Marshall Plan Thesis

Digital versus Analog Film

under the supervision of

FH-Prof. Mag. Markus Wintersberger

completed by

Michael Muellner

in the course of a semester abroad at the

SAN DIEGO STATE UNIVERSITY

Declaration

I declare that the attached research paper is my own, original work undertaken in partial fulfilment of my degree. I have made no use of sources, materials or assistance other than those, which have been openly and fully acknowledged in the text. If any part of another person's work has been quoted, this either appears inverted commas or (if beyond a few lines) is indented.

Any direct quotation or source of ideas has been identified in the text by author, date, and page number(s) immediately after such an item, and full details are provided in a reference list at the end of the text.

I understand that any breach of the fair practice regulations may result in a mark of zero for this research paper and that it could also involve other repercussions. I understand also that too great a reliance on the work of others may lead to a low mark.

Table of Contents

1 Introduction

Only a few years ago all the major movies were shot on analog film. Analog was standard for the last century , the audience got used to the look of film and the production companies established workflows around it. In the last years a revolution on the camera market took place, as the major companies started to bring out digital motion picture cameras. Later the introduction of digital lens reflex cameras capable of shooting movies forced them to invest more time and money in that area. Now everybody could archive a film like look without spending thousands of dollars on analog film cameras and filmstock.

In the last 4 month Sony, Canon, Panasonic and Red introduced low price digital motion picture cameras with a 35mm image sensor – aiming at the growing low budget film market.

The big advantage of the new technology is the lower cost. Filming on analog filmstock is expensive and time consuming. It is to assume, that 24 pictures of analog filmstock cost about $2. That makes at least $10,800 for a full-length movie (if there are no outtakes at all!). But not only the filmstock has do be paid, developing, scanning, postproduction and copying are cost intensive too. Its obvious that shooting on 35mm film is not affordable for independent movie productions.

Ten years ago the image quality of the digital cameras was not comparable to that of 35mm film. A lot of movies are still shoot on film and specially the older directors prefer the medium because of its artistic qualities.

2 Technical differences

2.1 The Camera

2.1.1 The analog motion picture camera

The motion picture camera is a device which transports and exposes the film. The first motion picture cameras were created at the end of the 18th century. From this time on the movie cameras have constantly improved, although the principle mechanism is still the same.

Analog motion picture cameras are available from various manufacturers. But they all function basically the same way.

The camera body usually looks like a big box, with several smaller boxes attached. On the front side of the box is the lensmount, where the movie lenses are attached.

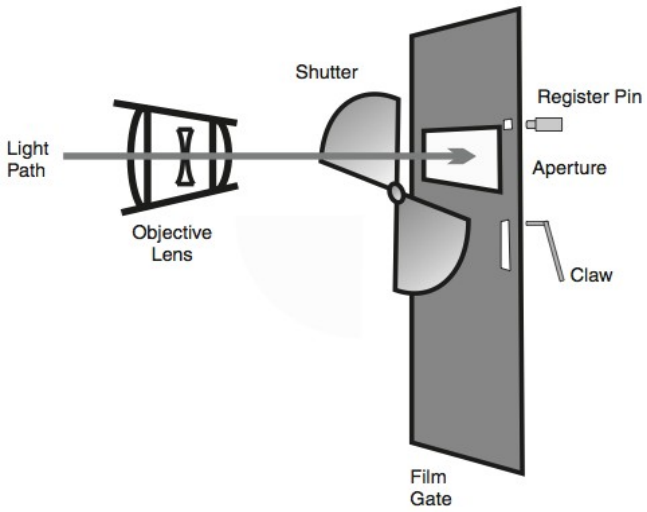
The pipe which comes out of the body is called viewfinder. It basically consists of mirrors and smaller lenses and displays a preview of the current shot. It is used to compose the shot and control the focus of the picture.

Picture 1: Arriflex 416

The intermittent mechanism

The main part of every motion camera is the intermittent mechanism. It is this mechanism, which transports the series of still pictures periodically. It is essential to avoid any exposing of the film while transported, therefore a mechanism known as **shutter** was developed. The shutter blanks off the aperture while the film is pulled through.[1]

The shutter usually is simply a half disc rotating in front of the film gate. The gate has a slot in it where the claw can enter the perforations in the film. The claw moves the film from on frame to the next.(cf. Picture 2 intermittent mechanism)



Picture 2: intermittent mechanism

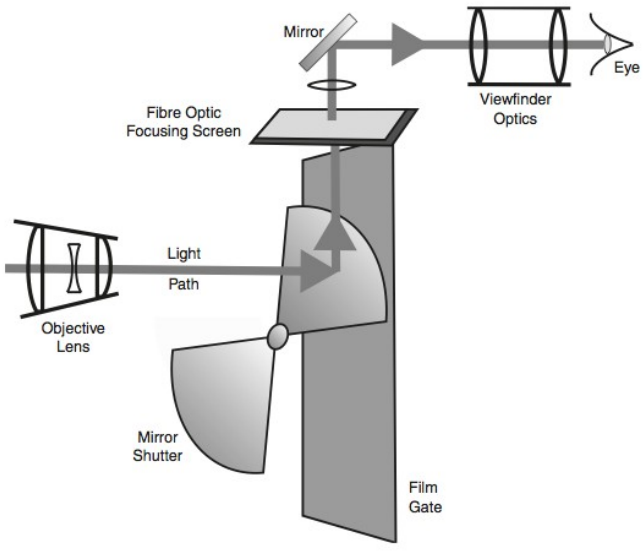
1 Focal Press, Practical Cinematography, 2nd Edition, Paul Wheeler, p.57

The reflex viewfinder

The viewfinder is used to compose and focus the image. Although the early viewfinders couldn't be used to pull the focus, because they didn't use the cameras main optical system. They were either attached to the side or the top of the camera. Its obvious that this early constructions weren't able to show the exact image. The difference between the picture on the film and the image in the viewfinder is known as parallax error.

The first camera with a viewfinder, which used the cameras main optical system, is the arriflex 35 mirror reflex camera introduced in 1937. The german engineers used a simple trick to revolutionized the design of film cameras. Instead of a shutter running flat to the film gate/stock they angled it 45°. Additional the shutters front surface was a mirror which maps the incoming light on a focusing screen. The picture is then sent threw the viewfinder and the viewfinders optics, direct to the camera mans eye.(cf. Picture 3: mirror reflex viewfinder)[2]

This technique made it not only possible to compose the perfect picture but also to easily get the right focus.



Picture 3 : mirror reflex viewfinder

The film magazine

The use of an external magazine for the film stock makes it possible to easily change the roll of film in any time. The magazine is a light-tight container.

2 Focal Press, Practical Cinematography, 2nd Edition, Paul Wheeler, p.44

The displacement magazine

The displacement magazine consists of a single camber, where booth, the exposed and the unexposed film rolls are stored. The advantages of that construction are smaller and lighter magazines and the timesaving displacement function.

Coaxial magazine

Here the film rolls are stored in two separate champers, which are arranged side by side.

2.1.2 The digital motion picture camera

Digital motion picture cameras are available from different companies. The cheapest digital cameras used for independent movie productions are video DSLRS, which are available for about $1500. Professional digital movie cameras can cost up to $80.000.

Although its is possible to get some good and high quality pictures with cheap cameras, it is recommended to use professional cameras for more sophisticated projects. The more expensive cameras are not only better in terms of picture quality and post production capabilities but are also compatible with most of the professional equipment like lenses, batteries, matt-boxes and other additional equipment used to get the desired results.

The principle function of a digital movie camera is completely different and much more sophisticated to that of an analog movie camera. For a digital image the picture coming from the lens has to be transferred into digital values. Therefore it must be divided into small parts, known as pixels. Each pixel has a value which can be stored in a binary number. This process is than reversed in the screening device (fex. Televison or beamer).[3]

The part of the digital movie camera, which transforms the analog image to digital values is the digital image sensor. It is the digital equivalent to analog film.

Pixels are only sensitive to light intensity and not to its quality (color). There are 2 common ways to get a colored picture :

Single chip

If the camera uses only one sensor the pixels on the sensor must be sensitive to all of the primary colors. Therefore a small color filter is put in front of every single pixel, so that every pixel is sensitive to one of the primary colors. The pixels are arranged on the sensor to get mosaics containing 2 green, 1 blue and 1 green pixel (known as bayer color filter mosaic).[4] It is possible to

3 Focal Press, Digital Cinematography, Paul Wheeler, p. 83
4 http://en.wikipedia.org/wiki/Color_filter_array

get every possible color by adding the red, green and blue values and interpolating the missing informations.

Thee chip

For this technique 3 sensors are needed, one for each of the primary colors. The incoming light is split into its red, green and blue components and delivered to the sensors. Prisms and glass is used to split the image coming from the lens and determine that it takes the same time to for every color to reach the receptor.[5]

Electronic viewfinder

Digital motion picture cameras use electronic viewfinders to provide an preview of the current frame. The function of a electronic viewfinder is simple: the image is captured by the sensor, processed and sent to a miniature display, which is positioned behind the optical viewfinder with the eyepiece.

There are many different kinds of electronic viewfinders available. High quality viewfinders have some additional functions and settings which are important for digital cinematographers.

Contrast and brightness

To make sure that the picture on the viewfinder has the same contrast and brightness as the captured video, it is recommended to adjust this settings before starting to shoot. Therefore a color bard can be switched on in the cameras menu.

Peaking

Peaking emphasis sharp edges on the picture and is used to easier check if the subject is in correct focus. The peaking knob on the viewfinder is used to adjust the level of peaking.

Black and white or color

Although there are color viewfinders available the professionals still prefer high resolution black and white viewfinders. The low resolution color viewfinders are simple not accurate enough, make it difficult to focus and often display false colors. Whereas a Black and white viewfinders allows the DOP to concentrate on the composing and the images focus.

The recording media

Just a few years ago all digital cameras used tapes as their recording media. That changed with the

5 Focal Press, Digital Cinematography, Paul Wheeler, p. 84

introduction of flash memories. Flash memories are fast, small and cheap. But the main advantage over digital tapes is, that flash memories are rewritable whereas tapes can only be reused a couple of times. Of course the possibility to easily transfer the recorded material to the computer workstation also contributed to the success of cf-cards, sxs cards and similar recording media.

The quality of a flash memory is determined by its size and writing speed. A higher writing speed rate allows to write more pictures (higher frame rate) with a higher quality.

Digital movie cameras usually use one of those replaceable medias:

Sd-card

Sd-cards are used by semi professional cameras and video DSLRS. Sd-cards are cheaper than any other kind of flash memory. They are available from 32mb up to 128gb with a writing speed up to 10Mbyte/s

cf-card

Compact flash cards are produced since 1994 but still used in a lot of electronic devices. They are usually found in more professional cameras. The biggest cf cards available have 128 gb with a writing speed of about 20Mbyte/s

Sxs card

Sxs cards are developed by sony and used in some professional cameras from sony and other companies. The are available in different memory sizes and have a writing speed of up to 800Mbit/s

P2

The P2 storage media format was developed by Panasonic, specially for video recording devices. Its available with a capacity up to 64gb and a data rate of 1.2Gbits/s

external recorder

Professional cameras offer the possibility to output the digital signal and record it to external devices. The video clips are usually compressed before they can be stored on removable flash memories. The compression is important to ensure that the size and data-rate doesn't overrun. External recorders make it possible to store the files uncompressed and therefore with a higher quality.

Some camera manufacturers like RED use there own flash memory or ssd drives, which are also flash based. SSD drives usually have higher data-rates which are essential to record uncompressed video or even RAW video information.

2.2 Image quality

2.2.1 Analog Film

Analog film stock is similar to photographic film and consists of photosensitive material. Unexposed Film material is also known as raw stock. The technical term for exposed material is “rushes” and after it is processed we call it “master negative”.

The quality of analog film stock varies and is determined by following characteristics:

Black and White or color

Black and white film is made out of silver salts, which are then converted to metallic silver.

It is possible to color black and white film in the post production. It was done with some old black and white movies, but is expensive and the results are not always sufficient for realistic projects. Although this technique can be used for more artistic projects to archive certain effects.

Color film uses at least 3 different layers of silver compounds, one layer for each of the fundamental colors (red, green, blue). Modern color filmstock uses as many as nine different layers of light sensitive materials to accomplish a higher image quality. This layers are referred to as emulsion.[6]

Color Temperature

Light sources have different color qualities. The Color Temperature indicates the color of the light source in degrees Kelvin. Analog film stock is available for different color temperatures. (cf. Color Temperature of Various Light Sources10) The two most common film types are daylight (type D film) which is designed for 5500k and tungsten illumination (type B film) set around 3200k[7]. Type A film[8] was used for “photo” bulbs, which were set at 3400k and are rarely used nowadays.[9]

If the color temperature of the used film stock varies from the color temperature of the light sources it is recommended to adjust the balance with conversion filters. This color balance filters are available for either the light source or the camera. Recommendations for the variety of available filters can be requested at the manufacturer of the film stock.

6 Focal Press, Digital Cinematography, Paul Wheeler, p.63
7 http://en.wikipedia.org/wiki/Film_stock, 11.10.2011
8 http://en.mimi.hu/photography/type_a_film.html; 11.10.2011
9 There are also some special types available e.g. for the use with infra red light.

Source	Degrees kelvin
Artificial Light	
Match flame	1700
Candle flame	1850
40-watt incandescent tungsten lamp	2650
75-watt incandescent tungsten lamp	2820
100-watt incandescent tungston lamp	28650
3200-degree Kelvin tungsten lamp	3200
Photoflood and reflector flood lamp	3400
Xenon arc lamp	6420
Daylight	
Sunlight: sunrise or sunset	2000
Sunlight: one hour after sunrise	3500
Sunlight: early morning	4300
Sunlight: late afternoon	4300
Sunlight: noon	5400
Direct mid-summer sunlight	5800
Overcast sky	6000
Average summer sunlight	6500
Summer shade	7100
Average summer shade	8000
Skylight can vary from	9500 to 30,000

Tabelle 1: Color Temperature of Various Light Sources[10]

Color Balance with Camera Filters

Camera Filters are used if the complete lighting of the scene has to be adjusted to the filmstock. This is usually the case when type B film is used to film outdoor scenes in sunlight. Most motion picture films are balanced for tungsten, because electric light sources are expensive when it comes to energy costs and deterioration. Therefore most cinematographers prefer shooting on film designed for tungsten light, if they have to decide for one specific filmstock.[11]

Correcting light balance

Color filter gels for light sources are available from various manufacturers. Common used color correction gels are CTB and CTO. CTB is the initialism for color correction temperature blue and is

10 Kodak-Cinematographers Field Guide 6, Kodak 2009 p. 34
11 Motion Picture and Video Lighting, Second Edition, Blain Brown p.158

used to correct tungsten light to match the color temperature of “Daylight”. CTO, which stands for correction temperature orange, whereas can change the quality of daylight to closely match the temperature of tungsten negative. [12]

It is important to test all filters before shooting.

Film speed

The sensitive of the photographic film is determined by the ISO or ASA system. The ISO system is a newer version of the ASA system ant therefore uses the same speed values. [13]

Faster film is usually more sensitive to light and does the job better at low light conditions. The higher sensitivity unfortunately results in more grain and noise on the final product.

Film Grain

Analog film stock is made out of small particles. The particles form the texture of the film, which is known as grain. Bigger particles are more sensitive to light than smaller particles, consequently slower filmstock has less grain than faster filmstock. Although faster filmstock is more likely the become grainy, due new technology and emulsions the difference is hardly noticeable anymore.

Grain on images is comparable with noise on sound recordings. If the signal to noise ratio is to bad, noise can become a problem. Just es well grain can become problematic in low light situation. Grain is specially noticeable in the shadows and darker mid tones, where few bigger particles stick out between the smaller, darker ones.

2.2.2 Digital Film

The quality of a digital picture depends not only on the sensor (comparable to the analog film stock) but also on the compression and downsampling of the final material. This chapter concentrates on the factors, which determine the final quality of the digital movie picture.

The Sensor

The equivalent of analog film stock in the digital world is the cameras Image Sensor. The Image Sensor consists of small light sensitive electronic parts which are able to convert the optical impulses into electronic signals.

12 Motion Picture and Video Lighting, Second Edition, Blain Brown, p158 f.
13 http://en.wikipedia.org/wiki/Film_speed#ASA, 22.11.2011

This parts are also known as pixel.

Digital tonal range

The value of every pixel is stored in a binary code. The analog value in form of electric tension is assigned to a binary value, which uses a combination of nulls and ones (2 bit code) referred to as bits. The electric tension can have infinite values whereas the binary value is depending on the number of possible bits. Consequently this results in an rounding error which leads to a slightly aberration in the color tone.

The number of possible color shades is depending on the number of possible bits. This leads to the bitrate, which describes the number of stored bits per second.

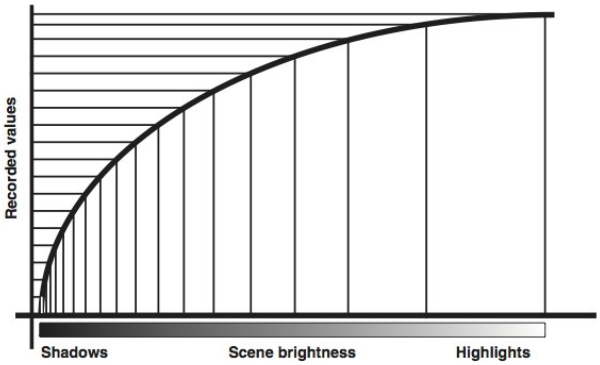
The digital tonal range is exponential rising (cf. the effect of adding more bits to the binary code)

1 bit (0 or 1) = 2	2 values
2 bit = 2 x 2	4 values
4 bit = 2 x 2 x 2 x 2	16 values
6 bit = 2 x 2 x 2 x 2 x 2 x 2	64 values
8 bit = 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2	256 values
10 bit = 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2	1024 values
12 bit = 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2	5096 values
14 bit = 2 ^14	16384 values

Tabelle 2: the effect of adding more bits to the binary code

The human eye is more sensitive to shadow detail than highlight detail. To create a real looking picture the quality of the shadow must be higher. For the digital world this means, that the gaps between the sample values should be shorter. Researches have shown, that at least 8192 different values are needed to ensure that an image looks real. Looking at the Tabelle 2 show us that this means at least 14 bit of data. To save memory and power, digital cameras use logarithmic sampling instead of the traditional linear sampling. This little trick enables more values where they are needed, in the darker areas and shadows, and makes it possible to record the same amount of information on a 10 bit file with only 1024 options. The audience of course doesn't notice any difference.[14]

14 High Definition Cinematography, 2nd edition, Paul Wheeler, p. 40

Linear sampling	Logarithmic sampling
	

Resolution

The **resolution** defines the number of pixels on the digital image sensor. A full-hd image for example has a resolution of 1920 x 1080 pixel.

There exist different opinions on how much pixels are needed to deliver a satisfying quality for cinema screens. A lot of post production people argue that a resolution higher than 1920 x 1080 (almost 2k) is not enough and 4k should be minimum for cinema productions. If the filme needs a lot and complex post productions then it is better to shoot on a higher resolution. This is usually the case for big green/blue box scenes.

35mm film can hold an equivalent resolution of 4k units, thats why the master is usually scanned with 4k for digital color correction and post production. But a lot of the picture quality is lost at the copy and printing processes. The original master is copied, scanned, printed and copied several times. After going threw projectors lens, which also degrades the picture, the final on screen quality is hardly better than 1.4k. Shots with a HD resolution of 1920 x 1080 pixels can be color corrected, copied and processed without a lose of quality and if a high quality digital projector is used to screen the movie the picture quality is even better than 1.4k and close to 2k. Even if the HD material has to be printed out the quality usually is comparable to 1.4k.[15]

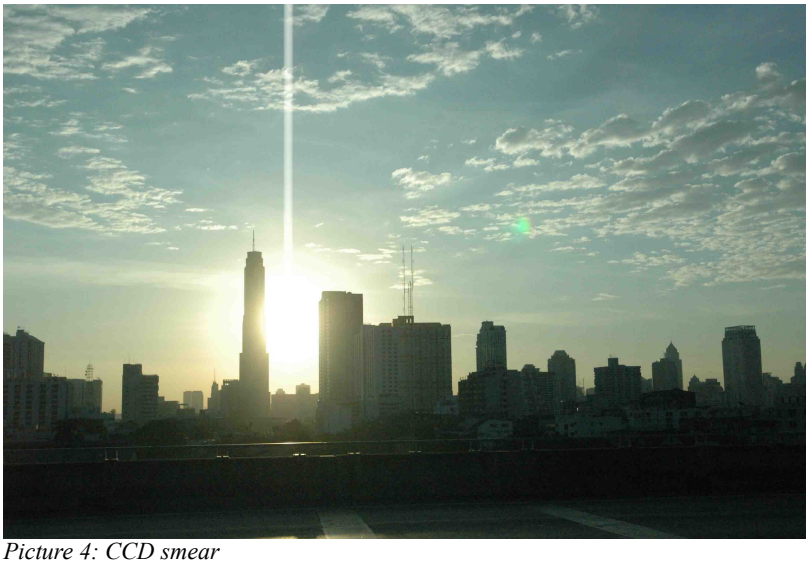
15 High Definition Cinematography, 2nd Edition, Paul Wheeler, p.42 f.

CCD or CMOS

There are two different types of sensors used in modern digital cameras, CCDs and CMOS sensor. The difference between this sensor types is only small, but important to know. To record an image the information of every pixel on the sensor has to be read and stored. This process takes some time and is handled different by CCD and CMOS sensors.

CCD sensor

The biggest advantage of CCD sensors is that they are read out sequentially. They also have a slightly better noise performance and dynamic range. Therefor CCDs need more power than CMOS sensors and are more likely to produce a ugly vertical smear form bright light sources. This smear is the outcome of a sensor overload. [16]



Picture 4: CCD smear

CMOS sensor

CMOS sensors are faster, cheaper and easier to implement. On a CMOS sensor the pixels are scanned horizontally, which is the biggest disadvantage of that technology. Fast horizontal movements can result in an undesired effect known as rolling shutter.

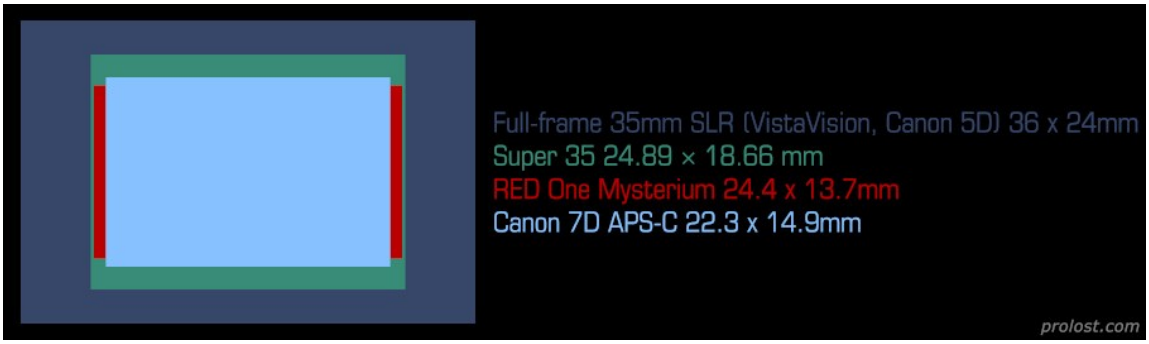
16 http://en.wikipedia.org/wiki/Image_sensor, 18.12.2011

Picture 5: rolling shutter

Sensor size

The size of the sensor has an important impact of the final pictures. It is the sensor size which draws the line between a video camera and a digital movie camera. Larger sensor have a lower signal to noise ratio, a better dynamic range and a higher light sensitivity. However it is the reduced depth of field which makes larger sensors outstanding for movie productions.

The size of super 35mm filmstock is about 24mm x 18 mm (don't get confused by the name, 35mm refers the the original full frame format with a width of 35mm). The size of digital 35mm sensor is similar to that of 35mm filmstock. That results in a film like look, which is appreciated by most of the audiences. Even APS-C sensors are only slightly smaller than analog 35mm film (cf. Picture 6: different sensor sizes).



Picture 6: different sensor sizes

Light sensitivity

The light sensitivity of booth, analog film and digital sensors, is determined by the ISO number. The ISO number was formally known as ASA standard. A higher ISO number usually results in more noise or grain.

A larger image sensor has larger pixels which receive more light, therefore the Signal to noise ratio is better, which is important to film at higher ISO numbers.

Dynamic range

The ratio between the highest and smallest possible value of a changeable quality is known as dynamic range. In terms of cameras the dynamic range determines the luminance range the camera can see. That's simply the detail range between the darkest shadows and the brightest highlights which the camera can record. The dynamic range is measured in f-stops (blend stops). The human eye can see a range of nearly 24 f-stops whereas the f-stop range of professional digital motion picture cameras is between 10 and 12 f-stops, which is equal to that of analog film. DSLRs have a dynamic range of about 7 to 8 f-stops.

Although the dynamic range of film and digital is equal, analog film has a advantage in recording highlights. This is especially noticeable when bright sunsets are filmed – digital cameras might have problems in such situations.

Image compression

One hour of uncompressed HD video material can easily exceed 500GB, depending on the frame rate and color depth. Although memory is becoming cheaper and cheaper this days, it is still a fact to be considered because of storage and transmission limitations.. Thats why there is always a desire to compress the video information. A lot of different technologies are used to archive the perfect balance between strong compression and satisfying picture quality.

Noways famous codecs include mpeg2, mpeg3, h.264, dct.

Even tough the quality and performance of various codecs may differ, they all use the same basic compression methods.

Chroma subsampling

Chroma subsampling makes use of the fact, that the human eye is less sensitive to position and motion of

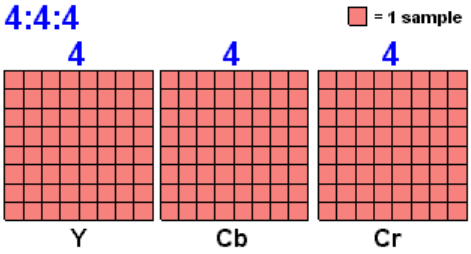
color than luminance. Therefor it is possible to reduce the color information and still get a perfect picture quality.

To reduce the color information the signal is divided into a luma (Y') component and two color difference components (chroma). It is than expressed as a 3 part ratio Luminance:ChromaR:ChromaB (Y:Cr:Cb). [17]

Different chroma subsampling types:

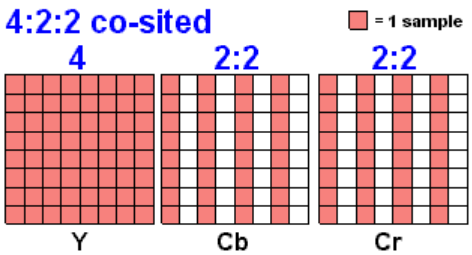
4:4:4

The signal is uncompressed and every channel has the same sample rate. This is used for high quality productions, film-scanners and postproduction.



4:2:2

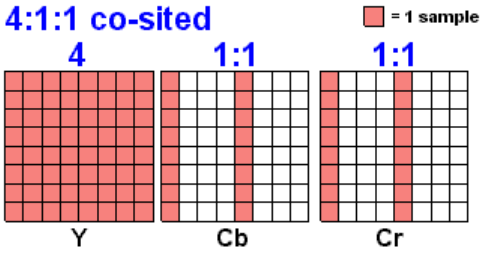
The sample rate of the chroma channels if half the sample rate of the luma channel. This reduce the the bandwidth by one-third. The quality is still very high, that's why it is used for prosumer and professional video decoding.



17 http://images.yourdictionary.com/chroma-subsampling, 22.12.2011

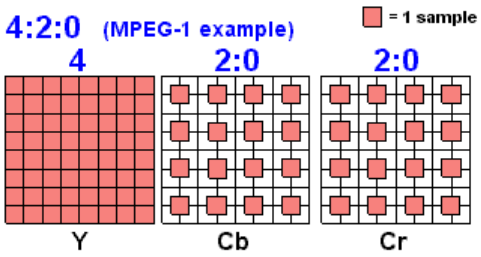
4:1:1

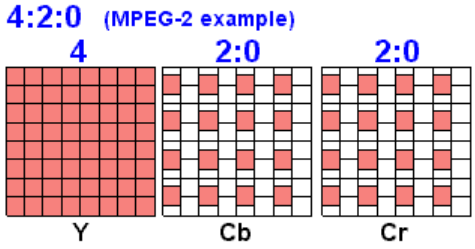
The color resolution is only one quarter of the luminance. The result is half the bandwidth of no chroma subsampling. This technique is used in Consumer cameras because the quality is not satisfying for High end Productions.



4:2:0

This means, that Cb and Cr are sampled at half the vertical and double the horizontal resolution. There are different variants of 4:2:0 chroma subsampling for example for MPEG-1 and MPEG-2.





But although 4:2:0 chroma subsampling is used by professional codecs, it limits the post production capabilities and therefore should be avoided if possible.

Inter frame prediction and Intraframe compression

Inter frame prediction makes use of the fact, that a lot of information in neighbor frames is identical. A lot of memory can be saved by only recording the changed information, instead of the whole frame. Therefore the frame is divided into macroblocks. The algorithm searches for matching blocks and reduces the information

by referencing to the first frame. Even if inter frame prediction can save a lot of resources, it is hardly used in professional equipment, because of the disadvantages in editing.

Intraframe compression records every frame on its own which makes it preferable for editing.

Lossless dada reduction

Modern codecs use some other methods to reduce the bitdepth and size of video signals. This techniques use some complex mathematical algorithms to compress the amount. They don't have an impact on the picture quality which is why I ignore them in this paper. Although keep in mind that they do affect the codecs max datarate .

RAW

Some cameras allow to record the raw information coming from the sensor. This enables a lot of possibilities in the Post production but results in a much higher data rate.

Hd video formats

An overview of important video formats and the codecs behind them.

	HDV	**HDCAM**	**XDCAM EX**	**XDCAM HD**	**AVC Intra**	**Redcode 28**	**Arriraw**
Used by	diverse	Sony	Sony	Sony	Panasonic	Red	Arri
resolution	1440x1080	1440:1080	1920:1080	1920:1080	1920:1080	4096:2304	2880:2160
Max bitrate Mbits/s	25	144	35	35	100	224-	224-336
compression	Mpeg2	DCT	mpeg2	mpeg2	mpeg4	wavelet	wavelet
inter/intraf.	Interframe	Intraframe	Inerframe	Interframe	Intraframe	Intraframe	Intraframe
Bit depth	8	8	8	8	10	12	12
Chroma-subsampling	4:2:0	3:1:1	4:2:0	4:2:2	4:2:2	Raw bayer	Raw bayer
gb/h	12	70	16	16	46	115	
for	Consumer / Semi-pro	Consumer / semi-pro	semi-pro/pro	pro	Pro	Pro	Pro

3 Post production

3.1 35mm film

Analog film must be scanned for further digital processing. It is recommended to scan the original master because the quality of the copies might be worse. The scanning of film costs money and needs a lot of memory, depending on the resolution. After the filmstock is scanned the final postproduction and color-grading possibilities are identical with that of digital film.

3.2 Digital film

If a lot of post production is planed, and specially if blue and greenbox shots are needed, it is important to shot on a camera which allows at least 4:2:2 chroma subsampling. Thats why video DSLRs are not really that good for shooting full length movies, because they only support a chroma subsampling of 4:2:0.

Best choice of course is to shoot in a raw format because then even the aperture can be fixed in post.

4 Production

The basic production workflow is identical for both mediums. The lighting is the same for both technologies. Although there are some differences which are expounded in this chapter.

4.1 35mm film

4.1.1 Clapper loader

The clapper loaders job is to operate the clapperboard at the beginning on each take. Between the takes he has to load the raw film stock into the magazines. Sometimes there is a designated Film Loader for that. In the digital movie world, the Clapper loader usually has to replace and label the tapes or memory cards.[18]

4.1.2 Exposure

Older Analog movie cameras, unlike digital cameras, don't have build in exposure meters, thats why a external exposure meter is absolutely necessary. Whereas I always would recommend the use of external exposure meters, because they allow a more exact lighting of the scene.

18 Practical Cinematography, second edition, Paul Wheeler, p.29

4.2 Digital

4.2.1 Digital imaging technician (DIT)

The Digital imaging technician takes care of all the visual aspects of the digital image. He collaborates with the director of photography to achieve a high image quality and to realize the DIPs artistic imaginings. Sometimes the DIT is also responsible for the media management.

4.2.2 White balance

Digital film cameras offer the possibility to set a manual white balance. This function can be very useful in blended light situations. The settings for the right white balance are usually found in the cameras menu and can be looked up in the handbook.

4.2.3 Variable Framerates

A filmmaker has to decide for a framerate before he starts with the shooting. Modern motion picture cameras are capable to shoot in various different framerates. The framerate is usually measured in fps (frames per second). The standard framerate for movies is 24p, which stands for 24 pictures per second or 24fps.

Digital motion picture cameras allow to use even higher frame rates for example 120 fps. Well used slow motion shots can really enhance the visual look of a movie by adding more drama to an action scene or more emotion to a romantic moment.

4.3 Technical problems

As we no, no technology is bug-free and the more complex the equipment is, the more technical problems can occur.

Analog movie cameras are on the market for years now and a perfect workflow around the different cameras has been developed. They are considered to be bug free, if used and serviced correctly.

New digital cameras are introduced every year and the costumers often have to serve as beta testers. The advantage is that most of the bugs are software-sided and are can be fixed by firmware updates. Nevertheless it is not recommended to buy the newest product for a full-length feature because bugs and system crashes cost time and money.

5 Long time storage

Even if the digital movie cameras are going to replace the old analog technology, analog film will still exist in the near future. People like the way digital systems work and they appreciate the possibilities they offer, but everybody knows how easy digital information gets lost. Film stock from 1920 can still be watched and books from 1500 can still be read, whereas hard discs have a durability of less than 15 years. Of course it is

possible to duplicate and renew the digital informations form time to time but that is expensive and time consuming. Apart from that nobody knows if a h.264 or similar codec can still be read out in 100 years.

Thats the reason why big archives and companies are still printing there movies out on analog filmstock, because they want to make sure that the next generations are also able to view there works.

6 Final conclusion

The advantage of 35mm film is the fact, that it is is analog. It doesn't use fixed values to describe the picture which in theory makes the picture smooth and soft even at a large size. In reality every time the analog filmstock is copied it loses some quality. Digital video material on the other side has a fixed resolution which leads to bad digital artifacts on bigger screening devices. Although Full-HD is standard for TV and 2k is standard for movie theaters nowadays, it is possible, that the resolution might increase in the future.

Digital movie cameras and projectors are already replacing the analog equipment and its is obvious that this trend will continue with the development of new technologies. But analog film will still be used for artistic manner and long time storage. I'm sure that a lot of movies will still be produced on 35mm film. For independent filmmakers the cost of the analog filmstock is simply to high and the advantages of the digital workflow are to big to be ignored.

7 References

7.1 Bibliography

Practical Cinematography, second edition, Paul Wheeler

Kodak-Cinematographers Field Guide 6, Kodak 2009

Motion Picture and Video Lighting, Second Edition, Blain Brown

Focal Press, Digital Cinematography, Paul Wheeler

High Definition Cinematography, 2nd Edition, Paul Wheeler

7.2 References from the Internet

http://en.wikipedia.org/ , 01/25/2012