

# Computer Vision Story

Mubarak Shah

## Computer Vision

- Computer Vision deals with **recovery** and **use** of **information** about **objects** present in a scene from images of the scene.

## Computer Vision

- Computer Vision emerged from:
  - Image Processing
  - Pattern Recognition

## Computer Vision

- Computer Vision started as an AI problem.

# AI

- Artificial Intelligence is the study of mental faculties through the use of computational models.
  - Search
  - NLU
  - Speech Recognition
  - Games
  - Computer Vision
  - Expert Systems

## Image Understanding

- To understand a single image of a scene, locate and identify objects, their structure, and spatial arrangements, and relationships with other objects.

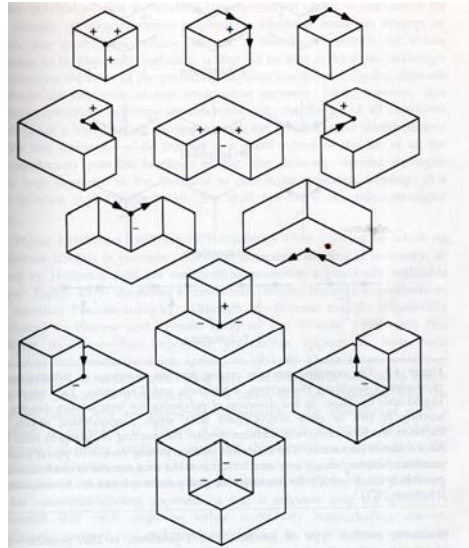
## Different Levels

- Low Level: Extraction of symbolic information
- Intermediate Level
- High Level: Interpretation

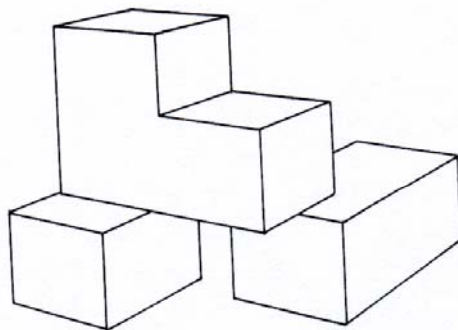
## High Level Vision

- Image Understanding
- Scene Interpretation
- Line Drawings

## Interpretation of Line Drawing



## MIT Copy Demo

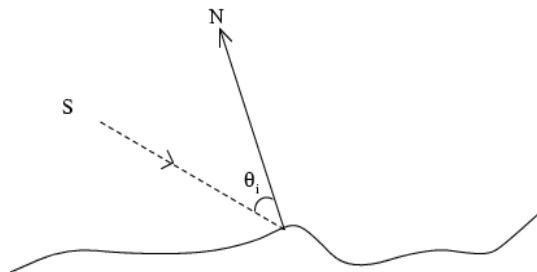


## What happened?

- In order to do line interpretation, need to extract lines from images
  - Horn-Binford line finder
  - Solve low level problems before high level problems can be solved.

## Horn: Physics Based Vision

- Optics
- Reflectance
- Illumination



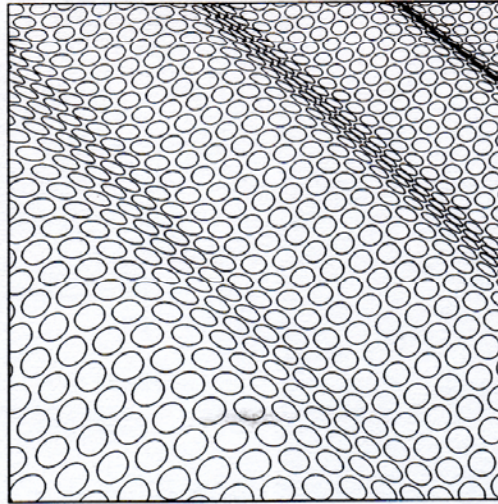
## Marr Approach

- Human vision system
- Shape from X: Recover 3-D from 2-D
- Quantitative vs Qualitative

## Shape from X

- Shading
- Stereo
- Texture
- Motion
- Contours

## Shape from Texture

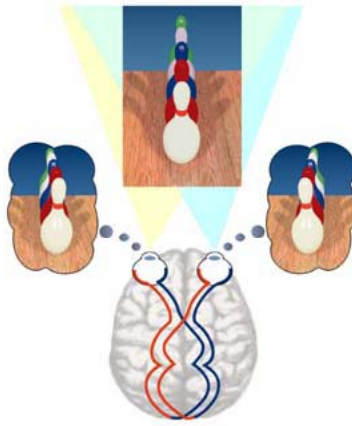


## Shape from Shading





## Shape from Stereo



## Marr's Three Levels

- Primal Sketch
  - Marr-Hildreth edge detector
- 2.5 Sketch
  - Marr-Poggio stereo algorithm
  - Grimson's stereo algorithm
  - Ullman's structure from motion
  - Pentland, Witkin, Kass,
  - Terzopoulos: surface reconstruction
- 3-D
  - Generalized Cylinders: Nishihara

## After 30 Years of Research

- Stereo is almost a solved problem
- Structure from motion is very hard
- Shape from shading is not interesting/applicable
- Range images did not help much
- Not much progress in understanding/recognition/interpretation

## Motion-Based Recognition

- A longer sequence leads to recognition of higher level motions, like walking or running, which consist of a complex and coordinated series of events that cannot be understood by looking at only a few frames.
  - 3-D is not necessary for recognition
  - Use motion directly for recognition vs
    - Recognition followed by reconstruction

## Video Understanding

- Gestures
- Activities
- Facial expressions
- Visual Speech
  
- Applications
  - Video Surveillance and Monitoring
  - Perceptual User Interface
  - Model-based Video Compression
  - Augmented Reality and Video Games
  - Synthesis of Video Sequences

## Copy Demo Using A Video Sequence:



## Making a Sandwich

[bread, lettuce, ham, bread]

A picture is worth a thousand words.



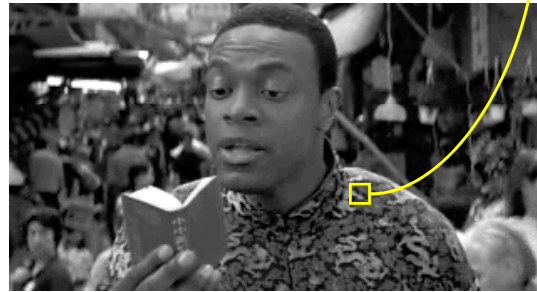
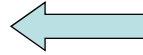
A word is worth a thousand pictures.



A H UNT

# What is an Image?

34	23	58	89	106	97	89	83	83	81
97	39	23	67	75	89	89	89	89	81
139	73	26	67	67	50	75	81	81	75
171	147	97	106	64	7	23	58	81	83
56	89	147	155	114	73	40	50	73	81
23	64	115	148	155	114	48	26	48	73
23	56	74	81	73	64	73	81	89	89
73	56	45	62	57	56	73	81	82	82
97	64	81	103	106	97	89	82	82	82
97	81	89	86	89	97	81	78	82	97



# Video Clip



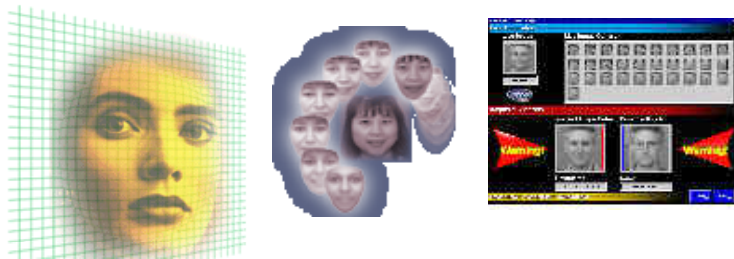
## Sequence of Images



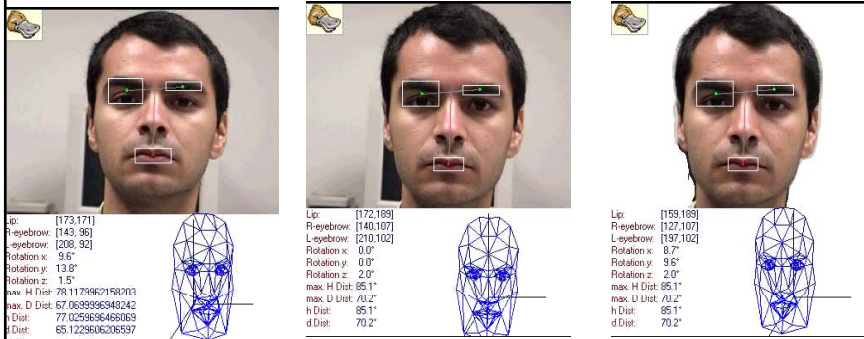
## Applications

- Face Recognition
- Robotics
- Remote Sensing: UAVs
- Computer Graphics
- Video Surveillance and Monitoring
- Video Data Mining

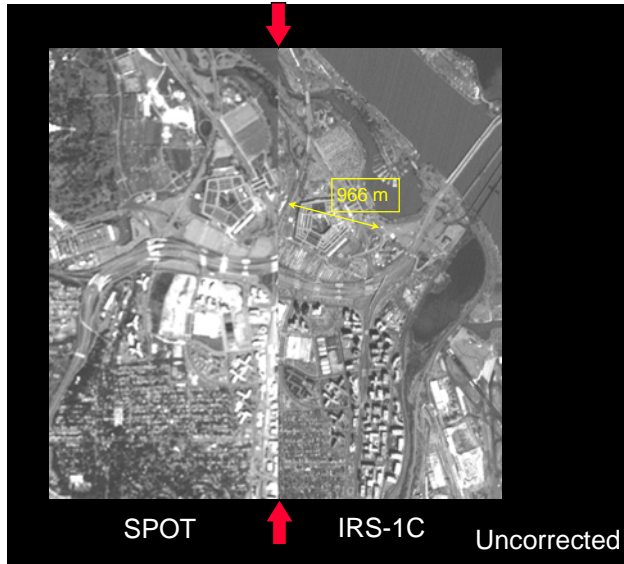
# Face Recognition



# Determining Face Orientation



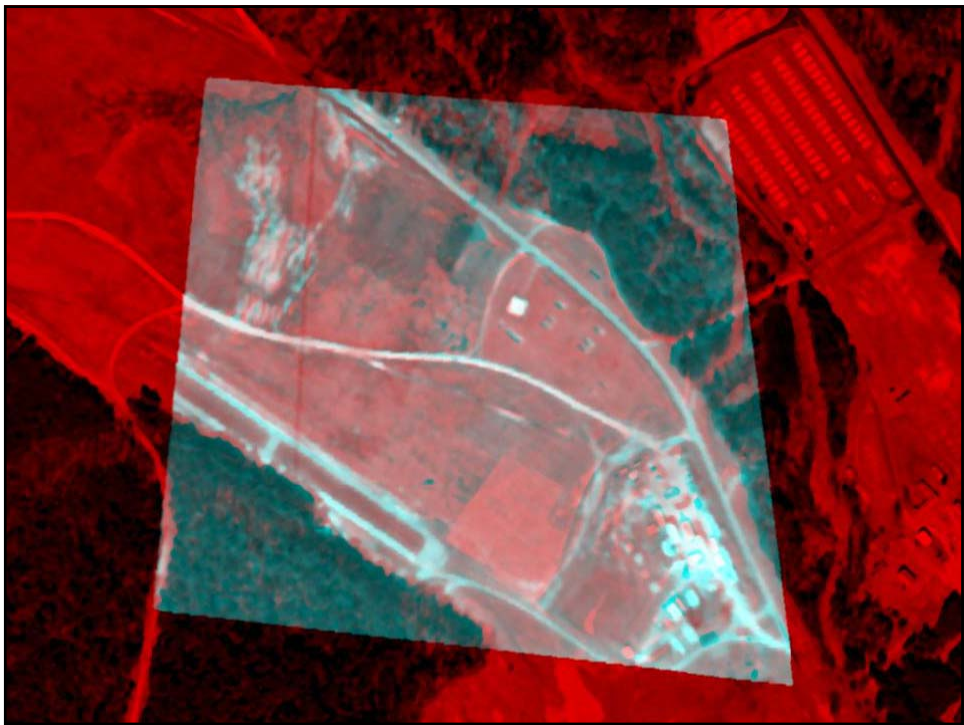
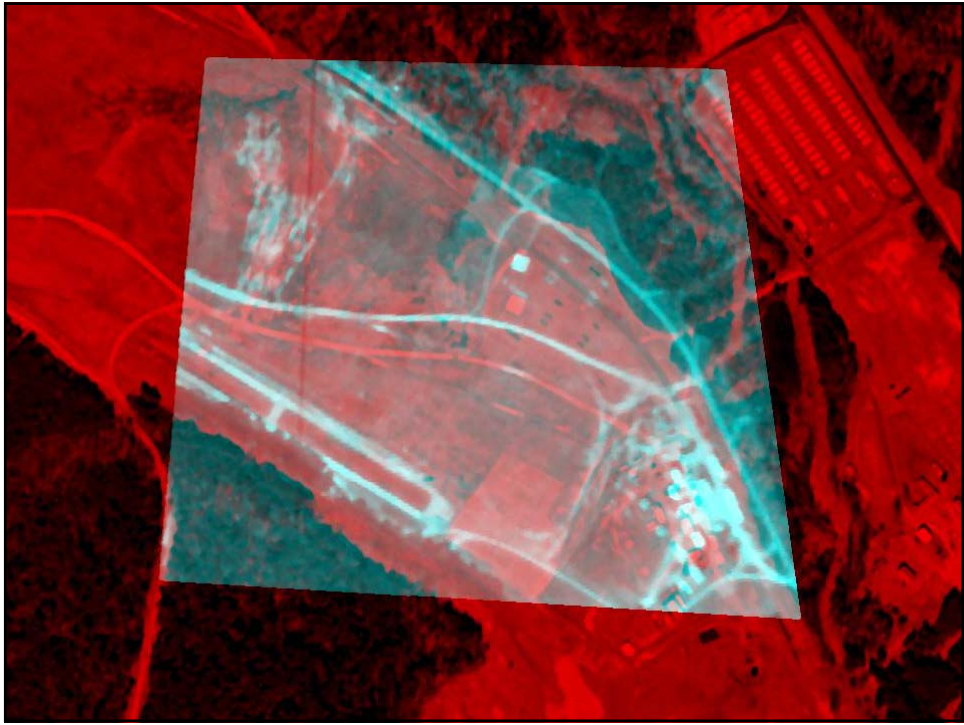
# Geo-registration



# Registered IRS-1C to SPOT







# Image-Based Rendering



## KNIGHT Crime Scene Detection System for The Orlando Police Department



Cameras



# Tracking



## Contour-based Object Tracking Using Level Sets



## Action Detection: Different approaches, different people, the same action

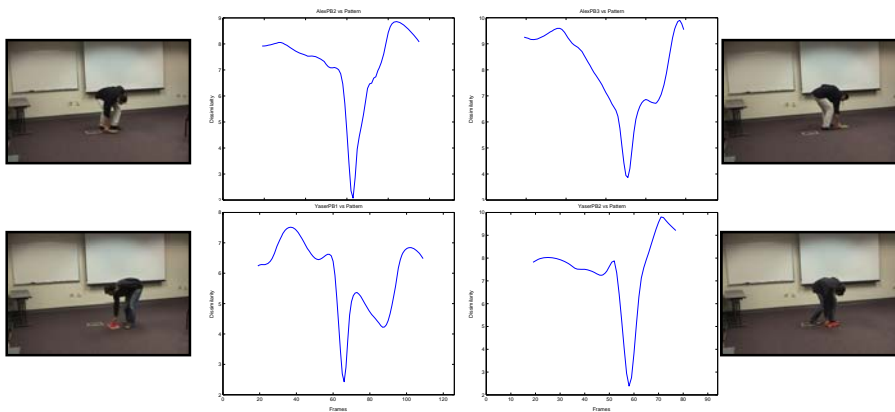


ReferencePattern



Test Sequences

## Action Detection: Different approaches, different people, the same action

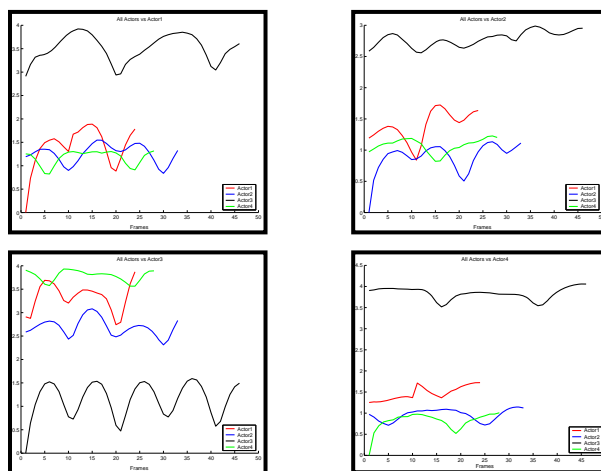


# Analyzing Actions

## *Odd One Out*



## 'Odd One Out'



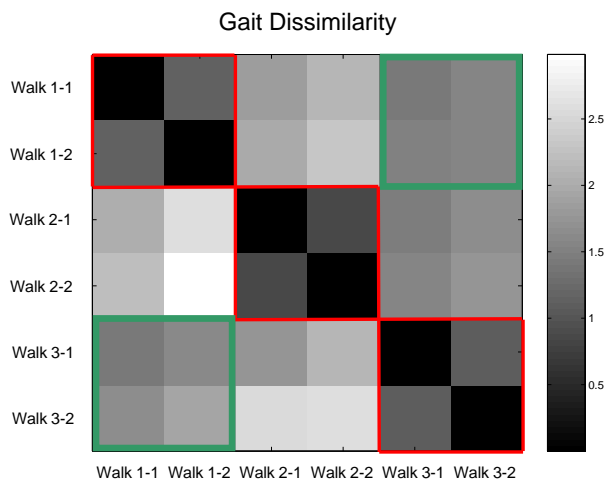
# Gait Analysis

- Three Actors viewed from two views each

## Gait Analysis: Human ID Dataset

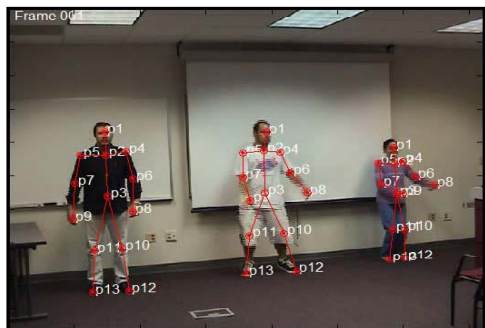


# Gait Analysis



# Action Synchronization

*Following the Leader*



# Action Synchronization

*Following the Leader*



# Outdoor Activities





## Scene Representation (Terminator II)

Obtained  
from the  
DVD



Detected  
by our  
algorithm

Chapter 26: Night Repairs



Chapter 29: Detailed Files



Chapter 30: Scalcedas Camp

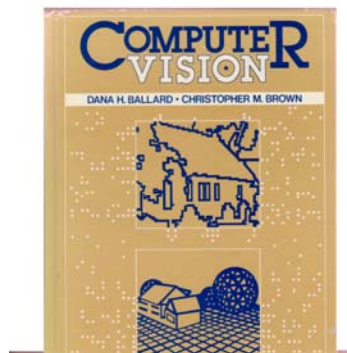


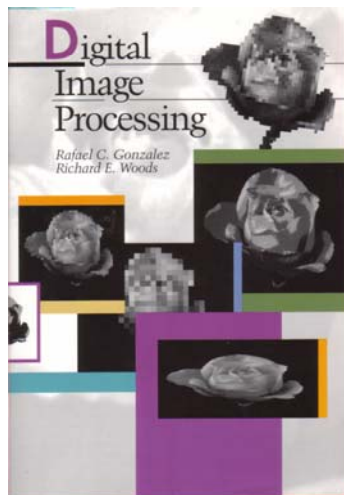
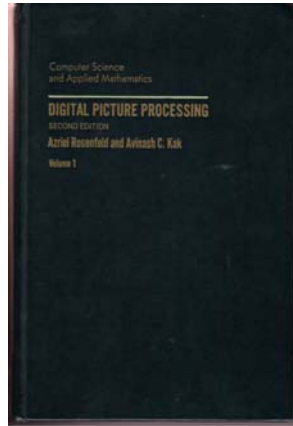
### A Shot Connectivity Graph (Larry King Live)

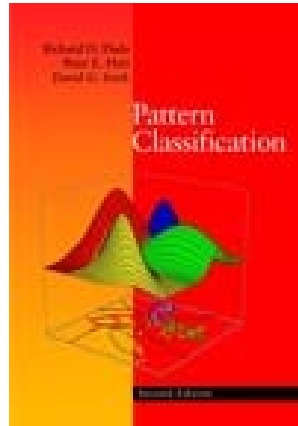


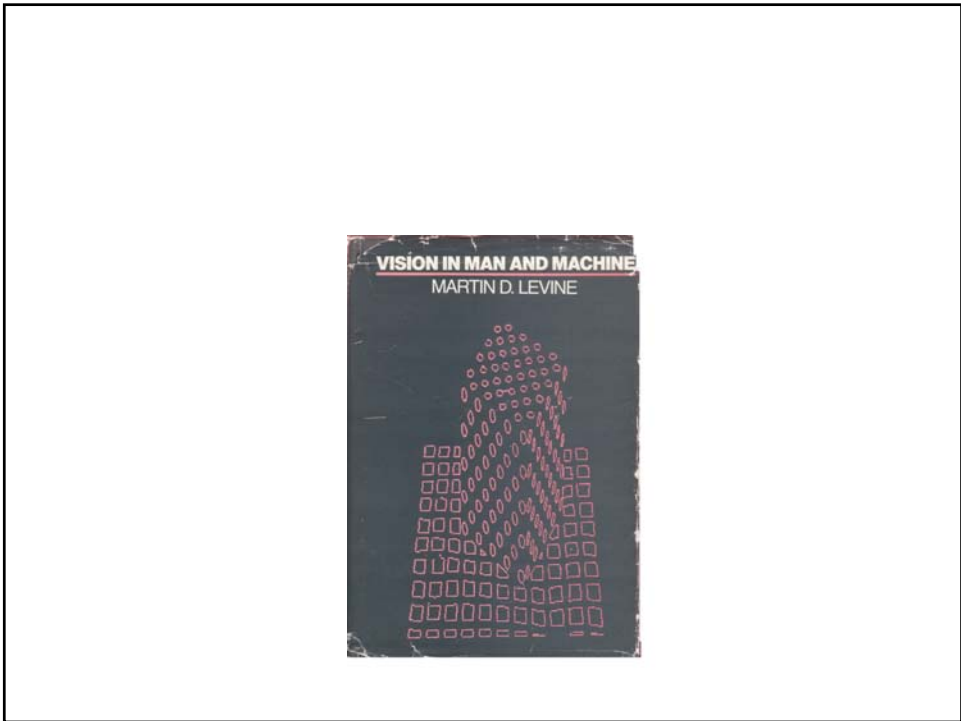
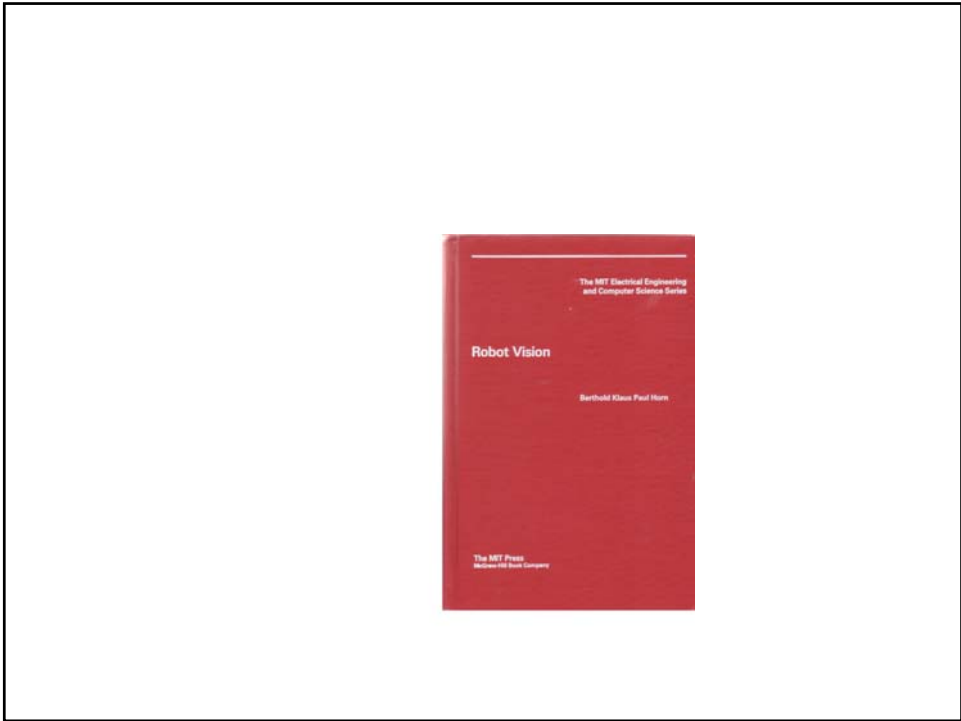
# Computer Vision Text Books

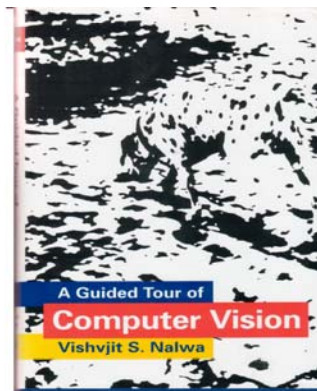
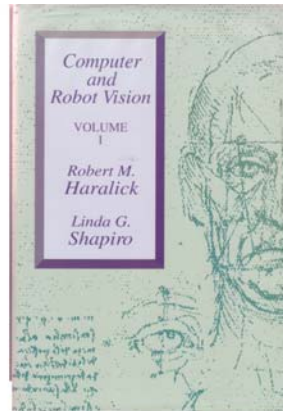
History

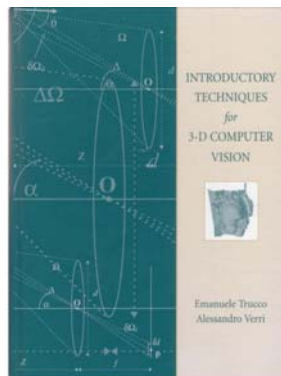
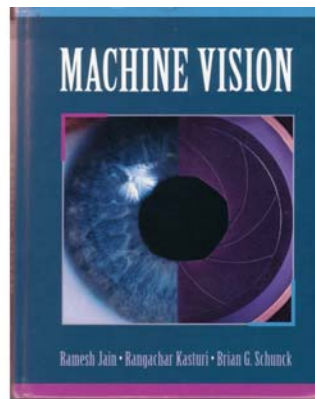


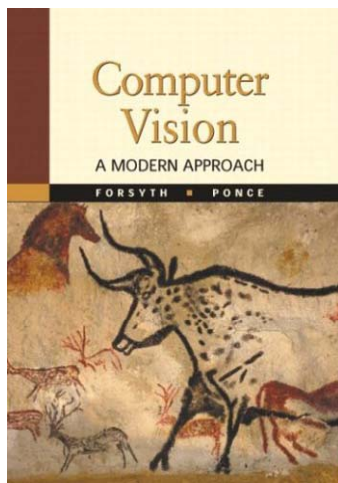
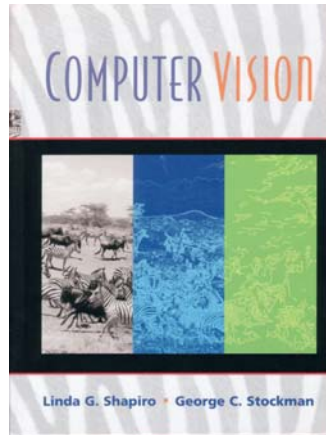








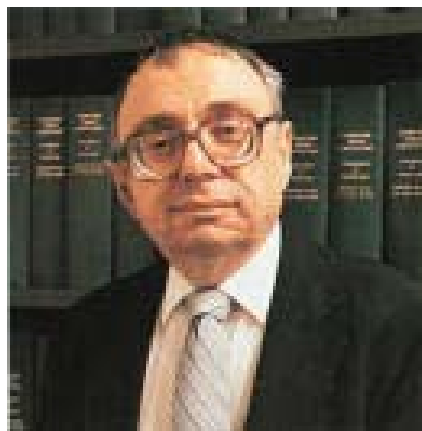






## Computer Vision Researchers

Azriel Rosenfeld



Berthold Horn



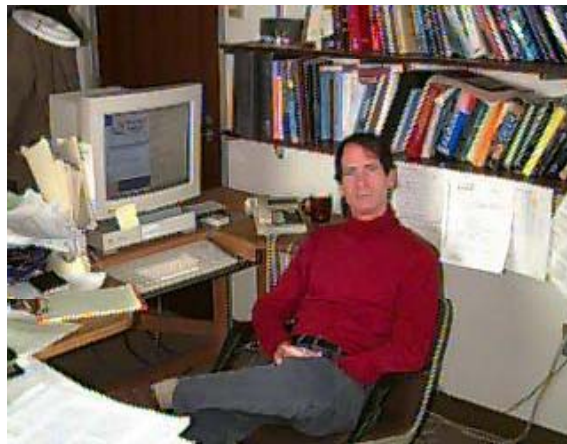
Thomas Huang



Jake Aggarwal



Chris Brown



Bob Haralick



Olivier Faugeras



Takeo Kanade



Sandy Pentland



Shree Nayar



John Canny



# Demetri Terzopoulos



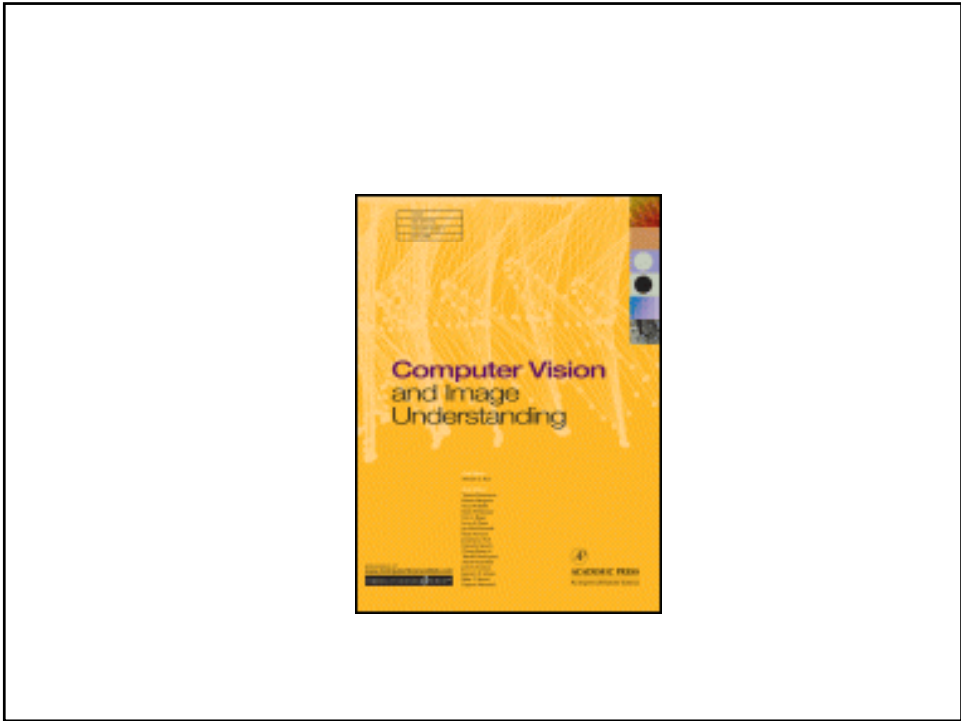
# Ramesh Jain

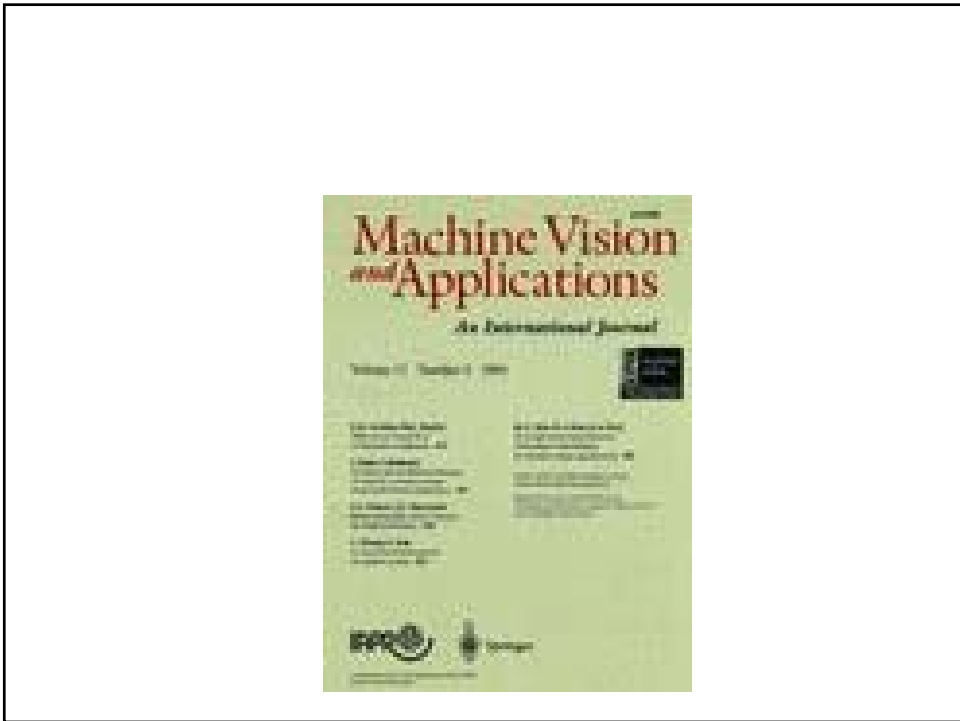
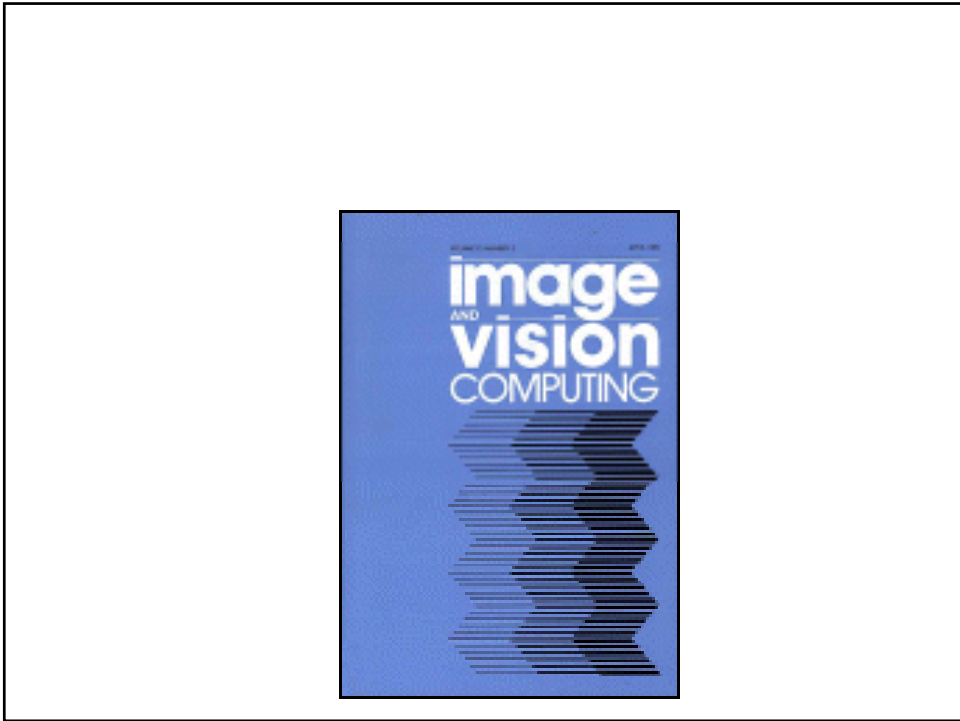


# Computer Vision Journals





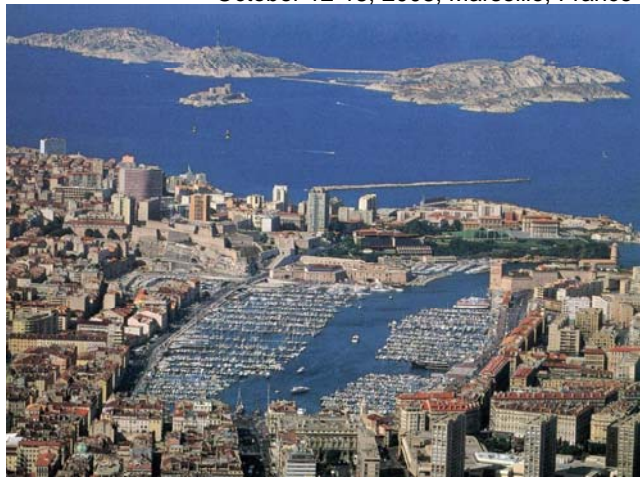




# Computer Vision Conferences

## European Conference on Computer Vision (ECCV, 2008)

October 12-18, 2008, Marseille, France



## International Conference on Pattern Recognition (ICPR, 2008)



## International Conference on Computer Vision (ICCV)

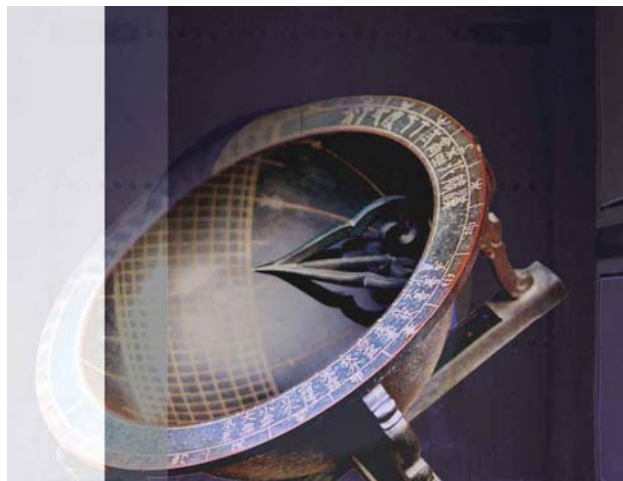
- September 29-October 2, 2009, Kyoto, Japan



# IEEE Conference on Computer Vision and Pattern Recognition (CVPR)



# Asian Conference on Computer Vision (ACCV)



# International Conference on Image Processing



Computer Vision at UCF

## Milestones

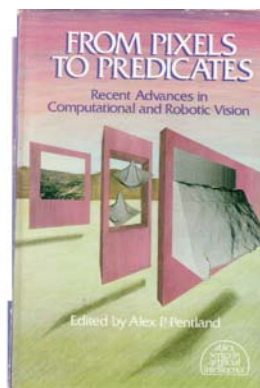
- Started in August 1986
- Developed four courses
  - Intro to Robot Vision
  - Computer Vision
  - Computer Vision Systems
  - Advanced Computer Vision
- Graduated first Ph.D. student in 1989
- Dr. Lobo joined in 1992
- Dr. Foroosh joined in 2002
- Dr. Tappen Joined in 2006

## Vision Books Used at UCF

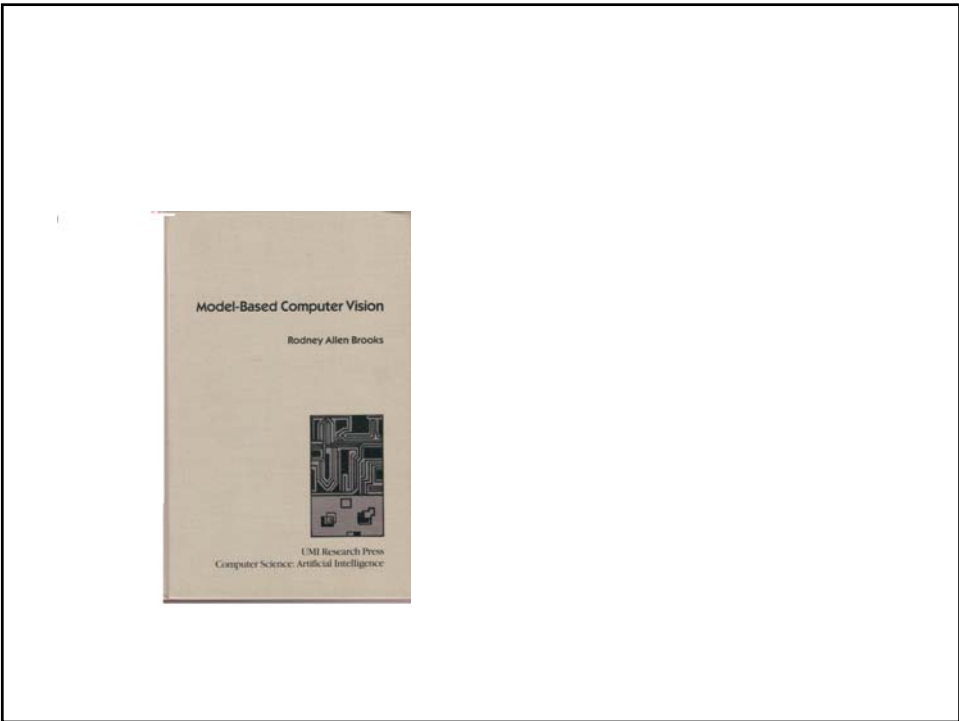
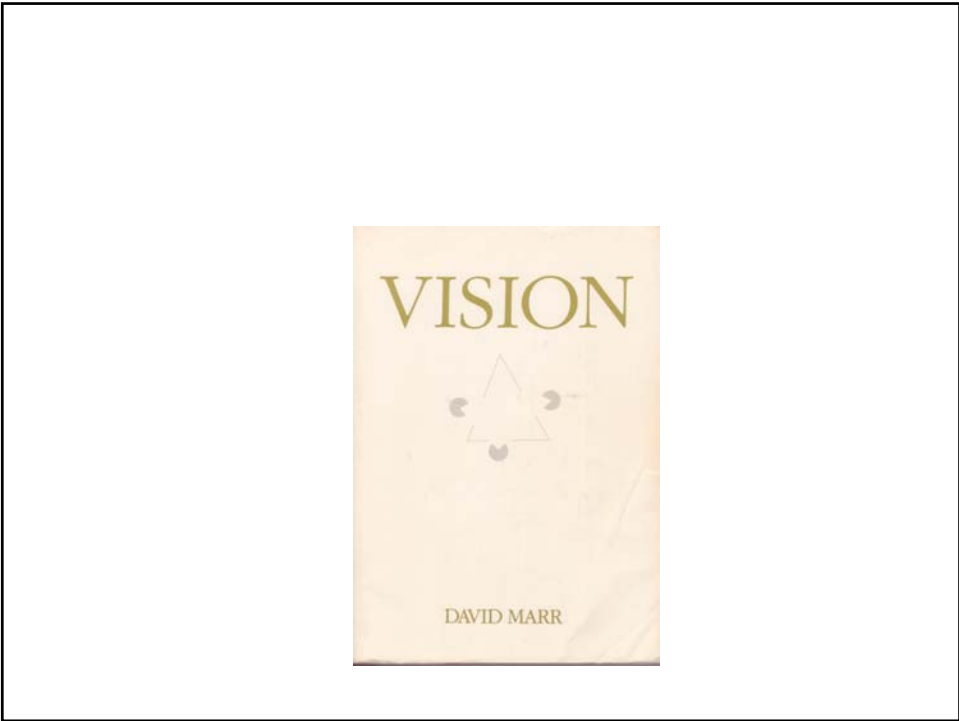
FUNDAMENTALS OF COMPUTER VISION<sup>1</sup>

Miharak Shah  
Computer Science Department  
University of Central Florida  
Orlando, FL 32816

December 7, 1997



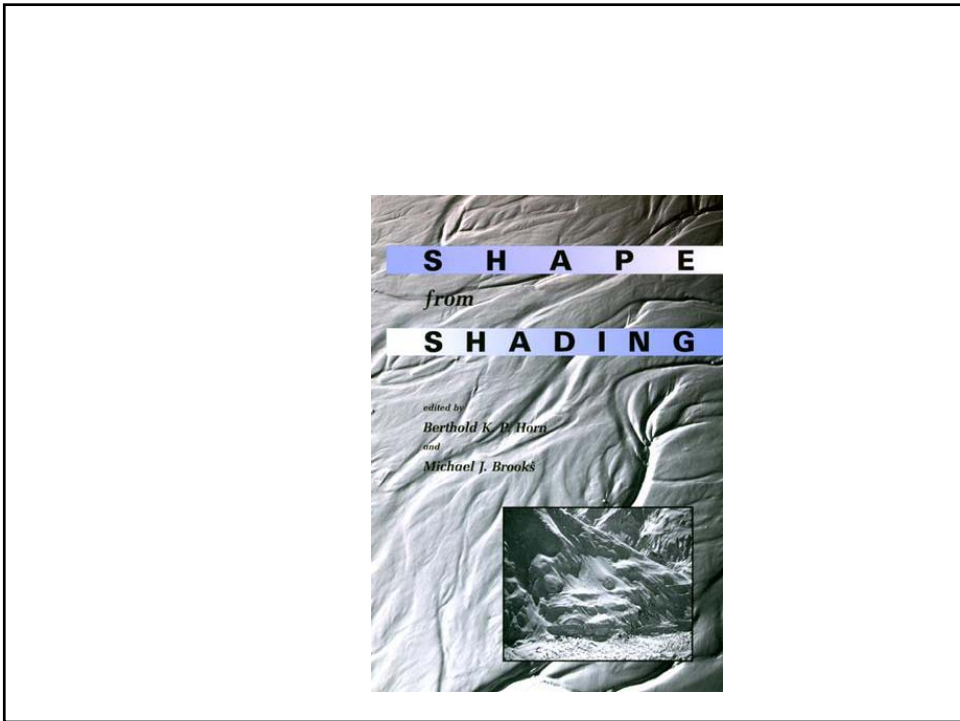
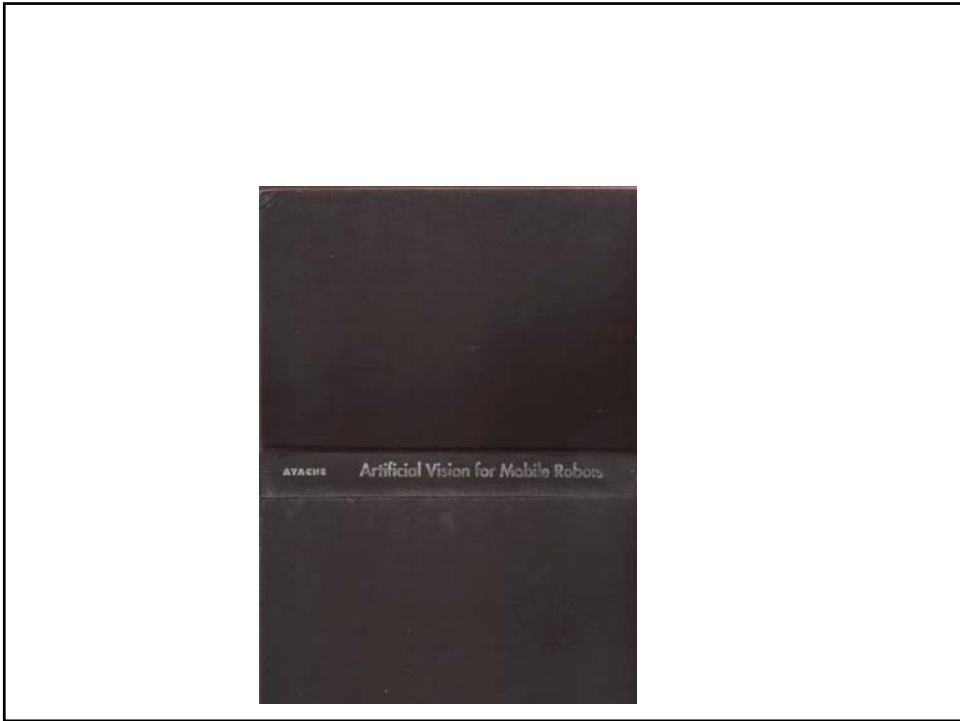


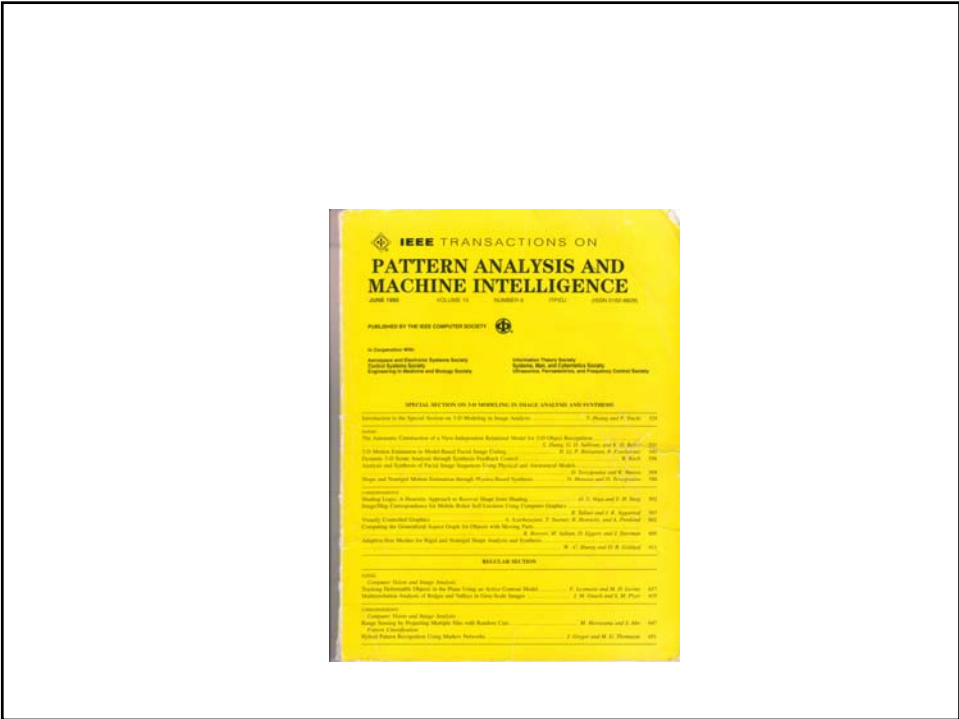


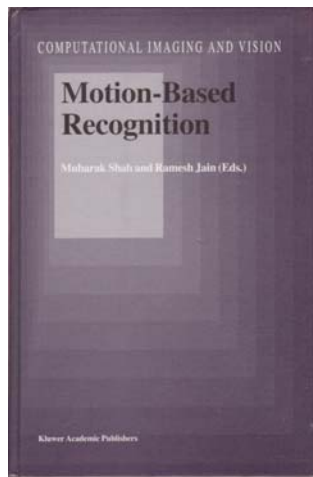
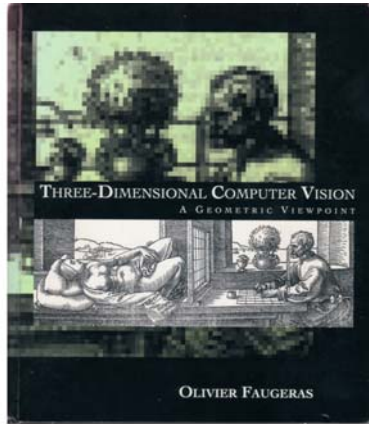
# Perceptual Organization and Visual Recognition

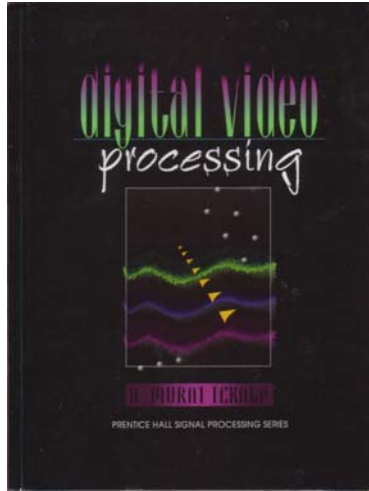
David Lowe  
Kluwer Academic Publishers,  
1985











Vision Ph.D. Graduates

## Donna J Williams, 1989

- Donna Williams, and Mubarak Shah. "[Edge Characterization Using Normalized Edge Detection](#)", CVGIP: Graphical Models and Image Processing, Vol. 55, No. 4, July 1993, pp 311-318.
- Donna Williams, and Mubarak Shah. "[A Fast Algorithm for Active Contours and Curvature Estimation](#)", Computer Vision, Graphics and Image Processing, Vol 55, No.1, January 1992, pp 14-26.
- Donna Williams, and Mubarak Shah. "[Edge Contours Using Multiple Scales](#)", Computer Vision, Graphics and Image Processing, September 1990, Volume 51, pp 256-274.

## Krishnan Rangarajan, 1990

- Krishnan Rangarajan, Bill Allen, and Mubarak Shah. "[Matching Motion Trajectories](#)", Pattern Recognition, Vol. 26, No. 4, pp 595-610, April, 1993.
- Mubarak Shah, Krishnan Rangarajan, and Ping-Sing Tsai. "[Motion Trajectories](#)", IEEE Transaction on Systems, Man and Cybernetics, Vol. 23, No. 4, August 1993, pp 1138-1150.
- Krishnan Rangarajan, and Mubarak Shah. "[Interpretation of Motion Trajectories Using Focus of Expansion](#)", IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol. 14, No. 12, December 1992.
- Krishnan Rangarajan, and Mubarak Shah. "[Establishing Motion Correspondence](#)", Computer Vision, Graphics and Image Processing: Image Understanding, July 1991, pp 56-73.
- Krishnan Rangarajan, Mubarak Shah, and David Van Brackle. "[Optimal Corner Detector](#)", Computer Vision, Graphics and Image Processing, vol. 48, pp 230-245, November 1989.

## Ping-Sing Tsai, 1995

- Ping-Sing Tsai and Mubarak Shah. "[Shape from Shading with Variable Albedo](#)", Optical Engineering, pp 121-1220, April 1998.
- James Cryer, Ping-Sing Tsai and Mubarak Shah. "[Shape from Shading and Stereo](#)", Pattern Recognition, Volume 28, No. 7, pp 1033-1043, July 1995.
- Ping-sing Tsai and Mubarak Shah. "[Shape From Shading Using Linear Approximation](#)" Image and Vision Computing Journal, 1994.
- Ping-Sing Tsai, Mubarak Shah, Katharine Keiter, and Takis Kasparis. "[Cyclic Motion Detection for Motion Based Recognition](#)", Pattern Recognition, Vol. 27, No. 12, 1994.
- Ping-Sing Tsai and Mubarak Shah. "[Shape from shading using linear approximation](#)", Image and Vision Computing, Vol. 12, No. 8, October 1994, pp 487-498

## Ruo Zhang, 1995

- Ruo Zhang, Ping-Sing Tsai, James Cryer and Mubarak Shah. "[Shape from Shading: A Survey](#)", IEEE Transactions on Pattern Analysis and Machine Intelligence, Volume 21, Number 08, August, 1999, pp 690-706.
- Ruo Zhang and Mubarak Shah. "[Shape from Intensity Gradient](#)", IEEE Transactions on Systems, Man and Cybernetics, PART A, May 1999.
- Ruo Zhang and Mubarak Shah. "[Iterative Shape Recovery From Multiple Images](#)", Image and Vision Computing, Volume 15 (1997), 801-814, November 1997.
- Ruo Zhang, Ping-Sing Tsai and Mubarak Shah. "[Photomtion](#)", CVGIP: Image Understanding, Vol. 63, No. 2, pp 221-231, March 1996.



## Yu Tian, 1997

- Yu Tian and Mubarak Shah. "[Recovering 3D Motion and Structure using Adaptive Hough Transform](#)", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol19, NO. 10, October 1997, pp 1178-1183.
- Yu Tian and Mubarak Shah. "[Motion Estimation and Segmentation](#)", Machine Vision and Applications, vol 9, pp 32-42, 1995

## Niels Haering, 1999

- Niels Haering, Richard Qian, and Ibrahim Sezan, "*A Semantic Event Detection Approach and Its Application to Detecting Hunts in Wildlife Video*", IEEE Transactions on Circuits and Systems for Video Technology, 1999.
- Niels Haering and Niels da Vitoria Lobo, "*Features and Classification Methods to Annotate Images with their Deciduous Tree Content*", Journal of Computer Vision and Image Understanding, 1999.

## Sohaib Khan, 2002

- From Thesis
  - S. Khan, M. Shah, “Tracking in the Presence of Occlusion”, ACCV 2000
  - S. Khan, O. Javed, Z. Rasheed, M. Shah, “Human Tracking in Multiple Cameras”, ICCV 2001
  - S. Khan, O. Javed, M. Shah, “Tracking in Uncalibrated Stationary Cameras with Overlapping Field of View”, PETS 2001, in conjunction with CVPR 2001
  - S. Khan, M. Shah, “Consistent Labeling of Tracked Objects in Multiple Cameras with Overlapping Fields of View”, PAMI 2003.
  - S. Khan, M. Shah, “Object-Based Segmentation of Video using Color, Motion and Spatial Information”, CVPR 2001

## Cen Rao, 2003

- “View-Invariant Representation And Recognition of Actions”, International Journal of Computer Vision, Vol. 50, Issue 2, 2002
- “View Invariance in Action Recognition”, Computer Vision and Pattern Recognition, CVPR 2001, Kauai, Hawaii, Dec 11-13, 2001
- Cen Rao, Alexei Gritai, Mubarak Shah, [View-invariant Alignment and Matching of Video Sequences](#). The Ninth IEEE International Conference on Computer Vision, Nice, France, 2003.
- Cen Rao, Mubarak Shah and Tanveer Syeda-Mahmood, [Action Recognition based on View Invariant Spatio-temporal Analysis](#), ACM Multimedia 2003, Nov 2-8, Berkeley, CA, USA, 2003.

## Zeeshan Rasheed, 2005

- **Book Chapter**
  - Video Categorization using Semantics and Semiotics, In Video Mining Techniques, KLUWER Academic Publishers, 2003
- **Journal Publications**
  - Zeeshan Rasheed and Mubarak Shah, “Scene Segmentation of Hollywood Movies and TV Shows”, IEEE Transactions on Multi-media, December 2005.
  - Zeeshan Rasheed, Yaser Sheikh, Mubarak Shah \On the Use of Computable Video Features for Film Classification,” IEEE Transactions on Circuit and Systems for Video Technology, June 2004.
- **Conference and Workshop Publications**
  - Scene Detection In Hollywood Movies and TV Shows, IEEE Computer Vision and Pattern Recognition Conference, 2003
  - Movie Genre Classification By Exploiting Audio-Visual Features Of Previews, IEEE International Conference on Pattern Recognition, 2002
  - A Framework for Segmentation of Talk & Game Shows, IEEE International Conference on Computer Vision, 2001

## Zeeshan Rasheed, 2003

- Tracking Across Multiple Cameras With Disjoint Views, Omar Javed, Zeeshan Rasheed, Khurram Shafique and Mubarak Shah, IEEE International Conference on Computer Vision, Nice, France, 2003
- M-KNIGHT: A Real-time Surveillance System for Multiple Overlapping and Non-overlapping Camera, Omar Javed, Zeeshan Rasheed, Orkun Alatas and Mubarak Shah, IEEE International Conference on Multimedia and Expo, 2003
- Human Tracking in Multiple Camera, Sohaib Khan, Omar Javed, Zeeshan Rasheed and Mubarak Shah, IEEE International Conference on Computer Vision, 2001

## Alper Yilmaz, Summer 2004

- Alper Yilmaz and Mubarak Shah, "A Differential Geometric Approach To Representing the Human Actions", Computer Vision and Image Understanding journal (accepted).
- Alper Yilmaz, Omar Javed and Mubarak Shah, "Object Tracking: A Survey", ACM Computing Surveys, December 2006.
- Alper Yilmaz and Mubarak Shah, "Matching actions in presence of camera motion", Computer Vision and Image Understanding Vol. 104 (2006), pp. 221231.
- Alper Yilmaz, Xin Li, and Mubarak Shah, "C-BOT: Contour Based Non-rigid Object Tracking Using Mobile Cameras", IEEE Transactions on PAMI, November 2004 - Vol. 26, No. 11.
- Alper Yilmaz, Khurram Shaque and Mubarak Shah, "Target-Tracking in FLIR Imagery Using Mean-Shift and Global Motion", Image and Vision Computing (invited paper), Vol. 21, Issue 7, pp. 623-635, July 2003.
- Cen Rao, Alper Yilmaz and Mubarak Shah, "View Invariant Representation and Recognition of Actions," Int. Journal of Computer Vision, pp 203-226, Volume 50, no 2, November 2002.
- Alper Yilmaz and Mubarak Shah, "Recognizing Human Actions in Videos Acquired by Uncalibrated Moving Cameras", IEEE International Conference on Computer Vision, 2005, Beijing, China, October 15-21. (Acceptance Rate 20%)

## Alper Yilmaz, Summer 2004

- Yun Zhai, Alper Yilmaz and Mubarak Shah, "Story Segmentation in News Videos Using Visual and Text Cues", International Conference on Image and Video Retrieval 2005, CIVR2005, July 20-22, 2005, Singapore.
- Alper Yilmaz and Mubarak Shah, "Actions As Objects: A Novel Action Representation", IEEE CVPR 2005, San Diego, June 20-26. (acceptance rate 20%)
- Alper Yilmaz, Xin Li, and Mubarak Shah, "Object Contour Tracking", Asian Conference on Computer Vision, January, 2004.
- A. Yilmaz and M. Shah, "Estimation of Arbitrary Albedo and Shape from Shading for Symmetric Objects", BMVC2002 - British Machine Vision Conference 2002, Cardiff, UK, 2-5 Sept 2002.
- Alper Yilmaz, Khurram Shaque, Mubarak Shah, "Estimation of rigid and non-rigid motion using anatomical face model", International Conference on Pattern Recognition, August 11-15, 2002 - Qubec City, Canada.
- Alper Yilmaz, Mubarak Shah, "Automatic Feature Detection and Pose Recovery for Faces", Asian Conference on Computer Vision, ACCV 2002, Melbourne, Australia, Jan 2002.

## Jiangjian Xiao, Fall 2004

- Xiaochun Cao, Jiangjian Xiao, Hassan Foroosh, and Mubarak Shah, "Self-Calibration from Turn-Table Sequences in the Presence of Zoom and Focus", *Computer Vision and Image Understanding* 102 (2006) 227-237.
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## 2003 Ph.D. Students

- Omar Javed
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- Alexei Gritai
- Paul Smith
- Imran Junejo
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## 2006 UCF Computer Vision Group



## 2007 UCF Computer Vision Group



# 2008 UCF Computer Vision Group

