

# SuperResolution: Industry Solutions

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# Multiple Image SuperResolution

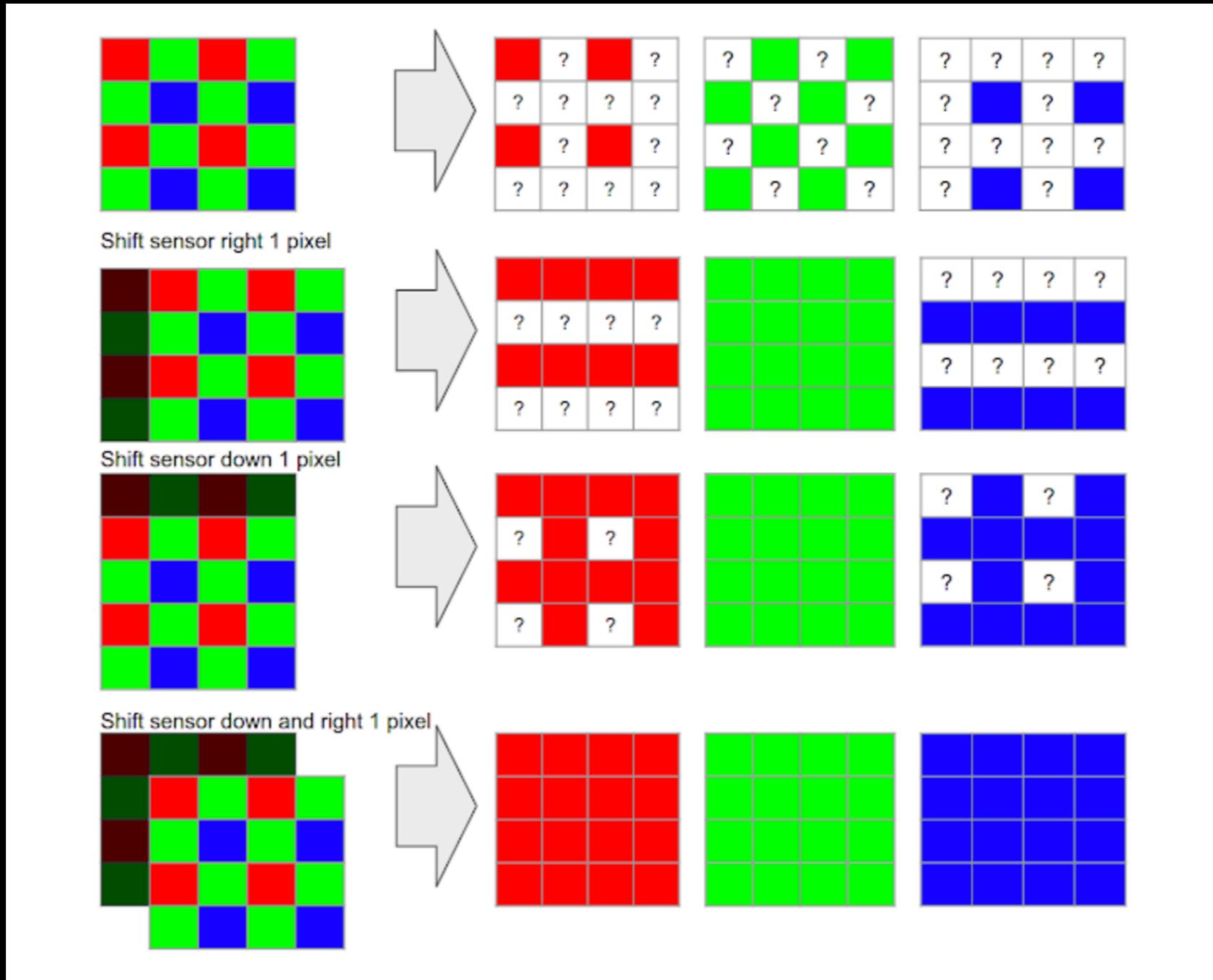
# Concept

- Take a sequence of images containing pixel shifts:
- Fixed shifts: Uses a special sensor shift mechanism inside the camera.
- Or
- Random shifts: Uses handshaking.
- Combine the data to generate a HR image.

# History

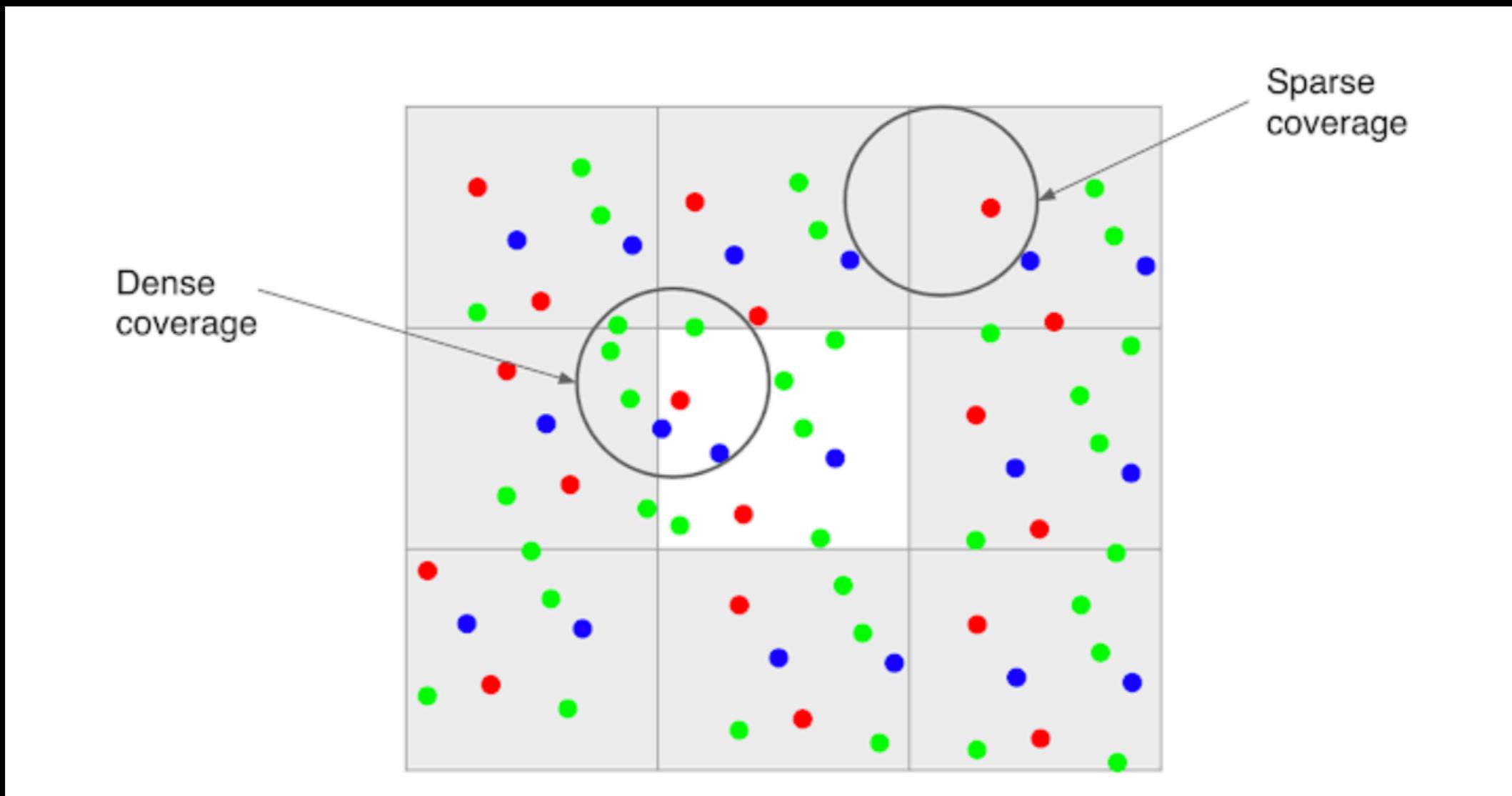
- 2011 - First SR for professional cameras (Hasselbad H4D-200MS) - Sensor Shift
- 2015 - First SR for consumer cameras (Olympus OM-D E M5 II) - Sensor Shift
- 2018 - First SR for cell phone cameras (Google Pixel 3) - Handshaking

# Google Pixel



If the pixel shifts were exact (fixed shifts), the holes in the diagram could be filled precisely.

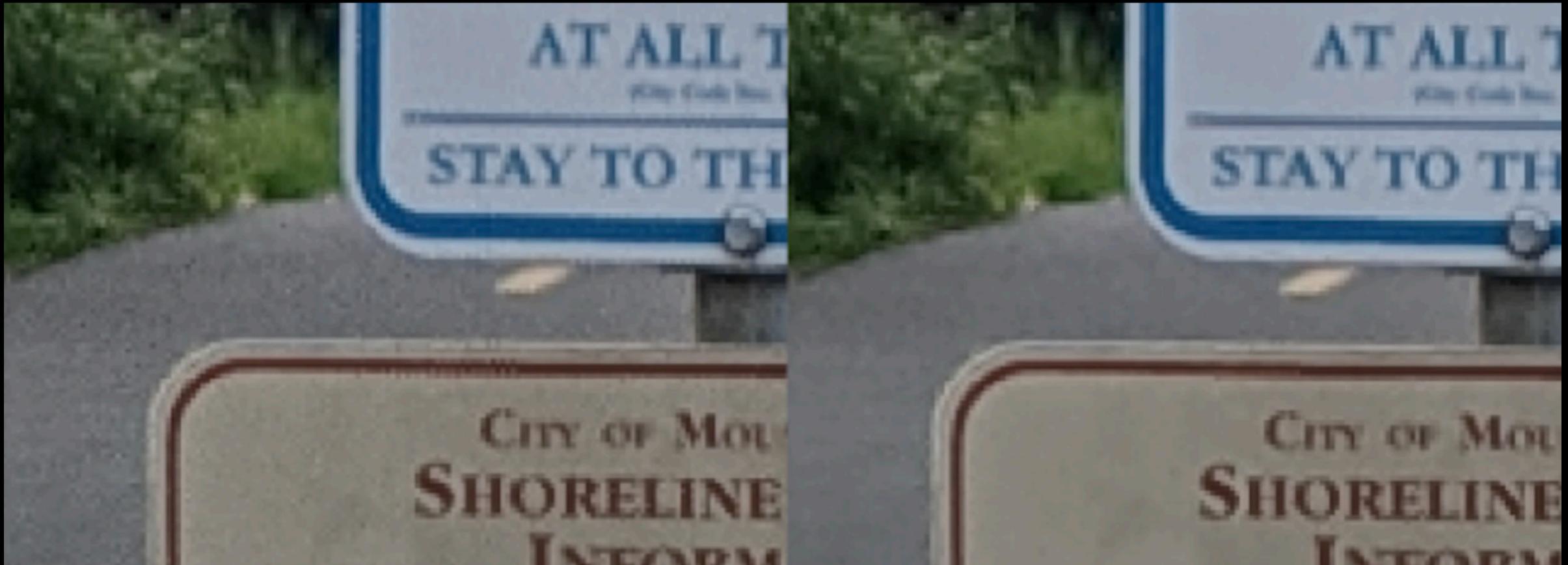
# Google Pixel



**When using handshaking, there will be sparse and dense regions of coverage.**

# Google Pixel

- As a result, an edge adaptive approach is applied.
- Specifically, only pixels that lie along edge directions are merged.
- In general, tradeoffs are made between image detail and resolution versus noise suppression and smoothing.
- i.e. If there is no strong edge direction, denoising occurs.
- Note: This is analogous to anisotropic diffusion and the bi-lateral filter.



The devil is in the details. Left image: A non ideal tradeoff between resolution and noise. Right image: A more ideal tradeoff between resolution and noise.

# Single Image SuperResolution

# Concept

- Using training images, create a bank of filters to map low resolution structure to high resolution structure.
- i.e. Decoder / generator network. Transpose convolution filters.
- Intelligently upscale a low resolution image, using the trained filter bank.

# History

- Google RAISR (2016)
- Topaz Labs (2018)
- Adobe SR (2021)

# Google RAISR (11/2016)

- <https://ai.googleblog.com/2016/11/enhance-raisr-sharp-images-with-machine.html>
- A bank of filters are trained using either 1) Low resolution and high resolution image pairs or 2) A low resolution image upsampled to a higher resolution, and, the real high resolution image.
- At runtime, RAISR “selects and applies the most relevant filter from the list of learned filters to each pixel neighborhood in the low resolution image”.
- Note: I suspect that this a “general way” of saying that a trained decoder /generator network (consisting of transpose convolutions) is being used.

# Topaz Labs (2018)

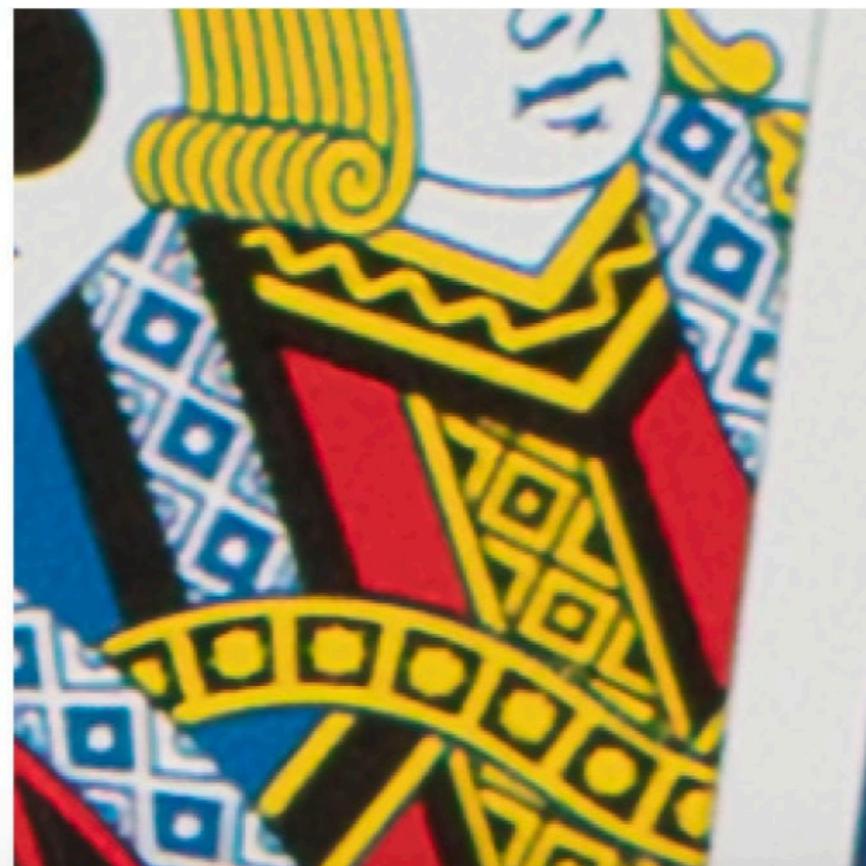
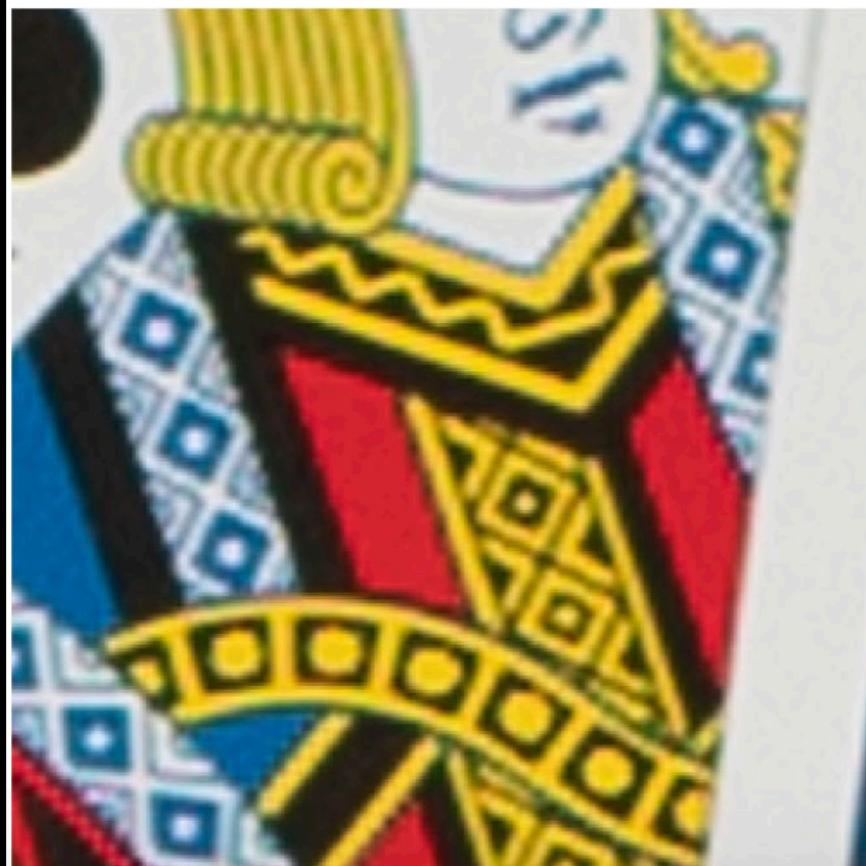
- This product allows you to upscale images by 32x.
- Topaz also has products to upscale videos, denoise images and sharpen images.
- Topaz states that “if you’ve used Topaz software since 2018, you would have received **more than 100** new or substantially improved AI models for image quality”.
- Topaz states that “we gather and input millions of data points to help the system understand what "image quality" means. This training usually takes weeks or months to complete”.
- The inference speed for the product is slow = minutes to process a single image.

# Adobe SR (3/2021)

- <https://blog.adobe.com/en/publish/2021/03/10/from-the-acr-team-super-resolution.html#gs.w2ww5o> (Single Image Super Resolution)
- Key Takeaways:
- The network was trained used “millions of pairs” of high resolution and low resolution image patches.
- A 2x resolution improvement was produced in the horizontal and the vertical directions = 4x.
- The network was trained using clean raw data.
- The network was trained using challenging examples (a lot of texture and a lot of fine details).

DODGES, IT IS IMPOSSIBLE  
the North in the usual way,  
method of our own. By a Law  
there is a constant attraction to  
such in temperate climates  
that even a Woman in reasonable  
several furlongs northward will  
yet the hampering effect of the  
quite sufficient to serve as a com-  
fort. Moreover, the rain (which falls at  
from the North) is an additional assis-

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# Adobe: Other

- In ~2000, Adobe licensed a plug-in from Genuine Fractals, that performed single image super resolution.
- Using Genuine Fractals, 4x, 16x ... improvements in resolution were possible.
- It would be interesting to compare the 20 year old fractal based results with the modern day super resolution results.

# Adobe: Other

In 2013, Adobe announced a feature that reduced camera shake blurring.



Ideally, we would like SISR to 1) fix images with motion blur and 2) upscale the image, resulting in a new high resolution, blur free image.