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 emerged from:
  - Image Processing
  - Pattern Recognition

Fairy Tale

- 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.
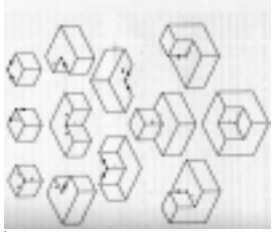
Different Levels

- 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
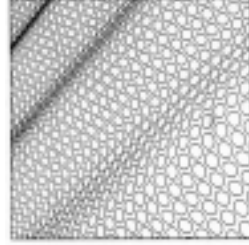- Illumination

Marr Approach

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

Shape from X

- Shading
- Stereo
- Texture
- Motion
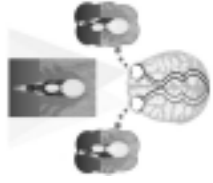- Contours

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

Computer Vision: Outlook

- Video surveillance and monitoring
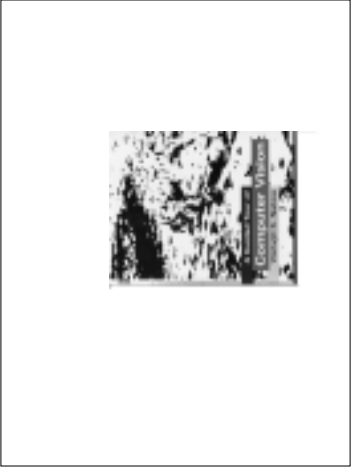- Multi-media
- Computer Graphics
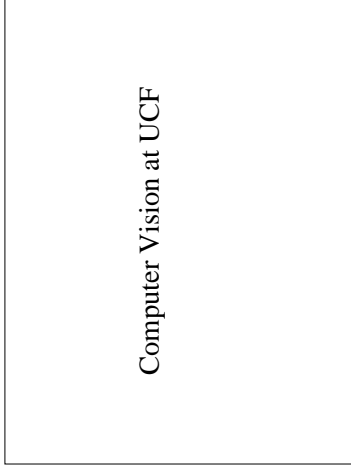
Computer Vision Text Books

History

Computer Vision at UCF

- 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
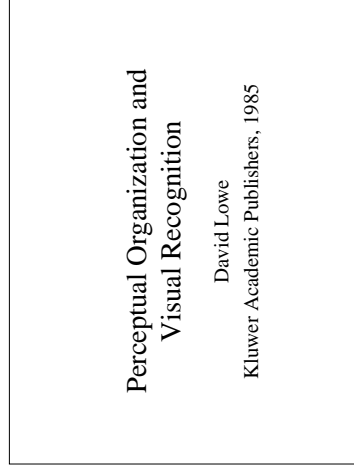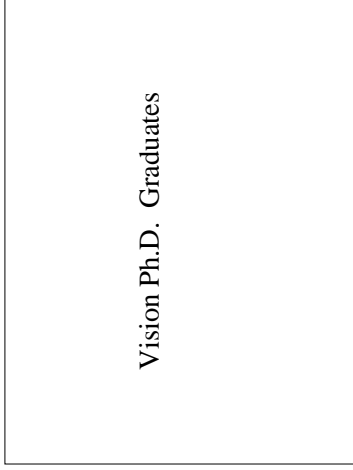- Dr. Lobo joined in 1992

Vision Books Used at UCF

VISION

Perceptual Organization and
Visual Recognition

David Lowe
Kluwer Academic Publishers, 1985

COMPUTER
VISION

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. "Photomotion", 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, Vol 19, N0. 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
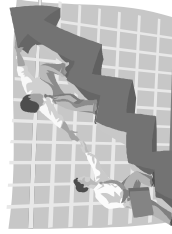
Niels Haering, 1999

- 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.

Current Ph.D. Students

- Sohaib Khan
- Cen Rao
- Omar Javed
- Zeeshan Rasheed
- Alper Yilmaz
- Orkun Alatas
- Lisa Spencer
- Yaser Shaikh
- Jiangjian Xiao
- Yun Zhai

End of Story