Anamorphic Projection – Photographic Techniques for setting up 3D Chalk Paintings

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Although it is centuries old, the art of street painting has been going through a resurgence. “3D” or “Anamorphic” paintings have become an extremely popular branch of the art, captivating audiences all over the world.

Developing a 3D image requires the artist to carefully distort the artwork in a way to compensate for the way that we perceive depth and distance: When we look at an image, our brain tells us that something that is far away from us will appear smaller than it will when it is close to us. Our brain also tells us that parallel lines will get closer together and that they will even intersect when they reach the horizon. Anamorphic images distort the image to compensate for these distortions fooling our brain into thinking that they are standing vertically instead of lying flat.

To understand how to set them up it is best to understand their basic mechanics. Although there are trigonometric techniques for calculating angles, projections and locating points in space those techniques are more suited to the computer programmer than the artist. Fortunately, there are also draftsmen’s techniques and photographic techniques for setting up anamorphic images. In this paper we will present a basic photographic technique for setting up images.

Before we get too far along, it is helpful to know that there are some rules to this game. And knowing some of the definitions and buzz words helps too.

- The first thing to know about a perspective drawing is that it works from only one angle. If you look at it from another angle the perspective will be off. If you look at it from the top it will be way off.
- The second thing to remember is that perspective distorts a drawing in a non-linear way. The farther you get from the focal point – in depth and width, the more distorted things get.
- Because the distortions are “logarithmic” in nature, 3D images can get large. Very large. Images of 20 feet, 40 feet, even 100 feet are common. If space is limited, the artist will need to design their images carefully.
- Further, because the images are logarithmic, a distortion that is set up for an 8x8 square cannot be used on a 12x12 square – the distortion is different!

For this discussion, we will use the following terms and definitions:

The “viewer” will be the person looking at our image. For the sake of argument the viewer will be a smartly dressed gentleman of average height – say 5'-9" tall. (This is somewhat arbitrary, as you will later discover).
- The “Viewpoint” will be the eye level of the viewer. For this discussion we will assume that our viewer has only one eye that is located in the center of his forehead 3” below the top of his head.
- The “Subject” the subject is the thing that we will be drawing. For this discussion, we will be drawing a silhouette of a child 3’-6” tall.
- The “Ground Plane” – this is the surface upon which we will project the image that we wish to draw.
- The “Picture Plane” an imaginary two-dimensional surface upon which our subject is located. For this exercise, we will assume that our subject is perfectly flat (just like a photo) and is standing in this plane. The significance of the picture plane is that it is the only two dimensional place in the entire projection and drawing space where there is no distortion. Objects that appear in this plane can be scaled (measured – up and down, right and left, but not towards or away from the viewer) and are in the proper proportion with each other. The significance of this will become apparent.

The “view point distance” is the distance between the viewer and the picture plane. For this discussion I will use a distance of 6’-0”. Why? Because many festivals are tight on space and are often crowded. Six feet is a reasonable distance – not too close, not too far.

The simplest way of understanding how this works is to break the problem down into two-dimensional views. In Architecture we call these views the “plan view” (the top view) and the “elevation” (the side view).

Let’s start with an “elevation” view we set up above. Let’s consider what our viewer sees when he looks at his child. If we were to draw a line from the viewer’s eye to the top of his child’s head and then extend that line until it hits the ground plan we would know how far away from the picture plane the top of his head should be located on the ground plane.
Through the magic of a CAD program (which is totally unnecessary for this exercise) we see that our 3'-6" tall child would need to be drawn 11'-1" tall. If we continue this exercise, we can project the point at which the shoulder, the elbow, the knee, and the ankle all hit the ground plane.

Now, let's take a look at the same image from the top (or the “plan view” as we architect's like to call it). In a similar manner we will draw lines from the view point to the side of the subject's head, the side of the shoulders, the elbow, etc.
Ok, now let’s employ a little draftsmanship and combine these diagrams.

By projecting the lines in the elevation view down onto the plan view and then connecting the dots where the lines cross we can now have a layout of what the subject would look like if projected out onto the pavement.

At this point some general observations about this setup are in order.

- Everything in this setup is variable – the view height, the distance to the subject (the picture plane) – everything.
- The taller subject is, the longer the projection will be. The logical extreme of this is reached when the height of the subject reaches or exceeds the viewpoint height. At this point, the length of the projection would be infinite.
- Therefore, if you wish to draw something that is tall, you would need to make some adjustments to your layout:
- Move the height of the viewer up (have them stand on a box, stairway, or ladder, for example)

- Move the base of the subject down: dig a virtual "hole" for the subject to stand in (ever wonder why so many street paintings show something popping out of the ground? It helps the perspective work!)

- Move the viewer towards the subject. This will, unfortunately, result in other distortions. The logical extreme here is when the viewer is on top of the subject and the projection becomes a "top view" plan. Short of all this, you can simply shrink your image down and accept the fact that the basketball player you are drawing will be smaller than full size. This isn't normally a problem because it is difficult to tell that something is short until you compare it with something else – give it context. Stand a person next to the image and your basketball player will appear short. Move them away, and it will be hard to tell.

And those are the basic mechanics.
Understanding the basic mechanics helps understand why things work the way that they do, but setting up an actual image in such a manner would be rather tedious. There are standard draftsman’s techniques for drawing things in perspective, however these methods can be difficult to learn and apply. The simplest method of developing a 3D image is to “reverse engineer” a photograph of your image using photo editing software such as Adobe Photoshop.

The first step in the process is develop a photographic layout of the image of your workspace. For this exercise we visited a local school yard and taped out an 8’ x 8’ square

Because we will eventually use this layout to distort an image, it is important to set an image up as precisely as possible. We used a carpenter’s square to make sure that our corners were square (one could use a piece rectangular piece of paper or a draftsman’s triangle as well).
We also verified that the corner-to-opposite-corner distances matched. This gives us the precision that we need for our photographic layout.

Once we have taped out our square we set our camera. In this example, we have positioned the camera 6'-0" back from the bottom edge of the layout and placed the camera 5'-6" above the ground.

From here we take a picture of the square. Aim the camera at the middle of the square (we gridded the square into quarters with pink string for this purpose). Adjust the zoom on the camera so that you get a photo of the entire square. This image will become the "layout grid" for setting up our 3D image.
Now that we have developed a photographic layout grid we move over to the computer. For this exercise we are using Photoshop, however there are other software packages with similar tools that will do the same thing. This exercise assumes that a basic working knowledge of Photoshop or other photo editing package.

We begin by opening the picture of our layout grid in Photoshop. We have cropped the image and rotated it slightly so that the bottom of the image is parallel with the bottom of the image. We have also opened several other images that we are going to use in our illustration.
The next step in the process is to assemble the illustration. Here, we have pasted several images into the layout grid. We recommend that the individual elements remain on separate layers as this simplifies the process of moving the elements around.

The blue taped line represents the edges of square; everything must fit within this square, otherwise it will overflow the boundaries. Once you are satisfied with your layout, link all of the layers together.
The next step is to draw a “square grid” in a separate drawing. The square grid must be of the same proportions as the grid that was taped out in the photo. For example, if an 8’x8’ space was taped out, then draw a grid that is 8x8 (inches, feet, centimeters – the physical units are not important as long as the proportions are the same!)

Make a copy of your square grid and paste it into your layout file on a separate layer. Scale the grid as necessary so that the top of the square grid aligns with the top and bottom of your image. Please note: it is absolutely critical when scaling grids that they are always scaled proportionally! Do not let the horizontal and vertical scales change differently.
Next, using the “perspective” tool, pull the corners of the layout image in until the blue tape aligns with the outside edge of the square grid. As we added horizontal and vertical center lines with pink string in our layout photograph we can see that these lines align with the horizontal and vertical center lines of our square grid.

The more precision you have in your taped layout image, the easier it will be to align the photographic and the square grids!
The distortion is now complete. You can turn off (and discard, if you wish) the photographic layout. The square grid can be used as a transfer grid, or the image can be printed out and pounced.

Before finishing, we will offer some general observations and some design suggestions that may be helpful in putting together a 3D image.

- The completed distortions can look weird. Sometimes they can look really weird! As things at the top of the image are really stretched, and at the bottom of the image are hardly stretched at all. In this example, we see that Red’s hat is taller than the rest of her body combined. And her feet are regular size.
Things to the left of center will lean to the left. Things to the right of center will lean right. The further to the side they are, the more that they will lean. Things that are in the lower corners will be distorted considerably.

Drawing images “full scale” often means drawing them very large. In order to paint my image “full size” the square would need to extend all the way to the face of the building, up the wall of the building and across the roof. More than 100 feet long.
If we were to design the image with the subject on his knees, the image is now much shorter – extending most of the way to the building.

With the subject sitting, the physical size of the rendering is much more reasonable!

Of course we could always dig a virtual hole!
Or simply shrink the subject down to fit. As silly as this might seem, scale is difficult for the brain to understand until there is something to measure it against; have someone stand next to the image and the subject looks short. Take away that point of reference and nobody will know the difference.

When composing 3D it is important to have a believable starting and stopping points. Drawing a subject from the waist up would appear as if the subject has been cut off at the waist! (always awkward!)

A flag pole that starts at the bottom and cuts off at the top would appear as a floating stump. The flagpole needs a base and the base needs to be connected to the ground. The pole needs a top and the top needs to be up in the air.

Whenever possible, incorporate shadows into your work. Shadows help connect your images with the ground plane.

Render the ground plane. And know where the ground plane ends.

If you can “break the boundary” of the image by letting heads poke above the horizon line or feet poke below the bottom it helps with the illusion.
People will ask “where should I stand to get the full 3D effect?” Using this technique, the answer will be “it varies, depending on the height of the photographer and the lens of their camera” We suggest that they look through their lens and then move backwards and forwards until the things in the image are standing straight up.

Using this simplified technique you should be able to prepare fun three dimensional images!