Three-Dimensional Viewing of Distant Objects with the 'Naked' Eye

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abstract

Simple apparatus which enhances three-dimensional recognition of object is contructed and examined. It is composed of only 4 plane mirrors and used to see objects directly. Landscape seen through it is very exotic, which might be compared to a Gulliver's view in Lilliput.

We obtain three-dimensional recognition of objects mainly by the parallax between our two eyes. However, the range of this recognition is limited by the space between the two eyes of about 6.5cm. If we can expand this space somehow, more distant objects will be recognized perspectively. This might be compared to the sight of fictitious giant monsters like "King Kong" or "Godzilla", which may see a landscape with a feeling just like we see a miniaturized copy of it because of large separations between their eyes.

We can expand the space between the two eyes optically by using four plane mirrors. As shown in fig. 1, two pairs of plane mirrors (large and small ones) are combined parallel with some spaces, like periscopes. Then these "periscopes" are placed horizontally and are directed to a common visual field, with a separation between small mirrors fitting to the space between the two eyes. If one looks at a landscape with this mirror system as we use a binocular telescope, the virtual positions (images by these two pairs of mirrors) of right and left eyes are widely separated as shown in fig. 1. This will results in the larger parallax between the two eyes and eventually brings about an enhanced perspective feeling to an observer even for distant objects. This apparatus might be named "macroscope" or "godzillascope".

One may say that this apparatus is merely a scaled-up version of a mirror-type stereoscope to view a pair of large stereographs. It is true, but did anyone notice that a real and single landscape itself can be an object of such a stereoscope?

Let k be the ratio of the effective baseline length to the human eyes' spacing. By the geometrical proportionality, same parallax as that with naked eyes is obtained for

k-times distant object through this appartus. Assuming the proportionality between the parallax and the perspective-sensing range, the observer will be able to recognize the perspective for *k* times more distant objects with this apparatus than by naked eyes. Besides, or as a result of the enhancement of the perspective, the observer will feel the landscape itself to be reduced to 1/*k* in the radial direction. The latter effect, which is of phycological nature, is the origin of the name "macroscope". On the other hand, the view angle of objects are not affected (no magnification or reduction) becaue this apparatus is copmosed of only plane mirrors.

The author have constructed a portable version of this apparatus to examine views of various landscapes through it. This was facilitated by employing a stepladder of expandable type as a frame. Its construction is illustrated in fig.2 and several dimensional parameters are listed in table 1. The virtual baseline length which is the most important parameter is 1.3m, 20 times as large as the separation of human's eyes. The eye mirrors are of surface-reflecting type to avoid double image.

This apparatus was examined by the author as well as tens of people around him in office and at home. Actually they could get an obvious three-dimensional feeling for objects at more than 1km distance by this apparatus. The author and almost all other observers have experienced the feeling of "landscape miniaturizing", mentioned above, as well.

A binocular telescope, which has somewhat large distance between objective lenses, also expands the viewing baseline and enhances the three-dimensional recognition. But, as it's main performance, it simultaneously magnifies the object and the view through it is far from the feeling of the naked eye vision. In contrast,

through the "macroscope" one can view a landscape with very natural feeling as if he/she is looking with naked eyes, except the feeling that the landscape is remarkably shrunk towards the observer. This is really an exotic and new experience of vision, far more attractive than the stereoscope which does not bring about a "live" view. Try to fabricate it by yourself and enjoy an experience of a Gulliver's view in the Kingdom of Lilliput!

In order to enjoy 3-dimensional views of vast geographical features extending to tens of kilometers, for example the Grand Canyon, greater space (several meters) between the two objective mirrors is required, as well as larger sizes of them to keep a large field of vision. It will simultaneously require a better flatness of the objective mirrors due to the use at long distances from an observer. (Alternatively, to avoid the use of large mirrors, one can combine a lens system of unitary magnification, but the natural feeling of vision may more or less be lost.) Such a large-scale version of this apparatus is envisioned as a built-in system installed in a building.

How large baseline and mirrors will be needed to get a perspective view of a starry sky?

Figures

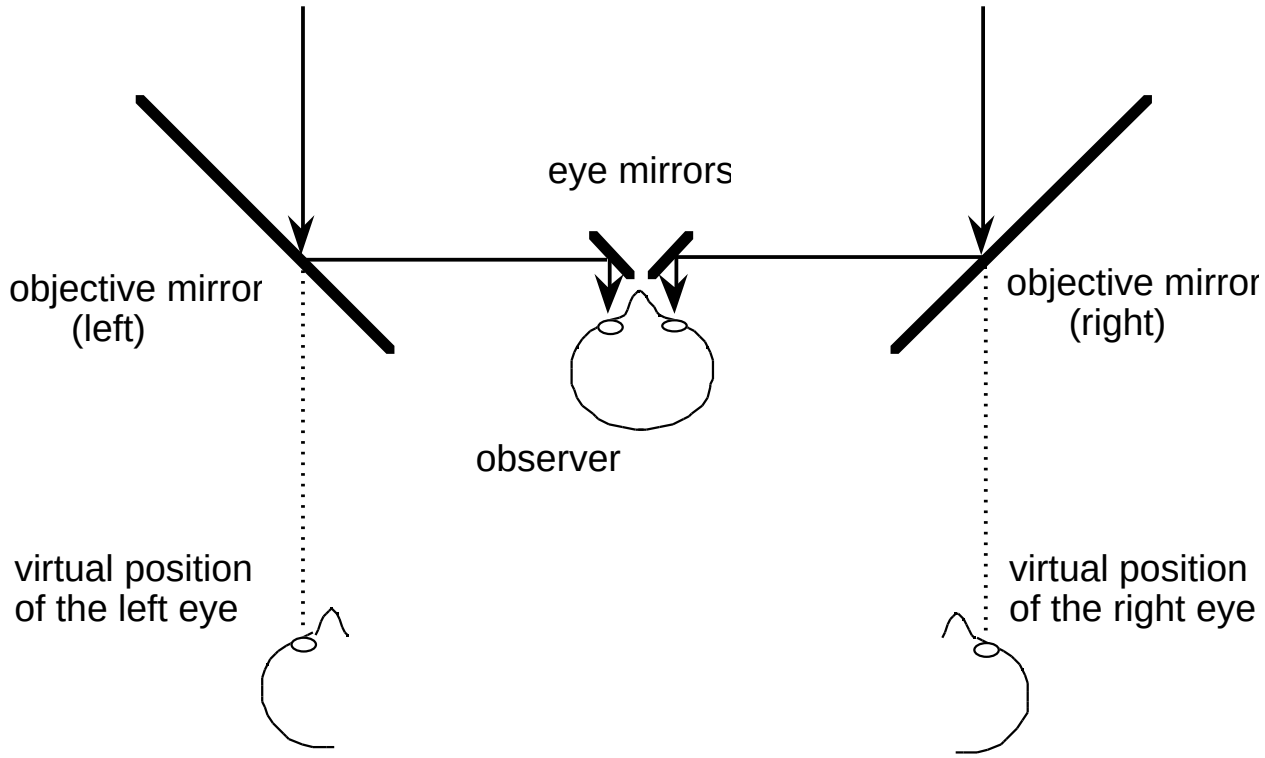

fig.1

fig.1

Illustration of the optical principle of the apparatus.

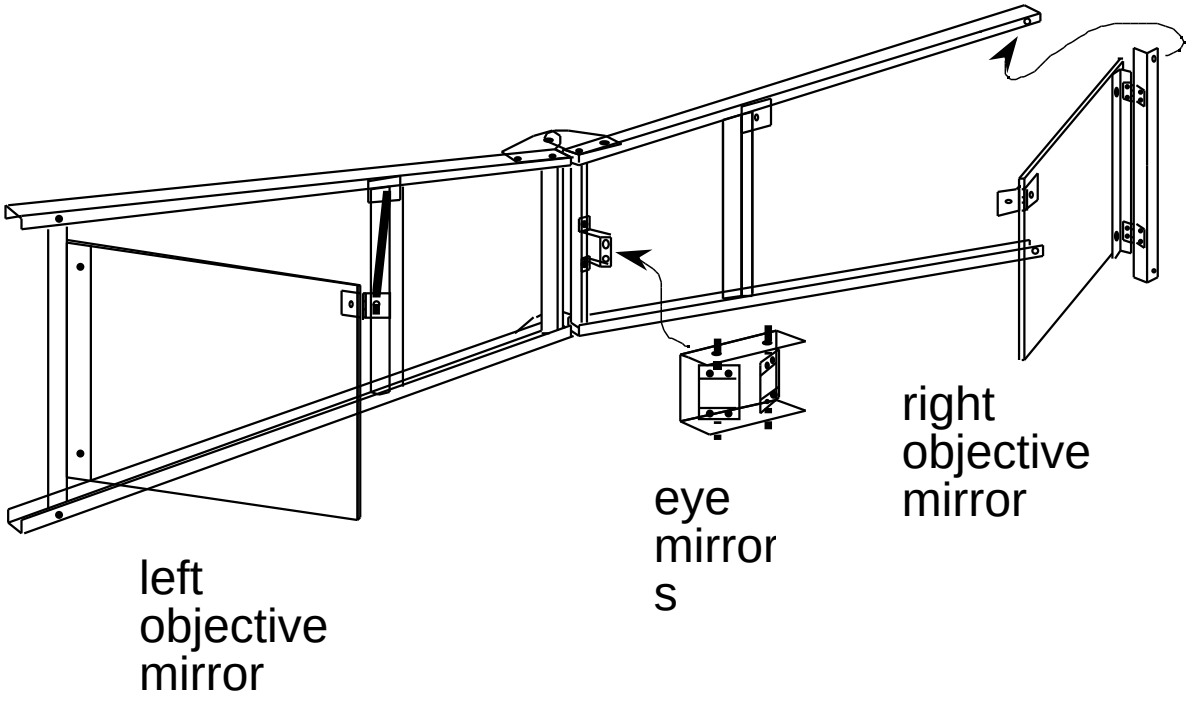

fig. 2

Construction of the apparatus employing a stepladder as a frame, seen from the observing side. The lowest step bars are removed and two stems are attached at both ends to fix the objective mirrors with hinges.

Table 1. Dimensional parameters of the prototype.

objective mirrors' size	450mm x 300mm
eye mirror's size	40mm x 40mm
frame width (expanded)	1770mm
frame height	450mm
effective baseline	1300mm