

The Perspective Machine of Vincent van Gogh

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Abstract

In this paper we demonstrate a likely usage of van Gogh's unique perspective frame based on surviving records, we also show how this method produces some of the characteristics of the artist's distinctive perspective, we also note that this perspective is equivalent to the General Pannini family of projections and illustrate how it can be reproduced photographically.

1. Introduction

Vincent Willem van Gogh (1853 - 1890) was a celebrated post-impressionist artist noted for pioneering colour in his art, but also for an apparent disregard of traditional perspective technique. Regarding his perspective, previous work suggests that van Gogh did TODO [Hee72] or TODO [Hee98], however we believe that TODO.

2. Characteristics of van Gogh's perspective

In February 1888 van Gogh moved from Paris to Arles in the south of France where he painted his most distinctive work and developed his characteristic perspective style. Here we illustrate two scenes that the artist painted that year multiple times, The Night Café (two versions from September 1888, Figures 1, 2) and Bedroom in Arles (three versions painted between October 1888 and September 1889, Figures 3, 4, 5).

We would like to draw attention to three aspects common to these paintings, the first two are typical of most perspectives, but it is the last that makes them stand out:

1. A radial composition with lines parallel to the view direction converging on a vanishing point.
2. Vertical features are drawn parallel to the sides of the canvas.
3. Horizontal features, that in three dimensional space would be orthogonal to the other two sets of lines, curve and converge both to the left and to the right of the picture.

See Figures 19, 20, 21.

Compare the Bedroom paintings with a sketch in a let-

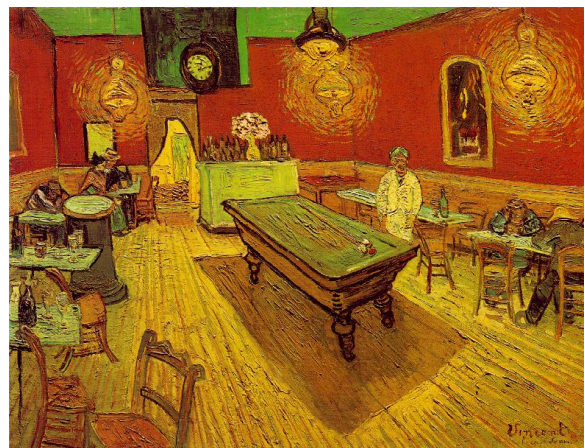


Figure 1: The Night Café, oil on canvas, Vincent van Gogh (September 1888).

ter to the artist Paul Gauguin in October 1888 Figure 7, the artist here has shown the horizontal features using a conventional perspective with no convergence. The graph paper used probably has something to do with this.

3. Comparison with classical perspective

The rules of renaissance perspective form a projective geometry, the principle is often described by showing an artist looking through a window and tracing the scene onto the glass, well illustrated by the engraving by Albrecht Dürer Figure 8. This technique produces a 'true' rectilinear pro-



Figure 2: The Night Café, watercolour, Vincent van Gogh (1888). This is a copy made by the artist as a design for a Japanese woodcut print.



Figure 3: Bedroom in Arles, oil on canvas, Vincent van Gogh (October 1888).

jection - Which is incidentally the same projection as produced by camera obscura, camera lucida, pinhole and 'normal' photographic lenses.

Rectilinear projection images preserve straight lines, i.e. any features that are straight in three dimensional space will be represented as straight lines on the canvas. Rectilinear projection has its drawbacks, wide angle-of-view pictures show extreme distortion around the periphery, indeed it is only possible to represent a scene with an angle-of-view less than 180° , in practice angles-of-view greater than about 90° produce unacceptable distortion.

(TODO an example of unacceptable distortion here)

Van Gogh in his own words describes his early education in perspective techniques as essential, he read Armand Cassagne's books [Cas66] and explored traditional perspective with his early Dutch paintings and drawings, an example



Figure 4: Bedroom in Arles, oil on canvas, Vincent van Gogh (September 1889).



Figure 5: Bedroom in Arles, oil on canvas, Vincent van Gogh (September 1889).

is Rooftops, View from the Atelier (1882) Figure 9 which shows features of a conventional rectilinear perspective.

4. A classical perspective machine

There are several techniques for assembling a rectilinear perspective, the one we wish to highlight here involves the use of a 'perspective machine' or 'perspective frame'. The concept is similar to the window analogy (Figure 8) described above, a rectangular frame with the same proportions as the canvas is suspended in front of the artist, this frame is strung with a square grid made from fine thread, a grid with the same proportions is also drawn on the canvas by the artist. Provided the artist can keep their eye in the same position, all they need to do is copy one square at a time from the scene to the canvas, and the result is a true rectilinear repre-

in the Hospital at Arles.jpg



Figure 6: Ward in the Hospital at Arles, oil on canvas, Vincent van Gogh (April 1889).



Figure 7: Bedroom in Arles, Letter to Paul Gauguin 706/B22, 17th October 1888, Vincent van Gogh.

sensation of the scene. Again Albrecht Dürer illustrated this principle well Figure 10.

Note that the requirement for the artist to keep one eye in the same position relative to the frame is onerous, a perspective machine typically includes an eyepiece or fixed pin so the artist can keep the same eye position, though this is sufficiently uncomfortable that modern artists rarely use such machines.

5. Van Gogh's perspective frame

We know from the artist's correspondence with his brother Theo that van Gogh had two custom perspective frames built in 1882, the letters contain diagrams illustrating the frame but little written description of the technique.



Figure 8: De Symmetria and Underweysung der Messung, Albrecht Dürer (1532). The perspective device here is a sheet of glass that the artist paints directly, copying the scene on the other side of the glass. Such a system requires that the artist keeps his eye in the same position throughout the whole process, so the machine necessarily provides a pin or eyepiece with an adjustable position.

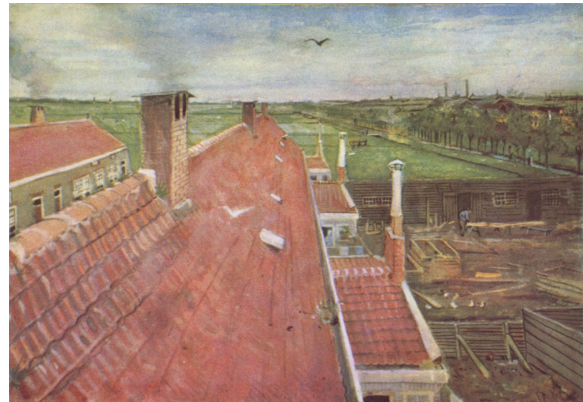


Figure 9: Rooftops, View from the Atelier, Vincent van Gogh (1882). This painting shows a mastery of conventional rectilinear perspective.

The first version of the frame was built in June 1882:

" ... I had more expenses in connection with the study of perspective and proportion for an instrument described in a work by Albrecht Dürer and used by the Dutchmen of old. It makes it possible to compare the proportions of objects close at hand with those on a plane further away, in cases where construction according to the rules of perspective isn't feasible. Which, if you do it by eye, will always come out wrong, unless you're very experienced and skilled.



Figure 10: De Symmetria and Underweysung der Messung, Albrecht Dürer (1532). An alternative perspective machine, the rectangular frame and adjustable eyepiece are the same as Figure 8, however, instead of drawing directly on a sheet of glass placed in the frame, a square grid is strung in the frame and duplicated on the paper where the final picture is drawn.



Figure 11: Production still from 'The Draughtsman's Contract', Peter Greenaway (1982). Note the eyepiece necessary to keep the artist's eye in the same position, this differs only slightly from Dürer's Figure 10 engraving which features a pin instead.

I didn't manage to make the thing the first time around, but I succeeded in the end after trying for a long time with the aid of the carpenter and the smith. And I think that with more work I can get much better results still."

Letter 235, June 1882 [vG82a]

Two months later, van Gogh is making a second version of the frame. van Gogh illustrated this with a sketch showing how he intends to use this new frame Figure 12, the artist is standing with the canvas in one arm, the frame is positioned with the centre at eye level, and there is no sign of any kind of eyepiece. Note that this sketch also shows a distinctive radial grid of string.

"I'll start with small things – but before the summer ends I hope to practise bigger sketches in charcoal with an eye to painting in a rather larger format later. This is why I'm having a new and, I hope, better perspective frame made, which will stand firmly on two legs in uneven ground like the dunes.

Like this, for example. (Figure 12)"
Letter 253, August 1882 [vG82b]

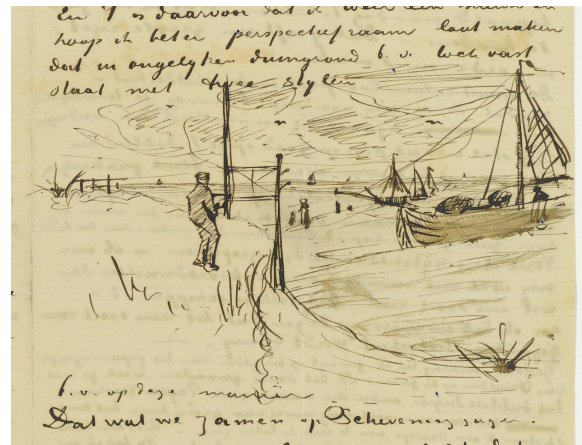


Figure 12: Sketch of perspective frame in use, Letter 253 to Theo van Gogh, Vincent van Gogh (August 1882). This illustrates the ability to set up the frame in difficult locations, notice how the two posts are set at different heights to accommodate the slope of the ground. See also enlarged detail Figure 13.

In the next letter to Theo, Vincent describes the frame in more detail:

"In my last letter you'll have found a little scratch of that perspective frame Figure 12. I've just come back from the blacksmith, who has put iron spikes on the legs and iron corners on the frame.

It consists of two long legs: (Figure 14)

The frame is fixed to them by means of strong wooden pegs, either horizontally or vertically.

The result is that on the beach or in a meadow or a field you have a view as if through a window. The perpendicular and horizontal lines of the frame, together with the diagonals and the cross – or otherwise a grid of squares – provide a clear guide to some of the principal features, so that one can make a drawing with a firm hand, setting out the broad outlines and proportions. 1 Assuming, that is, that one has a feeling for perspective and an understanding of why and how perspective appears to change the direction of lines and the size of masses and planes. Without that, the frame is little or no help, and makes your head spin when you look through it.

I expect you can imagine how delightful it is to train this view-finder on the sea, on the green fields – or in the winter on snow-covered land or in the autumn on the fantastic network of thin and thick trunks and branches, or on a stormy sky.

With CONSIDERABLE practice and with lengthy practice, it enables one to draw at lightning speed



Figure 13: Sketch of perspective frame in use, detail, Letter 253 to Theo van Gogh, Vincent van Gogh (August 1882). This detail from Figure 12 shows the distinctive radial grid. The artist is standing with the sketch board in one hand, there is no eyepiece, however the centre of the radial grid is placed exactly at eyelevel (i.e. note that the artists eye, the horizon and the grid centre are at the same vertical height).

and, once the lines are fixed, to paint at lightning speed.

It's in fact especially good for painting, because a brush must be used for sky, ground, sea. Or, rather, to render them through drawing alone, it's necessary to know and feel how to work with the brush." Letter 254, August 1882 [vG82c]

Here we show van Gogh's sketch illustrating the construction Figure 14, it consists of a rectangular frame that spans between two detachable posts, the posts are secured with pegs and holes that allow height adjustment and that can accommodate variable terrain. Note also the diagonal and orthogonal grid of string that intersects in the centre.

We know that van Gogh continued to use this frame, as he states in March 1888 after arriving in Arles:

"I made my last three studies with the help of the perspective frame you know about. I attach importance to the use of the frame, because it doesn't seem unlikely to me that several artists will use it in the not too distant future, just as the old German and Italian painters, certainly, and, I'm inclined to believe, the Flemish artists too, used it.

The modern use of this tool may differ from the use people made of it in the past – but – isn't it also true that with the process of painting in oils we nowadays achieve very different effects from

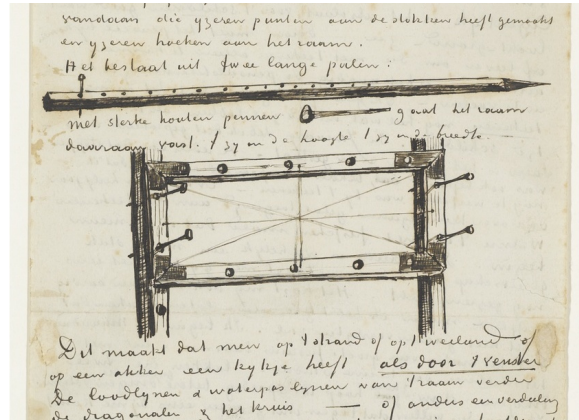


Figure 14: Detail sketch of perspective frame showing grid, Letter 254 to Theo van Gogh, Vincent van Gogh (August 1882). Note the distinctive radial grid of string. Instead of a tripod or table, the frame is supported by two sharpened posts which can be driven vertically into soft or uneven ground. Each post features a series of peg holes which are matched by peg holes in the frame, these allow the frame height to be adjustable. The frame can also be placed in portrait or landscape orientation.

those of the inventors of the process, J. and Hubert van Eyck? This is to say that I still hope not to work for myself alone. I believe in the absolute necessity of a new art of colour, of drawing and – of the artistic life. And if we work in that faith, it seems to me that there's a chance that our hopes won't be in vain."

Letter 585, March 1888 [vG88]

TODO [Wri83]

Unfortunately, the principle of van Gogh's perspective frame died with him two years later. Though we believe that it is possible to deduce it from this evidence left behind in letters and the paintings themselves.

6. Proposed usage

Presumably the grid was used in the same basic way as with a traditional perspective machine, i.e. the artist drew this diagonal grid on the canvas and copied the scene segment by segment by looking at the scene through the frame.

7. Tests with reproducing the technique

With our tests using a reproduction of the apparatus, the advantage of the diagonal grid becomes obvious - The grid of string looks the same and segments the scene in the same way whatever distance you are from the frame. There is no need to use an eyepiece, alignment can be retained just by the artist moving her head sideways such that a chosen fea-

ture in the scene always lines-up with the intersection of the grid.

A consequence of this is that the edges of the frame do not coincide with the edges of the canvas, the artist has to fill each segment from the centre outwards and can't easily compose the picture before they start.

In the photos you can see our test apparatus simply consists of a window with van Gogh's grid drawn on the glass with a permanent marker pen. You can see also that the grid segments the scene identically when viewed from different distances (the grid has been highlighted to make it more visible for print).



Figure 15: Test grid drawn on a window, by the author (2010). This differs from van Gogh's frame which has string forming the grid, note that unlike a traditional perspective machine where the frame is part of the grid, in this case the frame is irrelevant to the process.

(TODO more photos showing grid from different distances)

The sketch by one of the authors was quite straightforward to produce, the discipline of keeping the grid aligned with the view is actually very natural and not at all restrictive.

A consequence of the radial grid is that whereas with a rectangular grid you have no choice but to produce a precise rectilinear perspective, with the radial grid, the angular positions of features can be placed accurately, but the radial distance is something that still needs to be judged by eye – since the grid places no restriction on this. An assumption of this paper is that an artist will generally attempt to draw 'conformally', i.e. she will attempt to draw people and buildings with a 'true' proportion rather than stretching objects at the periphery like a rectilinear projection photograph. Each of these wedges provided by the frame can be easily filled conformally by the artist and the resulting image has some interesting properties:

1. Radial features are preserved due to the grid in the frame.

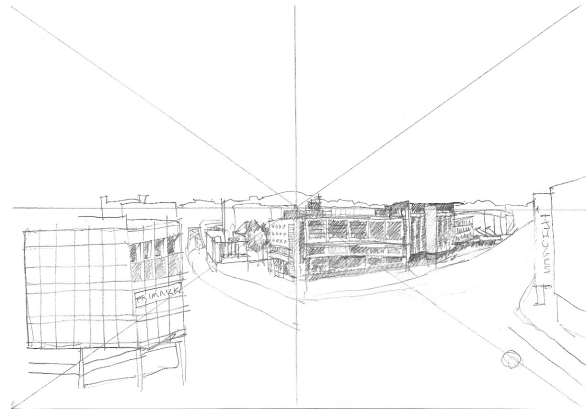


Figure 16: Sketch drawn with test grid, by the author (2010). Created using the grid drawn on a window shown above Figure 15.

2. Lateral features are drawn curved due to the increasing horizontal compression at the edges required to maintain minimal local distortion in combination with the preservation of angular position.

3. An extremely large angle-of-view is possible, the authors sketch is approximately 120° wide, something that isn't practical to achieve with a rectangular gridded perspective frame.

8. Pannini perspective

There is of course a projective geometry that matches these properties, this is provided by the 'General Pannini' [STM10] projection named after the eighteenth century vedutismo artist (Giovanni Paolo Pannini 1691 – 1765). Whereas Pannini himself used the orthographic variation, van Gogh's images are close to the stereographic variant.

A Pannini perspective grid is illustrated, this has a 10° spacing, notice that radial lines are equally spaced, vertical lines are straight and vertical, but the spacing increases away from the centre, horizontal lines bow as is necessary to maintain low local distortion.

This grid can be overlaid onto the artist's work, both *The Bedroom in Arles* and *The Night Café* paintings can be closely matched to the Pannini grid (Figures 19, 20), 21, in fact it is possible to read the angle-of-view of both paintings, the first is 65° and the second is 110° .

We don't have any evidence that van Gogh's frame was used in either of these paintings, indeed we don't know if it was ever modified to be suitable for use on a hard floor.

9. 3D reconstruction

TODO

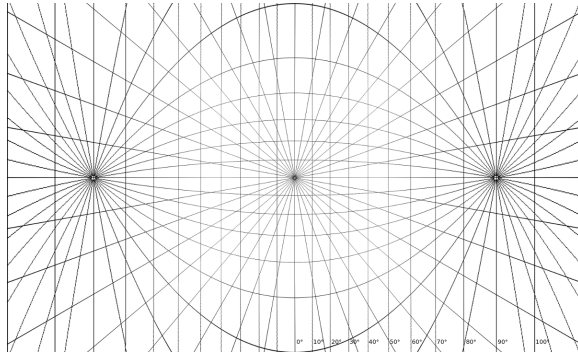


Figure 17: Pannini perspective grid, by the author.



Figure 18: Same view as the author's test sketch, but as a Pannini projection photo, by the author (2010).

10. Photographic example

The General Pannini projection has been added by the authors to the Hugin panorama stitcher [dea], with this is it possible to try and reproduce these kind of images photographically. Here we show an example of a similar scene to The Night Café, this has been photographed with multiple overlapping shots since the angle-of-view required is considerably wider than a normal lens can provide, the image shown has been simply assembled in Hugin and the projection set to 'General Pannini' without any further adjustment other than cropping.

(TODO similar photo exercise with bedroom)

11. Conclusion

Very close correlation between Pannini projection and some paintings by the artist. TODO more

Further research needs to look for the distinctive construction grid in paintings and sketches by the artist.

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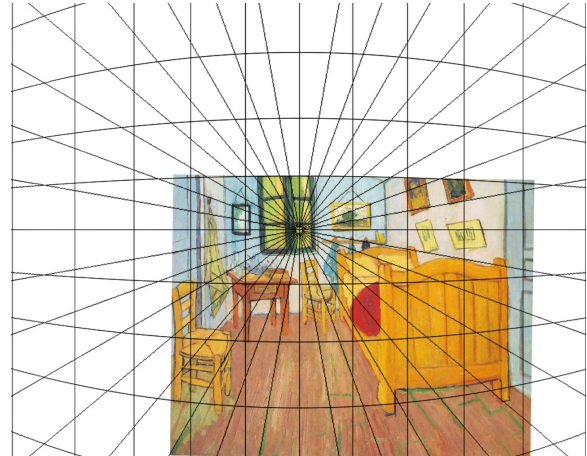


Figure 19: Bedroom in Arles with Pannini overlay, Vincent van Gogh (1888).

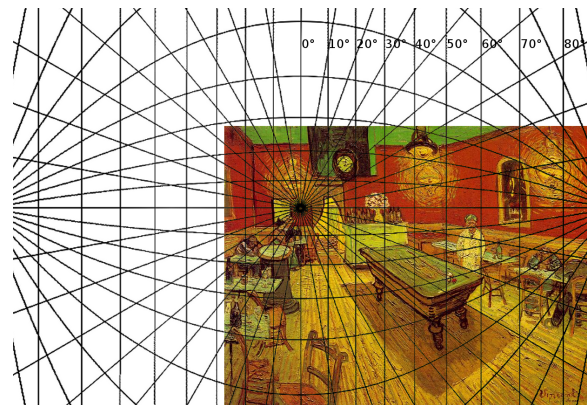


Figure 20: The Night Café with Pannini overlay, Vincent van Gogh (1888).

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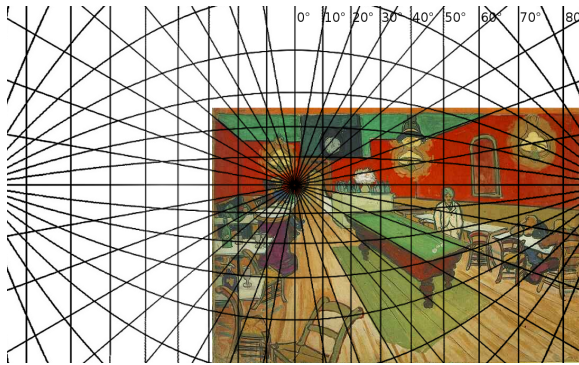


Figure 21: The Night Café with Pannini overlay, Vincent van Gogh (1888).

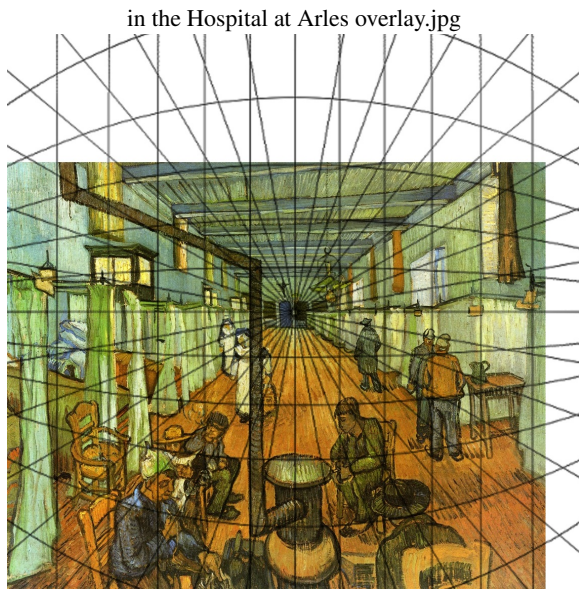


Figure 22: Ward in the Hospital at Arles with Pannini overlay, Vincent van Gogh (1889).

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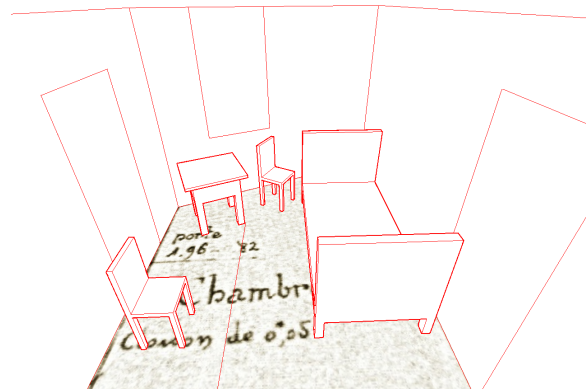


Figure 23: Bedroom in Arles reconstructed from plans, view from above, by the author (2010)

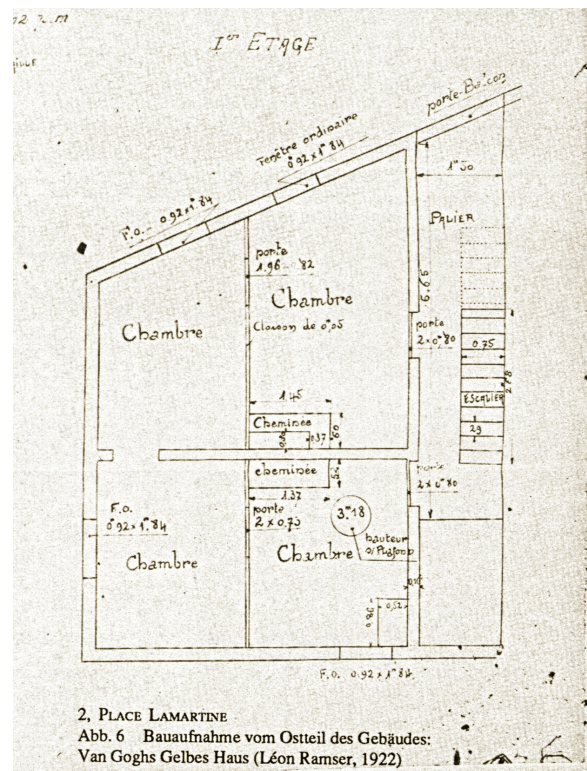


Figure 24: Bedroom in Arles plan, by XXXXX (XXXX) TODO

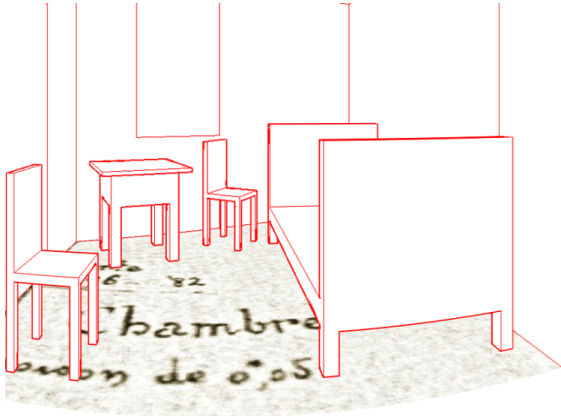


Figure 25: Bedroom in Arles reconstructed from plans and rendered in Pannini projection, by the author (2010)

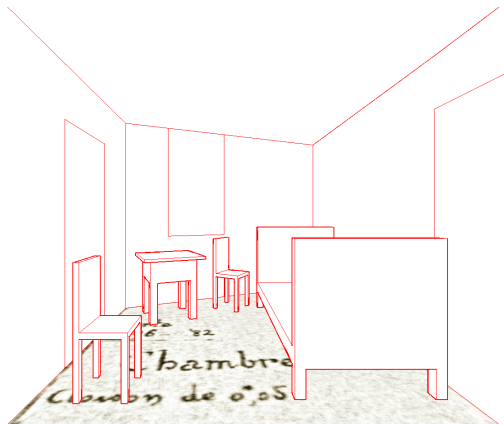


Figure 26: Bedroom in Arles reconstructed from plans and rendered in standard rectilinear projection, by the author (2010)



Figure 27: Bedroom in Arles reconstructed in the van Gogh museum, Amsterdam, [Rü]



Figure 28: Bedroom in Arles reconstructed in the van Gogh museum, Amsterdam, photograph from Figure 27, converted to Pannini projection by the author (2011)



Figure 29: The Cobden View, Pannini projection photograph by the author (2010).