CEVA®

The DSP Powerhouse

Implementing Feature Extraction On a Programmable Processor

www.ceva-dsp.com

April 2014

CEVA by Numbers

#1
DSP licensor dominant market share (>3X of any other DSP IP vendor)

5 Billion
CEVA-powered devices - shipped worldwide to date

#1
DSP architecture in handsets – more than 900m in 2013

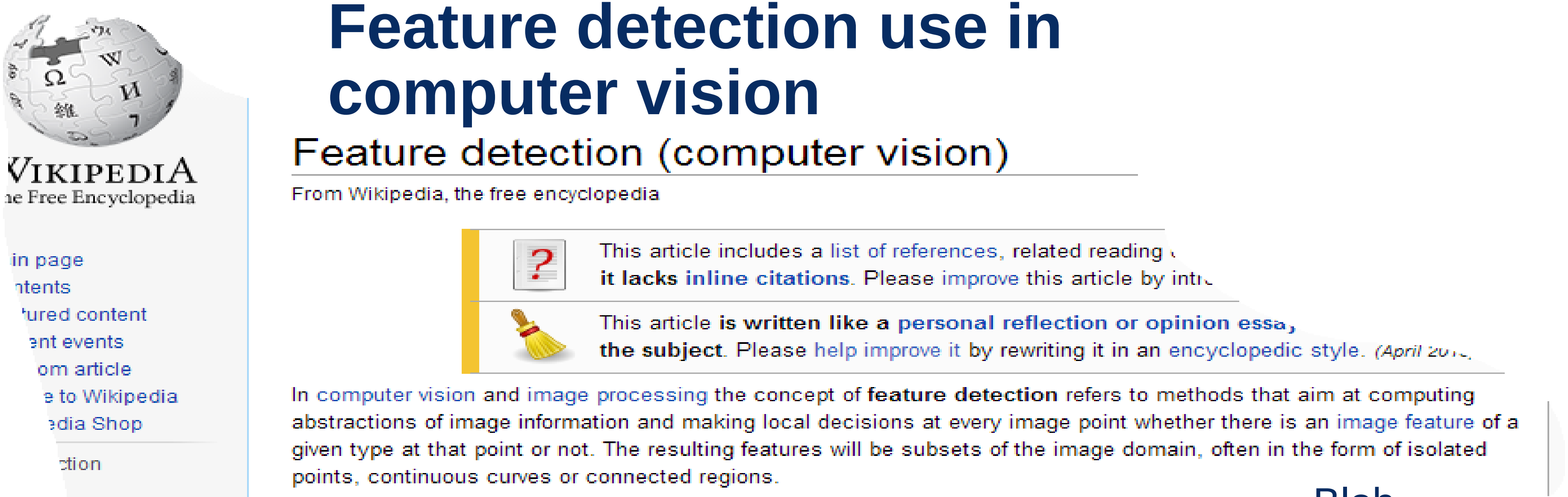
#1
in licensable computer vision and imaging Processors

>40%
Worldwide handset market share in 2013 (Strategy Analytics, December 2013)

#1
DSP core in audio – more than 3 billion devices shipped to date

> **220** licensees & **330** licensing agreements

Feature detection use in computer vision



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Feature detection (computer vision)

From Wikipedia, the free encyclopedia

This article includes a list of references, related reading
it lacks inline citations. Please improve this article by intr

This article is written like a personal reflection or opinion essa
the subject. Please help improve it by rewriting it in an encyclopedic style. (April 20

In computer vision and image processing the concept of **feature detection** refers to methods that aim at computing abstractions of image information and making local decisions at every image point whether there is an image feature of a given type at that point or not. The resulting features will be subsets of the image domain, often in the form of isolated points, continuous curves or connected regions.

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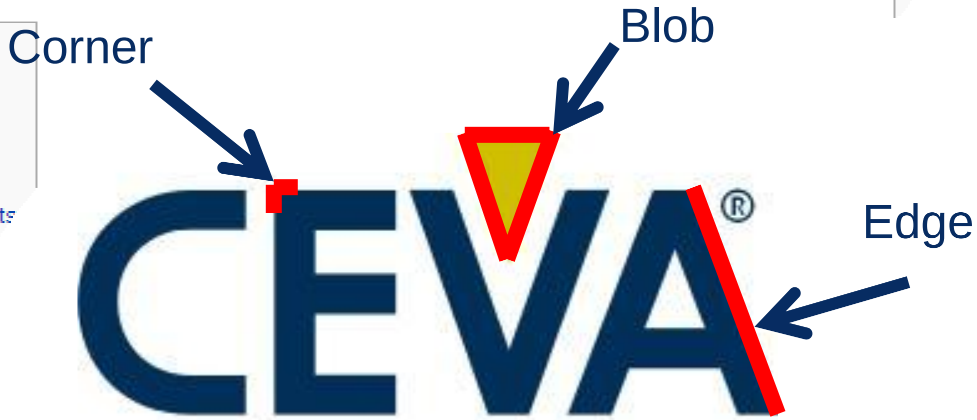
1 Definition of a feature
2 Types of image features
2.1 Edges
2.2 Corners / interest points
2.3 Blobs / regions of interest or interest points
2.4 Ridges
3 Feature detectors
4 Feature extraction
5 See also



Feature extraction = understand the content

Mobile

- Face detection and recognition
- Emotion detection
- Object detection and recognition
- Gesture control
- Augmented reality
- Depth map generation
- Panorama stitching
- Always on controls

Automotive

- Forward Collision Warning (FCW)
- Lane Departure Warning (LDW)
- Road Crossing Detection
- Traffic Sign Recognition (TSR)
- Pedestrian Detection (PD)
- Around View Monitor (AVM)
- Augmented Reality
- Gesture Control
- Driver Fatigue Warning
- Depth map generation

Surveillance

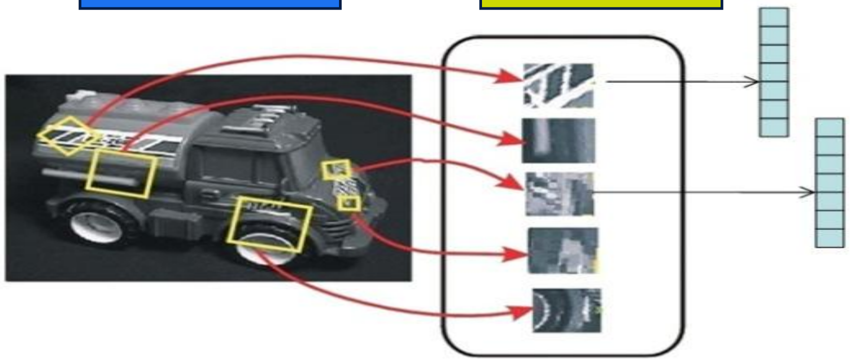
- Motion Detection
- Face Recognition
- Face / Body counting
- Object Detection & Tracking
- Background Removal
- Segmentation
- Irregular behavior detection
- Emotion Detection
- Age/Gender Detection

Wearable

- Face detection and recognition
- Emotion detection
- Object detection and recognition
- Gesture control
- Augmented reality
- Depth map generation

Typical feature flow

Pre process	Detect Key points	Build descriptors	Classification
• Sobel • Gaussian • Build image pyramids • Integral sum • Gamma normalization	• Harris corner • FAST • SIFT • SURF	• HOG • BRIEF • BRISK • SIFT • SURF • FREAK • LBP • HAAR	• SVM • Decision tree



Why Use a Programmable CV Processor?

CEVA®

Programmable CV Algorithm design → RLT design → Production → Chip ready

Short Time for Algorithm Development

NEVER STOP IMPROVING

Programmable CV Algorithm Design → Different Algorithm Design → Product Derivative Algorithm Design → Customer Specific Algorithm Design →

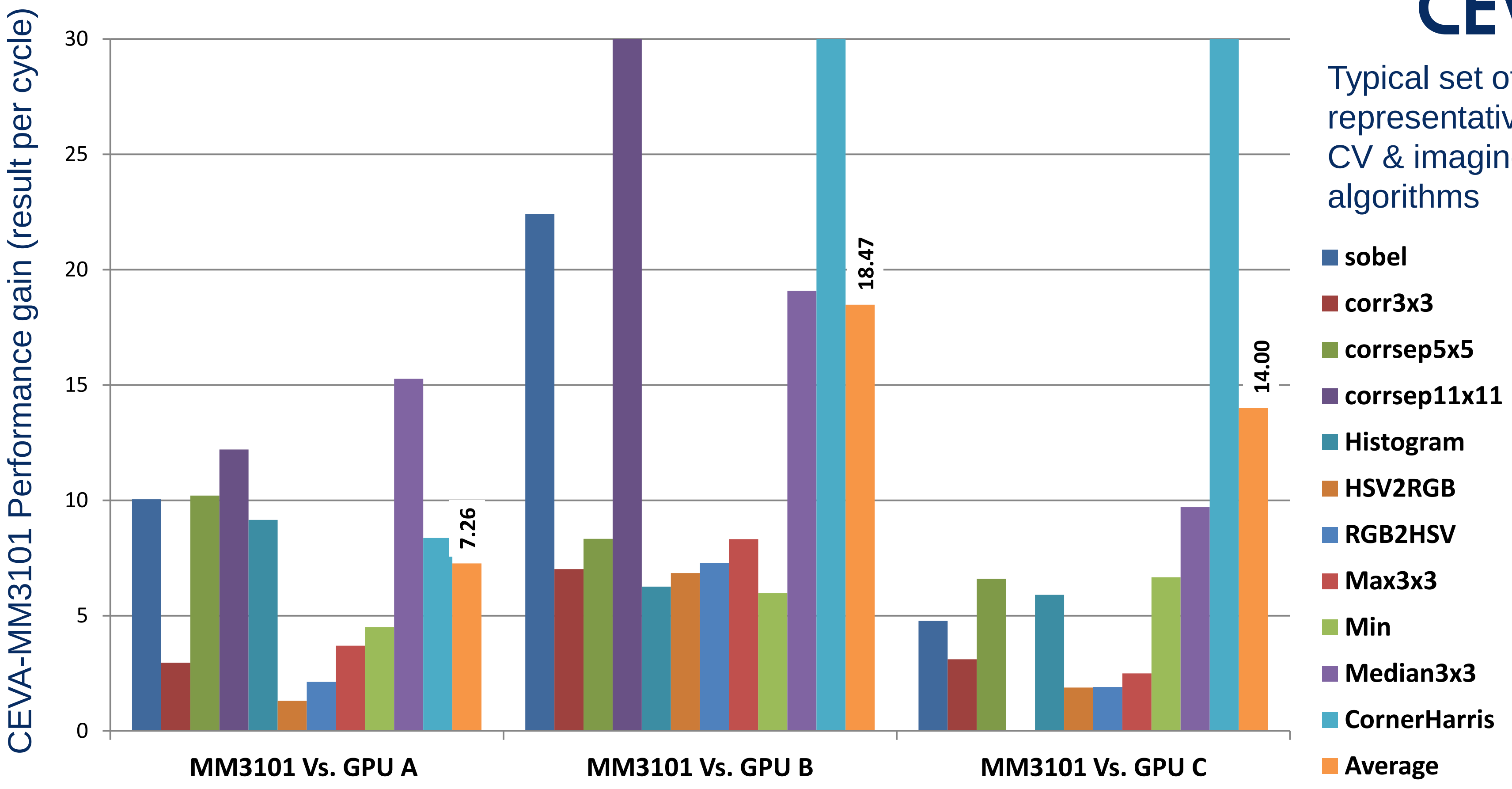
More time to improve algorithm

Support different use cases

Multiple derivatives from the same silicon

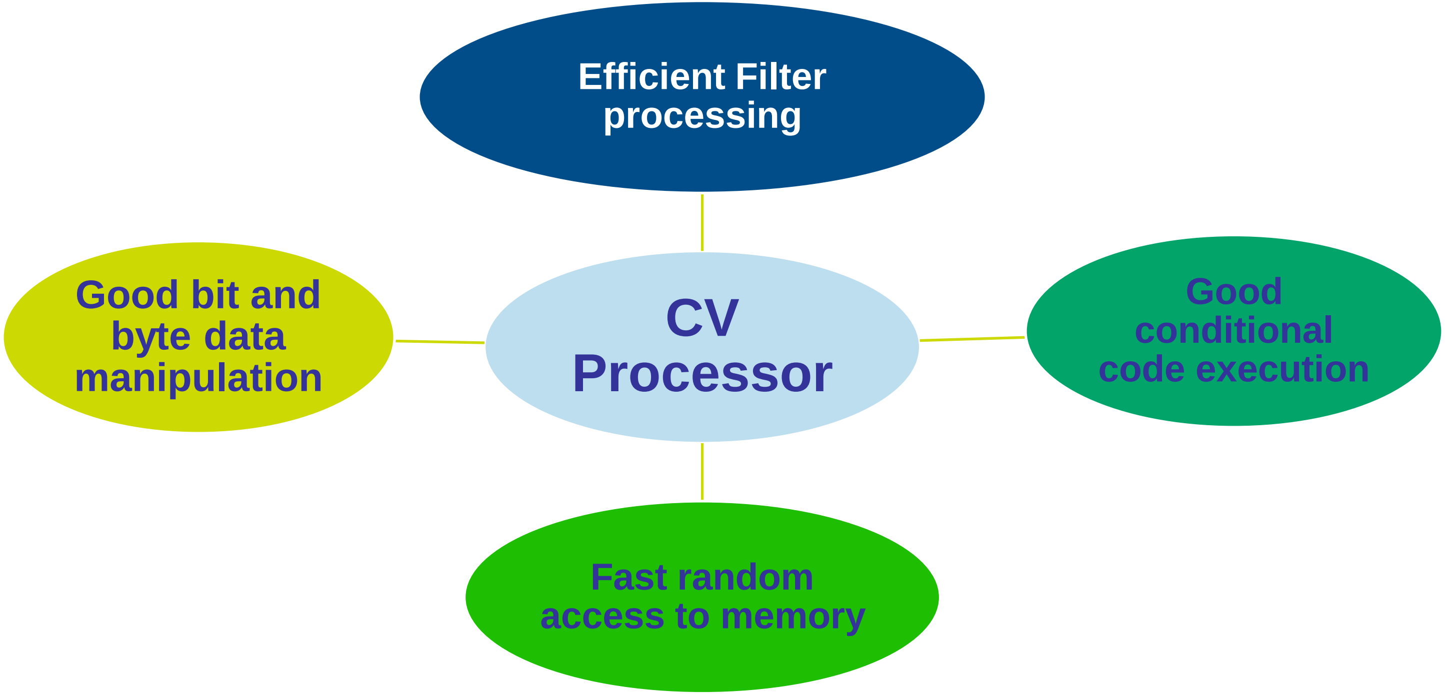
OEM differentiation

Why not use a GPU for CV?



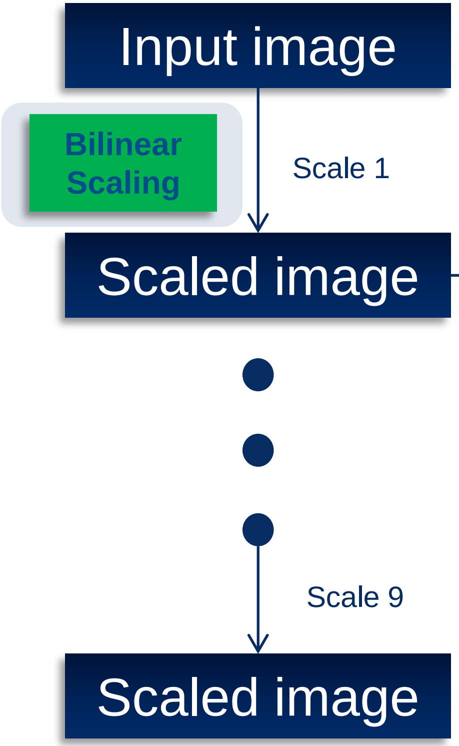
Typical set of representative CV & imaging algorithms

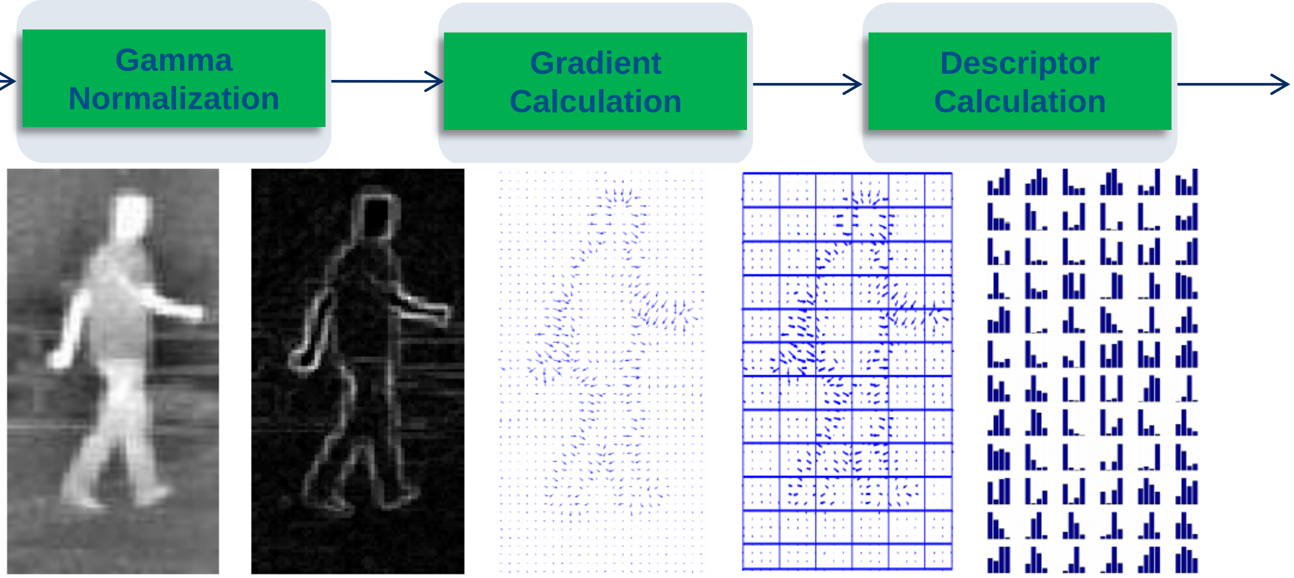
What is needed for efficient CV and Feature processing?



Flow Chart – HOG Descriptor

- HOG algorithm is based on Dalal & Triggs paper (2005)
- Common use is object detection, especially pedestrian detection
- Reference Code – OpenCV 2.4.3

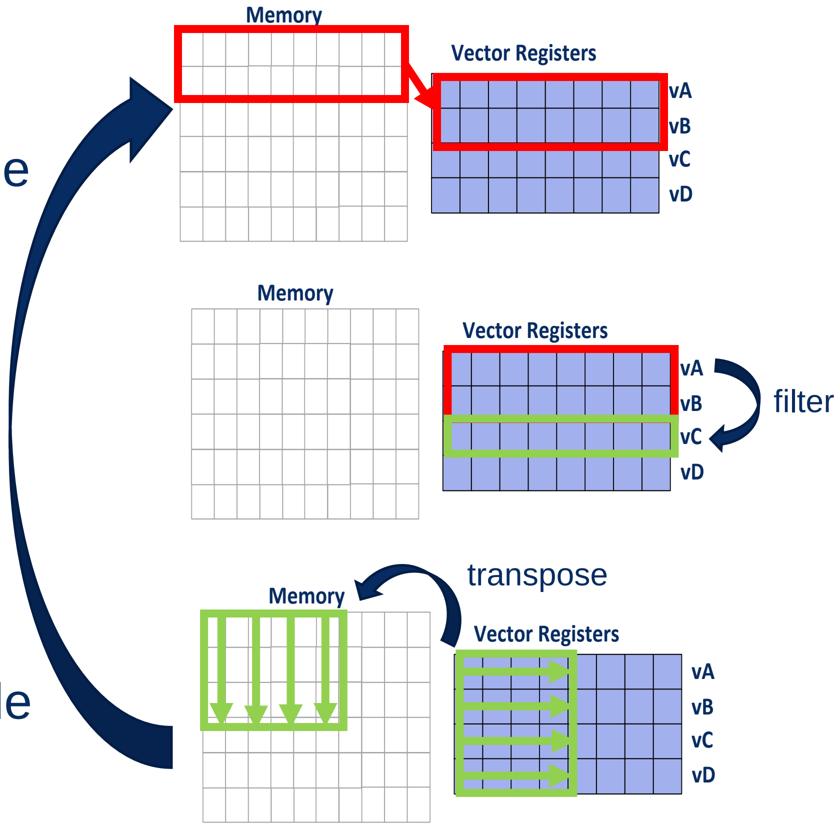




a b c d e

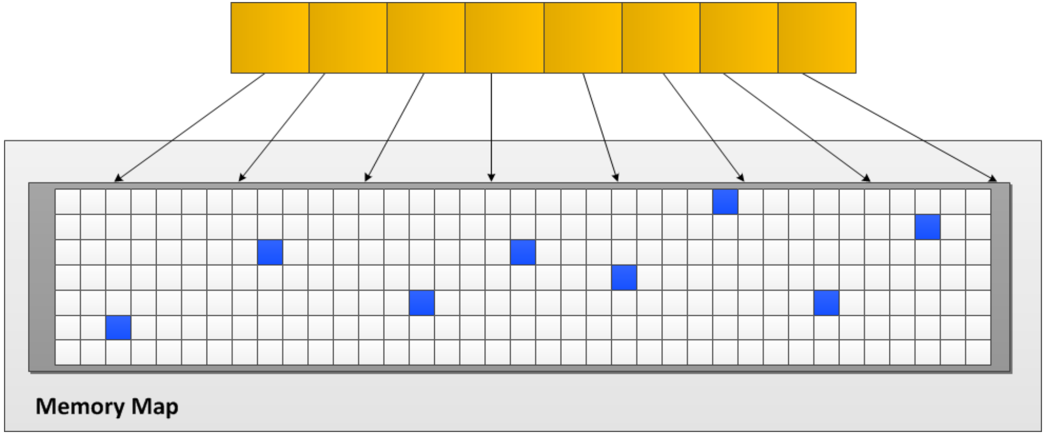
HOG – Bilinear Scaling

1. load 2 vectors of 8 pixels in single cycle
2. Perform 16 filter operations in single cycle
3. Store a transposed rectangle of 4X4 pixels in single cycle
4. Perform the load and filter again
5. Store 4X4 transposed to memory in single cycle



HOG – Gamma Normalization

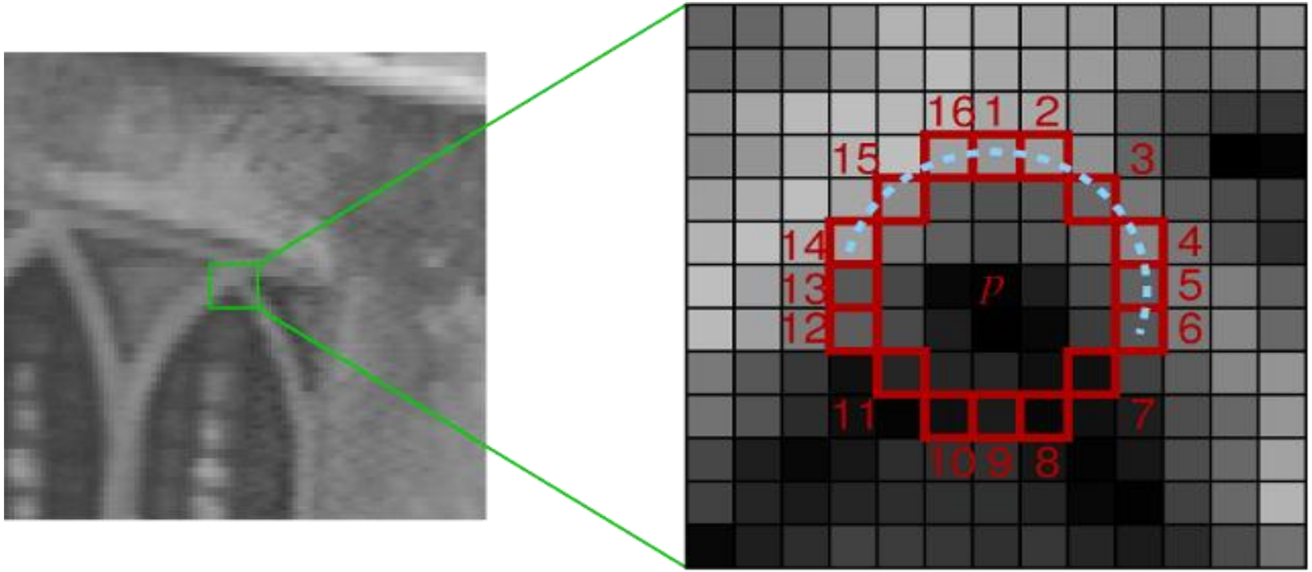
- Implemented using ‘Look Up Table’ (LUT) – 8 way parallel access to local memory in one cycle
- Parallel load mechanism :
  - Load 8 gamma values in a cycle



ORB – feature extraction

- ORB – Oriented FAST and Rotated BRIEF
  - An efficient alternative to SIFT
  - Pyramid is used for scale-invariance
  - Features are detected using FAST9 , Harris and non-max-suppress
  - Descriptors are based on BRIEF with normalized orientation

ORB – FAST9 implementation



Continuous arc of 9 or more pixels:

All much brighter then (p+Th)

or

All much darker then (p-Th)

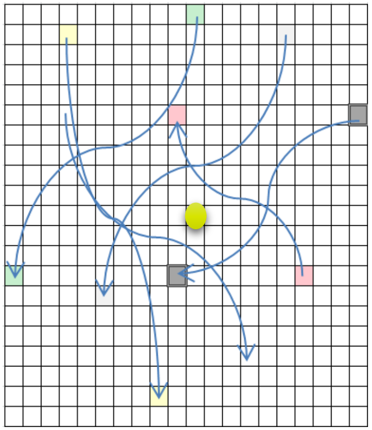
ORB – FAST9 implementation

- Early exit is used to detect potential positions
  - Long memory access of 32 bytes using
    - quickly load consecutive pixels
    - Vector compare is used to compare the center of the corner to the borders
  - Building a binary (bit) map with positions that need to be calculated
- Calculation of 8 positions in parallel
    - Using different two dimensional loads
    - Vector predicates are used selectively calculate only the locations that pass the threshold
    - Use 8 way parallel lookup table access to decide on consecutive locations

BRIEF – descriptor

Binary Robust Independent Elementary Features

- Oriented brief uses the normalized orientation and calculates a 256 bit wide descriptor
- The descriptor is calculated by comparison of pre-defined 256 pairs of pixels in the surrounding of the feature center
- Each pair comparison donates a single bit in the descriptor
- Orientation is normalized by rotating the image (or pairs coordinates, in our implementation) according to the moment of the feature center



CV Processors
Evolution = Programmability & integration

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TODAY	EVOLUTION PATH
Stand-alone Application	Heterogeneous Computing HSA, OpenCL
User Written Code	Pre optimized standard libraries OpenVX
Low Level Programming	C++, C99, Auto Vectorization

CEVA-MM3101 Highlights

Fully Programmable Imaging and Computer Vision DSP IP Platform

- 3rd generation multimedia platform IP
  - Specifically optimized ISA for imaging and vision applications
- Easy to develop & deploy efficient SW algorithms
  - Abstraction of offloading CV tasks from the CPU
  - Wide set of pre-optimized libraries
  - Automatic handling of system & memory complexities
  - Easy Android/OS plug-in via dedication layers
- Commercial tools suite & Dev boards
  - Supplies additional optional developer differentiation
- Expanding set of SW algorithms
  - In-house algorithms including full products or ref. demos
  - Complementary state-of-the-art partner technology

köszönöm תודה! *děkuji*

mahalo 고맙습니다

thank you

merci 谢谢 *danke*

Ευχαριστώ شكرا

どうもありがとう *gracias*