Image processing from X-Ray 1D and 2D Lobster eye optics

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Introduction

Precise X-Ray telescopes usually have Wolter type optics. Their disadvantage is narrow field of view – up to 1 deg. Another type of X-Ray optics is Lobster Eye (LE). It has wider field of view (up to 360 deg.) suitable for all sky monitoring. Lobster Eye optics can have different arrangements - Angel‘s or Schmidt‘s (two-dimensional) or it is possible to have only one-dimensional optics (vertical or horizontal type). Single 1D optics cannot display real image, but combination of vertical and horizontal type and post processing can create 2D image. Another complication during the image reconstruction is having multiple objects in the picture. Result of this process is power of objects number.

1D vs. 2D optics – Schmidt‘s arrangements

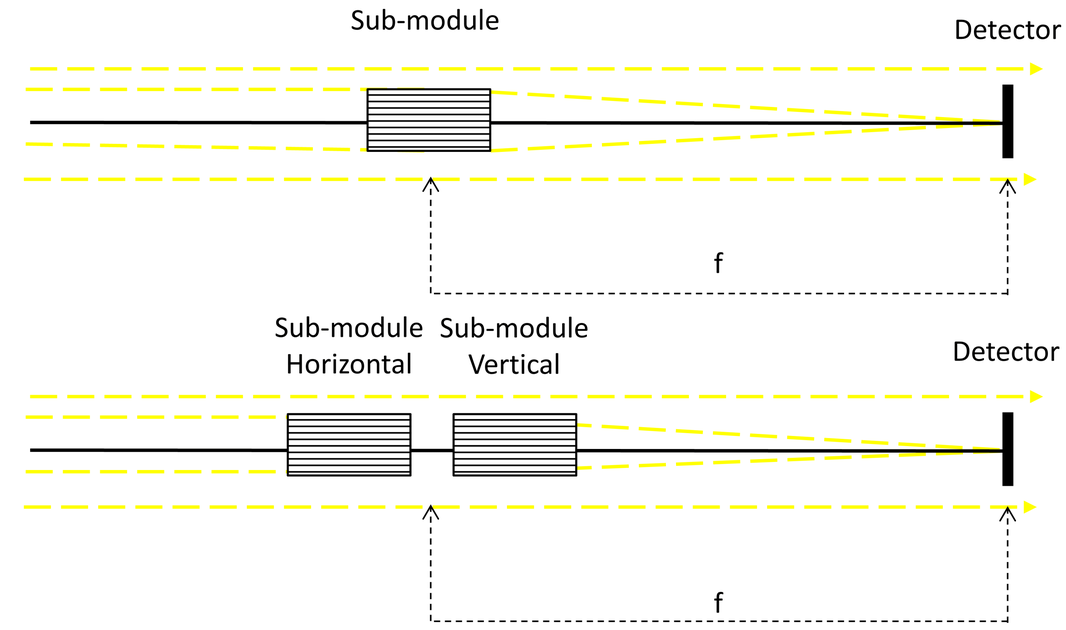


Fig. 1: Arrangement comparison of 1D (top image) and 2D (bottom image) LE optics

1D optics (top image) have lower losses of incoming rays because of only one reflection, but it is necessary to take two pictures for full image reconstruction compared to 2D Schmidt‘s arrangement which is in the bottom image.
Tested optics have aperture of 54x54 mm2 with focal length 1380 mm for horizontal sub-module and 1117 mm for vertical sub-module.

Taken images taken from optical bench

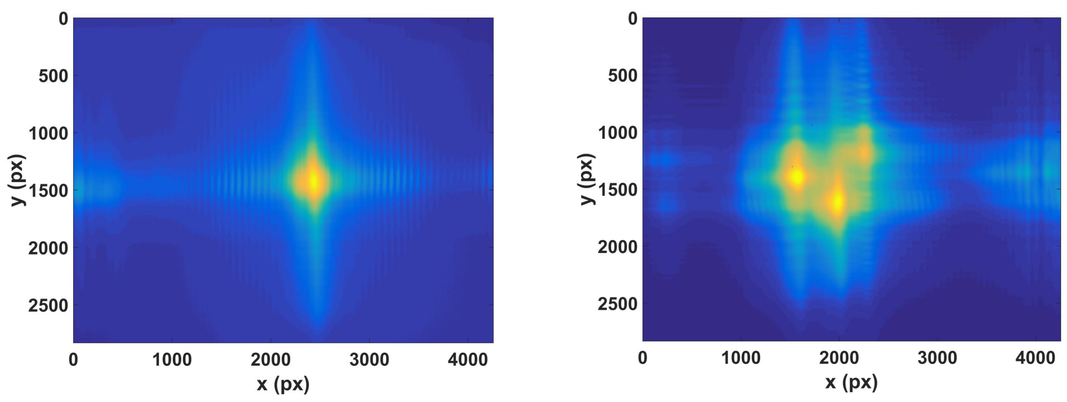


Fig. 2: Pictures taken with one (left) and three (right) sources in visible spectrum by the full frame camera with 2D LE optics

These pictures were taken with Lobster Eye optics in the Schmidt‘s arrangement on optical bench with one source (object) and with three. In this arrangement, it is not a problem to identify the number of objects, if they are so far to each other. The cost of this benefit is efficiency losses because of the second reflection.

Image processing results from two 1D LE optics

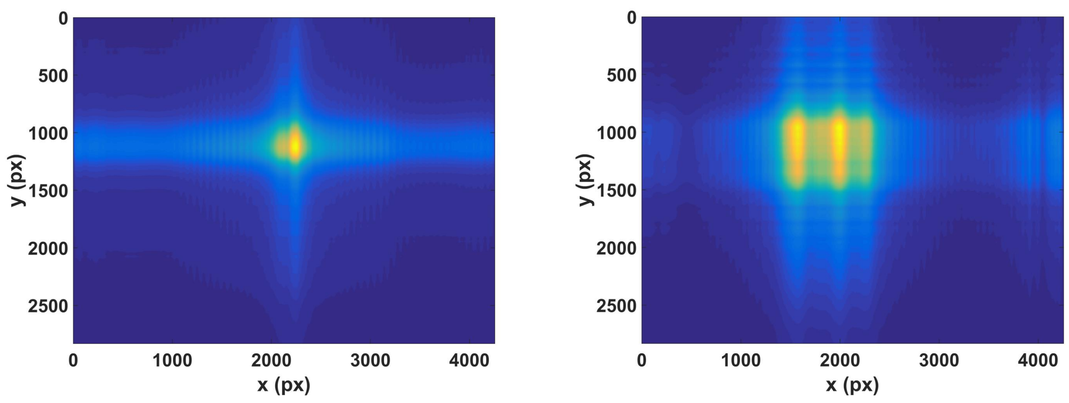


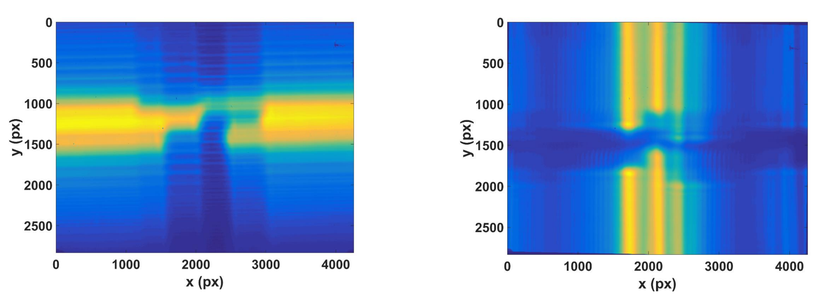
Fig. 3: Reconstructed pictures from horizontal and vertical images and processed into final image with one source (left) and three (right) sources in visible spectrum

Comparison of reconstructed images and taken 2D images where there is only one source, result is almost the same but with three objects in the picture there is a problem with virtual objects. In this case there are nine objects in total and it is necessary to identify which one is virtual and which one is real.

Conclusion

Method how to identify multiple object from two 1D images can be:

- The separation of each line and then reconstruction as one-line focus
- Using code mask and based on shades identify the right source as shown in the pictures (horizontal and vertical)



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