High quality photography on mobile phones

"Sorry for the quality, mobile." Almost everyone makes excuses when publishing a photo taken with a camera phone. What are the problems taking good quality pictures with camera phones and is there a way to solve them and bridge the gap between camera phones and compact cameras?

You may think there is very little difference between a cell phone camera and a point-and-shoot camera. Nowadays, mobile phone cameras have enough megapixels. The phones have enough storage capacity. Even the lens quality is not as bad as before and can compete with low-end compact cameras.

At the same time, a big gap still exists when it comes to the basis of photography – the light source. If you take pictures in daylight, you may be satisfied with the quality of mobile images. However, when you move to a less bright indoor environment, you start to notice the difference. Mobile images appear to have more noise, they are usually blurry and lack detail in shadows. Bright areas turn into pure-white spots. Faces seem unnaturally flat, especially when using a flash.

Getting into a darker environment extends the gap. While images taken with a regular camera are not very good but still do show a scene, mobile images become unacceptably blurry and show almost nothing but smeared lights and the camera's own noise.

Reality

Image blur due to unsteady grip is a significant problem for camera phones.

The reality for mobile phone imaging is:

- The size of the camera module is constrained. That means using a low-aperture lens. Very little light passes through.

- To be sure, the megapixel count is increasing. But lenses are not going to be any larger, so with more megapixels less light reaches each sensor element.
- Optical image stabilization requires additional devices such as gyros or “floating” optical devices and this is not an option due to size constraints.
- Amplification of sensor output (ISO-boost) amplifies noise proportionally.

Image blur does not appear in all shooting conditions. In fact, there is plenty of light reaching the sensor to get a perfect image in bright light / outdoors. Things change once we are under low luminance.

Solution

Almalence, Inc. has developed a **blurless exposure** technology that combines a special exposure mode and software post-processing to greatly reduce the blur effects and improve dynamic range. The majority of CMOS and CCD sensors available on the market can be “tricked” into this special exposure mode.

Blurless exposure should not be confused with multiple shot fusion techniques. Whilst it might be possible to attain similar results for hand shake blur and noise, multiple shot fusion will only make blur induced by the motion of the objects in the scene more severe. On the contrary, the proposed solution brings reduction in both blur due to hand shake and blur due to the motion of the objects in the scene.

Tests

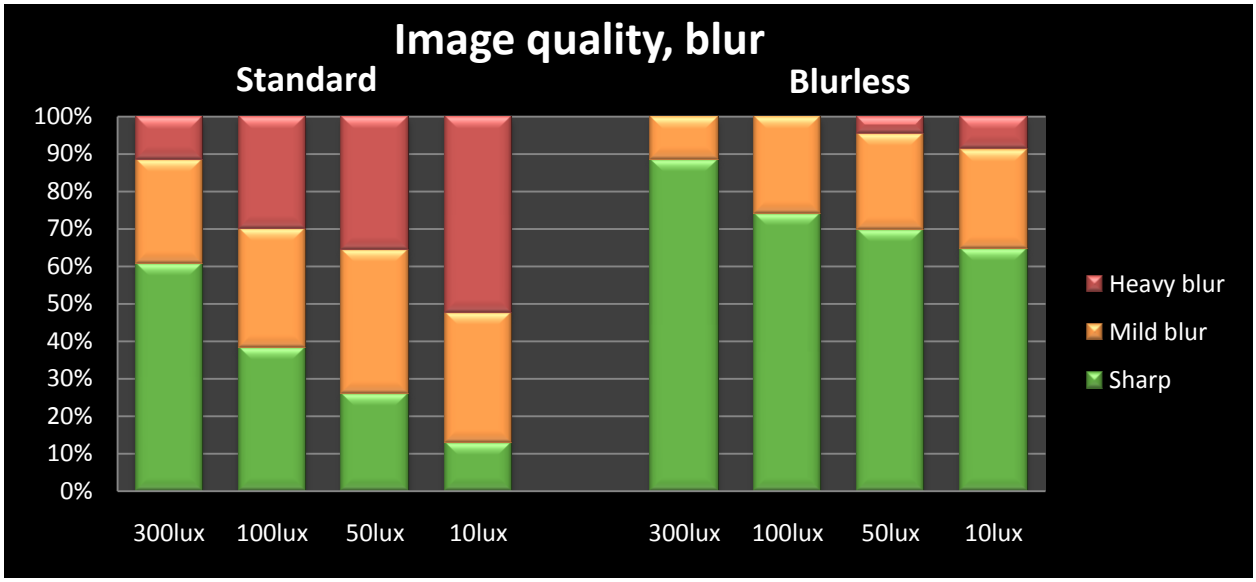
In order to objectively characterize imaging system performance in low light conditions, we have to standardize the illuminance of the test scene.

Lux – SI unit of illuminance, used in photometry as a measure of the apparent intensity of light.

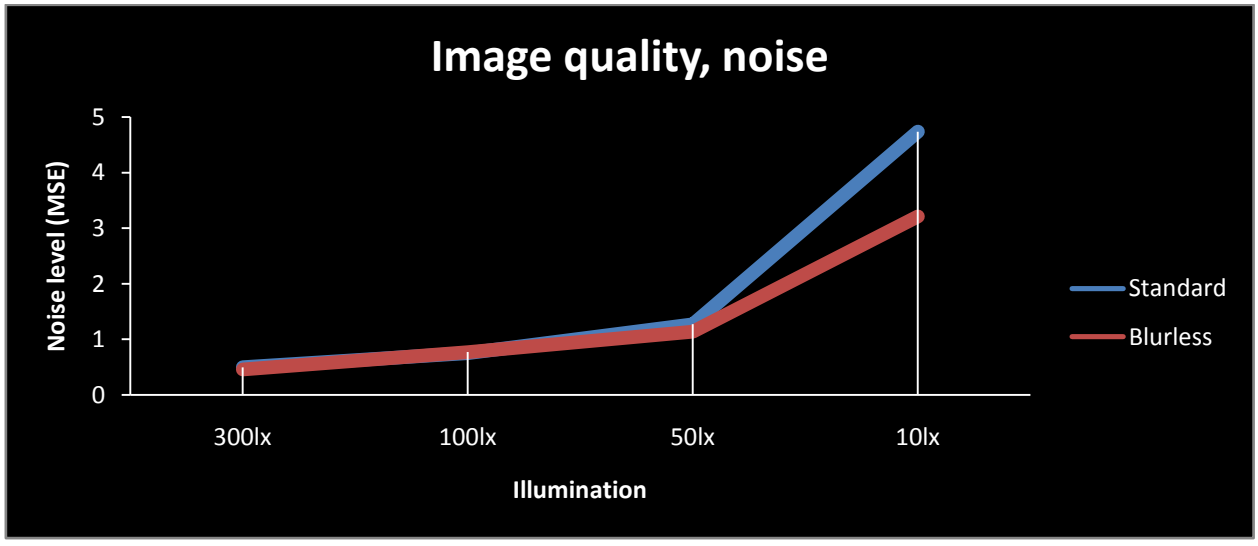
Low light conditions and reference illuminance:

Illuminance, lx	Typical conditions
320	Recommended office lighting
50-100	Living room light
50	Typical cameraphone LED flash from 1m distance
12	Typical cameraphone LED flash from 2m distance

In order to verify the solution, we ran tests for the most critical image characteristics in low light: hand shake induced motion blur and sensor noise. Tests were performed with a real 2 megapixel cameraphone. The results are summarized in two graphs on the next page.



Comparison shows a great reduction in the number of blurred images versus images taken with the usual exposure method. E.g., under 100 lux illumination, less than 40% of the shots turned sharp with usual exposure, while more than 70% did so using blurless exposure, with no heavily blurred images at all.



Noise levels are nearly the same at moderate illumination levels. In very low light (i.e., shadows or dark scenes), blurless exposure demonstrates significantly lower noise level.

Business opportunities

Blurless exposure is a technology that can be easily implemented in mobile devices with no investment in changing the hardware or production processes. Implementing this technology will give the device manufacturer a great competitive advantage by providing consumers with mobile imaging quality that was never available before.

Blurless exposure technology is available for licensing. Patent pending.

Technical characteristics

Blurless exposure is a combination of two elements: a special sensor readout mode and advanced post-processing. The latter part can be easily integrated with the usual post-processing operations (noise reduction, sharpening, etc), thereby reducing the overall image processing time.

Technical details:

- Processing speed:
  - On-screen preview: nearly instantaneous
  - Full-resolution image: 1.4 sec/mpix on OMAP 3 platform (Nokia N900, iPhone 3Gs, Motorola Droid, Palm Pre).

- Memory footprint: 4 x Sensor Megapixel count (i.e., 8 Mbytes for 2 Mpix sensor)

- Most of the sensors available on the market are suitable for this solution.

More details are available upon request.

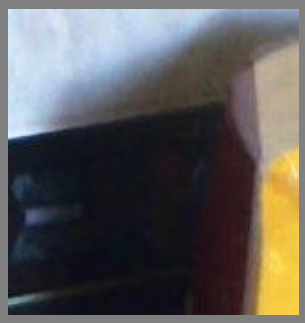
Limitations

- There is some post-processing delay before the full-resolution image becomes available to the user.

- Blurless exposure does not produce any improvements compared to standard shooting in either bright light conditions (above 1000Lux, e.g., bright sunlight) or very dark conditions (below 5Lux, e.g., moonlight).

Appendix A. Sample images

A typical shot (fragment) at 200 lux

Blur on watermelon, 100% crop	Blur and noise, 100% crop	Noise in shadows, 100% crop
		
Standard exposure	Standard exposure	Standard exposure
		
Blurless exposure	Blurless exposure	Blurless exposure

Even though average noise levels are similar, blurless exposure demonstrates a better result in shadows. An increase in dynamic range can also be seen by inspecting white tiles at the top and a dark area in the

frame. JPEG compression artifacts are seen on both images (heavy compression of the standard camera application was matched in blurless exposure samples).

Performance when motion is present in the scene:

Rotating wheel at 25 rpm, 20 lux

Standard exposure

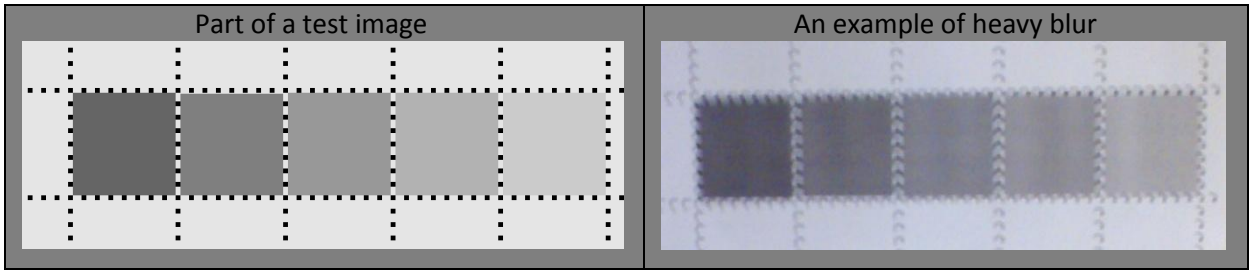
Blurless exposure

Blurless exposure is not only compensating for camera shake but also, to some degree, for motion in the scene. Better definition of the spokes is clearly visible.

Appendix B. Test methodology

- Lux measurements were obtained with a DT-1308 Light Meter.
- Testing was performed using a Linux-based Motorola A1200 cameraphone.
- Around 50 images were taken at each luminosity level using both standard A1200 bundled camera application and blurless exposure.
- To rank blur we used a method similar to that in dpreview.com (see http://www.dpreview.com/reviews/q109superzoomgroup/page12.asp).

Test image:



References

Led flash luminosity data:
http://www.ledjournal.com/images/White_Papers/Philips_Advantages%20of%20Power%20LEDs%20in%20Cameraphone%20Applications.pdf

Table of typical lux levels: http://en.wikipedia.org/wiki/Lux