



TI's Vision Library (VLIB)

Goksel Dedeoglu, Ph.D.
Vision R&D, Texas Instruments, Inc.



Agenda

- Introduction
- Vision Library (VLIB)
 - Accelerating computer vision on TI DSPs
 - Sample applications and their data flow
 - On-chip memory optimization
 - Getting VLIB, documentation, benchmarks
- Other libraries of interest



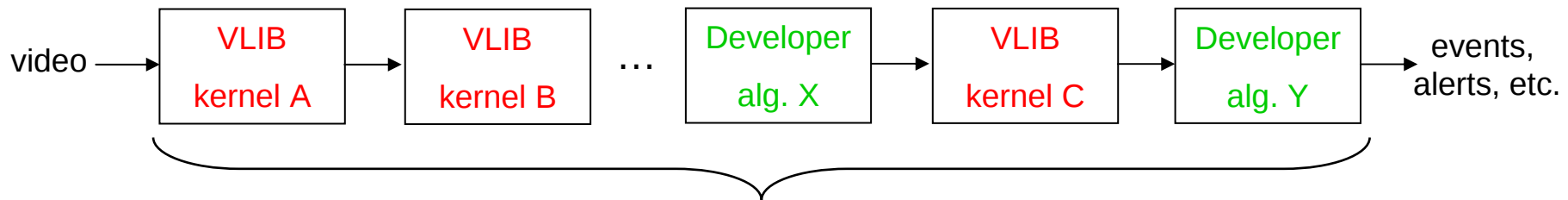
TI Vision Library (VLIB)

- Accelerates compute-intensive blocks of Computer Vision applications
 - Video Security
 - Automotive
 - Human-Device Interaction
- Target platforms
 - C64x and C64x+ DSP cores
 - Optimized via software pipelining, C6x intrinsics, and SIMD processing



Design considerations

- Driven by customer input
 - Surveyed 25+ customers and collected priorities
 - Customers did not want “vision answers”, but rather low-level building blocks upon which they could build their own applications, adding their own “secret sauce”
 - The result is a highly granular set of kernels that come in multiple flavors (e.g., 8-bit version + 16-bit version)



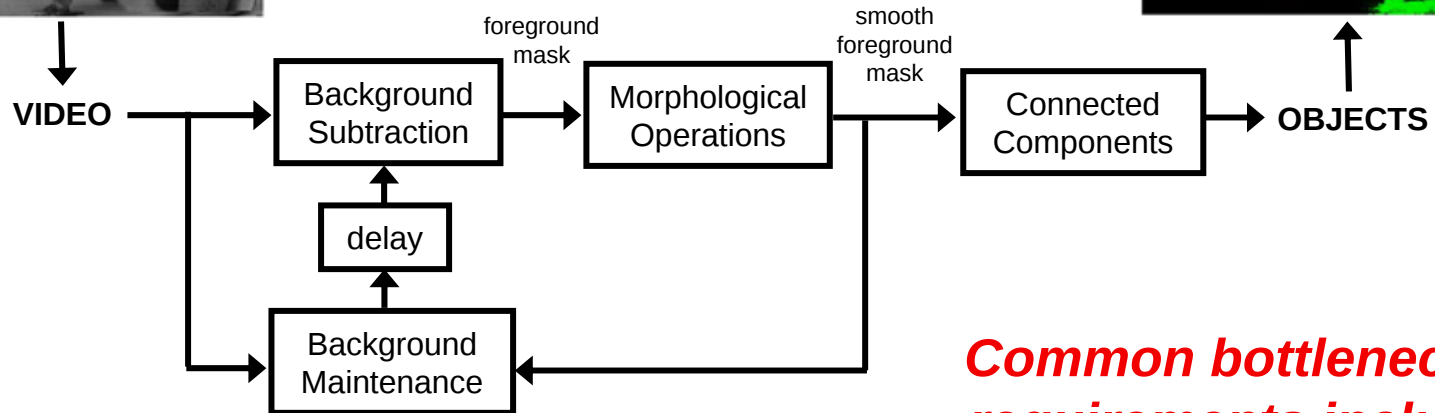
Preserves developer's IP, ensures optimal performance



Example application #1



“Moving Object Segmentation”

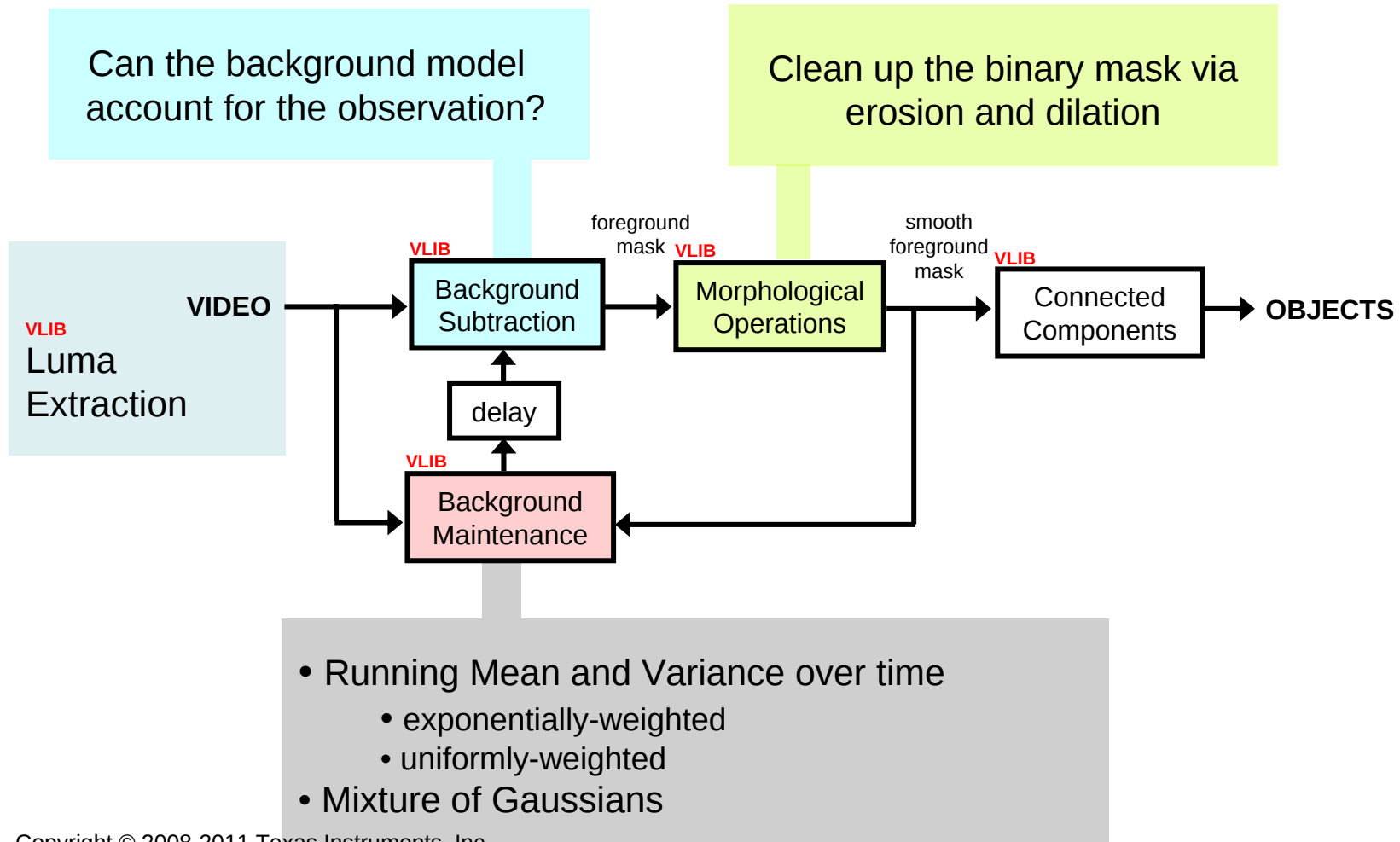


BACKGROUND MODEL

Common bottleneck for requirements including video analytics and intelligent occupancy sensing



Key algorithms for Moving Object Segmentation



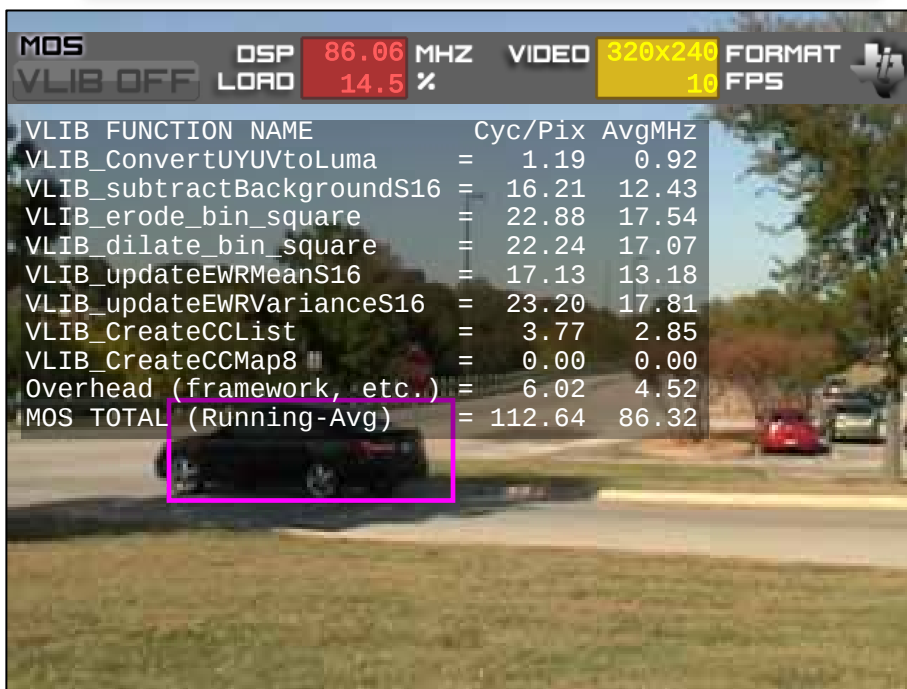


VLIB demonstration

~10x pixel processing improvement over standard C code

VLIB off: utilizing 14.5% total processing power, 86 MHz

VLIB on: utilizing 1.6% total processing power, 9 MHz





Moving Object Segmentation

16-bit precision, single Gaussian model

C64x+ MHz requirements (*VLIB on, **)

	@ 5 fps	@ 10 fps	@ 30 fps
QVGA	5	9	27
CIF	6	11	36
VGA	18	36	108
D1	21	41	123
HD 720p	54	110	333
HD 1080p	122	245	735

* assuming 50% overhead



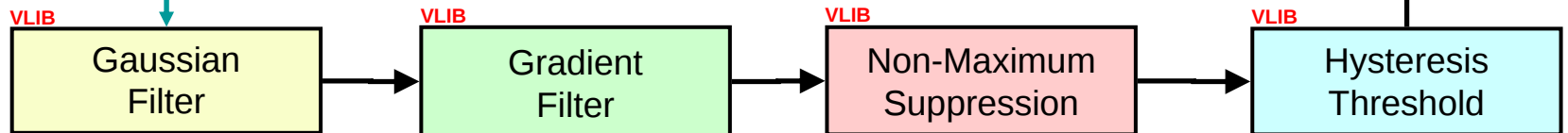
Example application #2: Canny edge detector



Input



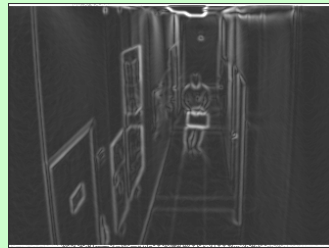
Output



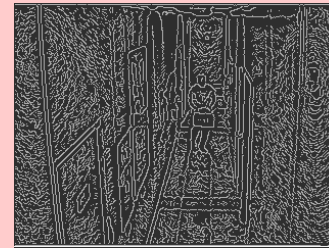
Remove camera noise & ensure smooth gradients



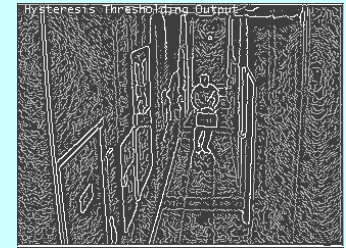
Compute horizontal & vertical gradients and their magnitude



Suppress those pixels which are not maxima along gradient

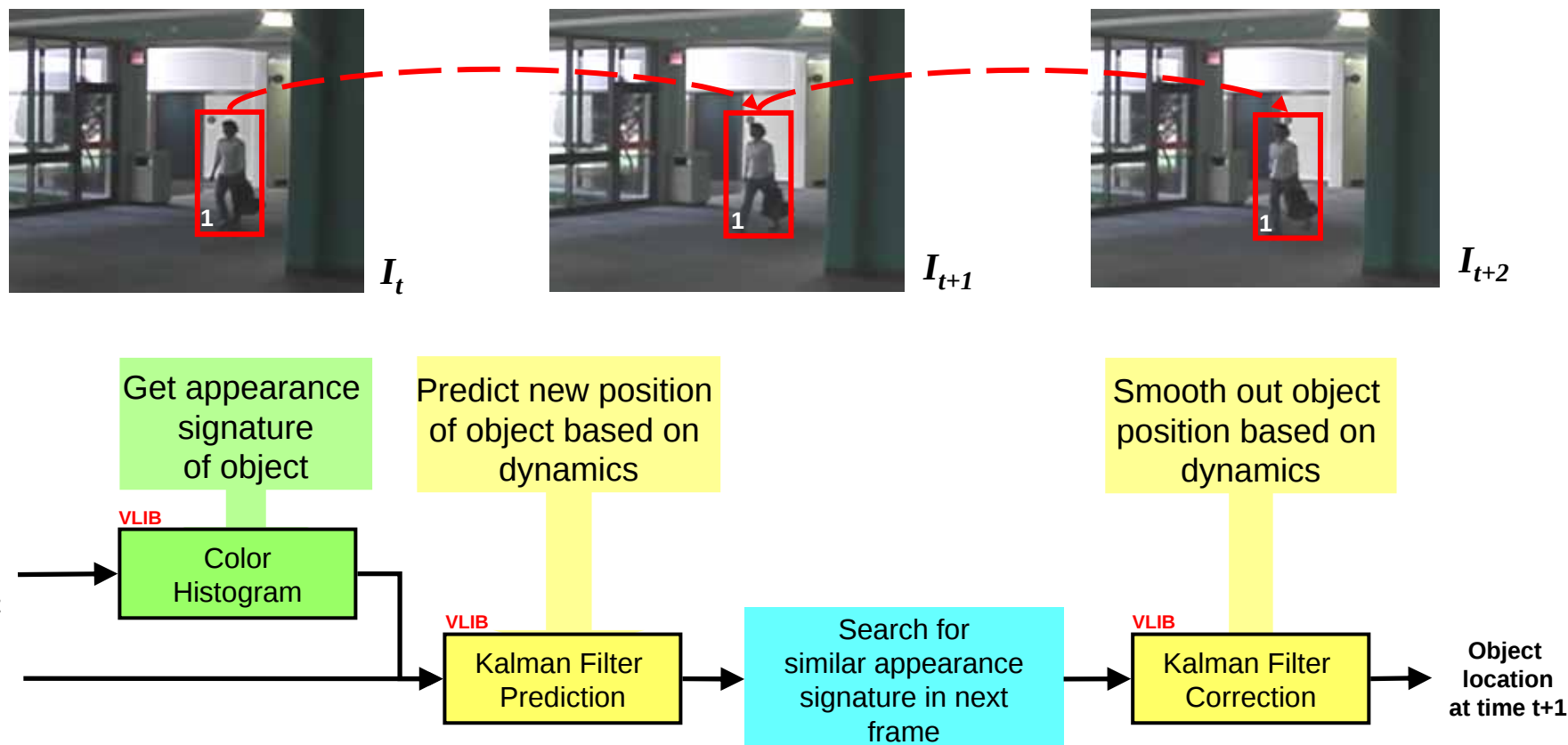


Trace over edge segments and link them



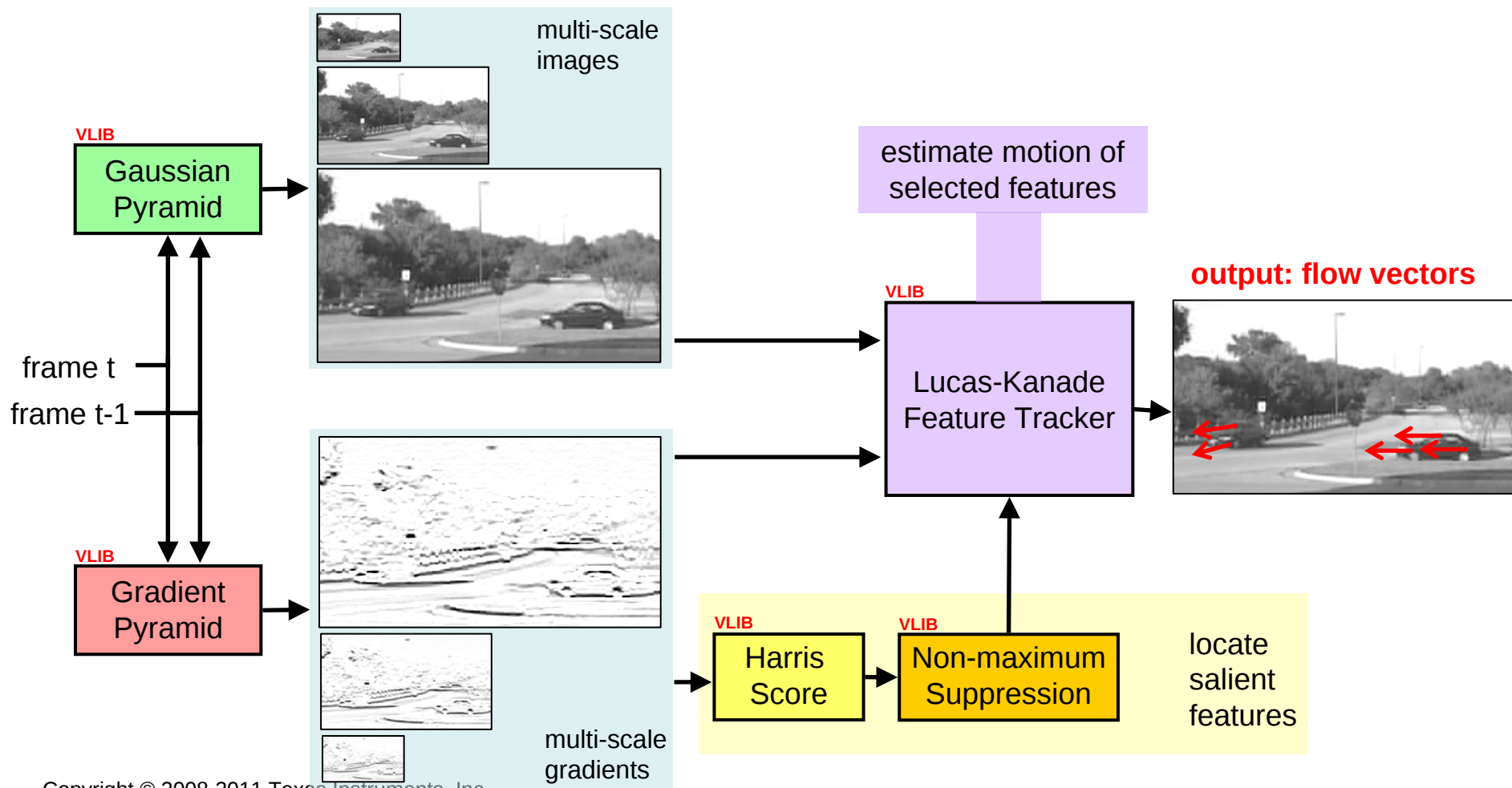


Example application #3: Object tracking





Example application #4: Feature tracking





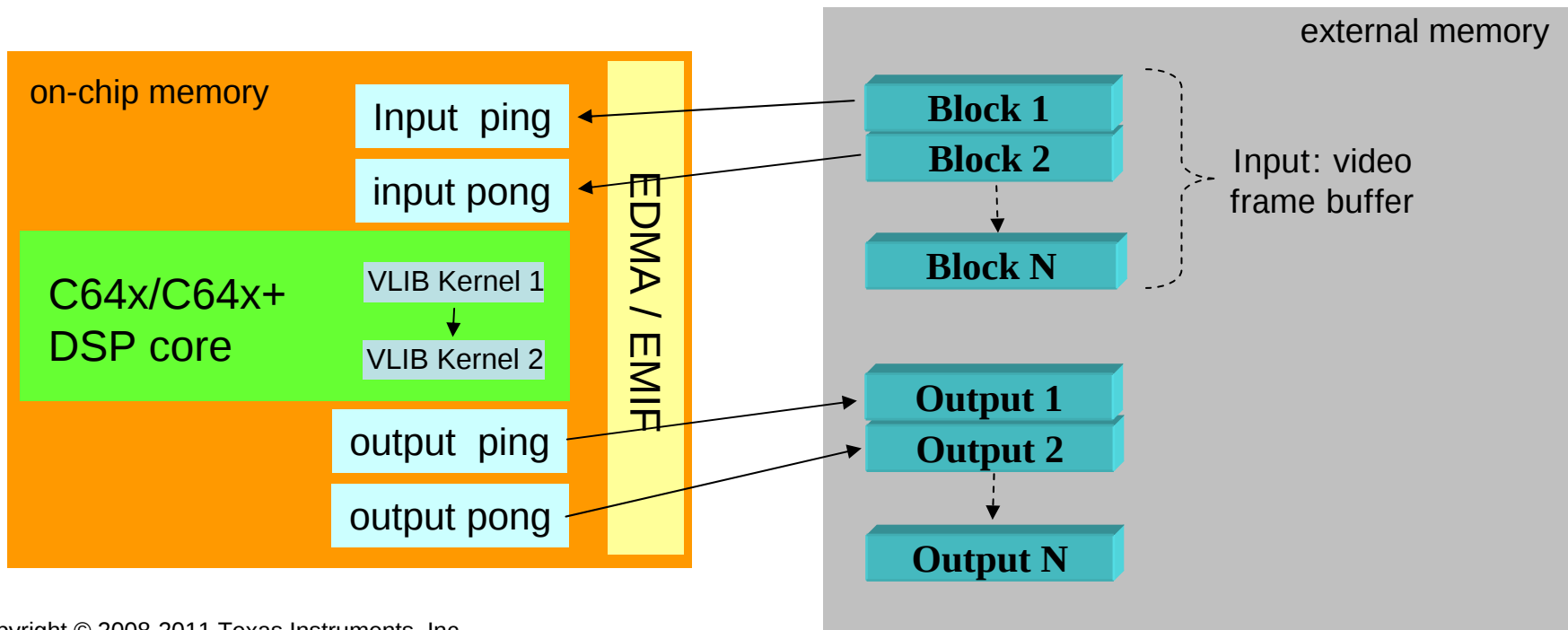
VLIB functions by category

- Background modeling & subtraction
 - Luminance Extraction from YUV:422
 - Exponentially-Weighted Running Mean & Variance
 - Uniformly-Weighted Running Mean & Variance
 - Statistical Background Subtraction
 - Mixture of Gaussians Background Modeling & Subtraction
 - Morphological Operations (Erosion & Dilation)
 - Connected Components Labeling
- Feature extraction
 - Harris Corner Score (7x7)
 - Hough Transform for Lines
 - Histogram Computation for Integer Scalars
 - Histogram Computation for Multi-Dimensional Vectors
 - Weighted Histogram Computation for Integer Scalars
 - Weighted Histogram Computation for Multi-Dimensional Vectors
 - Legendre Moments
 - Canny Edge Detection
 - Smoothing
 - Gradient computation
 - Non-maximum suppression
- Low-level pixel processing
 - Color Conversion YUV:422 interleaved to
 - YUV planar
 - RGB
 - LAB
 - HSI
 - Integral image
 - Image Pyramid (2x2 block averaging)
 - Non-Maximum Suppression (3x3, 5x5, and 7x7)
 - Gradient Image Pyramid (5-tap)
 - Gaussian Image Pyramid (5-tap)
 - First-Order Recursive IIR filters (horizontal & vertical)
 - SAD-based disparity for stereo
- Tracking, recognition, etc.
 - Lucas-Kanade Feature Tracking (7x7)
 - Kalman Filtering
 - Nelder-Mead Simplex optimization
 - Bhattacharya distance



Memory management

- VLIB enables efficient memory management by developers
 - Memory-agnostic: variables & image buffers can reside in on-chip or external memory (and rely on cache)
 - For optimal performance, DMA-based buffering recommended





VLIB package

- Collateral
 - 65 optimized kernels provided as object code and free of charge/royalty
 - API document
 - Test/example functions along with Code Composer Studio projects for the DM642, DM6437, and DM6446 SoCs
 - Bit-exact PC version of the library as well as corresponding Matlab-Simulink blocks
- VLIB 2.1 (Nov. '09)
- Submit a request at <http://www.ti.com/vlibrequest>



Other TI libraries of relevance

- IMGLIB: Imaging and Video Processing Library
 - Convolution, correlation, median filter, thresholding, Sobel, SAD, forward/inverse DCT, ...

<http://focus.ti.com/docs/toolsw/folders/print/sprc264.html>

<http://focus.ti.com/general/docs/litabsmultiplefilelist.tsp?literatureNumber=spruf30a>

- DSPLIB: DSP Little-Endian Library
 - FFT, FIR, IIR, matrix ops

<http://focus.ti.com/docs/toolsw/folders/print/sprc265.html>

<http://focus.ti.com/general/docs/litabsmultiplefilelist.tsp?literatureNumber=sprueb8b>



Thank you!