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PureView Technology (Optimisation & Evaluation Techniques in Image Processing)

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Abstract

PureView Technology is the combination of a super high-resolution image sensor and high-performance optics. It further applies advanced image processing algorithms and pixel oversampling to give the best quality outputs. It uses pixel oversampling method. Pixel oversampling combines many pixels to create a single (super) pixel. When this happens, we keep virtually all the details but filter away visual noise from the image. The speckled, grainy look we tend to get in low-lighting conditions is greatly reduced. One of the major benefits of this technology is lossless zoom. The level of pixel oversampling is highest when we're not using the zoom. It gradually decreases until we hit maximum zoom, where there is no oversampling. This technique thus allows us to have loss-less zooms even when we are using the camera for taking zoomed in photos. The core of this technology lies somewhere in the satellite imagery system which uses a similar method of pixel oversampling and high-resolution image sensors. With PureView, uses a system called oversampling, which takes the original greater number of megapixels captured with the enormous sensor and reduces them to a high-quality image consisting of only a few megapixels. Pixels are pulled together into groups of seven and those seven pixels are then condensed into one, so that even though the resulting photograph is only a few megapixel images it is of a better quality than those captured with more traditional five megapixel cameras. For example, Nokia Lumia 1020 uses a 41-megapixel camera to take the original image, however, reduces this to only an output of 5 megapixels. This thus produces a very clear picture.

Keywords: PureView, Pixel, Oversampling, Zooming, Interpolation

Introduction

PureView Pro imaging technology doesn't represent a step change for camera smartphones performance, but a quantum leap forward (http://conversations.nokia.com). The first device to feature Nokia PureView Pro camera technology is the Nokia 808 PureView, which gives people the means to take better images and video footage than ever before. It dispenses with the usual scaling/ interpolation model of digital zoom used in virtually all smartphones, as well as optical zoom used in most digital cameras, where a series of lens elements moves back and forth to vary the magnification and field of view. The starting point is a super-high-resolution sensor. This has an active area of 7728 x 5368 pixels, totaling over 41Mpix. When we zoom with the PureView, in effect we are just selecting the relevant area of the sensor. So with no zoom, the full area of the sensor corresponding to the aspect ratio is used. The limit of the zoom (regardless of the resolution setting for stills or video) is reached when the selected output resolution becomes the same as the input resolution. For example, with the default setting of 5Mpix (3072 x 1728), once the area of the sensor reaches 3072 x 1728, we've hit the zoom limit, thus always providing true image quality.

The main technology or algorithm behind this technology is the pixel oversampling. Pixel oversampling (http:// www.dpreview.com) combines many pixels to create a single (super) pixel. When this happens, we keep virtually all the detail, but filter away visual noise from the image. The speckled, grainy look we tend to get in low-lighting conditions is greatly reduced. And in good light, visual noise is virtually non-existent. This means the images we

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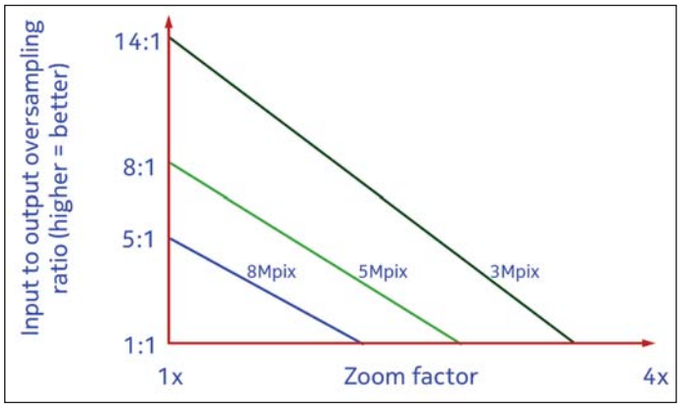
can take are more natural and beautiful than ever. They are purer, perhaps a more accurate representation of the original subject than has ever been achieved before.

Fig. 1: Graph Showing the Zooming Factor vs The Oversampling Ratio



The graph in Fig. 1 shows that more the zooming, the less the number of pixels are used for oversampling or creating one super pixel.

The level of pixel oversampling is highest when we're not using the zoom. It gradually decreases until we hit maximum zoom, where there is no oversampling. At this stage, Nokia PureView Pro optics and pixels start behaving in a more conventional way. But because only the center of the optics are used where there is less diffraction, we get better optical performance — including low distortion and high levels of resolved detail.

Even digital SLR images (http://i.nokia.com) have certain softness. With oversampling, however, images can be noise free, yet incredibly detailed and defined. Oversampling eliminates Bayer pattern problems. For example, conventional 8MPix sensors include only 4Mpix green, 2Mpix red and 2Mpix blue pixels, which are interpolated to 8Mpix R, G, B image (http://da5nsy.files.wordpress.com). With pixel oversampling, all pixels become true R, G, and B pixels.

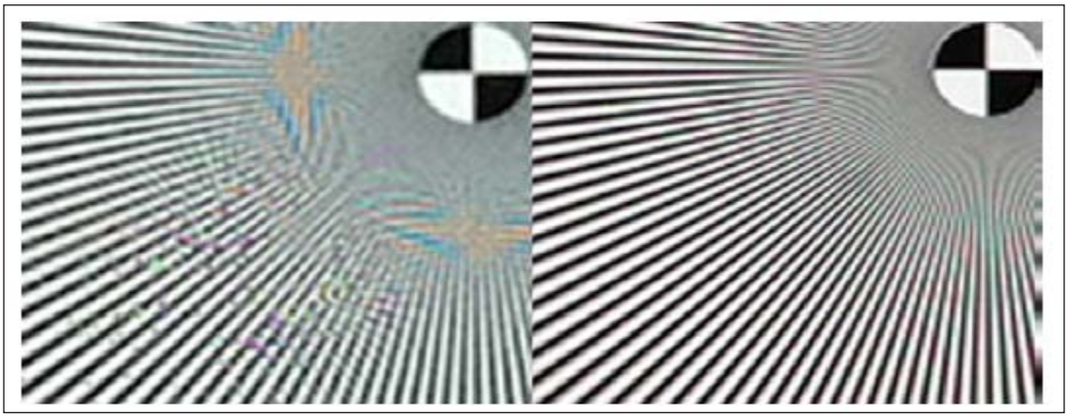
Oversampling

The main aim behind the development of this technology is to achieve better image quality while still keeping the size of the overall device as small as possible. With ever decreasing pixel sizes, the challenge for engineers is quite clearly to overcome the negative effects like high digital noise levels and the resulting poor low light performance. These have been overcome by the use of technology known as pixel oversampling.

Oversampling is different from mere cropping as it doesn't simply use part of the sensor to produce a lower resolution image. Instead, it still uses the full sensor, but downsizes the resulting image to say, 5M. The benefit of this is that this process of downsizing removes digital noise, while preserving the same level of detail we might get by shooting with the best 5 megapixel camera.

This means that taking a lot of pixels together and choosing the best pixel among them, simultaneously removing the pixels which are noise and the pixels which do not contain much detail. This thus gives us the best pixel from the group. Combining all these best pixels together, we get an image which is the best possible image (Fig. 2).

Fig. 2: Left: Normal 5 Megapixel Image. Right: Oversampled 5 Megapixel Image



The pixel now created is referred to as super pixel (http://ashwinananthapadmanabhan.wordpress.com) as it is the best pixel and has all the capabilities any best pixel must have.

Comparison of the Sensors used in PureView and Other Cameras

Fig. 3: Image Sensor Size Comparison

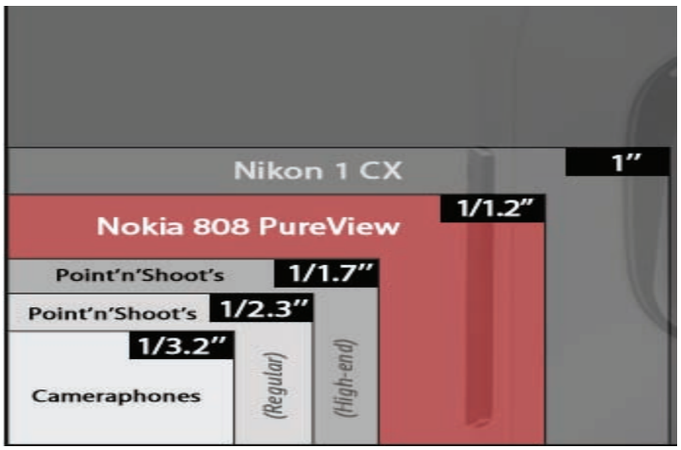


Fig. 3 shows the size of the image sensors that have been used in most camera phones. One thing worth noticing is that the size of image sensor is quite close to the image sensor used in the professional DSLR cameras (http://en.wikipedia.org). This gives the same amount of details as any DSLR.

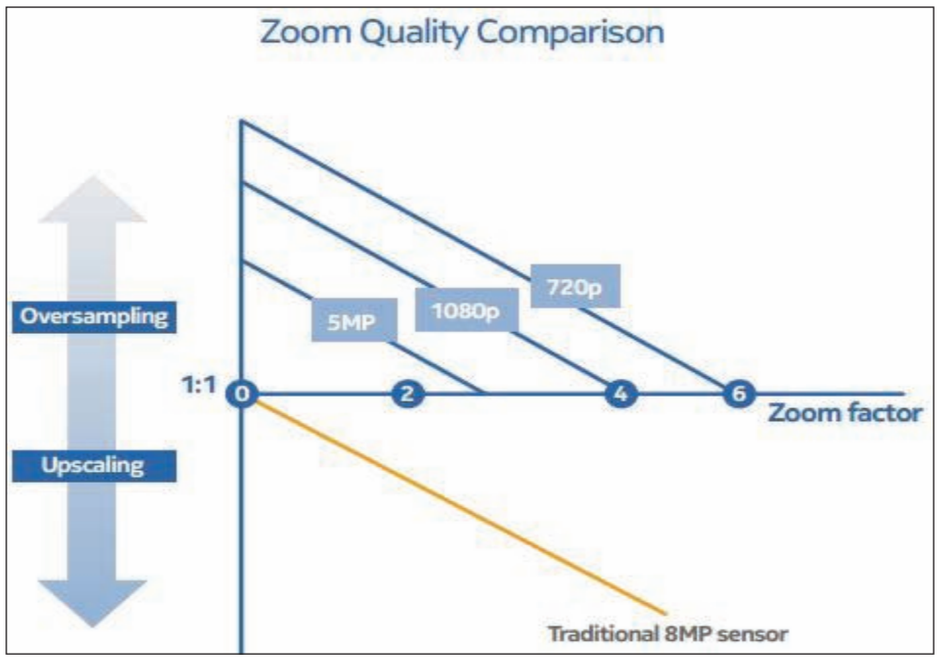
Considerations

Nokia does make some valid claims about avoiding vignetting (dark corners introduced when the lens housing blocks some of the light falling on the sensor) and distortion (caused by the glass of the lens, often digitally corrected in the camera) as benefits over a compact camera. Beyond that, the company also claims that you can preserve the f/2.4 aperture when at full zoom as, again, the lens isn't introducing limitations on the light path. This surely is an advantage over the compact cameras.

Zooming

One of the major benefits of this technology is lossless zoom (Nokia Web Presences). The level of pixel

Fig. 4: Oversampling vs High Resolution Zoom, Compared with Conventional Digital Zoom. High Oversampling is Said to Mean High Image Quality



oversampling is highest when we're not using the zoom. It gradually decreases until we hit maximum zoom, where there is no oversampling. The system gives us the best balance between zoom and oversampling based on how you frame and compose the scene or subject by use of an advanced image processor. When zoomed in, the seven pixels that originally form that basis of each pixel in the final image are reduced in number, so zooming in half way means that perhaps three or four pixels are condensed into one for the final image. Maximum zoom involves focusing on a five megapixel segment of the full 41 megapixel (http://europe.nokia.com) layout, with no oversampling occurring but a detailed, high-quality image still being produced which is far better than could be achieved with normal digital zoom.

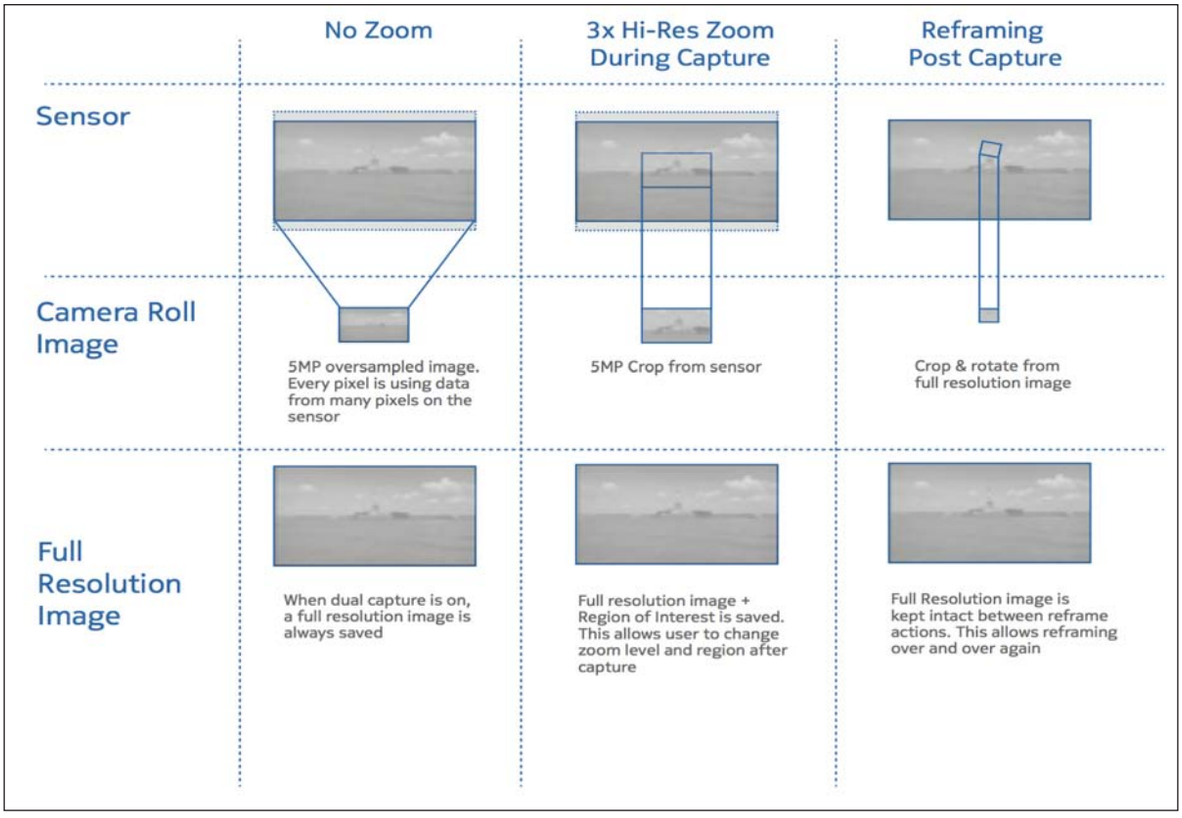
As we know, putting a zoom lens on a phone will make it impractically bulky. Traditionally phones use digital zoom instead. In doing so, they use less of the sensor, but give you the same size image and upscale to try to preserve the detail. The results are poor, lacking in detail and introduce noise. All these problems are solved by the use of PureView technology.

To meet the immense processing requirements (over 1 billion pixels per second and 16x oversampling), the Nokia team developed (http://conversations.nokia.com) a special companion processor to the sensor that handles pixel scaling before sending the required number to the main image processor. Once that's out of the way, we get lossless zooming with the same effective viewing angle – in 35mm equivalents, it's 28mm in 4:3 aspect ratio and 26mm in 16:9. And depending on the resolution, we get a variety of zoom levels. In 5MP stills, for instance, we get around a 3xzoom.

Why PureView?

The solution tackles a problem that affects camera phones specifically, and that's size. Having a bulky phone isn't acceptable, but as more and more people capture pictures with their phone, camera performance has become the new area of research for smartphones (http://europe.nokia.com). With the traditional cameras and the technologies, it is nearly impossible to achieve any higher number of pixels, keeping the size of the whole unit small, i.e. as the number of mega pixels in the devices are increased, the

Fig. 5: The Use of Pixels During Various Stages



size of the image sensor as well as the overall size of the phone increases.

With the use of PureView this problem is solved as the only thing whose size is increased is the image sensor and not the whole camera unit. This means that the other optical sensors such as the lens etc are kept of the same size and only the digital image sensor is increased in size.

Fig. 6: Output from a Standard 5MP Camera Shows Noise as Variance in the Signal

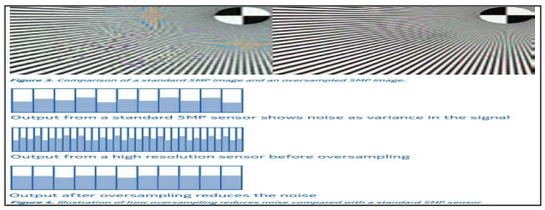


Fig. 7: Output From a High Resolution Sensor Before Oversampling

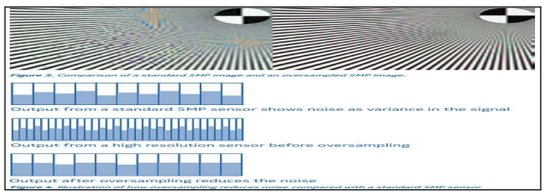


Fig. 8: Output After Oversampling Shows Reduces Noise Levels

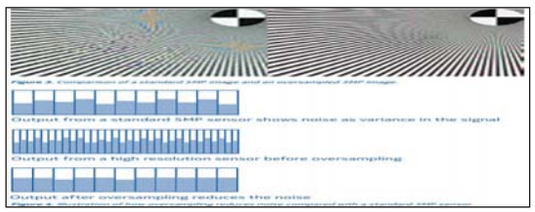


Fig. 6 through 8 show how oversampling reduces noise as compared to a normal 5 megapixel camera and ultimately leads to a clearer picture in the output.

Limitations

PureView is a technology that uses modern algorithms and better image sensors, rather than the actual assembly in any traditional camera. As the output is digitally controlled, there are always limitations in the fields where user can change the settings to get the desired output. Naturally, there is greater versatility and control in "real" cameras.

In camera systems using PureView, the user can definitely get much better zooming capabilities, but the other functions such as adjusting the ISO settings (http://www.youtube.com), adjusting the aperture and other settings are no longer in the hands of the users, and only point and shoot capabilities are left. Thus for any professional photographer, this technology might prove to be of no use. This technology is thus suitable for mobile phones to decrease the size, but not for the professional cameras, as it removes a lot of settings that are essential in professional photography.

Conclusion

Though the PureView technology is developed by Nokia, many such technologies can be developed with the pixel oversampling, interpolation, good optics, and good image sensors all integrates. With the use of PureView the only thing whose size is increased is the image sensor and not the whole camera unit. This means that the other optical sensors such as the lens etc. are kept of the same size and only the digital image sensor is increased in size. This can prove to be of great advantage in the modern smartphone era, as the image sensor is very thin compared to the optical lens, thus even on increasing the surface area of the image sensor the overall thickness of the phone would not be increased. PureView thus allows us to have more number of pixels and better image quality while at the same time keeping the size of the device small.

A special companion processor if added to the sensor that handles pixel scaling before sending the required number to the main image processor can give us no-loss zoom results. This gives us lossless zooming with the same effective viewing angle – in 35mm equivalents, it's 28mm in 4:3 aspect ratio and 26mm in 16:9. And depending on the resolution, we get a variety of zoom levels. In 5MP stills, for instance, we get around a 3xzoom. The PureView technique also helps in providing lossless zoom due to its large image sensor.

This technology is future ready as we expect faster processors and better optics at more affordable rates.

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