Theory & Practice of

Close-Up

3D Photography

By George Themelis

NSA/ISU - 2019
Outline

• What is a close-up?

• Theory
  - Close-up in 2D (magnification)
  - Close-up in 3D (stereo base, deviation)

• Equipment & Techniques
What is A Close-up?
Which is a close-up?
<table>
<thead>
<tr>
<th><strong>Distant</strong></th>
<th>![Distant Image]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(has infinity)</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th><strong>Close-up</strong></th>
<th>![Close-up Image]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Macro</strong></th>
<th>![Macro Image]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(M &gt; 1)</td>
<td></td>
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</tbody>
</table>
Question:

Do you need to get close to your subject to take a close-up?
**Answer:**

Not necessarily, you can stay far back and zoom in (and/or crop to enlarge the picture)

With digital photography this is easier to do today and it is done a lot in certain areas of photography, for example Nature Photography

A close-up will be defined by the size of the object photographed (magnification), unrelated to the distance to the subject
**Magnification**

\[ M = \frac{\text{Size of Image}}{\text{Size of Object}} \]

**Size of Image - Where?**

- On film / sensor
- On camera’s screen
- On computer display
- In projection

**Technically, on film/sensor**

A macro lens capable of 1x magnification, produces an image on the sensor that has the same size as the object.

A practical solution around this ambiguity is to assume a “full frame” (24x36mm) sensor.

Size of Object = 240mm
Size of Image = 24mm

Magnification = 24/240 = 1:10
Magnification

Relationship between:
- Image Size
- Object Size
- Distance
- Focal Length
- Magnification

What is known here:
- Image size = 36mm
- Focal Length = 400mm
- Distance (measured) = 4.5m

We can calculate:
- Magnification = 1:11 = 0.09x
- Object Size = 405mm
What is the Magnification here?

We know:
Distance to the subject = 4.5m
Object size = 75mm

We assume: that the image is recorded on a full frame sensor, so the vertical image size is 24mm

\[ M = \frac{\text{Image Size}}{\text{Object Size}} = \frac{24\text{mm}}{75\text{mm}} \]

\[ M \sim 1:3 = 0.33x \]

We can now calculate the “equivalent focal length” = the focal length that a full frame camera would use to get the same vertical field of view

\[ M = \frac{\text{EF}}{I} \]

\[ \text{EF} \sim 1400\text{mm} \]

“Full Frame” Assumption” This picture was recorded with on a full frame (24x36mm) sensor, so the vertical height is 24mm.

This picture appears as if it was recorded on a full frame sensor (24x36mm) using a lens of 1400mm focal length
What is a close-up?

**Traditional Distant 3D photography:** Normal photography when the near object is at 2.1m from the camera.

Using a 35mm FL lens, standing 2.1m from the subject gives a vertical field of view of 1.5m, or a magnification of 24/1500 ~ 1/60

**Traditional Definition of Macro:** Anything with magnification of 1:1 or larger (or object size 24mm in height or smaller)
**Objective:**

Adjust F & I to get an appropriate image size (magnification)

**Technical challenges:** Focus close

<table>
<thead>
<tr>
<th>Recording Variables</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal Length (F)</td>
<td>Image Size (magnification)</td>
</tr>
<tr>
<td>Distance (I)</td>
<td></td>
</tr>
</tbody>
</table>
Close-ups in 3D

<table>
<thead>
<tr>
<th>Recording Variable</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stereo Base (B)</td>
<td>Stereoscopic Deviation (P)</td>
</tr>
</tbody>
</table>

Objective:

Keep the stereoscopic deviation under control

Adjust the stereo base / distance to get a decent (not too small, not excessive) amount of stereoscopic deviation
Both the Stereo Base (B) and distance (I) are very important in 3D photography, but it is the ratio of B/I that determines the amount of depth in the picture.

For distant 3D photography traditionally a *ratio of 1/30* is recommended.

Through trial and error, I have found that a *depth ratio of about 1/20* works well for close-ups.
Stereoscopic Deviation in Close-ups

\[ M \times D \times t \]

**Object Thickness**
Or depth range, distance from the front to the back

**Magnification**

**Depth Ratio**

<table>
<thead>
<tr>
<th>Type of picture</th>
<th>Recommended $D = B/I$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distant</td>
<td>1/30</td>
</tr>
<tr>
<td>Close-Up</td>
<td>~ 1/20-1/30</td>
</tr>
</tbody>
</table>
# Summary of Equipment for Close-Up

<table>
<thead>
<tr>
<th>Method</th>
<th>B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stereo camera</td>
<td>50-75mm</td>
<td>x</td>
</tr>
<tr>
<td>2. Close-up stereo camera</td>
<td>20-40mm</td>
<td>x</td>
</tr>
<tr>
<td>3. Stereo Camera + attachment</td>
<td>~30mm</td>
<td>x</td>
</tr>
<tr>
<td>4. 3D lens</td>
<td>10-15mm</td>
<td>x</td>
</tr>
<tr>
<td>5. Two cameras &amp; mirror (Macrobox)</td>
<td>0-50mm</td>
<td>X</td>
</tr>
<tr>
<td>6. Twin cameras + long lenses</td>
<td>100-150mm</td>
<td>X</td>
</tr>
<tr>
<td>0. Single camera and shift</td>
<td>0-inf</td>
<td>X</td>
</tr>
</tbody>
</table>
One camera & shift

- A **single camera** is perhaps the **easiest** and **least expensive** way to take close-up/macros
- Take one picture, shift the camera, take another picture, done!

**Advantage:** Flexible stereo base

**Drawback:** For stationary objects only

**Starting recommendation for Stereo Base:**
\(~ 1/20-1/30 \times \text{Distance to Nearest Object}~

Slide Bar or free held? With digital and SPM, free hand is OK
Converge or not? It is OK to converge to save image width
Flash? Do not shift flash if shadows are formed
1. Standard 3D Camera

A standard 3D camera (B~55-75mm) can be used for close-ups **if the background is blocked**. Instead of coming closer, it is better to:

**Stay back and zoom-in**

*Every time you double the distance and zoom-in (to maintain the same magnification - image size) the deviation is reduced by half*

*provided that the background is blocked*

\[ p = M D t \]
2. Close-up camera

Variety of 3D video cameras and phones, etc.

20 - 30 mm
Panasonic Lumix 3D1

Panasonic Lumix 3D1 at a Glance - Positives & Negatives

+ Good image quality
+ Well-aligned images
+ Image stabilization
+ Wide angle focal length
+ Well-suited for close-ups
+ Good battery performance
+ Compact & easy to use

- Limited exposure control
- No ISO adjustment
- No ability to turn flash on
- Flash between lenses
- Narrow base for general 3D
- No 3D display
3. Stereo Camera & Attachment

- Attachments use **mirrors** or **prisms** to allow stereo cameras to take close-up or macro pictures.

- These attachments redirect the light and effectively **reduce the spacing of the recording lenses**.

Two examples include:

- **Cyclopital 3D attachment** for the Fuji 3D camera

- **RBT macro attachment** for RBT cameras
4. Stereo Lens (B ~10-15mm)

One camera lens with two lenses, records side-by-side stereo images that share the same film / sensor area.
Panasonic 3D Lens

- **Micro 4/3 mount lens**
  Produces a 3d (MPO) file in certain (all recent) micro 4/3 cameras by Panasonic and Olympus

- **Two lenses, 10mm apart**

- **12.5mm FL, f12 fixed aperture, fixed focus**
  (Range: 0.6m-INF, estimated focus at 0.9m)

- **Not good for general 3D photography**
  (D = B/l = 1/90, extremely weak depth)

- **Very good for macros thanks to its very short lens spacing, but it needs to be modified to focus closer**
## Panasonic 3D Lens Modification

### Modifications to focus closer (increase magnification)

<table>
<thead>
<tr>
<th>Extension</th>
<th><img src="image1.png" alt="Extension Image" /> <img src="image2.png" alt="Extension Image" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>Close-up Lenses</td>
<td><img src="image3.png" alt="Close-up Image" /> <img src="image4.png" alt="Close-up Image" /></td>
</tr>
</tbody>
</table>
Panasonic 3D Lens & CU lenses

1. Velcro
2. Reverse adapter rig
3. Special attachment
### Advantages

- Convenience
- Portability
- Reliability

### Disadvantages

- Not Flexible
- Lower resolution

<table>
<thead>
<tr>
<th>Depth</th>
<th>Extension</th>
<th>Washers 0.5mm</th>
<th>Washers 0.8mm</th>
<th>Distance from Camera Back</th>
<th>Distance from Lens</th>
<th>Conv Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weak</td>
<td>0 (as is)</td>
<td>0</td>
<td>0</td>
<td>~36 inches</td>
<td>~900mm</td>
<td>1/90</td>
</tr>
<tr>
<td></td>
<td>0.5mm</td>
<td>1</td>
<td>0</td>
<td>12 inches</td>
<td>10&quot; (250mm)</td>
<td>1/25</td>
</tr>
<tr>
<td>Good</td>
<td>0.8mm</td>
<td>0</td>
<td>1</td>
<td>10 inches</td>
<td>8&quot; (200mm)</td>
<td>1/20</td>
</tr>
<tr>
<td></td>
<td>1.0mm</td>
<td>2</td>
<td>0</td>
<td>8 inches</td>
<td>6&quot; (150mm)</td>
<td>1/15</td>
</tr>
<tr>
<td></td>
<td>1.3mm</td>
<td>1</td>
<td>1</td>
<td>6 inches</td>
<td>4&quot; (100mm)</td>
<td>1/10</td>
</tr>
<tr>
<td>Strong</td>
<td>1.6mm</td>
<td>0</td>
<td>2</td>
<td>5.5 inches</td>
<td>3.5&quot; (90mm)</td>
<td>1/9</td>
</tr>
<tr>
<td></td>
<td>2.4mm</td>
<td>0</td>
<td>3</td>
<td>4.3 inches</td>
<td>2.3&quot; (60mm)</td>
<td>1/6</td>
</tr>
</tbody>
</table>
USE of FLASH in Macro

1. Freezes Motion
2. Allows using small f-stops
3. Darkens Background
4. Consistent Light

1) The position of the light can affect the character of the picture.
2) Front even lighting is the least exciting but it shows the most details, without distractions.
3) Side-lighting can create shadows, adding drama to the picture.
4) Back-lighting can bring up interesting details that are missed with front lighting.
5) Experiment with the position of the flash. Different subjects work better with different directions of light. It is not a one size fits all.
6) Having a flash with flexible arms or using two (or more) flash units that can be positioned independently, is the best way to experiment with different flash/light placement.
5. Two cameras & mirror

Macrobox for Canon SDM cameras—Features:

- Adjustable stereo base from 0mm to 50mm
- Filter threads in cover allows to use filters
- High-quality half mirror w/ anti reflex coating
- Made out of lightweight but stable plastic
- Cost ~ 450 Euros

http://www.digi-dat.de/
Traditional Close-up/Macro 3D Photography:
Reduce the distance to the subject and the stereo base

Jacobus G. Ferwerda
(1910-1990)
Increase F, I, B. Keep the same ratios of F/I (Magnification) and B/I (Depth ratio).

Reduce I (distance) & B (stereo base) using moderate F.
Similarity Principle

You can take a close-up with:
Normal/wide lenses by getting closer (I)
Longer lenses from a longer distance (II)

Pictures that have:

- **Same magnification** \(M = F/I\)
- **Same depth ratio** \(D = B/I\)

**Look surprisingly similar** *

if the background is blocked

* Similar = same size, same stereoscopic deviation but different perspective (ratio of size of near to far object)
6. Twin cameras & Long lenses

Panasonic bottom-to-bottom w/ Olympus lenses 75mm lenses

Samsung side-by-side w/ 500mm mirror lenses

Panasonic TZ80 (24-720mm) side-by-side

Panasonic FZ2500 (24-480mm) bottom to bottom (left) and top-to-top (right)

Canon 6D with 100-400mm lenses top-to-top
# Choice of Cameras

**Requirements:**
- Reasonable Synchronization
- Long focal length (> 300mm)

<table>
<thead>
<tr>
<th>Camera Type</th>
<th>Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compact Travel superzoom</strong></td>
<td>Small sensor Compact size Long zoom</td>
<td>Panasonic TZ70/80 (24-720mm) wired by Tendam <a href="https://www.tendam3dequipment.com/">https://www.tendam3dequipment.com/</a></td>
</tr>
<tr>
<td><strong>Bridge Superzoom</strong></td>
<td>Small/medium sensor Fixed lenses/long zoom Good quality</td>
<td>Panasonic FZ2500, 24-480mm (1”) Sony RX10, 24-600mm, 1” sensor Nikon P series (P1000, 24-3000!)</td>
</tr>
<tr>
<td><strong>Interchangeable Lenses</strong></td>
<td>Medium/Large sensor DSLR / mirrorless</td>
<td>Panasonic/Olympus M4/3 cameras Canon DSLR, Nikon, Sony, etc</td>
</tr>
</tbody>
</table>
Issues when using Long FL Lenses

Alignment & Focus

Vertical Alignment

Horizontal Alignment

If the cameras are pointed parallel, there will be partial Image Loss \((= M \times B)\) The lenses must converge!
Different Camera Mounting Configurations

1. Horizontal (side-by-side)
   - Works ok for smaller cameras
   - Flexible stereo base for hypers
   - Not easy to use w/ large cameras on the field

2. Vertical
   - Portable - can be held with a grip or monopod
   - Easier Vertical Alignment
   - Easy to convergence
   - Smaller stereo base
   - Top-to-top: Use VF for 3D viewing
   - Vertical orientation not best for 3D
Viewing in 3D

The holy grail of 3D photography?
well… one of them!

It’s like using a Giant pair of binoculars

- See a clear & sharp 3D image under ambient light, including full sun
- Can tell if the cameras are aligned (zooms matched, vertical alignment)
- Can see & set the stereo window by adjusting the convergence
- Can see the 3D composition & move around to improve it
- Can see the effect of the background & move around to eliminate distractions
- Improved ratio of good pictures & reduced time in post processing
- Preview the picture taken in 3D (true for mirrorless cameras, not DSLR)

Note: To compose the image in 3D the stereo base has to be fixed (around 6” or 150mm with most larger cameras). One can increase the stereo base but will not be able to compose in 3D, but can always return the cameras back to 6” to preview the recorded image in 3D
**Twin cameras with long lenses**
(lenses 300mm or longer)

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large distance to subject</td>
<td>Large, heavy, expensive</td>
</tr>
<tr>
<td>Modern Features (Stabilization)</td>
<td>Alignment is critical</td>
</tr>
<tr>
<td>DOF (throw BG &amp; FG out of focus)</td>
<td>Focus is critical</td>
</tr>
<tr>
<td>Possibility of 3D Viewfinder</td>
<td>Synchronization issues</td>
</tr>
<tr>
<td>General Purpose Cameras</td>
<td>Perspective distortions</td>
</tr>
</tbody>
</table>

**Bottom Line:** One can take pictures (example: nature action shots) that are impossible with any other method, and still use the cameras for other types of photography.
Panasonic FZ2500

Distance ~ 2m  (D ~ 1/15)

EF = 480mm

Red Milkweed Beetle

EF ~ 1500mm
Perspective Distortions

Due to the large distance to the subject

Cardboard Cutout
(depth distortion)

Size Distortion
Perspective Distortion #1

Cardboard Cutout (depth distortion)

The stereo picture appears as if it is composed of cardboard cutouts instead of real objects.

This happens because there is no sufficient depth within individual subjects vs. the overall depth in the scene.

Can be reduced by increasing the stereo base or changing the composition.
Size Distortion

Object farther away appear larger in size

This happens because objects have similar image sizes since they are photographed for a large distance (reduced perspective).

The brain expects the object far away to appear smaller. Because it is not smaller, the brain sees it as larger in size.
Perspective Distortions

Due to the large distance to the subject

**Cardboard Cutout**
(depth distortion)

The stereo picture appears as if it is composed of cardboard cutouts instead of real objects

**Size Distortion**

Object farther away appear larger in size

---

**Good News!**

Both distortions are minimized in close-ups (i.e. when photographing objects with limited depth range)
Perspective Distortions
Due to the large distance to the subject

More Good News!
You might like them !!
Summary

• **Close-up**: Magnification = 1:60 to 1:1 (object size 1 to 60 inches). Anything larger is a distant shot, anything smaller is macro, which has its own challenges.

• **Close-up in 2D**: \( M = \frac{\text{Image size}}{\text{object size}} = \frac{\text{Focal Length}}{\text{Distance}} \). Assuming a full size sensor, Image Size = 24mm, \( F = \text{Equivalent Focal Length} \). If you know 2 out of 3 variables, you can calculate the third.

• **Close-up in 3D**: The ratio of Stereo Base / Distance (Depth Ratio), determines the amount of depth. Recommended value for close ups: 1/20-1/30.

• **Similarity**: 3D pictures with same Magnification (image size) and Depth Ratio, look similar provided that the background is blocked. Traditionally, close-ups are taken by getting closer and reducing the stereo base. An alternative is to stay back and zoom in and keep the same stereo base or even increase it.

• There are various equipment used for close-ups. For starters one can use a **single camera** or a **stereo camera** (stay back and zoom in). The **Panasonic 3D1** (B=30mm) is a fine close up stereo camera and the **Panasonic 3D lens** (B=10mm) is an inexpensive way to experiment with close ups.

• **Twin cameras with long lenses** can be used for close-ups from a longer distance mainly for nature 3D photography. Bridge cameras make a good candidate for such pair. When configured top-to-top, one can use both view-finders for 3D composing, like using binoculars.
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