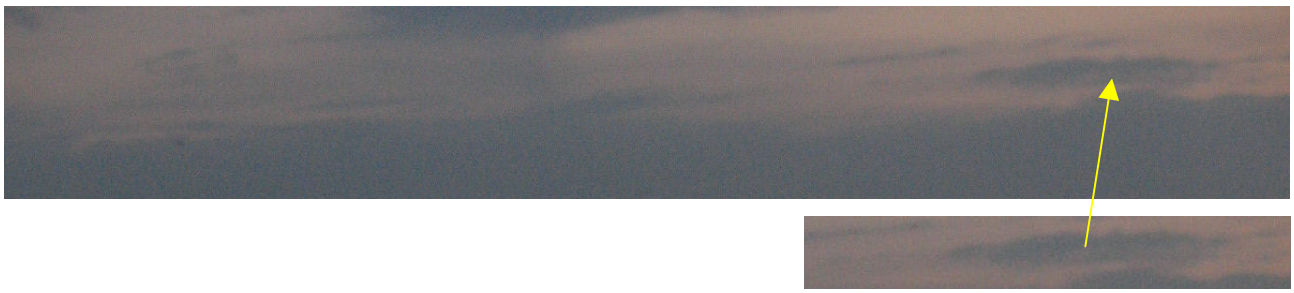
Dear our customers!

We would like to thank you a lot for purchasing our products and writing us a lot of warm and kind words about them. It pleases us to know that our products help you to get the results you really need. But right now only you know what problems with image you had and what efforts you made trying to find the right solution. You got valuable personal experience and it would be nice to share it with other customers working with image enhancement graphic editors, various plug-ins including ours. We start a new column “From the user’s personal experience” where each of you can show you pictures "before" and "after" and accompany them with a few words about what kind of annoying problem it was, what way you found for a picture improvement and what settings were optimal from your perspective. Why not to take part in such a good deed? Be an expert in image processing! It will be like Master Class from your side and heartfelt gratitude from other users will be an award to you. Please do not hesitate to join us in the column “From the user’s personal experience”. We hope you always have something valuable to say to other people. Feel free to ask any questions concerning image processing and enhancement. Any comments in this area are welcome as well.

Our first attempt to learn more about the user’s experience in image enhancement area was made this March. At that time we have launched a public opinion poll concerning what enhancement techniques people would like Photoshop plug-ins to have. Four months later the voting was closed and everyone looking at the results at http://www.imageskill.com/newsletters/news_07232007.html can notice that the noise removal problem is on the top of our voting list. May be my brief remarks below on the digital camera noise sources and experts advices on the noise reduction in a process of image capture is as good a place as any to start our new column “From the user’s personal experience”. So let us go.

1. What is digital camera noise?

Asking somebody what noise means in digital image you can get an answer that noise is something appearing in it that is absent in real scene. Look at the image below captured at sunset and at its fragment taken from the upper right corner. I doubt whether you



see something irrelevant there using zoom, say 50%. But at zoom higher than 150% (look at zoomed fragment below) foreign noise structure having nothing to do with sky and cloud becomes strongly visible.

There are two main types of such noise: chrominance noise and luminance noise. The former usually appears as small, off-colored spots or specks in the image while the latter usually appears as small, dark spots that often look like film grain. Both types of noise degrade the image quality and annoy a viewer, making image unnatural. Unfortunately noise is an essential part of the Universe that is necessarily present in any event of our life including image capture process. Technical progress can reduce its appearance too much but cannot remove noise completely. It is present everywhere in an image even if you capture it with professional camera. Zoom in an image like was done above to be certain that it is true. But doing that you can notice an amazing fact that the same noise may annoy you differently on various image contexts. It is explained by characteristic property of human visual perception when any foreign details may be easily observed on uniform tonal areas (such as blue skies and shadows) while the same ones may be practically invisible on textured areas or on edges.

2. Noise origin in digital camera.

Working with films not long ago any photographer could anticipate what noise appearance might be in image. One can decrease noise if necessary by using fine-grained films with low sensitivity or by special chemical processing. Dealing with digital camera everyone is far from certain how noise can degrade an image under given camera settings. Where is the problem? The problem is that digital imaging is a highly manipulative medium. It means that the final color image you look at the display is the result of the process of converting capturing light on a electronic sensor into the color value of the image pixels. This process includes converting photons into electrons,

amplification of the produced the electrical signal and using digital camera built-in software for transformation of electrical signal into the final color image. Any stage of such a conversion has its own forms of noise.

What are the main sources of noise in a digital camera image? They can be roughly classified as random noise (photon shot noise, dark current shot noise), fixed pattern noise (due to variations in the manufacturing of sensors, each pixel has small differences in sensitivity) and readout noise.

First of all each individual detector in the sensor referred to as a pixel (the abbreviated form of 'picture element') converting photons into electrons can produce unwanted artifacts due to the haphazard way that photons arrive at the pixel. It is so-called photon shot noise representing nature's fundamental limit on noise performance in light detection systems. Its level is defined by square root of a signal.

Another type of random noise in digital camera images is dark noise. It is defined by the electrical signal of the sensor without incoming light. This noise can be subtracted away from a captured image by taking a dark field image just before or after the actual image.

The resulting effect of random noise is equivalent to small statistical variations of color values that are observed even if the same pixel would be exposed several times by the same amount of light.

Long exposures and high temperatures cause fixed pattern noise surrounding so-called "hot pixels". This noise looks as bright or dark points in digital images. If pictures are taken under the same settings, the fixed pattern noise does not change significantly from picture to picture. There are some built-in reductions technologies canceling this noise efficiently by taking picture in absence of a signal and subtract this image from the real image.

Among other main sources of noise in digital camera images readout noise is appearing in the process of reading of electrical charges and converting them to an analog signal suitable for digitization. Readout noise is important when exposures are short, but becoming less significant as exposure increases and sky background photon noise begins to dominate.

3. How do some digital camera characteristics and settings influence on noise level?

3.1. Sensor geometrical size

The problem is that lots of consumers are fixated on megapixels assuming that a camera with more megapixels must take better pictures than one with fewer. Unfortunately it is not true. Actually an important camera factor affecting the quality of the final image is the image sensor size. When it is fixed the more megapixels sensor has the smaller individual pixel size is. In fact it increases sampling density and spatial resolution of the image produced for a given focal length lens but increases noise level and therefore reduces the actual light sensitivity. Under these constraints, there is a tradeoff between spatial resolution and light sensitivity and optimal performance can be reached with much lower megapixels than you actually have. If however you are stickler of megapixels then keep in mind that bigger sensor gives less noisy ("grainy") image. So try to choose digital camera having high size sensor. In this case you can get higher actual sensitivity.

3.2. ISO settings.

Camera's ISO settings describe the absolute light sensitivity of the camera's image sensor. They are often rated as factor of 2 such as 50, 100, 200, or 400 but go as high as 800, 1600, and even 3200 on some advanced models. The principle here is very simple – the lower ISO setting is the slower image sensor reaction to incoming light will be. It means that a photo at ISO 100 will take half as long as to reach the same level of exposure as one taken at 50 under other camera's settings being equal. Experts recommend using a lower ISO setting when capturing overly bright scenes, since it reduces the light sensitivity of the image sensor and a higher ISO setting when shooting under dimmer conditions (cloudy days, indoors, etc.) since it increases the light sensitivity of the image sensor. But everyone should know that while increasing ISO setting digital camera processor amplifies the electrical signal thus increasing equivalent noise level. Unfortunately high sensitivity and noise are inseparable when one always accompanies other. For most of consumer digital camera noise becomes visible starting with ISO 200 and higher. It means that you can forget using high ISO settings in practice even if they might be set formally in your camera. But compromise is always possible when sensitivity increasing can help you capture the scene. To learn more about actual noise level of your camera look at full size test images made under different luminance conditions and different ISO settings. You can make these experiments yourself or look at the relevant results at http://www.imaging-resource.com/MFR1.HTM?view= where various digital

cameras of different manufacturers were tested. If you are not going to do so there is only one advice how to minimize digital image noise – it is to avoid using high ISO settings.

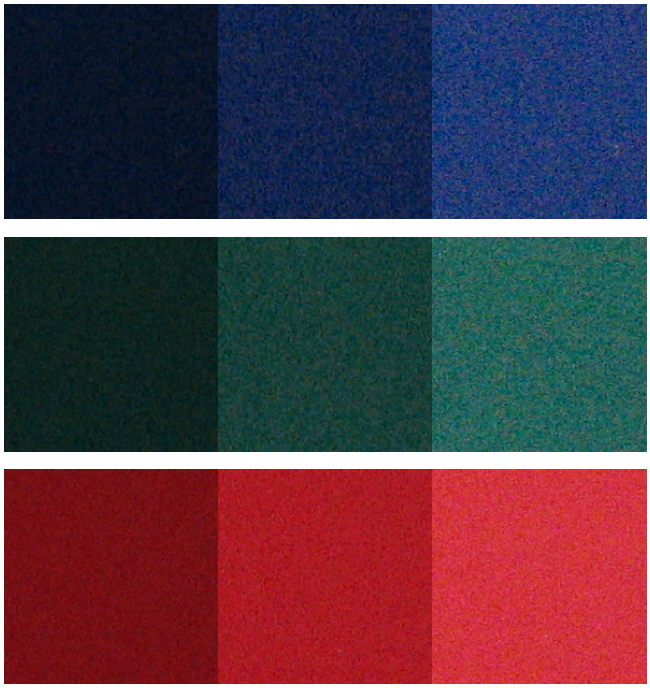
Some our examples below illustrate how ISO settings affect on noise appearance.

Canon EOS 350D (sky's fragments)

ISO 100 ISO 800 ISO 100 ISO 400

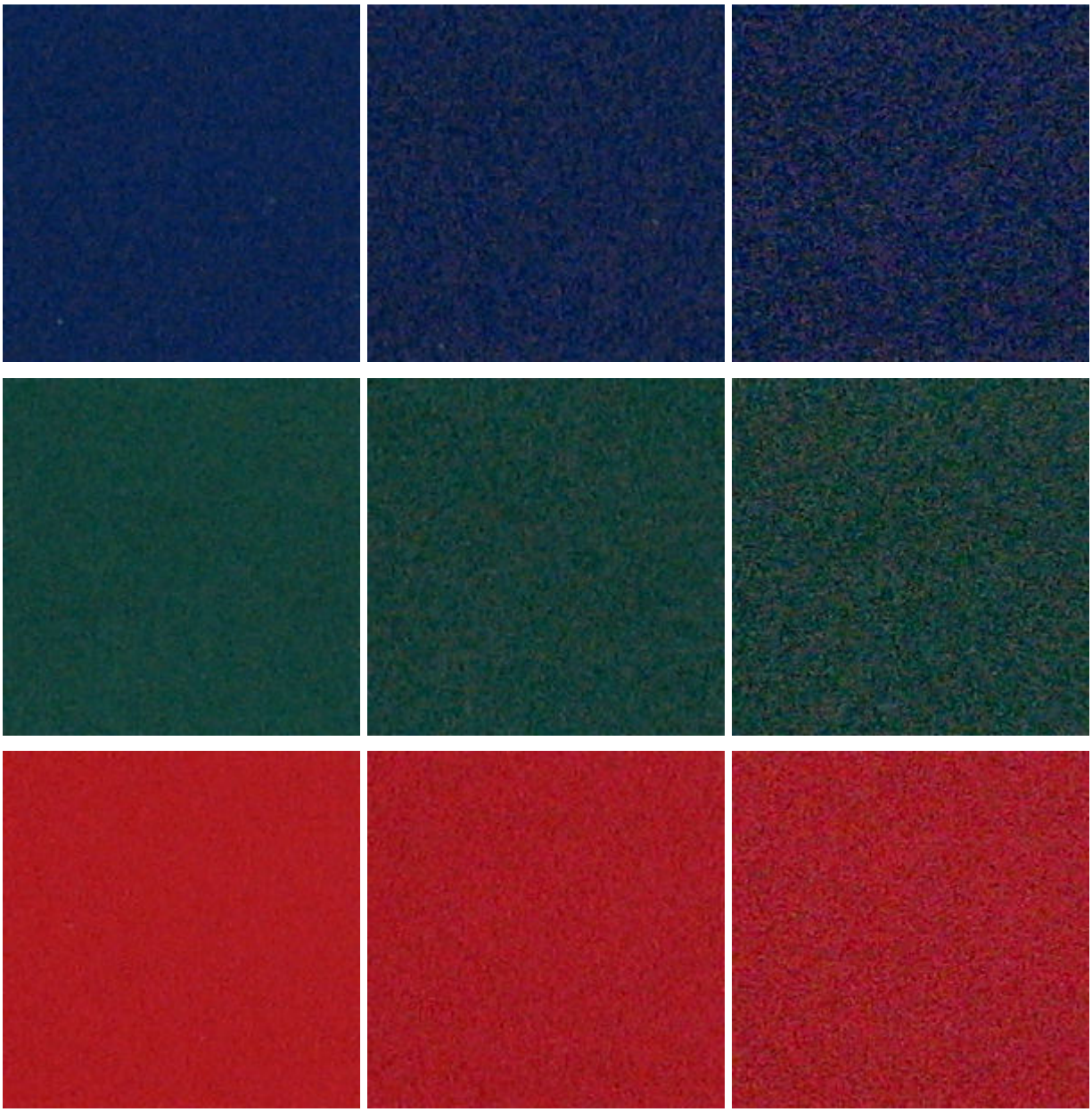
Canon Power Shot A630 (color patches)
(F number = 4, Exposure time = 1/125, EV = 11)

ISO 200 ISO 400 ISO 800



Canon Power Shot A630 (color patches)

ISO 200, EV = 10 ISO 400, EV = 11 ISO 800, EV = 12



3.3. Long exposure

Long exposures (usually 1-2 seconds or more) may lead to appearance of pattern of colored dots (slightly larger than a single pixel), often referred to as "stuck pixels" or "hot pixel" noise. But sometimes you can get noticeable noise increasing even if your exposure speed that is originally much faster is slowed. The example below illustrates such effect for digital camera Olympus C740UZ capturing test image at ISO setting of 400 and nearly the same exposure value EV of 11.

ISO = 400 (F number = 4, Exposure time = 1/125, EV = 11)

ISO = 400 (F number = 8, Exposure time = 1/30, EV = 11)

Useful hint here to prevent noise appearance is to avoid slow or long exposures.

3.4. Sensor temperature

It is known that the higher sensor temperature is the higher noise level it creates. Fortunately normal digital camera using does not mean its extra heating. But nevertheless keep your camera from external excessive heat and try more often to switch it off.

My brief remarks above do not pretend to complete the picture of noise origin in digital camera and to show how to prevent this noise increasing in the process of image capture. To everyone who is going to learn more about it I would like to advice to read an interesting tutorials concerning digital camera image noise at http://www.cambridgeincolour.com/tutorials/noise.htm
http://www.cambridgeincolour.com/tutorials/noise2.htm
and informative article at http://www.ronbigelow.com/articles/noise-1/noise-1.htm written by Ron Bigelow

To learn more about various Digital Camera characteristics visit http://www.imaging-resource.com/DIGCAM01.HTM

To everyone who is interested in noise reduction after image was captured I would like to advice to read an excellent paper of Michael Almond at http://www.michaelalmond.com/Articles/noise.htm. It deals with 22 of popular digital noise reduction tools but Michael's personal 5 hits by February 2005 are the following

1. Noise Ninja
2. Neat Image
3. Picture Cooler (PC-only)
4. Noiseware
5. Grain Surgery

Some reviews about Imagenomic Noiseware, Imagenomic Noiseware 4, Neat Image Noise Reduction, PictureCode Noise Ninja you can see at http://www.photographyreview.com/cat/digital-photography-software/noise-reduction-software/PLS_5647crx.aspx

Personally I like to work with noise removal filters designed by JascSoftware. In Jasc Paint Shop Pro 8 it was ISO Noise Removal filter and in the later versions Jasc Paint Shop Pro 9, Corel Paint Shop Pro X and XI it is called as Digital Camera Noise Removal filter. You can read a wonderful tutorial concerning this filter at http://www.jpkabala.com/PDF/DCNR.pdf written by Kris Zaklika.

Good luck.
Mikhail
ImageSkill team.