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Using Computational Power to Overcome Camera Hardware Constraints

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Cadence User Conference, May 11, 2017
Shanghai

About Almalence

Almalence
Innovative Imaging Technologies

Expertise in computational imaging, optical and optomechanical design, and vision processors

- Products for wide range of cameras from mobile to DSLR
- Vendor to Top mobile OEMs
- Intel Portfolio Company
- Strong patent portfolio

Technologies enabling
Higher Image Quality
Better Camera Designs
New Products

Target Markets

Mobile VR DSC/DSLR
Drones IoT Industry Medical

"Almalence is taking an innovative approach to actively disrupting the industry" – Forbes

The Physical Limits in Conventional Camera and Optical Design

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- Mobile cameras: quality limited
  small sensor and lens, no optical zoom
- Mobile cameras: optical design limits
  Thinner? Wider aperture? Cheaper? ➡ quality degradation
- DSLRs: limited quality of zoom or wide FoV lenses
  Optical system not ideal at all focal lengths and across entire FoV
- Drones: weight issues
  Lighter ➡ lower quality
- Industrial: athermalization issues
  Lenses needed to perform well across the entire t^0 range
- VR Displays: aberrations and low resolution
  No practical way to improve as the lens must be thin and lightweight

Two Influences Allowing New Computational Possibilities

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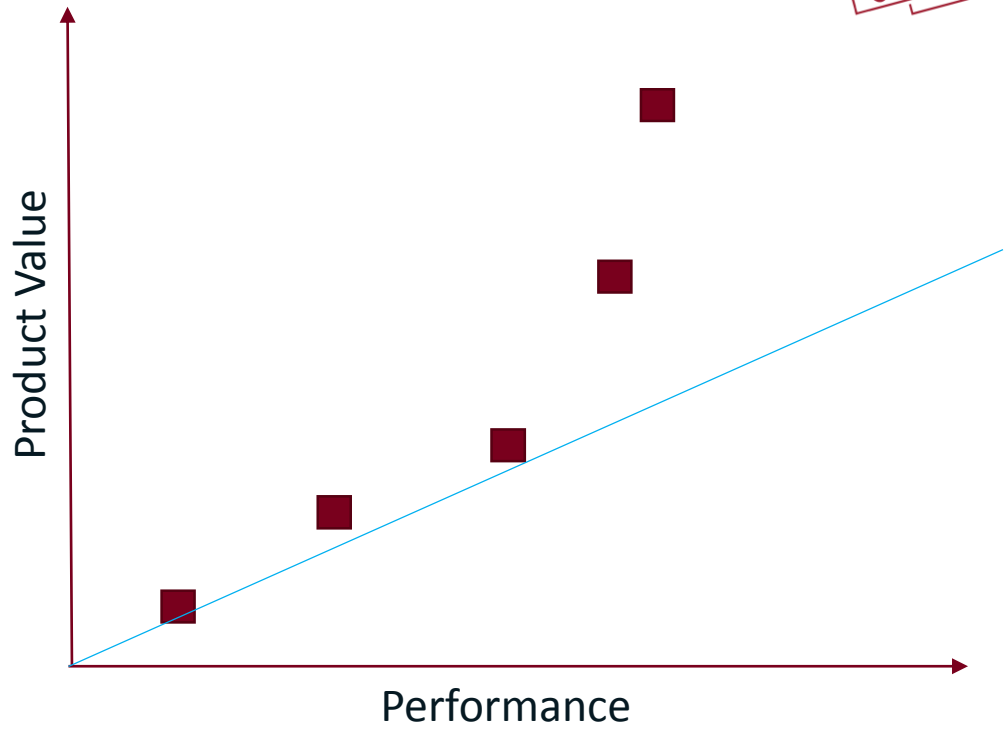
- Almalence's advanced technology
  - Higher image/video quality with mobile cameras
  - Thinner, wider f/ and cheaper mobile camera designs
  - 1" sensor in mobile form factor
  - Aberration free, high resolution VR/AR display

- Power/Efficiency from new vision processors vs. apps processor

  Tensilica P5/P6:
  - 2x higher speed
  - 10x lower power consumption



A **HUGE** step-up in product features, user experience and product value to end-users

SuperSensor – Mobile Camera Quality Enhancement

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Simultaneous, real-time, **higher resolution, lossless zoom, better low light performance, higher dynamic range** on size-constrained mobile cameras.

Native Video

With SuperSensor

Still frames from 1080p videos from same device –native camera (top) and Almalence Video SuperSensor (bottom).

Full video files: http://almalence.com/doc/supersensor-at-video-framerates/videofiles/Almalence-Video-Super-Sensor-demo-clip-1.zip

Patents granted and pending

Video SuperSensor - Real Time Video on a VPU

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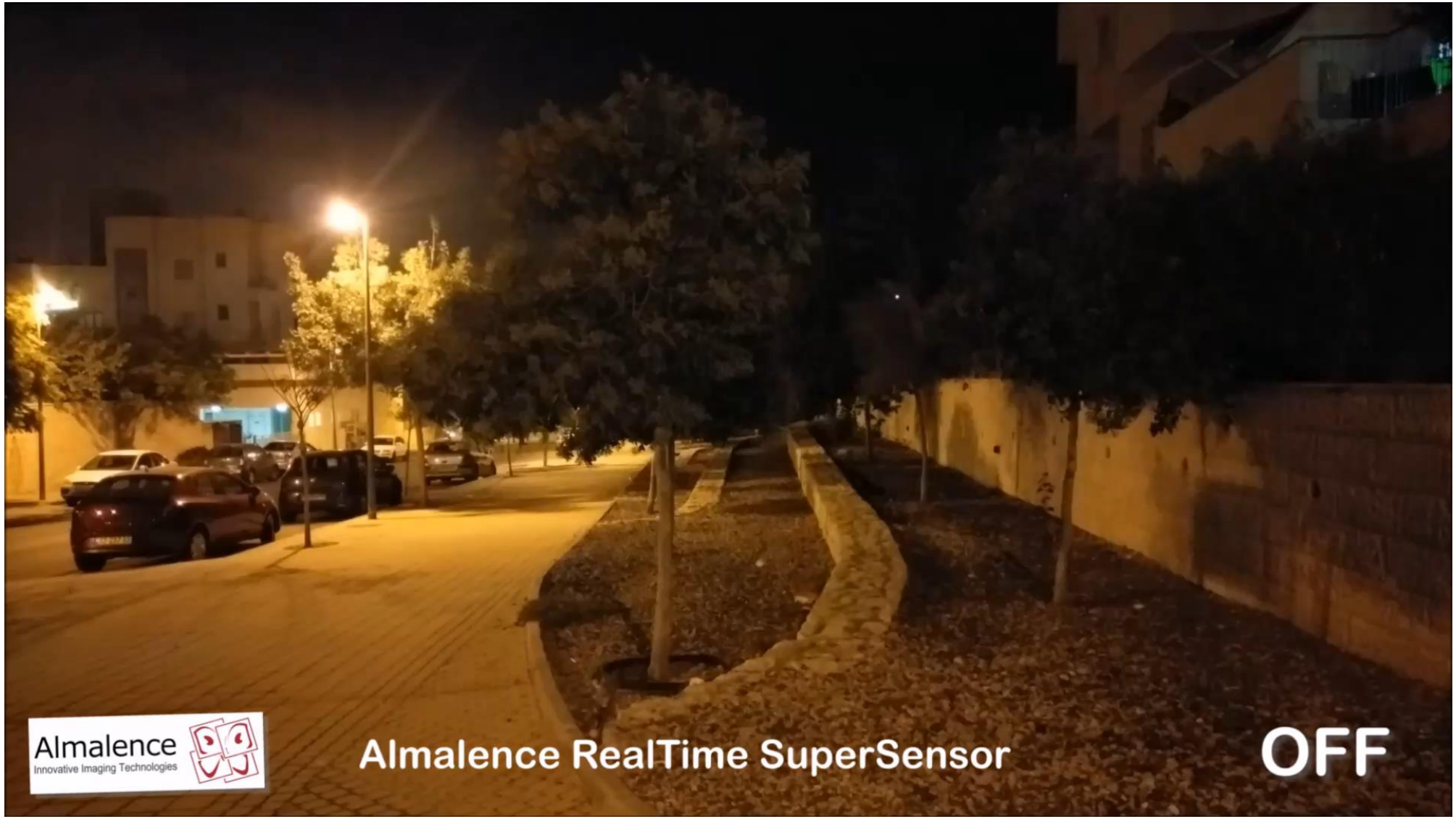

Simultaneously: • Zoom • Low Light • High Dynamic Range • Backlight • Stabilization

VPU: 1080p @ 30fps. **CPU:** 15fps → 3-5fps due to overheating and throttling

Software to Beat the Hardware Competition

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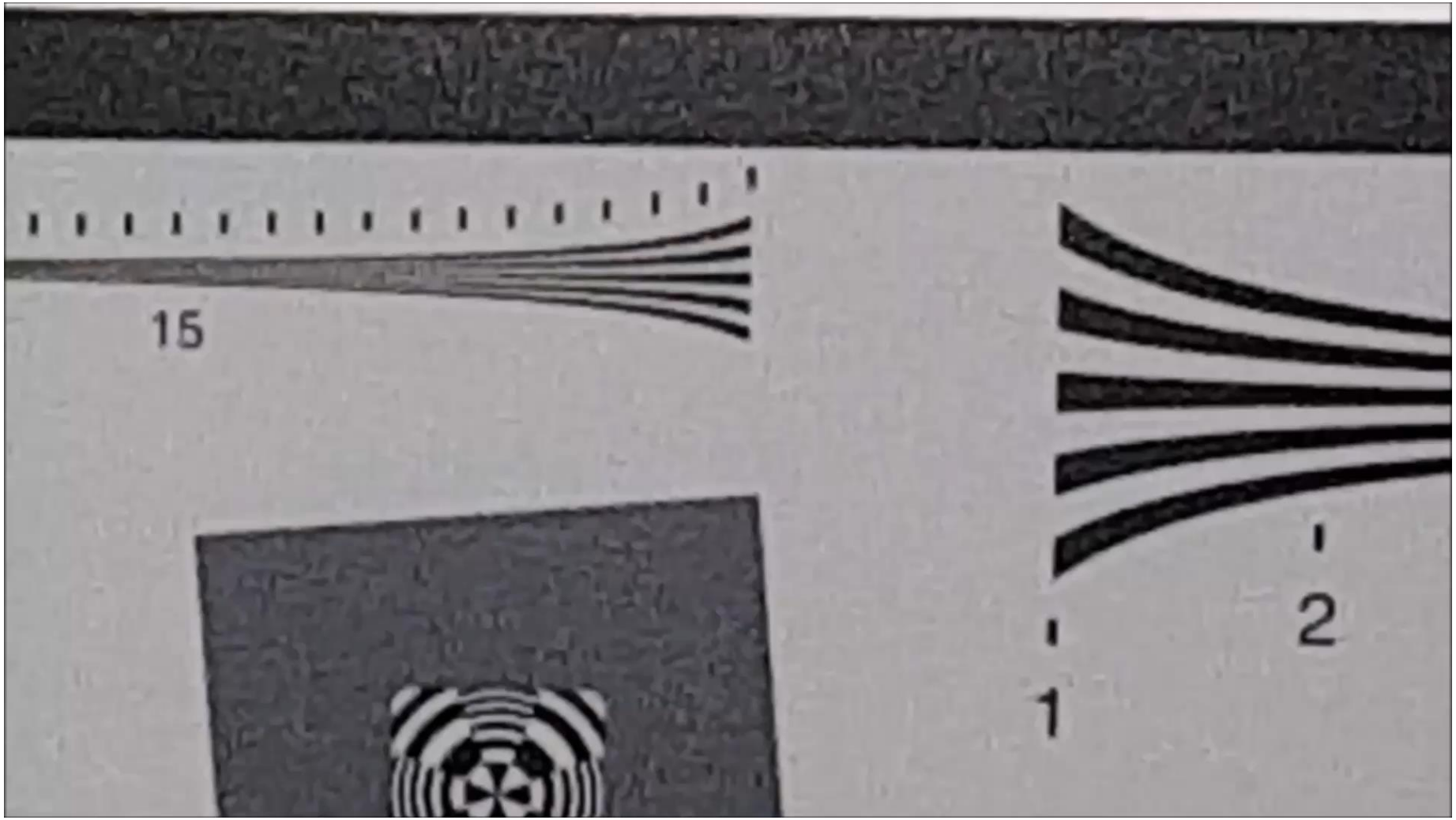
HTC 10 outperforms Samsung S7 at 8x zoom when running Video SuperSensor:



SuperSensor and Dual Camera Hardware

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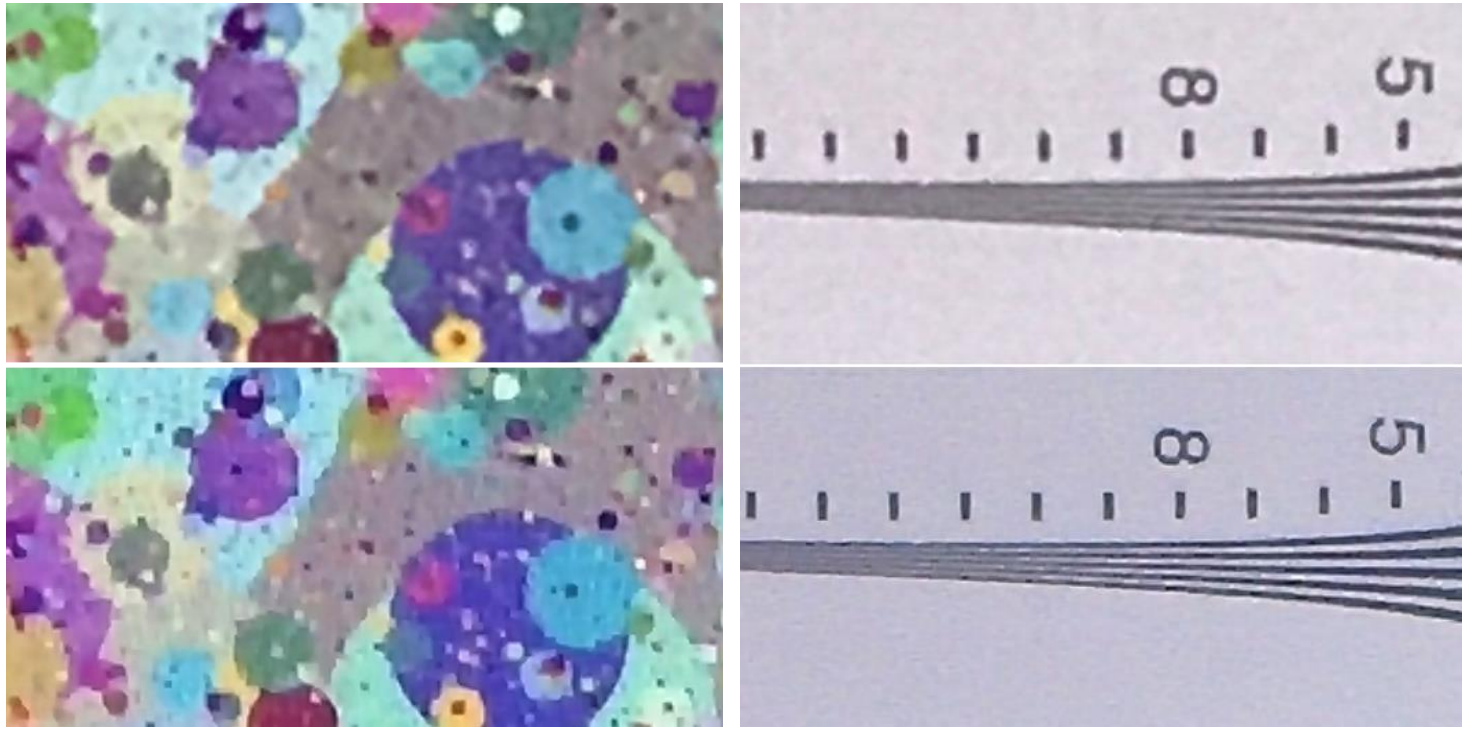
SuperSensor compliments dual camera hardware extending the lossless zoom range.



Top: **iPhone7+ uses 2x tele camera** to take better zoomed images, but it's still **not enough at higher zoom levels.**

Bottom: SuperSensor enables lossless zoom with the same camera.

Simultaneously, SNR is improved solving the problem of narrow aperture of tele camera.

Digital Lens: Virtual Element Replacing a Part of an Optical System

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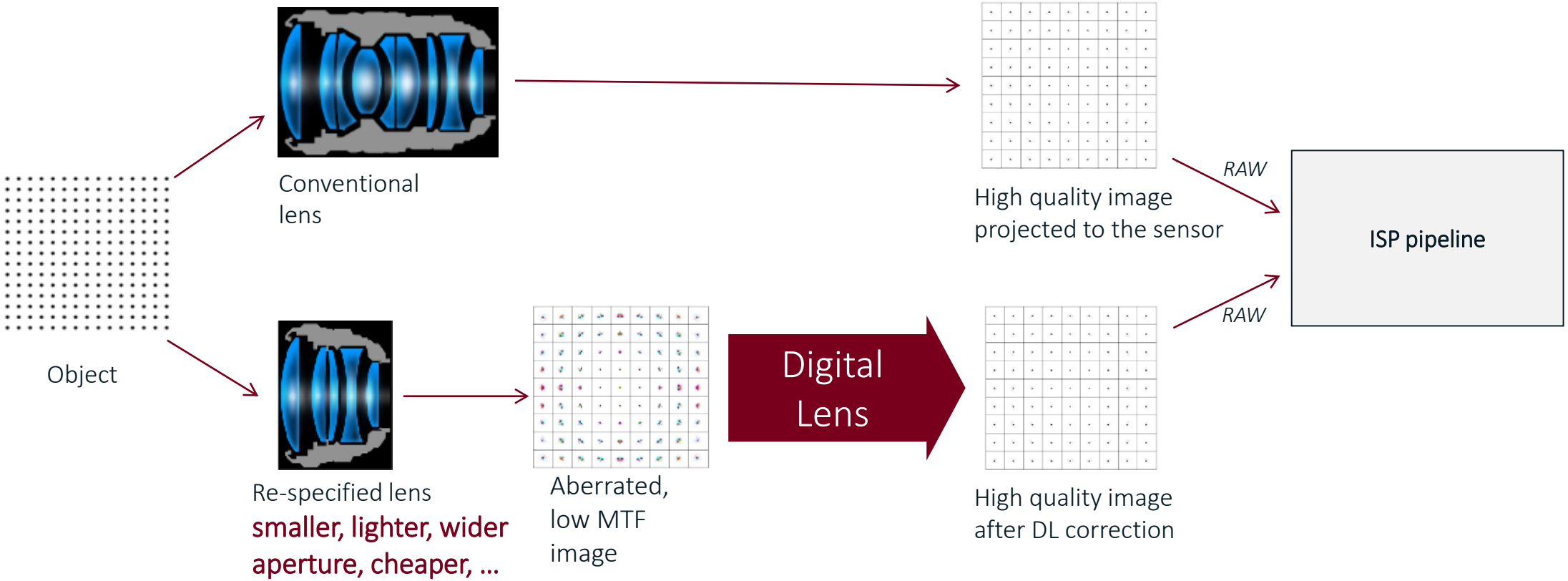
Image quality compromised to achieve better design is corrected by Digital Lens, without adding extra size or weight.



Patents granted and pending

Digital Lens Flexibility

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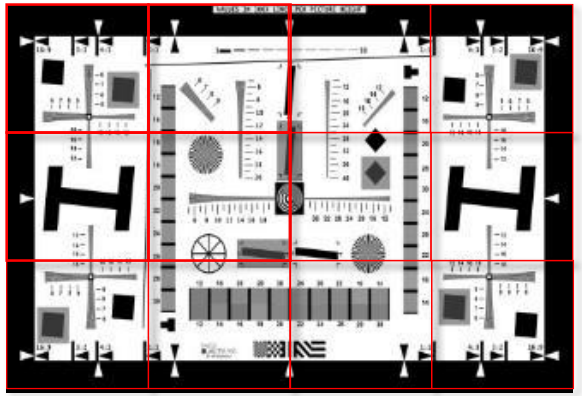
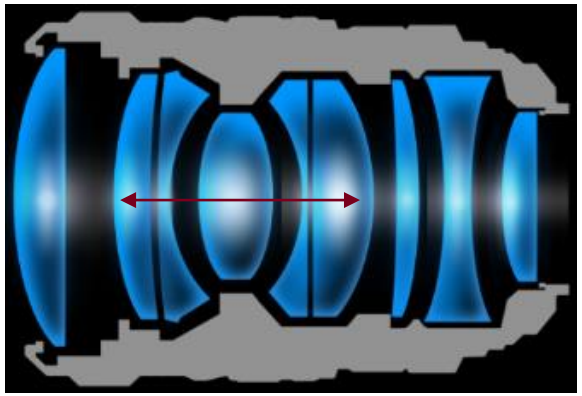
- The Digital Lens correction is parametrized to allow the same processing component to work as a correcting element with variable properties.
- Single DL element performs different corrections:



In different parts of FoV



At different focal lengths and apertures

Optionally, to improve reject rate of module manufacturing

Digital Lens for high-end DSLR

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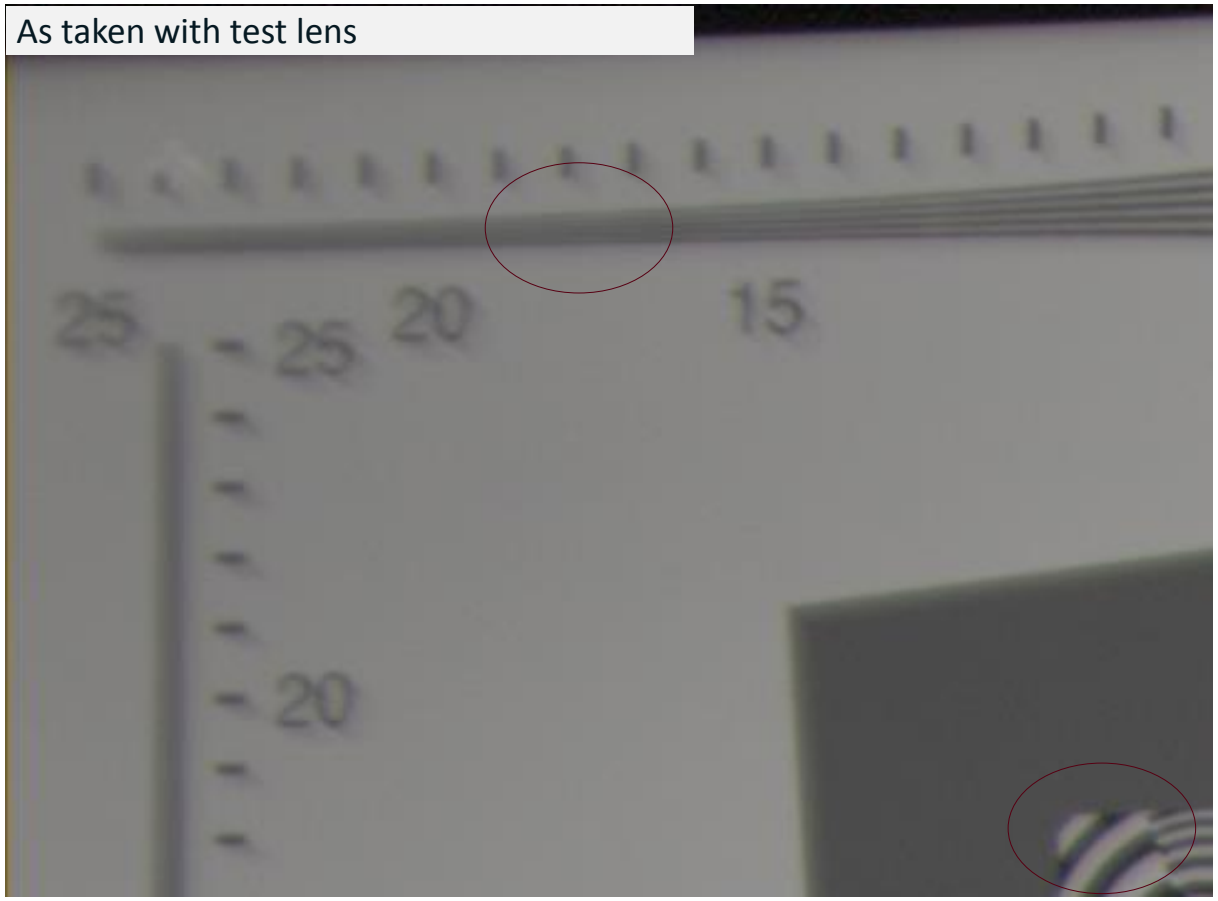
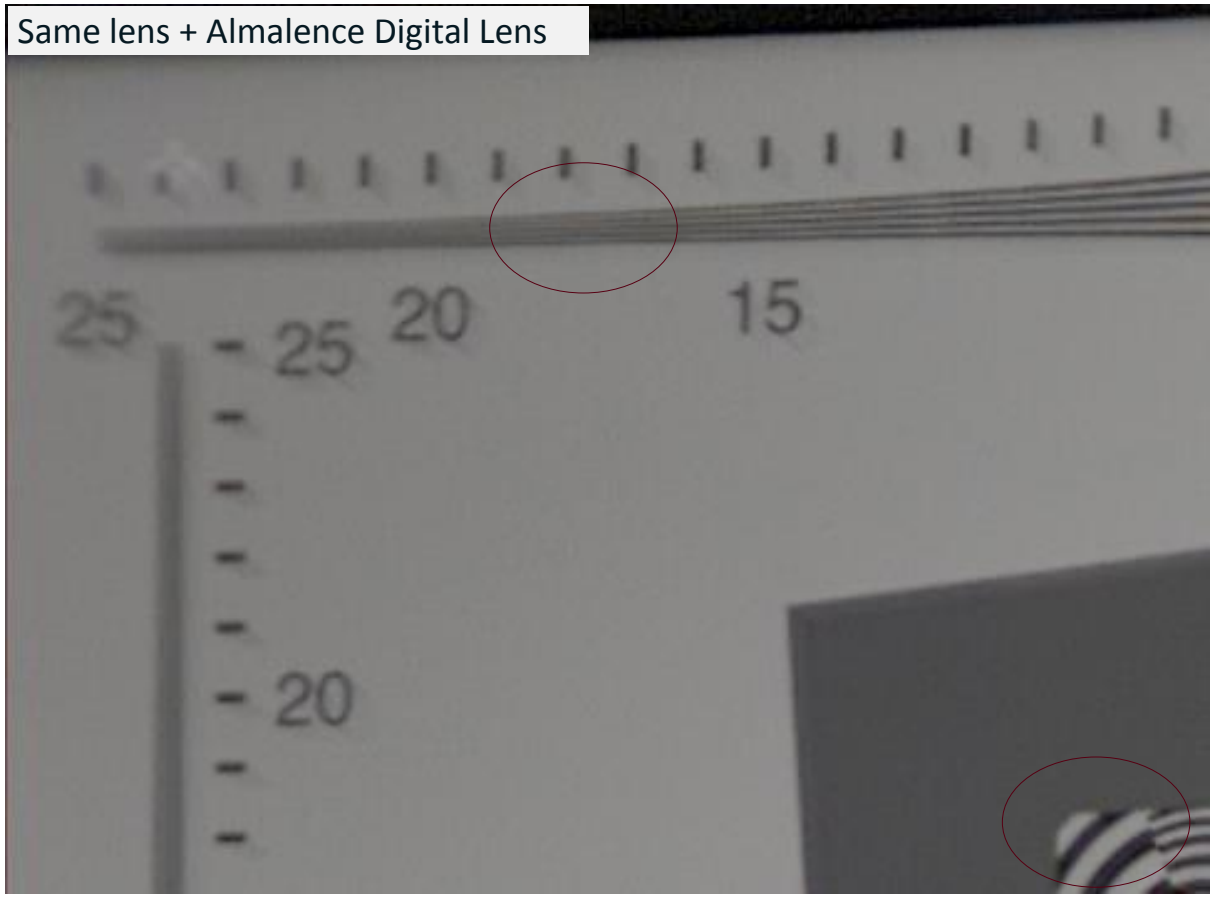
As taken with test lens



Same lens + Almalence Digital Lens



Tamron 28-300mm f/3.5-6.3

Image “softness” (low MTF) and chromatic aberrations in the corners

- CA crossing: 0.767 px → 0.077 px
- MTF30: 0.23 cy/px → 0.31 cy/px
- SNR degradation: just 0.8db

without adding any size or weight

Digital Lens Applications Examples

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DSLR:

- Quality deficiency in corners (low MTF & CA) compensated by DL
- Conventional improvement: using larger, heavier, more expensive lens

Tamron 28-300 f/3.5-6.3
Small, Light, $600

Canon 28-300 f/3.5-5.6.
Big, Heavy, $2,400

Thinner mobile camera:

- Existing 4.5mm TTL design reduced to 4mm
- Conventional approach: compromised image quality but restored to target level with DL

Remove the bump

Thinner laptop cover

Yield increase:

- 60% increased to 90% (simulation)
- Estimated BoM reduction $0.7/unit

Reduce reject rate with DL

Other:

- Wide aperture • 180/360^{o} • light weight • athermalization

1” Sensor Camera in Pocket Form Factor?

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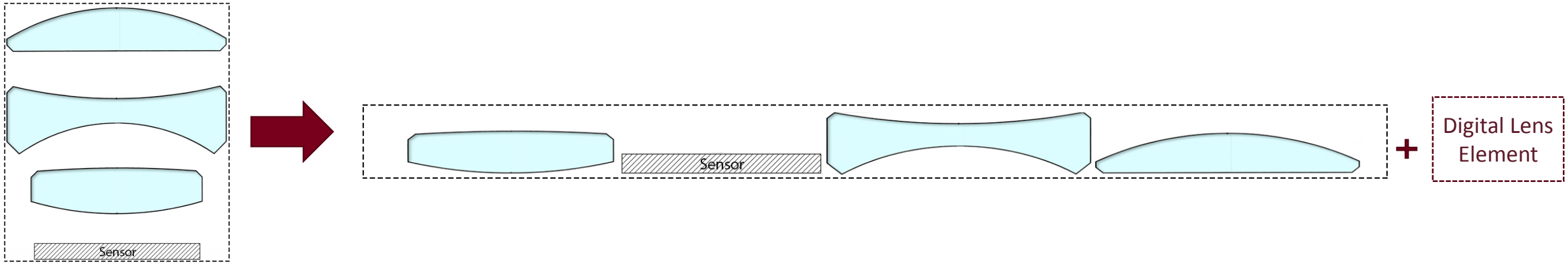
Solution: to make a part of optics **digital** and the remaining part **collapsible**

- The quality of physical (collapsible) part is compromised:
- The digital part corrects the quality degradation, adding no size or weight



Conventional lens

Few thin elements collapsing into a single plane

Patents granted and pending

mDSLR: Real DSLR Quality in Mobile Form Factor

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Innovative collapsible optical design to enable big sensor camera in a smartphone

The 1st target module:

- 1” sensor, f/2.4
- 3mm height of entire camera module (collapsed)
- Quality on par with entry-level mirrorless (Sony α6000 as ref)
- Can be embedded into mobile phone

Expanded: 15mm

Collapsed: 3mm

Possible future designs:

½” sensor 1.5mm TTL camera for smart watch,
Full frame sensor 5mm TTL camera,
Multi-focus collapsible camera, and more.

Applications:

Mobile phones
Drones (light weight, compactibility),
Smart watch
Ultra-compact DSC/DSLR

Patented IP:

Optical design
Image processing
Mechanical design

Patents granted and pending

The Challenge to High Quality, Aberration-free VR/AR

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- Thin and lightweight VR/AR lenses are prone to aberrations, which spoil user experience.
  No fix with conventional optical design.
- VR HMD makers are moving to higher resolution displays but the picture quality is already at the limit of the optics now.
- Almalence Digital Lens technology is the only way to achieve better picture quality without using big and heavy optics.

Image as seen thru VR lens

Thru the same VR lens, pre-corrected by **Almalence DL**:
More details, CA significantly reduced

(Verified simulation with Samsung Gear VR)

Patents granted and pending

Pure computational technique: no size/weight, flexible

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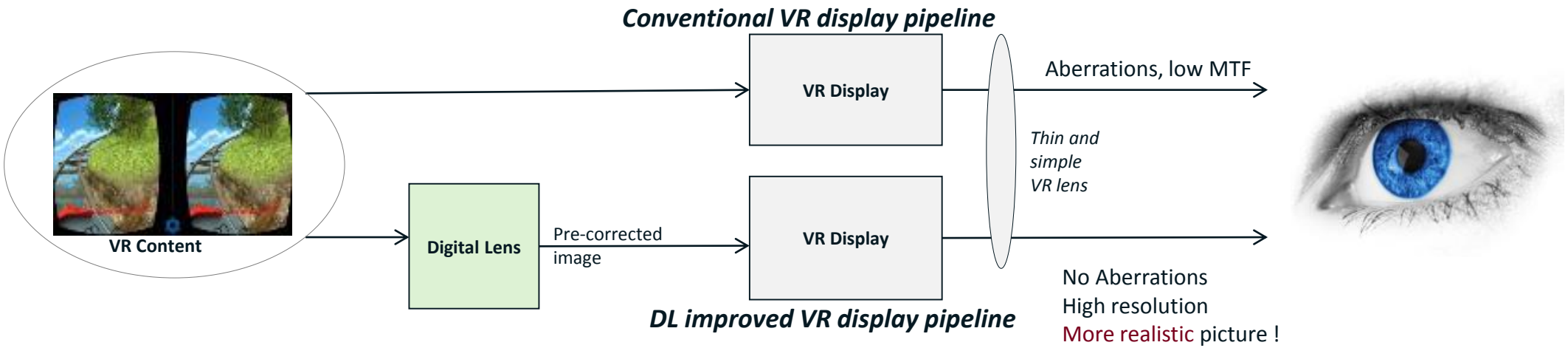
- Digital Lens works as a pre-correction in the display pipeline acting as a virtual “corrective lens element”
- Without heavier and more complicated optics, DL compensates for all aberrations including longitudinal chromatic and causing MTF degradation in the HMD lens
- Eye pupil position is factored to apply proper pre-correction
- Single implementation can be used to improve any new or existing HMD optical design



Conclusion

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- New computational power enables image enhancement at video framerates
- Virtual lens elements address a range of challenges, allowing to create innovative optical designs previously unachievable by optical hardware alone
- New compelling product categories become possible that were otherwise limited by the size and weight of conventional camera designs.

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