

## Three-dimensional (3D) vision

How comes that we can see in three dimensions? That we can tell which objects are closer, and which are more distant?

**Parallax is the key!** Objects observed from different viewpoints shift relative to each other, depending on their distance from the observer. Here the two “viewpoints” are two human eyes:



Here is what the left eye sees.



And here, what the right one sees.

Note that in the left-eye image closer objects (fountain, tree) are shifted to the right with respect to the more distant object (White House). And in the right-eye image, they are shifted to the left (look at the main door, how the fountain shifts!).

Suppose you go to a trip, say, to Hawai. You arrive late in the night. In the morning you look through a tiny window. You see only two palm trunks – but not their leaves, not where the trunks grow up from the ground. But you immediately know that the thinner palm is located closer to the cottage than the other one!

How comes? It's the parallax effect that allows our brain to find out how far the object is located from the observer.



What the left eye sees.



What the right eye sees.

The brain compares the two images and finds out that the thinner Trunk exhibit a much stronger parallax effect than the other one – meaning that it is closer.

Later, you get pretty close to the window – now you can see the leaves. Now one can tell which palm is the nearer even with one eye closed. The perspective additionally help the brain to “construct” a precise 3D Image.



Left eye

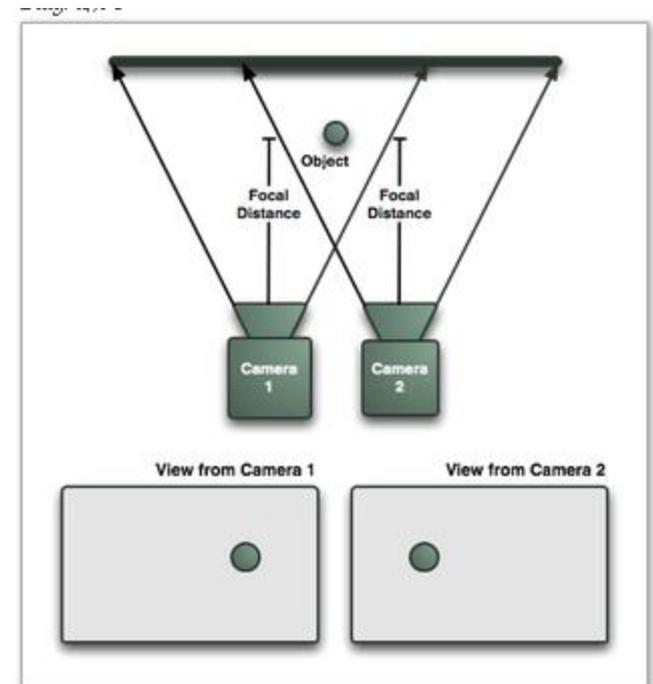


Right eye

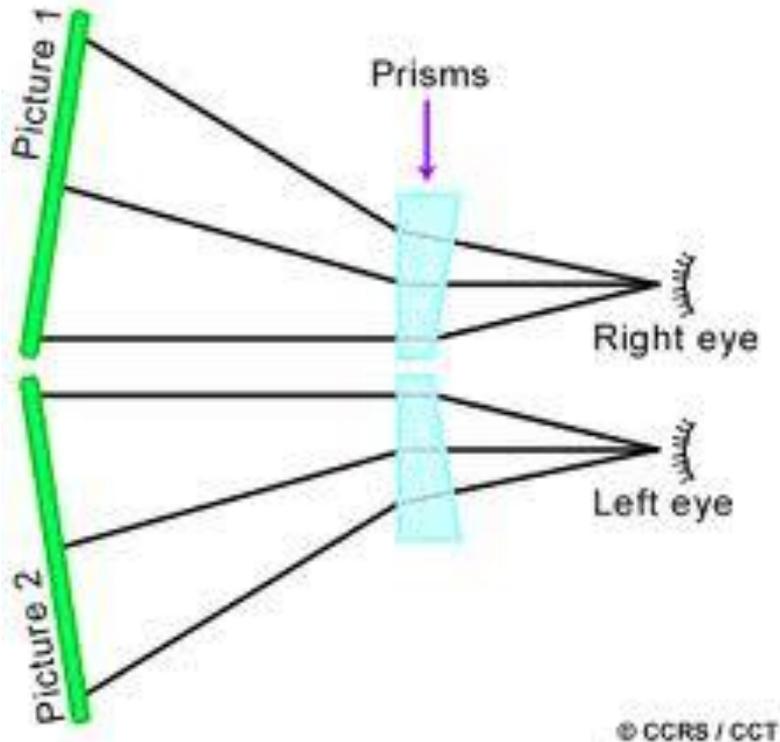
How exactly the brain processes the images from two eyes, and how it “constructs” the 3D image in our mind? – we don’t know in detail.

However, we know how to “cheat” the brain – it may generate a 3D image even though the eyes don’t see the real world, but only flat pictures.

The White House pictures in the first slide were taken by a so-called “stereoscopic camera”: it has two lenses, 2 - 3 inches apart (more or less, like human eyes), two separate image sensors, each one recording a separate picture. In other words, the camera “mimics” our two-eye vision.



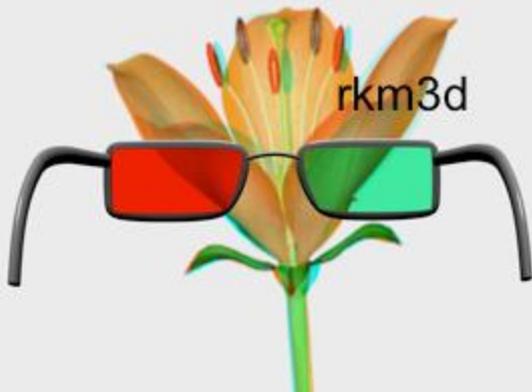
The picture pair can be then viewed using a “stereoscope” – i.e., a device that “splits” our vision: the left eye sees only the “left” picture, and the right eye -- only the “right” picture. And thus an “artificial 3D visual impression” is created in the watchers mind.



Schematic of a so-called “biprism stereoscope” (there are many other possible designs).



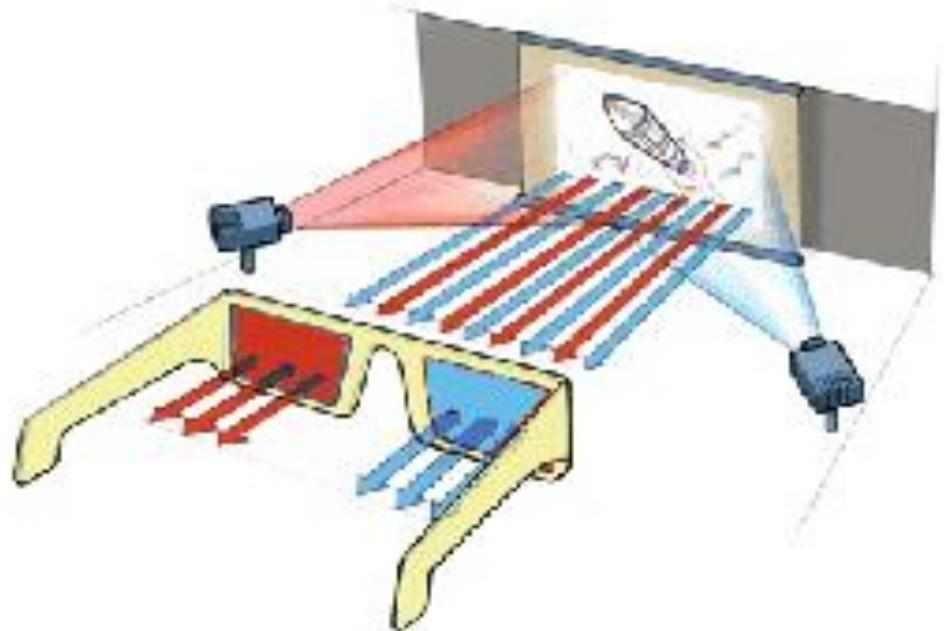
A historic stereoscope, probably from the Civil War times.



**Anaglyphs – red-green (older) and red-cyan (newer) stereograms.**

**The object is photographed through a red filter (left camera) and a cyan filter (left). Images from both channels are projected on the same screen, and viewed by red-cyan glasses.**

**We will see how it works!**



**3D movies utilizing light polarization techniques (e.g., “Avater”). The principle is similar as in the case of red-cyan anaglyphs, but instead of two different colors and glasses with color filters, two perpendicular polarizations are used for projecting the “left-eye” and the “right eye” images on the same screen.**

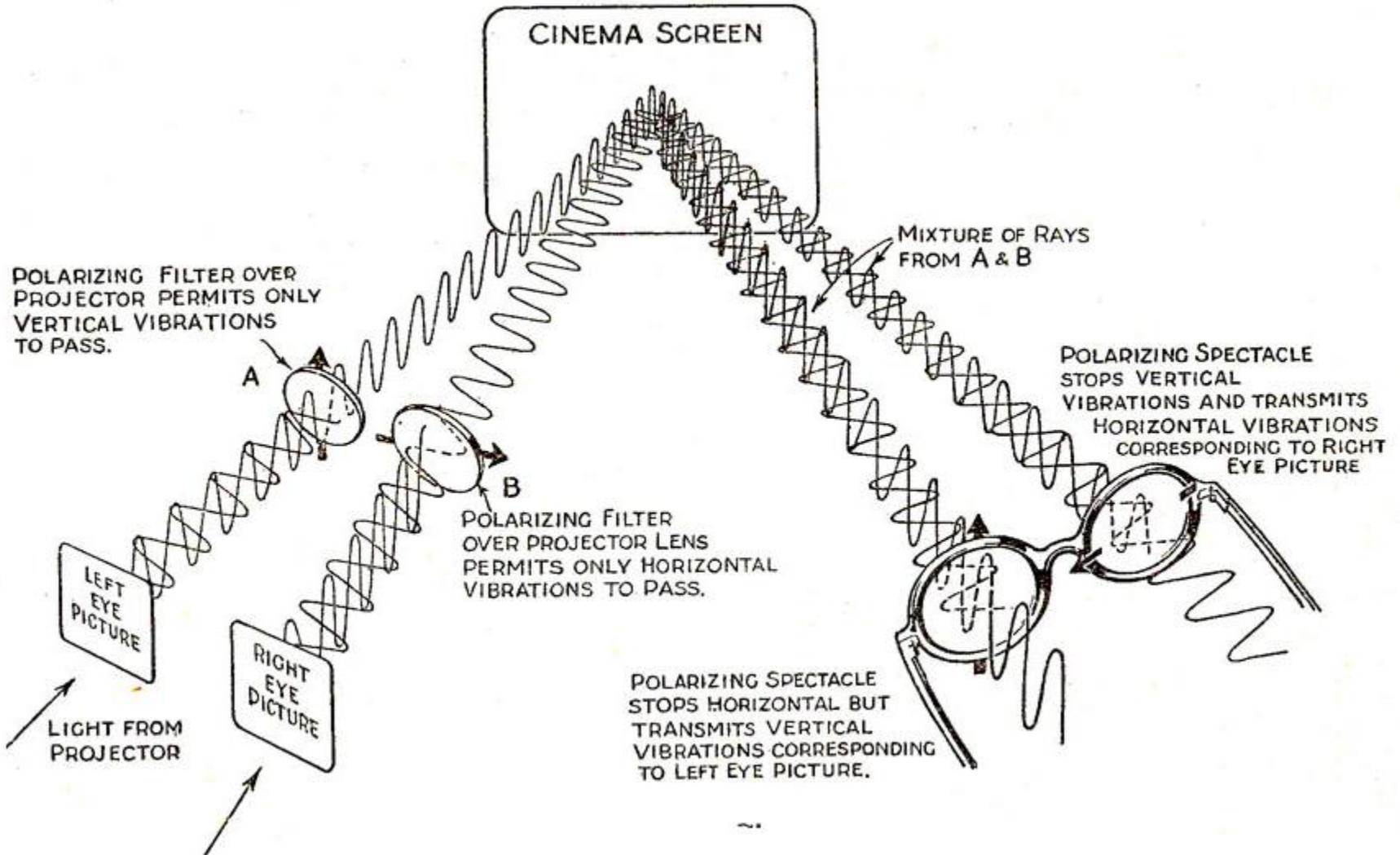
**The viewers wear glasses with polarization filters. The left-eye filter transmits only the polarization corresponding to the left-eye image, and the right-eye filter – only the polarization corresponding to the right-eye image.**

**As far as colors are concerned, this technique renders them very accurately – so it is superior to the red-cyan anaglyphs.**

**However, it cannot be used for generating 3D TV or 3D computer images**

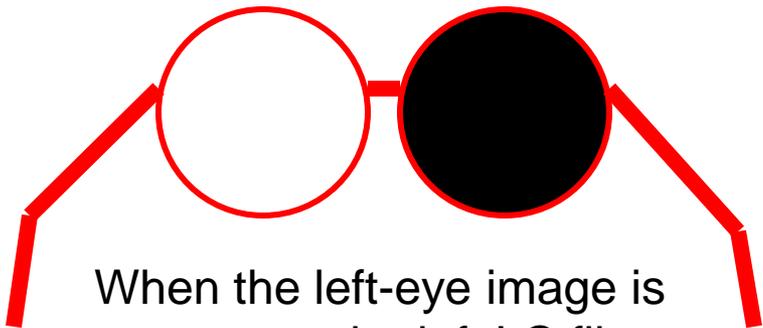


# Another scheme of a 3D movie projection & viewing, showing more details.



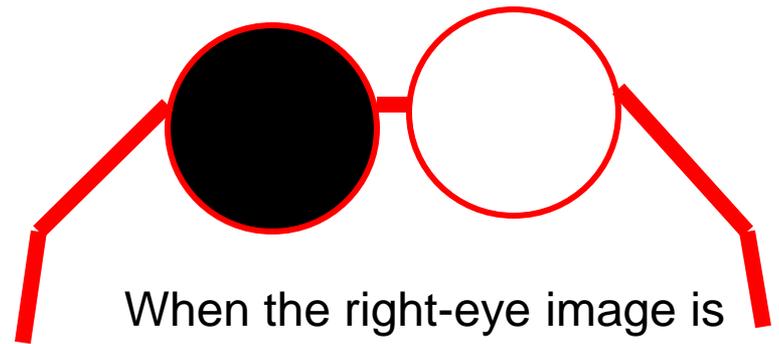
## 3D TV with so-called “active LC glasses”:

The “left-eye image” and the “right eye image” alternate on the screen, in rapid succession (e.g., 60 times per second)



When the left-eye image is on screen, the left LC filter opens up, while the right is in the “closed” state..

...and...



When the right-eye image is on screen, the right LC filter opens up, while the left is in the “closed” state..