Using dual cameras to realize DSLR image quality and performance in smartphone

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Senior VP, Altek Corp.
Altek - High quality digital image solution
for Consumer & communication, medical and automotive customers

altek Group
Digital imaging solution provider
to first tier customers

Wearable & Camera module
Mobile Image solutions
Medical & Automotive

+ other tier I customers
Altek: One Stop Service

From image processor, ASIC design camera lens to manufacturing/assembling - We provide a variety of services to meet our customers’ demands.
Dual Camera is the Trend to enhance consumer experience in mobile phone

altek is leading the wave.
Specialty to enable huge mass production.

Honor 6+
hTC M9+
ZTE Axon

Coming more...
Dual Camera Module Structure

Asymmetric

Sub Cam 2MP

Main Cam 20MP 13MP 8MP

Symmetric (short baseline)

Symmetric (long baseline)

8MP+8MP 13MP+13MP
altek Total Depth Solution

**Reliable solution with high quality depth map**

1. Dual camera module (frame) design
2. Dual camera module production
   - Alignment / calibration / test
3. AP-side SW
   - Instant AF / Bokeh
   - Depth Engines
   - IQ tuning & balancing
   - Static/dynamic correction

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![Dual camera module design](image-url)
Dual Cam Solution using Qualcomm Snapdragon AP

Leverage QCT’s multicore, GPU and DSP to achieve dual cam features.

- Calculate depth map
- Instant AF
- Bokeh
- Fusion
- ...

Dual Cameras

Qualcomm AP
# Depth Engines

<table>
<thead>
<tr>
<th>Types of Depth Maps</th>
<th>Sparse Depth Map</th>
<th>Dense Depth Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications</td>
<td>Real-time apps,</td>
<td>High quality effects at stills, such as</td>
</tr>
<tr>
<td></td>
<td>such as Instant AF, object tracking,</td>
<td>Bokeh, segmentation, ...</td>
</tr>
<tr>
<td></td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Examples</td>
<td><img src="image1.png" alt="Example Image" /></td>
<td><img src="image2.png" alt="Example Image" /></td>
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</table>
## Type of latest High Speed AF

<table>
<thead>
<tr>
<th></th>
<th>altek Dual AF</th>
<th>PDAF</th>
<th>Laser AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting cond.</td>
<td>Wide range</td>
<td>Low light NG</td>
<td>High light NG</td>
</tr>
<tr>
<td>Subject Distance</td>
<td>Full range</td>
<td>Short &lt; 80cm</td>
<td>Short &lt; 40cm</td>
</tr>
<tr>
<td>Touch AF</td>
<td>Full frame</td>
<td>iPhone6 center only</td>
<td>Center only</td>
</tr>
<tr>
<td>AF Speed</td>
<td>&lt;200ms</td>
<td>~300ms</td>
<td>~300ms</td>
</tr>
<tr>
<td>AF Method</td>
<td>Direct</td>
<td>Hybrid</td>
<td>Hybrid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Must fine search</td>
<td>Must fine search</td>
</tr>
</tbody>
</table>
DSLR Optical-like Depth-of-Field Effect

Smart Phone altek Bokeh

DSLR Canon 5D Mark II
21MP (Full frame), F1.8 50mm
Smart Phone vs. DSLR Image

Smart Phone 28mm F2.0 (original)
Smart Phone 28mm F2.0 (dual cam)
DSLR 50mm F1.8
Module Reliability is the key issue
(Required for Volume Production)
(1) Alignment (Production)
(2) Mechanical Strength (HW)
(3) Dynamic Deform Correction (SW)

<table>
<thead>
<tr>
<th>Dir.</th>
<th>Alignment</th>
<th>Mechanical Reliability (after drop/tumble test)*</th>
<th>Capability of Dynamic correction</th>
<th>Field Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx</td>
<td>&lt; 0.2°</td>
<td>&lt;1°</td>
<td>1.5°</td>
<td>Good</td>
</tr>
<tr>
<td>Ry</td>
<td>&lt; 0.2°</td>
<td>&lt; 1.5° ~ 1.7°</td>
<td>3.0°</td>
<td>Good</td>
</tr>
<tr>
<td>Rz</td>
<td>&lt; 0.2°</td>
<td>&lt;1°</td>
<td>1.5°</td>
<td>Good</td>
</tr>
</tbody>
</table>

*Test criterion:
- Drop test: 160cm/15 drops (1drop@6face + 1 Front and 2 drops @4 corners)
- Tumble test: 100cm/50 cycles (100 drops)
Scene - Low Light Environment (1/2)

Dynamic Correction

Depth Map after drop without Deform correction

Depth Map after drop with Deform correction
Scene - Low Light Environment (2/2)

Dynamic Correction

Wrongly blur the main object due to depth error (without Deform correction)
Next ...
Symmetric Color + Mono
Capture more signal information while keeping phone thickness.

Symmetric Dual camera

- Same slim form factor
- Enhance image quality

13MP Color

13MP Mono

Camera bump : NG
21MP, 1.55um? How?
Breakthrough Camera

*Slim “21MP 1.55um” (Equivalent)*

- Slim *(Module height ~4.3mm, 1/3” sensor)*
- High resolution *(Equivalent to 21MPixel Bayer)*
- Low light performance *(Equivalent to ~1.55um pixel)*
- High dynamic range *(2X wide light range)*
- Fast instant AF *(<200ms, even at low light)*
- Bokeh *(Emulate shallow depth of field)*
The Nature of Bayer and Mono Camera

- Higher Sensitivity
- More Detail
- Keep Depth-based Apps

Color/Bayer

SNR 27.5 dB
SNR 40.4 dB

Mono

SNR 28.7 dB
SNR 43.2 dB

Color

Mono

More Light (Less gain)
Less Light (Higher gain)

Color Photosite
Monochrome Photosite
The Nature of Bayer and Mono Camera

- Higher Sensitivity
- More Detail
- Keep Depth-based Apps

Color/Bayer vs Mono

<table>
<thead>
<tr>
<th>SNR</th>
<th>Color</th>
<th>Mono</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.3  dB</td>
<td>SNR 27.5 dB</td>
<td>SNR 28.7 dB</td>
</tr>
<tr>
<td>22.9  dB</td>
<td>SNR 22.9 dB</td>
<td>SNR 43.2 dB</td>
</tr>
<tr>
<td>40.4  dB</td>
<td>SNR 40.4 dB</td>
<td>SNR 43.2 dB</td>
</tr>
</tbody>
</table>

Less Light (Higher gain)
More Light (Less gain)
Quality Evaluation (V0.40)
Resolution Evaluation (1/2)

ISO12233 Chart ISO100

Sony Z3 Phone w 20.7M Sensor

altek 13 Mono+13 Color Fusion
Resolution Evaluation (2/2)

ISO12233 Chart ISO100

Sony Z3 Phone w 20.7M Sensor

altek 13 Mono+13 Color Fusion
Noise Evaluation (1/2)

24-Color Chart and ISO12233 Chart at ISO800

13 Color

altek 13 Mono+13 Color Fusion
Noise Evaluation (2/2)

24-Color Chart and ISO12233 Chart at ISO800

13 Color

altek 13 Mono+13 Color Fusion
The Fusion of Mono and Color Image

1. No Bayer pattern, higher resolution
2. No color filter, high sensitivity, better noise performance

Using **mono image as base** to do fusion,
Take advantage of high resolution and lower noise
Scene#1  1/2
Image Overview (~3 Lux)

- Auto mode
- ISO 4800
- Exposure time 1/11s
- F 2.0
Scene#1 2/2

Better Noise level and Details
Scene#2 1/4

Image Overview (Deep low light ~0.2 Lux)

- Auto mode
- ISO 2400
- Exposure time 1/11s
- F 2.0

Fused Result
Scene#2 2/4

Color Image  Fused Image  Mono Image

Vivid Color & Brighter
Scene#2 3/4

The detail is much better
Scene#2 4/4

1. Color lose
2. No text

Vivid Color & Brighter
**HDR**

*come form color & mono sensor* *(260Lux vs. 1800Lux)*

- Auto mode
- ISO 100
- Exposure time 1/165s
- F 2.0

Fused Result
**HDR**

*come form color & mono sensor*
The End

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