TOSHIBA
Leading Innovation

Novel Video and Image Processing beyond Commoditization

Takashi Miyamori, Senior Manager
Digital Media SoC Dept.
Center for Semiconductor Research & Development
Toshiba Corporation

Commoditization of Digital Media Products

Digital Still Camera
Digital TV
DVD recorder
Car Navigation
Smart Phone
Tablet
etc.

Commoditized!

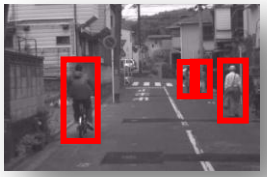
New Features

New Markets

Medial

Health Care

ADAS

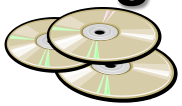


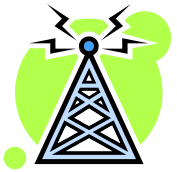
e.g. Image Recognition SoC
TMPV7500 family

Video and Image Processing

- **Digital TV, Smart Phone, Tablet, etc.**

① Frame Rate Converter





VoD

Commodity Decoder

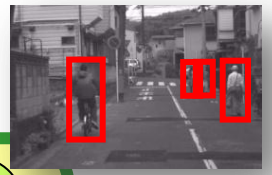
Post-Processing

Frame Base

Pixel Base
Line Base

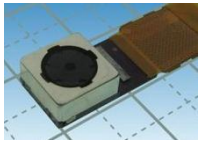
Display

- **Digital Still Camera, Camcorder, Smart Phone, Drive Recorder, ADAS, etc.**



② Multi-View Camera Module

CMOS Image Sensor



Camera

Pre-Processing

Pixel Base
Line Base

Frame Base
ROI Base

Encoder

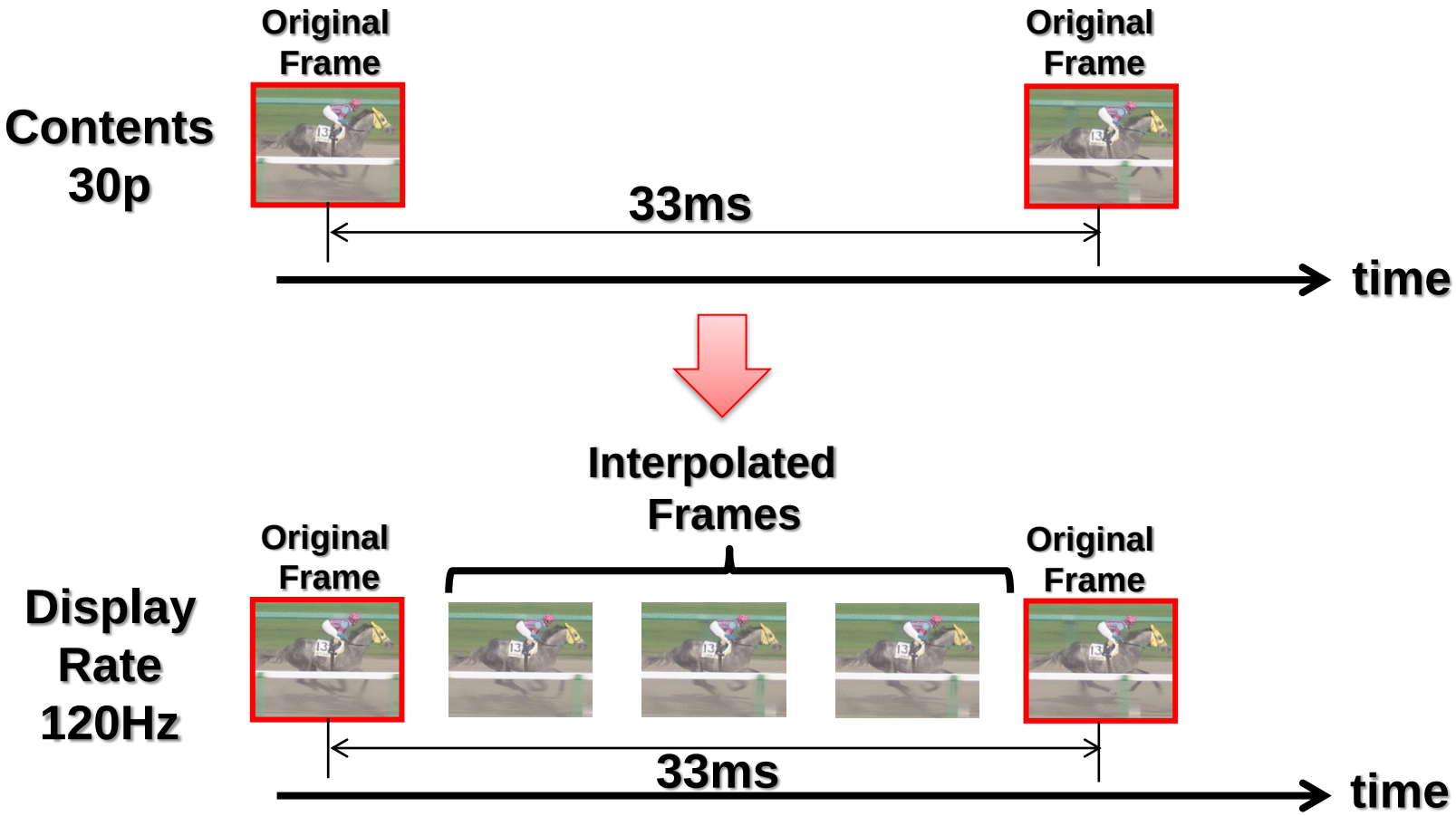
Commodity

- JPEG
- MPEG2/4
- H.264
- HEVC etc.

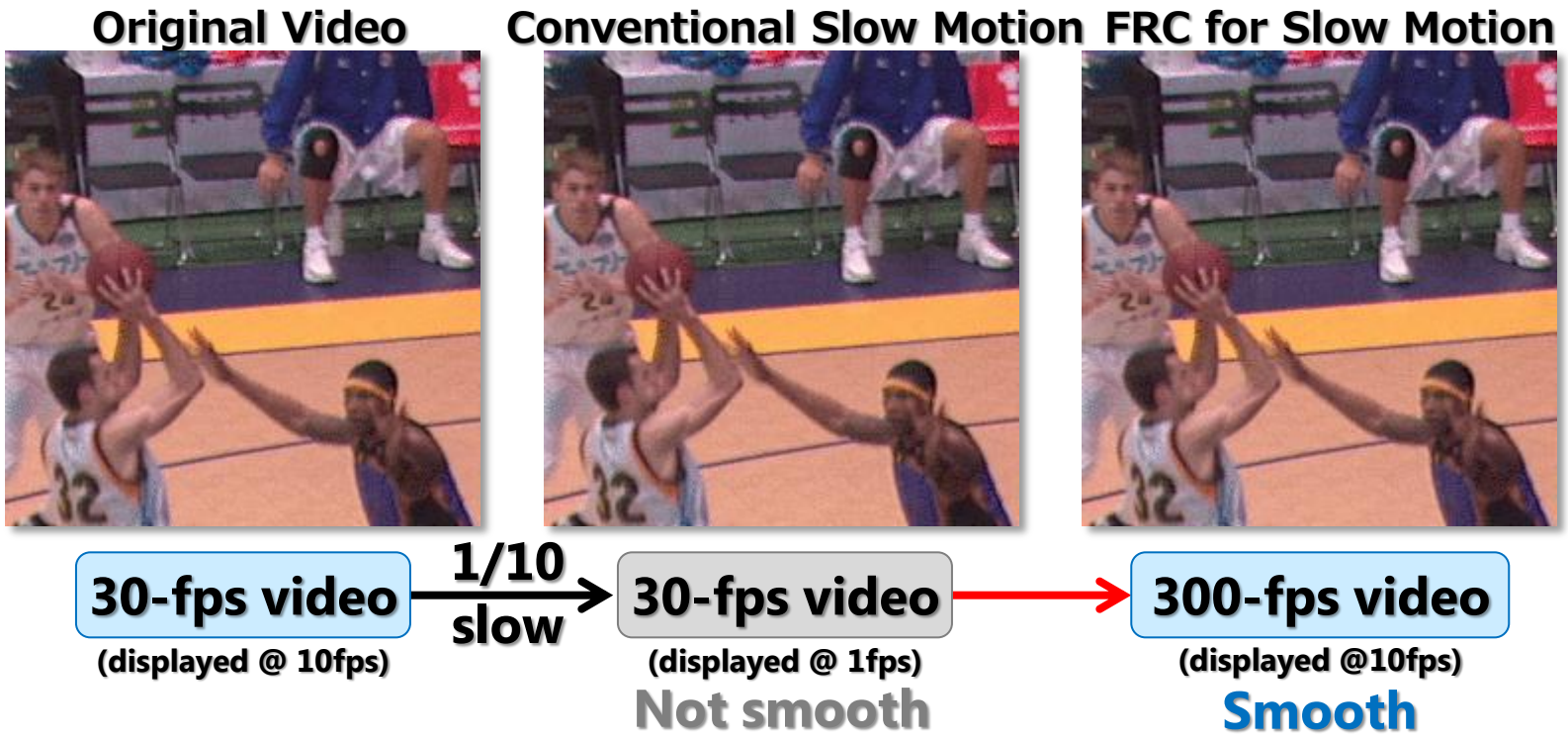
Image Recognition

Frame Rate Conversion (FRC)

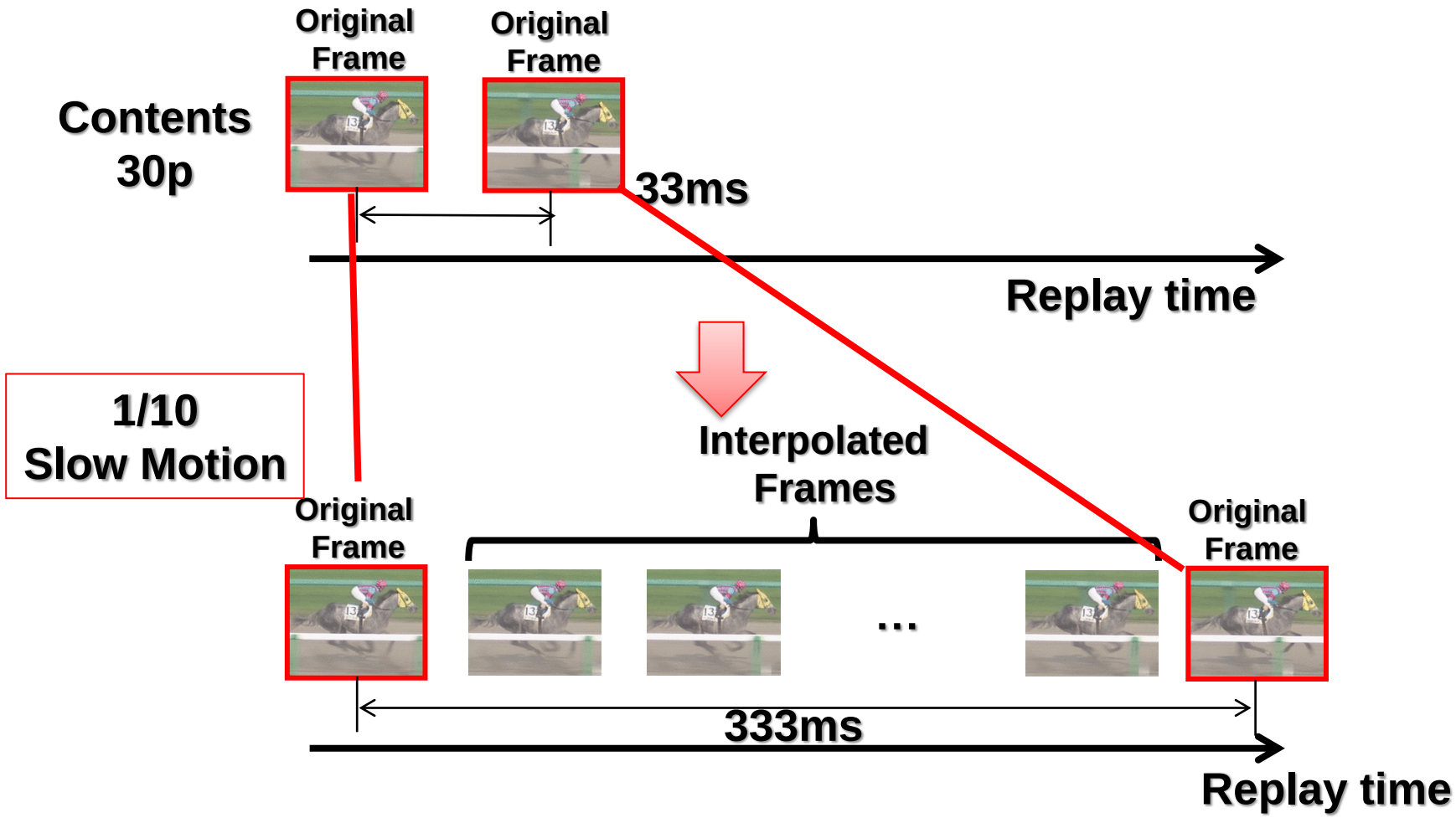
- **Conventional Frame Rate Conversion for DTV**



FRC for Slow Motion Movie



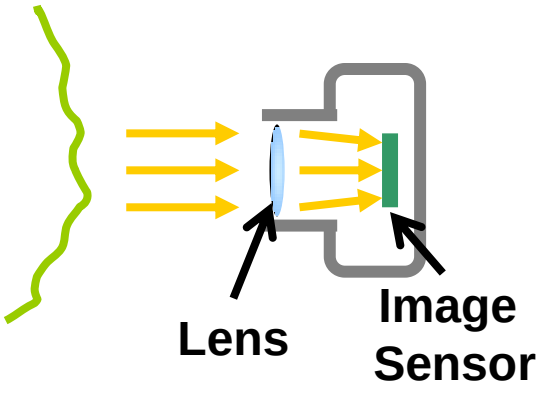
FRC for Slow Motion Movie



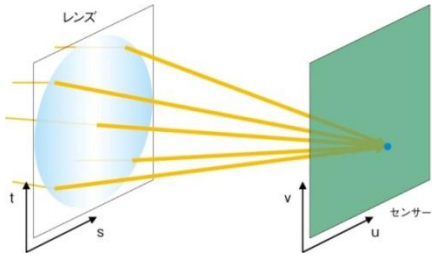
More accurate motion estimation is required.

Computational Camera

＜Conventional Camera＞



Lost information in image

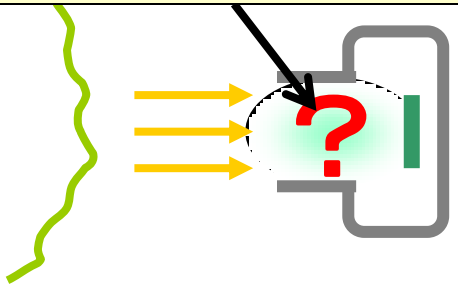


Lost the light field information because it has been integrated on the sensor

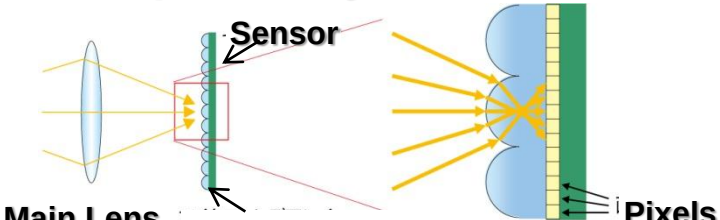
***) Light field: light direction in space**

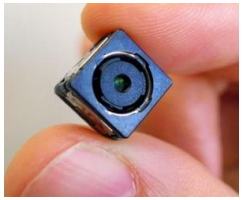
＜Computational Camera＞

New camera hardware (e.g. lens, diaphragm, sensors, etc.) and digital signal processing

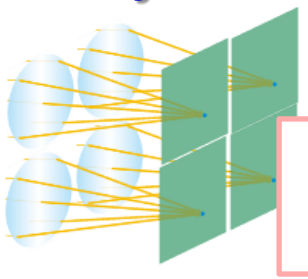


◆ Compound Eye Camera



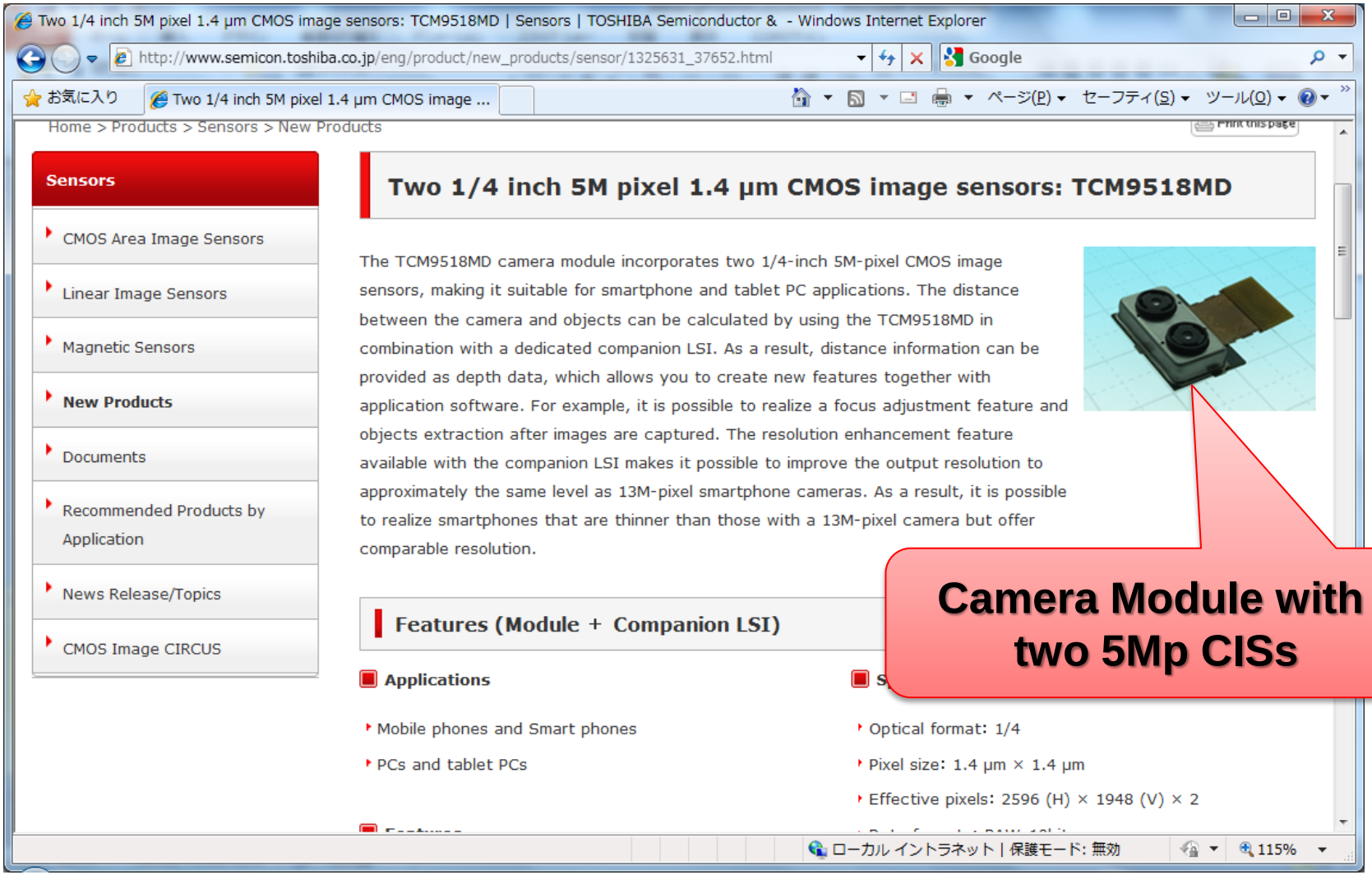


◆ Array Camera

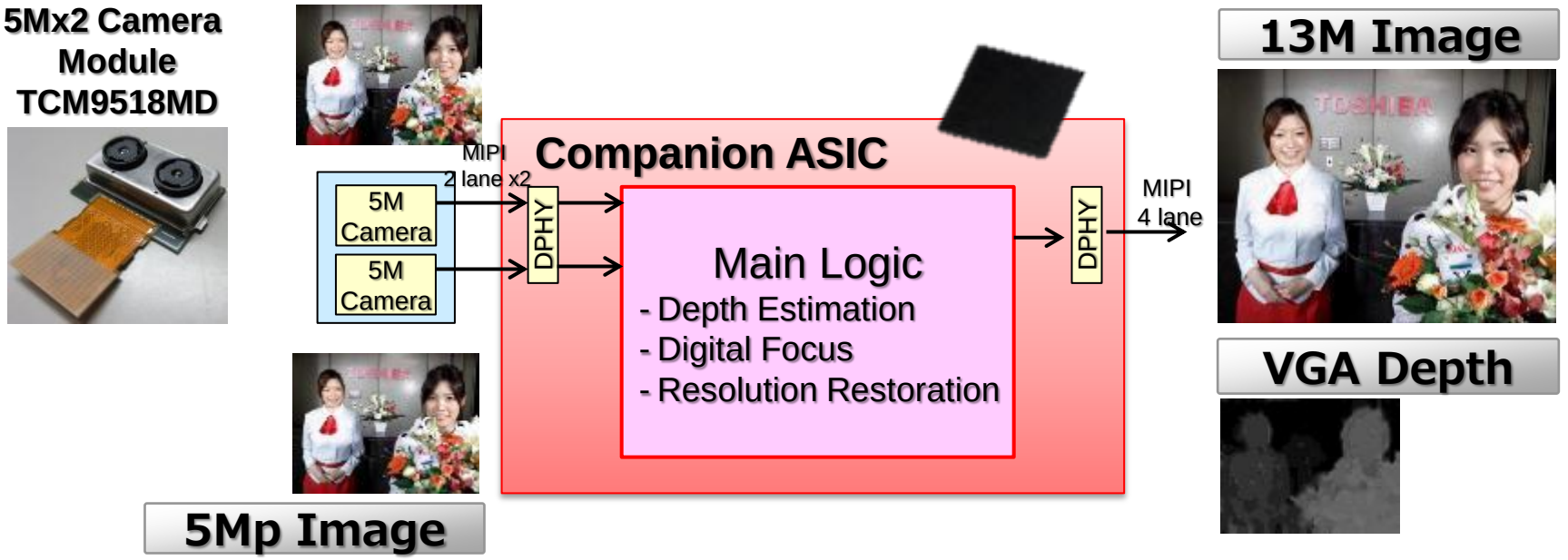


Captured different light direction using multi-camera

Multi-View Camera Press Release(Sep. 26th, 2013)



Array Camera Module and Companion ASIC

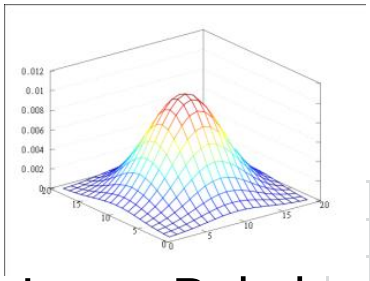


- **Two 5Mp (1.4um) and companion ASIC**
- **13M high resolution image output and VGA depth map output at 24fps**
- **Fast digital auto-focus feature without mechanical VCM**
- **Low height: 4.65mm**

<Spec. of Companion ASIC>

Process	40nm CMOS
Package Size	6mm x 6mm
Input	5M pix. x 2 ch.
Output	13M pix (Digital Focus, Deep Focus) + VGA depth map
I/Os	MIPI CSI2 2-lane x 2 (In), MIPI CSI2 4-lane x 1 (Out), I^2C

Refocus Processing using Depth Information



Large Bokeh

Point Spread Function(PSF)

$$I(x)=K_{r(x)} \otimes I_0(x)$$

Image w/o Bokeh

Varies in accordance with Depth

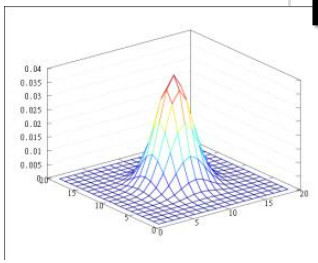
Size of Circle of Diffusion

Deblur

Blur

Original Image

Small Bokeh



Macro

INF

Depth

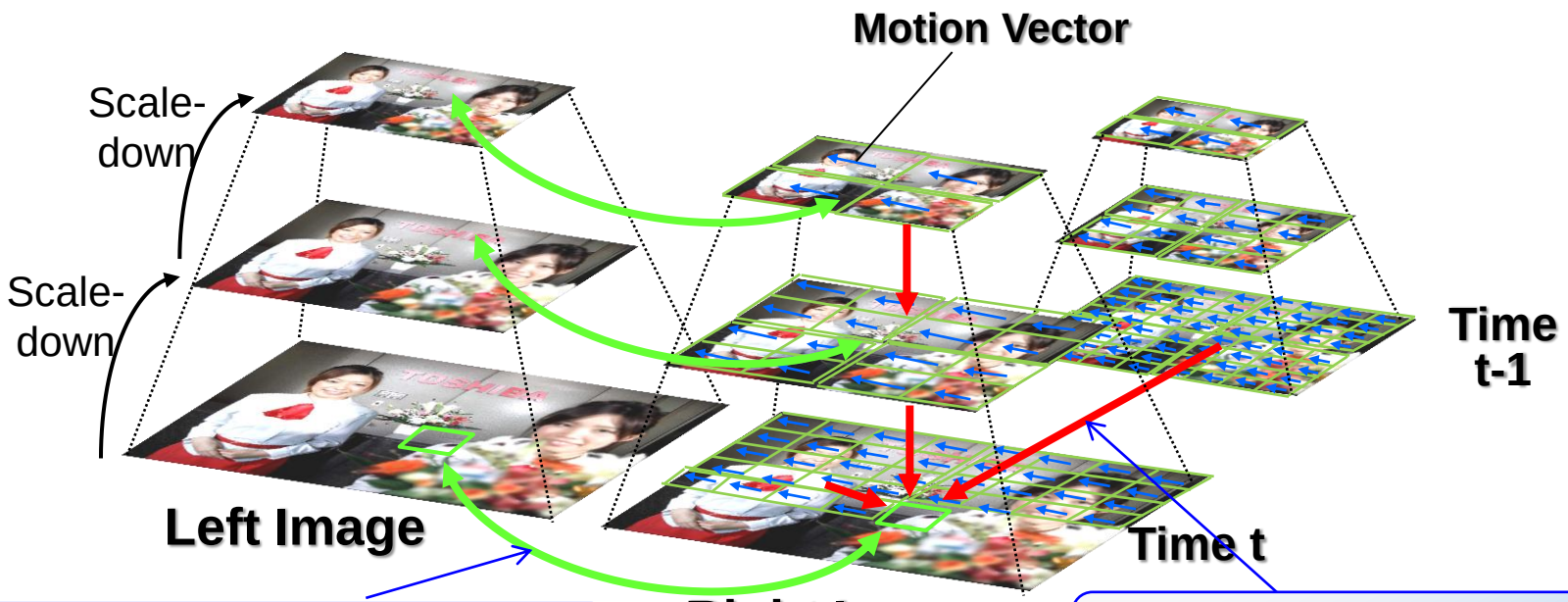
In focus

$$I_0(x)=G_{r(x)} \otimes I(x)$$

Inversed Filter of PSF

4D Recursive Search

Takuma Yamamoto, et. al, “High-Accuracy Motion Estimation with 4-D Recursive Search Block Matching,” GCCE, 2012



Step 2

Search the corresponding point from the copied motion vectors

Step 1

Copy motion vectors from:

- **Right side in the same layer**
- **Upper layer**
- **Previous frame**

4D = 3D (2D + hierarchical search) + time

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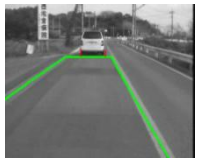
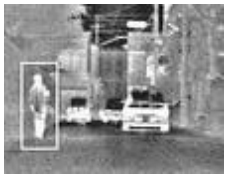
Image Recognition SoC Family Roadmap



White line detection



Night vision

1st gen.

Multi-Core(MPE x 3)

ARM Cortex™A9 MPCore™

2nd gen.- Quartetto
TMPV7506XBG

Multi-Core (MPE x 4)+HWAx6
Camera input: x4

2nd gen.- Duetto
TMPV7504XBG

Camera input: x2

ES

3rd gen.
TMPV7528XBG

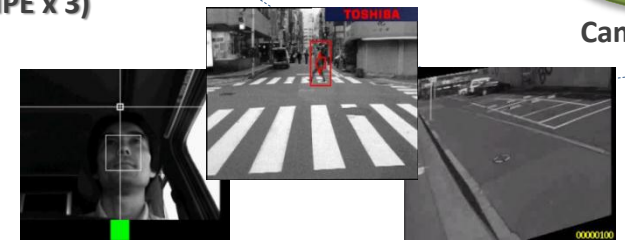
Multi-Core
(ARMx2+MPEx4+HWAx6)
Camera input: x4

Small package
(11mm x 11mm)

ES

2nd gen. – Solo
TMPV7502XBG

Camera input: x1



Pedestrian Detection using CoHOG
Parallel execution of multiple applications

Planning

Next gen.

X10 performance
from 2nd gen.

- Supports new HWA effective for pedestrian detection at night.
- Performance improvement. Possible to executes more applications simultaneously.