Outline

I. Introduction

II. Smart Camera Architectures
   1. Wireless Smart Camera
   2. Smart Camera for Active Vision

III. Distributed Vision Algorithms
   1. Fusion Mechanisms
   2. Vision Network Algorithms

IV. Requirements and Case Studies

V. Outlook
CHAPTER I: Introduction

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Technology Cross-Roads

**Image Sensors**
- Rich information
- Low power, low cost

**Sensor Networks**
- Wireless communication
- Networking

**Signal Processing**
- Embedded processing
- Collaboration methods

**Vision Processing**
- Scene understanding
- Context awareness

Smart Camera Networks

Architecture? Algorithms? Applications?

Potential impact on design methodologies in each discipline
Sensor Networks Perspective

- Opportunities for novel applications:
  - Make complex interpretation of environment and events
  - Learn phenomena and behavior, not just measure effect
  - Incorporate context awareness into the application
  - Allow network to interact with the environment

- Change of paradigm:
  - High-bandwidth sensors (vision)

Vision Processing Perspective

- Novel approach to vision processing:
  - Use the additional available dimension: space
    - Data fusion across views, time, and feature levels
  - Design based on effective use of all available information (opportunistic fusion)
  - Utilize multiple views to:
    - Overcome ambiguities
    - Achieve robustness
    - Allow for low complexity algorithms
  - Use communication to exchange descriptions - not raw data
    - In-node processing

- Change of paradigm:
  - Networked vision sensors
Smart Camera Networks

New Paradigm

- High-bandwidth data
- In-node processing
- Low-bandwidth communication
- Collaborative interpretation

Smart Camera Networks

- Rich design space utilizing concepts of:
  - Vision processing
  - Signal processing and optimization
  - Wireless communications
  - Networking
  - Sensor networks

- Novel smart environment applications:
  - Interpretive
  - Context aware
  - User centric
Smart Camera Networks

- Processing at source allows:
  - Image transfer avoidance
  - Descriptive reports
  - Scalable networks

- Design opportunities:
  - Processing architectures for real-time in-node processing
  - Algorithms based on opportunistic data fusion
  - Novel smart environment applications
  - Balance of in-node and collaborative processing:
    - Communication cost
    - Latency
    - Processing complexities
    - Levels of data fusion

Smart Camera Networks

- Vision sensing requires awareness of:
  - Privacy issues
    - Employ in-node processing
    - Avoid image transfer
    - Applications that provide services not based on monitoring / reporting
  - Bandwidth issues
    - Transmit processed information not raw data
    - Transmit based on information value for fusion / query-based
  - Processing demand
    - Employ separate early vision and interpretive processing mechanisms
    - Layered processing architecture: Features, objects, relationships, models, decisions
      - Employ data exchange and collaboration across different layers
Application Potentials

Examples by: Chen Wu, Chung-Ching Chang, Huang Lee, Joshua Goshpom, Itai Katz, Kevin Gabayan
Wireless Sensor Networks Lab, Stanford University

Application Potentials: View Selection

- Select best view of person of interest in real-time tracking
- Data exchange between cameras determines which one to stream visual data
Application Potentials: Assisted Living

- Detect accidents at home

Application Potentials: Multi-Finger Gesture

- Manipulate virtual world with free hand gesture
  - Pan
  - Rotate
  - Zoom out
  - Zoom in
Application Potentials: Face Profiling

- Interpolate and reconstruct face model from a few snapshots

![Face Profiling Diagram]

Application Potentials: 3D Model Reconstruction

- Observations at t1
- Observations at t2

![3D Model Reconstruction Diagram]
Application Potentials: Virtual Reality

- Place people in virtual world

• Smart camera architectures
• Image sensing techniques for smart cameras
• Embedded vision programming
• Fusion of vision and other sensors
• Distributed vision processing algorithms
• Distributed appearance modeling
• Collaborative feature extraction, data and decision fusion
• Architectures and protocols for camera networks
• Wireless and mobile image sensor networks
• Position discovery and middleware applications
• Vision-based smart environments
• Surveillance and tracking applications
• Multi-view vision for human-computer interaction
• 3D scene analysis
• Distributed multimedia and gaming applications

First ACM / IEEE International Conference on Distributed Smart Cameras (ICDSC-07)
September 25-28, 2007
Vienna, Austria

www.ICDSC.org

Tutorials:
• Tzuhan Chen, CMU, USA: “Smart Camera Arrays”
• Andrea Cavallaro, Queen Mary University of London, UK: “Smart Cameras: Algorithms, Evaluation and Applications”
• Bjoern Gottfried, University of Bremen, Germany: “Ambient Intelligence and the Role of Spatial Reasoning: Smart Environments with Smart Cameras”
• More TBA
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