The Future of Photography

Ricardo J. Motta
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View from the Window at Le Gras Niépce 1826

Original

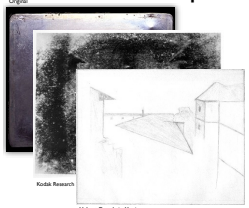
View from the Window at Le Gras Niépce 1826

Original

Kodak Research Laboratory 1952

View from the Window at Le Gras Niépce 1826

Original

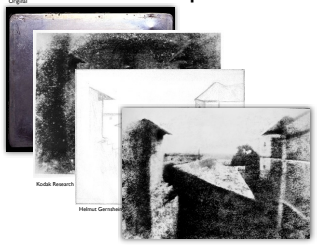


Kodak Research

Helmut Gernsheim Version

View from the Window at Le Gras Niépce 1826

Original



Kodak Research

Helmut Gernsheim Version

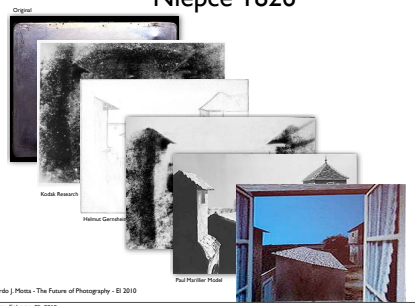
View from the Window at Le Gras Niépce 1826

Original

Kodak Research

Paul Mariller Model

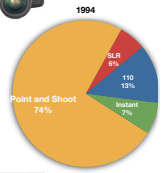
View from the Window at Le Gras Niépce 1826



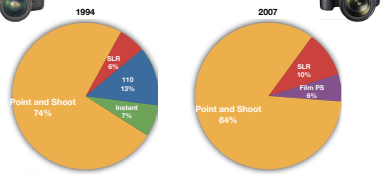
Outline

- The Last 15 Years
- The State of Digital Photography
  - Mature Functions
  - Emerging Functions
- Post-Digital Photography

US Camera Sales

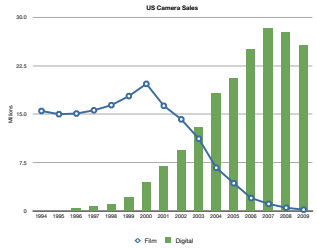


US Camera Sales



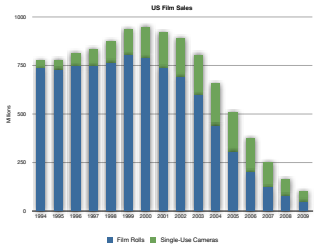
PMAI 2009 Data

Transition Film to Digital



PMAI 2009 Data
Excludes Camera Phones and Single Use Cameras

Transition Film to Digital



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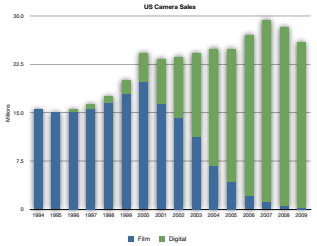


PMAI 2009 Data

Why Digital Photo Won

- Instantaneous Feedback
- Automatic Operation
- Non-sequential Operation
- Sharing and Distribution
- Compact cameras
- Low Cost
- Good quality
- Printing and Display

Now What?

Why do we Photograph?

- To document and preserve
- To share and communicate
- To understand, analyze
- To enjoy the craft and technology
- For social motivations
- To create

My Thesis

Many of the motivations that leads us to photograph will be better served by new and different technology

In the long term, photography as we know today will continue to exist just as a visual art

Some of the first steps in that direction are observable now

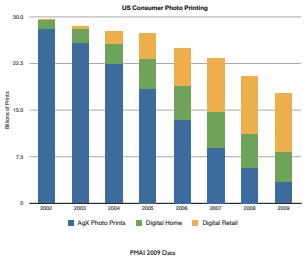
The End of the Existing Roadmap Mature Technologies

- Printing
- Resolution
- Compression
- Camera DSP
- Auto-Exposure
- Storage

Mature Technologies

- Printing
- Resolution
- Compression
- Camera DSP
- Auto-Exposure
- Storage

Photo Printing is Decreasing



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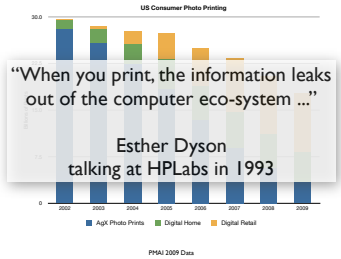


"When you print, the information leaks out of the computer eco-system ..."

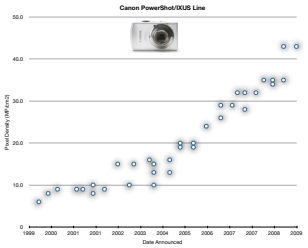
Esther Dyson
talking at HPLabs in 1993

Mature Technologies

- Printing
- Resolution
- Compression
- Camera DSP
- Auto-Exposure
- Storage

Feb 18, 2009

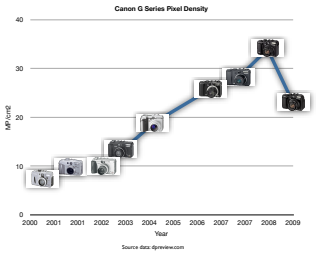
Ever Increasing Pixel Density



Limits to Resolution

- Diffraction Limit
- Lens Cost
- Motion and Blur
- SNR
- Manufacturing Precision
- Operating Precision (AF)
- Array Size
- Dynamic Range
- Flare
- Artifacts

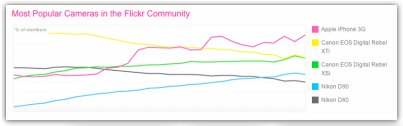
Evolution of Canon G Line

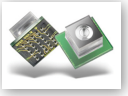


Mature Technologies

- Printing
- Resolution
- Compression
- Camera DSP
- Image Pipeline/AE
- Storage

The Age of the Camera Phone





Why Camera Phones?

- Quality approaching DSC
  - Low res OK - printing not required
  - Sensitivity high enough for most situations
- Large display for review and sharing
- Well integrated with metadata (GPS, date time, voice anotations)
- Well integrated with communications
- Small, low cost, always available

Current Image Quality Limitations for Camera Phones

- Low SNR and Dynamic Range
  - Small well capacity makes exposure critical
- Low quality Optics and limited AF
  - High F#, aberrations, vignetting, cross talk, flare
- Rolling exposure
  - Motion and lighting artifacts, no regular flash
- Poor IR filtering
  - Hot mirror causes IR contamination and purple spot

Poor IR Filtering

http://pocketnow.com/thoughts/clarification-the-pink-spot-syndrome

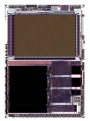
Emerging Functionality

- Metadata
- Smart Light
- Raw/Post Workflow
- Augmented Reality
- High Speed
- Advanced CMOS Sensors
- Photo/Video Convergence
- Robotic Capture
- Total Recall
- Motion Flow Computing
- Browsing and Searching
- DIY Cameras
- HDR
- 3D Capture
- Stereo and range
- Reflectance Field Capture
- Plenoptic Capture
- Biometrics
- Machine Vision
- Segmentation and matting
- Compositing
- Image Based Rendering
- Photo-Sharing
- Computational Photography
- Compressive Sensing

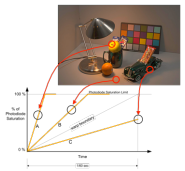
Emerging Functionality

- Capture all of reality - decide what to see and how to render it later
  - HDR
  - Smart Light
  - Photo/Video Convergence
  - Reflectance Field Capture
  - Plenoptic Capture
  - Total Recall
  - Robotic Capture

HDR Video Capture

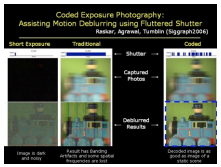


- Pixim built the first video rate HDR capture CMOS sensor and DSP
- Per pixel ADC allows multiple reads with a single reset
- On-board memory allows very high frame rate
- Image is read hundreds of times during each video frame exposure
- Only the highest SNR data is saved to memory



Smart Light

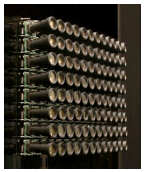
- Spatial and/or temporal modulation of the light enables many new modes of capture, some examples:
  - Flashes from multiple angles allow better image segmentation and picture enhancement (Raskar, et al, SIGGRAPH 2004)
  - Combining micro-projectors with structured light enables 3D capture
  - Pulsing LED illumination on-off with fast capture allows subtraction of the ambient light illumination
  - Pulsing the LED illumination at random intervals allows motion deblurring (Raskar, et al, SIGGRAPH 2006)



Convergence Video-Photo

- Key factors driving the convergence:
  - CMOS sensors do not require mechanical shutter
  - Solid state storage instead of tape
  - Increases in bandwidth for RAM, DSP and flash memory
- Choice between stream low res and high res stills disappears with semiconductor progress
- Difference may remain on the industrial design and usage

Light Field Capture



- Array of cameras can do much more than any element
  - Stereo or 3D from parallax
  - HDR from multiple exposures across sensors
  - High speed from exposure phase
  - Better color and multispectral by having different channel per sensor
  - Higher resolution by stitching or super-resolution methods
  - Selective focus and FOV
  - Higher resolution by overcoming diffraction limit of single lens
- Several different configurations have been proposed
  - Behind the in blocks (Keith Fife at Stanford)
  - Behind the lens with microlenses (Ren Ng, Stanford), or apertures (Adelson and Wang, MIT)
  - In parallel (Levoy et al, Stanford)

Reflectance Field Capture

- For a given scene, the hemisphere of ambient illumination is captured in HDR
- Real objects are captured with multiple lights at high speed so that any complex illumination can be synthesized by a combination of base images
- Real and artificial geometry can be inserted into any scene by this method

http://www.debevec.org/

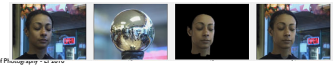
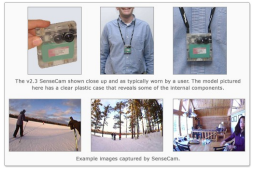


Photo Events

- Weddings
- Birthdays
- Yearbooks
- Family Reunions
- Performing Arts
- Sports/Team
- Cruise Ships
- High School Proms
- Nursery/Day Care
- Graduations
- Church Events
- Tourism
- Nature

Total Recall

- Sense-Cam
  - Work at Microsoft Research originated by Gordon Bell
  - Capture 100% of ones daily life
  - Use to aid memory or as a form of note taking
- Alternative camera from Johan Frossen


The v2.3 SenseCam shown close up and as typically worn by a user. The model pictured here has a clear plastic case that reveals some of the internal components.

Example images captured by SenseCam.

Robotic Capture

- Most elements are already in place
  - Sony Party-shot - Automatic Photographer
  - GigaPan Epic imager
  - Tessera FotoNation face recognition for cameras and cell phones
  - Existing CCTV equipment combined with existing tracking software
    - Visit London and ask for the tapes where you appear as a trip memento

Why do we Photograph?

- To document and preserve
- To share and communicate
- To understand, analyze
- To enjoy the craft and technology
- For social motivations
- To create

(Reuters/Kevin Lamarque)

Plenoptic Capture