**ITI517** Computer Vision

### Introduction

### Chang-Su Kim

Some figures are excerpted from the book "Computer Vision Algorithms and Applications" by R. Szeliski

### **Course Outline**

- Pre-requisites
  - Signals and Systems
  - High School Math
  - or Common Sense
- Course Homepage
  - Homepage: <u>http://mcl.korea.ac.kr</u>
- Questions
  - You are welcome to come to my office (Engineering Bldg, Rm 508) and ask any questions any time
  - Tel: 02-3290-3217
  - Email: <u>changsukim@korea.ac.kr</u>
- Teaching Assistant
  - \_ 최환
  - Email: <u>hwanc@mcl.korea.ac.kr</u>
  - Tel: 02-3290-3806

### **Course Outline**

- Assessment Methods
  - Assignments & Attendance: 30%
    - Small coding projects
    - Problem solving assignments
  - Mid-term Exam: 30%
  - Final Exam: 40%
- Textbook and References
  - Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2011. (<u>http://szeliski.org/Book/</u>)
  - David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2003.
  - Linda G. Shapiro and George C. Stockman, *Computer Vision*, Prentice Hall, 2001.

### **Tentative Course Outline**

Week	Topics	Events
1	Introduction, Binary Image Analysis	
2	Binary Image Analysis	
3	Machine Learning Basics	
4	Machine Learning Basics	
5	Machine Learning Basics	
6	Machine Learning Basics	
7	Filtering	
8	Mid Exam	18 April 2023
9	Edge Detection	
10	Segmentation	
11	Segmentation	
12	Pyramidal Image Representation	
13	Texture	
14	Stereo	
15	Motion	
16	Final exam	15 June 2023

### What is computer vision?

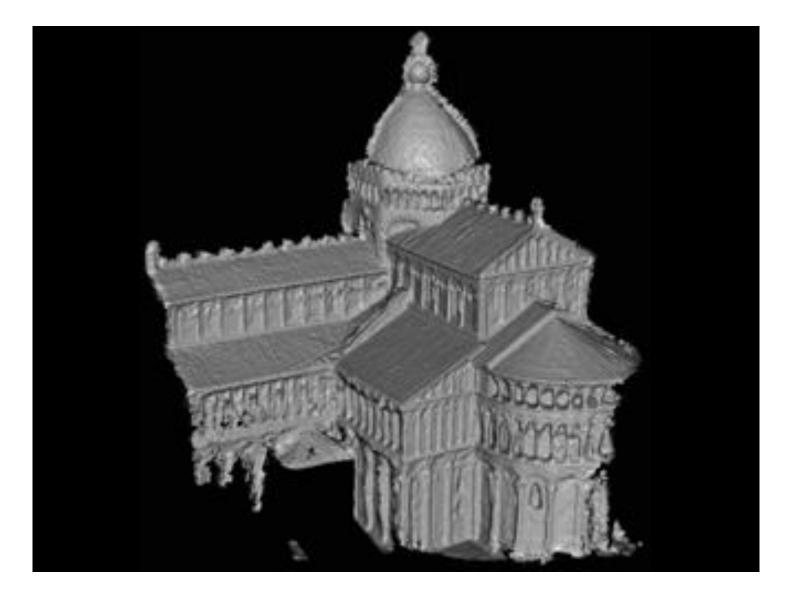
# HVS and Computer



### Examples



# Examples





















































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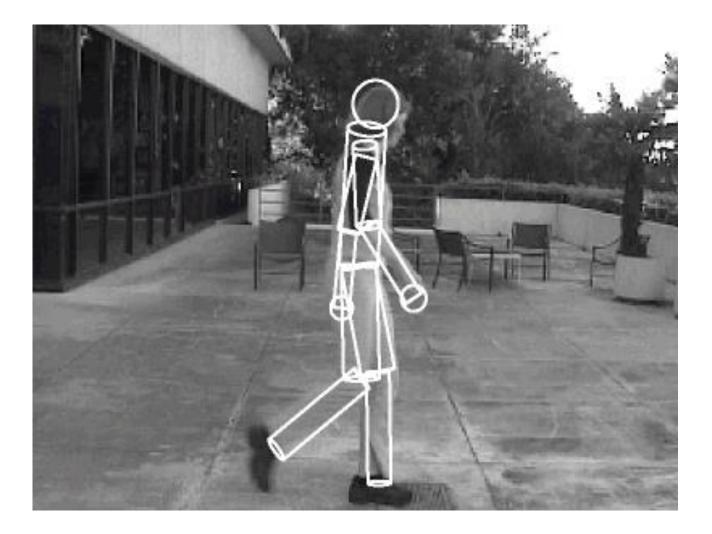




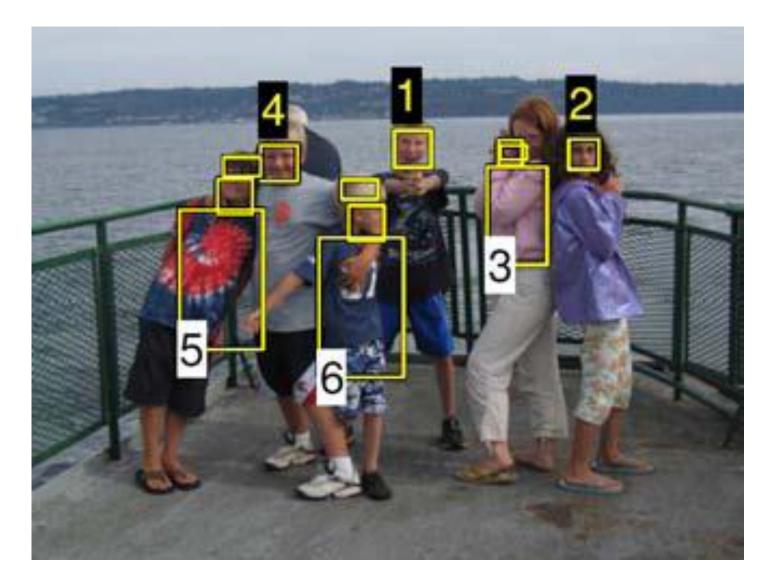




# Examples



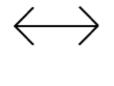
# Examples

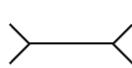


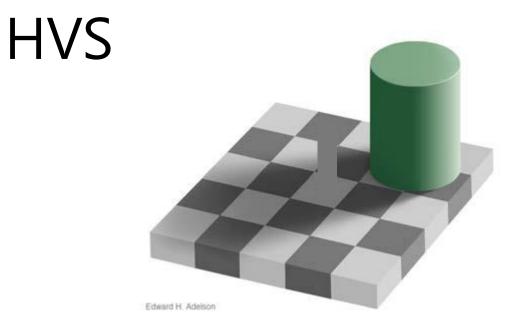
### How many are there?

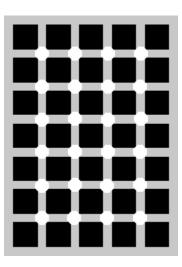


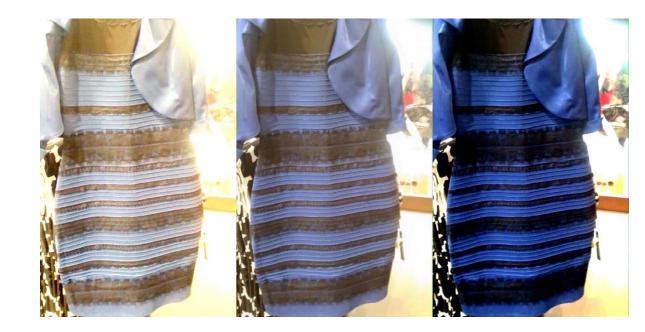
### • Side results



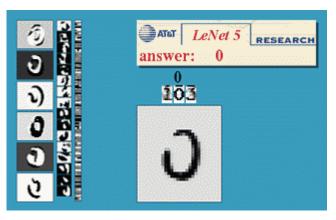








### Applications



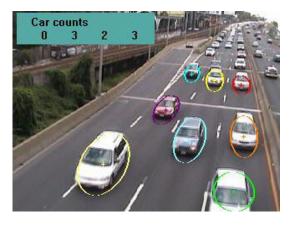




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# Applications



(a)



(b)











Input Photographs

2D Sketching Interface

Geometric Model

Texture-mapped model

(d)

### A Brief History

1970

1980

1990

2000

Digital image processing Blocks world, line labeling Generalized cylinders Pictorial structures Stereo correspondence Intrinsic images Optical flow Structure from motion Image pyramids Scale-space processing Shape from shading, texture, and focus Physically-based modeling Regularization Markov Random Fields Kalman filters 3D range data processing Projective invariants Projective invarinters Projective invariants Pr	Learning
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- Short history
- Recent big bang

### Hot! 2018

#### English

Top publications - English

Learn more

Business, Economics & Management	Publication	h5-index	h5-median
Chemical & Material Sciences	1. Nature	379	560
Engineering & Computer Science	2. The New England Journal of Medicine	342	548
Health & Medical Sciences	3. Science	312	464
	4. The Lancet	259	418
Humanities, Literature & Arts	5. Cell	224	339
Life Sciences & Earth Sciences	6. Chemical Society reviews	224	329
Physics & Mathematics	7. Journal of the American Chemical Society	218	293
Social Sciences	8. Proceedings of the National Academy of Sciences	215	286
Chinese	9. Advanced Materials	201	301
	10. Angewandte Chemie International Edition	198	276
Portuguese	11. Journal of Clinical Oncology	197	265
Spanish	12. Physical Review Letters	196	282
German	13. Chemical Reviews	194	332
Russian	14. Nano Letters	192	270

45. IEEE Conference on Computer Vision and Pattern Recognition, CVPR	140	214
	100	

### Hot! 2023

	Publication	h5-index	h5-median
1.	Nature	444	667
2.	The New England Journal of Medicine	432	780
3.	Science	401	614
4.	IEEE/CVF Conference on Computer Vision and Pattern Recognition	389	627
5.	The Lancet	354	635
6.	Advanced Materials	312	418
7.	Nature Communications	307	428
8.	Cell	300	505
9.	International Conference on Learning Representations	286	533
10.	Neural Information Processing Systems	278	436

### Supplementary Video

Moving Window Regression: A Novel Approach to Ordinal Regression

> Anonymous CVPR 2022 submission Paper ID 6920

### Supplementary Video

#### Eigenlanes: Data-Driven Lane Descriptors for Structurally Diverse Lanes

Anonymous CVPR 2022 submission Paper ID 6918 Supplemental Video on DPICT: Deep Progressive Image Compression Using Trit-Planes

# What is Computer Vision?

 Develop computational algorithms to mimic or replace the functionality of human visual system



### **Tentative Course Outline**

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13	Texture	
14	Stereo	
15	Motion	
16		Final exam

### **Binary Image Analysis**

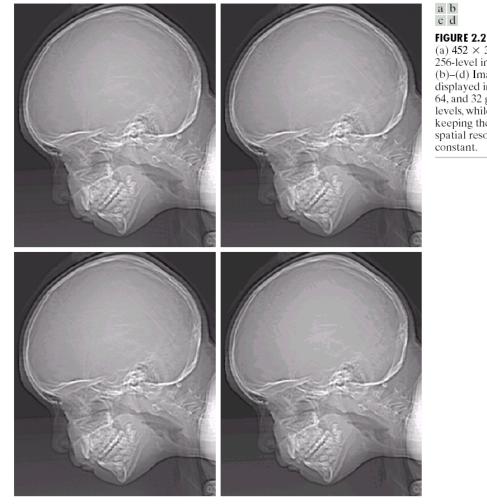


FIGURE 2.21 (a)  $452 \times 374$ , 256-level image. (b)-(d) Image displayed in 128, 64, and 32 gray levels, while keeping the spatial resolution

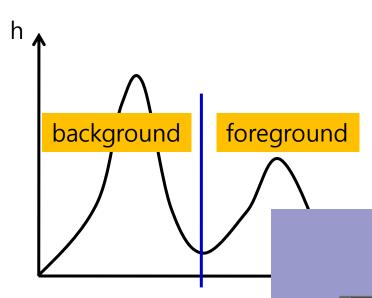




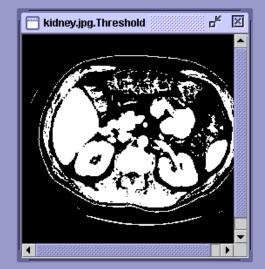




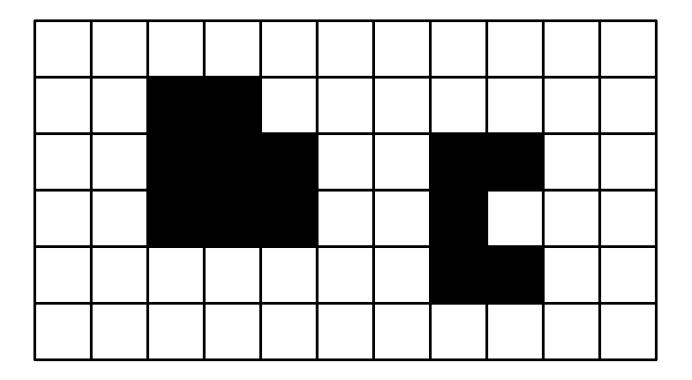
### **Binary Image Analysis**







# **Binary Image Analysis**



How many objects are there?

# Pattern Recognition Concepts

- Recognition
  - To know that



apple from our knowledge

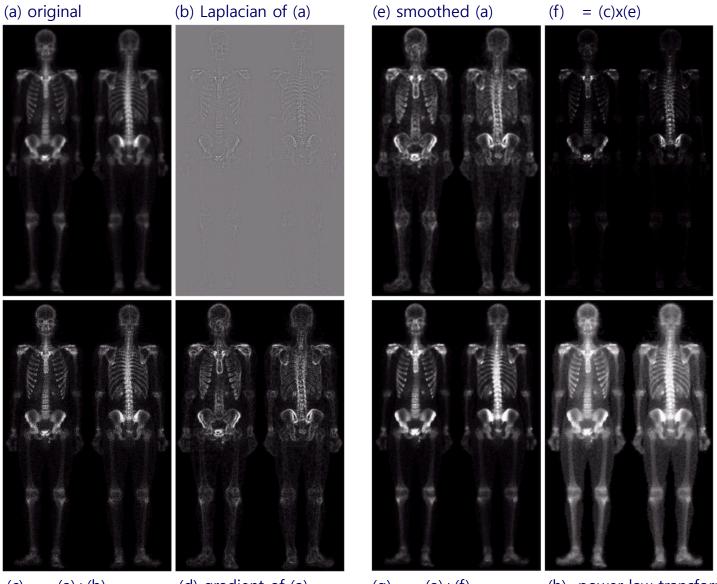
#### rec·og·nize 🔿

rec·og·nize (rĕk'əg-nīz´) verb, transitive
rec·og·nized, rec·og·niz·ing, rec·og·niz·es

- To know to be something that has been perceived before: recognize a face.
- To know or identify from past experience or knowledge: recognize hostility.
- 3. To perceive or show acceptance of the validity

- Computer vision
  - To make useful decision based on sensed images
  - It includes visual pattern recognition

### Image Filtering and Enhancement



(c) = (a)+(b)

(d) gradient of (a)

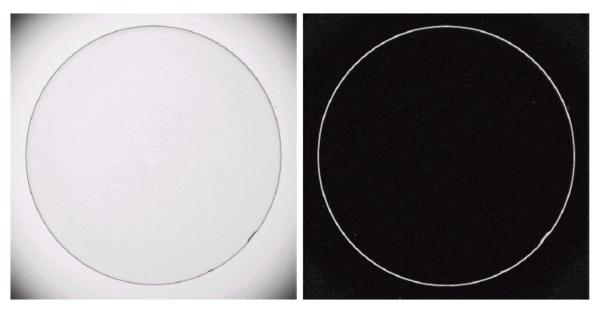
(g) = (a)+(f)

(h) power-law transform of (g)

### Image Filtering and Enhancement

#### Input image

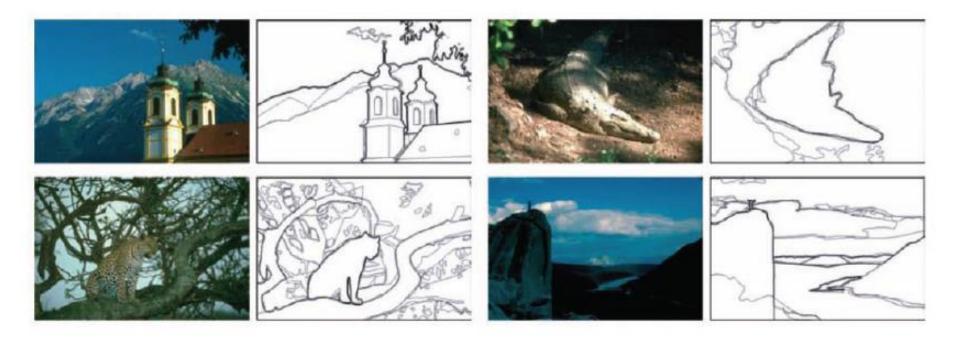
#### Gradient image



#### a b

FIGURE 3.45 Optical image of contact lens (note defects on the boundary at 4 and 5 o'clock). (b) Sobel gradient. (Original image courtesy of Mr. Pete Sites, Perceptics Corporation.)

### **Edge Detection**

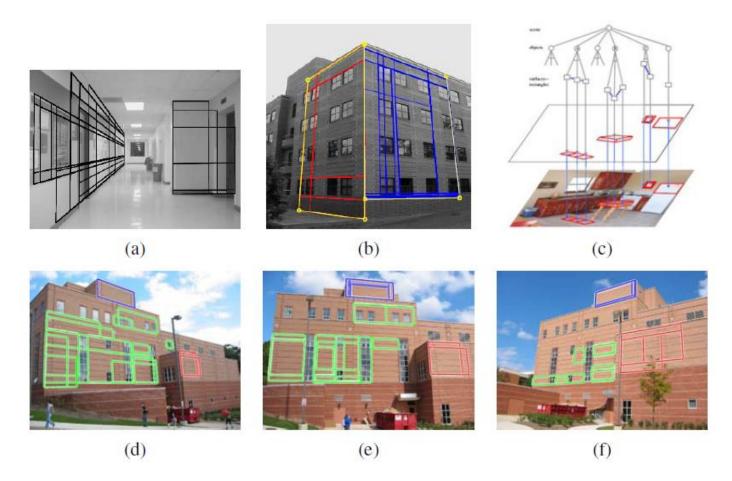


**Figure 4.31** Human boundary detection (Martin, Fowlkes, and Malik 2004) © 2004 IEEE. The darkness of the edges corresponds to how many human subjects marked an object boundary at that location.

### Edge Detection



### Edge Detection



**Figure 4.47** Rectangle detection: (a) indoor corridor and (b) building exterior with grouped facades (Košecká and Zhang 2005) © 2005 Elsevier; (c) grammar-based recognition (Han and Zhu 2005) © 2005 IEEE; (d–f) rectangle matching using a plane sweep algorithm (Mičušìk, Wildenauer, and Košecká 2008) © 2008 IEEE.



Original image



2 clusters



5 clusters



#### 10 clusters

20 clusters

50 clusters

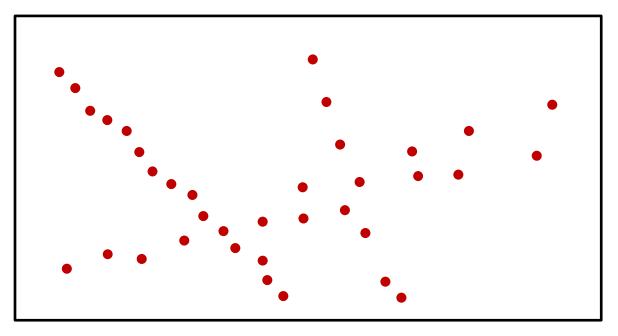
Image

Clusters on intensity

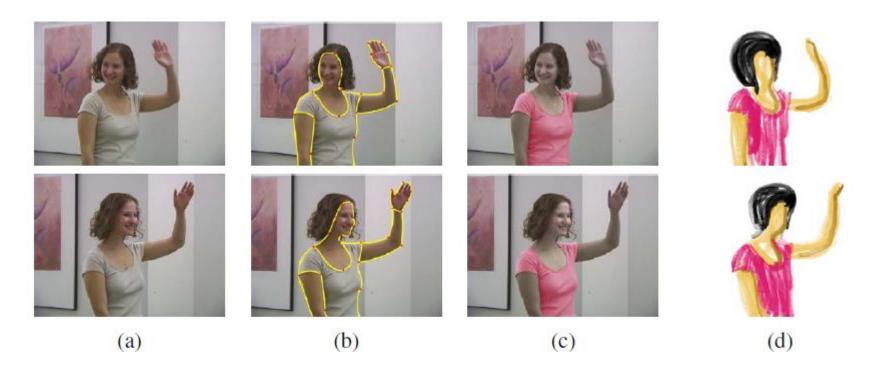
Clusters on color



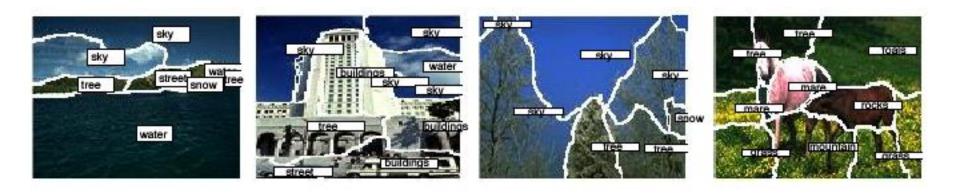
K-means clustering using intensity alone and color alone (5 clusters in each case)

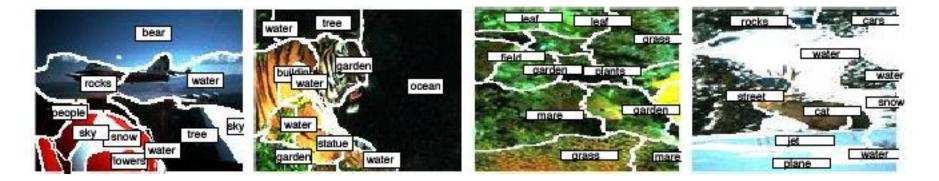


- Three main questions
  - What line represents this set of points best?
  - Which lines gets which points?
  - How many lines are there?

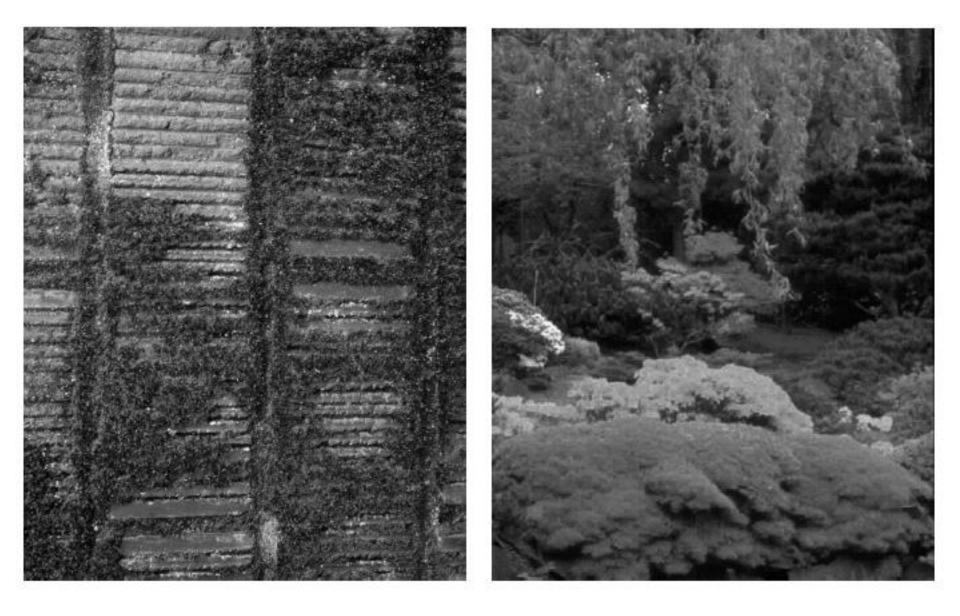


**Figure 5.12** Keyframe-based rotoscoping (Agarwala, Hertzmann, Seitz *et al.* 2004) © 2004 ACM: (a) original frames; (b) rotoscoped contours; (c) re-colored blouse; (d) rotoscoped hand-drawn animation.





### Texture



### Texture

# squared responses vertical horizontal

### classification



black: neither horizontal nor vertical dark gray: horizontal bright gray: vertical white: both

#### smoothed mean

### Texture

### Example

ut it becomes harder to lau cound itself, at "this daily i ving rooms," as House Der escribed it last fall. He fai ut he left a ringing question ore years of Monica Lewin inda Tripp?" That now seen Political comedian Al Fran ext phase of the story will



### Synthesized Texture

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### Stereo

#### Left

#### Right



### Stereo





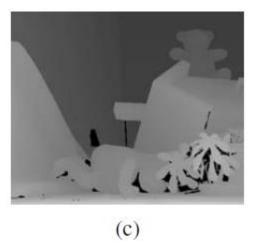
Disparity Map

### Stereo





(b)



(a)



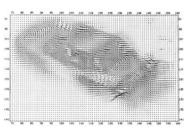




(d)

### **Motion**





(a)



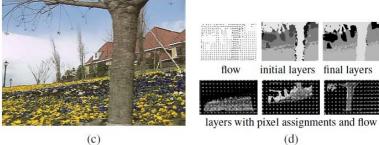






Figure 8.1 Motion estimation: (a-b) regularization-based optical flow (Nagel and Enkelmann 1986) © 1986 IEEE; (c-d) layered motion estimation (Wang and Adelson 1994) © 1994 IEEE; (e-f) sample image and ground truth flow from evaluation database (Baker, Black, Lewis et al. 2007) © 2007 IEEE.

### Motion

