

Trends in Signal Processing Applications and Industry Technology

IEEE Industry DSP Standing Committee (IDSP-SC)

Moderator:

Fa-Long Luo

(Chair of IDSP-SC)

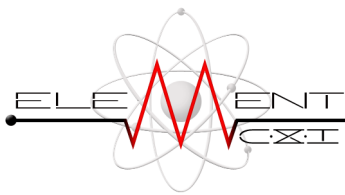
Expert Speakers:

Ward Williams, Element CXI, USA

Rajesh Narasimha, Texas Instruments, USA

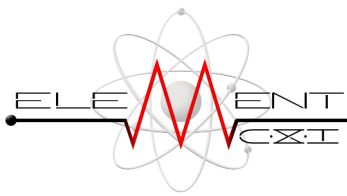
Raghuveer M. Rao, Army Research Laboratory, USA

- Introduction to IDSP-SC (*Fa-Long*)
- Overview: Emerging SP Applications and Industry Technology (*Ward*)
 - ❖ Digital and Software RF Processing
 - ❖ Single-Chip for All Digital Processing
 - ❖ SP and Nano-Scale Technology
 - ❖ SP in Reconfigurable/Cognitive Radar
 - ❖ SP in Smart Internet of Things
 - ❖ SP in Cloud and Service Computing
 - ❖ SP in Smart TV
 - ❖ SP in 3D TV
 - ❖ SP in 4K-TV and UHD TV
- Case 1: SP Makes Smart-Phones/Smart Processing (*Rajesh*)
- Case 2: Autonomous System Perception (*Raghuveer*)



Introduction to IDSP-SC

- One of 13 Technical Committees of IEEE SPS
- Promote Emerging SP Applications and Industry Technology
- Promote Industry Participation in the SPS and IEEE
- Organization of the Industry Technology Track (ITT) for ICASSP since 1999
- Organization of the Emerging SP Applications Track (ESPA) for ICASSP from 2012
- Organization of Special issues for IEEE SPS Transactions and Magazines.
- Representative in DSP-related standardization activities, regulation bodies and industrial alliances.
- Organization of special sessions for IEEE SPS flagship conferences.
- Nomination of papers for the IEEE SPS Paper Awards
- Nomination of individuals for IEEE SPS Major Awards.
- Sponsorship and Advisory services for activities such as DSP-related professional certification programs.
- 24 Current Elective Members (Experts from Industry, Academic and Government)
- Three-Years Term and 5 New Members are Open for Year 2012 (Nomination-Welcome)

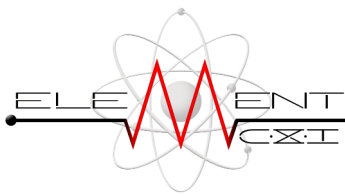


➤ Overview: Emerging SP Applications and Industry Technology

Ward Williams, Element CXI

- Digital and Software RF Processing
- Single-Chip for All Digital Processing
- SP and Nano-Scale Technology
- SP in Reconfigurable/Cognitive Radar
- SP in Smart Internet of Things
- SP in Cloud and Service Computing
- SP in Smart TV
- SP in 3D TV
- SP in 4K-TV and UHD TV

Connectivity, Enabling Technology, and Display



Definition:

- ✓ *Replace Analog Processing with Digital Processing as Much as Possible*
- ✓ *Move A/D and D/A as Front as Possible*
- ✓ *Digital Compensation for Analog Impairments as Many as possible*

Benefits:

Low Power, High Flexibility, Low Cost, Multiple Standards, and Multiple Modes for Wireless Communication, Digital Broadcasting, Radar and Sonar)
10% PAPR (Peak-to-Average Power Ratio) Reduction >> OPEX Savings

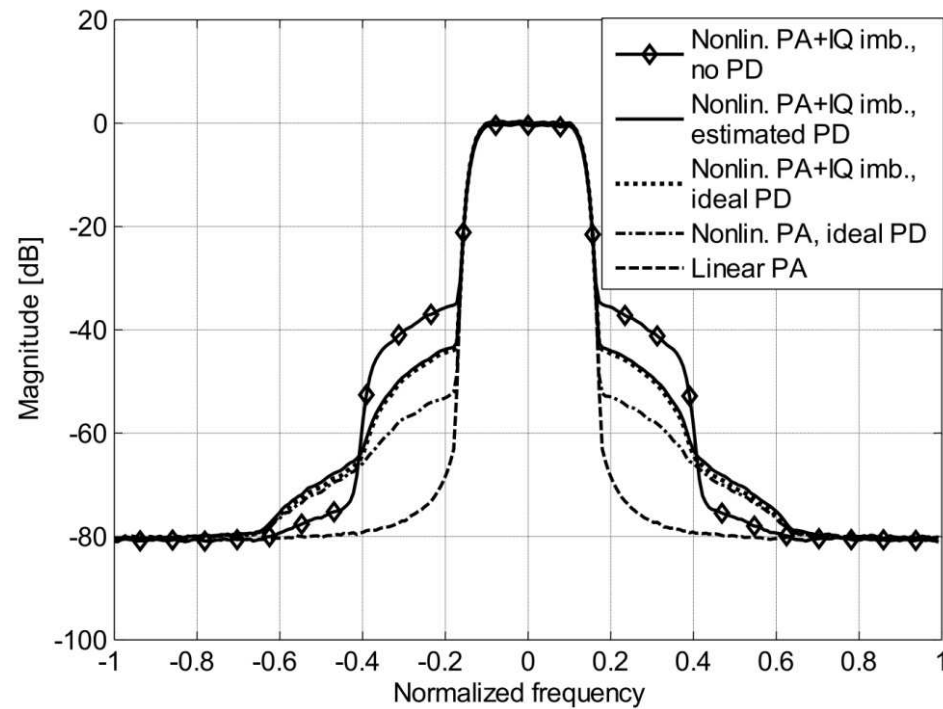
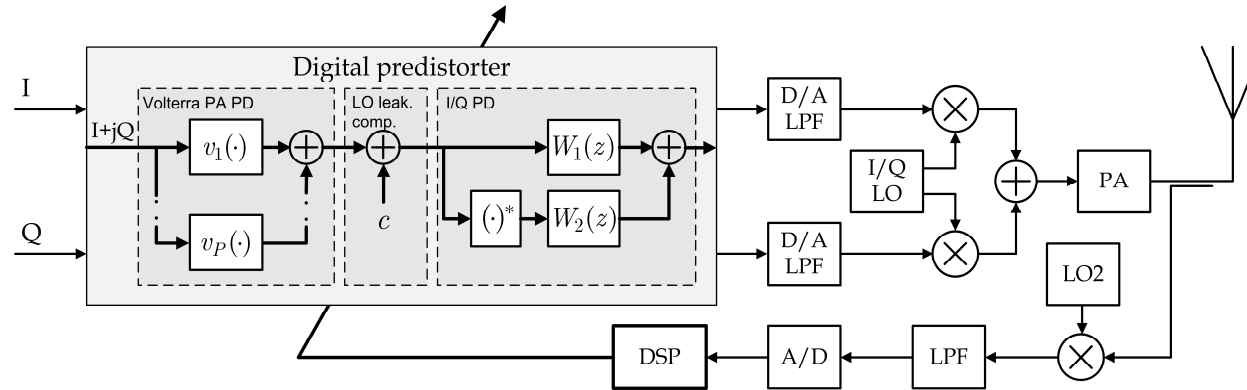
Open Topics:

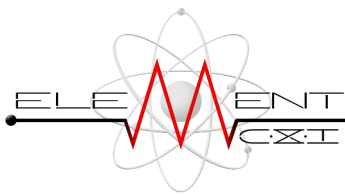
- *Digital Pre-Distortion (DPD) and Crest Factor Reduction (CFR)*
- *Digital-Up Conversion (DUC) and Digital-Down Conversion (DDC)*
- *ADC and DAC*
- *Re-sampling Algorithms and Mismatch/Imbalance Compensation*
- *Noise Shaping and Pulse Shaping*
- *Numerical Controlled Oscillator and Digital Mixer*

New Book: [*Digital Front-End: Circuits and Signal Processing*](#)

See Exhibitor: Cambridge University Press

Representative Case: Joint DPD for PA and IQ Mismatch





Single-Chip Solution for All Digital Processing

Definition:

Single Computing Platform to Perform all Digital Processing from RF through Base Band to Multimedia Application Layer

Benefits:

Replace ASIC for Flexibility/Upgrade

Replace FPGA/DSP for Performance/Power Consumption

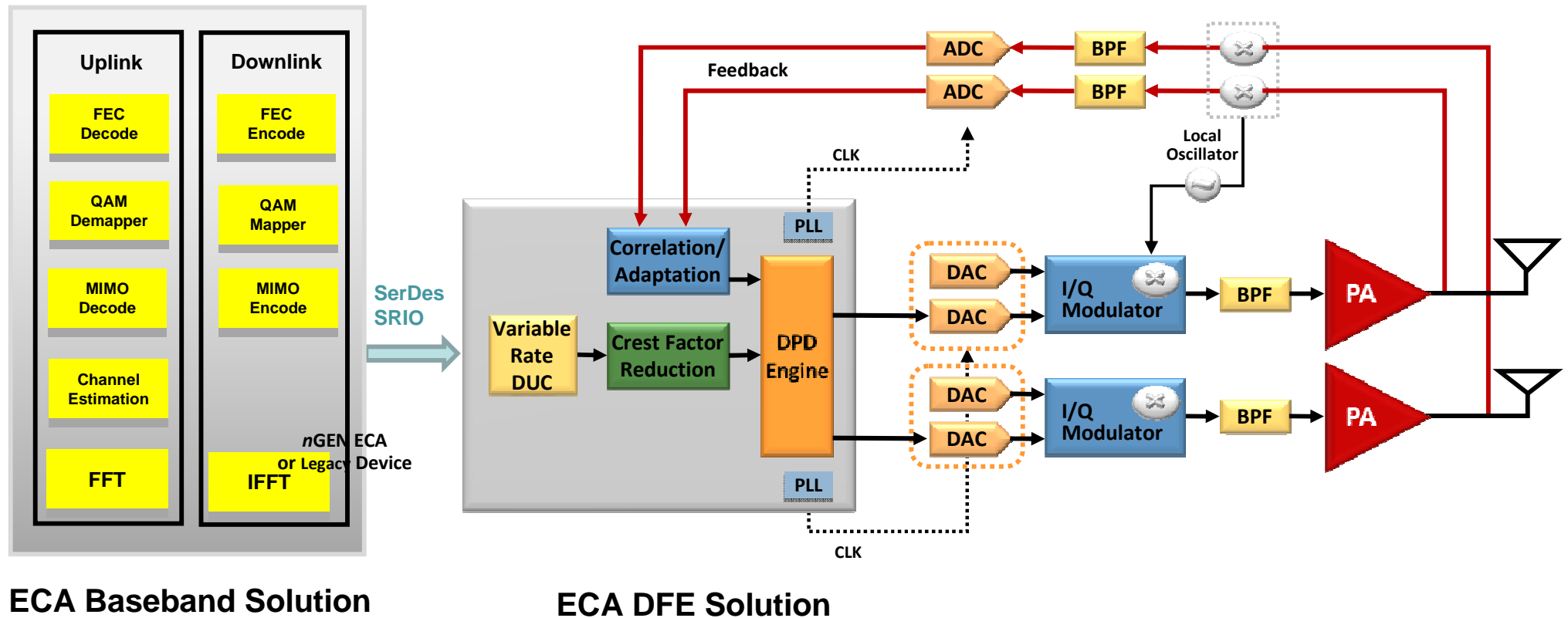
Replace FPGA/DSP +Hardware Accelerators for Interface/Programming

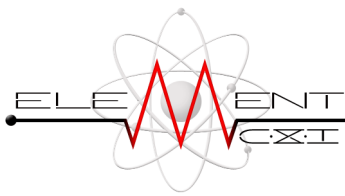
Open Topics:

- *Manycore/Multicore Architecture and Programming Models*
- *Homogeneous/Heterogeneous Architecture and Programming Models*
- *FPGA/DSP +Programming Hardware Accelerators*
- *Reconfigurable Architecture and Programming Models*
- *As Good as ASIC in Performance/Power/Prize/Size*
- *As Flexible as FPGA/DSP in Multiple Standards/Modes/Layers/Algorithms*
- *As Easy as C in Programming Model*

Representative Case: Single ECA Chip for Baseband/DFE

- *Low cost, lower power replacement for FPGAs and DSPs*
- *Ideal for both baseband and digital front end processing*





Definition:

Technology in Nano-Scale Includes: Nano-Network, Nano-Robotics, Nanosecond Processor (GHz Scale), Nanoscale CMOS Circuits and Sensors, 3D IC and Wafer

Benefits: The Olympic Motto: *Citius, Altius, Fortius- Faster, Higher and Stronger*

Open SP Related Topics:

- *Nanosecond Processor based Real-Time SP Implementation (to Perform Matrix Computation in Nanosecond)*
- *Nano-Scale CMOS based Image Sensors and Processing*
- *High-Speed and Low Power ADC, DAC and Re-sampling*
- *Low-Voltage Nanometer CMOS based Radio Frequency Signal Processing and Circuit Integration in Wireless Communication*
- *3D Circuit Based Signal/Data Processing, Storage and Computing*
- *High-Frequency Filter Design and Implementation in Nano-circuitry*
- *Optical Signal Processing with Nanophotonic Structures/Quantum Dots*



Definition:

“A radar adapts intelligently to its environments on the basis of a plurality of potential information sources”

Benefits:

Adaptive Radar Scheduler/Data Product Generation

Adaptive Transmit/Receive Chain

Enhanced Real-Time Adaptivity

Open Topics:

Adaptive Power Allocation

Digitization and Processing of RF and Front-End

Diversity Technology (Time/Frequency/Spatial/Embedded Domain)

High-Performance Computing Platform and Programming Model

Knowledge-Aided Processing and Learning

Environmental Dynamic Database and Data Mining

Definition:

All devices and places are universally IP enabled and an integral part of the Internet .

*These devices are called **smart objects** whose examples are mobile phones, personal health devices and home automation, to industrial automation, smart metering and environmental monitoring systems.*

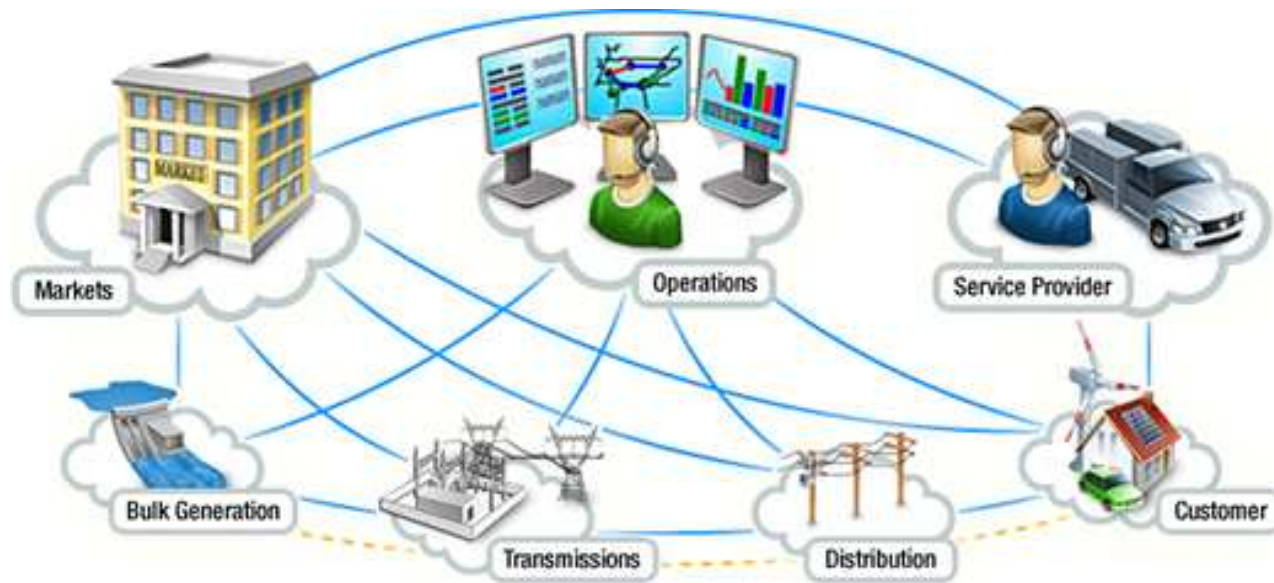
Benefits:

Better Environmental Monitoring, Energy Savings, Smart Grids, More Efficient Factories, Better Logistics, Better Healthcare and Smart Homes.

SP Related Open Topics:

- *Ubiquitous Information/Signal/Data Capturing/Sensor*
- *Wireless Embedded Technology (ZigBee/Proprietary networking solutions)*
- *RFID: Circuits and Integration*
- *Information/Signal/Data Coding and Compression*
- *Security Authentication, Key Management and Routing Algorithms*

Representative Case: Smart Grid



Six Components: Bulk Generation, Transmission, Distribution, Customers, Operations, Markets and Service Providers

Three Layers: (i) the Power and Energy Layer, (ii) the Communication Layer and (iii) the IT/Computer Layer

Signal Processing Mainly in Layer II: Smart Metering and its Wireless Communication Architectures; SoC Microcontroller with Ultra-Low-Power Operation (TI's MCU Chip), Modeling for Power Grid Data and State Estimation; Algorithms for Real-time Fault Detection, Isolation, Recovery, and Load Balancing.

- Smart /Connected TVs and displays of all sizes
- 3D TVs and other CE devices
- Next generation and next-next generation resolutions

Definition

Related Terms: IPTV, iTV (interactive TV), Social TV, Mobile TV, Personal TV, IMS (IP Multimedia Service) and MBMS (Multimedia Broadcast and Multicast Services)

Convergence in Three-Levels:

Terminal level: One Device Fits and Enables All

Service Level: Fixed, Mobile, Cable, Wireless and Digital Broadcasting

Transport and Network Level: A Common and Standardized Set of Protocols and at Access Layer on the basis of Different Radio Technologies.

Benefits (compared to traditional TV)

Interactivity, Video-on-demand, Broadcast, Unicast, Multicast and Geocast, Time-Shifting Programming, Triple-Play, Third or Quad-Screen , Experiences and Mobility.

SP Related Open Topics:

Baseband Processing in DVB-T/H/SH/T2 , ISDB-T/S, CMMB, T/S-DMB , ATSC/MH

Basedband Processing in 3G, 4G and beyond

Multimedia Coding and Decoding /Cross-Layer Coding

White-Space and Dynamic Spectral Management

Digital Front-End and Software Defined RF

Digital Right Management

Circuits and Signal Processing for Display Technology

Definition:

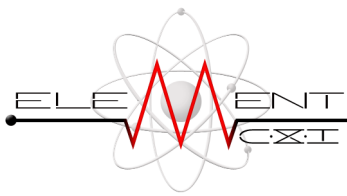
Extending multimedia contents and communications with a third dimension, or otherwise capturing a dynamic scene in three dimensions and generating an optical duplicate of it at a remote site and in real-time.

Benefits:

Enable stereoscopic depth perception with providing different images to each eye

SP Related Open Topics (Entire Chain)

- *3D Capture and Processing/Multi-Camera Synchronization , Recording and Tracking*
- *3D Representation/ 3D Segmentation (Texture, Object, Point Mesh and Volumetric) representations*
- *3D Transmission/3D Streaming (Multi-View Compression/Coding/Decoding)*
- *3D Display (Auto/Stereoscopic/Holographic) and Format*
- *DSP/ASIC Processors/Co-Processors /GPU for 3D*
- *Combination of 3D Video/3D Audio (Surround Sound)*
- *Human Factors (Benefits, New Applications and Side Effects)*
- *3D Content-Based Retrieval , Indexing and Recognition*
- *Transfer and Compatibility Between 3D and 2D*



SP in 4K-TV and UHD-TV (SHV-TV)

Definition:

4K-TV: Resolution: 4,096p x 2,160p (double times HDTV: 1920*1080))

UHD-TV (Ultra High Definition-TV) and SHV-TV (Super-High Vision TV)

Resolution: 7,680p x 4,320p (four time HDTV)

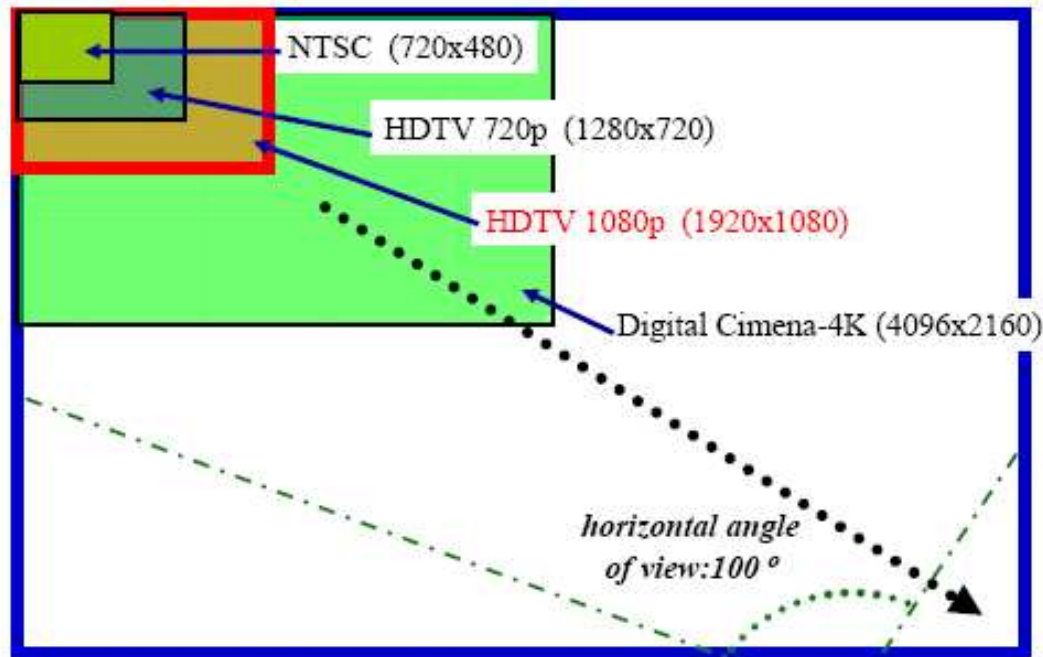
Benefits:

To further improve the quality and resolution of the delivered content and to bring highly realistic sensation for users/ to improve the related coding technologies/ communication and broadcasting infrastructure.

SP Related Open Topics (Entire Chain)

- *Compression, Coding and Decoding*
- *Color Conversion, Color Correction, Down-Sampling and Up-Sampling*
- *Capture, Recording and Tracking*
- *Transmission, Digital Broadcasting and Steaming*
- *Display Technology and Format*
- *DSP/ASIC Processors/Co-Processors /GPU and SoC*
- *Human Factors (Benefits, New Applications and Side Effects)*
- *Perceptual Quality Assessment and Modeling*

- **Representative Case: 4K-TV/UHD-TV Through Ultra-High Speed Wireless Communications using Terahertz Waves**



Super Hi-Vision /Ultra-High Definition Video(7680x4320)



24 Gbit/s for UHD-TV, which requires over 40 GHz DSB Bandwidth for ASK Modulation Format → 300~500 GHz: Terahertz Waves based Technology

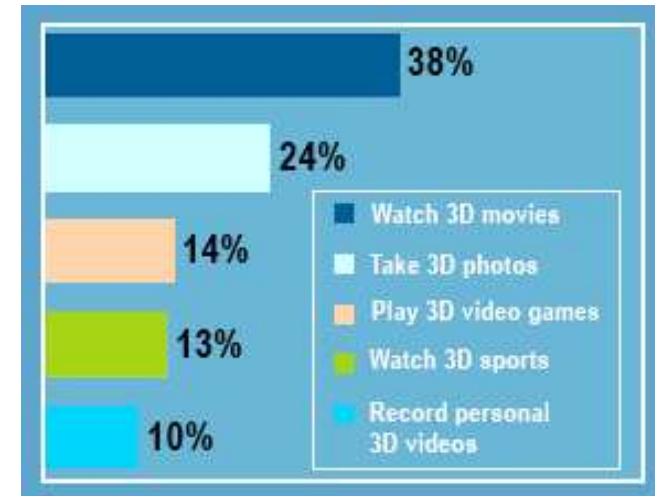
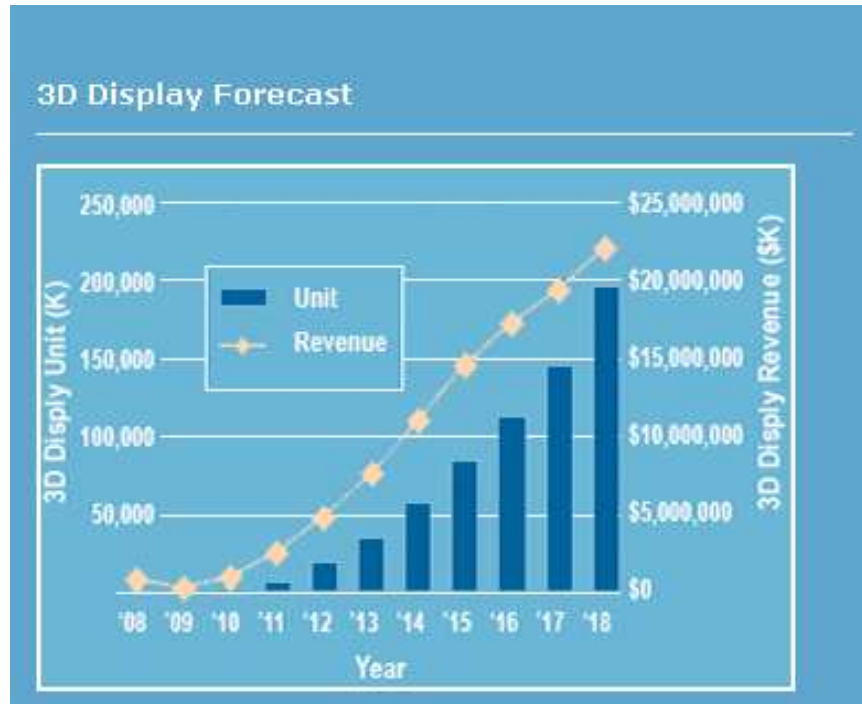
SP Makes Smart Phones/Smart Processing

Rajesh Narasimha

Video, Image and Vision Lab
Systems and Applications R&D Center
Texas Instruments

These slides are based on public information and do not pertain to Texas Instruments.

3D Market



- 3D movie space is doubling each year with live-action theatrical performance accounting for about 50% with the rest being 3D animations and sourced from 2D-3D conversion techniques.
- 3D televisions is projected to reach a total of 23.4 million units worldwide for 2011
- 3D is not marketed as a must-have technology but as a desirable feature
- 3D broadcast television content has been primarily for sports, but in future will move into primetime entertainment, movies, documentaries, and other features

3D TV

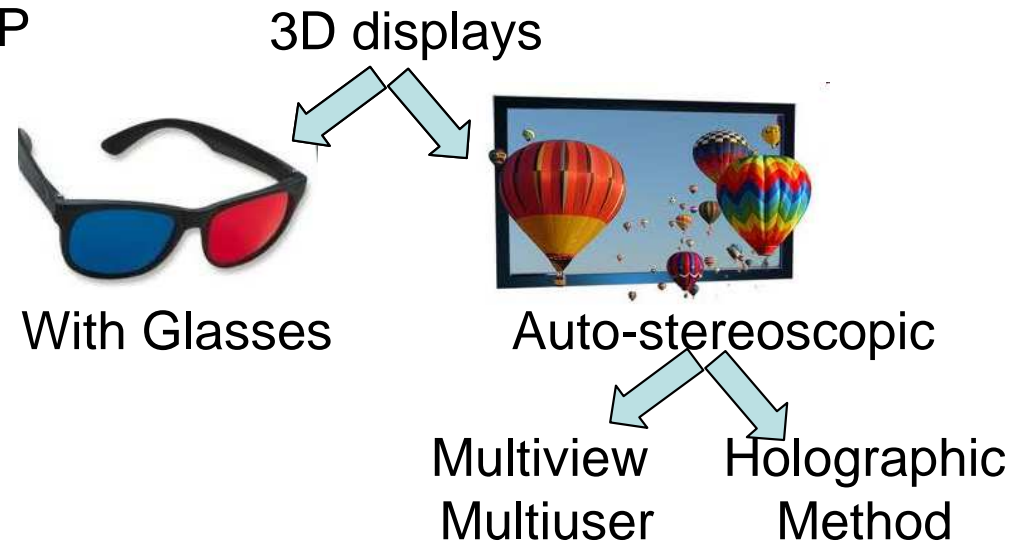
TV Type : Plasma, LCD, LED and DLP



Panasonic Plasma



Sony LED



- Full HD is a must have feature and TV manufactures are aggressively marketing this to promote Blu-Ray
- Technical issues are to be solved
 - Loss in brightness,
 - Crosstalk (Ghosting/Leakage)
 - Missing standards and compatibility
- Real-time 2D-to-3D conversion is very important for consumer 3D systems but is very far from achieving satisfactory/robust results
- However, lacking social acceptance of wearing glasses is the major problem
- Community and market researchers agree: Glasses will only be a transition technology towards auto-stereoscopy

3D Smart Phones

- Smartphone 2.0 Era with 3D's (Dual-core technology with 1Ghz processor, Dual Memory and Dual Channel – **LG Optimus 3D**)
 - significantly improved performance and run-time compared to smart phones offering 1GHz dual-core processors, as a result of the simultaneous and thus faster transfer of data between the dual-core and dual-memory
 - supports Faster web browsing, high quality gaming and HD videos
 - Seamless multitasking, content sharing, 3D playback and recording
 - easily upload and stream 3D content and share each other's creations on YouTube's dedicated 3D channel (youtube.com/3D)
 - **No glasses, auto-stereoscopic with 24mm separation and 2D-3D conversion features**
- **HTC EVO 3D** - 5MP dual camera for 3D pictures and videos with Dual LED Flash + 1.3MP camera in front for video calling + 1.2 GHz dual-core processor

➤ **Technical Challenges**

- Color/Contrast mismatch
- Auto-convergence for various scenes
- Misalignment correction
- Stereo Crosstalk
- Resolution mismatch

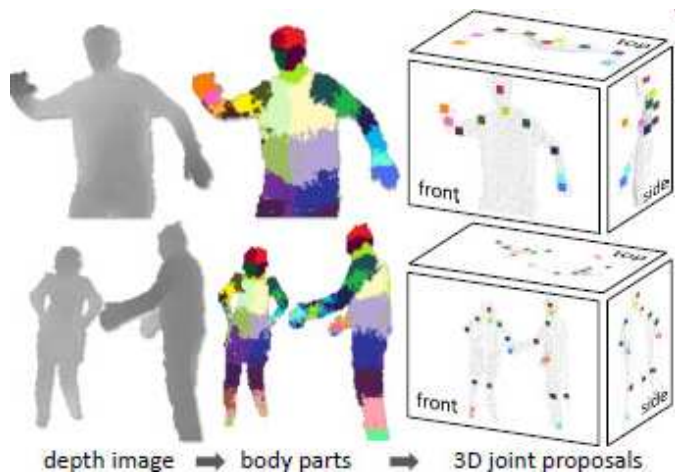


Gesture recognition and Motion Sensing

- Depth Maps based on Time Of Flight and Structured Light
- Microsoft Kinect was named the “Fastest Selling Consumer Electronics Device,” by Guinness Book of World Records
- Open source tools for various platforms and software development kits (SDK) are available for developing AR and Gesture recognition apps
 - Examples are Kinect SDK for Windows, Qualcomm AR SDK and GestureTek Maestro3D SDK
- GestureTek, Soft Kinetic, Microsoft, OMEK and Primesense are the key companies in computer vision based gesture recognition and motion sensing.



Real time skeleton tracking by PrimeSense



Microsoft Kinet Body Tracking

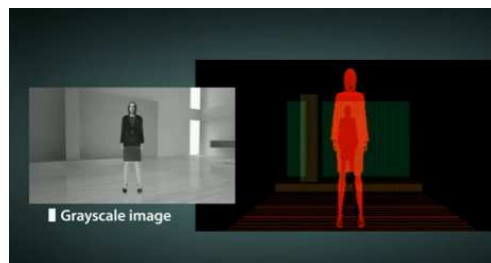
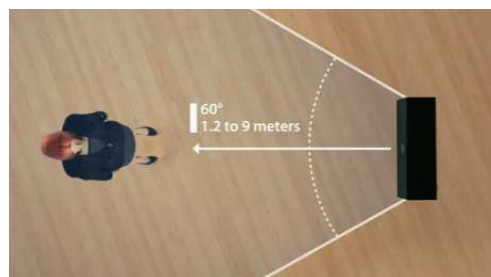


Tele-presence or Immersive Video Conferencing by Nuvixa

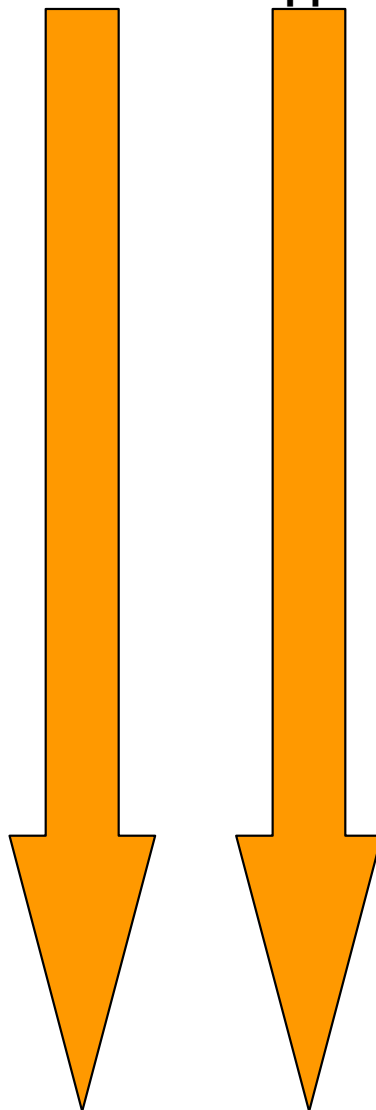


Interactive Displays by GestureTek

Example : Time of Flight based Applications



TOF depth Map
Generation Apps



Interactive
Display



Interactive
Mirror



Interactive Map



Interactive
Gesture Game



Interactive
Multimedia TV



Augmented Reality Applications



Acer AR advertisement



Tissot Watch AR experience



LEGO AR kiosk



BMW's AR data goggles teaches users vehicle maintenance



Layar- mobile AR browser



Word Lens : AR for real-time translation



AudiHUD



GM HUD - AR window shield



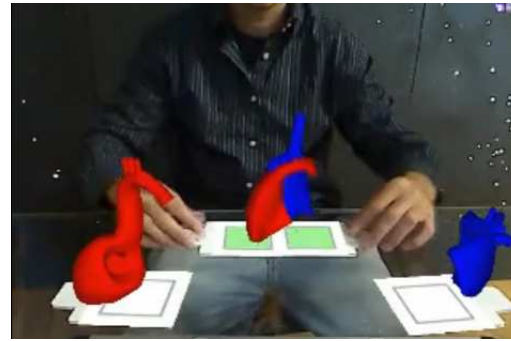
Google Goggles allows you to search the web through photos

Augmented Reality Applications

AR in Education



AR Books



Building the Human Heart



X-ray vision



QR "Quick Response" Code is a matrix code (or 2D bar code) to allow its contents to be decoded at high speed

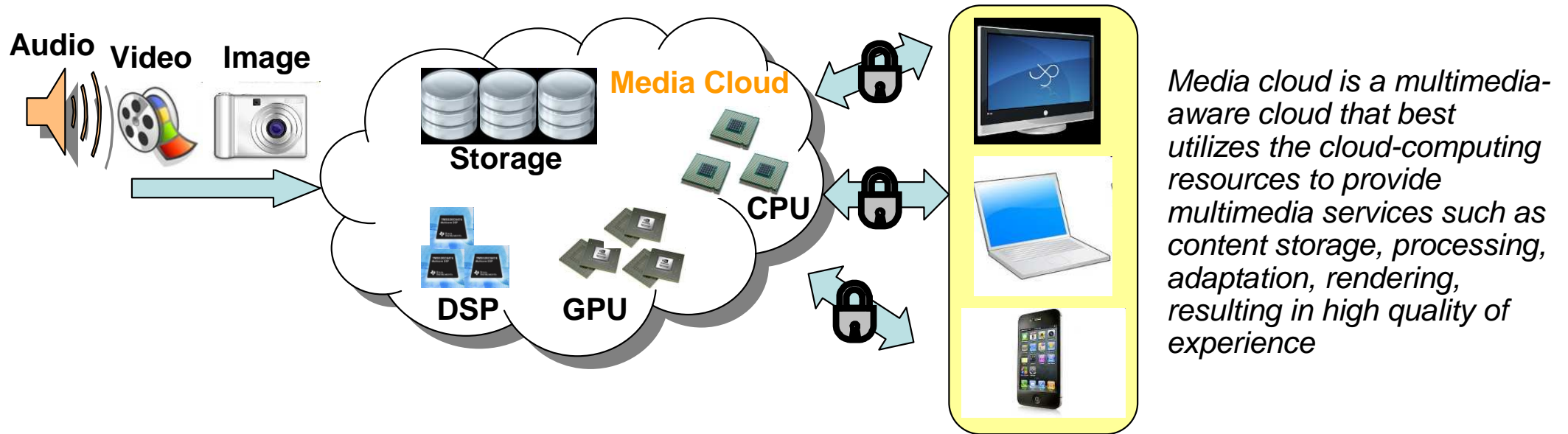


Microsoft Tag

➤ Technical Challenges

- Sensor Noise
- Registration and Tracking
 - Aligning a virtual object with 3D co-ordinate in the reality view
- Shadow and Illumination
- Virtual object rendering
 - Digital content rendered by the AR app and superimposed on the reality view.

Video Infrastructure on the Cloud



Media cloud is a multimedia-aware cloud that best utilizes the cloud-computing resources to provide multimedia services such as content storage, processing, adaptation, rendering, resulting in high quality of experience

- Internet video alone will account for 57% of all consumer Internet traffic in 2014 of which 3D and HD Internet video will be 80%. Almost 66% of the world's mobile data traffic will be video by 2014
- Examples :
 - Green Parrot Pictures provides video restoration and enhancement for cloud-based YouTube videos. The technology also uses less bandwidth and improves playback speed
 - Visual Search Tools such as Google Goggles and superfish.com offload computer vision algorithm computation onto the cloud.
 - Intel's Low Power Mobile Computer Vision
- Challenges
 - Bandwidth vs. Computation tradeoffs
 - Delivery of various types of multimedia and services to millions of users simultaneously (VoIP, video conferencing, streaming, video/image search, image-based rendering, video transcoding and adaptation etc...)
 - multimedia adaptation capability that fits different types of devices, including CPU, GPU, DSP, display, memory storage, and power ensuring QoE to various clients (TV, PCs, handheld devices and mobile phones)

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The Challenge:

“To understand the environment with respect to objects, events & processes and communicate this understanding to a human being”

Spatiotemporal perception

Soldier on patrol

context recognition

Dismount

Rifle

object recognition

Foreground vegetation

preprocessing



sensors



- Robust real-world algorithms for mid-level tasks
- Generating “complete” ontologies of scenes/ scenarios of interest
- Discerning and describing events beyond trained set
- Robotic perception:
 - Computation
 - Scalability over robot platforms
 - Interfacing with intelligence and HRI
- “Ground truthing” and performance characterization
- Performance optimization

- Multimodal sensors – implies multichannel signal processing
- Multiband processing & fusion
- Cue and behavior inference
- Symbolic representations

