Credible Repair Of Sony Main-Sensor PDAF Striping Artifacts
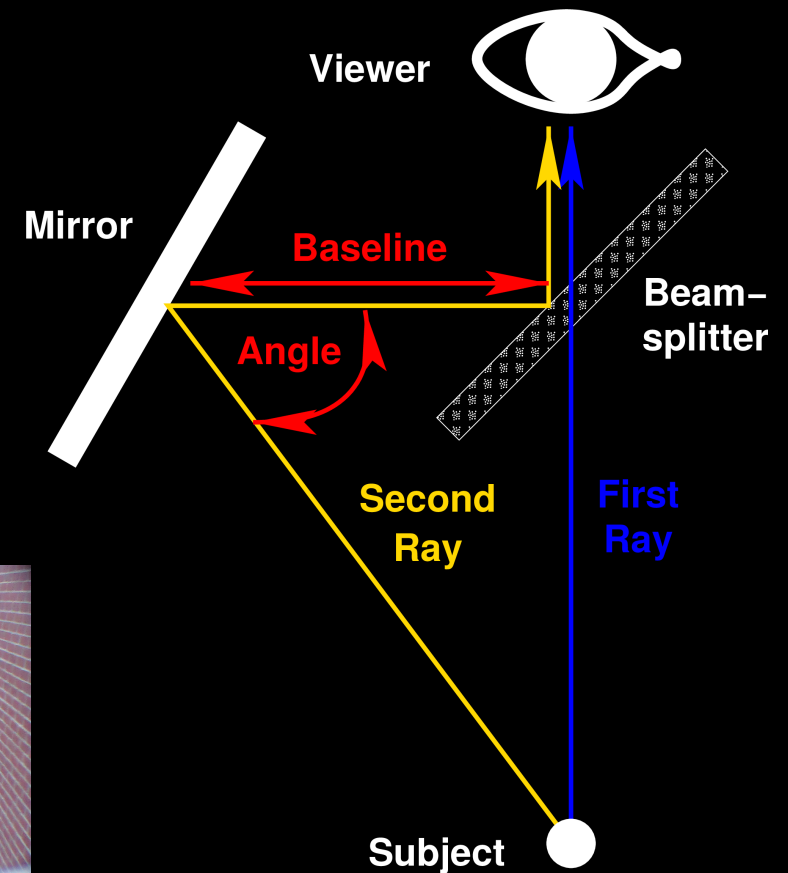
Henry Dietz

PMII-585, Noon, January 15, 2019

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Electrical & Computer Engineering

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Focus Using An **Optical Coincidence Rangefinder**

- Two *different* points of view, superimposed by mirrors
- Aligned views ⟹ in focus
- Misalignment shows both direction and distance to achieve focus

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Phase-Detect AutoFocus (PDAF) Using An SLR

- SLR means Single Lens Reflex; a mirror deflects lens projection to optical viewfinder
- Two *different* points of view *within one lens* e.g., left vs. right sides (Maxxum 9000, 1985)
- Separate PDAF detector:
  - Main mirror beamsplits to another mirror and optics targeting the PDAF sensor
  - PDAF sensor has pairs of point sensors seeing rays from opposite sides of lens
  - Misalignment gives distance & direction

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Mirrorless AutoFocus?

- **Mirrorless** cameras use electronic live view from the main sensor as viewfinder
- 2010 Sony A33 SLT beamsplitter to PDAF
- Use the main sensor for AF:
  - Contrast Detect AF (CDAF), aka Depth From Focus (DFF)
  - Depth From Defocus (DFD)
 - Dual Pixel AF (DPAF)
  - **Masked Pixel AF**

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Masked Pixel AutoFocus?

- Better view separation than DPAF
- Used in many cameras
- Microlens + mask distinguishes views
- *Many variants*; shown is from Sony US20110063484A1
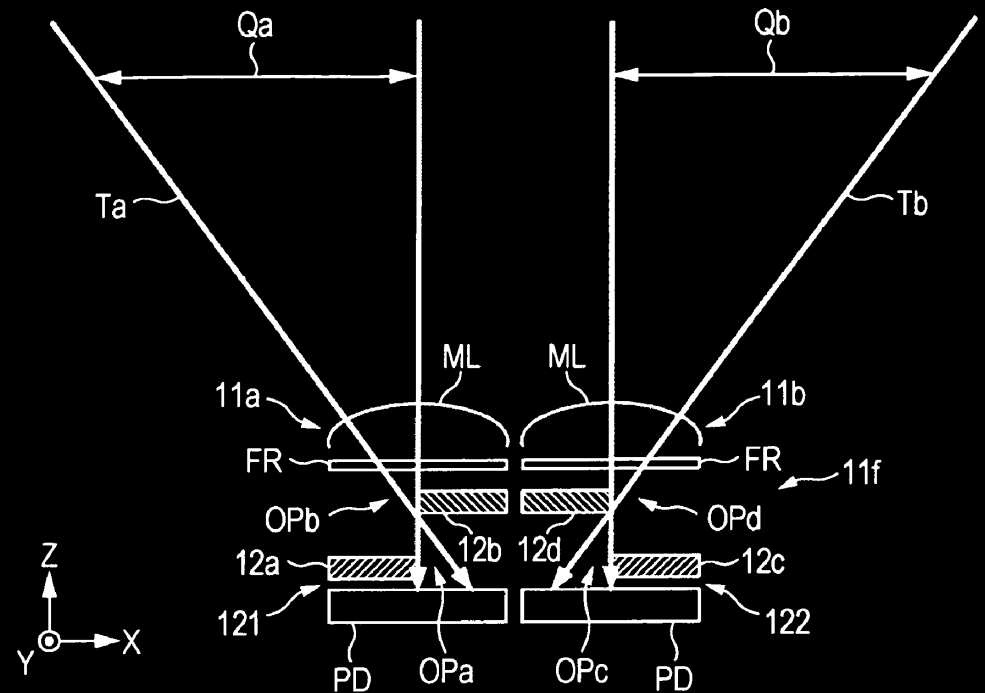
Problems With Masked Pixels?

- Masked pixels see less light,
  which can reduce low-light AF performance
- Masked pixels don't see all views thru lens;
  pixel value needs adjustment or is
  ignored and interpolated over
- Light not sensed has to go somewhere;
  stray light could interfere with pixel values

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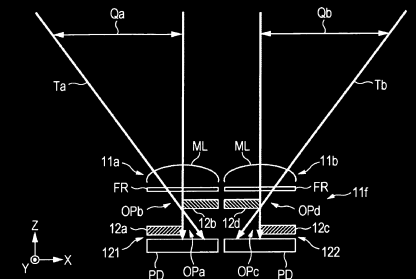
Crop from DPReview photo by Rishi Sanyal, April 2018

We Can Credibly Fix It!

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In case you couldn't see...

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A Brief Timeline

- 6/2017, Sony A9 line artifacts noted by Rishi Sanyal, Bill Claff, Jim Kasson, Horshack, etc.; correlation with PDAF lines established
- Similar defects noted in RX100V, Fuji X-T2... these artifacts had been around for years
- 4/2018, A7III artifact analysis @DPReview, pippo27 postprocessing, **KARWY-SR** repair tool (Kentucky's ARW Stripe Removal)
- 12/2018, RawTherapee 5.5 postprocessing
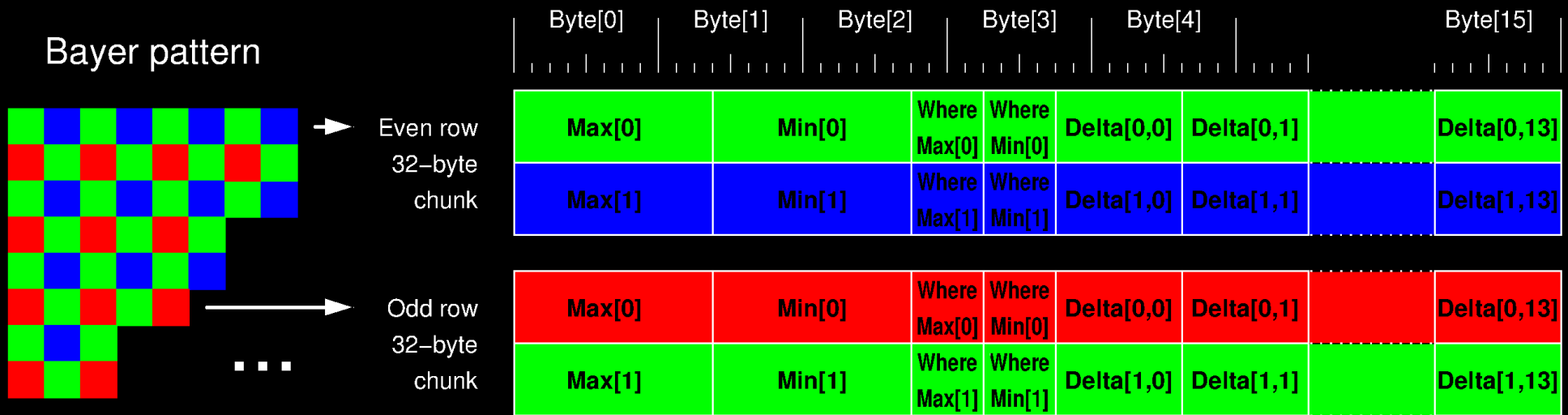
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Characterizing The Problem

- Difficult because it affects many models
- Very difficult because it's rare...
  had to create problematic circumstances:
  - Lenses with big rear elements, lighting flare
  - No lens at all; flare generated with penlight
  - Lens adapter with built-in flare light

Characterizing The Problem

Model	Stripes	Severity	Common?
RX100IV	–	–	Never (no PDAF)
RX100V	Bright	Moderate	Yes
NEX-5	–	–	Never (no PDAF)
NEX-7	–	–	Never (no PDAF)
A6000	Bright	Very	Yes
A6500	Bright	Minor	Yes
A7	Dark	Minor	No
A7II	Dark	Moderate	No
A7RII	Bright	Very	No
A9	Bright	Very	Yes
A7RIII	Bright	Very	Somewhat
A7III	Bright	Very	Yes

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KARWY-SR Design

Bayer pattern

	Byte[0]	Byte[1]	Byte[2]	Byte[3]	Byte[4]		Byte[15]
Even row 32-byte chunk	Max[0]	Min[0]	Where Max[0]	Where Min[0]	Delta[0,0]	Delta[0,1]	Delta[0,13]
	Max[1]	Min[1]	Where Max[1]	Where Min[1]	Delta[1,0]	Delta[1,1]	Delta[1,13]
Odd row 32-byte chunk	Max[0]	Min[0]	Where Max[0]	Where Min[0]	Delta[0,0]	Delta[0,1]	Delta[0,13]
	Max[1]	Min[1]	Where Max[1]	Where Min[1]	Delta[1,0]	Delta[1,1]	Delta[1,13]

. . .

- Credible *repair* of compressed ARW2 raw files
- Leverage algorithms from KARWY
- Fast without prior info about PDAF locations
- Run locally in a WWW browser (JavaScript)

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Credible repair of Sony ARW2 raw image data

Welcome to the beta test version 20180318 of the free program KARWY-SR, which runs locally in your web browser to perform "Stripe Removal." The stripes we're talking about are the ones like the above, which run horizontally across the sensor in landscape orientation and are probably related to the PDAF pixels on the sensor. This version only can repair this artifact in **compressed Sony ARW2 raw files**, and the result is also a compressed ARW2 file. Simply drag & drop ARW2 file(s) below, wait typically less than 30 seconds, and save the "Link to processed file" to a file with a name ending in .arw. The image displayed is just the original JPEG thumbnail; it has *not* been repaired, but is displayed to make it easier for you to know which file is which when converting multiple ARW2 files.

We created the original KARWY (pronounced car-we) to credibly repair compression artifacting in Sony ARW2 raw files. However, the original version is compiled C code which requires Adobe DNG Converter, ExifTool, ImageMagick and XZ as helpers, making installation a pain. Thus, we made KARWY available to run remotely on our servers via a WWW form interface. That means it does its computations much faster than KARWY-SR, but you have to wait as big raw files are sent to and from the server. We hope to add functionality of the original version to KARWY-SR... but for now, the two tools are separate, and you should use KARWY-SR first and then KARWY to repair a file suffering both types of artifacting.

Drop a compressed Sony ARW2 raw file here or

[Choose Files] No file chosen

DSC00087.ARW

Link to processed file

ARW2 from Sony ILCE-7M3.

DSC09659.ARW

Link to processed file

ARW2 from Sony ILCE-6500.

The *Aggregate.* The *only* thing set in stone is our name.

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Credible Repair Algorithm

- Mark artifacted pixels:
  1. Confirm compressed ARW2 input
  2. Create preview image, extract camera info
  3. Decode ARW2 into linear 16-bit samples
     with noise bounds & random noise added
  4. Scan to mark "brighter line" sequences
     (could just check PDAF locations...)
  5. Mark single-pixels between marked pixels

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Credible Repair Algorithm

- Compute repaired pixel values:
  1. Replace marked pixels with statistically-biased value interpolated from +/-2 rows (Nikon Z6/7 banding lacks randomness)
  2. In C version, refine using texture synthesis (slow: hundreds of patterns per pixel)
  3. Recompress & overwrite changed 16-pixel ARW2 blocks (saves packing operations)
  4. Return link to corrected-in-place file
- Typical 24MP ARW2 repair <5s

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Most Repairs Are Very Good

A6000 original image crop (left), tighter crop, KARWY-SR repair

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RawTherapee 5.5 vs. KARWY-SR Repairs
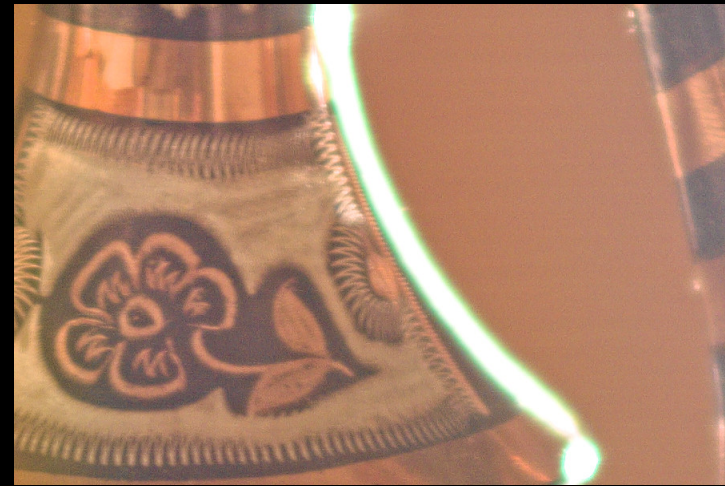
Original (top left), crop (bottom left), RawTherapee (top right), KARWY-SR

RawTherapee 5.5 vs. KARWY-SR Repairs (Enhanced)

Enhanced original crop (left), RawTherapee (middle), KARWY-SR (right)

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Repair Quality Evaluation

- They're *credible*, right?
- ***Zero*** user complaints
- DPReview evaluation ⇒
- Repair is **not perfect**:
  - Blonde hair fooled it
  - Some hint of lines is visible in solid areas
- Does not fix dark lines
- Compressed ARW2 only

Sony 'striping': here's the fix   791

Published Apr 18, 2018 | Rishi Sanyal, Carey Rose

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Take a look at the PDAF stripes across the female model's face in this image (cropped from an original vertical shot). The bad news is that it looks terrible. The good news? There's a fix.

When we published our original Sony a7 III sample gallery, we and our readers had some concern over odd striping artifacts viewable in some images, such as the one above.

It's known as 'PDAF striping' and it's not limited to a single camera, or even a single brand. It's likely due to light reflections off the metal masks of on-sensor phase-detect pixels. Masked pixels, as opposed to a split dual-pixel design that obviates the need for metal masks, is to the best of our knowledge a design choice: the approach enables high performance AF even during 10 to 20 fps bursts.[1] The unfortunate side effect is the potential - albeit rare - for single pixel stripes in transitions from blown areas to darker

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Conclusions

- Masked pixel PDAF is & will be common for mirrorless, video, and even cell phones
- Can artifacts be prevented?
- Credible repair is cheap and effective
- Repair requires matching noise statistics

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