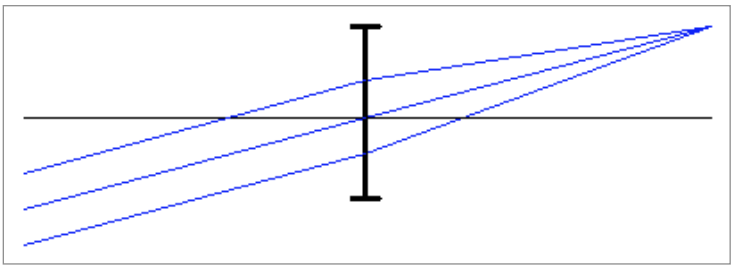
Q: What is Distortion?

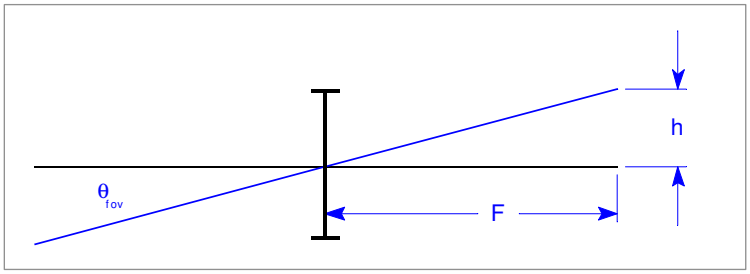
And what is the difference between local distortion and global distortion?

A:

Consider an idealized lens, as sketched below:



As a further simplification, consider only the chief ray (the ray through the center of the pupil).

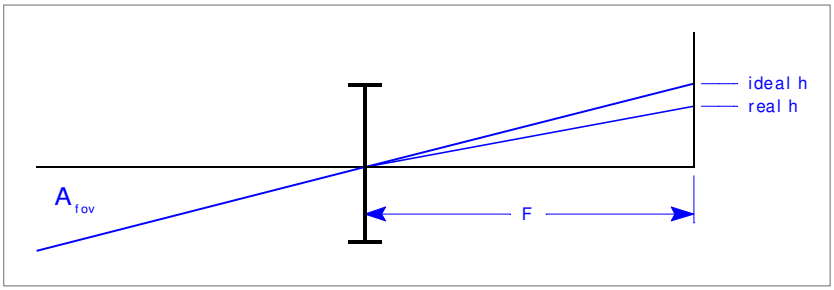


In an ideal lens, there is no distortion, and the height of a point on the image is simply:

$$h = F \tan(A)$$

Distortion

However, in a real lens the image point "h" may differ from this idealized view. For example, consider this situation:

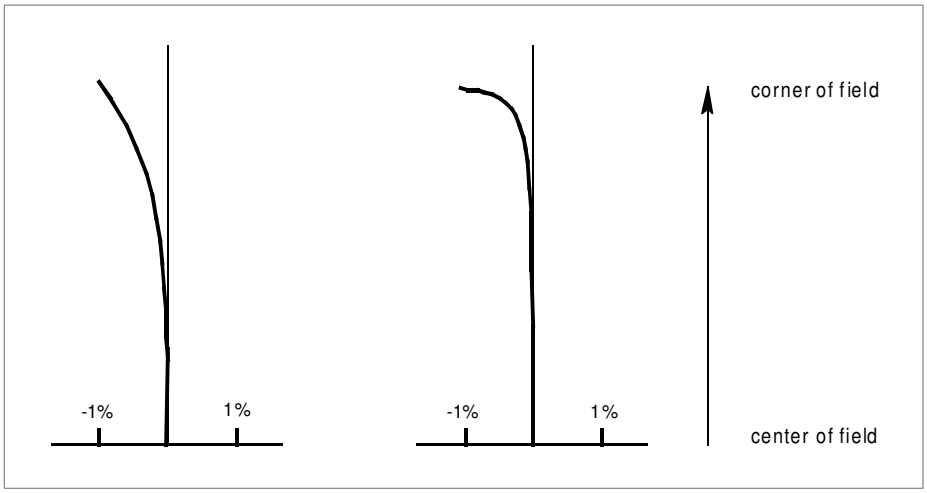


The height t of the point "ideal h" is F tan (A). The height of the point "real h" is different. Such a lens is said to have distortion.

Distortion is defined as:

(real h - ideal h) / ideal h

Here are two possible distortion plots:



Both lenses have about 1% distortion, a value that is normally acceptable, even in visual instruments like cameras.

Local distortion:

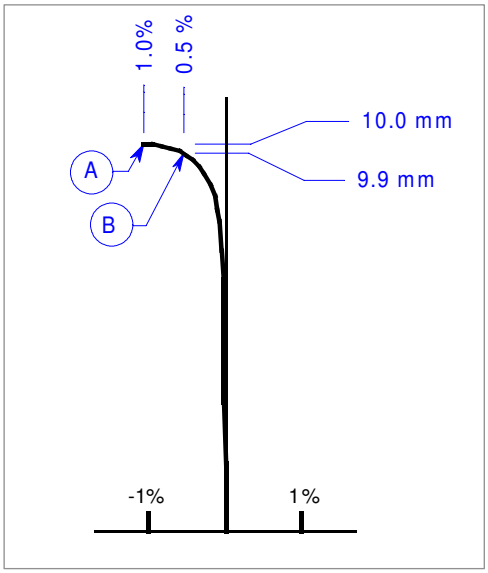
Besides the absolute value of distortion, it is also important to consider the local slope of the distortion curve. Consider the two curves above. The lens on the right has a problem at the edge of the field.

A numerical example may clarify the problem:
Without distortion the height of points A and B would be 10 mm and 9.9 mm respectively.

With distortion, the heights are

hA = 10 mm x (1 – 1.0%) = 9.9 mm
hB = 9.9 mm x (1 - 0.5 %) = 9.85 mm

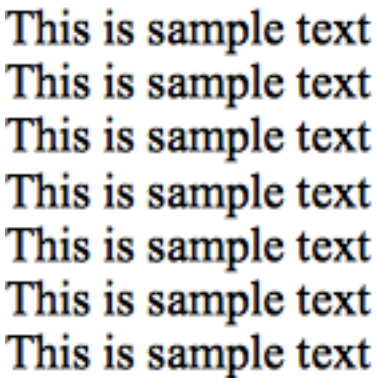
Two points that should appear 1/10 mm apart will appear to be separated by only half that distance.



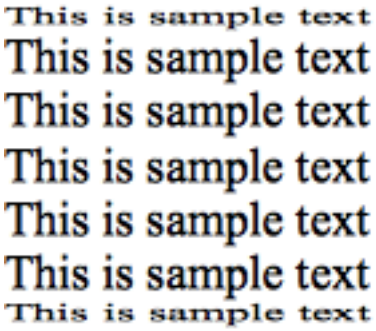
A real world example:

The author found out about this problem the hard way several years ago. The product was a scanning display, and the output from the prototype looked like this:

What was expected:



What appeared:



The problem was a distortion curve exactly like the one presented above. *Total* distortion was fine. *Local* distortion was severe.