Motivation: Is local image processing more efficient than raw transmission?

Proposed Scenario

1. **Wireless Camera Network**
   Battery operated camera sensors are connected via a wireless link over a variety of terrain

2. **Digital Signal Processing (DSP) Processor**
   Advances in DSP processor design allows for complex math operations on a single low cost, low power chip

3. **Scale Invariant Feature Transform**
   Robust object detection algorithm that is accurate regardless of any combination of scale, rotation, varying illumination, or occlusion

Local Processing Advantages

1. **Minimal Number of Transmissions**
   Images can be processed and only the data of interest is sent rather than every image

2. **Minimal Transmission Time**
   When transmission is necessary only relevant results are sent and none of the transmission time and energy is wasted

3. **Maximum Time Spent In Hibernation**
   Processing takes less time then transmission resulting in savings

4. **Maximum Power Savings**
   More time spent in hibernation means more power savings

Platform: Scale-Invariant Feature Transform (SIFT) on the Blackfin Processor

**SIFT Algorithm Outline**

1. **Scale-Space Extrema Detection**
   Step over all scales to find keypoints of interest

2. **Keypoint Localization**
   The keypoints of interest are given a location and a scale at which it is most prominent

3. **Orientation Assignment**
   Each keypoint is given an orientation that is used as a reverence when it is transformed

4. **Keypoint Description**
   An image neutral representation is given to the keypoint so that it can be compared with in other images

Component Operation & Data Flow

Sensor Functionality

1. **Wakeup from hibernation**
   Wakeup Imager

2. **Capture image**
   Initialize Imager

3. **Process image with SIFT**
   Capture Image

4. **Send results via transmitter**
   Transmit Results

5. **Return to hibernation**
   Transition to Sleep

Peripheral Interfaces

- **Transmitter**
  - UART

- **Imager**
  - I2C/TWI

SIFT Power Consumption

- Initialization: 0.004
- Gaussian Blur: 0.465
- DOG: 0.121
- Detect Keypoints: 0.132
- Refine Keypoints: 0.162
- Keypoint Orientation: 0.252
- Total: 1.136

- SIFT Timing & Energy Consumption

- Initialization: 0.004 sec
- Gaussian Blur: 0.087 watt
- DOG: 0.089 watt
- Detect Keypoints: 0.126 watt
- Refine Keypoints: 0.467 watt
- Keypoint Orientation: 0.129 watt
- Total: 1.434 watt

CPU & SIFT Transitions

Hardware

- Blackfin 533
- A-V EZ-Extender
- ADSP-BF533 EZ-Kit Lite
- Micron MT9V022

SIFT Timing & Energy Consumption

- Initialization: 0.004 sec, 0.004 watt, 0.004 J
- Gaussian Blur: 0.465 sec, 0.136 watt, 0.063 J
- DOG: 0.121 sec, 0.089 watt, 0.011 J
- Detect Keypoints: 0.132 sec, 0.126 watt, 0.016 J
- Refine Keypoints: 0.162 sec, 0.467 watt, 0.025 J
- Keypoint Orientation: 0.252 sec, 0.129 watt, 0.032 J
- Total: 1.136 sec, 1.434 watt, 0.148 J