**KECE471** 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://portal.korea.ac.kr</u>  $\rightarrow$  <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>

# **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	Pattern Recognition Concept	
4	Filtering and Enhancing Images	
5	Edge Detection	
6	Segmentation	
7		Mid exam (11 APR 2017)
8	Segmentation	
9	Segmentation	
10	Pyramidal Image Representation	
11	Pyramidal Image Representation	
12	Texture	
13	Texture	
14	Stereo	
15	Motion	
16		Final exam (13 JUN 2017)

# What is computer vision?

# HVS and Computer



# Examples



# Examples





















































w.google.co.kr/imgres?imgurl=http://www.paris-tours-guides.com/imag...











# Examples



# Examples



## How many are there?



### • Side results











# Applications







About Hobileye | Press Room | Contact III | Hasufacturer Products | Consumer Products | Partners







# Applications



(a)



(b)







(c)



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 Structure from shading, texture, and focus Shape from shading, texture, and focus Physically-based modeling Regularization Markov Random Fields Kalman filters 3D range data processing Projective invariants Factorization Physics-based vision Physics-based vision	Graph cuts Particle filtering Energy-based segmentation Particle filtering Energy-based segmentation Subspace methods Subspace methods Image-based modeling and rendering and rendering Ature synthesis and inpainting Computational photography Feature-based recognition MRF inference algorithms Category recognition
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- Short history
- Recent big bang

# Hot!

### Google Scholar

Chinese

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English

nglish	Top publications - English Learn more		
Business, Economics & Management	Publication	h5-index	h5-median
Chemical & Material Sciences	1. Nature	355	495
Engineering & Computer Science	2. The New England Journal of Medicine	329	495
Health & Medical Sciences	3. Science	311	431
Humanities, Literature & Arts	4. The Lancet	248	381
Life Sciences & Earth Sciences	5. Cell	223	343
Physics & Mathematics	6. Proceedings of the National Academy of Sciences	217	280
	7. Journal of Clinical Oncology	205	306
Social Sciences	8. Chemical Reviews	193	339
hinese	9. Physical Review Letters	191	263
ortuguese	10. Journal of the American Chemical Society	190	250
erman	11. Nature Genetics	188	270

#### 65. IEEE Conference on Computer Vision and Pattern Recognition, CVPR 118 167

Search Scholar

Q

# Many Interesting Topics



2. Image Formation



3. Image Processing



4. Features



5. Segmentation



6-7. Structure from Motion



8. Motion



9. Stitching



12. 3D Shape



10. Computational Photography



13. Image-based Rendering



11. Stereo



14. Recognition

# What is Computer Vision?

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



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5	Edge Detection	
6		Mid exam (8 APR 2015)
7	Segmentation	
8	Segmentation	
9	Segmentation	
10	Pyramidal Image Representation	
11	Pyramidal Image Representation	
12	Texture	
13	Texture	
14	Stereo	
15	Motion	
16		Final exam (15 JUN 2015)

# **Binary Image Analysis**



(a)  $452 \times 374$ , 256-level image. (b)-(d) Image displayed in 128, 64, and 32 gray 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



(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 Lewir inda Tripp?" That now seer Political comedian Al Fran ext phase of the story will



### Synthesized Texture

THE TOTAL COULD INSELL, ACTUME OF LOW ACDE Y it ndatrears coune Tring rooms," as Heft he fast nd it l ers dat noears outseas ribed it last of best bedian Al-F econicalHomd it h Al. Heft ars of as da Lewindailf I lian A1Ths," as Lewing questies last aticarstical1. He is dian Al last fal counda Lew, at "this dailyears d ily edianicall. Hoorewing rooms," as House De fale f De und itical counsestscribed it last fall. He fall. Hefft rs oroheoned it nd it he left a ringing questica Lewin . icars coecoms," astore years of Monica Lewinow seee a Thas Fring roome stooniscat nowea re left a roouse bouestof MHe lelft a Lést fast ngine làunesticars Hef vd it rip?" TrHouself, a ring ind itsonestud it a ring que: astical cois ore years of Moung fall. He ribof Mouse )re years ofanda Tripp?" That hedian Al Lest fasee yea nda Tripp?' Holitical comedian Alét he few se ring que olitical cone re years of the storears ofas l Frat nica L ras Lew se lest a rime 1 He fas quest nging of, at beou

## Stereo

#### Left

### Right



### Stereo





Disparity Map

## Stereo





(b)



(a)







(f)

(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

