Introduction: Object Localization and Recognition Using Image Sensors

Object Detection Using Image Sensors
- Image sensors
  - Image sensing allows detection and recognition of objects
  - Image processing algorithms such as frame differencing make object detection feasible
  - Inexpensive image sensors widely available
- Applications
  - Surveillance and habitat monitoring etc.

Object Localization and Recognition
- Object localization by stereo vision
  - Camera calibration: internal camera parameters, relative rotation and transition of two cameras
  - 3D reconstruction: images from two calibrated cameras of an object can determine object location
- Recognition and high resolution image
  - High resolution images are required for some recognition-based applications such as vehicle classification and human identification
  - Pan-tilt-zoom camera provides high resolution image as well as extended coverage

Problem Description: Energy-Aware High Resolution Image Acquisition

Objective
- High resolution pan-tilt-zoom cameras offer high localization and recognition performance but consume considerable energy
- Low resolution cameras consume less energy but offer poor quality images
- We use two-tier system to improve detection/latency performance versus energy consumption

Proposed Solution: Two-tier High Resolution Image Acquisition

Two-tier System
- Tier 1: Stereo pairs of Cyclops
  - Object detection: frame differencing
  - Object localization: 3D coordinate via stereo vision
  - Platform-specific optimization: custom precision arithmetic
  - PTZ control: computation of pan-tilt-zoom
- Tier 2: Canon pan-tilt-zoom (PTZ) camera
  - Wake-up if Cyclops detect object of interest
  - Pan-tilt & zoom to the object using 3D coordinate from Cyclops
  - High resolution image capture: potential for further advanced object recognition
- Performance of two-tier system
  - Object detection and high resolution image acquisition with less power consumption are comparable to single-tier system
  - Extended coverage is possible in some applications depending on image resolution requirement in each tier

Results
- Object localization
  - MATLAB simulation: localization error of stereo pair of Cyclops
  - Root mean square error (RMSE) is ~5% at 5m from the pair when using 128 by 128 pixels and 20cm camera separation.

- Object detection and high resolution image acquisition
  - Coverage example of two-tier system
  - Tier 1: radius: 5.4m, angle: 43.5 deg.
  - Tier 2: radius: 25.3m, angle: 180 deg.
  - Tier 1: 640 by 480, zoom: 16x,
  - Tier 2: 128 by 128, detection threshold: 4 pixels

- System power consumption
  - Coverage example of two-tier system
  - System power consumption with various numbers of sensors in tier 1 and object appearance rate