3DTV와 실감방송 기술

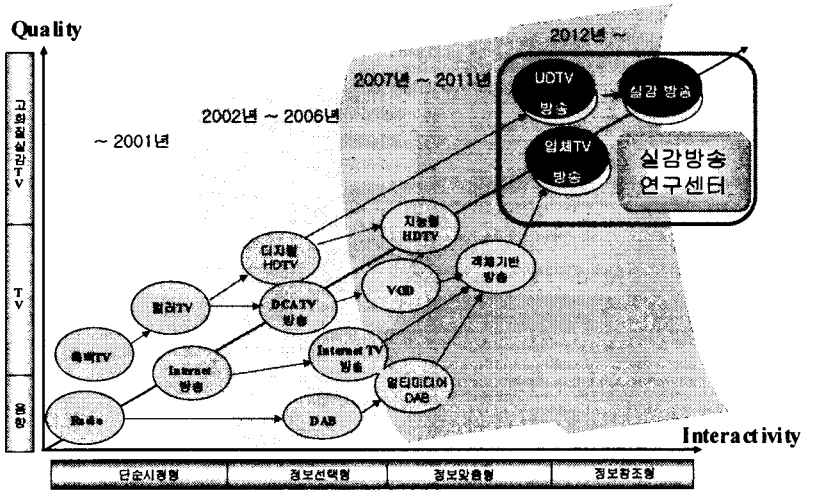
2004. 10. 13.

호 요 성

발표 내용

- 실감방송 연구센터 소개
- 다차원 실감미디어 처리 기술
  - 실감미디어 획득 및 생성
  - 실감미디어 처리 및 압축
  - 실감미디어 재현 및 상호작용
- 맺음말

방송 기술의 발전 추세



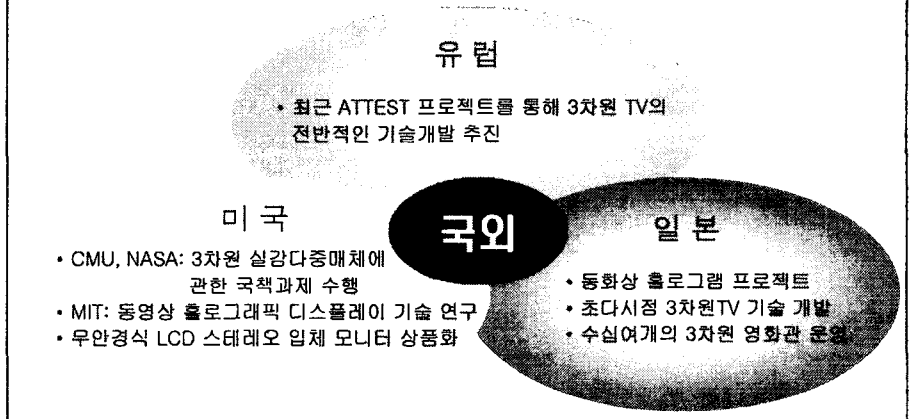
[출처: NTRM, 2003]

실감방송이란?

입체영상 및 입체음향 | 다차원 실감미디어 처리기술 | 실감나는 방송 서비스

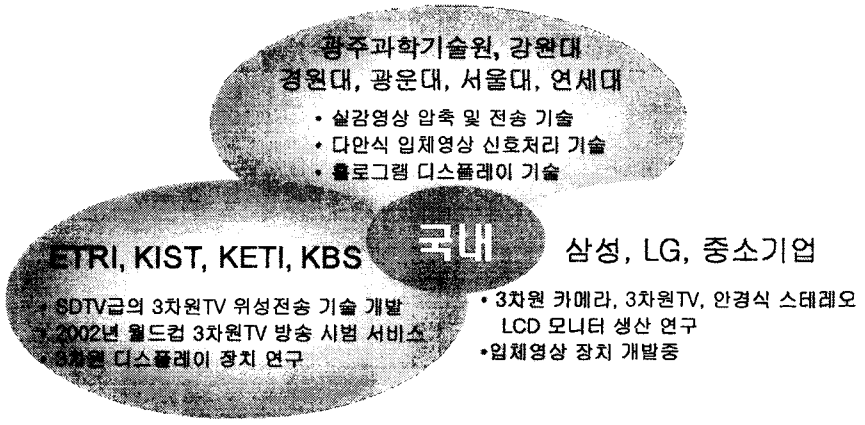
사용자에게 실감나는 방송 서비스 제공

기술 동향(국외)



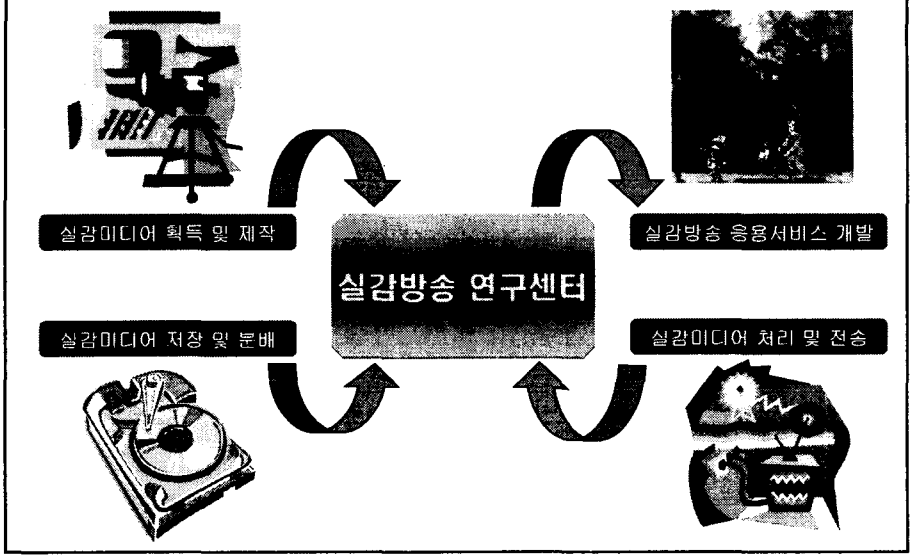
수분 이국, 유럽, 일본 등에서 입체영상 관련 연구 수행

기술 동향(국내)

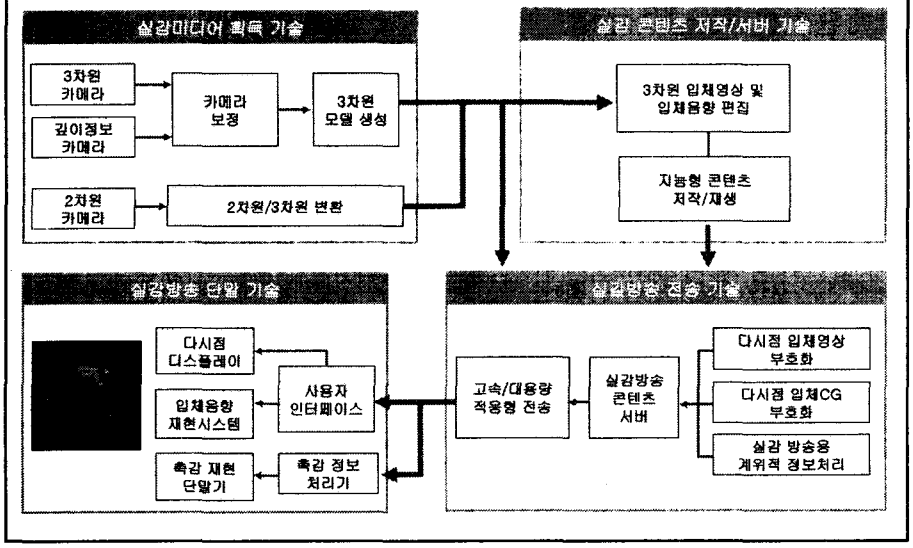


일부 대학/연구소/산업체에서 입체영상 관련 기초기술 연구

주요 연구 분야

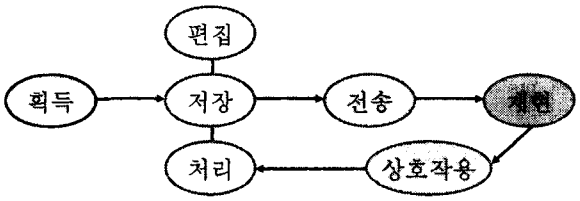


실감형 방송 시스템 구성도

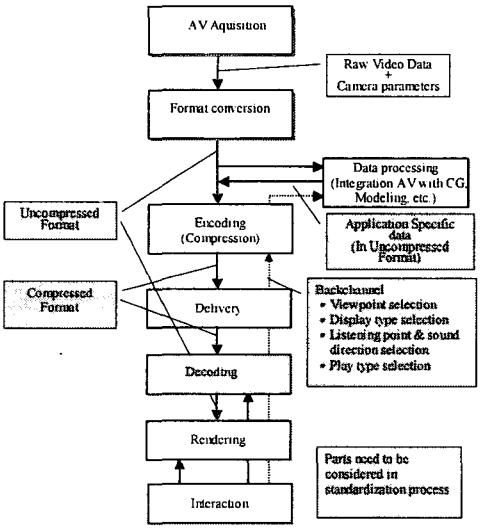


다차원 실감미디어 처리

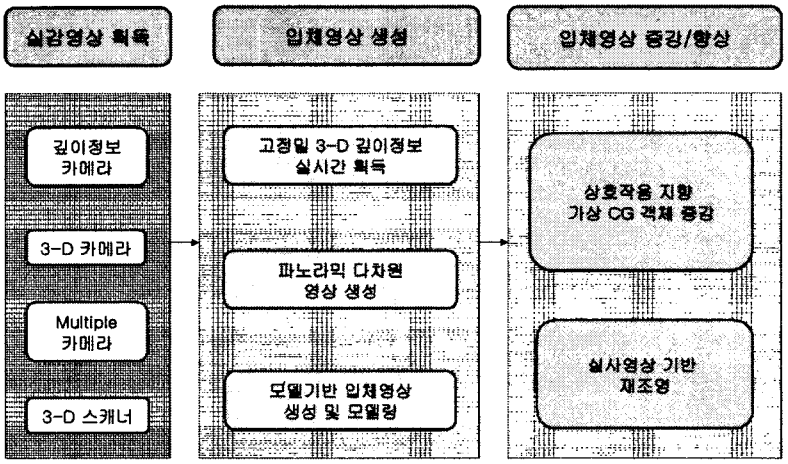
- 신호 분류
  - 1차원 신호: 음성신호, 음향신호
  - 2차원 신호: 영상신호(정지영상, 동영상)
  - 3차원 신호: 입체영상, 입체음향
- 응용 분야
  - 다차원 입체게임, 실감방송, 가상현실
- 연구 분야



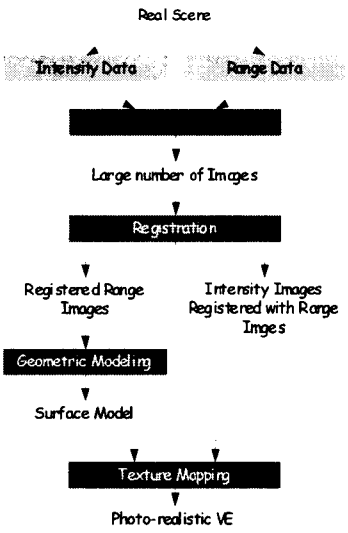
다차원 A/V 시스템 구조



3차원 입체영상 획득/생성



3차원 입체영상 획득 과정



3차원 영상 모델링

- Mesh-based Approach
  - 구성요소: vertex, edge, face
  - Polygonal or Triangular Meshes
  - Rendering of Surfaces with Photometric Information
  - Progressive Mesh, Level of Details(LOD)
- Voxel-based Approach
  - Voxel(volumetric element) vs. Pixel(picture element)
  - 구성요소: 3-D array of voxels(uniform grid)
  - Octree vs. Quadtree
  - Pyramid 분해 기법: 점진적 모드(progressive mode)

Mesh-based 3-D Modeling

Connectivity Information
(Identifier List of Vertices)

$C_l = \{v_i, v_j, v_k\}$

i, j, k : Vertex Index
for Each Triangle

Vertex Position
(3D Floating Vectors)

$V_i = \{x_i, y_i, z_i\}$

Photometry Information
- Normal Vectors
- Colors
- Texture Values

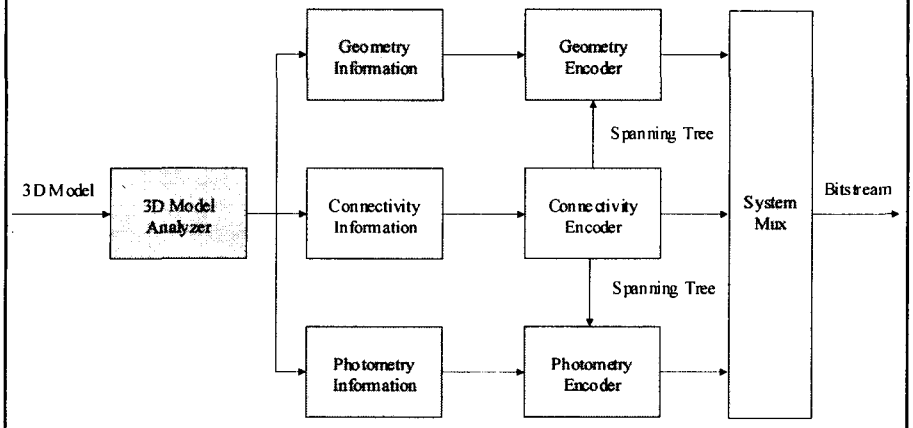
Why Compression?

- Surfaces of a 3D model are described by very dense triangular meshes in most applications (1 million vertices/model)
- Storage, Manipulation, Transmission and Rendering need large memory, bandwidth, processing time and resources.

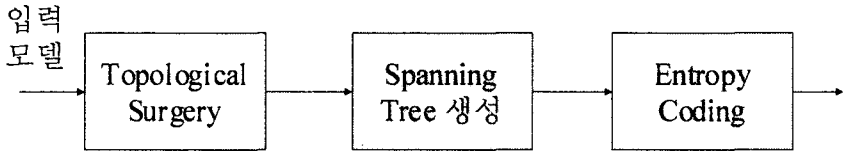
Geometry data contains a large amount of data
(32bits x 3 = 96 bits/vertex)

Data Compression

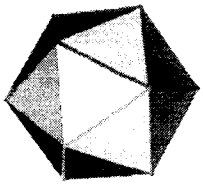
3차원 모델 부호화



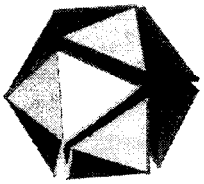
연결정보 부호화



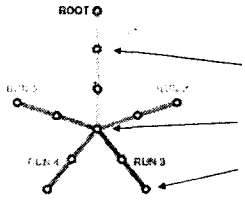
Topological Surgery



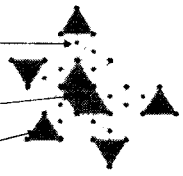
(a) 3D Model



(b) Cut Model

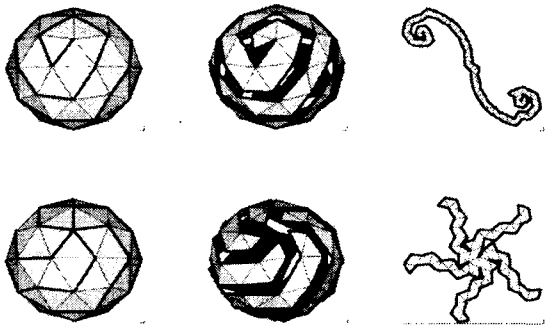


(c) Vertex Spanning Tree



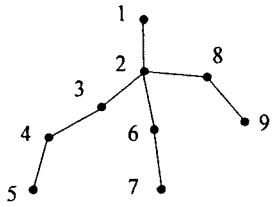
(d) Triangle Spanning Tree

Surface Peeling



Cutting strategy should be effective to minimize the number of triangle and vertex runs

Coding of Spanning Trees



Vrun : 1 0 1 1 0 1 0 1 0

Vleaf : 0 1 1 1

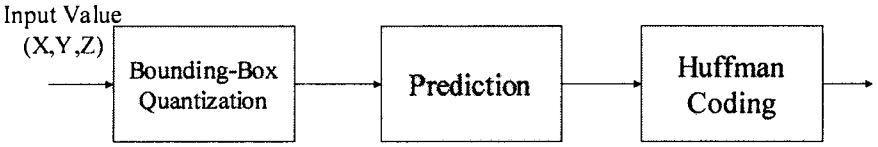
Vchild : 01

Adaptive Arithmetic Coding

	# 0's	# 1's	Total
Vrun	# runs (4)	# vertex + # loop - # runs (9 + 0 - 4 = 5)	# vertex + # loop (9)
Vleaf	# runs - # leaf (4 - 3 = 1)	# leaf (3)	# runs (4)
Vchild	# runs - # leaf (4 - 3 = 1)	2*# leaf - # runs + # loop - 1 (2*3 - 4 + 0 - 1 = 1)	# leaf + # loop - 1 (3 + 0 - 1 = 2)
Loopstart	# leaf - 1 (3 - 1 = 2)	# loop (0)	# leaf + # loop - 1 (3 + 0 - 1 = 2)

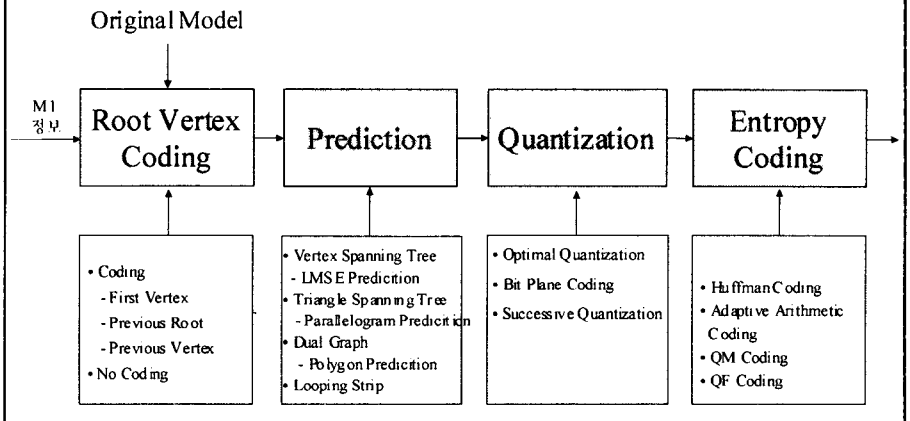
기하정보 부호화

- Bounding Box Approach



- Problems
  - Large Quantization Errors
  - Vertex Merging Problem

Geometry Compression



Linear Prediction

- Use the father-son relationship defined by the vertex spanning tree to trace all ancestors
- Find prediction coefficients by LMSE method
- Perform linear prediction

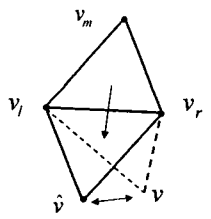
$$\hat{x}_n = \sum_{i=1}^{P} \lambda_{x_i} x_{n-i} \qquad \hat{y}_n = \sum_{i=1}^{P} \lambda_{y_i} y_{n-i} \qquad \hat{z}_n = \sum_{i=1}^{P} \lambda_{z_i} z_{n-i}$$

- Obtain prediction errors

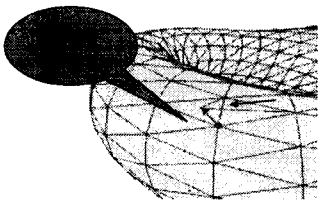
$$\Delta x_n = x_n - \hat{x}_n \qquad \Delta y_n = y_n - \hat{y}_n \qquad \Delta z_n = z_n - \hat{z}_n$$

Parallelogram Prediction

- Basic Assumptions
  - Three ancestors form a parallelogram with predicted vertex
  - Lie on the same plane
- Problems
  - Use a single adjacent triangle → located at a biased position
  - Vertex on a curved surface may not be predicted effectively

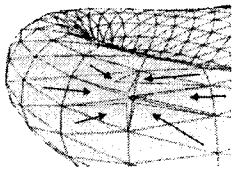


$$\hat{v} = v_l + v_r - v_m$$

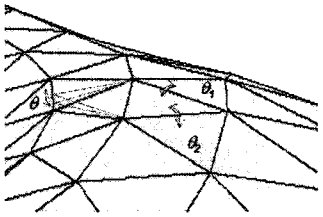


Joint Prediction

- Average Predictor
  - Use all neighboring vertices that precede the current one
  - Average of parallelogram prediction values
- Dihedral Angle Predictor
  - Estimates the dihedral angle between two triangles.



<Average prediction>



<Angle prediction>

Error Metric

$$mean\_error = \frac{1}{2}\sum_{i=1}^{n}(dist_1(i) + dist_2(i))$$

Where,

A: Original Model
B: Reconstructed Model
n: Number of Vertex
$dist_1(i)$: Distance between vertex *i* of A and closest vertex of B
$dist_2(i)$: Distance between vertex *i* of B and closest vertex of A

광학정보 부호화

- Normal Vector
  - Average Prediction
  - 6-4 Subdivision Quantization
- Texture
  - Average Prediction
- Color
  - Mapping Table
  - DPCM

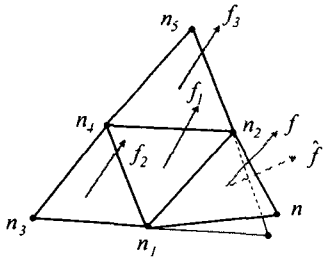
Average Predictor

- Basic Assumptions

$$n = \frac{n_1 + n_2 + n_4}{3} \qquad f \cong \frac{f_1 + f_2 + f_3}{3}$$

n_1, n_2, n_3, n_4, n_5 : encoded value

n, f : unknown value



Prediction Rule

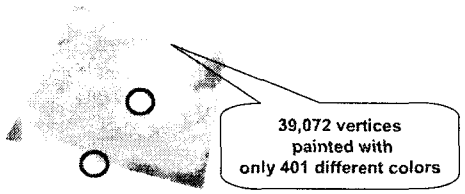
$$\hat{n} = n_1 + n_2 - n_3 + n_4 - n_5$$

Prediction Residual

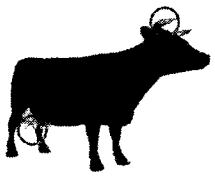
$$\Delta n = n - \hat{n} = (1, \theta, \phi) - (1, \hat{\theta}, \hat{\phi})$$
$$= (0, \Delta\theta, \Delta\phi)$$

Color Coding

- Properties of Color
  - Limited precision of the coloring system
  - A small set of colors recurring frequently over vertices
- Purpose
  - High coding gain for frequently recurring colors

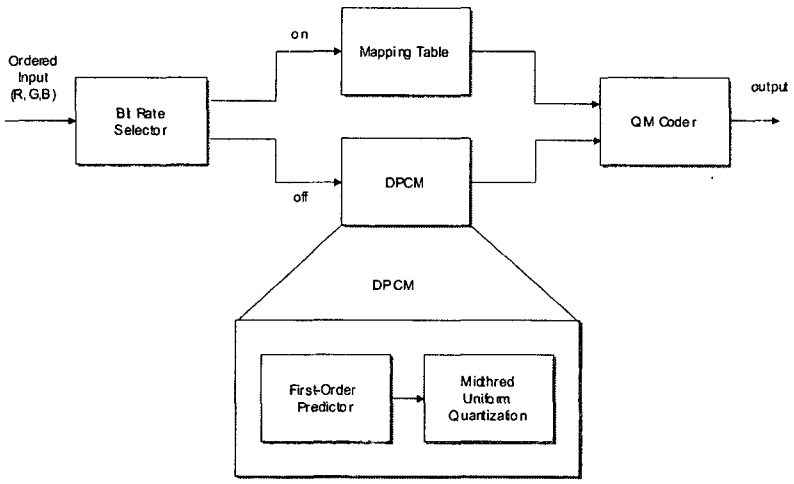


< HUMIDITY>



< COW >

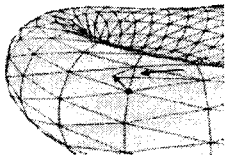
Adaptive Color Coding

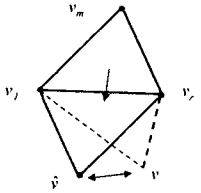


기하정보 변환 부호화

- 기하학 정보 압축
  - 예측 부호화 방법
  - 변환 부호화 방법
- 연결성 정보 압축
- 광학적 정보 압축

예측 부호화 방법



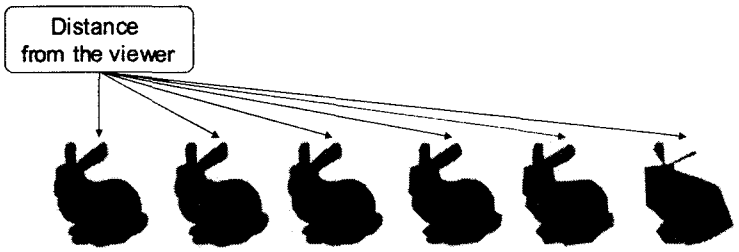


$$\hat{v} = v_l + v_r - v_m$$

평행사변형법을 이용한 예측 부호화 방법

Progressive Mesh

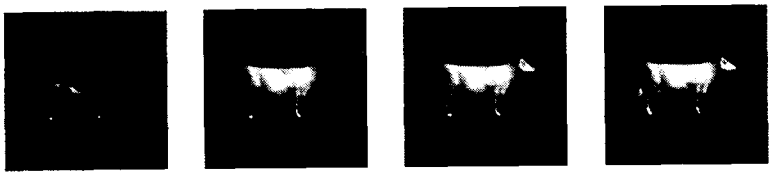
- Incremental Representation of 3-D Models



- **Fully-detailed mesh** when the model is close to the viewer
- **Coarse approximation** as the object recedes away from the viewer

데이터 분할

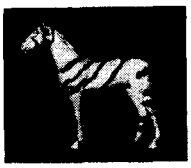
- Incremental Rendering



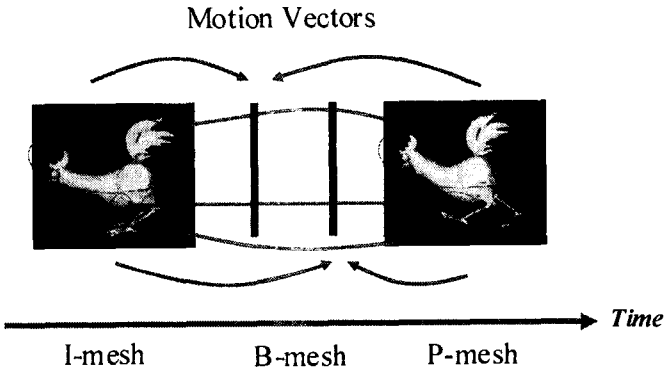
25% 50% 75% 100%

Received Packet Ratio

- Error Resilience



3-D Animation Model Coding



실감미디어 재현

- 실감방송 서비스 요구사항
  - 입체영상, 입체 음향
  - 고화질, 고음질
  - 사용자 상호작용
  - 시각+청각+촉각

맺음말

- 다차원 실감방송 서비스
  - 실감미디어 획득 및 생성
  - 실감미디어 처리 및 압축
  - 실감미디어 재현 및 상호작용
- 관련 표준화 작업
  - MPEG-4 SNHC/AFX
  - MPEG-4 3DAV Coding