Stereoscopic 3D (TV) 영상처리

연구개발 동향 및 기술개요

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Outline

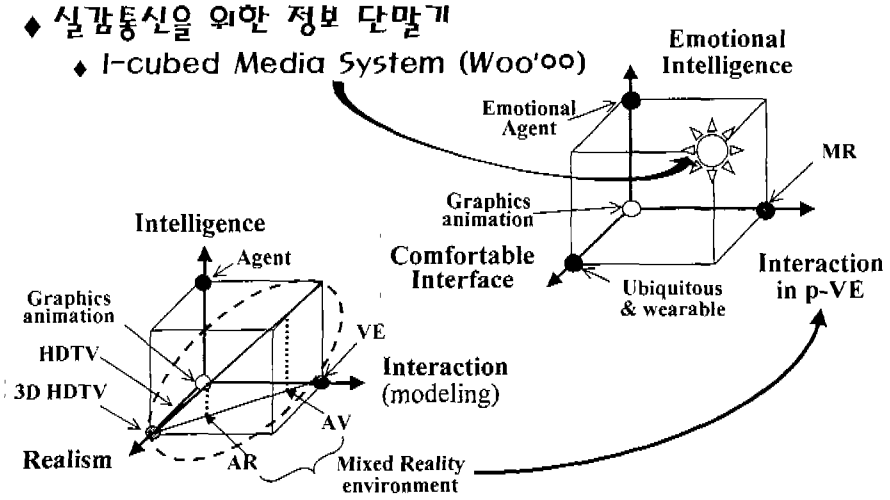
- Introduction
  - Motivation and research activities
- Multiview Image Acquisition
  - Camera geometry and 3D distortion
- Stereo Video Compression
  - Scalability tools and Multiview profile
- Functionality for 3D Applications
  - View synthesis & pi-VE
- Summary and Conclusion

Introduction: KJIST U-VR Lab

- Main focus of ***U-VR Lab***
  - PUI for smart environment in 10 years
  - 3D 실감통신: 가상 vs. 현실 (VR/AR/MR)
- What's PUI?
  - 개인화 (Personalization)
    - 지능화 (perceptual/emotional intelligence)
  - 편재성 (Ubiquity)
    - 편재된 경박단소 (ubiquitous/wearable computing)
  - 통합화 (Internetworking)
    - 유무선 통신: 광(고속) vs. 무선(개인화)

Introduction: 실감통신 요소기술

- 실감통신을 위한 정보 단말기
  - I-cubed Media System (Woo'00)

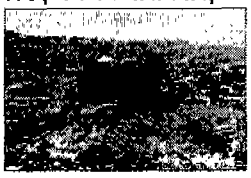


Introduction: 실감통신기술 발전과정

- *Audio-visual Communications*
  - 음성통신: Mono-> Stereo -> 3D sound
  - 영상통신: (motion+color+HD+?)
    - 사진->흑백TV->칼라TV->HDTV('98)->?
- *What's next?*
  - 오감통신: 시각, 청각, 후각, 미각, 촉각
  - 육감통신? emotion & imagination
- *Where is 3D(TV)?*
  - 실감통신을 위한 정보 단말기
  - 3D HDTV *vs.* 3D HMD

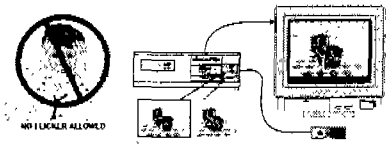
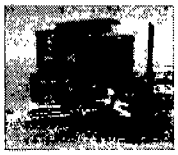
Introduction: Why 3차원 영상?

- *Why 3D with multiview?*
  - 실감통신: 임장감, 실존감, 자연감
    - Mono 3D cues: Focus length, linear/aerial perspective, texture gradient, light & shade, occlusion, motion parallax, etc.
    - 3D with Stereo-cues: binocular disparity (Human: b5mm), convergence angle, etc.
  - (Object-based) functionality (and interactivity)
  - 응용분야: 정보통신, 방송, 의료, 교육/훈련, 군사, animation, Game, *VR/MR/AR*, CAD, etc.



Introduction: 3차원 영상 단말기

- What about 3D Display?
  - 안경식: 편광방식과 시분할방식
    - Free-view
    - Anaglyph
    - Polarized glasses
    - Shutter glasses
  - 비안경식
    - Volumetric display
    - Stereoscopic : Barrier vs. Lenticular
  - What's next? 지능형 3D 단말기
    - 3D HDTV vs. Hologram (volumetric)
    - See-through 3D HMD (AR)

Introduction: 3차원 영상처리 연구동향

- 유럽
  - Cost230: 3DTV
  - DISTIMA (92-95): 3DTV
  - PANORAMA (96-98): 3D Telepresence
- 일본:
  - TAO, NHK, NTT, SANYO, ATR
- 미국:
  - CMU, MIT, NASA-JPL, USC, SRI, etc.
- 한국
  - 원자력연구소, KIST, SAIT
  - KAIST, KJIST, KNU, POSTECH, 광운대 etc.

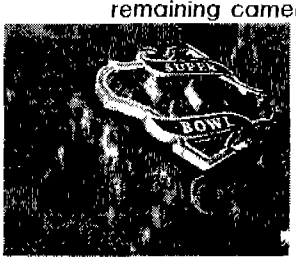

Introduction: 3차원 영상처리 연구동향

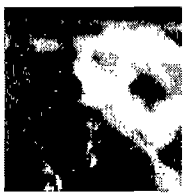
- RACE2405: DISTIMA (92-95)
  - To develop SW/HW to realize 3D TV
  - Approach: MPEG-2 Compatible Codec
    - Video over ATM (9Mbps): left (6-7Mbps), right (3-2Mbps)
    - Up to 4 video channels w/ Dolby surround sound

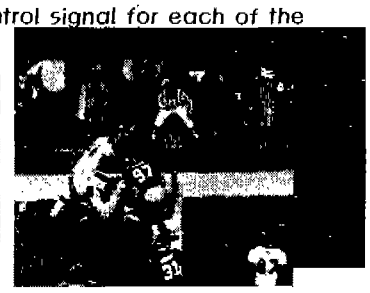
- ACTS AC044: MIRAGE (-98)
  - virtual studio
- ACTS-AC092: PANORAMA (95-98)
  - To develop SW/HW to realize 3D telepresence
  - Approach
    - WPG1: synthesis (parametric 3-D scene description)
    - WPG2: analysis (coding & intermediate-view synthesis)
    - WPG3: 3-cam's, autostereoscopic display, headtracking

Introduction: 3차원 영상처리 연구동향

- EyeVision: 3D goes to Superbowl (CBS & CMU)
  - Super Bowl XXXV @ Raymond James Stadium, FL
  - How does the system work?
    - about 30 cameras w/ computer-controlled zoom and focus
    - A human operator manipulates a movable pan-tilt tripod
      - > The tripod is equipped with sensors to measure its angle
    - The master cam-head mimicks the motion of the tripod
    - Information from the master cam is fed to a computer
      - > pan-tilt angles, zoom, focus, etc.
    - The computer computes the control signal for each of the remaining cameras







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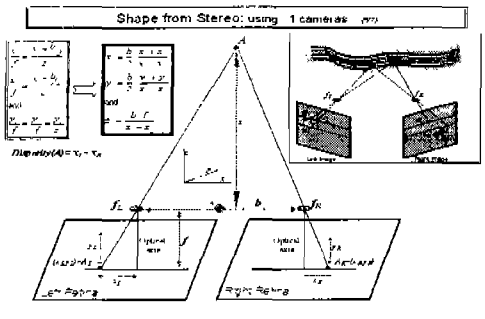
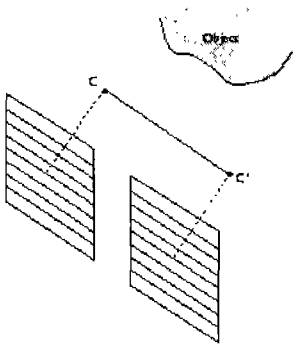
3차원 영상획득

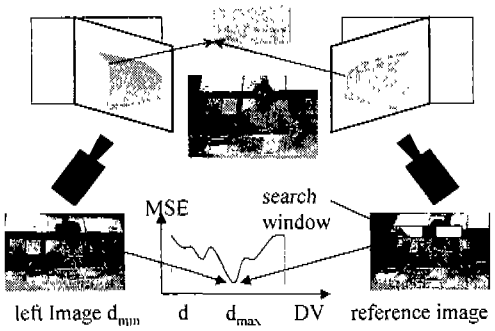
- 3D image acquisition
- Camera Setup: Parallel
  - Simple DE: horizontal direction disparity
  - No 3D distortion: depth plane is linear

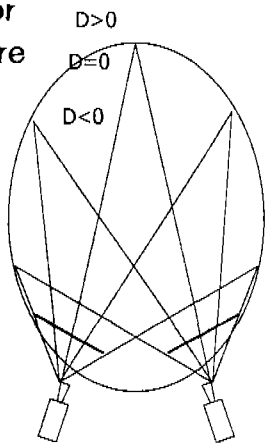




3차원 영상획득

- Camera Setup: Angled Camera Setup
  - Keystoning: vertical direction error
  - Eye fatigue: Depth plane curvature
  - requires adjustment before DE





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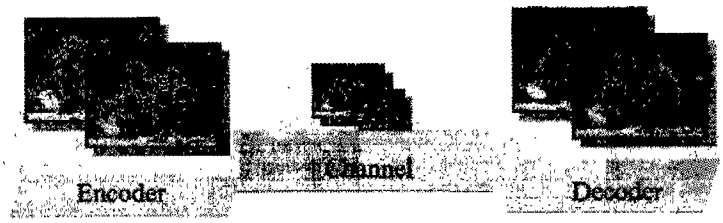
3차원 영상압축

- Why 3D with multiview?
  - 실감통신: 임장감, 실존감, 자연감
  - (Object-based) functionality (interactivity)
- Trade-offs: 실감 vs. 대정보량
  - Channel BW, protocols, data amount



3차원 영상압축

- Main Coding Issues
  - Coding Efficiency
    - Occlusion detection and treatment
    - Joint motion/disparity estimation
  - Compatibility with Standards
    - MPEG-2: scalability
    - MPEG-4: object-based scalability
  - Functionality (interactivity)
    - Accurate & smooth disparity estimation
    - Segmentation or object-based coding

3차원 영상압축

♦ Problem Formulation: (Joint Optimization)

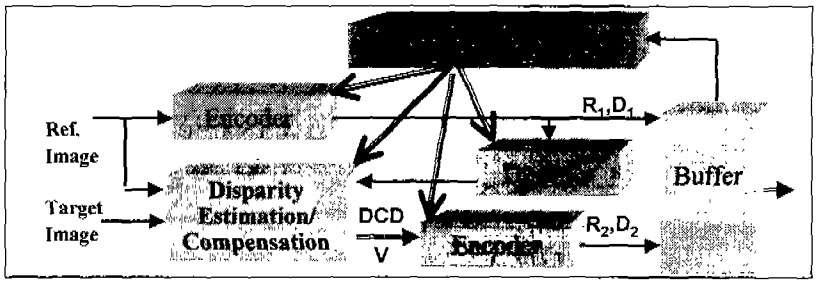
Given F_1, F_2, R_{budget}

Find $\hat{X} = (V, Q_1, Q_2)$

such that $\hat{X} = \arg\min_{V}\{D_1(Q_1) + \alpha \cdot D_2(Q_2 \mid Q_1, V)\}$

subject to $R_1(Q_1) + R_2(Q_2 \mid Q_1, V) \le R_{budget}$

where "α" supports *Fusion vs. Suppression* theory

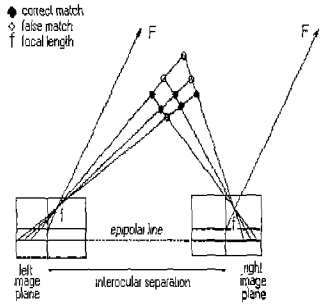


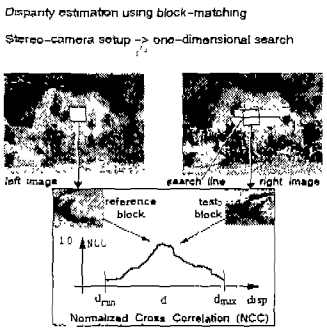
3차원 영상압축

♦ Motivation of 3D Coding

- ♦ Bottleneck: limited channel bandwidth
- ♦ Redundancy: temporal & binocular

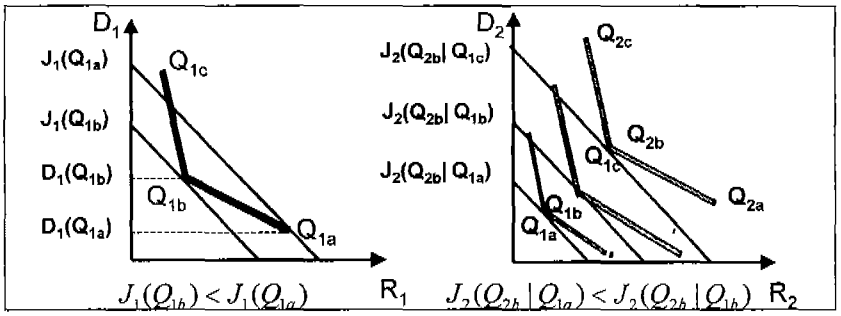
♦ Disparity Estimation





3차원 영상압축: Main Coding Issues

- Coding Efficiency
  - Blockwise Dependent Quantization
    - ORD plot with 3 different quantizers
      - > Lagrangian cost: $J=J_1+J_2$, where $J_i=D_i+\lambda R_i$, i=1,2
      - > can be $J_1(Q_{1a})+J_2(Q_{2b}|Q_{1a}) < J_1(Q_{1b})+J_2(Q_{2b}|Q_{1b})$

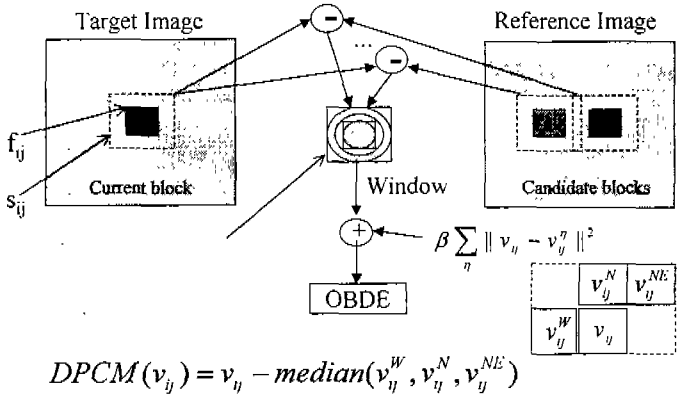


$J_1(Q_{1b}) < J_1(Q_{1a})$ $\quad J_2(Q_{2b}|Q_{1a}) < J_2(Q_{2b}|Q_{1b})$

(IEEE Tran. On CSVT, vol. 9, no.6, pp.861-867, Sep. 1999.)

3차원 영상압축: Main Coding Issues

- Coding Efficiency
  - DE w/ FSBM & DC w/ Adaptive OBM



$$\beta \sum_{\eta} \| v_{ij} - v_{ij}^{\eta} \|^2$$

$$DPCM(v_{ij}) = v_{ij} - median(v_{ij}^{W}, v_{ij}^{N}, v_{ij}^{NE})$$

(IEEE Tran. On CSVT, vol. 9, no.6, pp. 194-200, Mar. 2000)

3차원 영상압축: Scalability

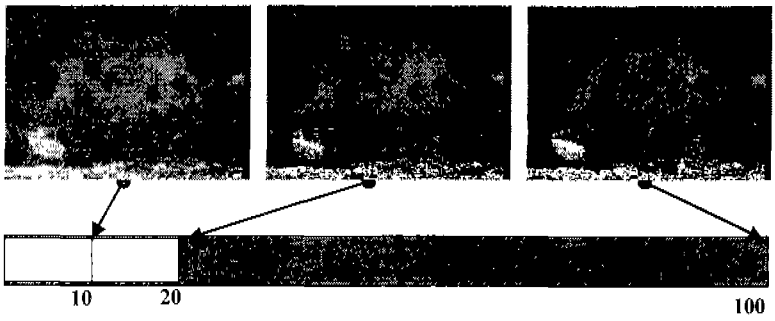
- Why scalability?
  - Priority: error resilience on noisy channel
  - Multi-quality video services (VOD, HDTV, etc.)
  - Internetworking of standards or equipment
- Basic Idea of Scalable Coding
  - Layered or hierarchical coding
  - Independent coding of the lowest layer
  - Dependent coding of each following layers
  - Coding complexity & quality scalability

3차원 영상압축: Scalability Tools

- Data Partitioning
  - Break a coded bit-stream into essential & additional parts
- SNR (Quantization Noise) Scalability
- Spatial (Resolution) Scalability
- Temporal (Resolution) Scalability
- Hybrid Scalability

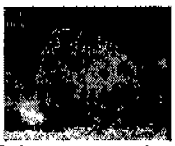
3차원 영상압축: SNR Scalability

- Control Quantization Step
  - Quantization Noise Scalability
  - Each layer coded at the same resolution w/ different quality

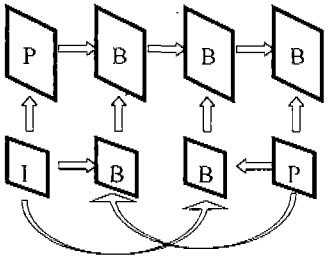


3차원 영상압축: Spatial Scalability

- Extended Pyramid Coding
  - Base layer: coded at lower (sampling) resolution
  - Enhancement layer: upsampled and predicted from the BL
- ❑ Backward compatibility: H.26x, MPEG-1.

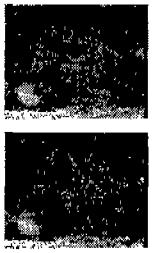

Enhancement layer

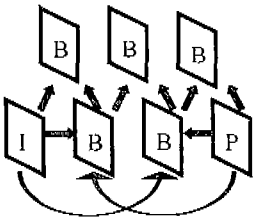

Base layer



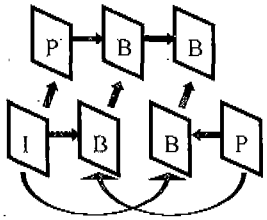
3차원 영상압축: Temporal Scalability

- Basic idea
  - BL: codes higher priority bitstream at a lower frame rate
  - EL: codes the intermediate frames
- Prediction Configuration





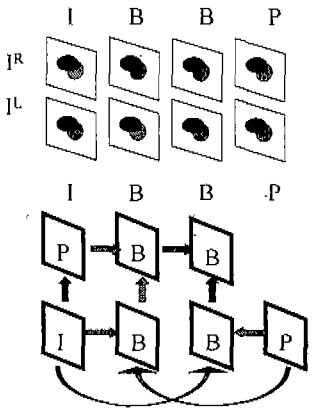
Interlayer MC

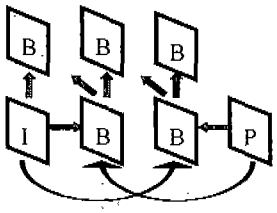


MC & interlayer MC

3차원 영상압축: Stereo Video Coding

- Simulcast vs. Compatible Coding

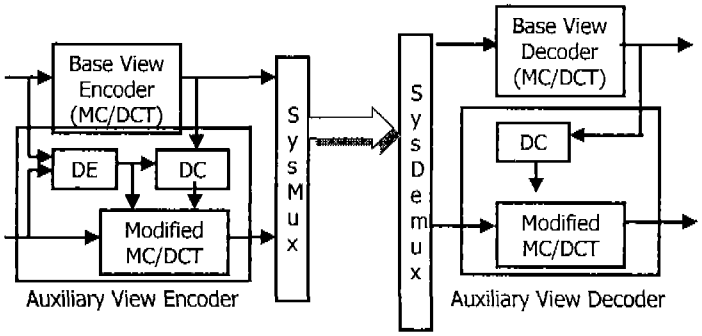




Hybrid?

3차원 영상압축: Stereo Video Coding

- Structure of Stereo Codec
  - MPEG-2 (13818-3 AMD 3): Multiview Profile (9/9b)
  - Temporal scalability



3차원 영상압축: Stereo Video Coding

- Experimental Results
  - Input Sequences
    - CCIR-601 4:2:2 format with 720x576 at 25Hz (interlaced)
    - Prediction distance M=3, intraframe distance N=12
    - Target bit rates: 6 Mbps + 2 Mbps
  - ❑ Results (by A. Puri, AT&T)

Sequence	Simulcast	DC-DC	DC-MC
Train	31.75	+1.83	+2.81
Manege	26.64	-0.28	+2.20
Tunnel	33.12	-3.17	+1.24
Aqua	30.59	-2.81	+0.50

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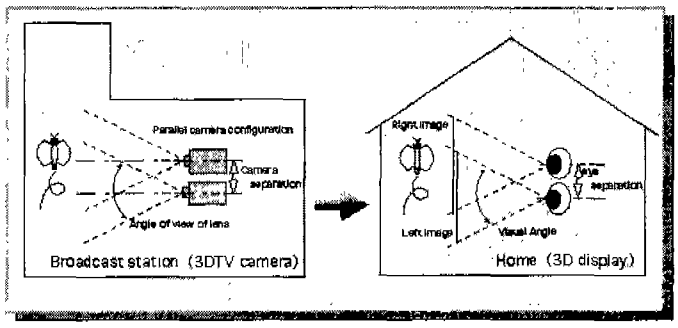
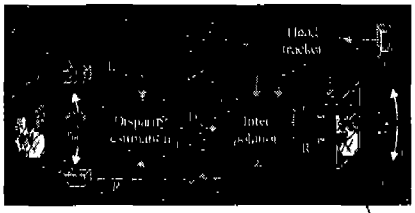
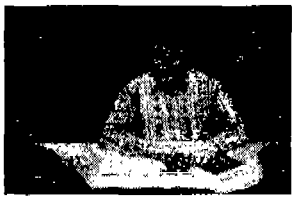
- Why Intermediate-view Synthesis?
  - 3D HDTV Cameras *vs.* Human eyes (60-65mm)
  - Functionality (*w/* head tracking)

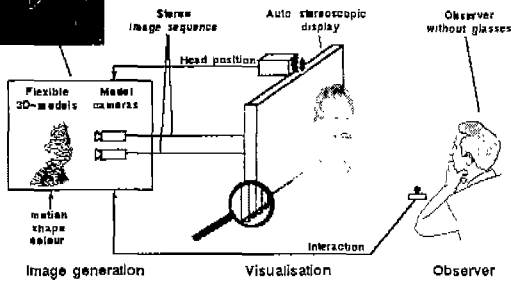


3차원 영상처리

♦ *Intermediate-view Synthesis*

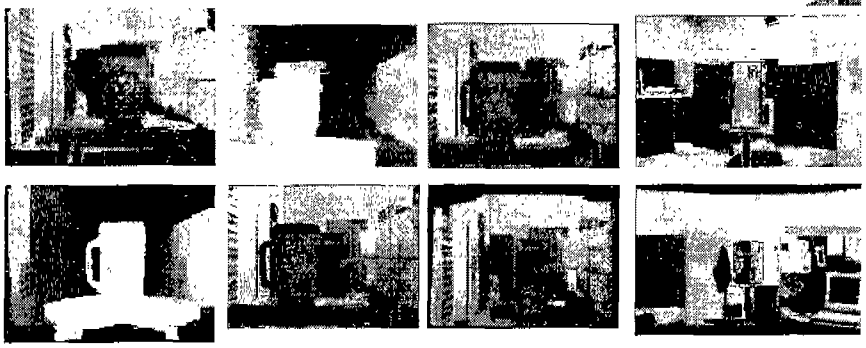






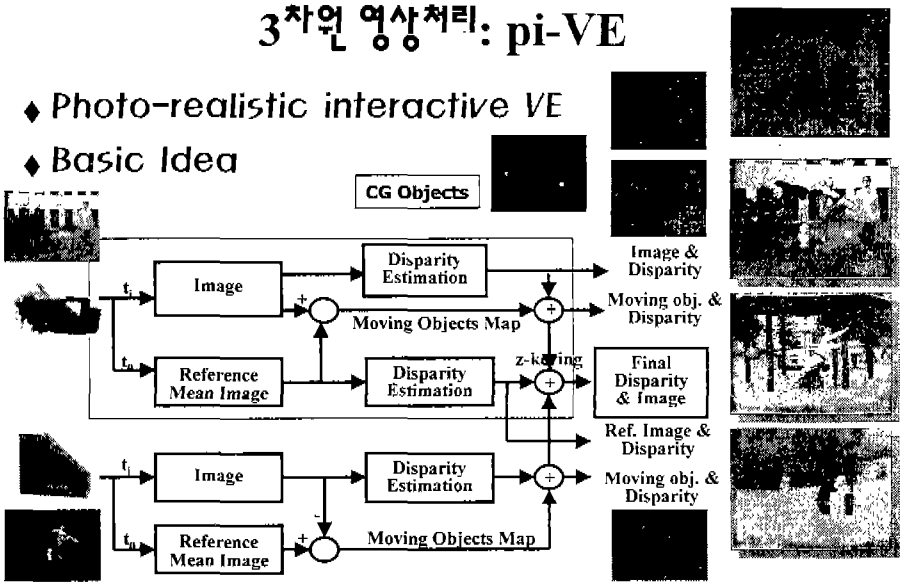
3차원 영상처리

♦ *A Multivalued Representation for View Synthesis (N.L. Chang)*



3차원 영상처리: pi-VE

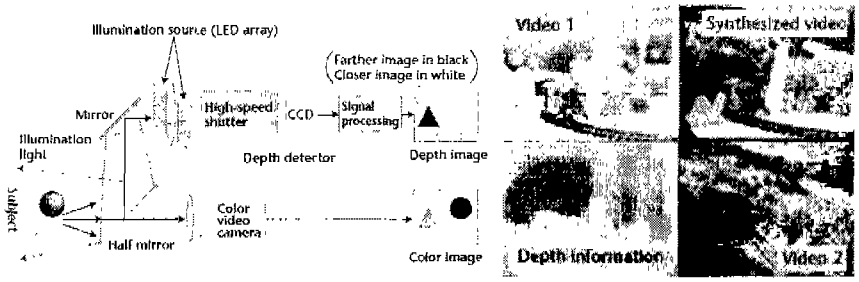
- Photo-realistic interactive VE
- Basic Idea



(in Proc. SPIE VCIP'01, vol. 4310 Jan. 2001)

3차원 영상처리

- Axi-vision camera (NHK)



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  - Camera Geometry and 3D Distortion
- Stereo Video Compression
  - Scalability tools and Multiview Profile
- Functionalities for 3D Applications
- Summary and Conclusion

Summary and Q&A

- Possible Research Topics
  - 입체영상 영상 촬영 기술 (calibration)
  - 고화질 입체영상 압축/저장/전송/복원
    - object-based coding (MPEG-4)
    - Efficient representation of segmented objects
  - 대화면 디스플레이용 영상화질 개선 기술
  - 고화질 입체영상 편집기술
    - Object-based Functionality:
      - > Background separation
      - > Object-based Segmentation
    - Flexible Viewing Angle
      - > Multiview video vs. Synthesis of intermediate-view
    - 입체영상 복원 기술 (VR/MR/AR/Virtual studio)
  - PUI: personalized 실감 통신
    - 감성정보처리 기술 & Interactive 영상 정보처리