Vision Correction in Camera Viewfinders

Douglas A. Kerr

Issue 2
March 23, 2015

ABSTRACT AND INTRODUCTION

Many camera viewfinders are equipped with a lever or knob that controls “adjustable vision correction”, primarily to allow users who are nearsighted or farsighted to obtain a sharp view of the viewfinder image without their eyeglasses. In this article, we examine how this works and learn about the unit “diopter” which is used to quantify the amount of correction in effect.

REFRACTIVE DEFECTS IN HUMAN VISION

Ideally, the human eye is able and willing to *accommodate* (that is, focus on) objects at distance from perhaps 10” in front of the eye to infinity. But for many people, this ability is limited, the limitation typically increasing with age. Four prominent shortcomings in accommodation (“refractive defects”) are:

- *Myopia* (nearsightedness)—Here, the person’s range of accommodation is “biased” in the near direction, and thus the eye cannot focus on distant objects.

- *Hyperopia* (farsightedness)—Here, the person’s range of accommodation is “biased” in the far direction, and thus the eye cannot focus on near objects.

- *Presbyopia*—Here, the person’s eye has a very limited range of accommodation, the distance of focus being very nearly “frozen”. In the most common situation, that is at a substantial distance, in which case the effect is similar to hyperopia. This defect is especially associated with increasing age[1].

These refractive defects are often mitigated by the use of *corrective lenses*, typically in eyeglasses or contact lenses. In the case of the myopia and hyperopia (and for less extreme presbyopia), these are usually simple, basic lenses, often with spherical surfaces, although we may be led to aspherical surfaces to get best performance in the situation that we want the lens, overall, to be “flatter” that the ideal spherical design would call for, for aesthetic reasons.

---

[1] The prefix “presby” means essentially, “pertaining to old age”. Recall that the Presbyterian church is so-called because of its system of governance by “elders”.

For myopia, the corrective lens is one that diverges the rays of light (a lens that is "net concave"). For hyperopia (and hyperopic presbyopia), the lens is one that converges the rays of light ("net convex"). The role of the lens is to effectively shift the "biased" range of accommodation back to nearly where it should be so that the user can accommodate both far and near objects. (For severe presbyopia, the range is so limited that this won't work. There, the user will usually need bifocal glasses, which have lenses of differing focal length used for far and near vision.)

REFRACTIVE POWER AND FOCAL LENGTH

The refractive effect of a lens is determined by its focal length. A flat glass plate, which has an infinite focal length, has no convergent or divergent effect. As the focal length decreases in magnitude (I say it that way since we can have both positive and negative focal lengths), the refractive effect of the lens increases.

In fact, we quantify the converging or diverging effect of the lens by stating its *refractive power*[2], which is the reciprocal of its focal length. The usual practical unit of power is the *diopter*[3]; the power in diopters is the reciprocal of the focal length in meters. A positive value denotes a converging lens; a negative value, a diverging lens.

Thus, if a lens has a focal length of 2.0 m (that would be a converging lens), its refractive power is 0.5 diopter. If a lens has a focal length of -0.4 m (that would be a diverging lens), its refractive power is -2.5 diopters.

In a prescription for corrective lenses, the power of the lenses is stated in terms of their power in diopters (with the positive or negative sign as appropriate). Lenses with a positive power will be prescribed for hyperopia (and hyperopic presbyopia), and lenses with a negative power for myopia.

---

[2] Do not confuse this use of the word with "power" as sometimes used in connection with the *magnification* of a telescope, as when we speak of an "8-power telescope). This is a wholly different thing.

[3] In modern scientific work (under the International System of Units), the unit diopter is deprecated. Rather, refractive power is just denominated in the *inverse meter* (symbolized m^{-1}). But in practical optical engineering, the unit diopter is widely used.

THE CAMERA VIEWFINDER

The viewfinder's virtual image

A camera viewfinder forms a *virtual image* of the scene, which appears to the viewer to be at a certain location. But the virtual image doesn't really exist—there is no unique optical phenomenon occurring at its apparent location (as there is for a real image). It is "simulated" by the optical system for the benefit of the viewer's eye, a crafty "optical illusion". Thus its description as "virtual".

Apparent distance of the viewfinder image

In the basic viewfinder concept, the virtual image created by the optical system of a camera viewfinder appears to be at an infinite distance. By that we mean that, when the eye focuses on the viewfinder image, it has to focus on it in the same way it would focus on a physical object at an infinite distance.

But in fact, not every human can focus on an object at infinity (persons with myopia cannot). And even for persons with "normal" vision, the eye's muscles that control focusing have to tense to produce focus at infinity. In fact, for a "normal" eye, if the muscles controlling focus fully relax, focus is at a fairly close distance—perhaps 1 meter.

To take advantage of this for the comfort of the user, most camera viewfinders are thus designed to present the virtual image at an apparent distance of about 1 meter.

Note that this is precisely what we would have if we first constructed a viewfinder whose image appeared to be at infinity and then placed in front of it a (diverging) lens with a power of -1 diopter.

Vision correction

It is often difficult to use a viewfinder when wearing glasses. In order to allow users with refractive defects to effectively use the viewfinder with their glasses off, many camera viewfinders are equipped with a "vision correction" system, adjusted by a lever or knob. Technically, what it does is vary the distance at which the viewfinder image seems to be. But the result is precisely what we would have if:

- the viewfinder produced the virtual image at infinity, and
- we had between that image and our eye a corrective lens whose refractive power could be varied (over both positive and negative values) by adjusting the control.

Thus, the vision correction system of the viewfinder can take the place of a basic corrective lens.

In many cases, the effective refractive power of this virtual corrective lens (based on the "raw" image being located at infinity) is indicated on a scale on the adjusting control, calibrated in diopters. Even if it is not actually marked in diopters (directly or indirectly), the camera specification may state the effective refractive power of the virtual corrective lens, at both extremes of the range of adjustment, in diopters.

Note that if the vision correction adjustment is set to the -1 diopter position, then the viewfinder image appears to the user to be at a distance of 1 meter (as is typical for viewfinders without adjustable vision correction). As we described before, this is considered to give the most "comfortable" observing to people with fully "normal" vision.

In fact, it is very common in viewfinders with adjustable vision correction to have a "detent" at the -1 diopter position.

Additionally, it is common for the available range of vision correction adjustment to be centered about this -1 point. For example, on a Canon EOS 20D digital SLR camera, the range of the vision control adjustment is specified as being from -3.0 to +1.0 diopter (a range of ±2.0 diopters about the default setting, -1.0 diopter).

Terminology

It is common to refer to the vision correction adjustment control on a viewfinder as "the diopter (or dioptric) adjustment", or even worse, as "the diopter". I discourage such usage. It's a little bit like calling the elevating crank on a camera tripod the "the inch adjustment" (for the first case) or "the inch" (for the second case).

EXTENDING THE RANGE OF VISION CORRECTION

Supplemental vision correction lenses

Sometimes, for users requiring very severe vision correction, the range afforded by the integral vision correction adjustment of the viewfinder is insufficient to provide the required correction.

Thus, especially for SLR cameras, the manufacturer often provides a series of supplemental vision correction lenses. These can be slipped on the viewfinder eyepiece (sometimes into a frame that takes the place of the normal viewfinder "eyecup") to provide a correction value outside the normal range.

Note that to a first approximation, when two lenses, or the equivalent, are “piled on”, their joint refractive power is very nearly the sum of their individual powers. So the power of the supplemental lens essentially adds (algebraically) to that which represents the internal vision correction of the viewfinder.

Determining the needed total correction

Whether we are thinking in terms of correction values within the range of the viewfinder adjustment or beyond, it is difficult to estimate the needed value based on the user’s eyeglass “prescription”. For one thing, typically the eyeglass prescription (in the case of bifocals, the prescription for the “distant vision” portion) is usually intended to provide the best viewing by the person for objects at a distance of 20 feet. But the correction provided by the finder is in terms of a “native image” at infinity.

Designation of supplemental vision correction lenses

Most camera manufacturers (but not Canon; see below) identify the various supplemental vision correction lenses in the series for a particular camera (or family) in terms of their refractive power in diopters.

Thus, with such a lens in place and the control on the viewfinder set to a particular correction value, the effective correction would be the algebraic sum of the value set on the viewfinder and the value for the particular supplemental lens.

The Canon scheme

Canon does not identify their supplemental lenses with their refractive power. They identify them with the net effective correction power we would have with the lens in place and the viewfinder’s own vision correction adjustment set to -1.0 diopter (the “default” setting of the adjustment for Canon cameras).

Thus, a Canon supplemental lens with a refractive power of +2 diopters would be labeled (and designated in the catalog) as “+1 diopter”.

The object of this peculiar-sounding scheme is that with a supplemental lens in place having a certain designation, the available range of correction would center about that value, and it would be the effective correction value we get with the control set at the “detent”.

Thus, with a "+1 diopter" lens in place on an EOS 20D, the range of correction would be +1 ±2 diopters (that is, from -1 to +3 diopters, +1 diopter at the "detent").

This situation of course explains the curious fact that in the Canon catalog, for any given type of camera, there will be a "0 diopter" lens (we would think that this didn't do anything) and no "-1 diopter" lens (which in fact wouldn't do anything).

Notation

It is common to speak of a supplemental vision correction lens as "a diopter".[4] I discourage this usage (but if you insist, you are in good company: Canon describes them as "dioptric adjustment lenses". Nikon refers to them as "eyepiece diopters", Hasselblad refers to them as "correction diopters".)

WHAT ABOUT ASTIGMATISM

In the refractive defect *astigmatism*, the eye's lens is asymmetrical, which results in the eye focusing at one distance for lines oriented in one direction and at another distance for lines at right angles to that first orientation.

Correction of astigmatism in eyeglasses involves the addition to the lens contour of a component which is in effect that of a cylindrical (rather than spherical) lens. A cylindrical lens only has refractive power along one axis. In eyeglasses, the axis of the cylindrical component is chosen to match the orientation of the person's astigmatism.

The internal vision correction mechanism of camera viewfinders (at least any I have ever heard about) does not provide for the correction of astigmatism. Doing so would require the simulation of a "cylindrical" lens having variable refracting power and variable orientation, a very complicated and costly arrangement.

Thus the user whose refractive defect includes any significant component of astigmatism will probably not be able to use the viewfinder without his glasses.

---

[4] *Supplemental closeup lenses*, which are mounted on the camera's main lens to allow focusing at a closer distance than otherwise, are also designated in terms of their refractive power in diopters, and are often spoken of as "diopters". I discourage this usage as well.

EFFECT OF IMPROPER SETTING ON FOCUSING OF AN SLR CAMERA

There is a common misconception that setting the vision adjustment control on the viewfinder of a single lens reflex (SLR) camera to other than the optimum point for the user will cause the manual focusing process to give an incorrect camera focus result. This is not so. A little thought experiment will show why.

Suppose we start with the camera properly focused on some object, with the vision correction adjustment set ideally for the user. The image of the object will be fully sharp to the user.

Now suppose we intentionally substantially offset the vision correction control. Likely the viewfinder image will no longer be sharp to the viewer, since his eye can no longer focus properly on it.

Can we restore the image to a sharp appearance by shifting the focus of the camera to an incorrect point (making it appear that this is the correct focus setting)? No. That only produces a blurred basic finder image. The eye sees this as further blurred (because of its inability to focus at the image distance). But no “false” position of best camera focus is produced by this situation. The “least blurred” image to the user will still occur when the camera is properly focused.

That least blurred image will, however, still be somewhat blurred. Accordingly, it is much more difficult to determine exactly where this occurs than in the case where the image is actually seen as “sharp” at the point of proper focus.

Thus, it is certainly worthwhile to use an appropriate setting of the vision correction control when focusing manually. But not because an improper setting offsets the apparent point of proper camera focus. It just makes it harder to tell just where that is, potentially leading to an greater uncertainty in focus setting.

SETTING THE VISION CORRECTION CONTROL

How can we set the vision correction control to its best point? Typically, users are told to look through the viewfinder at a scene and adjust the vision correction control until the image they see is the sharpest.

But if the camera itself isn’t yet properly focused on the scene, the finder image will never appear sharp to the eye—the “internal” finder image is itself blurred. Thus it can be difficult to discern when this blurry image is most sharply reproduced to the eye.

A better way is to adjust the control until the sharpest view is obtained of such things as crosshairs, zone circles, or cropping marks on the focusing screen of the viewfinder, which are always themselves sharp to begin with. In fact, to avoid the unpredictable components of the viewfinder image itself from confusing this operation, it is often best to deliberately greatly misfocus the camera so the viewfinder image just becomes a soft overall blur, a benign cloudlike background for the delicate object (such as a crosshair) we are trying to bring into sharpest view.

#