Electrical & Computer Engineering
and
Research in the Video and Voice over Networks Lab
at the University of California, Santa Barbara

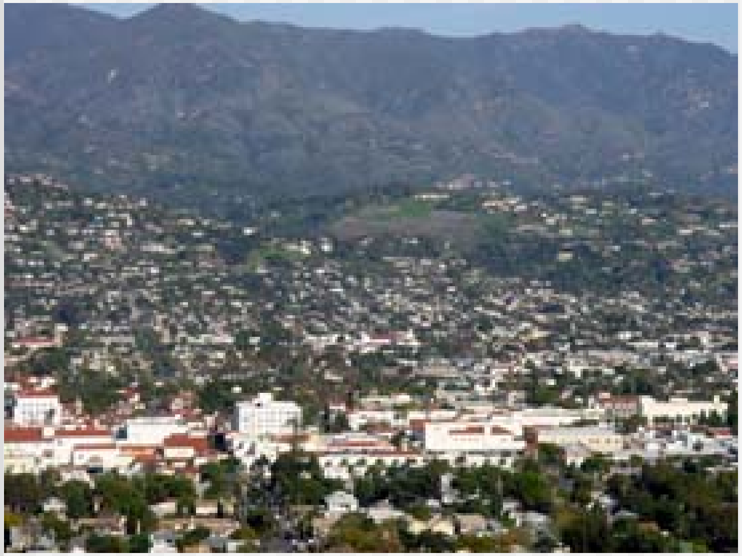
Jerry D. Gibson

October 19, 2011

Santa Barbara

- http://www.santabarbaraca.com/

Santa Barbara



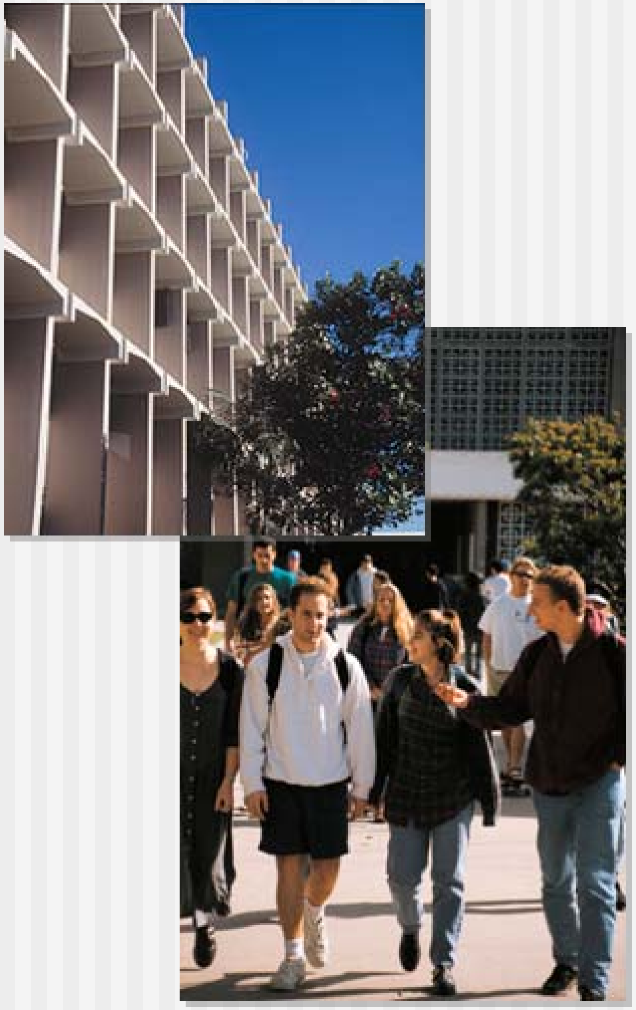
View of UCSB from the Pacific Ocean

View of UCSB from the Mountains

Main ECE Department Offices

ECE Department Statistics

- Faculty Size: 38
  - FTE: 35.58
- Graduate Students: 271 (F10)
- Undergraduate Students:
  - EE: 209 (F10)
  - CE: 152 (F10)
- Degrees Awarded (2010-2011)
  - PhD's: 33
  - Master's: 49
  - Bachelor's: EE: 40; CE: 16



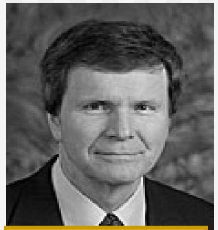
ECE Faculty Quality

- IEEE Fellows: 25
- American Physical/Acoustical Society Fellows: 5
- AAAS Fellows: 2
- Presidential Young Investigators: 6
- NSF Career Awards: 8
- ONR Young Investigators: 1
- ARO Young Investigator: 1
- UCSB Academic Senate Distinguished Teaching Awards: 9

ECE Faculty Quality – Cont'd

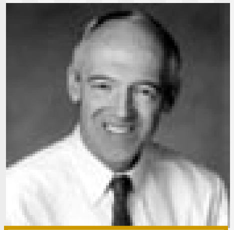
- 3 members of National Academy of Sciences
  - Gossard, Kroemer, and Rabiner
- 10 members of National Academy of Engineering


David Auston

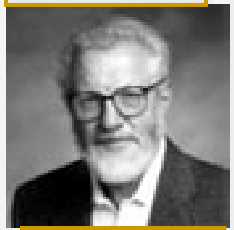

Rod Alferness


John Bowers


Larry Coldren


Arthur Gossard


Petar Kokotovic

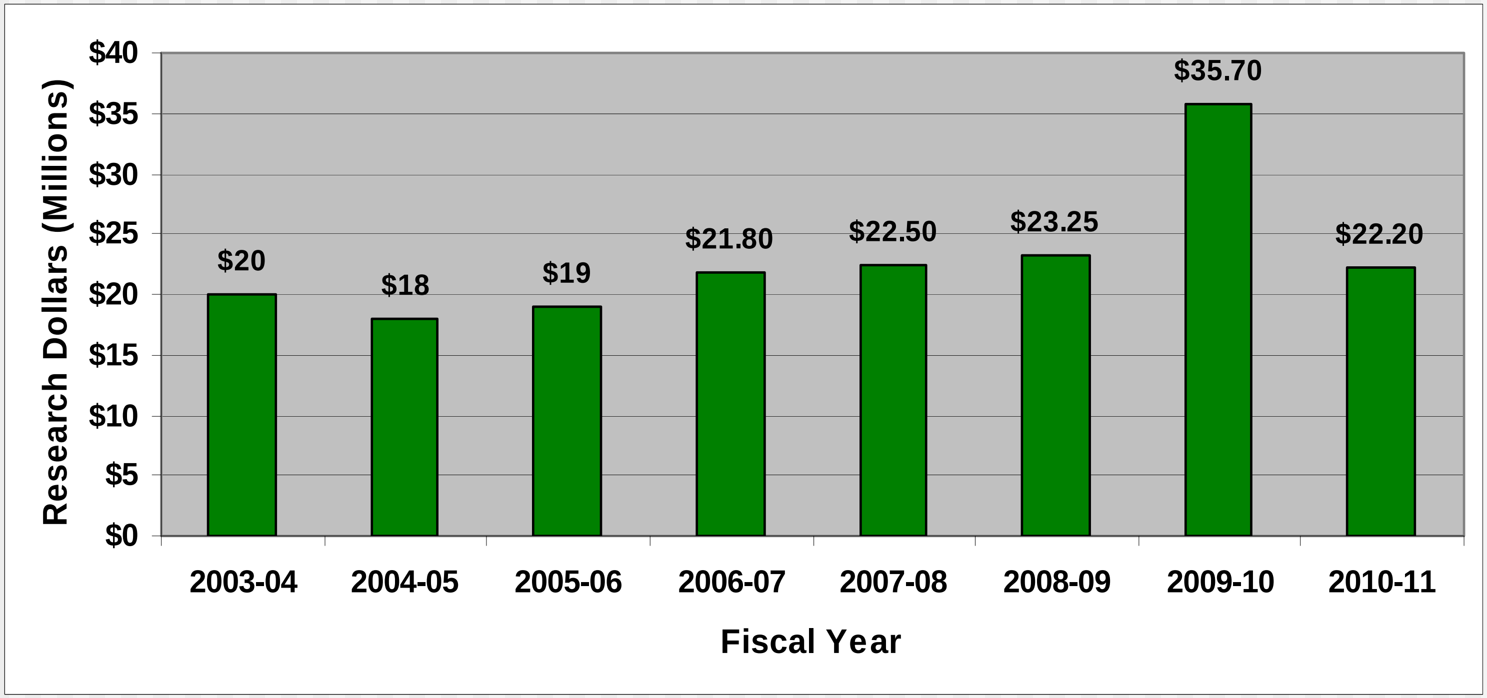

Herb Kroemer


Umesh Mishra


Sanjit Mitra


Larry Rabiner

ECE Research Funding



2009-10 Total: $35.7M

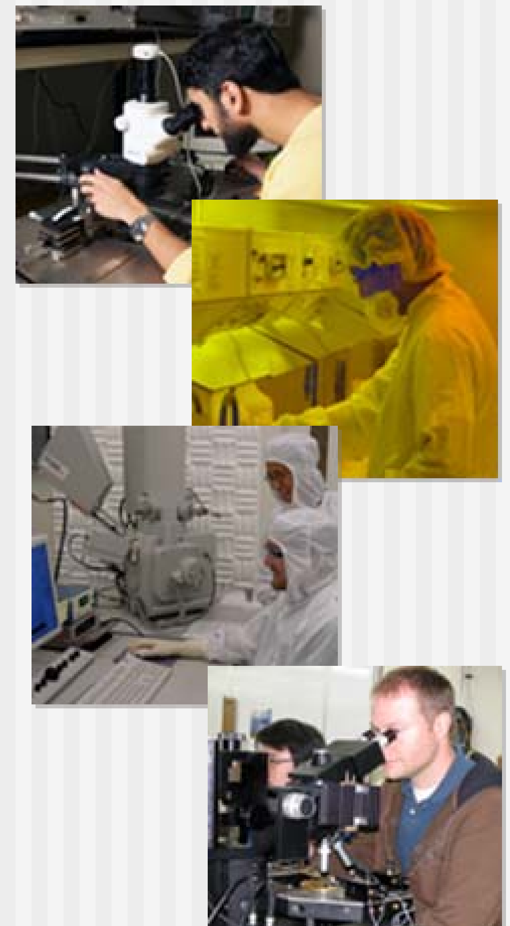
- Government: $32.5M
- Industry: $2.8M
- Other: $0.4M

2010-11 Total: $22.2M

- Government: $19.5M
- Industry: $2.4M
- Other: $ 0.3M

National Research Council Assessment of Research Doctoral Programs

- UCSB’s ECE department ranks among top five ECE departments in the nation
- Rankings are based on 20 program characteristics
  - 5th according to R-ranking
  - 4th according to S-ranking



NRC Rankings

1. Princeton University EE 1-3
2. Stanford University EE 1-3
3. Harvard University DEAS-Engineering Sciences 1-3
4. California Institute of Technology EE 4-8
5. UCSB ECE 4-8

- Others: Illinois 4-13, MIT 6-18, Berkeley 7-26

Other Rankings

- U. S. News Ranking of ECE Department is 17th
- UCSB ranked No. 35 in “Times Higher Education” World University Rankings for 2011-12
- UCSB ranked No. 24 of U. S. Universities in “Times Higher Education” World University Rankings for 2011-12

Ratio of UCSB Bachelor’s Degree Recipients to Faculty Members

- ASEE Newsletter January 2011
  - UCSB ranks 17th for “lowest ratio of bachelor’s degree recipients to faculty members”
  - Reflects UCSB’s emphasis on teaching and mentoring

ECE Faculty by Research Area

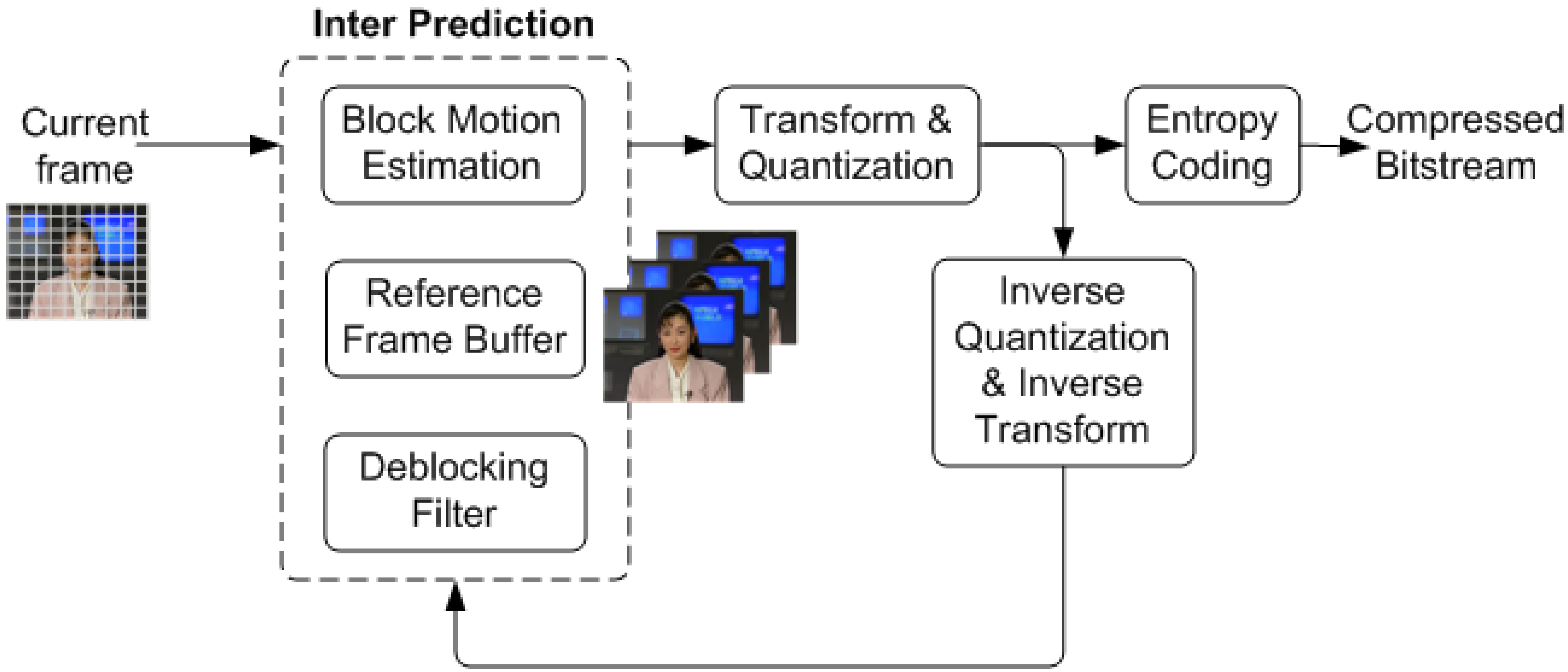
- Communications, Control, and Signal Processing (14)
- Computer Engineering (13)
- Electronics & Photonics (12)

ViVoNets Group

ViVoNets Lab Research

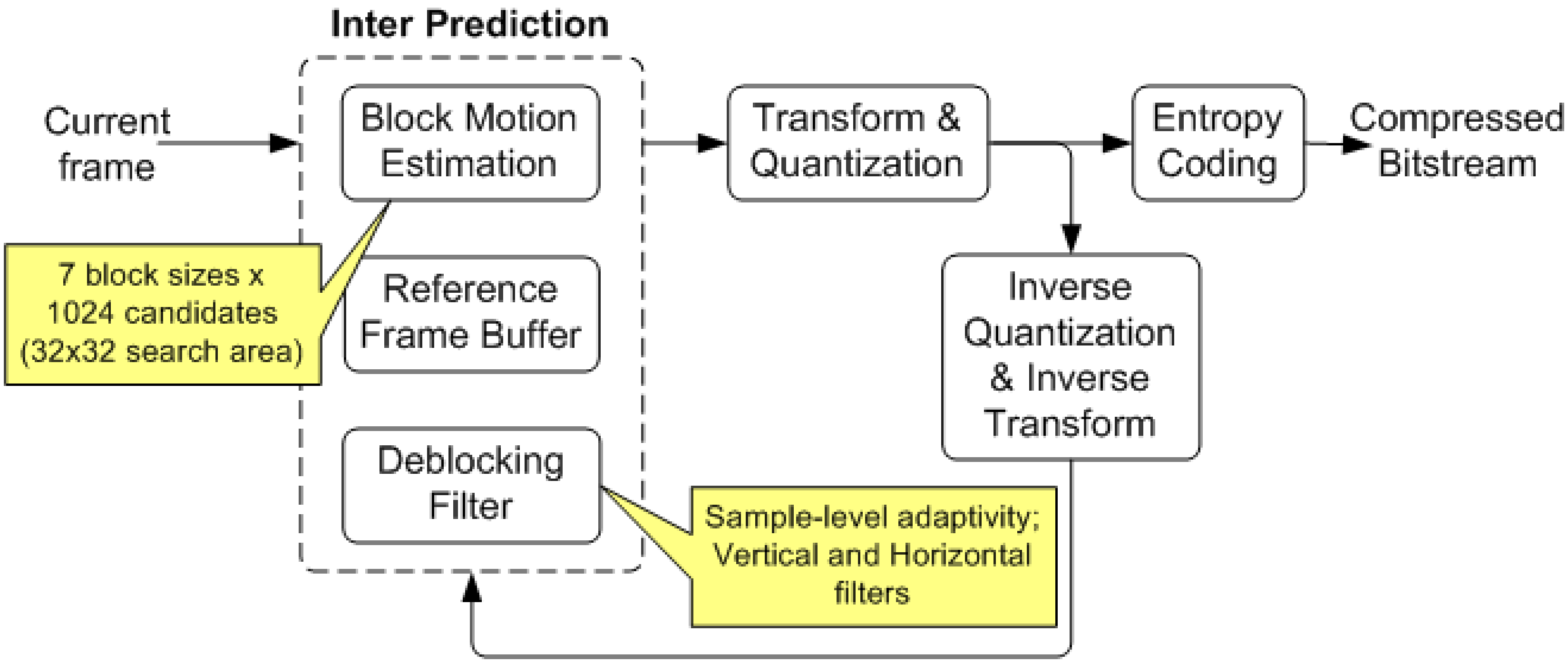
- All aspects of the transmission of voice, audio, still images, and video over mulithop, wireless, heterogeneous networks, with a particular emphasis on handheld devices and highly mobile broadband networks.
- Preprocessing and postprocessing methods, such as video stabilization, scene relighting, and 3D processing, particularly for multiple cameras.
- **Overarching Goals:** Advance the understanding of fundamental limits on system performance and to contribute to the state-of-the-art in digital signal processing, perceptually based performance measures, source coding, channel coding, and modulation.

Standard Video Encoder: High Complexity



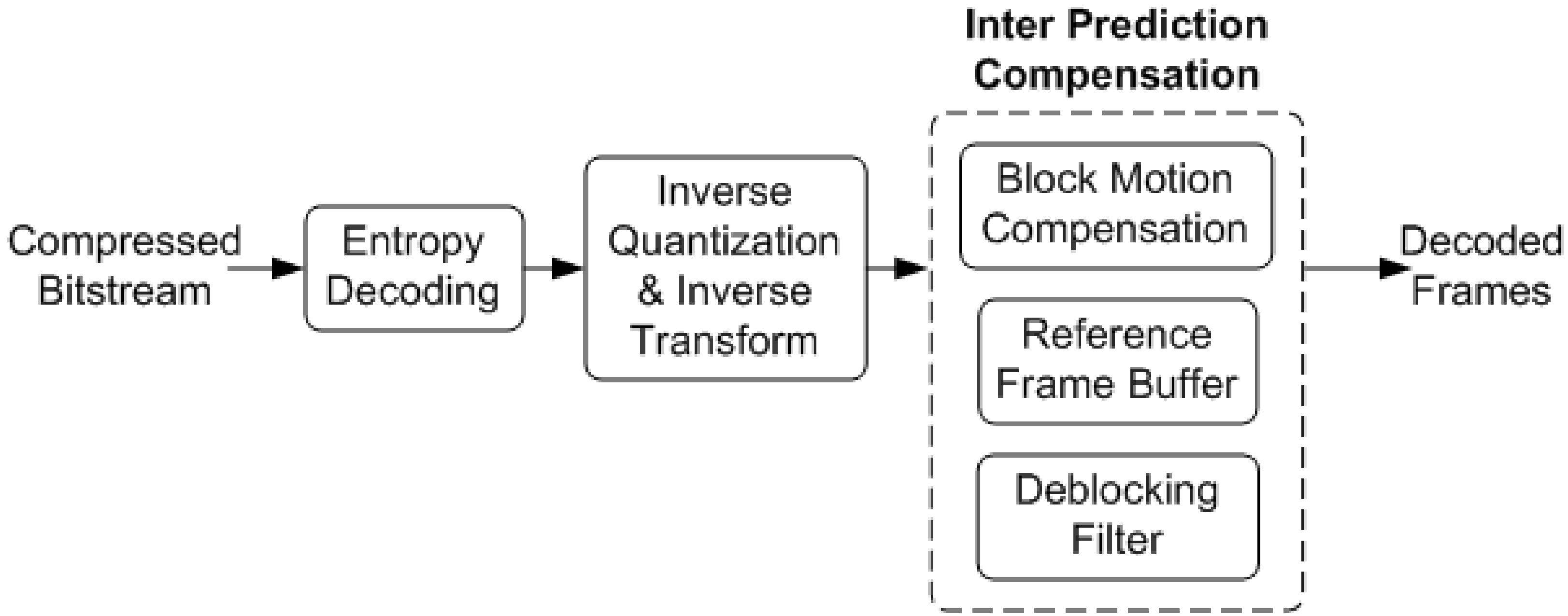
Block diagram of H.264 inter encoder

Standard Video Encoder: High Complexity



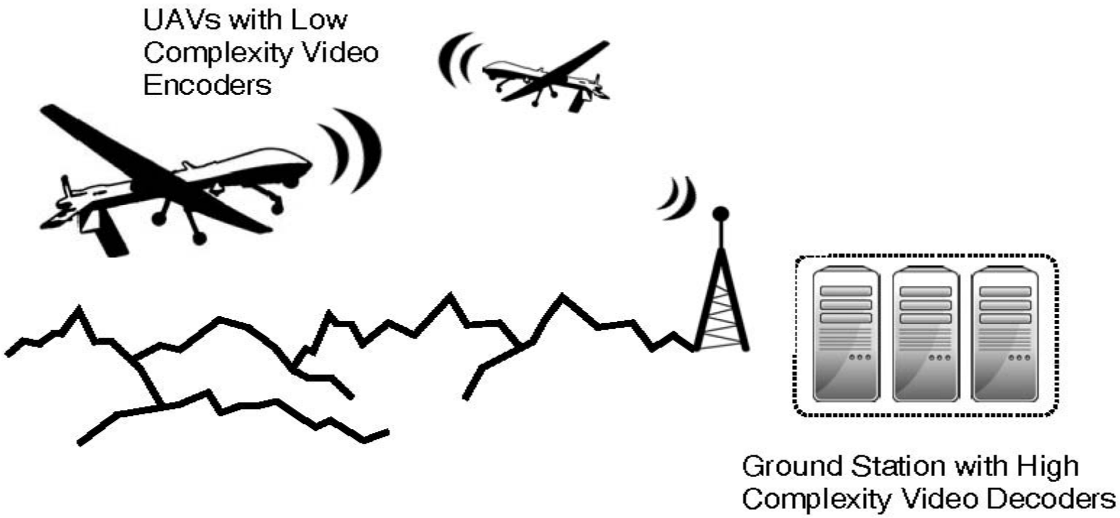
Block diagram of H.264 inter encoder

Standard Video Decoder: Low Complexity



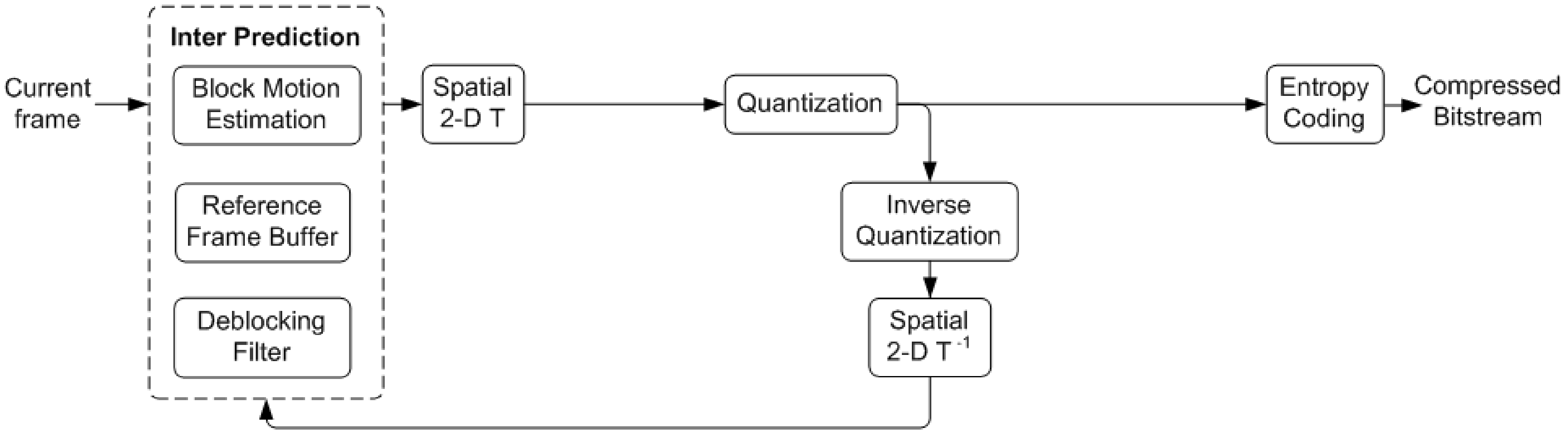
Block diagram of H.264 inter decoder

UAV Problem: Low-complexity encoders + High-complexity decoders



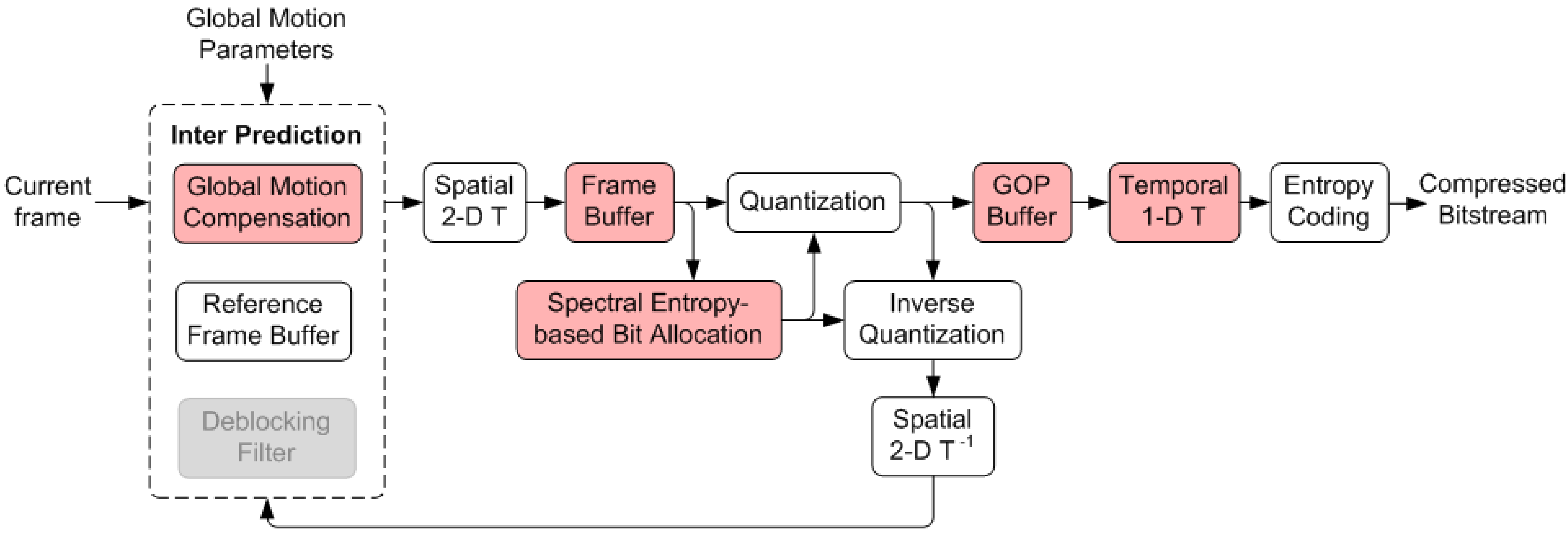
- Space, weight, and power (SWaP) constraints and high failure rates of UAVs - low-complexity encoder.
- Little limitation on the computational resources at the ground station - high-complexity decoder.
- Primarily global motion due to known movement of UAV and camera mounts.

Low-Complexity Video Encoder



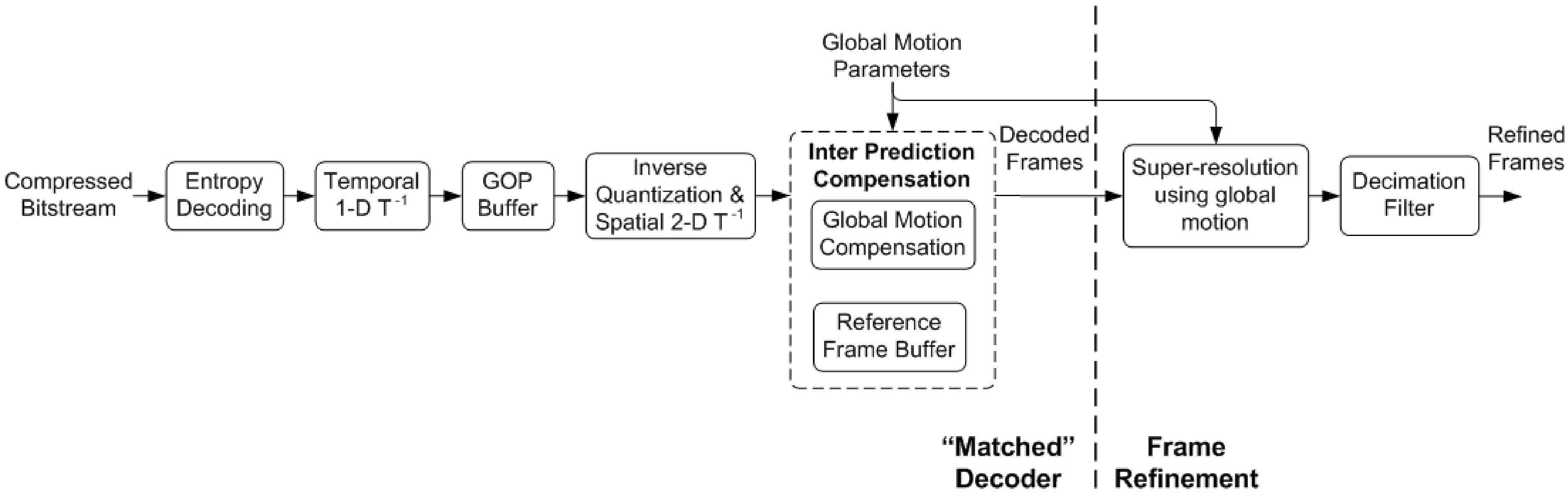
Block diagram of H.264 inter encoder

Low-Complexity Video Encoder



Block diagram of the proposed inter encoder

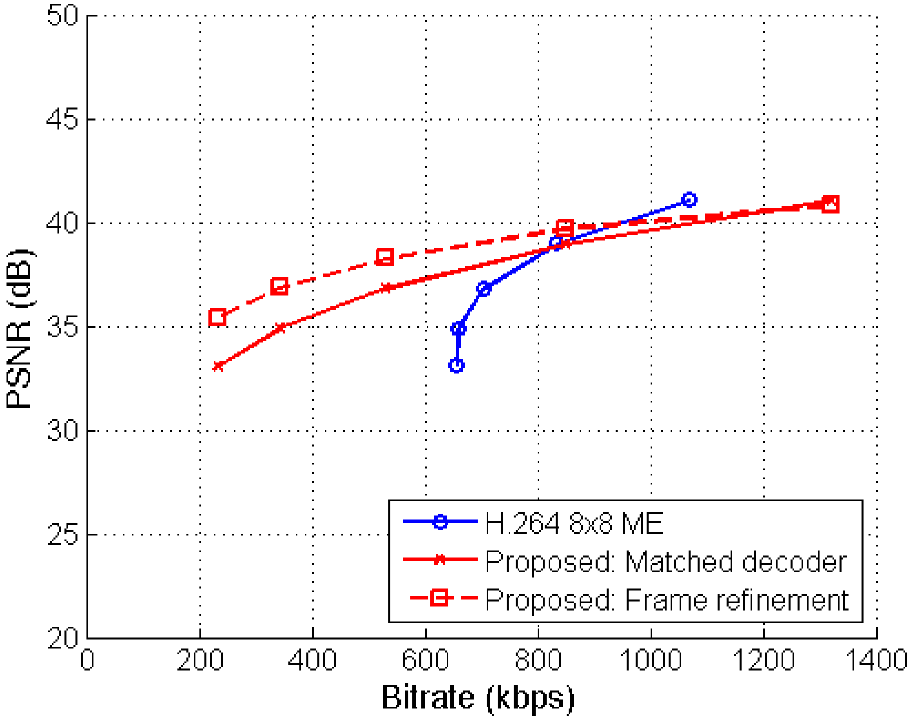
High-Complexity Video Decoder

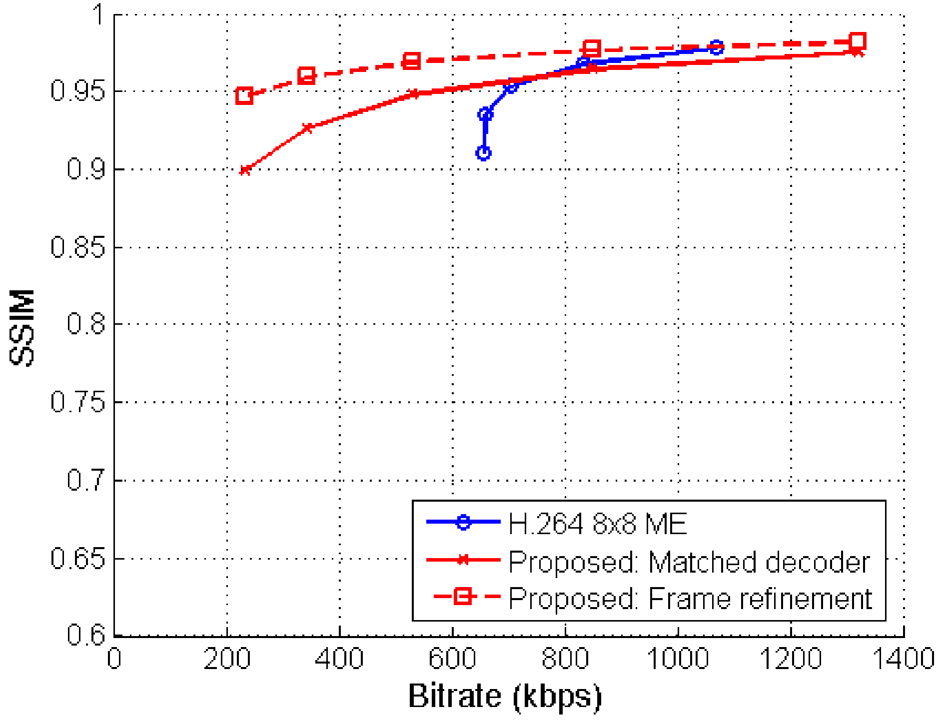


Block diagram of the proposed inter decoder

Results: Original Input Sequence

Results: Quality vs. Bit rate





Results: Reconstructed Sequences

Matched Decoder

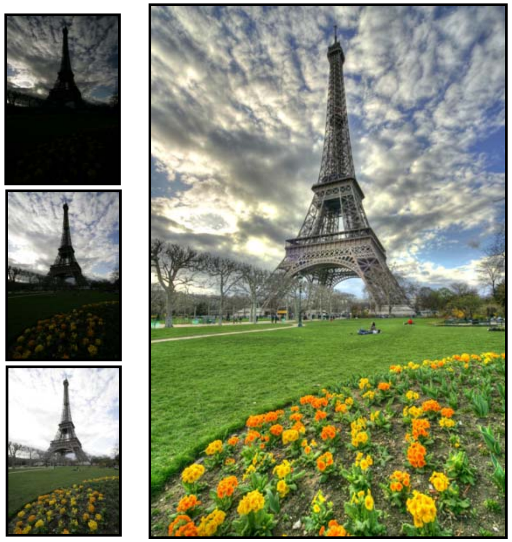
342.3kbps, 34.89 dB, 0.9265 SSIM

High-Complexity Decoder

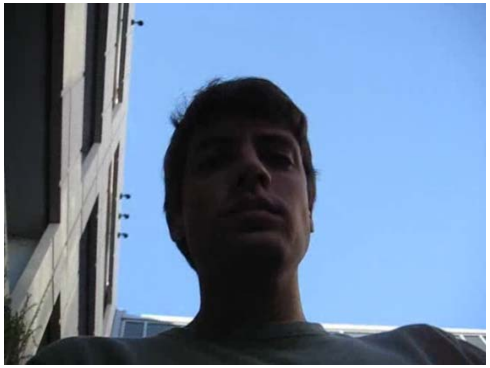
342.3kbps, 36.87 dB, 0.9596 SSIM

High Dynamic Range Video for Handhelds

- Inexpensive video cameras have limited dynamic range – saturated pixels [6]
- HDR photography combines multiple exposures, yet we **need new methods for video** [7]
- Applications:
  - Videoconferencing
    - Saturated pixels on user's face hurt experience
    - Mobile/Handhelds: extreme outdoor lighting conditions
  - Security/Surveillance [8]
    - Dynamic range crucial to "see" environment
    - Temporal fidelity secondary
  - Need low-cost solution (<$10)



HDR Still Photography

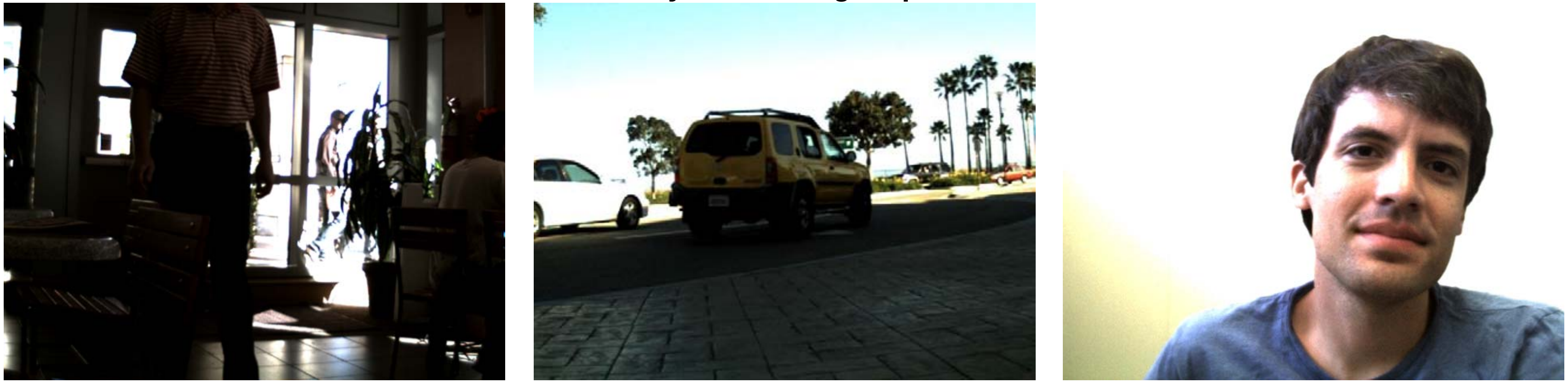


Mobile Videoconferencing (poor lighting!)

Recent Results on High Dynamic Range Video for Handhelds

- Alternate between short/long exposures
- Combine adjacent frames to achieve HDR at the **same frame rate**
- Need to **remove ghosting** with motion compensation and filtering [9]

Low Dynamic Range Inputs



High Dynamic Range Outputs

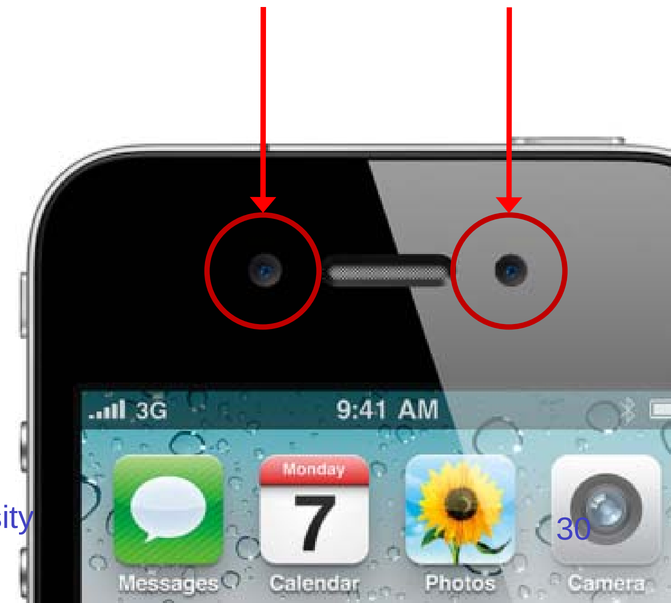
Viewing and Sensing 3D Video on Handhelds

- Glasses-free autostereoscopic displays now available on handheld gaming devices and phones
- Back-facing stereo cameras are standard
- Front-facing stereo cameras – **3D Videoconferencing**
- 3D can enhance experience if done correctly

HTC EVO 3D

LG Thrill

Front-facing Stereo Camera?



Issues for Handheld 3D Videoconferencing

- How to achieve effective and comfortable 3D for video communications on handhelds
- Close-up stereo photography is notoriously difficult! [10-11]
  - Optimal camera placement for display and analysis not the same
    - Need small stereo baseline (~9mm!) to reduce disparities
    - Need wider baseline for significant depth reconstruction
  - Need to **adjust disparities in real-time** according to scene depth [12]
- **Combine 3D and HDR**

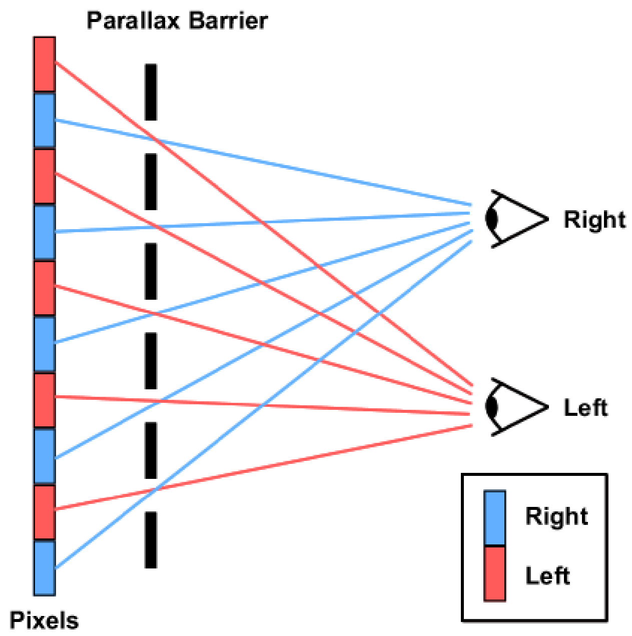
Handheld 3D Videoconferencing

Nintendo 3DS "Depth Slider"

Stereoscopic Displays

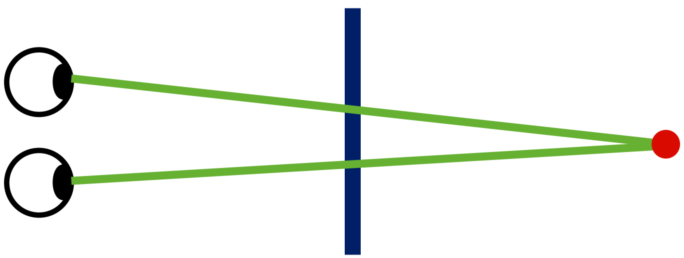
- 3D works by directing different light to each eye

Autostereoscopic: No glasses!

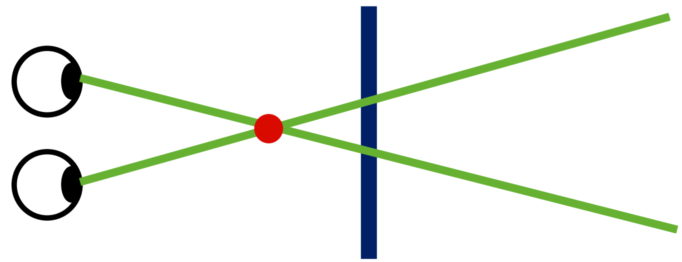


Left/Right Disparity Places Objects in 3D Space

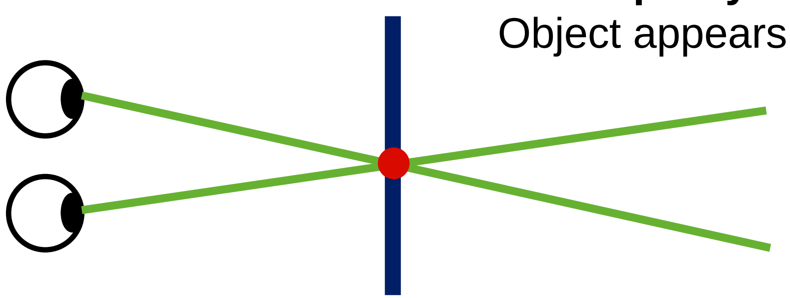
Positive Disparity
Object appears behind the display



Negative Disparity
Object appears in front of display



No Disparity
Object appears on the display



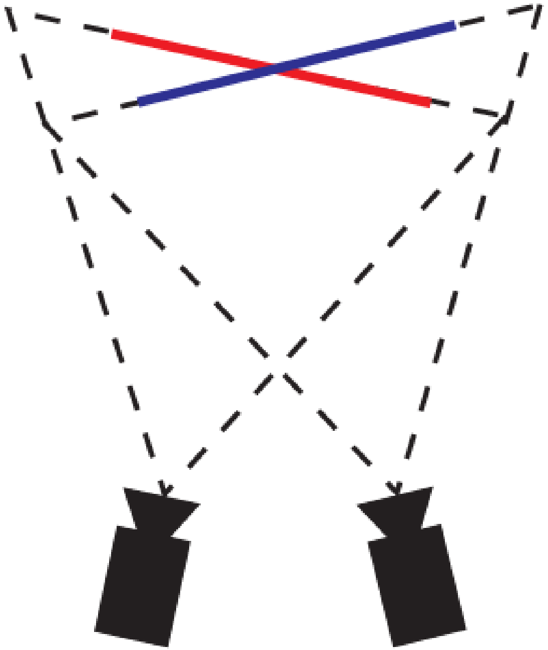
What’s the Problem?

- **Convergence** — brain processes disparities and converges eyes to fuse a desired depth
- **Accommodation** — pupils adjust to focus light from a desired depth
- The link between the two is broken by stereoscopic 3D

Large disparities cause discomfort and fatigue

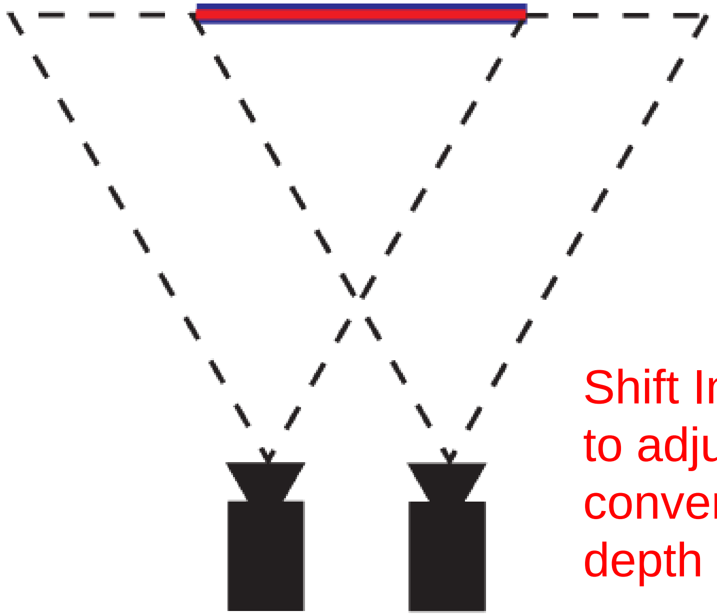
Camera Alignment: Converged vs Parallel

Objects at the convergence depth appear on the screen. Disparity goes to infinity as depth increases!



Converged Cameras

Convergence depth at infinity. All objects appear in front of the display, yet maximum disparity is limited.



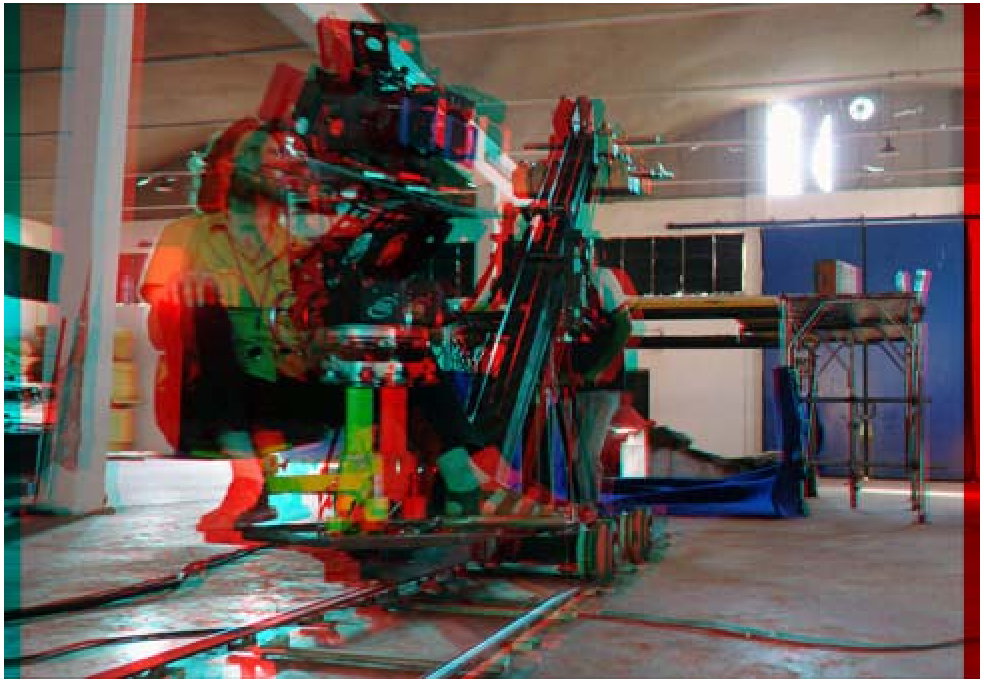
Shift Images to adjust convergence depth

Parallel Cameras

Shift Convergence

Converged on Foreground

Shift Convergence



Converged on Background

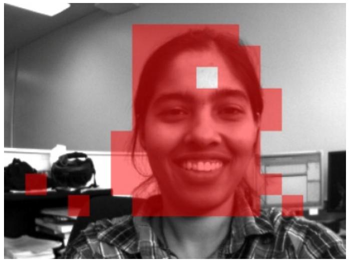
How is disparity controlled in movies?

- The director can adjust camera separation and convergence angle on a **per shot** basis
- The disparities of individual frames and transitions may be adjusted in **post-production**
- Need **automatic methods** for real-time footage!

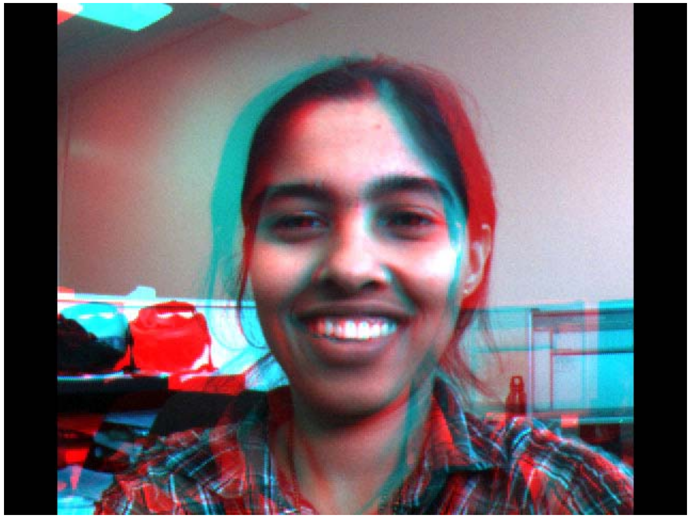
Disparity Remapping for Handheld 3D Communications

- Shift left/right images obtained by parallel cameras to align the front of the face [13]
- The entire scene appears **on or behind the display**, maximizing **viewer comfort** and **3D perception**

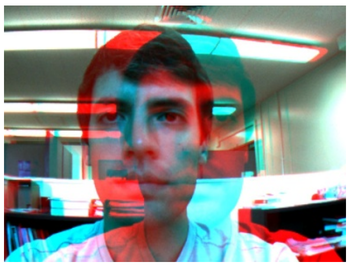

Input Frames


Foreground Mask


Shifted Frames

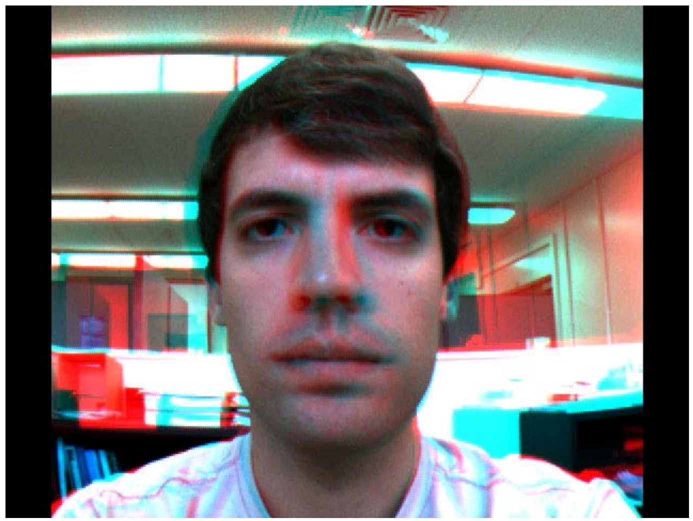

Shifted Frames with Adjustment [13]

Disparity Remapping for Handheld 3D Communications

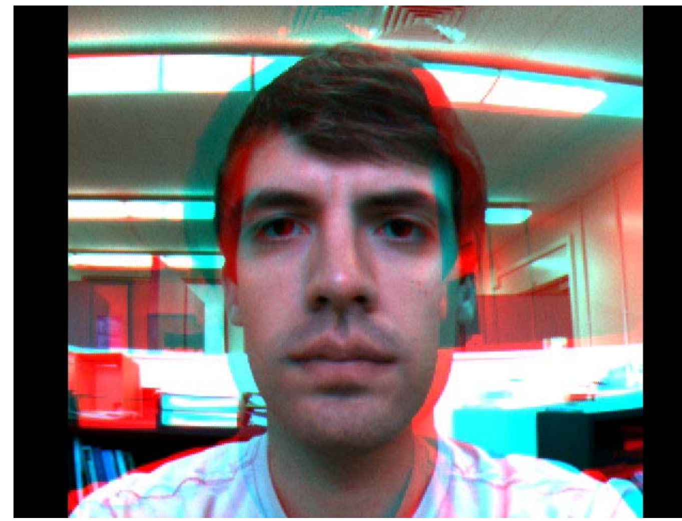


Input Frames

Foreground Mask

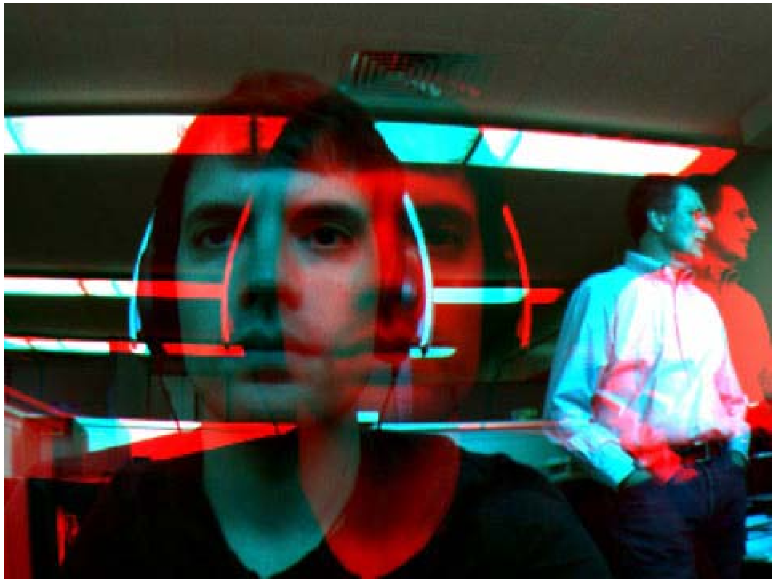


Shifted Frames



Shifted Frames with Adjustment [13]

Disparity Remapping for Handheld 3D Communications



Input Video

Output Video with Dynamic Stereo Alignment [13]

References

[6] E. Reinhard, G. Ward, S. Pattanaik, and P. Debevec, High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2005.

[7] S. B. Kang, M. Uyttendaele, S. Winder, and R. Szeliski, “High dynamic range video,” in ACM SIGGRAPH, New York, NY, USA, 2003, pp. 319–325.

[8] S. Mangiat and J. Gibson, Inexpensive High Dynamic Range Video for Large Scale Security and Surveillance, MILCOM, Baltimore, MD, Nov 2011.

[9] S. Mangiat and J. Gibson, “High dynamic range video with ghost removal,” in SPIE Optical Engineering & Applications, 2010.

[10] L. Lipton, Foundations of the stereoscopic cinema: a study in depth. Van Nostrand Reinhold, 1982.

[11] B. Mendiburu, 3D Movie Making: Stereoscopic Digital Cinema from Script to Screen. Focal Press, 2009.

[12] Manuel Lang, Alexander Hornung, Oliver Wang, Steven Poulakos, Aljoscha Smolic, and Markus Gross, “Nonlinear disparity mapping for stereoscopic 3d,” ACM Trans. Graph., vol. 29, no. 3, pp. 10, 2010.

[13] S. Mangiat and J. Gibson, “Disparity Remapping for Handheld 3D Communications,” submitted to IEEE ESPA Conference, 2012.

Graduate Student Research and Internship Topics

- Video communications, compression, and processing
- Voice and audio communications, compression, and processing
- Video and voice over wireless networks
- Handheld video and voice wireless communications
- Digital signal processing