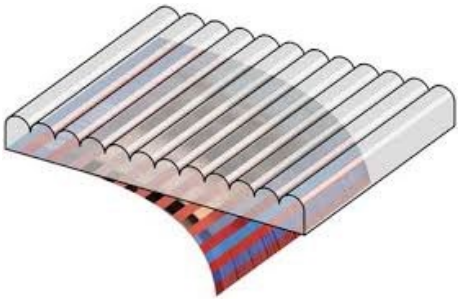
Lenticular artworks and how to appraise their technical attributes – a document for art buyers and curators.

What is a lenticular image?

A lenticular image is a type of three-dimensional picture that can be viewed without the aid of 3D glasses. It can also be an animated picture.

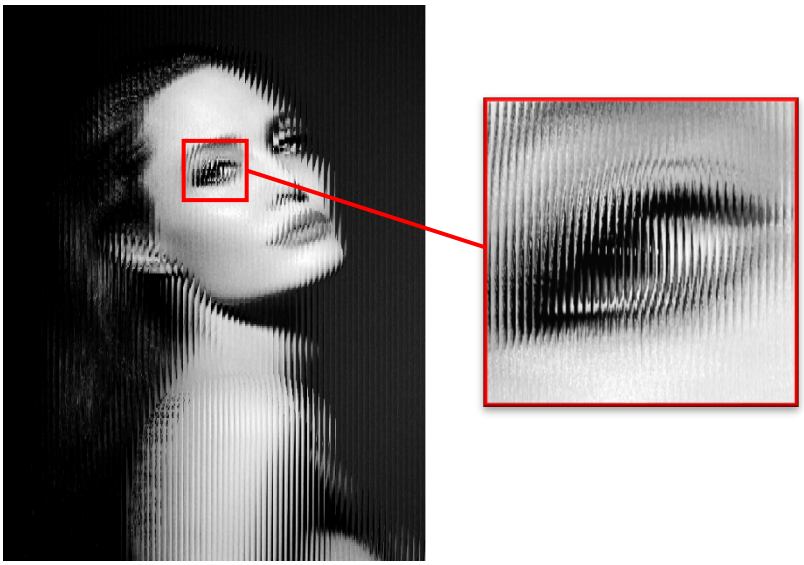
The term 'lenticular' refers to the long thin parallel lenses called lenticules which are arranged on a flat transparent sheet to make a lenticular lens.

A lenticular image comprises of two layers, a lenticular lens, which faces the observer, and a printed image, comprising of a multitude of separate images or views, which is usually adhered or printed directly to the back of the lens.



To create a three-dimensional image a subject is first photographed from up to two hundred different angles of view to create a sequence of images. Such images or views can also be computer generated.

The sequence is then combined to form a single image by 'interlacing' them together in vertical strips using a specialised computer program. This is called the interlaced image. [1]



The interlaced image, which contains all the views originally recorded, is then either directly printed onto the back of the lenticular lens or is first printed onto a separate piece of film or paper and adhered to the back of the lens in perfect register. This process, often done by hand, is technically extremely challenging. Once combined, the lenticular lens then acts to decode the printed interlaced image and present a three-dimensional image to the viewer.

3D lenticular imaging combines photography with optical lenses to create a three-dimensional sculptural work. For this reason, lenticular artworks may also be described as photographic light sculptures.

A brief history of lenticular imaging

The first patents known to describe lenticular imaging were filed in 1912 and the first lenticular images made soon thereafter.

Two of the most important names in the early development and commercialisation of lenticulars are Professor Maurice Bonnet (1907-1994) of France who opened the world's first 3D lenticular portrait studio in Paris in 1942 and Victor Anderson of the USA who, through is company Vari-vue, was responsible for the commercialisation of lenticulars worldwide during the 40's, 50's and 60's.

Two other names of repute are Paul Hess (1896-1973) and Harvey Prever (1916-1999) who together created many notable 3D lenticular portraits of Hollywood's leading actors and actresses during the 50's 3D movie craze.

Maurice Bonnet, 1940's

Hess & Prever, 1953

The first 3D lenticular magazine cover appeared in 1964 for Look Magazine and featured a portrait of Thomas Edison surrounded by several of his inventions.

From the earliest days artists have utilised the medium of lenticular imaging. Roy Lichtenstein famously produced lenticular artworks in the 1960's.

Roy Lichtenstein, *Fish and Sky (from Ten from Leo Castelli portfolio),* 1967

By the 1980's the appeal of lenticulars had begun to wane, perhaps due to the greater appeal of laser holograms, however a resurgence of interest occurred in the late 90's thanks to the advent of high resolution inkjet printers, easy to use computer interlacing software and commercially available lenticular lenses. This revived the commercial lenticular industry and spawned a host of independent lenticular image makers and 3D artists. Over recent years several well-known artists have utilised the medium to create lenticular artworks.

Peter Blake, Eiffel Tower, 2010

Julian Opie, *Bibi Running*, 2012

Rob Munday, *Naturalium* 1, 2017

How to appraise the technical attributes of a 3D or animated lenticular artwork.

The lenticular medium is a technically complex process and lenticular artworks can vary enormously in quality. It is therefore important to understand and be able to appraise their technical attributes as well as their aesthetic ones. The technical attributes to be aware of are listed below (the most important in bold):

1. The type of lenticular lens used
2. The type of lenticular print used
3. The method used to create the image sequence
4. **The registration accuracy of the lens with respect to the print which determines:**
    a. **The position and accuracy of the viewing zone**
    b. **The angle through which the image can be seen**
    c. **The distance from which the image is ideally viewed**
5. Optical artefacts
6. Cosmetic defects
7. The illumination of lenticular artworks and archival considerations

1. The type of lenticular lens used

There are several types of lenticular lenses used to create lenticular artworks and this choice can greatly affect the technical quality of the artwork with respect to sharpness, level of distortion and clarity of the image. This is primarily due to the optical quality of the lenticules, the flatness and rigidity of the lenticular lens, the thickness and hence accuracy of focus of the lenticular lens, the light transmittance of the material used and its durability or scratch resistance. In order of increasing quality, the types of lenticular lenses that are commonly used to make lenticular artworks are:

1. Extruded acrylic plastic lenses – the most commonly used for commercial applications and art.
2. Optical grade acrylic resin lenticules cast onto plastic film - used for commercial applications.
3. Optical grade acrylic resin lenticules cast onto plastic film which is then laminated to an acrylic or glass substrate – used for both commercial applications and art.
4. Optical grade acrylic resin lenses cast directly onto an acrylic or glass substrate – the highest possible quality currently used for art.
5. Glass lenses – the ultimate but no longer found.

Lenticulars lenses also vary in resolution i.e. how many lenticules there are per inch and in thickness. It may seem advantageous to use a higher resolution lens with smaller lenticules as this will create a smoother looking lenticular image however these parameters also affect the angle of view or 'look-around' of a lenticular image and its depth.

Unfortunately, there is an optical trade-off between the angle of view and the depth of a lenticular image. A lower resolution, thicker lenticular lens with larger lenticules will have a smaller the angle of view but can display a deeper lenticular image. This type of lens, say one with 20-30 lenticules per inch, is therefore more commonly used for larger format lenticular artworks where sharp depth is considered more important than a wide angle of view. The angle of view is usually less than 30 degrees. Conversely, a higher resolution, thinner lenticular lens with smaller lenticules will have a wider angle of view but limited depth. Such lenses, say with 40-100 lenticules per inch, are thus

more commonly used to make smaller lenticular artworks and commercial lenticulars. These will not be as deep but will have an angle of view greater than 30 degrees.

Summary: Lower resolution optical grade acrylic resin lenses, either applied to film and then laminated to acrylic or glass sheets or directly applied to acrylic or glass sheets offer the best optical quality for art, the sharpest and deepest images, the least distortion, and excellent clarity but will have a slightly smaller angle of view.

2. The type of lenticular print used

The interlaced image can be printed in several ways and using a number of different materials. In order of increasing quality, the types of lenticular prints that are commonly used to make lenticular artworks are:

1. Offset lithography printing direct to the back of the lenticular lens – used for commercial mass reproduction applications.
2. UV inkjet printing direct to the back of the lenticular lens - used for both commercial display applications and art.
3. Inkjet printing onto paper or film which is then laminated to the lenticular lens - used for both commercial display applications and art.
4. C-Type photographic printing onto paper or film which is then laminated to the lenticular lens - used for both commercial display applications and art.
5. C-Type photographic printing onto paper or film which spaced at some distance from the lenticular lens and clamped into position - used for art.

With respect to the type of printing method used and the advantages thereof, the choice is very much the same as for 2D art prints. The only exception is direct UV printing. Whilst this is the simplest and cheapest method of printing a lenticular artwork, lenticular images may appear grainy and mottled and with limited depth. This is due to an optical affect caused by the application of the UV ink directly to the lenticular lens.

Offset lithography printing is primarily used for volume production onto high resolution, thin lenticular lenses and thus is used for commercial applications and large runs of smaller lenticular artworks.

Both inkjet pigment printing and C-Type photographic printing onto paper can be used to produce high quality front lit reflective lenticular artworks. C-Type printing onto transparency film however provides the highest quality prints for backlit lenticular artworks.

Summary: The best type of lenticular print currently available is a C-Type transparency which is not laminated to the lenticular lens but held in such a way that there is an air space between the lenticular print and lens. This enables the best registration and focus with the fewest optical and cosmetic defects (see below).

3. The method of creating the image sequence

The techniques employed to capture or create the image sequence and the methods used to post process and remove the various distortions inherent in it can greatly affect the integrity and effectiveness of the final 3D result. There are three main techniques used to create the image sequence:

1) Conversion of a single 2D picture into a 3D image sequence using specialised software.

2) Photography, using a multi-camera system, a single translating camera system or an object rotation system.
3) Computer generation, using a 3D modelling and rendering program.

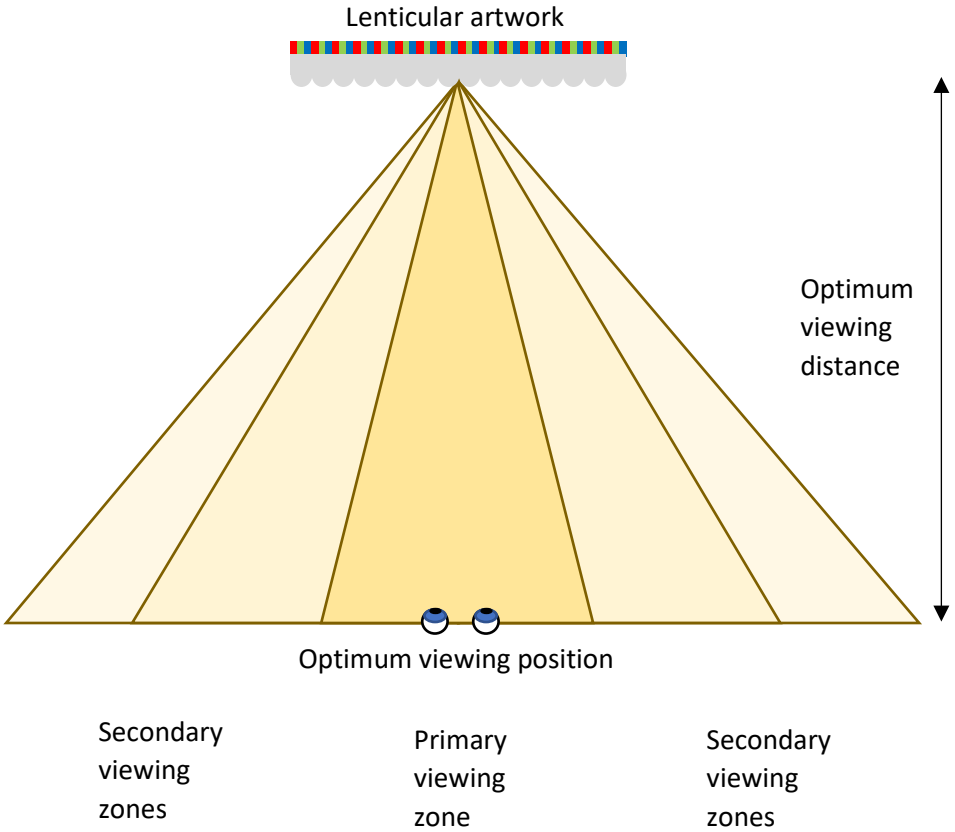
By far the best way to create an image sequence for a 3D lenticular artwork is to either shoot photographic images of the subject directly, using a specially designed and dedicated 3D camera system, or to computer generate the images required. Providing that such images are shot, or computer generated, and post processed in the correct manner, through the correct angle or view and from the correct distance and the various image distortions inherent in the process are correctly removed then the final 3D lenticular artwork will display an undistorted, realistic 3D image with the intended depth and will be comfortable to view.

An image sequence which has not been created correctly however may result in a distorted lenticular image which swings or moves unrealistically as the viewer moves and which appears too shallow or too deep. The 3D image may also be uncomfortable to view.

The process of converting a single 2D picture into a 3D sequence using a special computer program is frequently used by artists, for example, if the subject of the photograph is no longer available to shoot or the sitter of a portrait is no longer alive. This process however is problematic and often results in an unrealistic and distorted three-dimensional image or portrait. Look out for sunken eyes and misshapen torso's and parts of images which appear too shallow or too deep.

4. The registration accuracy of the lens with respect to the print

With respect to the technical quality of a lenticular artwork, the registration accuracy of the lenticular lens with respect to the printed image the most important. To explain how to see if a lenticular artwork has been correctly registered it is helpful to first look at the following illustration of a lenticular artwork seen from above.



You can think of a lenticular image as having a window hovering some distance away from it through which the viewer looks to see the image. This is the primary viewing zone, shown above in dark yellow.

When you view a lenticular artwork, you will naturally stand directly in front of it and at a comfortably viewing distance, depending upon the size of the artwork and the display environment.

A technically correct lenticular should therefore produce a primary viewing zone which is perfectly centralised, the correct distance away and with perfectly vertical and straight edges.

Very often when viewing a lenticular artwork, you will notice that the primary viewing zone or window through which you look is not centralised, has slanted or curved edges and is often too close to the artwork. This forces the viewer to stand to one side or too close to view the artwork which, in turn, results in a reduced viewing angle and a compromised 3D image.

The positional accuracy of this primary viewing zone is of upmost importance to the technical quality of a lenticular artwork, both 3D and animated, and is entirely attributable to the accuracy of the registration between the image print and the lenticular lens.

You will also see from the diagram above that to the sides of the primary viewing zone are secondary viewing zones, shown in lighter yellow. As you move towards the left or right at some point your eyes will pass into these secondary viewing zones, the image will 'flip', and you will see the same 3D or animated image repeated. The image seen in these alternative viewing zones however will not be as high quality. It will not perfectly match the real scene or object that was originally shot and will contain distortion. These secondary images however can be seen in all lenticulars and are perfectly normal.

How to tell if the primary viewing zone is centralised and at the correct distance from the artwork:

Firstly, stand directly in front of the lenticular artwork. Then move or sway left and right to make sure that the edge of the viewing zone on both sides are equidistant from your central viewing position. If one edge appears to cross the lenticular sooner than the other, then the primary viewing zone is not centralised correctly and thus the lenticular image will not show the correct view from directly in front. In a worst-case scenario, very often seen with commercial lenticulars, the primary viewing zone is so badly offset that you see the edge of the viewing zone running down the middle of the lenticular when standing directly in front. Check also that the edges of the primary viewing zone, as they pass your eyes and the lenticular image, are vertical. If they are slanted or curved, then this too is an error that will lead to a reduced viewing angle and a poorer quality image.

To check that the primary viewing zone lies at the optimum distance from the artwork, once again stand directly in front of the lenticular artwork at the optimum viewing distance and move or sway left and right until the edge of the viewing zone passes by your eyes. If the edge passes by almost instantaneously then the viewing zone is at the correct distance and you will see the correct 3D image through the maximum angle of view. If, however the edge of the viewing zone passes by much more slowly, the viewing zone does not coincide with the optimum viewing distance and thus the angle of view will be reduced, and you will not see the best possible image.

5. Optical artefacts

Occasionally you may see undesirable optical artefacts in the lenticular image such as banding or stripes running vertically through the image, especially from extreme angles, and moiré patterns. There are several reasons why such optical artefacts can occur and, of course, it is preferable to have

a lenticular image which is free from them however, if present, and depending upon severity, they do not usually greatly affect the integrity of the lenticular image.

6. Cosmetic defects

Small bubbles, caused by dust trapped between the image print and the lenticular lens when the two are laminated together, may occasionally be found. Ideally a lenticular artwork would be bubble free however perfect lamination is sometimes difficult to achieve, especially for very large format artworks. Also, lenticular lenses can sometimes contain various defects such as scratches and lens distortions. The surface of the lenticular lens should be clean, scratch free and void of any obvious defects.

7. The illumination of lenticular artworks and archival considerations

All lenticular images, whether front lit or back lit, are best viewed in diffuse light, such as an LED light panel. A lenticular artwork should not be illuminated with one or more spot lights as this causes bright bands of light to be reflected from the lenticular surface preventing the artwork from being viewed properly.

Direct sunlight should never be allowed to fall on a lenticular artwork and the lenticular should be protected from UV light by a glass or acrylic UV filter.

The archival properties of a lenticular artwork are the same as for a 2D art print made using the same printing method and kept under the same conditions.

Final summary: From the above, it follows that the highest possible quality lenticular artwork can be made by use of:

a) A lenticular lens comprising of optical grade acrylic resin lenses cast directly onto an acrylic or glass substrate
b) *A print comprising of a C-Type transparency (or reflective) print*
c) *The above lens and print are held in register with each other and at the correct focal length by way of an air spaced clamping system.*

Rob Munday, Artist and Holographer, 2019

(1) Sequence shown: Portrait of Angelina Jolie for Guerlain by Rob Munday.