The ***LIBERATOR***® and the Internet

Digital, Progressive Scan CMOS Camera and the Internet

Twenty years ago, only a handful of physicist and defense planers used the Internet. Now, billions of people access it every day. The Internet has wrought the biggest change in human communications sense the printing press. Billions of wealth will be crested as broadband and wireless networks become globally ubiquitous.

The Internet began with text, in the form of email and arcane scientific publications. With commercialization and faster processors came graphics, still photographs, voice, music and games. The next big thing was transport of black and white video then delayed full-motion and now near real-time, life-like (HDTV) images. All brought about by the phenomena of Convergence. In order for this process to reach its full potential there must be greater bandwidth (up to 100Mbits) and high quality HD video must become seamlessly interoperable with computers and scalable to accommodate the transition.

The ***LIBERATOR***® progressive-scan, digital, video camera addresses the need for both interoperability and scalability. It does so through changes in capture technology and the evolution of the economics that drives the Internet.

Capture Technology

The power and speed of computer processors is evolving at an incredible rate. Gordon Moore, a co-founder of Intel, stated that the power of the silicon chip would double approximately every 18 months, with proportionate decreases in cost. "Moore's Law" drives not only computers, but all electronics used in networks, telecommunications, wireless, satellites, and the signal output from "true digital" video cameras. As broader bandwidth becomes available, network users will embrace higher and higher quality video for consumer products, business-to-business commerce, health care, homeland security and defense.

Today, however, two technical issues stand in the way:

- At the outset of digital video conventional methods of capturing video images used analog technology
- The video information is processed to create "interlaced" formats where each frame is divided into two fields and mixed in time to produce a signal that confounds computers

  For decades, image capture technology for commercial cameras had been wedded to the Charged-Couple-Device (CCD). While this technology has been effective, it is inherently susceptible to analog artifacts. Plus it must be de-interlaced and digitized to be interoperable with computers and the Internet.

  Computers, and their peripherals such as networks and displays, are designed to be inherently linear in their "thinking." But interlaced formats are non-linear, providing half of the video information, then trying to turn time backwards to provide the other half. In the process, artifacts are created that are impossible to remove, and the fidelity of the image is degraded. A simple example of the degradation in an image is given in the two illustrations at the end of this paper, which show snapshots of a rolling multicolored ball. The top illustration is of an interlaced video format and the bottom picture shows a progressive format.

  Computer engineers recognized the inherent shortcomings of interlaced displays many years ago by the fact that text characters, then the only information transmitted, were badly "jagged" and nearly unreadable. NASA's $20 bill experiment (below) illustrates the potential "recognition" problems caused by an interlaced image on a computer display. Consequently, all computer displays are designed around progressive formats.

  To overcome the disadvantages of CCD technology and significantly improve camera performance, DARPA and NASA's Jet Propulsion Laboratory (JPL) invested in developing Complementary Metal-Oxide Semiconductor Sensors (CMOS). Subsequently, DARPA contracted with Liberty Imaging and

Kollmorgen, Inc, Electro-Optical Division, which has a 90-year tradition of designing submarine periscopes for the U.S. Navy, to explore two HDTV camera designs. The work included adapting the first generation HDTV CMOS digital sensor developed by Photobit, Inc., a spin-off of JPL.

Following this R&D stage, Liberty began working with design fabricators like Rockwell Scientific to develop commercial versions of what is now called CMOS Active Pixel (AP) imaging System on a Chip (iSoC).

As a digital device, this American technology not only offers superior images compared to analog CCD's, but is addressable and programmable, two controlling mechanisms essential to achieving scalability.

Liberty is implementing the international HDTV progressive video production standard known as SMPTE 296M (1280H X 720V or 720p) and SMPTE 274M (1920H X 1080V or 1080p) which are the first full-motion (60Hz) commercially viable HDTV format that eliminate undesirable interlace artifacts and are fully interoperable. Further invaluable DSL bandwidth, internet-compatible SMPTE 259M-C (720H X 480V or 480p) can be derived for homeland security applications. Each standard was developed as, highly desirable, widescreen (16 X 9 AR) to more accurately depict the real world view of human activity.

Liberty uses bin-sampling techniques to create 480p pictures that are superior to images captured by native 720p or 480p CCD cameras. Moreover, both simulations and experiments have shown that a better 480p image can be obtained from 720p than from the HDTV interlace 1920H X 1080V format, which memorializes the interlace artifacts in the resulting 480p image.

Internet Economics

The ***LIBERATOR®*** camera is designed to maximize the scalable flexibility of this new digital sensor technology.

Since progressive-scan formats are inherently computer-compatible, computer design techniques are heavily used in the ***LIBERATOR®*** camera. This design strategy gives Liberty the same growth and cost advantages that it gives to the computer designer. Furthermore, since the ***LIBERATOR®*** is inherently digital, from the light collecting sensor to the signal output, processing is only limited by the speed of the circuitry and the economics of building it to provide the required function.

CMOS-AP-iSoC facilitates on-chip processing making the sensor addressable and programmable. This smart-camera feature provides unprecedented remote control of the camera to accommodate planned and unforeseen changes. Liberty's camera design, when fully developed, broadens this concept by introducing an in-camera open-architecture processing station. Third-party developers can write application-specific "analytics" software to auto-control the camera or operate on the signal. They could, for example, enhance the dynamic range where the area of interest has moved into the shadows. The long-range goal is to develop the Basic Camera as a generic tool.

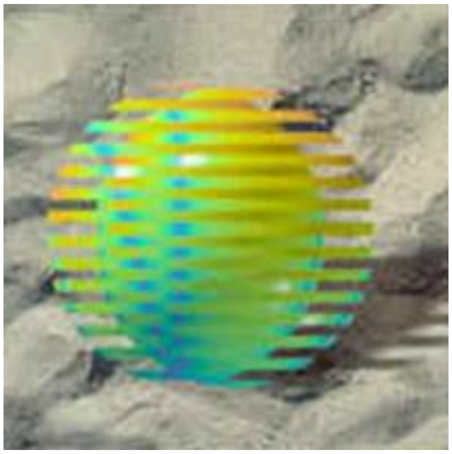
The one thing that frustrates the distribution of quality video today is the slowness of the present Internet infrastructure. However, this bandwidth problem is changing quickly. Through industry/government partnerships, the Next Generation Internet is developing advanced networking technologies and revolutionary applications that leverage them, and demonstrating these capabilities on test beds that are 100 to 1,000 times faster end-to-end than today's Internet.

The future of video over the Internet is open-ended. Progressive Scanning is an important component, and digital production standards are now in place. What is needed is a flexible generic camera that can provide a compatible and scalable signal to meet the various format needs of the evolving Internet. The ***LIBERATOR®*** takes advantage of innovative CMOS sensors and Moore's Law to provide progressive-scan cameras that are designed to scale up in support of the emerging worldwide digital infrastructure.

When interfaced with Liberty's new patented broadband wireless dual use systems it will constitute the next major evolutionary stage in the development of advanced imaging communication.

The ***LIBERATOR***® is coming!

Interlaced versus Progressive Scan Image Capture



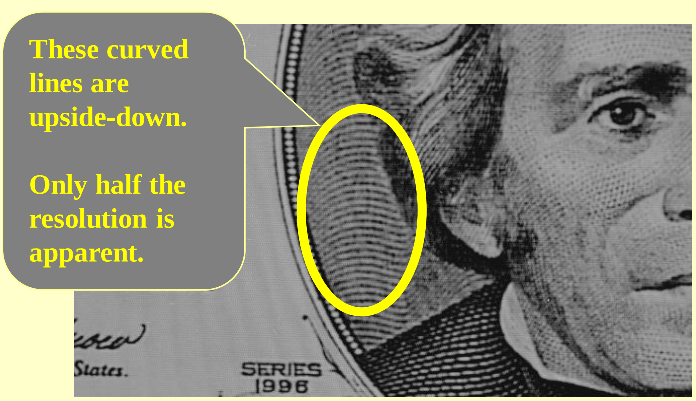
To the left is an image that is composed of two fields of interlaced video. Since the billiard ball has moved between the times the first field and the second field, the edges of the ball exhibit an artifact that is not correctable.

To the right, is a progressive-scanned image of the same scene and motion as shown. Notice that the ball is shown as two, separate, smooth spheres. A succession of such images, appears in motion picture frames, provides a very high-quality presentation of motion that is free of artifacts.

Images Courtesy of NASA, DTV Program

Close-Up Interlace Freeze Frame

$20 Bill Framing



Close-Up Interlace Freeze Field

Close-Up Progressive Freeze Frame