3D Lens adaptors which enable playing of 3D digital content, whose effect can be felt along with 3D polarizing glasses.

These projectors implement normal projector functions like keystone correction (to make the image appear like a perfect rectangle), electronic focus and zoom (with memory, so that the picture size doesn't change on the screen when the display format is changed). Some projectors also help maintain the luminance levels automatically.

The digital cinema projectors must confirm to the SPB-2 and other anti-tampering requirements of the DCI – Digital Cinema Intitiatives which might want the projectors to require physical keys to open the body (instead of screws), automatically start recording logs when the projectors are opened and a host of other security measures.

Advantages of Digital Cinemas

¤ The films used in analog cinemas (based on vinyl records) degrade with time, but digital images do not. And even if a DVD is scratched, it could easily be backed up in a hard disk or another DVD, for example.

¤ Digital cinemas can be shown and managed in the theatres by unskilled labour (with minimal training) as the management terminal is PC-based and simple to handle, unlike analog film based cinemas, which need dedicated personnel for receiving, prepping, showing, dismantling and returning the movie tape films.

¤ Distribution of digital cinema's (electronically via Internet, satellites or even hard disks) are simpler, fast and in-expensive than the time taken and cost incurred for the shipping and handling of heavy film tapes.

¤ Supply rarely matches the demand in the movie industry – suddenly a picture might become a huge hit and the demand for showing it in additional screens might arise. It is much easier and faster to distribute additional copies for digital cinemas in those situations.

¤ Addition/deletion of scenes after the movies have been released is easier/cheaper with Digital cinemas.

¤ Piracy could be more effectively monitored with robust copy protection, encryption and water marking processes for digital cinemas. The chances of introducing a new anti-piracy technology is higher in the digital format.

¤ The solid state projectors used with Digital Cinemas are smaller and occupy less space than their analog counterpart.

¤ The digital tapes/external hard disks used in digital cameras (camcorders) cost much lesser than analog film based cameras – the same scenes can be shot many more times till the director is satisfied without worrying about the cost of the film tapes.

¤ The scenes can be previewed immediately after they are shot with a digital camera – so the director can immediately judge if a change in lighting conditions are required or a re-shoot is required etc.

¤ A lot of tools are available for introducing special effects in digital cinema. In fact, the scenes could be created fully using special effects/animation in the computers.

¤ There are management software's available for digital cinemas which can automatically schedule the movies showing in various screens in a multiplex without manual intervention.

¤ There is a body formed by the major production studios called DCI – Digital Cinema Initiatives which is engaged in standardising the major specifications for digital cinemas to ensure interoperability between major vendors of digital cinema.

¤ Digital cameras are often highly configurable and use detachable modular components for flexibility and upgrade-ability. They can also record high resolution images up to 4096 x 2304 pixels.

¤ If a theatre can play digital cinemas, it can also broadcast events – live or hold meetings/conferences with minor changes in the theatre facilities.

¤ Digital 3D uses polarization instead of coloured glasses (used by older 3D cinemas) to portray the 3D effect. This ensures that the colour of the finished image is not corrupted.

¤ Digital cameras are considered to be better for indoor shooting/ shooting at nights with a very low light.

¤ Digital cinema is advantageous for low budget cinemas made with limited man-power as such movies have lower budgets and alternatives are available for cheaper capturing, editing, processing, recording and distribution of digital cinemas.

Disadvantages of Digital Cinema

¤ Even though the digital data may not get scratched/grained etc, the digital projector pixels would break/degrade over time.

¤ The quality of digital projection is comparable with analog film based projection. Some people feel that the quality of analog film based projection is better than digital projection and the image reproduction is more natural. But digital technology is improving everyday.

¤ Most of the theatres are equipped with film based projectors and to replace them entirely with digital projectors would involve a lot of cost and re-designing for the theatre owners.

¤ Digital data always has a higher risk of getting pirated than their analog counterparts.

¤ Digital technologies are prone to technological obsolescence. With newer technologies/improvements introduced so fast, the existing digital equipments might get outdated faster and some of them may not be upgradeable to newer technologies, introducing a higher risk on investing in them.

¤ Analog/film based cameras are even today considered better for outdoor/day-light shoots as digital cameras produce inconsistent images when exposed to high brightness environments.

¤ If the digital camera uses 4k resolution to capture digital images for good clarity, the cine projector displaying that image also needs to support 4k resolution to display the images at that clarity. But, there are a very few 4k projectors installed in theatres around the world.

¤ The digital standards of recording/playback keep changing and hence many digital cinemas are converted to analog films for storage and archival.

¤ Some Analog high-quality formats like IMAX etc, cannot be achieved by their digital equivalent cameras/ projectors.

¤ The chemical process of exposing film to light is well documented and understood by cinematographers. It also produces reliable images, based on film-stock. In contrast, each digital camera has a unique response to light and digital treatment processes are not mastered fully by cinematographers.

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