Mixture of Gaussians (MoG)

1) Background Subtraction
- Compute intense kernel early in vision flow
- Extracts ForeGround (FG) pixels from BackGround (BG) scene

2) Mixture of Gaussian (MoG)
- Adaptive learning-based BG tracking for static camera position

3) MoG Computation and Communication Demands
- 1080p60 in SW infeasible (24.3 GOPs)
- 20 (float) or 13 (integer) Blackfin DSP
- 32 bits per Gaussian parameters: (weight, mean, standard deviation)

MoG Computation Realization

1) RTL Design
- Hand-crafted RTL implementation
  - Guided by system-level exploration / specification
- Full-HD (148.5 MHz)
- System pipeline (77 stages)
  - Macro pipeline (7 stages)

MoG Communication Realization

1) Communication Components
- Independent traffic management
  - Separate clock domains
- Dedicated Gaussian size unit
  - Transferring only important bits
- 2 DMA channels for Gaussian parameters
- Dedicated interconnect for burst transfer
- Async FIFOs
  - Bridge clock domains
  - Compensate for slow interconnect (148.5MHz pixel vs. 125MHz bus)

Experimental Results

1) Zynq 7020 Realization
- Design spreads over chip
- Significant routing overhead
- 34% DSP slice utilization
- Resolution limited to 1080p @ 30FPS
  - Due to the Zynq peak memory bandwidth limitation: 4.2 GBs

2) Power Consumption
- 60x more power efficient than SW (Cortex A9)
- 480mWatt on-chip power
- Only 19% for computation
- 67% for transferring Gaussian parameters

System Exploration

1) Design Flow
- Starting from system pacification
  - Captured in an SLDL
  - Coarse-grain parallelism

2) Parameter Precision, Bandwidth / Quality Trade-off
- Precision adjustment of Gaussian parameters
- Transfer stores only relevant bits of model
- Reduce bandwidth at cost of quality

MoG specification

MoG Micro-Pipeline in HDL (77 pipes)

3) Functional Evaluation
- Correct FG detection for many scenes
  - Scenes with different complexity
  - Indoor/outdoor multiple moving objects
- >99% similarity [MS-SSIM] to specification model

Publication