Brief History of Imaging Technology

v7 Tim Vitale © 2007

Digital imaging is the next step is the continual improvement of imaging with light. A newer light-capturing imaging media will follow, some day. Currently, lenses are the limiting factor in the development of digital imaging.

The use of light to "render an image" began with the Camera Obscura around 1550; it used a simple lens focused on a wall or a drawing board so the image could be traced. That basic technology was used by Niépce in 1816 to form an image on paper, which was unfortunately not permanent. Later, in 1826, Niépce made the first permanent photograph using photosensitive bitumen on a pewter lithography plate.

While many early photographic images were one of a kind such as the Daguerreotype, Ferrotype or Ambrotype. Paper (1939, waxed afterwards) and glass plates (1851) were the earliest negatives. Collodion Wet Plate (cellulose nitrate in ether solvent) technology was invented by Frederick Scott Archer in 1851. Wet Plates (collodion) were used through the 1920-30s by prepress because of their controllability and dimensional stability. Eventually they were replaced by Kodalith film in 1931. The Gelatin Dry Plate was brought into wide-scale production by Kodak in 1878. Dry Plates remained in use until 1913, through the 1920s, because of their familiarity, resolution and dimensional stability.

Film (around 1885) became the dominant image carrier beginning around 1889-91, as amateur roll film, then as sheet film in 1913-15, by the professional photographer transitioning from glass plates. However, glass plates were is use through the 1930s by professional photographers and newspaper printers (we call them Pre-Press).

Cellulose nitrate still film base was transitioned starting around 1925 to cellulose acetate film base. However, cellulose acetate began to be used in amateur motion picture film starting in 1908-12 and was required by law for amateur motion picture applications. The final transition to acetate base was made between 1938 and 1948 depending on format. While cellulose acetate is not as volatile as nitrate motion picture film, it degrades faster than its nitrate precursor. Fortunately, the acetate base does not destroy the gelatin emulsion, as does the strong nitric acid that evolves from degrading nitrate base.

Despite it 60-120 year assured deterioration rate, acetate base is still in common use today on 80-90% of all films. It is said that Estar base (polyester, Mylar) is now being used on all Kodak Sheet film, starting in 2000-01. Oddly, some historic nitrate-based film is in better condition today than some acetate-based film. Fortunately the gelatin image (pellicle) can be salvaged from degrade acetate film, whereas it is destroyed by the nitrate base deterioration. Both film bases will degrade unless in cold storage.

Color film technology began in 1915 as a two-color process. Around 1932-33 the 3-color process was developed. Earlier glass based methods (colored starch grains) developed by the Lumiere brothers, Autochrome, France 1907 and Thomas Manley invents Raydex (Ozobrome) color pigments on carbon paper in 1905, showed the way and are still in limited use today for their high permanence. All color film was released on acetate base. Color photographic dyes will fade in 10-45 years, at a minimum. Cold storage is the only preservation method. Kodak now estimates 250 years of stability for there post-1990 E6 Ektachrome films; on display they have a very short lifetime.

Film photography rose to a very high technological state before it was eclipsed by digital. Film and lenses were strategic WWII material and became critical in cold war espionage. Film remained the cutting edge of technology through the 1980s, but it is now a historical technology practiced by film aficionados or those slow to adopt newer technologies. Kodak fins its film manufacture to be very profitable, however, when movie theaters transition to digital display the end of fil while shortly follow for economic reasons.

Lenses reached a penultimate state just before WWII and topped out in the 1970s. Computer-aided design help to improve basic prime and zoom lens designs, but coatings are the current cutting edge of lens development. Most lens designs being used today were developed over 80-100 years ago.

The progression of light-based imaging begins with pseudo-lenses made of stone, and then…

Color Code Key

Lens history; Pre-Photography; B&W Photography; Color photography & Digital Photography

- **Polished stones** were used to magnify and condense light circa 3000 BC, or earlier
- **Glass** was invented in Bronze Age, and then perfected by the Egyptians 3000- 2500 BC
- Greek and Chinese scholars describe basic principals of optics and camera, circa 300-400 BC
- Aristotle writes of a darkened room [Camera Obscura, Latin: dark room] with a small hole in one wall focusing an inverted image on the far wall 330-300 BC
- **Reading Stone**, a glass sphere use to read by magnified letters, around 1000 AD
- Ibn el-Haitam Arabic Physicist described the first Lenses and Camera Obscura around 1000 AD
- First Camera Obscura with a lens: when Girolamo Cardano (1501-1576) suggested replacing the hole with a biconvex lens to improve the image in 1550s
- Giovanni Battista della Porta (1538-1615) published what is believed to be the first account of the possibilities of Camera Obscura as an aid to drawing in 1558
- Galileo made his astrophysical studies using a early **telescope** in 1610
- Newton discovers that **white light** is composed of colors of light (spectrum) between 1664-66
- Johann Heinrich Schulze mixes chalk, nitric acid, and silver, notices darkening on side of flask exposed to sunlight, first photo-sensitive compound, silver nitrate, 1727
- Thomas Wedgwood, **Sun Pictures**, leather w/silver nitrate, deteriorate w/more than candle, 1800
- Lithography on stone & metal plate, France 1813
- Nicéphore **Niépce** combines Camera Obscura with photosensitive paper, not permanent, 1816
- **First permanent image** light-sensitive "bitumen of Judea" on Pewter, Niépce in 1826
- Joseph Jackson Lister **reduced chromatic aberrations in lenses** by introducing concept of several lenses, each with a portion of the full magnification, formerly required of one lens in 1830
- Light-sensitive silver iodide on copper, developed with Mercury vapor, **Daguerreotype** in 1833
- **Chevalier Achromatic** lens, 2 elements cemented, still in today's point-and-shoot cameras 1835
- **First paper negatives** in 1839
- **William Fox Talbot**, silver chloride paper, **Calotype**, two exp., produce positive print, 1840-41
- **Petzval Achromatic Portrait Lens**, first "specifically designed photographic lens" in 1941
- **Niepce de St Victor** and **Louis-Désiré Blanquart-Evrard** experiment w/ albumen plates 1847
- **Wet Collodion Plates** created by Frederick Scott Archer (cellulose nitrate) 1851, thru 1930's
- **Salted Paper Prints** 1841-60, followed by wide use of albumen prints 1860
- **Color Daguerreotypes**, first Hillotype (1851) and then Heilochrome (1853), short life in 1850s
- **Louis-Désiré Blanquart-Evrard** produces first albumen print (printing-out) in 1850
- **Ambrotypes and Tintypes** (Ferrotypes) positives on glass and metal respectively 1855-57
- **Crayon Portraits** by itinerate photographer, printed-out capture w/crayon design layer 1860-1900
- Ernst Abbe joins Zeiss (Jena), develops **Abbe sine condition**, improving optics significantly 1873
- **Silver Photographic Print** technology developed, both printing-out and developed-out, in 1870
- **Dry Gelatin Plates** glass plate negatives, 1878, used through 1930s by pro-photogs & pressmen
- William Wills discovered the **Platinum Print** in 1873, reached market in 1881
- **Gelatin emulsion papers** developed, gelatin and collodion (cellulose nitrate polymer) in 1885
- **Baryta layer** introduced to prints, increases reflectiveness and expands tonal range, about 1885
- Otto Schott joins Abbe & Zeiss, produces glass equal to Abbe's work, **Apochromatic lens,** 1886

- Silver bromide - gelatin emulsion **Printed Out Paper** (light) available 1885, glossy in 1890
- Kodak paper roll negative, sold in camera only, in 1888
- Silver gelatin emulsion on cellulose nitrate **film** first developed in 1889
- Silver bromide -gelatin emulsion **Developing Out Paper** (chemical bath) in 1895
- Carl Zeiss Foundation develops "Anastigmat Lens" with no astigmatism or field curvature, later known as **Protar** camera lens in 1890-94
- Dr. Rudolph, Zeiss Jena, develops **Planar** lens w/ 2 symmetrical groups, most copied style 1896
- Gabriel Lippman developed first **direct color process**, Photochrome in 1891
- Silver-gelatin prints supplant Albumen prints, 1895
- Dr. Schott (Zeiss) develop rare earth glass (Jena glass) in 1901
- Dr. Rudolph develops **Tessar** high resolution & contrast lens with 4 elements in 3 groups 1902
- Thomas Manley invents Raydex (Ozobrome) proportional color pigments on carbon paper, 1905
- **Dufay** ruled color screen process on glass in 1905, later on film
- Colored starch on glass developed by Lumiere brothers, **Autochrome**, France 1907
- Kodak announces Safety Film base in 1909; opens acetate factory in Australia, 1908
- Fredric Ives develops major dye imbibition advance, Trichromatic Plate Pack (3 neg, 1 exp) 1911
- Kodachrome 2-color process 1915
- F.J. Christenson develops first silver dye bleach process in 1918
- Leitz releases the **Leica I,** 35 mm camera w/ 5-element Elmax or Elmar (4-elmt, 3-gps) lens 1925
- Eastman Technicolor 2-color motion picture process 1927
- Finlay square dot 3-color screen on film 1929
- Zeiss Icon AG releases **Contax I,** 35 mm camera with Zeiss f1.5 lens (Dr. Bertele, 7-elmt) 1932
- Eastman **Technicolor** 3-color process 1933
- **Carbro** print process, proportion deposit of pigment layer on paper, from Ozobrome, 1930-40
- **Technicolor** movie film process, three B&W negatives were made using color filters, 1932
- First viable three layered color positive film color process (**Kodachrome**) in 1935
- **Dufaycolor** ruled screen process on film 1935
- Nikon releases **Nikkor 50 mm** lens, mounted on **Hanza Canon** (Canon rangefinder) in 1935
- Zeiss develops lens **vacuum deposition coatings**, reducing internal reflections and flare, increasing contrast and resolution in 1935, not available until 1940, only Sweden & Switzerland
- **Agfacolor**, also a tripack color reversal process, 1936
- Kodachrome have low dye stability from inception (1935) through 1937, improved in 1937
- Kodak Azochrome (1940) silver dye bleach print from Eastman Wash-Off, to **Dye-Transfer** 1945
- First multi-layer **Color Negative** films developed in 1941
- First color print from a color negative film, **Kodacolor**, (red tone emphasis) in 1942
- Kodachrome color reversal film is supplanted by **Ektachrome**, with blue tone emphasis in 1946
- Ektachrome E1, E2 & E3 had poor cyan and yellow dye stability, 1940s through 1976
- Nikkor lenses equal Zeiss and Leica multi-coated equivalents in the early 1950s
- Carl Zeiss Dresden (East) release **first SLR** (prototyped before WWII in Jena) in 1949
- Carl Zeiss (west) release their SLR, Contaflex, 1953
- Carl Zeiss (west) releases **Contarex** (Cyclops), first SLR with integrated light meter, in 1958
- Nikon releases the **Nikon F** body with metering (more compact and affordable) in 1959
- Lens designs with more advanced coatings reach point of penultimate performance in the 1960s
- First instant color process, instant dye diffusion Polaroid, **Polacolor** in 1963
- Silver dye bleach process refined, positives prints from transparencies, Ilford, **Cibachrom**e, 1963
- First viable digital **CCD** imager by Boyle & Smith at Bell Labs in 1969
- Excellent lens designs become cheaper, resolution reaches point of diminishing returns in 1970's
- Ochi's ground breaking **8x8 pixels CCD** sensor in 1972
- Ray Kurzweil invents CCD-flatbed scanner for OCR (becomes Xerox Textbridge 1980) 1975
- Ektachrome **E4** with good dye stability supercedes others in 1977
- Schneider begins using multi-coated (flare suppression) lenses, 1977, completes full line by 1978
- First viable color digital imager (video still 570x490 pixels) **Sony Mavica** B&W 0.79 MP in 1981
- Pentax demonstrates **Nexa**, B&W still video camera prototype in 1983
- **Canon RC-701,** 0.40 MP Pro color still video camera & analog transmitter, LA Olympics, 1984
- First full **Megapixel Camera**, Kodak **Videk** 1320x1335 pixels,1.4 MP 1987
- Canon RC-250 **XAPSHOT**, 0.20 MP consumer level ($499) video still color camera, 1988
- Chinon developed **video still back** for its CP9-AF 35mm SLR camera 640x480 pixel CCD, 1988
- **JPEG & MPEG file formats** developed, using DCT compression technology, 1988

- SONY **ProMavica MVC-5000** 2-chip vid-still, first transmit instant color images over phone, 1989
- Ektachrome **E6** claims 240-year dark fading stability, 1990
- **Photoshop 1.0** Mac only, John & Thomas Knoll wrote & licensed to Adobe (1988), v1 1990
- Nikon QV-1000C, **first DSLR**, B&W video still camera, 0.38 MP, F-mount lenses, $20K, 1991
- **Dycam 1** (gry) & Logitech **FotoMan** (wht), B&W, first consumer digital (1 MP CCD) camera, 1991
- **Mike Collette** invents the **digital scanback** on seeing **Kodak's 6K trilinear CCD array**, 1991
- Kodak introduces **PhotoCD** (heavy compression and YCbCr color space) in 1992
- **Kodak DSC 100** (1024x1280, 1.3 MP CCD, $30K) first Pro DSLR, F3 body w/ Extl' HD, 1991
- **Crosfield Celsis-130**, 3-CCD, 3072x2320 pixels, single-shot studio photography, 1991
- **Kodak DCS 200**, 1.53 MP built-in HD, Nikon N8008 body, $30K, 1992
- Canon **EOS Prototype** DSLR, 1.3 MP, 1993
- **Mike Collette** licenses the 6000x7520 (45/135 MP) digital scanback to **Dicomed** in 1994
- **KODAK DCS 420** (1524x1012 pixels) Nikon N90X body, 1st storage on PC cards, $11K, 1994
- **Nikon E2**/S (Fuji DS-505, DS-515) 1st DSLR to have 35mm full frame (no crop), 1994
- **Epson 720 dpi Desktop Color Inkjet Printer**, MJ-700V2C first "photo quality" printer, 1994
- **Photoshop 3.0 for** Mac, Win, IRIX & Solaris, added Layers, no 16-bit yet, 1994
- **Canon / Kodak EOS DCS 3**, Canon EOS-1N body, 1.3 MP CCD (1012x1268) in 1995
- **Kodak DCS 460,** Nikon N90S body, 6 MP (2036 x 3060), 18MB in 12 bits, $28K, 1995
- **Dicomed Bigshot 4000** 1st one-shot lgr than 35mm frame sz (4096x4096) 17 MP $35-55K, 1996
- **Nikon E2N/s** (Fuji 505A, 515A) Nikon F4s body, 2/3-inch 1.3 MP (1280x1000) CCD $10K. 1996
- **BetterLight** (Collette) releases **6K** (6000x8000) scanback **quality superior to sheet film**, 1997
- **Kodak DCS 520** (Canon EOS D2000) EOS 1N body (1.3x) 2MP (1728x1152) $16K, 1998
- **Kodak DCS-560** (Canon EOS D6000) EOS 1N body (1.3x) 6MP (2008x3040) 12-bit, $30K, 1998
- **Foveon** CCD chip with "depth-based color sensitivity" RGB digital sensor, 1998
- **Photoshop 5.0** added Color Management, 16-bits and History Pallet, 1998
- Kodak uses **Estar base for all sheet film** beginning in 2000/01, roll film still on acetate base
- **Canon 1Ds** (2704x4064, 11 MP) first DSLR recognized w/ **quality superior to 35 mm film,** 2003
- Kodak announces discontinuation of slide projectors by 2008, in 2004
- Kodak discontinues all Eastman Ektachrome Color Reversal motion picture film thru-out 2004
- Kodak discontinues producing B&W paper, June 2005
- **BetterLight** releases **8K** (8000x10600) 254 MP scanback, 2004
- **BetterLight** releases **Super 10K** (10600x13600) 433 MP (649 MP w/expanded) scanback, 2007

Digital imaging is capable of recording spatial and color information well beyond the limits of film. Film-based imaging has been superceded by newer technology. Digital technology offers imaging with no intervening technologies such as film dyes, dye couplers, processing or film base, all with no physical deterioration. In addition, the photographer can edit and output at the highest level of competence, once reserved only for color service bureaus.

Remastering analog images into the digital domain preserves the image because it can be captured without loss and there is no physical deterioration once it's held in the digital domain. Color-shifted film and prints can be corrected using tools in Photoshop.

Digital images need a file format that holds the digital image data securely and permanently --TIFF. Storage of image information is crucial for its long-term preservation. Although digital images can be stored indefinitely without deterioration, they can be lost through negligence. A digital file can be permanently "lost" if it is stored without regard for basic computer technology or on inappropriate storage media. The recommended storage medium is the hard drive (HDD), which is viable for 5-10 years. Although a HDD can fail, it is usually backed up on another HDD, or the files are stored in an internally redundant RAID array (mode 5 or 6). Optical media (CDR, DVD-R) fail without warning (3-25 yrs) and their (disk) readers won't be available in 15-20 yrs.

Image capture using automated imaging functions can easily compromise digital images permanently. Although the automated functions make digital imaging easier for the inexperienced, they remove control from the operator and can alter the fundamental

image data captured by the CCD/CMOS and analog-to-digital converter (ADC) before the file is even written. Even with a neutral gray target in the frame, the full tonal range information can be compromised before the file is saved. It is always best to store image information in the TIFF format (file wrapper) using its uncompressed version.

Compression of an image file diminishes the potential of the numerical image data by throwing sections away to save space or improve download speed. If the original image data is not as important as the space it occupies or the speed of download and network movement, compression could be used, but preferably not as a default operation. Image data alteration occurs even during the use of lossless-type compression, despite the unchanged appearance of the image on screen or in print. Lossy compression is more effective at reducing file size and increasing download speed. The new JPEG2000 wavelet compression technology is superior to JPEG DCT compression, but JPEG2000 implementation remains problematic.

JPEG2000 is sometimes claimed to be lossless, but this claim is based on visual evaluations not of the actual RGB numbers making up the image The JPEG2000 compression is not reversible, there is no free lunch. JPEG and JPEG2000 encode the original RGB image data using the YCrCb color space (developed for video), permanently altering the original numerical data.

Digital workflow has put all imaging processes into the hands of one operator. The film workflow, in contrast, utilizes at least three skilled crafts to bring a color image from the photo-studio, to processing and then printing. The differences between digital and film-based workflows are revolutionizing how images are captured, used, stored and viewed.

Tim Vitale
Paper, Photographs &
Electronic Media Conservator
Film Migration to Digital Format
Digital Imaging & Facsimiles
Preservation & Imaging Consulting
Preservation Associates
1500 Park Avenue
Suite 132
Emeryville, CA 94608

510-594-8277
510-594-8799 fax
tjvitale@ix.netcom.com
<http://briefcase.yahoo.com/tvitale@pacbell.net>
[use of the above URL may require a "Yahoo! ID" to download files]