Algorithms for improving image processing in mobile photography *

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1   Introduction

Today slightly every smartphone has a camera. It is very convenient, until we speak of quality of photos, captured with phone. By this article I will suggest way to improve quality by some algorithms and methods for post-processing that can be included to camera app. I choose this topic because as photograph myself, I was always unpleasant by my photos taken by phone. It maybe arranges for some people, but after seeing photos taken on beginner-class camera I struggled on insufficient quality of taken images. So, this article would add some possible solutions to the problem of poor dynamic range of photos taken with mobile devices nowadays.

2   What are possible solutions?

How can we solve problem with bad quality of photos? There are two ways: by improving hardware or improving software. But why just don't install large sensors (with big pixels in it) from the cameras to the smartphones, making a huge hardware improvement?

It all because of dimensions of the smartphones. Today it's no way that big sensors can be handled in smartphone, which width is mostly limited to 10mm. If you know how camera work, you maybe recently understand the reason why it so, and it is not the size of sensor, but the size of the lens. The sensor is not a solar panel-like device whose size determines how much light you collect. The sensor is behind the lens and in fact, the lens is the determining factor. A large diameter lens captures a lot of light. It almost doesn't matter how large the sensor is. And by installing large sensor at once we should install lens with huge focal length. This is the main issue for relatively thin smartphone.

img of camera structure

In simple words, larger sensor (with big pixels in it) will require larger optics in

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terms of aperture and focal length. This means that the body of the phone will
need to be thicker in order to provide the required distance between the lens
and the sensor.

So if we can not just increase the sensors size, we need to go in another way,
namely improve software. The biggest problem is lack of tones and colors, or
in other words, lack of dynamic range. Especially in high-contrast photos. To
understand what dynamic range is, we can imagine it as a piano keyboard.
There is a range of tones, in which we can see like piano has keyboard with
limited width, through which we can play. And the wider it is, the better. Even
human eye can not see all range at once, but sensors with big pixels in digital
cameras can because of manual exposure, so we can put exposure exactly where
we want it to be. Only the biggest and most expensive sensors can accommodate
all 12 stops (there is a 12-stop difference in the highlights and shadows). But
we are talking about matrices with small pixels, by which we want to cover all
range of tones.

The simplest decision is to combine few under- and over-exposed photo into one
frame. Doing that we create HDR photo. [1]

3   HDR photos

Yes, HDR photographs can solve the problem and make dynamic range wider.
But like every technology it has some problems.

Main problem is difference between over- and under-exposed images... Firstly
lets see some explanation (expl. 3.1), and then one more (expl. 3.2) to fully un-
derstand why is it happening.

With that knowledge in head we can conclude that main problem is difference
in images, captured in a)a different time, b)with different important settings,
such as shutter-speed. [1]

3.1   Explanation

Some fact to remember:

- Dynamic range is the range between the maximum and minimum measur-
  able light intensities.

- Combining few photos with different exposures usually creates HDR image

3.2   Explanation

How are made under/over-exposed images

- Over- and under-exposed images are made by decreasing or respectively
  increasing shutter-speed in camera.

4   Under-exposing images

Problems start with moving objects in frame. Different shutter-speed causes
the difference in frames that in turn combines into final picture. Also, over-

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[1] The speed at which the shutter of the camera closes.

exposed images has more distortion because shutter-speed is relatively slow. To remove the difference Google [5] scientists firstly changed few photos with different exposure to few underexposed ones. That helped to achieve more similar primary photos, remove photos that captured on slow shutter-speed and in this way to better merge them into one.

...But there is one more problem: several frames even on the same exposure still need some time to make. In motion, it becomes mostly impossible.

5   Burst photographs and buffer

Another possible decision from Google Research is buffer. So, at once you open the camera app, it starts to make burst photograph. [3] It keeps doing it all the time, before someone make a photo. By this way, some last photos from buffer are compare with the photo made on the moment the shutter was pressed. Then from all photographs picking the sharpest image. This approach is commonly known as lucky imaging [2].

Also, in modern smartphones there are usually more than one camera, and my suggestion is to improve the number of burst photographs by at the time of creating a shot, take images from three modules at once.

6   Conclusions

I described a system for improving quality of photo by taking few underexposed frames from buffer and then to combine them all to one image. It possibly can increase dynamic range of photo and also to produce better resolution. Also, I counted disadvantages of modern HDR technology and offered a replacement.
[4]

References

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