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Keystone effect

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The **Keystone effect** is caused by attempting to project an image onto a surface at an angle, as with a projector not quite centered onto the screen it is projecting on. It is a distortion of the image dimensions, making it look like a trapezoid. In the typical case of a projector sitting on a table, and looking upwards to the screen, the image is larger at the top than on the bottom. Some areas of the screen may not be focused correctly as the projector lens is focused at the average distance only.

Illustration of the Keystone Effect

Contents

Theory behind Keystone

The distortion suffered by the image depends on the angle of the projector to the screen, and the beam angle. The distortion (on a two-dimensional model, and for small focus angles) is given by:

$$\frac{\cos(\epsilon - (\alpha/2))}{\cos(\epsilon + (\alpha/2))}$$

where • is the width of the focus, and

• is the angle between the screen axis and the central ray from the projector

From the formula is clear that there will be no distortion when • is zero, or perpendicular to the screen. See a derivation of this formula at Derivation of the equation to combat Keystone (http://freespace.virgin.net/tom.baldwin/keyst_deriv.html)

Keystone Effect in Stereo Imaging

See [1] (http://www.microscopyu.com/articles/stereomicroscopy/stereointro.html)

In stereo imaging, two lenses are used to view the same subject image, each from a slightly different perspective, allowing a three dimensional view of the subject. If the two images are not exactly parallel, this causes a keystone effect. This is particularly noticeable when the lenses are close to the subject, as with a stereo microscope, but is also a common problem with many 3d stereo camera lenses.

Solving the problem

The problem arises for screen projectors that don't have the depth of focus necessary to keep all lines (from top to bottom) focused at the same time. The problem can be solved by:

- Move the projector more to the center of the screen, if this does not interrupt vision
- Tilt the screen in a small angle
- Use some type of software on the projector (or computer controlling the projector). Well known video card producer NVidia delivers a package called NVKeystone with most of their software solutions.

Correction

Keystone correction, colloquially also called **keystoning**, is a function that allows multimedia projectors that are not placed perpendicular to the horizontal centerline of the screen (too high or too low) to skew the output image, thereby making it rectangular. Without such correction the image will appear as a horizontal trapezoid, the shape of an architectural keystone; hence the name of the feature.

It is often necessary for a projector to be placed in a position outside the line perpendicular to the screen and going through the screen's center, for example, when the projector is mounted to a ceiling or placed on a table top that is lower than the projection screen. Keystone correction is a feature included with many projectors that provides the ability to intentionally "distort" the output image to recreate the original rectangular image provided by the video or computer source, thus eliminating the skewed output that would otherwise result due to angled projection.

It is rare for a projector to have the ability to correct horizontal keystoning distortion (too far left or right of the vertical centerline of the screen), although Sony has had capable projectors in its line-up with the feature dubbed *Side Shot*. Typically this is easily corrected by moving the projector left or right as necessary, or less often by lens shifting.

Functionality

In modern projectors keystone correction technology is performed digitally (rather than optically) via the internal (LCD) panels or (DLP) mirrors of the projector, depending on the technology used. Thus, when applying keystone correction to an image, the number of individual pixels used is reduced, lowering the resolution and thus degrading the quality of the image projected. Home theater enthusiasts would argue that keystoning should not be used because of the impact it has on image quality. However, it is a useful technology in cases where the projector cannot be mounted directly in front of the screen, or on projectors utilizing lens shift technology where the projector must be mounted outside the frame of the screen.

See also

- Homography
- Perspective correction

External links

- Keystone Correction: Digital and Manual
  (http://www.presentationmart.com/resources/keystonecorrection.asp)

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