Title
Energy-aware High Resolution Image Acquisition via Heterogeneous Image Sensors

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Energy-Aware High Resolution Image Acquisition via Heterogeneous Image Sensors

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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.

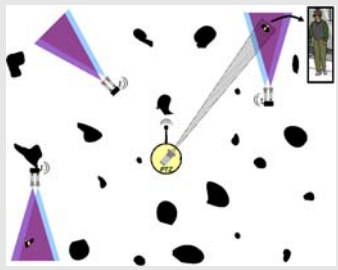
Object Localization and Recognition

- **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

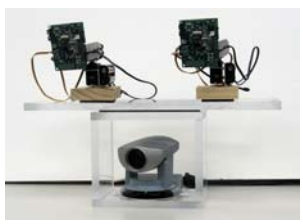
- **High resolution pan-tilt-zoom cameras offer high localization and recognition performance but consume considerable energy**
- **Low resolution cameras consume less energy but offer poor quality images**
- **We use two-tier system to improve detection/latency performance versus energy consumption**



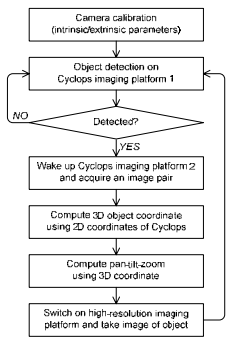
Proposed Solution: Two-tier High Resolution Image Acquisition

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



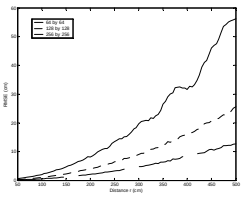
• One Canon PTZ camera and two Cyclops platforms



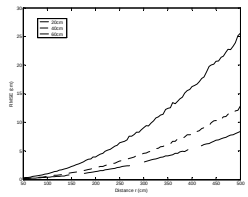
• Task flow of a system with two Cyclops platforms and a single high-resolution imaging platform

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.

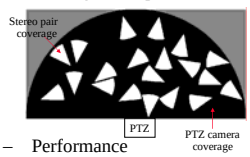


RMSE with different resolutions with 20 cm camera separation



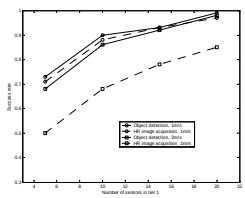
RMSE with different camera separation with 128 by 128 resolution

- **Object detection and high resolution image acquisition**
  - Coverage example of two-tier system

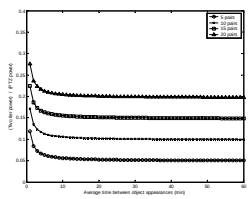


Tier 1: radius: 5.4m, angle: 43.5 deg.
Tier 2: radius: 25.3m, angle: 180 deg.
(Object size: 30cm by 30cm,
Tier 1: 128 by 128, detection threshold: 4 pixels
Tier 2: 640 by 480, zoom: 16x,
object occupies more than 160 by 120 pixels)

  - Performance



Success rates of object detection and high resolution image acquisition with various numbers of sensors in tier 1



System power consumption with various numbers of sensors in tier 1 and object appearance rate